



Thematic Session



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EFFECTS OF CLIMATE CHANGES ON MEAT PRODUCTION AND SUSTAINABILITY OF LIVESTOCK SYSTEMS

Dr. J. Abraham

Founder Director

Centre of Excellence in Meat Science and Technology,

Kerala Agricultural University, Thrissur, Kerala.

E-mail: johnabraham.dr@gmail.com

Introduction

In view of the huge population increase globally, the greatest challenge during the ensuing decades would be in ensuring food security and nutritional security. Rapid urbanisation, decrease in agricultural productivity, increased awareness about the nutritional requirements, decreased land holdings, unprecedented climatic changes, globalisation and free trade are all creating new challenges in securing food for the growing population globally. The global population may reach 9 billion by 2050 and as such, demand for foods of animal origin is expected to grow at peak levels. The global food system is experiencing profound changes as a result of anthropogenic pressures. The Intergovernmental Panel on Climate Change (IPCC 2018) during its recent meeting at Incheon, warned that the climatic changes globally is drastically increasing the atmospheric temperature and that it is affecting the food production and health of the population adversely. The ever increasing human population, together with changes in consumption patterns will evoke strain on production systems globally. The pattern of food habits are also changing world wide, especially in Asian and African countries due to improved income, awareness about nutritional requirements and social developments.

Against this background, the global food production system will have to improve its resource use efficiently and environmental performance significantly to ensure sustainability of global food production and consumption. Livestock, the largest land use sector on Earth, is an important part of this puzzle. Many solutions to challenges of feeding the world sustainably lie in how we manage the sector. The demand for livestock products is projected to grow substantially in the coming decades. This growth will be driven by increasing populations, economic growth and rapid urbanization in many parts of the developing world. The main conclusions from such projections is that a shift in diet patterns with more animal products and fats is likely to happen, mostly in developing world, as a result of increased incomes and urbanization.

There is significant uncertainty about how livestock systems might evolve to meet the increased demand for livestock products and what social and environmental consequences of these changes will be. In addition, the dynamics and patterns of agricultural production and the functioning of ecosystems will be significantly affected by climate change and increase in climate variability. Major changes thus can be anticipated in livestock systems, although the nature of changes is not easy to foresee. Livestock systems in developing countries are changing rapidly in response to a variety of drivers. Livestock products are an important agricultural commodity for global food security because they provide 17% of global kilocalorie consumption and 33% of global protein consumption (Rosegrant *et al.*, 2009). The livestock sector accounts for 40% of the world's agriculture gross domestic product (GDP). It employs 1.3 billion people and creates livelihoods for 1 billion of the population living in poverty. Climate change is seen as a major threat to the



survival of many species and ecosystems, and the sustainability of livestock production systems in many parts of the world. There is a growing demand for livestock products, and its rapid growth in developing countries has been deemed the "livestock revolution" (Wright *et al.*, 2012).

Worldwide milk production is expected to increase from 664 million tonnes (in 2006) to 1077 million tonnes (by 2050), and meat production will double from 258 to 455 million tonnes (Alexandratos and Bruinsma, 2012). Livestock or meat production is likely to be adversely affected by climate change, competition for land and water, and food security at a time when it is most needed (Thornton, 2010). Global climate change is primarily caused by greenhouse gas (GHG) emissions that result in warming of the atmosphere (IPCC, 2013). The livestock sector contributes 14.5% of global GHG emissions (Gerber *et al.*, 2013), and thus may increase land degradation, air and water pollution, and declines in biodiversity (Bellarby *et al.*, 2013). At the same time, climate change will affect livestock production through competition for natural resources, quantity and quality of feeds, livestock diseases, heat stress and biodiversity loss while the demand for livestock products is expected to increase by 100% by mid of the 21st century (Garnett, 2009). Therefore, the challenge is to maintain a balance between productivity, household food security, and environmental preservation (Wright *et al.*, 2012).

The Role of Animals and Animal Products

Importantly, although often overlooked, meat, milk, eggs, and other animal products, including fish and other sea foods, will play an important role in achieving food security for several reasons. First, animal products are an important source of high-quality, balanced, and highly bioavailable protein and numerous critical micronutrients, including iron, zinc, and vitamins B-12 and A, many of which are deficient in a large portion of the world's population. Thus, moderate consumption of animal-sourced foods play an important role in achieving a nutritionally balanced diet, especially in the developing world. Second, because they are recognized as high-quality foods, global demand for animal products is almost certain to continue to increase dramatically. The drivers of the increased demand for animal products include not only population growth but also increased affluence, especially in the developing world, where most of the increase in population will occur.

Third, farm animals are critical to a sustainable agricultural system and especially for smallholders who comprise most of the world's farmers. Farm animals contribute not only to a source of high-quality food that improves nutritional status but also additional resources such as manure for fertilizer, on-farm power, and other by-products, and, in addition, provide economic diversification and risk distribution. Moreover, increased efficiencies in the past several decades through genetic selection and improved management technologies have saved a large amount of resources, including water and land, and have substantially reduced the carbon footprint of animal production.

Fourth, ruminants such as buffalo, cattle, goats, and sheep, efficiently convert the forages from grasslands into high-quality animal products, and grazing also can promote the health and biodiversity of grasslands if managed appropriately. This is important because grassland pastures cover >25% of the Earth's land surface and, despite being home to nearly a billion people, comprise primarily marginally or non-arable land. However, sustainable farm animal production will also require a more complete understanding of their impact on the environment. For example, a report by the FAO of the UN estimated that livestock, and

especially ruminants, contribute as much as 18% of greenhouse gas emissions, but others have suggested that this is a gross overestimate and that the actual value may be as low as 3%. Regardless, as farm animal production continues to increase, we need to be concerned with not only greenhouse gases but also the impact of farm animals on soil, water, and biodiversity. We also need to better understand the specific role, if any, of animal products in the diet on global increase in noncommunicable diseases such as type 2 diabetes, obesity, and cardiovascular disease, because noncommunicable diseases are now responsible for more deaths worldwide than all other causes.

Global Livestock Production

Global meat production and consumption continues to rise (Fig. 1). Meat production has tripled over the last four decades and increased 20 percent in just the last 10 years. Industrial countries are consuming growing amounts of meat, nearly double the quantity in developing countries. World beef production is increasing at a rate of about 1 percent a year, in part because of population growth but also because of greater per capita demand in many countries (Fig. 2). The largest fraction of the greenhouse effect from beef production comes from the loss of carbon-dioxide (CO_2) absorbing trees, grasses and other year-round plant cover on land where the feed crops are grown and harvested. Second most important is the methane (CH_4) given off by animal waste and by the animals themselves as they digest their food. When considering the future of sustainability, the outline of the food system is a critical aspect. An understanding of the factors that influence meat and fish consumption is important for developing a sustainable food production and distribution system. This is especially the case because the importance of the food system as a driver of global environmental change can be expected to increase. National dietary patterns not only have ecological and economic development contexts, but also a regional/cultural context. Food consumption patterns, particularly meat and fish consumption, have serious consequences for environmental sustainability also.

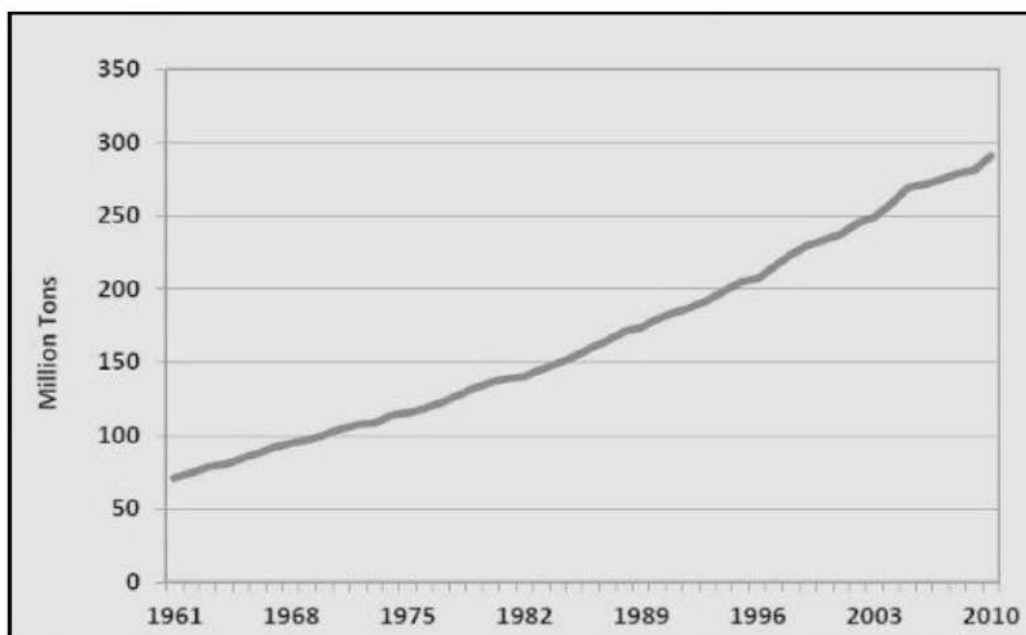


Fig. 1. World Meat Production 1961-2010 (World watch Institute, 2014)

	U.S. Beef Consumption (millions of tons)	CO ₂ -Equivalent Greenhouse Gases from U.S. Beef Production (millions of tons)	World Beef Consumption (millions of tons)	CO ₂ -Equivalent Greenhouse Gases from World Beef Production (millions of tons)
2009 (projected)	14	210	72	1,100
2020 (projected)	15	230	80	1,200
2030 (projected)	17	250	87	1,300
Cumulative (2009–2030)	340	5,000	1,800	26,000

Quantities are rounded to two significant digits

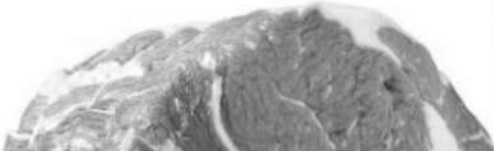


Fig. 1. World Beef Production (UNEP, 2012)

There is growing interest in understanding the interaction of climate change and agricultural production and it is motivating a significant amount of research. There is still limited research regarding the impacts of climate change on livestock production (IPCC, 2014). This paper mainly focus on the impacts of climate change on livestock products especially meat and food security.

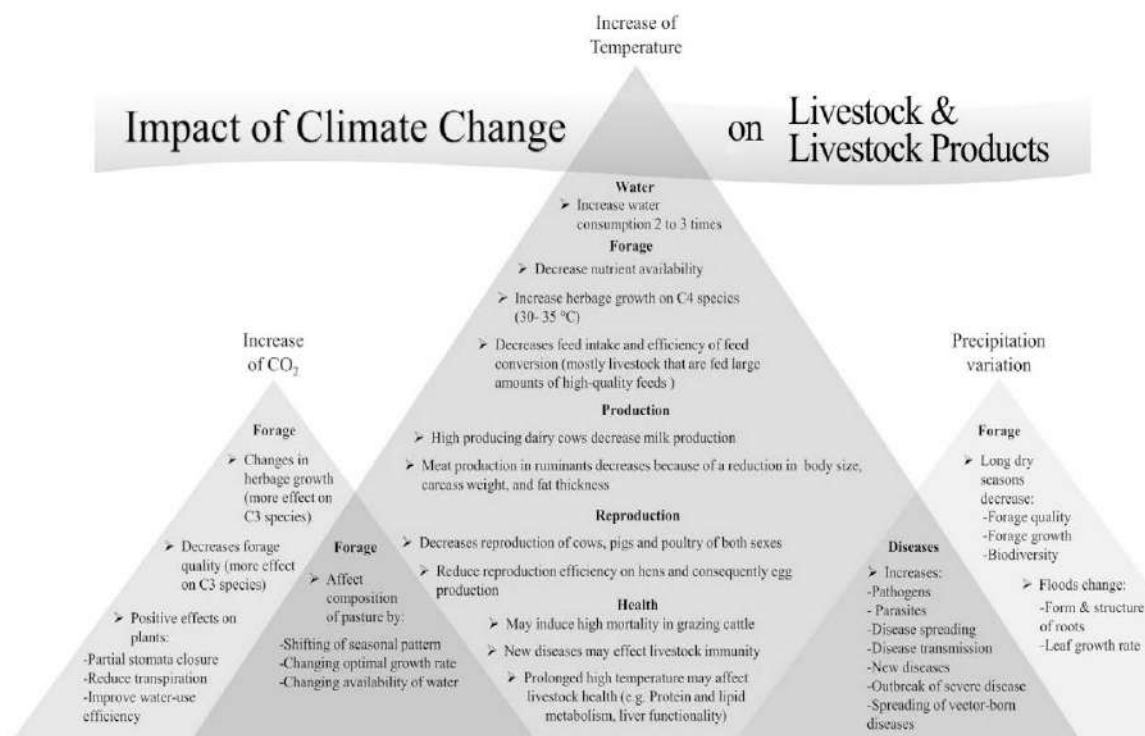


Fig. 3. Impacts of Climate Change on Livestock (Rojas-Downing, *et al.* 2017)



Impact of climate change on livestock Population

Despite uncertainties in climate variability, the IPCC Fifth Assessment Report identified the increase in global average surface temperature by 2100, which is between 0.3 °C and 4.8 °C (IPCC, 2013). The potential impacts on livestock include changes in production and quality of feed crop and forage, water availability, animal growth, meat and milk production, diseases, reproduction and biodiversity (Polley *et al.*, 2013). These impacts are primarily due to an increase in temperature and atmospheric carbon dioxide (CO₂) concentration, precipitation variation, and a combination of these factors (Polley *et al.*, 2013). Temperature affects most of the critical factors for livestock production, such as water availability, animal production, reproduction and health. Forage quantity and quality are affected by a combination of increases in temperature, CO₂ and precipitation variation. Livestock diseases are mainly affected by an increase in temperature and precipitation variation.

Effect of Heat stress on livestock

All animals have a thermal comfort zone, which is a range of ambient environmental temperatures that are beneficial to physiological functions (FAO, 1986). During the day, livestock keep a body temperature within a range of ± 0.5 °C (Henry *et al.*, 2012). When temperature increases more than the upper critical temperature of the range (varies by species type), the animals begin to suffer heat stress (FAO, 1986). Animals have developed a phenotypic response to a single source of stress such as heat called acclimation (Fregley, 1996). Acclimation results in reduced feed intake, increased water intake, and altered physiological functions such as reproductive and productive efficiency and a change in respiration rate (Lacetera *et al.*, 2003).

Heat stress on livestock is dependent on temperature, humidity, species, genetic potential, life stage, and nutritional status. Livestock in higher latitudes will be more affected by the increase of temperatures than livestock located in lower latitudes, because livestock in lower latitudes are usually better adapted to high temperatures and droughts (Thornton *et al.*, 2009). Heat stress decreases forage intake, milk production, the efficiency of feed conversion, and performance (Wyman *et al.*, 1962). Warm and humid conditions cause heat stress, which affects behaviour and metabolic variations on livestock or even mortality. Heat stress impacts on livestock can be categorized into feed nutrient utilization, feed intake, animal production, reproduction, health, and mortality.

Feed nutrient utilization and feed intake :- Livestock have several nutrient requirements including energy, protein, minerals, and vitamins, which are dependent on the region and type of animal. Failure to meet the dietary needs of cattle during heat stress affects metabolic and digestive functions (Mader, 2003). Most of the research concerning feed intake in meat animals has been focused on cattle. Thermal livestock stress decreases feed intake and efficiency of feed conversion, especially for livestock that are fed large amounts of high quality feeds. In the case of cattle, feed intake reduction leads to a negative energy balance and reduced weight gain. Reduction of water intake may also decrease sweating and feed intake.

Animal production :- One of the major causes of decreased production in the dairy and beef industry is heat stress (Nardone *et al.*, 2010) and significant economic losses have been related to this. The United States livestock industry has an annual economic loss between 1.69 and 2.36 billion US dollars due to heat stress (St-Pierre *et al.*, 2003). High-producing dairy cows generate more metabolic heat than low-producing dairy cows. In the case of meat production, beef cattle with high weights, thick coats, and darker colours are



more vulnerable to warming (Nardone *et al.*, 2010). Global warming may reduce body size, carcass weight, and fat thickness in ruminants (Mitloehner *et al.*, 2001).

The same is true in pig production, where larger pigs will have more reduction in growth, carcass weight, and feed intake (Nardone *et al.*, 2010). Piglets' survival may be reduced because of a reduction of sows feed intake during suckling periods with temperatures greater than 25 °C, which reduces the milk yield of the sow (Lucas *et al.*, 2000). The poultry industry may also be compromised by low production at temperatures higher than 30 °C (Esminger *et al.*, 1990). Heat stress on birds will reduce body weight gain, feed intake and carcass weight, and protein and muscle calorie content (Tankson *et al.*, 2001). Heat stress on hens will reduce reproduction efficiency and consequently egg production because of reduced feed intake and interruption of ovulation. Egg quality, such as egg weight and shell weight and thickness may also be negatively affected under hotter conditions.

Reproduction :- Reproduction efficiency of both sexes of livestock may be affected by heat stress. In cows and pigs, it affects oocyte growth and quality, impairment of embryo development, and pregnancy rate (Nardone *et al.*, 2010). Cow fertility may be compromised by increased energy deficits and heat stress. Heat stress has also been associated with lower sperm concentration and quality in bulls, pigs, and poultry (Kunavongkrita *et al.*, 2005).

Health :- Prolonged high temperature may affect metabolic rate, endocrine status, oxidative status, glucose, protein and lipid metabolism, liver functionality (reduced cholesterol and albumin), non-esterified fatty acids (NEFA), saliva production, and salivary bicarbonate (HCO_3) content. In addition, greater energy deficits affect cow fitness and longevity (King *et al.*, 2006).

Mortality :- Warm and humid conditions that cause heat stress can affect livestock mortality. Howden *et al.* (2008) reported that increases in temperature between 1 and 5 °C might induce high mortality in grazing cattle. As a mitigation measure, they recommend sprinklers, shade, or similar management practices to cool the animals.

Climate Change Impact on Meat Industry

Significant research has been done on heat stress impacts on meat quality and composition especially in cattle, sheep, goat, pig and broilers. High temperature and humidity results in increased meat pH, less expressed juice, cooking loss and drip loss. During exposure to high temperatures the energy utilization gets decreased while the energy expenditure is increased for thermoregulation. This deteriorates the quality of the meat by decreasing the muscle glycogen leading to increase in the muscle pH. The functional properties of meat such as colour, water holding capacity (WHC) and myofibrillar fragmentation index (MFI) are also negatively influenced during heat stress in ruminants. Further, the animal management practices during climate change also can indirectly affect the meat quality. For example, rearing heat-tolerant *Bos indicus* cattle is an effective adaptation strategy against the prevailing harsh climatic conditions. This can lead to tougher and less juicy beef. Besides the qualitative alterations driven by the heat load on the animals, carcass weight losses in heat stressed animals also has economic significance.

Ante-mortem temperature stress is a major determinant for live carcass weight losses, hot carcass weight and retail meat yield. Energy partitioning for thermoregulation accompanied with reduced feed intake to reduce heat load resulted in live weight losses. From these findings it is evident that heat stress declines both qualitative and quantitative characteristics of meat. However, this adverse effects of heat stress on meat



quality is variable based on the region of animal origin. This warrants developing region specific appropriate strategies to cope up with heat stress to improve meat production in the changing climate scenario.

Improving the resilience for livestock production under ensuing climate change scenario

(Sejian *et al.*, 2017)

a. Strengthening the assessment of climate change threats

- Improved forecasting and warning
- Building awareness of climate change and its consequences

b. Enabling informed choice of adaptation strategy

- Raise awareness of the value of different livestock breeds
- Raise awareness of the value of different management strategies
- Build capacity for integrated land use planning
- Build knowledge on fodder production and conservation
- Strengthen herd health and reduce mortality
- Strengthen understanding of the carbon cycle in livestock systems

c. Strengthening capabilities to act

- Developing skills in the livestock sector
- Developing resources in the livestock sector
- Developing infrastructure

d. Creating an enabling environment for adaptation

- Policy engagement
- Strengthening markets
- Organizations
- Land and resource tenure
- Transhumance
- Strengthening women livestock keepers' rights
- Pastoral codes and ministries

Approaches to livestock research and development under changing climate scenario

1. Matching livestock breeds with changing environments

- Characterization of SR breeds
- Concepts to combine phenotypic and molecular characterization with production systems data
- Geo-referencing of breed distributions to link to GIS referenced data on natural environment, etc.
- Developing similarity indices for environments and breeds
- Improving local breeds



2. Making adjustments in husbandry practices e.g. feeding, breeding, rangeland management
3. Diversifying income and employment to withstand climate shocks and seasonal effects
4. Strengthening or developing extension systems that respond to the changes
5. Institutional strengthening and improved decision-making capacities of the national systems

Conclusions

Climate change will affect livestock production and consequently food security. Livestock production will be negatively impacted (due to diseases, water availability, etc.), especially in arid and semiarid regions. In addition, climate change will affect the nutritional content of livestock products, which are one of the suppliers of global calories, proteins and essential micronutrients. Under the climate change scenario, elevated temperature and relative humidity will definitely impose heat stress on all the species of livestock, and will adversely affect their production and reproduction. The immediate need for livestock researchers aiming to counter heat stress impact on livestock production is to understand the biology of heat stress response components in deep and measures of animal well-being, giving researchers a basis for predicting when an animal is under stress or distress and in need of attention. The future research needs for ameliorating heat stress in livestock are to identify strategies for developing and monitoring appropriate measures of heat stress; assess genetic components, including genomics and proteomics of heat stress in livestock; and develop alternative management practices to reduce heat stress and improve animal well-being and performance.

Substantial efforts are also needed to identify specific genes associated with tolerance and sensitivity to heat stress. Most of the research concerning livestock production focuses on cattle; more studies must be performed on non-ruminants. Climate change may induce livestock diseases (e.g. outbreaks of severe diseases or new diseases), affecting animals that are not usually exposed to those diseases; there is a need to evaluate the dynamics of those diseases on livestock and how animals adapt to them. Climate change adaptation, mitigation practices, and policy frameworks are critical to protect livestock production. Diversification of livestock animals (within species), using different crop varieties, and shifting to mixed crop-livestock systems seem to be the most promising adaptation measures.

The study of sustainable livestock future needs the recognition that the livestock sector cannot be studied in isolation. Developing trends and alternating growth scenarios of how the sector might accommodate the increase in livestock products, need an integrated approach. At the same time, most concerned with the evolution of global food system need to accept that the livestock sector needs a sophisticated treatment in future assessments due to its connectedness to food and other economic systems. The livestock sector, the largest land user on Earth, holds a large stake in how to achieve the balance between food production, livelihoods and environmental objectives. It is essential that we continue researching it with urgency, consistency and rigor that it merits to ensure its contribution to the sustainability of global food systems in future.

(Reference will be available from author)





Technical Session - I

Innovative Trends in Production of Livestock Products



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Key Note Addresses

Session-I - Key Note Address-01

MEAT ANIMAL PRODUCTION AND UTILITY - NEED FOR INNOVATIVE AND PRAGMATIC APPROACHES

Dr. N. Kondaiah

Former Joint Commissioner (Meat & Meat Products) DAHD (GOI)
Former Director, National Research Centre on Meat (ICAR), k_napa50@yahoo.co.in

Indian livestock sector is an unique one with large populations of different species and diverse breeds. Production by masses is the characteristic as compared to mass production of developed countries. Relevant production interventions and policies as permitted by Constitutional provisions need to be pursued to exploit and realize the full production potential to sustain the farmers interest in animal production activities. This is essential to meet food and nutrition security, employment and for balance of payments with forex earnings from exports. The essential aspect of livestock production sustainability depends on the sustained utility of the species including meat utility of the culled and excess populations. The importance of economic demand driven production in the changing socio-economic conditions and land utilization need prime consideration in the development of programmes and policies in livestock sector. In a populous country like India mixed farming of crop and livestock production is the most efficient one for sustainability. Meat utility of livestock species promotes productivity and lifetime economics of the species which are critical for sustainability. Innovative interventions and pragmatic approaches need to support sustained livestock production under a range of situations. While the farmers are concerned with animal production allied sectors such as dairy, meat, leather and feed need to support with modern technologies, value addition and competent marketing approaches including export. Government need to protect the interests of the stakeholders with their active involvement and considering expert advice. In the post wto era Indian livestock sector to play an important role with increasing urban populations and rising incomes which compound the demand for livestock products. Efficiency in productivity commands the prospects.

Sustainable animal production largely depends on feed supplies and costs, production efficiency and utilization of products. Modern technologies and policies need to support each one of these aspects of animal production to achieve maximum gain under a range of situations. Effective utilization of produce is important and depends on hygienic production, cost efficient processing technologies, creating demand for the product, innovative marketing approach, utilization and proper disposal of byproducts and waste and providing a positive image. Indian livestock production is production by masses rather mass production by few. It is estimated that about 70 million rural households own livestock of one species or the other. Women constitute about 69% of workforce engaged in livestock sector. The resource-poor small and marginal farmers and landless labourers own majority of the livestock resources. Hence sustainable development of the livestock sector would lead to more inclusive development and empowerment of women. Mixed farming with value addition to crop sector is largely practiced and has been considered the most efficient one. Meat production is a byproduct utility of livestock sector –an efficient resource utilization approach.



Traditionally, livestock production in India and many developing countries has been a part of mixed farming systems, which had a high degree of environmental sustainability and considered the most efficient one. But, in the recent years with changing land utilization pattern and socio-economic changes semi-intensive and intensive livestock production systems are emerging as entrepreneurial ventures to meet the increasing demand for livestock products including meat and byproducts. In order to achieve better economics of these ventures and also sustaining traditional systems- efficiency in the utilization of resources in livestock production, processing and marketing have become important requiring innovations and adoption of technologies. Pragmatic approaches need to be given higher priority for sustaining prospects of livestock for livelihood, food and nutrition security and employment. *The unfettered right of farmers to organize animal production on modern and scientific lines as per Article 47 and 48 of the Constitution and the need for active involvement of farmers and other stakeholders in formulating policies, rules and regulations need to be supported.*

Complimentary efforts of dairy, meat, leather and feed sectors are demanded in solving the challenges faced in the sustained production and utilization of livestock species. Farmers need to be supported to face a range of situations developing on account of increased economic and social pressures that are compounding his constraints. Farmers interest can not be compromised and scientific interventions need to favour the farmers. As dairy and leather sectors are well developed and modernized, need to contribute in sustained production with appropriate production interventions and bringing increased awareness among the farmers towards realizing the maximum production potential of the livestock resources and other input items. All the co-sectors of livestock production need to implement model programs through adoption of villages for demonstrating realization of increased production potential and must work in tandem with other associated sectors for augmenting livestock prospects. The meat export sector having integrated modern establishments for value chain approach in the utilization of the meat animals (largely culled and excess buffaloes) have been contributing towards fetching increased income to the farmers. On similar lines modern dairy plants have been contributing in milk processing and marketing to benefit the farmers and the well developed leather sector has also been contributing to slaughter economics and increased farmers income. Developmental programmes and policy approaches need to facilitate all these associated sectors of livestock production and utility in order to sustain farmers interest in livestock production to contribute for food and nutrition security, livelihood, employment and economy of millions of the farmers and others associated with these sectors.

Sustainable livestock production and utility is compounded with a number of aspects that have either direct or indirect role on the purposes and functions of livestock. Cattle, buffaloes, sheep, goats, pigs and poultry are the major meat animals. Cattle and buffaloes are mainly reared for milk and draught purpose and provide meat as by-product. Sheep, goat, pig and poultry are reared primarily for meat production and manure is additional advantage. Goats also provide milk.

Major functions of meat animals:

- Production of meat, milk, manure, leather and draught power.
- Collection of plant feed - especially that which is otherwise unavailable, for physical or economic reasons.
- Conversion of nutrients otherwise unsuitable for human consumption.
- Concentration of nutrients present in the original food in low concentration.
- Maintenance of continuity of human food supply during times of crop failure.
- Complimenting crop production.



If livestock are important for production, subsistence and wealth it is to be expected that man takes an interest in livestock and places a value on them. The more important the economic functions of livestock, the greater that value will be (Hans E. Jahnke (1982) *Livestock Production Systems And Livestock Development In Tropical Africa*. KielerWissenschaftsverlagVauk, Postfach 4403, D -2300 Kiel 1). During the last two decades, studies in drought prone, distressed districts of Maharashtra, Karnataka and Andhra Pradesh have revealed that the incidences of farmers committing suicide were mostly confined to families exclusively dependent on rain fed agriculture, while rural families dependent partly or fully on dairy husbandry for their livelihood were able to face the stress successfully. Thus livestock is an important and integral part of Indian agriculture and rural economy (Hegde,2010, In Souvenir of IGFRI Foundation Day, November 2010).

Role of meat sector in Sustainable production

The importance of utilization aspects of livestock for meat has not received due attention due to lack of positive understanding on the importance of meat function in livestock production. However, with newer practices in livestock keeping (buffaloes, sheep and goat and pigs) (semi-intensive and intensive production systems) it has become important to consider appropriate strategies of utilization to ensure reasonable returns to sustain modern production system with higher production costs as compared to traditional methods which are shrinking due to the changes in land utilization and socio-economic changes. Also, it is necessary to provide meat and meat products to ever growing consumers with changing life-styles demanding variety, convenience and quality. Thus appropriate strategies for better utilization of meat animals are important both for increasing species productivity and meeting consumer demands for these protective foods.

Emergence of Meat function and the need for full potential realization

Relevance of meat sector has increased in the country due to changes in livestock rearing purpose and functions necessitated by socio-economic changes, increasing urbanization, mechanization in agriculture, changes in crop production and land utilization pattern due to increasing human populations and diversification in land use. There could be any number of factors exerting pressure on livestock production activities which may vary from place to place. But importance of livestock over the decades has only increased in most countries due the role of livestock in society in particular association with the livelihood of resource poor farmers. Women are very distinctly associated with livestock in developing countries like India. Draught utility has decreased over the years due to mechanization in crop production and transport sectors. This has lowered utility of some of the species of livestock like cattle but buffaloes have been compensated by milk and meat functions. Among live stock products while milk economy is important for cattle and buffaloes but meat economy is no less important. However, meat economy of cattle and buffaloes is restricted in some of the states in particular the cattle meat function utility in most of the states. With increasing economic and social pressures working on livestock production it would not be possible to continue with sustained livestock production unless the meat function is realized to the full extent with modern marketing approaches. Thus, the need for meat sector development has emerged for increased utility of the species in the larger interest of society.

Meat consumption among world countries

Population growth, per capita income growth, changing consumer habits are the contributory factors that drive animal products consumption. As countries develop, they pass through a "nutrition transition", by which higher incomes translate first into a demand for more calories, and then into a demand for more protein (typically from animal sources) as well as for other nutrients coming from fruit and vegetables (OECD/FAO 2016, OECD-FAO Agricultural Outlook 2016-2025, OECD Publishing, Paris, https://doi.org/10.1787/agr_

outlook-2016-en). The world's population is projected to rise from 7.4 bln in 2016 to 8.1 bln in 2025, with 95% of this increase occurring in developing countries. By 2025, there will be 6.7 bln people living in developing countries and 1.4 bln in developed countries.

Growing populations, rising affluence and urbanization are translating into increased demand for livestock products, particularly in developing countries. Global demand is projected to increase by 70 percent to feed a population estimated to reach 9.6 billion by 2050. Much of the growth in demand is being supplied through rapidly expanding modern forms of intensive livestock production, but traditional systems continue to exist in parallel. Demand growth thus also presents opportunities for an estimated 1 billion poor that depend on livestock for food and income.

Top meat eating countries (kg / capita / per year) (2017)

Country	Kg/capita/year	Country	Kg / capita / year
Australia	93.0	Canada	70.5
United States	91.1	Malaysia	54.9
Israel	86.0	South Africa	50.7
Argentina	84.7	Saudi Arabia	50.5
Uruguay	82.9	Russia	50.2
Brazil	78.1	South Korea	50.2
New Zealand	73.5	China	48.8
Chile	72.5	India	3.6

Source: Database OECD Agricultural Statistics

Low per capita consumption of meat in India

India per capita meat consumption at about 4 kg per year is dismally low as compared to the world average of 35 kg or many other countries. India ranks last in beef and veal; 11th from the last in sheep and goat meat; 9th from the last in pork; 7th from the last in poultry consumption with a rank of 3 from the last in total meat consumption. India per capita meat consumption is only 11 percent of World average consumption and including fish and eggs India consumption is only 16 percent of World average.

Average per capita consumption (kg/year) of Meat, fish and eggs in India and World

Products	India	World	India% of World
Bovine meat	0.81	6.49	12.48
Sheep& Goat	0.58	1.88	30.85
Pig	0.28	12.14	2.31
Poultry	1.88	14.13	13.31
Other meat	0.14	-	-
Offals edible	0.38	-	-
Fresh water fish	3.48	21.64	17.88
Marine fish	0.39		
Eggs	2.58	9.8	26.33
Total	10.52	66.08	15.92

Requirement for animal protein and animal products in India

ICMR Recommendation (NIN) : 1 g Protein/ Kg Body wt. of 65 NPU;

Idealistic : 180 Eggs and 9 to 11 Kg. Meat/ Person/ Annum (No reference available..).

Minimum Animal Protein – Nutritional Demand (Altschul, 1965):It has been reported (Altschul, 1965) that for National diets it is much simpler to assume that a diet which contains 30 g per day of protein from animal sources (meat, milk, eggs, fish etc.) will be of adequate quality regardless of the source of the remainder of the protein. An average of less than 30 g per day may be questionable quality especially for the sensitive elements of the population, and less than 15 g of animal protein per day poses almost the certainty of protein mal-nutrition for part of the population.

- 30g / Day/ Person-diet quality adequate regardless of remainder of protein
- Less than 30g- may be questionable quality-especially for sensitive elements of the population
- Less than 15g - results in protein malnutrition

It is also reported that apersons daily protein intake should be about 1 g per Kg body weight for adequate nutrition and ideally 30 to 50 percent of the daily protein intake should be animal protein to provide an optimal range of amino acids. In view of mixed diets followed in India, 20g/ Per day/ Person – considered to be essential – from milk, meat, eggs & fish (from- milk 10g; meat 4g; Fish 4g; eggs 2g for Non-vegetarinas; and for Vegetarians- 20g from milk). However, present availability is 10g - against world average of 29 g.

Estimated demand for meat, milk, fish and eggs for 1275 million population:

a. Based on providing minimum 20g animal protein per day / person

Animal products	Present production	Products required	% Increase desired
Milk (mt)	165.40	173	4.59
Meat (mt)	7.40	11	48.65
Fish (mt)	11.41	11	-3.68
Eggs (billion)	88.14	107	21.4

Basis: 20g/ Per day/ Person – considered essential –from milk, meat, eggs & fish - from- milk 10g (285ml); meat 4g (34g carcass wt.); Fish 4g (34g carcass wt); eggs 2g (one egg in 3 days) for Non-veg; and for Vegetarians- 20g (570ml) from milk per day per person

b. Based on providing ideal 30g animal protein per day / person

Animal products	Present production	Products required	% Increase desired
Milk (mt)	165.4	260	57.19
Meat (mt)	7.4	17	129.73*
Fish (mt)	11.41	16	40.23*
Eggs (billion)	88.14	161	82.66

Basis: 20g/ Per day/ Person – considered essential – from milk, meat, eggs & fish - from- milk 15g (420ml); meat 6g (46g carcass wt.); Fish 6g (46g carcass wt); eggs 3g (one egg in 2 days) for Non-veg; and for Vegetarians- 20g (855 ml) from milk per day per person



* When export of meat is considered (at 15 lakh MT / year) - total requirement would increase to 18.5mt and percent increase desired will be 150. When marine exports are considered at 1.19mt-total fish required will be 17.19mt and the percent increase desired will be 50.

As livestock production has many other benefits from their purposes and functions it is relevant and justified to have the productive foods (animal products) consumption at desired level (30g per person/day) rather at minimum essential level (20g per day/person). A number of socio-economic, food and nutrition aspects would be adequately met with increased animal products consumption- in particular in Indian situation. Thus, the need for increased emphasis on meat animal production.

Livestock and crop production: Livestock production activities are a must for sustaining soil health and there by sustained crop production with farm yard manure and dung. Soil health is the capacity of the soil to function. Population growth, industrialization and climate change threaten soil health (FAO, 2015). While the soils were deficient of only nitrogen in the year 1950 but in the year 2000 ten nutrients (N, P, K, Fe, Zn, S, Mn, B, Mo, Cu) are deficient in the soils which would increase too. Healthy productive soils ensure food secure world. The Working group for Animal husbandry XI five year plan estimated that as much as 800 mt of animal dung would be available annually in India of which even if 1/3rd is used as manure, it would provide 7.5 mt of nutrients (2.90 mt of N, 2.75 mt of P₂O₅ and 1.89 mt of K₂O). Sustainable, regenerative and ecofriendly systems are the alternatives to chemical agriculture and need to be supported as developmental programmes.

Land availability, livestock numbers and productivity: Excessive livestock populations when exist in the absence of effective slaughter are reported to result soil degradation, erosion, silting of water bodies and contribute for water shortage and adverse effects on eco-balance. While the land available for human and animal use has nearly remained the same during 1951-2011, human population increased by 235.15 percent and total livestock increased by 74.89 percent from 292.8m in 1951 to 512.1m in 2012 with the existing slaughter regulation. The land availability per person has decreased from 0.53 ha in 1951 to 0.15 ha in 2015. In addition poultry has increased by 892 percent from 73.5m in 1951 to 729.2m in 2012. With increase in fish farming under pond culture the need for land has also increased in human food production system. The land pressure has been increasing for various activities which demand efficient livestock production system. Thus livestock production and utilization demands pragmatic approaches and scientific production practices. Excessive populations would result pressure for natural resources and thereby competition among the species and adverse effects on eco-balance. It is necessary to determine and stabilize optimum number of productive populations of livestock to meet the requirements for animal products. Relevant slaughter policy is the best practiced approach to stabilize animal populations.

Land : man ratio during different decades

Decades	Land ¹ (mha)	Population (m)	Land: man ² (ha / person)
1951	192.23	361.09	0.53
1961	193.65	439.23	0.44
1971	195.31	548.16	0.36
1981	197.15	683.33	0.29
1991	196.57	846.30	0.23
2001	194.12	1028.74	0.19
2011	192.23	1210.19	0.16
2015	192.15	1277.10	0.15

¹Land available= Reporting area for land utilization statistics –(Forests+ Not available for cultivation). ²Land : man ratio= Land available (mha)/ Human population (m)



Slaughter and meat export policy have only positive effect on the reduction of excessive livestock and thereby contributing for ecobalance. There are a number of expert reports including that of National Commission on Agriculture suggesting for reduction of excessive numbers and keeping of optimum number of better producing animals.

Meat Utility for Efficiency and sustainability of animal populations:

With mechanization in agriculture the meat function received priority over draught function in case of cattle. Report of the Expert Committee on the Prevention of Slaughter of Cattle in India (Government of India , Ministry of Food and Agriculture, January, 1955 page-64-69) referring to the issues of more number of cattle and shortage of feed observed that *"...inefficiency leads to excessive numbers, while excessive number leads to inefficiency. It is only by breaking this vicious circle that progress can be achieved."* It may be appropriate to quote a few lines from the book, *The Dying Cow- Can it Survive ?* by Bajrang Bahadur Singh Bhadri (1963) the then Lieutenant Governor, Himachal Pradesh. Under Chapter Three, What is wrong with the present policy? It is mentioned that: *".....There does not seem to be any other alternative in getting rid of the useless and wild animals. This has created a very anomalous position in so far as:*

- (a) the people who are supposed to keep the cow are not interested in it and are not agitating for any kind of protection;
- (b) the people who agitate for protection invariably do not keep a cow; and
- (c) the people, who implement the policy, generally neither keep a cow nor agitate therefor."

It is necessary that in the interest of farmers the excess and unproductive animals must be removed with advantage to the farmer. Animal production efficiency could only be improved by practicing scientific animal production practices which invariably include the important practice of culling the poor producers and retaining the better producing animals with optimum utilization of the input resources. Thus, slaughter of unproductive animals is an essential function to increase animal production efficiency and the same is being practiced World over to sustain and stabilize the animal populations with advantage. This aspect need to be considered with out any delay as the adverse implications of stray cattle have been reported extensively.

Slaughter and Meat export policy: The slaughter policy need to be oriented for achieving higher productivity along with production enhancement approaches. Meat export policy deserves a support in this respect for increased livestock productivity and utility in the larger interest of the stakeholders in particular farmers and National economy. Meat export basically facilitate demand driven growth in sustained livestock production and utilization. Culling is essential in Indian situation with shortage in feed and fodders and the need for increased productivity and better returns for the resource poor farmers in particular who keep 1-3 cattle and buffaloes in small holder situation. Meat export to be considered as value addition approach of crop production as the crop residues and agri-byproducts are largely converted through meat animals to meat for export in the modern meat plants for international trade and to earn higher returns. In the post wto era it is necessary to earn foreign exchange to meet balance of payments for import of many essential items.

Success case of buffaloes and meat export: As a result of world class infrastructure and practice of modern and scientific practices buffalo meat export has been growing sustainably with desirable effect on population and productivity over the past four census periods from 1992 onwards. Though the draught function of buffaloes has been decreasing due to mechanization in agriculture and other socio-economic changes but the milk and meat (including exports) have been contributing for the sustainability. Salvaging male buffalo calves and their rearing for optimum weights would substantially increase meat and leather productivity. India is



number one in buffalo population, meat and milk production, but in terms of meat productivity India stand at rank 7 (among the world buffalo producing countries) largely due to under utilization of the male buffalo calf potential. Use of superior males, effective culling, improved reproductive efficiency, reducing calf mortality, attaining higher mature body weights, complete feed formulations etc will go a long way in making buffalo production a flourishing enterprise to benefit the farmers and the nation. Buffalo meat exports forms 95 percent of total meat exports. Since the year 2010 the unit realization of buffalo meat has substantially increased both on Rs/Kg and US \$/ Kg. This has been possible due to the integrated meat export plants established in the country to meet the quality requirements of importing countries and the popularity of buffalo meat among the consumers in the importing countries. The buffalo meat export potential could be easily doubled with the utilization of male buffalo calf potential available in the country.

Share of buffalo meat export in the World beef trade: World beef export trade in 2018 was at 10.47 mt carcass weight equivalent. Indian buffalo meat exports at 1.9 mt carcass weight equivalent hold 2nd position after Brazil (2.03mt) among the 32 beef exporting countries. In value terms World beef export was 44.4 billion US\$ in 2017 and India at 3.9 billion forms 8.78 percent and ranks 4th after USA, Australia and Brazil. In 2017, world total meat imports totaled US\$120.6 billion and total meat exports were US\$124.1 billion. India need to improve its rank in value terms also with exports to countries that fetch higher rates. Quality meat production from male buffalo calves and FMD disease free zone establishment need to be pursued for any substantial increase in exports. India banned export of beef from cattle decades back which has adversely affected cattle utility. Meat utility of male cattle including that of beef export is the dire necessity to sustain cattle prospects and improve cow economy for milk production.

Buffalo Meat Export- quantity , value and unit realization during last 18 years (2001-2018)

Year	Quantity (MT)	Value		Unit value	
		Rupees- crore	US\$-million	Rs / kg	US\$ / kg
2001	288003	1374.93	300.99	47.74	1.05
2005	337778	1774.52	395.48	52.53	1.17
2010	495058	5480.92	1156.31	110.72	2.34
2015	1475526	29282.58	4781.18	198.46	3.24
2016	1314534	26688.08	3924.63	203.02	2.99
2017	1323576	26161.49	3911.97	197.66	2.96
2018	1350564	26033.83	4036.89	192.76	2.99

Source : Apeda statistics.

Estimated availability of buffaloes and meat production potential

Category	Population As per 19th Census (m)	Available potential for Meat (m)	Meat Production (lakh MT)	Value Realization	
				\$ (m)	Rs.(Crores)
MBC under 1 year	20.16	21	17.12	5992	38948
FBC under 1 year	20.16	3.00	2.40	840	5460
Adult males - over 3 years	5.30	1.06	1.11	333	2164
Adult females - over 3 years	56.59	14.15	12.73	3819	24823
Total	102.21	39.21	33.36	10984	71395



Assumptions :

Both MBCs and FBCs available potential is expected to increase with increase emphasis on early age calf management and expected economic benefits. On the assumption that each 10 lakh MBCs when reared and used for meat 1/3rd number each to 200 kg, 250 kg and 300kg live weight would produce about 83000 MT (0.83 lakh MT) boneless meat —

In the event buffalo population is stabilized at the current level of 108 million with increase in productivity there would be 3-5 million additional buffalo numbers available for meat production.

Rates for veal taken as US\$ 3500/MT and buffalo meat at US\$3000/ MT as boneless.

US\$ conversion at Rs 65 per US\$

FMD-Disease Free Zones for animal products export: FMD is the major trans boundary disease that has international trade implications as a number of countries are free of FMD and can not compromise a risk. India is following OIE- Progressive Control Pathway (PCP) for eradication of FMD and zoning approach is the most appropriate in a large country of continental type. Establishment of FMD-DFZ has a number of benefits both of direct and indirect. In view of small holder nature of animal production and importance of livestock economy to the large number of farm holdings that keep livestock, a number of benefits could be realized by the farmers with FMD -DFZ. Increased contribution to National economy from Dairy , Meat, leather sectors – through higher export performance and increased foreign exchange earnings could be achieved. India competitiveness would increase in the post-wto scenario. Farmers returns get increased by way of:

Elimination of losses on account of FMD morbidity and mortality of livestock; Increase in productivity of livestock and Higher returns for livestock products on account of increased export to high value markets.

Animal preservation acts- Constitutional obligations :Slaughter of animals is a State subject and State legislatures have exclusive power to legislate as per Entry 15 of List II in the Seventh Schedule of the Constitution which reads as under: Preservation, Protection and Improvement of stock and Prevention of animal diseases, veterinary training and practice.

Relevant articles concerned with this subject are:

ARTICLE 48 "*Organisation of Agriculture & Animal Husbandry. The State shall endeavour to organise agriculture and animal husbandry on modern and scientific lines and shall, in particular, take steps for preserving and improving the breeds and prohibiting the slaughter, of cows and calves and other milch and draught cattle*"

According to Article 48, agriculture and animal husbandry has to be organised on modern and scientific lines which certainly include production and utilisation of meat animals by practicing slaughter of animals. Culling of unproductive and excess animals and their effective utilisation including slaughter for meat and other animal by products production is an essential requirement of organising animal husbandry on scientific and modern lines.

ARTICLE 47 : "*Duty of the State to raise the level of nutrition and the standards of living and to improve public health-*



The State shall regard the raising of the level of nutrition and the standard of living of its primary duties and, in particular, the State shall endeavour to bring about prohibition of the consumption except for medicinal purposes of intoxicating drinks and of drugs which are injurious to health"

Slaughter of animals and hygienic meat production satisfies all the directives under Article 47. Raising of level of nutrition could be achieved through meat consumption as meat comes under protective foods and rich in nutrients. Raising of standard of living of its people is made possible by earning increased income through animal production activities (including meat animal production, slaughter and meat trade). Improvement of public health is possible through hygienic meat production and prevention of livestock deaths due to diseases and old age by practicing effective culling and slaughter. Thus, slaughter of animals is not against Constitution and it is in the interest of the people at large and there are a number of Hon'ble Supreme Court judgments on the matter.

Animal preservation acts and their relevance in the current times: The Animal preservation acts with unscientific restrictions on utility of animals have not benefited neither the livestock species nor the farmers and the Nation. Instead of compensating the lost functions of cattle some of the State Govts. have proposed Policy interventions of complete ban on cattle slaughter which have adversely affected the cow species economic utility to the farmer and sustainability of cattle species prospects is at stake. All the unreasonable bans on slaughter of unproductive, low productive and unwanted animals by the farmers are contributing negatively and definitely leading to the depletion of the species (persistent decline year after year). Thus, when a ban on slaughter is proposed an appropriate compensation to the stake holders need to be considered. Farmers organizations need to demonstrate these aspects.

Either altogether withdrawal of the acts or amending the acts with pragmatic provisions in view of the present socio-economic and land utilization changes to the benefit of the primary stakeholders- the farmers and other associated stakeholders of livestock sector would be more appropriate to comply with Articles 47 and 48 of the Directive Principles of State Policy. Bringing awareness among the farmers for achieving better production efficiency to realize the maximum production potential of the species of livestock with relevant interventions would go a long way in the sustainable production of livestock with minimal effect on climate changes. The least, the policies could do would be not to interfere with the wisdom of the farmers in the disposal of culled, unproductive and excess animals to his advantage and professional bodies need to facilitate the same. The unfettered right of farmers to organize animal production on modern and scientific lines as per Article 47 and 48 of the Constitution and the active involvement of farmers and other stakeholders in formulating policies, rules and regulations need no emphasis in considering the pragmatic approaches. The rules and regulations need to be :pragmatic, socially acceptable, easily adoptable, inclusive and in National interest.

The National Food Security Act, 2013 (No 20 of 2013) states, -an act to provide for food and nutritional security in human life cycle approach, by ensuring access to adequate quantity of quality food at affordable prices to people to live a life with dignity and for matters connected therewith or incidental thereto.

The National Policy for Farmers, 2007, which aims to improve viability offarming through sustainable development of agriculture sector with the main goal to improve welfare of farmers and farm income, also provides for sustained development of the livestock and fisheries sectors.

The National Livestock Policy, 2013 has been formulated to have a policy framework for improving productivity of the livestock sector in a sustainable manner, taking into account the provisions of the National Policy of Farmers, 2007 and the recommendations of the stakeholders, including the States.



Expert bodies need to review the present Animal Preservation Acts of different states to assess as to what extent the provisions in these acts are relevant in terms of the Constitutional provisions and other acts in the current context of socio-economic pressures on the farmers to continue with sustainable animal production.

Clean Meat Production: Improvement of slaughterhouses to produce hygienic meat is the most important requirement for developing organized meat industry. Clean meat production is to the benefit of all the stakeholders comprising meat animal producers, traders, meat workers, entrepreneurs, consumers, law enforcers and common people at large. The demand for meat is ever increasing due to increase in population, increase in income and urbanization. And thus the need for increased concern towards efforts for clean meat production, as increasing demand compromises on quality aspects.

Criteria- Scientific design of Slaughter House:

- Practice of meat hygiene regulations
- Prevention of cruelty to animals & humane method of slaughter
- Prevention of contamination of carcass and edible offals
- Separation of clean and unclean operations
- Performing operations conveniently & easily
- Economy in operations

An estimate indicates the fund requirement for improvement of all the slaughterhouses in the country is about Rs 15000 crores. Essential infrastructure facilities to produce hygienic meat is an important requirement and private entrepreneurs need to be facilitated to take up slaughter and meat production activities for domestic and export market. This is a pre-requisite for compliance with FSSAI regulations in meat sector.

Byproducts utility and waste management

Byproducts disposal with better returns is essential for the economics of meat plant operations. Technologies and investments for higher utility with increasing demand need to be explored. Marketing avenues including exports for diverse processed products from slaughter byproducts would immensely benefit the abattoir economics and returns from meat animals to farmers as well.

Waste management has become a serious challenge for the abattoir industry. Traditional methods of rendering, incineration, land filling/composting have become out dated as a result of disease risk, environmental emissions or environmental contamination and lack of land availability and public protest. Authorities further restricted the transport, handling and processing of abattoir by-products and waste. Alternative methods of handling waste materials are crucial to the success of abattoir industry with better economics and public image.

Meat borne Pathogens and food safety concerns

About 75% of the new diseases that have affected humans over the past 10 years have been caused by pathogens originating from an animal or from products of animal origin (WHO, 2011- www.who.int/zoonoses/vph/en/). Most of the developing countries have very poor infrastructure facilities for slaughter of animals and modernizationslaughterhouses is not taking place due to various socio-economic conditions. Demand for meat is increasing and the over crowded slaughter in the existing poor facilities is further compounding the meat borne pathogen risks that cause health risks. Also the modern consumption pattern of



storing the meat and interest to explore newer cooking methods due to exposure to varied cultural situations and culinary practices and modern cookery gadgets etc. the food safety risks are expected to increase. Improper meat handling during transport, retailing and consumption are compounding the meat borne risks. Emerging and remerging meat borne pathogens also have frequently brought in alarming problems of food safety. Clean healthy animals, good abattoir facilities and practices for hygiene and sanitation ensure pathogen risk free meat. Important meat-borne bacterial pathogens: *Campylobacter*, *salmonella*, *Escherichia coli* 0157, *Listeria Monocytogenes*, *Staphylococcus aureus*, *Clostridium perfringens*.

Conditions in slaughterhouses covering infrastructure facilities in different sections and practices followed in these sections in performing different activities for producing meat from the animals including management of the environment in the slaughterhouse and its surroundings and transport of meat to whole sale or retail butcher shops, sale to consumer and preparation for consumption by the consumer have implications in contributing to meat contamination with pathogens and cause health hazards. There is no alternative except to produce clean meat free of pathogen contamination and post production handling and preparation in the sanitary environment before consumption. Any deviations in the production and consumption chain would result variable food safety risks as pathogens can enter and grow at any stage of the meat chain.

Climate change implications of Indian Livestock sector

Climate change implications attributable to Indian livestock and meat sector are minimal in view of mixed farming and dual or triple purpose rearing of bovines but productivity improvement with pragmatic interventions deserve priority for sustainable livestock production and minimizing the green house gas (GHG) emissions. Some of the identified deficiencies/ constraints of the livestock sector and meat function utility that are affecting sustained prospects of livestock for livelihood, food and nutrition security and employment need to be attended on priority. Culling of unproductive animals for meat utility and providing balanced nutrition with supplementary feeding to the productive populations will go a long way in minimizing adverse climate change implications. Retaining large number of stray animals will be adversely commented in respect of their contribution to climate change in addition to direct adverse effect on farmers economy and social amity.

Meat Processing and products: It is an important requirement for organized meat sector development to give emphasis to meat processing and products sector. Prospects are large in domestic as well as export market for processed products. Meat processing must achieve as many of the advantages of meat processing and value addition in Indian context of better utilization of tough meats from culled stock as they constitute a considerable proportion of meat animals. Production minced meat and minces meat based products offer a great scope from tough meats. Value addition is an important avenue for efficient utilization of livestock resources with increased demand and higher returns. Small scale ventures of value added products would go a long way in improving the economics of livestock production and meeting the consumer demands. Organized development of processed meat sector is important to realize full benefits from meat animals and contribute for sustained meat production. Also, it is necessary to produce value added meat products to meet the requirements in the post WTO period for effectively facing global competition both to check large scale imports to the detriment of domestic sector and to promote exports. The growth of processed meat sector assures the farmers a regular off take of their produce at reasonable prices and provides a variety to the consumer.



Pragmatic and prospective interventions

1. A massive programme to exploit the complimentary advantage of mixed farming and multi-utility of livestock in particular cattle and buffaloes.
2. Defending livestock sector to the benefit of the primary stake holders-the farmers
3. Pragmatic slaughter policies- to organize animal husbandry on modern and scientific lines as per Article 47 &48 of The Constitution.
4. Promoting meat utility of livestock including exports to sustain economic demand driven livestock production in particular bulls and bullocks of cattle
5. Promoting Meat production and processing as value addition approach in agriculture
6. Improvement/ modernization of slaughter facilities for better public image of the sector.
7. Development of livestock markets on priority
8. Interventions in the early age nutrition and management of calves, lambs, kids etc. for higher productivity and species lifetime economics.
9. Promoting balanced rations with emphasis on urea-molasses with easy availability to farmers.
10. Promoting decentralized small scale crop residue based feed processing units
11. Removal of urban dairies which are not relevant today with extensive packed milk distribution.
12. Involvement of stakeholders and experts in formulating rules and regulations related to livestock sector
13. Disease Free zone approach to be promoted for FMD control and eradication
14. Professional bodies need to defend livestock sector prospects

(Reference will be available from author)



Session-I : Key Note Address-02

**GLOBAL FOOD POLICIES - AIMED TO ENHANCE THE MEAT
PRODUCTION AND QUALITY**

Prof (Dr) K Sarjan Rao

MVSc., Ph.D., FNAPM., FNADSI, FANA.

Dean of Student Affairs, Former Professor and University Head

Dept. Of Livestock Production and Management, Sri Venkateswara Veterinary University, A.P, India.

The number of undernourished people globally rose from 777 million in 2015 to 815 million in 2016. The stunting among children under age five fell from almost 30 percent in 2005 to 23 percent in 2016 with 155 million children affected. If the current trend continues, 130 million children will be stunted in 2025, 30 million above the World Health Assembly target. The 2017 Global Hunger Index (GHI) indicates that worldwide levels of hunger and under nutrition have declined over the long term. At 21.8 on a scale of 100, the average GHI score for 2017 is 27 percent lower than the 2000 score (29.9 (Global Food Policy Report, IFPRI, 2018). By the year 2050, the world population grows to 9.7 billions 800 millions suffer with chronic hungry, 2 billions with micronutrient deficiency, overweight and obesity. In order to meet the food need sustainably there is a need to improve agricultural productivity inclusive of livestock produce. (FAO, 2018). Meat is a rich source of proteins, conjugated Linoleic acid (CLA), minerals such as Iron, Zinc and Selenium, L-carnitine, Histidyl dipeptides (carnosine and anserine), Creatine, Taurine, B complex vitamins, Glutathione, Ubiquinone, Lipoic acid, etc. The meat processing industry is driven by increasing consumer demand for healthier meat products which includes enriched products with fiber and Omega-3 fatty acids and reduced levels of fat, Cholesterol, Sodium and Nitrite as there is increased awareness about the effect of food on human health in terms of incidences of coronary heart diseases, hypertension, and cancer. Research shows that there will be around 80 per cent growth in meat demand by 2022 driven by the desire for convenience, which will be at the heart of the adoption of processed meat, fish, and poultry products. The global market for processed meat is estimated to be USD 362 billion in 2012 and is projected to reach USD 799 billion by 2018 with a compound annual growth rate of 14.3%. The market for meat processing equipments is USD 7.7 billion in 2012 and by 2018 it is projected to reach USD 11.5 billion with a CAGRI of 7.2%. This paper discusses on the global policy issues which support the enhancement of meat production and quality.

The food gap is the difference between the amounts of food produced in 2010 and the amount necessary to meet likely demand in 2050. This gap is estimated to be 7,400 trillion calories, or 56 percent more crop calories than were produced in 2010. (World Resources Report, 2018: Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 10 Billion People by 2050)

World Hunger and Malnutrition: By 2030, the world's population is projected to increase again, by slightly more than one billion to 8.6 billion, and to increase further to 9.8 billion in 2050. Of the net 2.2 billion increase expected in the world between 2017 and 2050, 1.3 billion, or more than half, will be in Africa. By 2050, most of the world's people – 54 percent, or 5.2 billion – will live in Asia, 26 percent in Africa (2.5 billion), 8 percent in Latin America and the Caribbean (780 million), 7 percent in Europe (716 million), 4 percent in North America (435 million), and 1 percent in Oceania (57 million). In developing countries, 2.3



million child deaths (41 percent of the total child death rate) are ascribed to malnutrition (Schroeder and Brown, 1994). According to WHO, every day about 830 women die from preventable causes related to pregnancy and childbirth and 99 percent of all maternal deaths occur in developing countries (WHO, 2016).

Although substantial progress was made between 1990 and 2012 in addressing hunger and under nutrition—rates of hunger decreased from 18.6% to 11.8% globally, and the percentage of children stunted fell from 39.6% to 23.8% (Global Panel, 2016), still the problem persists. One in eight people in the world live in extreme poverty; 815 million are undernourished; 1.3 billion tonnes of food are wasted every year; six million children die below 5 years of age each year; more than 200 million people are unemployed. In one estimate one in eight people in developing countries still fail to obtain sufficient protein and energy from their diets, and even more suffer from some form of micronutrient deficiency and also the number of people in the world suffering hunger increased from 777 million in 2015 to 815 million in 2016. (FAO, 2016). The United Nations 2030 Agenda for Sustainable Development, with its 17 Sustainable Development Goals (SDGs) and 169 targets, has become the universally endorsed framework accepted by all and applicable to all countries inclusive of India. The SDGs build on the success of the 2000–2015 Millennium Development Goals (MDGs) and aim to do even more to end poverty and hunger.

Under nutrition or Malnutrition can be described as 'lack of proper nutrition, caused by not having enough food, not eating enough food containing substances, and other direct and indirect causes, necessary for growth and health'. Five forms of major under nutrition conditions exist, which includes--

i) Stunting in children under five – a form of growth failure which develops over a long period of time in children under five years of age when growing with limited access to food, health and care. Stunting is also known as 'chronic under nutrition', although this is only one of its causes. In children, it can be measured using the height-for-age nutritional index. Stunting is often associated with cognitive impairments such as delayed motor development, impaired brain function and poor school performance, as it often causes these negative impacts. Among the Developing countries, India, Vietnam, Pakistan, Sri Lanka, Philippines and Indonesia are the leading countries with 44.2, 33.1, 31.6, 22.5, 20.9 and 20.8 % of the children below 5 years are suffering with underweight.

ii) Wasting in children under five – children who are thin for their height because of acute food shortages or disease. Also known as 'acute malnutrition', wasting is characterised by a rapid deterioration in nutritional status over a short period of time in children under five years of age. Wasted children are at higher risk of dying. In children, it can be measured using the weight for-height nutritional index or mid-upper arm circumference (MUAC). There are different levels of severity of acute malnutrition: moderate acute malnutrition (MAM) and severe acute malnutrition (SAM).

iii) Micronutrient deficiencies – suboptimal nutritional status caused by a lack of intake, absorption or use of one or more vitamins or minerals. Excessive intake of some micronutrients may also result in adverse effects. The international community has focused on several micronutrients that remain issues globally including iron, zinc, vitamin A, folate and iodine, as they are the most difficult to satisfy without diverse diets. One general indicator of micronutrient deficiencies is anaemia, as this syndrome is caused by the deficiency of many of them, and its effects are exacerbated by several diseases.

iv) Moderate and severe thinness or underweight in adults – a body mass index (BMI) less than 18.5 indicates underweight in adult populations while a BMI less than 17.0 indicates moderate and severe thinness. It has been linked to clear-cut increases in illness in adults and is therefore a further reasonable value to



choose as a cut-off point for moderate risk. A BMI less than 16.0 is known to be associated with a markedly increased risk for ill health, poor physical performance, lethargy and even death; this cut-off point is therefore a valid extreme limit.

v) Overweight and obesity in adults – the abnormal or excessive fat accumulation that may impair health. BMI is a simple index of weight-for-height that is commonly used to classify overweight and obesity in adults. Overweight and obesity are major causes of many NCDs, including non-insulin-dependent diabetes mellitus, coronary heart disease and stroke. They also increase the risks for several types of cancer, gallbladder disease, musculoskeletal disorders and respiratory symptoms. (UNICEF for under nutrition, World Health Organization (WHO) for overweight, WHO for thinness and child overweight, WHO for anaemia). Hence, a **healthy diet** can prevent any of the above conditions.

A healthy diet: is sufficient and balanced in terms of quantity, quality and safety,

- Quantity : sufficient dietary energy to maintain life, support physical activity and maintain a healthy body weight, and enough macro and micronutrients to meet nutrition and health needs, but with without excessive consumption of dietary energy.
- Quality: containing diverse nutrient-dense foods from basic food groups including vegetables, fruits, whole grains and cereals, dairy foods and animal and plant-based protein foods, while limiting foods and beverages high in saturated and trans fats, added sugars and salt.
- Safety: with foods free from biological, chemical and physical contaminants that lead to food-borne disease.

Examples : Based on the available scientific evidence on the link between diet, malnutrition and diseases, the World Health Organization (WHO) recommends the following as a diet that prevents malnutrition in all its forms. Diets which are:

- High in fruits, vegetables, legumes (e.g. lentils, beans), nuts and whole grains (e.g. unprocessed maize, millet, oats, brown rice)
- **Intake of Animal Source Foods (ASF)** (e.g. dairy, meat, eggs, fish and shellfish) in moderation, and limit processed meats.
- Low intake of refined sugars that are added to foods or drinks by the manufacturer, cook or consumer, and concentrated sugars naturally present in honey, syrups, fruit drinks and fruit juice concentrates.

Unhealthy Diets : Use of unsaturated fats or vegetable oils (e.g. found in fish, avocado, nuts, sunflower, canola and olive oils) **over saturated fats** (e.g. found in fatty meat, butter, palm and coconut oil, cream, ghee and lard). Industrial trans fats, or partially hydrogenated oils (found in processed food, fast food, snack food, fried food, baked goods, margarines and spreads) are not part of a healthy diet.

Functional Gains of Livestock Produce: Livestock sector can play a key role in improving the lives of millions by: providing the world with sufficient and reliable supplies of meat, milk, eggs and dairy products; increasing the direct consumption of animal-source foods; helping to generate income and create employment; and strengthening the assets that rural households use to achieve their livelihood objectives. It can also help improve children's cognitive and physical development as well as school attendance and performance; empower rural women; improve natural resource-use efficiency; broaden access to clean and renewable

energy; and support sustainable economic growth. Finally, it can generate large scale revenue and foreign exchange; create opportunities for value addition and industrialization; stimulate smallholder entrepreneurship, close inequality gaps; promote sustainable consumption and production patterns; increase the resilience of households to climate shocks; and bring together multiple stakeholders to achieve all these goals.

Table 1. The Nutrient Composition per 100 g of lean red meat (Neumann *et al.*, 2013)

	Beef	Veal	Lamb	Mutton	Adult Australian RDI
Moisture (g)	73.1	74.8	72.9	73.2	
Protein (g)	23.2	24.8	21.9	21.5	46-64
Fat (g)	2.8	1.5	4.7	4.0	-
Energy (kJ)	498	477	546	514	6.5-15.8MJ
Cholesterol (mg)	50	51	66	66	-
Thiamin (mg)	0.04	0.06	0.12	0.16	1.1-1.2
Riboflavin (mg)	0.18	0.20	0.23	0.25	1.1-1.6
Niacin (mg)	5.0	16.0	5.2	8.0	14-16
Vitamin B6 (mg)	0.52	0.8	0.10	0.8	1.3-1.7
Vitamin B12 (ug)	2.5	1.6	0.96	2.8	2.4
Panthenic acid (mg)	0.35	1.50	0.74	1.33	4-6
Vitamin A (ug)	<5	<5	8.6	7.8	700-900ug RE*
Beta-carotene (ug)	10	<5	<5	<5	700-900ug RE*
Alpha-tocopherol (mg)	0.63	0.50	0.44	0.20	7-10
Sodium (mg)	51	51	69	71	460-920
Potassium (mg)	363	362	344	365	2800-3800
Calcium (mg)	4.5	6.5	7.2	6.6	1000-1300
Iron (mg)	1.8	1.1	2.0	3.3	8-18
Zinc (mg)	4.6	4.2	4.5	3.9	8-14
Magnesium (mg)	2.5	26	28	28	310-420
Phosphorus (mg)	215	260	194	290	1000
Copper (mg)	0.12	0.08	0.12	0.22	1.2-1.7
Selenium (ug)	17	<10	14	<10	60-70

Table 2 : MAJOR MICRONUTRIENTS (PER 100 G) CONTAINED IN SELECTED ANIMAL-SOURCE FOODS (Neumann *et al.*, 2013)

ANIMAL -SOURCE FOOD (ASF)	IRON (mg)	ZINC (mg)	VITAMIN B ₁₂ (ug)	VITAMIN A ^b (ug RAEC)	CALCIUM (mg)
Meat					
Beef, Medium fat, cooked	0.32	2.05	1.87	15	8
Goat meat (moderately fat)	2.3	4.0	1.13	0	11



Liver,beef	10	4.9	52.7	1500	8
Mutton	2	2.9	2.2	10	10
Pork	1.8	4.4	5.5	2	11
Poultry	1.1	4.0	0.10	85	10
Milk whole, unfortified	0.01	0.18	0.39	55	119
Hen eggs, cooked	3.2	0.9 (raw)	2.0 (raw)	500	61

Conversion of Human inedible to edible food: During the past 15 years the world has seen a major increase in livestock food products. Between 2000 and 2014, global production of meat has increased by 39 percent. Livestock consume a third of all cereals produced and use about 33 percent of global arable land. They occupy 2 billion ha of grasslands, of which about 700 million could be used to grow crops. Yet the cereals used to feed livestock make up only 13 percent of their overall diets, with another 1 percent coming from other human-edible crops. Grass and leaves make up 46 percent of livestock diets: 19 percent comes from crop residues; 8 percent from fodder crops; 5 percent from oilseed cakes; 5 percent from other by-products; and 3 percent from other plant sources that are not edible for humans. Of the plant material fed to livestock, 86 percent would be inedible by humans directly but is converted into valuable food for human consumption and contributes greatly to food and nutrition security.

Trends in Global Livestock Meat Productivity: Global meat production is projected to be 19 percent higher in 2030 relative to the 2015–2017 base periods. While the largest producers (Brazil, China, the European Union (Member Organization) and the United States of America) will continue to dominate meat production, developing countries are expected to account for almost all of the total increase and the bulk of additional meat production will in fact come from developing countries, where production – notably from Argentina, China, Brazil, India, Mexico and Pakistan – will account for 77 percent of the additional output. Poultry meat will remain the primary driver of growth in global meat production in response to expanding world demand for this affordable source of animal protein. As per the reports of OECD and FAO, 2017 meat production will expand rapidly in countries that produce surplus feed grains. Chicken meat and pork now account for almost 70% of global meat production. The most rapid growth has occurred for chicken meat, which has increased more than 13-fold since the 1960s, while total meat production has risen about 4.5-fold. Global meat production is projected to be 19 percent higher in 2030 relative to the 2015–2017 base periods.

Role of Animal Source Foods (ASF) in Malnutrition and Hunger:

ASFs are nutrient-dense and palatable sources of energy and high-quality protein, and also provide a variety of essential micronutrients, some of which, such as vitamin B₁₂, riboflavin, calcium, iron, zinc, and various essential fatty acids, which are difficult to obtain in adequate amounts from plant-based foods alone (Murphy and Allen, 2003).

Global Reports on Beneficial effects:

- Animal Source Foods contribute to the global human diet with 33 percent of protein intake and 17 percent of calorie intake. Livestock and animal-source foods provide readily digestible protein and essential nutrients, and can make critical contributions to ending hunger and improving food security and nutrition. (Rosegrant et al., 2009).
- Meat increases iron and zinc absorption from fibre- and phytate-rich plant staples (Gibson, 1994). Brown et al. (1998) noted that only ASFs have the potential to provide enough calcium, iron and zinc



for infants. In the case of vitamin B₁₂, all requirements must be met from ASFs, as there is virtually no vitamin B₁₂ in plant-based foods (FAO and EU, 2017).

- Animal Source Foods are a source of therapeutic compounds such as antimicrobial peptides, while porcine and bovine insulin have long been used to treat human diabetes.
- The 2017 Global Hunger Index (GHI), developed by IFPRI, captures the multidimensional nature of hunger by considering four indicators – undernourishment, child wasting, child stunting, and child mortality. Countries with large GHI scores, such as Chad, Central African Republic, Liberia, Madagascar, Sierra Leone, Sudan, and Zambia, suffer from extremely alarming or alarming levels of hunger. However, as countries increase their capacity to supply the population with larger amounts of animal protein, their GHI score tends to decrease.

Global Reports on ill effects due to Excess consumption of ASF:

- Developed countries and an increasing number of developing nations suffer from adverse health effects, such as overweight and obesity, associated with excessive consumption of red and processed meat and from related chronic diseases (Neumann et al., 2010). Links between disease and overconsumption of ASFs have for years been ascribed to their content of saturated fatty acids. Recent studies, however, have begun to cast doubt on the strength of these links, at least as concerns diets containing moderate levels of animal products (e.g. Fogelholm et al., 2015; Praagman et al., 2016).
- At the current low levels of consumption of ASFs by the rural poor in developing countries, even small increases in ASF intake provide nutritional benefits that far outweigh any acute or chronic disease risks associated with high consumption of red meat and animal products in high-income countries or high-income households in developing countries (Randolph et al., 2007).
- Animals, including farm animals and derived products, also pose risks to human health. Such risks can be direct, e.g. through the transmission of zoonotic pathogens, including emerging viral diseases such as Ebola virus and Middle East respiratory syndrome corona virus (MERS-CoV); through the development of bacteria resistant to antimicrobials; and through increasing concentrations in the environment of the residues of medicines, supplements and contaminants. Or they can be indirect, like non-communicable diseases such as cardiovascular disorders, which occur if ASFs are consumed in excess.
- It was estimated that more than 600 million people globally – i.e. almost one person in ten – became ill after consuming contaminated food in 2010. Of these people, 420 000 died, with the highest toll in the African region. At a global level, the most frequent causes of food borne illness were diarrhoeal disease agents, particularly Norovirus and *Campylobacter* spp. Non-typhoidal *Salmonella* spp. were the major causes of death. In total, 40 percent of the burden was borne by children under five years of age. Diarrhoeal disease agents accounted for 18 million DALYs, or 54 percent of the global burden, of which non-typhoidal *Salmonella* spp. alone was responsible for four million DALYs and *Campylobacter* spp. for more than two million DALYs. It was estimated that the parasite worm *Taenia solium* caused 2.8 million DALYs.
- A study conducted by ILRI (Grace et al., 2012) found that 56 zoonoses were responsible for an estimated 2.5 billion illnesses and 2.7 million deaths a year



- Increasing livestock numbers, intensified management, faster animal turnover, confinement of large numbers of animals in small spaces as well as habitat fragmentation through expansion of livestock production all increase the probability of outbreaks of emerging zoonoses. These include Bovine Spongiform Encephalopathy (BSE), Highly Pathogenic Avian Influenza (H5N1), Severe Acute Respiratory Syndrome (SARS) and MERS, some of which may have pandemic potential (Cohen, 1992; Shea, 2003). A study found that more than 70 percent of the infectious diseases to emerge in humans since the 1940s can be traced back to animals, above all wildlife (Jones et al., 2008) and many of these are food-borne and resistant to antimicrobial medicines. They include SARS and associated corona virus in bats, civet cats, and other mammals; Ebola virus in wildlife; and rabies and associated viruses (Bennet, 2006; Calisher et al., 2006; FAO, 2013; Jones et al., 2008; Turmelle and Olival, 2009). A significant proportion of such microorganisms found in livestock and/or wildlife can be transmitted to humans directly, via the environment or through ASFs.
- Animals and ASFs can also transmit to humans the residues of medicines, supplements, and contaminants. They can affect health through a single exposure, resulting in acute poisoning, or through long-term exposure, affecting the reproductive and immune systems, (e.g. external hormone residues), or causing non-communicable diseases (NCDs) such as cancer.
- Overconsumption of ASFs is associated with an increase in the burden of NCDs on humans, particularly of cardiovascular disorders mainly linked to cholesterol and saturated fatty acids levels (Steinfeld, 2013; Wang and Beydoun, 2009) but also of overweight and certain forms of cancer.
- Inappropriate use, overuse and abuse of antimicrobials in animal production contribute to the increase in AMR in pathogens causing human infections across the globe (Landers et al., 2012). It has been estimated that, if no action is taken today, by 2050, ten million lives a year and USD 100 trillion of economic output are at risk from drug-resistant infections. Today, approximately 700 000 people die of drug-resistant infections every year. Low- and middle-income countries face the greatest burden from the growth in drug-resistant infections (O'Neill, 2016).

Global Policies on enhancement of Meat Production, Consumption, Processing and Quality:

1. **Enhanced Meat Production-Influence on Water Footprint:** A mainstream practice for water footprint assessment relies on the methodology developed by the WFN. The total water footprint of an individual or community has three components: the blue, green and grey water footprints : The blue water footprint is the volume of freshwater consumed from global blue water resources (surface and ground water that lies beneath the surface) to produce the goods and services consumed by individuals or communities. The green water footprint is the volume of water evaporated, transpired or incorporated by plants (i.e. consumed during the production process) from global green water resources (rainwater stored in the root zone of the soil). The grey water footprint is the volume of freshwater required assimilating a given load of pollutants, taking account of natural background concentrations and existing environmental water quality standards. In a WFN-based assessment, the total water footprint is the sum of blue, green and grey water flows. The water footprint for meat increases from 4 300 l/kg for chicken to 5 500 l/kg for goat meat, with pig meat requiring 6 000 l/kg, sheep meat 10 400 l/kg and beef 15 400 l/kg. In order to sustain, the water footprint in the nature, the meat production should be regularized while optimizing the productivity and reducing the burden on the water foot prints.



2. **Enhanced Meat Production-impact on Energy Resources :** Opio et al (2013) and Gerber et al (2010) has estimated that for production of 150 g of chicken and 150 g beef, 2800 and 7650 kilo joules of energy used resulting the production of 780 g CO₂ eq and 10170 g CO₂ eq of GHG emissions occur in nature.
3. **Emissions of GHG due to Enhanced Meat Production:** Gerber et al., (2013) estimated that livestock are responsible for 14.5 percent of global emissions. Beef and cow milk are the two commodities with the highest total emissions, accounting for 3.0 and 1.6 gigatonnes CO₂ eq, respectively. They are followed by chicken meat and eggs with 0.83 gigatonnes, pig meat (0.82 gigatonnes), buffalo meat and milk (0.7 gigatonnes) and small ruminant meat and milk (0.5 gigatonnes). Remaining emissions are allocated to other poultry and to non-edible products. Emission intensities vary greatly among producers, especially in ruminant products. Buffalo meat is the commodity with highest emission intensity, with an average of 404 kg CO₂eq per kg of protein, followed by beef, with an average of 295 kg CO₂ eq per kg of protein. The emission intensity of meat and milk from small ruminants and milk from buffalo are 201, 148 and 140 kg CO₂eq per kg of protein, respectively. Cow milk, chicken meat, eggs and pork have lower emission intensities, all below 100 kg CO₂eq per kg of protein. In order to aim to reduced GHG emissions from agriculture and livestock, the producers should aim to enhance the productivity by following controlled feeding management to reduce the enteric fermentation process.
4. **Optimizing the Global meat consumption due to its impact on Global Warming:** GlobAgri-WRR Model, with source data from FAO, 2017 reported that from the baseline 2010 consumption pattern, to 2050 meat consumption should be reduced to a threshold relative value of 30% . In order to achieve this, the ruminant meat consumption should be reduced to 52 calories per person per day in all regions of the globe in order to mitigate the GHG emissions.
5. **Converting Meat as an inexpensive and poormans Food:** Animal Sourced food calories are upto 20 times more expensive than Cereal relative Calorie Price for ASF and mainly for meat. The caloric prices are calculated on the basis of the ratio of the price of one calorie of a given food relative to one calorie of the cheapest cereal source. (AJAE,2018). Trostle and Seeley (2013) proved that the meat consumption (Kg/year) depends on the per capita GDP of the country and most of the Asian countries including India has less than 50 Kg per capita consumption due to their earnings of less than 5000 USD GDP per person. Brazil, Argentina has higher per capita meat consumption (300 kg/year) with per capita GDP of more than 5000 USD, proves the fact that meat is an expensive food compared to cereal based diets.
6. **Meat Consumption –addition of supply chain costs:** According to the USDA Economic Research Service (ERS), the percentage of consumer spent towards the food is high in Pakistan, followed by Philippines, Egypt, Vietnam, Indonesia, Russia, China, South Arabia and India with about 25.5%. USA consumer spent towards the food is minimal when compared to all the countries, although, their spending is mostly for ASF. The breakdown of the "Food Dollar" reveals that for a dollar spent in 2015 by consumers on domestically produced food, only 8.6 cents went to farmers, 15.6 cents went to processors, 9.3 cents went to wholesalers, 12.7 cents went to retailers, and 34.4 cents went to pay for services provided by the catering industry (ERS and USDA, 2017). In other words, about 91 percent of consumers' annual expenditure on domestically produced food goes to providers of non-agricultural food and services and around 9 percent goes to farmer. Enhanced productivity at a cheaper cost of production of meat and avoidance of market chains help the producers profit making.



7. Quality Issues of processed and Packaged meat foods:

Since 2015, the George Institute for Global Health, with other partners, has been establishing large databases of the nutrient content of packaged meat foods, collected using proprietary mobile technology in eight markets: Australia, China, Hong Kong, India, New Zealand, South Africa, the UK and the US. Mexico's Institute for Public Health (INSP) has compiled a similar database. 48 Studies concluded that there is increase of the overall dietary content of added or free sugars, saturated and trans-fat, salt and diet energy density, while decreasing protein, dietary fibre, potassium, iron, zinc, magnesium and other micronutrients leads to obesity, dyslipidemia, hypertension, gastrointestinal disorders and cancer, including breast cancer.

The nutritional quality of each product was determined by applying the Health Star Rating system (developed and used in Australia, but applicable in any market). Products are rated between 0.5 stars (least healthy) to 5 stars (most healthy) and any product that scores 3.5 or above is considered healthy. On average across all nine markets, 31% of products have a Health Star Rating of 3.5 or more, meaning 69% of products did not meet the healthy threshold and are thus of relatively low nutritional quality. Country specific regulations and health star /quality control ratings on the packaged and processed meat products need to be enforced.

8. Quality Concern-Anti Microbial Residues in Meat : The History of Anti Microbials presence in meat showed the evidence of Pencillin (1929), Sulfanilamide (1935) itself. David Sanz et al., (2015) also reported the highest incidence of positive samples in poultry (9.7%) meat while the lowest rate was found in porcine samples (3.4%). Half of the positive screening samples (53%) also showed a positive result with supplementary tests indicating that tetracyclines, aminoglycosides sulphonamides and quinolones presence in these samples. Aminoglycosides were the predominant residues in poultry while tetracyclines were more frequent in bovine and porcine samples. Sulphonamides were the main family of residues found in ovine.

Of late, inappropriate use, overuse and abuse of antimicrobials in animal production contribute to the increase in AMR in pathogens causing human infections across the globe (Landers et al., 2012). It has been estimated that, if no action is taken today, by 2050, ten million lives a year and USD 100 trillion of economic output are at risk from drug-resistant infections. Today, approximately 700 000 people die of drug-resistant infections every year. Low- and middle-income countries face the greatest burden from the growth in drug-resistant infections (O'Neill, 2016). FAO has developed an Action Plan on AMR in food, agriculture and the environment (FAO, 2016) which addresses four major focus areas:

- Improve awareness on AMR and related threats.
- Develop capacity for surveillance and monitoring of AMR and AMU in food and agriculture, including livestock.
- Strengthen governance relating to AMU and AMR in food and agriculture, including livestock.
- Promote good practices in food and livestock–agricultural systems, and the prudent use of antimicrobials.

The FAO Action Plan supports the WHO-led Global Action Plan on AMR (WHO, 2016), and both highlight the necessity of applying a "One Health" (One Health, 2018) approach, with the involvement of public health and veterinary authorities, the food and livestock–agricultural sectors and other concerned partners.

Table 3: LODs (µg/Kg) of Equinox and Explorer for several antibiotics and sulphonamides in bovine muscle (MOHFW, 2014)

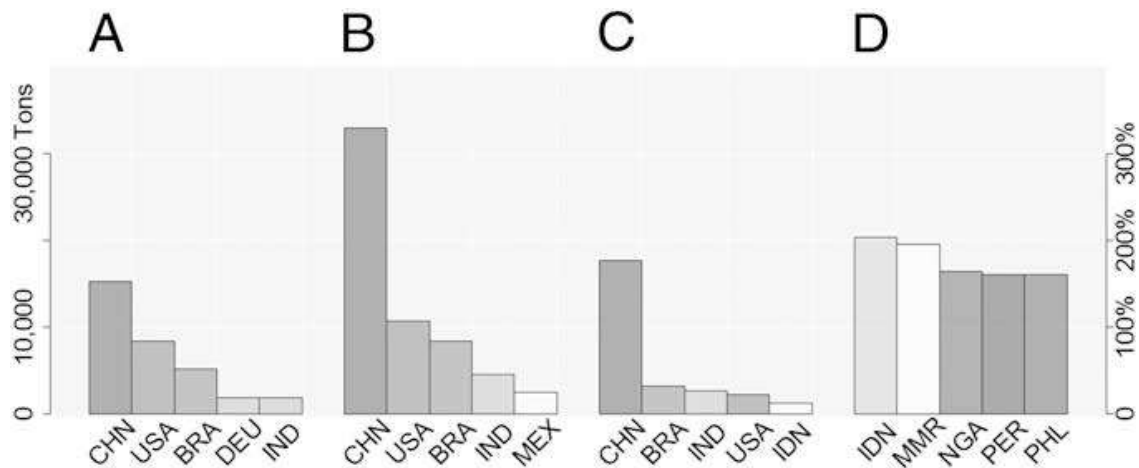
LOD (ug/kg)	Equinox	Explorer	UE-MRL
Doxycycline	≤ 5000	200	100
Tetracycline	n.e	500*	100
Oxytetracycline	n.e	700*	100
Penicillin G	>5000	5*	50
Amoxicillin	n.e	10	50
Cafalexin	n.e	>500	200
Gentamycin	n.e	400*	50
Neomycin	≤10000	300*	500
Tylosin	>10000	100	100
Erythromycin	n.e	200*	200
Enrofloxacin	100	n.e	100*
Norfloxacin	200	n.e	-
Sarafloxacin	100	n.e	-
Marbofloxacin	100	n.e	150
Ciprofloxacin	25	n.e	100 ^a
Danofloxacin	200	n.e	200
Difloxacin	300	n.e	400
Flumequine	2000	n.e	200
Sulfathiazole	>10000	200	100
Sulfamethoxypyridazine	n.e	300*	100
Sulfadiazine	n.e	200*	100

Table 4 : Codex Maximum Residues Limit (MRLs) and Acceptable Daily Intake (ADI) levels of some important antimicrobial drugs in food of animal origin(MOHFW, 2014)

Antimicrobial	Target tissue (ppm)				
	Acceptable daily intake (ppb)	Muscle	Liver	Kidney	Fat
Ampicillin	--	0.050	0.050	0.050	0.050
Benzy 1/Procaine	0-30	0.050	0.050	0.050	0.050
Benzy 1 penicillin	-				
Cloxacillin	-	0.300	0.300	0.300	0.300
Erythromycin	-	0.400	0.400	0.400	0.400
Gentamicin	0-20	0.100	0.200	0.500	0.100

Sulfadimidine	0-50	0.100	0.100	0.100	0.100
Sulfonamides (combinations)	0-50	0.100	0.100	0.100	0.100
Streptomycin	0-50	0.600	0.600	0.100	0.600
Oxytetracycline	0-30	0.100	0.100	0.100	0.100
Tetracyclines (OTC+CTC+ TC)	0-30	0.100	0.100	0.100	0.100
Trimethoprim	-	0.050	0.050	0.050	0.050

Fig. 1 : Largest Five Consumers of Anti Microbials in Livestock in 2010 and their Projections for 2030 (OIE, FAO 2018)



- (A) Largest five consumers of antimicrobials in livestock in 2010.(B) Largest five consumers of antimicrobials in livestock in 2030 (projected).(C) Largest Increase in antimicrobial consumption between 2010 and 2030.(D) Largest relative increase in antimicrobial consumption between 2010 and 2030.

CHN, China; USA, United States; BRA, Brazil; DEU, Germany; IND, India; MEX, Mexico; IDN, Indonesia; MMR, Myanmar; NGA, Nigeria; PER, Peru; PHL, Philippines.

9. **Pesticide Residues in Meat:** The maximum permissible levels of pesticide residues are indicated below. Much of the research work showed the levels are within the normal range in India.

Table 5 : Maximum Residues Limits (MRLs) of Pesticides (ppm) in Meat

PFA rules		Codex standards	U.S
Pesticide standard		Meat & poultry	Cattle meat
Aldrin/dieldrin	0.2	0.2	0.3 (fat)
Chlordane	-	0.05	0.3
Aldicarb	-	0.10	0.01
Carbaryl 1	-	0.10	0.10



Chlorpyrifos	0.1	2.0	0.2
Cypermethrin	0.2	0.02	0.05
DDT and its metabolites	7.0 (fat)	5.0 (fat)	5.0 (fat)
Decamethrin/deltamethrin	-	0.03	-
Endosulfan	-	0.10	0.2
Fenvalerate	1.0	1.5	1.5
Heptachlor	0.15	0.2	0.2
Hexachlorob enzene	0.2	0.2	0.5
Lindane	2.0	1.0	7.0
Monocrotofos	0.02	0.02	-
Propoxur	-	0.05	-

10. Food Allergens in Meat:

A recent analysis by U.S. PIRG shows that the total number of recalls of meat in the U.S. fell between 2017 and 2018. However, the long term trends are far less positive with recalls of meat and poultry rising 66 percent between 2013 and 2018. In an even more troubling development, the most hazardous Class I recalls of meat and poultry are up 83 percent since 2013. Class I refers to food that presents serious health risks such as containing botulinal toxins or undeclared allergens.

11. Genetic Interventions for quality and nutritional traits:

Responding to concerns about the possible health risks of consuming meat and meat products and, at the same time, aiming to increase the beneficial effects of meat and eggs in human diets, some livestock production systems are modifying their processes so as to improve both the quality and nutritional traits of meat (Pighin et al., 2016). Techniques designed to produce pigs with a more balanced ratio of unsaturated to saturated fat acids in their meat have, for instance, been developed in Japan (Kues and Niemann, 2004).

Intensive use of antimicrobial agents is recognized as one of the principal causes of AMR (O'Neill, 2016). Against this background, the use of naturally disease-resistant animals (DRAs) has been advocated as a longer-term policy and strategy for reducing antimicrobial usage. This would diminish AMR in farm animals (Woolhouse et al., 2015), as the use of DRAs requires a lower number of treatments than for susceptible animals (Mattioli et al., 1998; Murray and Black, 1985).

Cationic AMPs, which represent a new class of antibiotics derived from livestock species, have the ability to remain unaffected by classical resistance genes so that, to date, no cases of antimicrobial resistance have been recorded for AMPs (Kues and Niemann, 2004).

12. Global Research Interventions for the Production of Healthier Meat: 1.To produce the healthier meat, three way scientific interventions are recommended vic.,



i) modifications of carcass characteristics: A vitamin E-supplemented diet in poultry, pigs and cattle prolongs the shelf-life of these products. The antioxidant activity reduces rancidity and helps the meat retain its colour (Pszczola, 1998). By using partitioning agents like anabolisers, growth hormones, etc., or immunisation strategies, it is possible to alter those metabolic processes that regulate the use of nutrients during growth, thus promoting protein synthesis and reducing fat deposition (Bass et al., 1990; Beermann, 1994; Byers et al., 1993). The administration of somatotropin to pigs can lead to a 60% reduction in carcass fat, a 70% increase in carcass protein content and 27% less lipid content in lean tissues containing as much as 40 and 37% less of SFAs and MUFAs, respectively, and no differences in PUFAs (Solomon, 1994).

ii) Manipulation of Meat Raw materials: The most immediate system consists of extensive trimming to remove external and internal fat from the carcass; further trimming is done on primal cuts and, where necessary, the defatting is completed on retail cuts – (Jimenez-Colmenero et al., 2001).

iii) Reformulation of meat products: Fat reduction is achieved by reformulation. This consists of combining, pre-selected meat raw materials (leaner and of known composition) with appropriate amounts of water, fat (animal or veget with technological processes give the product certain desirable characteristics, such as improved composition, sensory and technological properties, safety, nutritional value, convenience, etc. Consequently, the development of low-fat products means that factors associated with meat raw materials, non-meat ingredients, and manufacture and preparation procedures (Jimenez-Colmenero et al., 1996).

Modifications of fatty acid profiles could be achieved by supplementation viz., Sausages containing high concentrations of monounsaturated acids have been made with meat raw materials from pigs fed on safflower, sunflower and canola oils (Jimenez -Colmenero et al., 2001). The second procedure consists of replacing part of the animal fat normally present in the product with another more suited to human needs, i.e. with less saturated fatty acids and more monounsaturated (oleic) or polyunsaturated acids, and with no cholesterol. Although simple fat replacement does not reduce the caloric content, it does greatly improve the nutritional quality of the product. Both fish oils (Omega-3 polyunsaturated oil) and vegetable oils (partially hydrogenated from corn, cottonseed, palm, peanut and soybean, peanut, high-oleic acid sunflower, cotton seed, olive) have been used in the product preparations such as patties and sausages (Liu et al., 1991; Paneras et al., 1998). Depending on the kind of oil, products may present some differences (including sensory differences) from their reference products, but these differences can be readjusted by means of one or more strategies for the production of low-fat products (Jimenez-Colmenero, 1996).

Reduction of Cholesterol: A completely different approach to reduce cholesterol uptake is by including an interesting new component that is increasingly attracting the attention of a variety of researchers, in meat products, namely conjugated linoleic acid (CLA; octadienedecadienoic acid 18:2). Ringseis et al., 2008). Paneras et al. (1998), using olive, cottonseed and soy oils, obtained frankfurters (10% fat) with up to 59% less cholesterol than normal frankfurters containing 30% animal fat.

Reduction in sodium and salt: Certain commercial preparations used in the meat industry, which contain 43% less sodium and do not have the sensory disadvantages frequently associated with NaCl substitutes (Pszczola, 1999).

13. Global Nutrition Report (2018) suggests

1. Break down silos between malnutrition in all its forms through enhanced productivity and consumption of ASF including meat



2. Prioritise and invest in the data needed and capacity to use it.
3. Scale up financing for nutrition – diversify and innovate to build on past progress
4. Galvanise action on **healthy diets** – engage across countries to address this universal problem
5. Make and deliver better commitments to end malnutrition in all its forms – an ambitious, transformative approach will be required to meet global nutrition targets which are **SMART** (specific, measurable, achievable, relevant and time-bound) commitments.
6. Mechanisms to address food loss and waste

For every kilo of meat produced at global level, about 200 g are lost or wasted. In middle- and high-income countries, including India consumer waste accounts for approximately half of total meat loss and waste. A third of all food produced (around 1.3 billion tons) is lost or wasted every year, with loss in the beginning of the food supply chain mostly occurring in developing countries and waste at the consumer end of the chain being the main issue in developed economies (FAO, 2011).

Addressing this inefficiency in the food chain systems for developing countries, this requires considerable investment to develop infrastructure in producer areas to prevent losses, awareness raising and information gathering to track and manage food loss and waste. Such efforts make economic sense; currently food waste costs over US\$400 billion per year, and this is projected to increase to US\$600 billion within 15 years (WRAP, 2015). Reducing consumer food waste by 20–50% in 2030 would already result in savings of US\$120–300 billion a year (WRAP, 2015) and help tackle the nearly 7% greenhouse gas emissions which emanate from food loss and waste.

(Reference will be available from author)

Lead Papers

Session-I - Lead Paper-01

CLIMATE CHANGE AND LIVESTOCK MEAT PRODUCTION : SIGNIFICANCE AND IMPACT ON BOTH QUANTITY AND QUALITY

**Veerasamy Sejian^{*,1}, P.R. Archana², Wilfred Ruban³, M.Bagath¹,
G.Krishnan¹ and Raghavendra Bhatta¹**

¹ ICAR-National Institute of Animal Nutrition and Physiology, Adugodi, Bangalore-560030

² School of Agriculture and Food, The University of Melbourne, Victoria, Australia

³ Department of Livestock Product Technology, Hebbal Veterinary College,
Karnataka Veterinary Animal and Fishery Sciences University, Hebbal, Bangalore, India

1. Introduction

Climate change has added to the enormity of India's food-security challenges. Climate change affects food security in complex ways. Climate change affects all dimensions of food security and nutrition: Food availability, food access, food utilization and food stability. It impacts crops, livestock, forestry, fisheries and aquaculture, and can cause grave social and economic consequences in the form of reduced incomes, eroded livelihoods, trade disruption and adverse health impacts. However, it is important to note that the net impact of climate change depends not only on the extent of the climatic shock but also on the underlying vulnerabilities. According to the Food and Agriculture Organization (2016), both biophysical and social vulnerabilities determine the net impact of climate change on food security. Therefore, reducing the risks to food security from climate change perspective is one of the major challenges of the 21st century.

Livestock contributes greatly to food security because: (1) they are suppliers of global calories, proteins, and essential micronutrients, (2) they are produced in areas that have difficulty growing crops, (3) most of the feed for livestock is not appropriate for human consumption, and (4) they provide manure for crop production. Sustainable livestock production needs more research, extension, and demonstration. Livestock are an important contributor to food security, but it is important to maintain an efficient conversion of natural resources to human food to sustain a neutral food balance. One of the major challenges in the world is to increase meat production for the projected world population of 9 billion by 2050. Efforts have been made to achieve this through improved livestock production systems, a step towards realizing food security.

Climate change is seen as a major threat to the survival of many species, ecosystems and the sustainability of livestock production systems in many parts of the world. Nevertheless, global demand for livestock products is expected to double during the first half of this century, as a result of the growing human population, and its growing affluence. Meat and meat products are especially gaining relevance as it acts as important source of protein and the essential amino acids needed for humans. Also meat industry is a major source of economic output. Hence in the changing climate scenario the role of meat industry is gaining global



significance. This chapter is therefore an attempt to collate and synthesise information pertaining to impact of heat stress on meat production in livestock. Efforts were made to cover the impact climate change associated heat stress on both livestock meat quantity and quality variables.

2. Meat production statistics from major livestock species

Important livestock species used for meat purposes around the globe are pig, cattle, poultry, sheep and goat, among which pork is the most widely, consumed meat followed by poultry, beef and mutton. Meat consumption especially in the developed countries is on the rise and has almost doubled compared to developing countries. World meat production is projected to continue to rise mainly to meet the needs of growing population, changing life patterns and affluence. In 2017, it is anticipated that world meat production would be doubled with 262.8 metric tons production value compared to 1986 value. In meat industry, the poultry sector has emerged to be the fastest growing enterprise over the years. The meat industrial growths are mostly expected from Asia, Latin America, Middle East and from other developing countries. In pork production, South and East Asia topped during the years 2013-15 with 67.13 million tonne, followed by Western Europe with 23.25 million tonne. Latin America has the highest beef production, followed by South and East Asia. In poultry production, South and East Asia ranks first with 32.74 million tonne, followed by Latin America and North America. In mutton production, South and East Asia ranks first with 6.39 million tonnes.

3. Climate change and concept of multiple stresses affecting livestock production

In the present changing climate scenario, there are numerous stresses other than the heat stress which constrain the livestock and have severe consequences on their production. The projected climate change seriously hampers the pasture availability especially during the period of frequent drought in summer. Thus, livestock suffer from drastic nutrition deficiency. Both the quantity and the quality of the available pastures are affected during extreme environmental conditions. Further, with the changing climate, animals have to walk a long distances in search of pastures. This locomotory activity also put the livestock species under enormous stress. Hence it's not only the heat stress that need to be counteracted but the nutrition and walking stress are also of great concern. When exposed to one stress at a time, animals can effectively counter it based on their stored body reserves and without altering the productive functions. However, if they are exposed to more than one stress at a time, the summated effects of the different stressors might prove detrimental to these animals. Such a response is attributed to animal's inability to cope with the combined effects of different stressors simultaneously. In such a case, the animal's body reserves are not sufficient to effectively counter multiple environmental stressors. As a result their adaptive capabilities are hampered and the animals struggle to maintain normal homeothermy.

4. Climate change impact on livestock meat industry

Significant research has been done on heat stress impacts on meat quality and composition especially in cattle, sheep, goat, pig and broilers. High temperature and humidity results in increased meat pH, less expressed juice, cooking loss and drip loss. During exposure to high temperatures the energy utilization gets decreased while the energy expenditure is increased for thermoregulation. This deteriorates the quality of the meat by decreasing the muscle glycogen leading to increase in the muscle pH. The functional properties of meat such as color, water holding capacity (WHC) and myofibrillar fragmentation index (MFI) were also negatively influenced during heat stress in ruminants. Further, the animal management practices during climate change also can indirectly affect the meat quality. For example, rearing heat-tolerant *Bos indicus* cattle



is an effective adaptation strategy against the prevailing harsh climatic conditions. This can lead to tougher and less juicy beef. Besides the qualitative alterations driven by the heat load on the animals, carcass weight losses in heat stressed animals also has economic significance. Ante-mortem temperature stress is a major determinant for live carcass weight losses, hot carcass weight and retail meat yield. Energy partitioning for thermoregulation accompanied with reduced feed intake to reduce heat load resulted in live weight losses. From these findings it is evident that heat stress declines both qualitative and quantitative characteristics of meat. However, this adverse effects of heat stress on meat quality is variable based on the region of animal origin. This warrants developing region specific appropriate strategies to cope up with heat stress to improve meat production in the changing climate scenario.

4.1. Heat stress impacts on carcass characteristics

Reduced dressing percentage and carcass weight loss have huge economic significance, especially in small ruminant meat. At elevated ambient temperature, dressing percentage has been reported to be enhanced in broiler chicken. However, contrary results of reduced dressing percentage and associated carcass weight loss has also been reported in broiler chicken exposed to high ambient temperature of above 30°C. Further, there are also reports suggesting significant reduction in subcutaneous, intramuscular and abdominal fat percentage in heat stressed broiler chicken. In pigs exposed to warmer summer temperature, the fat deposition in the muscle was found to be significantly reduced and this was attributed to the reduced feed intake and energy consumption in order to reduce the metabolic heat load. Further, a study also revealed that in growing pigs, lipid metabolism was enhanced in liver and adipose tissue during heat stress resulting in increased fatness in muscle. Increased back fat thickness and reduced lean % was also reported in the same study, further confirming the enhanced adiposity during heat stress in pigs. Further, it was reported that heat stressed pigs possess an increased carcass length, probably as an adaptive mechanism to adjust the body surface area to the body mass ratio for better heat dissipation.

Heat stress driven carcass weight loss, dressing percentage decrease, reduced fat thickness and leaner carcass have also been established in beef cattle raised under elevated ambient temperature. In cattle, during elevated environmental temperatures, instead of subcutaneous fat, internal fat depots will be enhanced like pigs, accompanied by enhanced muscle marbling which is a preferred trait in some beef markets. However, higher temperatures could also result in dark cutting beef which has been a major concern in US and Oman beef markets. The reduced marbling also occurs in beef cattle when the farmers adopt heat-tolerant cattle sires such as Brahman crosses as a management strategy against heat stress. In sheep, dressing percentage was found to be reduced because of the enhanced muscular activities leading to hypertrophy and increased size in majority of the vital offals such as liver, kidney, heart, blood and also head and feet. Carcass weight loss in goats transported during peak summer hours had resulted in live weight and carcass weight loss, reduction in intramuscular fat content or marbling mainly because of the moisture loss and tissue shrinkage.

4.2. Heat Stress impact on meat quality

Turn over from the meat industry commensurate with the supply of safe, nutritious, and good quality meat to the consumers. Market failure is mainly linked with the consumer preference and acceptability of meat. Further, the preference by consumers and processors depends mainly on the meat quality, which is determined by several factors. Meat quality is assessed by two main aspects: nutritional value, which is merely determined by meat composition and is an objective measure while eating quality that is a subjective assessment of meat by consumers and processors which includes the meat colour, tenderness, juiciness and flavour. Heat stress has its effect on various organoleptic quality factors which are determined by sensory and



visual perception of the consumers such as colour, shear force, tenderness, juiciness, flavour and palatability of meat.

4.2.1. Meat pH and colour

Depending on the duration of heat stress, there would be changes in the meat pH during the post-mortem period. During conversion of muscle to meat, there would be decline of pH from 7.0-7.2 to pH 5.5-5.7 during 24 hrs post slaughter. However, if the animal encounters any kind of stress such as heat stress immediately prior to slaughter, glycogen will be released to blood and converted into lactic acid. This sudden increase in acidity may result in a condition termed as pale soft exudative (PSE) meat, which is very common especially in pork. This PSE is the major cause for the rejection of pig and poultry meat in the market both by the consumers and the meat processors and is more pronounced during the summer months.

Meat pH is intricately related to several other attributes, leading to reduced WHC, accelerated rigor mortis and paler colour. Reduced WHC in turn result in increased cooking loss, shearing force, drip loss and reduced flavour. Rana et al. (2014) in an experiment on heat stressed sheep, reported that the increased ultimate pH of meat during heat stress may affect the cooking loss and keeping quality of meat. Similarly in a study on Black Bengal goats, Hashem et al. (2013) also established increased meat pH during heat stress exposure and they interrelated this to the cooking loss of meat. However, in the breast muscles of broilers, chronic heat stress significantly decreased the meat pH, increased L^* and drip loss. Further, during acute heat stress in broilers, increased L^* and decreased a^* and b^* have also been reported. These authors attributed such alterations to the denaturation of sarcoplasmic proteins and scattering of light. However unlike as in PSE, if the animals are exposed to heat stress for longer duration, all glycogen reserves will be fully depleted. This would result in insufficient amount of lactic acid after slaughter, thereby increasing the meat pH and resulting in a condition termed as dark, firm and dry (DFD) in pigs and dark-cutting in beef cattle. High pH would be accompanied with higher WHC and increased light absorbance, thereby imparting dark colour to the meat. Dark cutting beef or DFD meat is a serious concern among the beef producers because of the consumer rejection for their undesired appearance.

Colour of meat can be evaluated by visual appearance and also as instrumental colour (lightness L^* , redness a^* and yellowness b^*). As the consumers usually relate the colour of meat, fat content and visual appearance to the freshness, quality and safety of meat, color is considered a vital meat parameter. Meat colour is essentially affected by the pre-slaughter stressors, among which temperature stress has been identified as a critical factor. Castrated sheep during heat stress showed increased values of colour parameters (L^* , a^* , b^*) of meat along with augmented activity of creatin kinase which is related to the muscular damage and mutton quality. However, reduced colour (L^* , a^* , b^*) has also been reported in heat stressed sheep. In contrast, higher lightness (L^*) and lower redness (a^*) have also been reported in turkeys exposed to heat stress. Further, in both the thigh and breast muscles exposed to heat stress, higher L^* , b^* and lower a^* were established in broilers.

4.2.2. Meat tenderness and juiciness

Eating quality of meat is primarily determined by the meat tenderness and juiciness. At high ambient temperatures, the rigor mortis development after slaughter would be more severe leading to enhanced stiffening of meat. Further with the accompanying alterations in meat pH and moisture losses during heat stress, meat gets firmer and drier, resulting in reduced tenderness and eating quality. Literature suggests that the enhanced dehydration in animals exposed to heat stress during the process of respiration and evaporation



reduces the meat tenderness and quality. In goats, it has been studied that ante-mortem stress related generation of lactate is another factor reducing the tenderness of the meat. Further, juiciness of meat also was found to be compromised in goats exposed to extreme environmental temperature. Enhanced marbling score or intramuscular fat deposition in beef during heat stress results in, toughening of meat. Further, the sensory parameters such as tenderness and juiciness are interrelated and the tougher meat was found to be associated with less juice content during heat stress condition. Similarly Kadim et al. (2006) also reported that in sheep and goats, meat tenderness was declined on exposure to increased ambient temperature.

4.2.3. Heat stress impact on proximate composition of meat

During heat stress in broilers, higher moisture content and fat content have been reported along with reduced protein content in thigh and breast muscle. These authors suggested the reason for reduced protein deposition, to the decreased ribosomal activity and increased fat deposition, especially the abdominal fat, to the reduced basal metabolism and physical activities during heat stress. Further, these authors also reported increase of moisture content in the breast meat, but not in the thigh muscle. Similar result of reduced crude protein was reported in the meat samples of sheep exposed to heat stress. However in the same study, no significant alterations were reported in dry matter, ash and ether extract in meat samples of control and heat stressed sheep. Likewise, another study in black Bengal goats concluded that heat stress caused no variations on dry matter, crude protein and ash, but ether extract varied significantly in heat stressed group. Like meat safety, reports pertaining to impact of heat stress on meat proximate composition are very scanty and therefore future research efforts are needed to fully understand the mechanisms associated with heat stress compromised proximate composition of meat.

4.3 Climate change and Meat safety

It is generally assumed that meat safety could be affected by the changing climatic conditions. In poultry, retail meat contamination with pathogens such as *Salmonella* or *Campylobacter* showed peak occurrence in summer. In fact, one of the primary causes for foodborne illness in humans through consumption of poultry products is attributed to the seasonal upshoot of the food-borne pathogens such as *Salmonella* and *Campylobacter*. Such bacterial pathogens have the potential to alter the neuroendocrine responses of the host during heat stress exposure enhancing their chances of proliferation and pathogenicity. This direct effect of microbial pathogens on the stress hormones and mediators is the emerging concept of 'microbial endocrinology' which affects the safety of meat and meat products. Pig carcass was established to be contaminated with *Escherichia coli*, during elevated ambient temperature exposure. However, the mechanism underpinning the increased prevalence of these pathogens during summer could not be established. Further, in cattle it was reported that the faecal shedding showed increased count of *Campylobacter* with the temperature rise during spring season in the temperate wet climate of New Zealand. However, studies pertaining to the impacts of climate change on meat spoilage and safety are inadequate particularly in red meat and this warrants further research investigations.

5. Conclusion

Climate change associated heat stress negatively influences both carcass characteristics and meat quality. Further to the adverse consequences on meat characteristics, heat stress also brings about significant alterations in the on meat quality and safety. Heat stress negatively influences meat pH, water holding



capacity, shear force, myofibrillar fragmentation index and sensory attributes (tenderness, juiciness, colour and appearance) which are the determinants of the consumer preference and acceptability of meat. The heat stress driven carcass weight losses have significant economic implication in meat industry. From the discussions in this chapter, it may be concluded that the current understanding of the intricate mechanisms underlying the meat quality deterioration during heat stress exposure is inadequate and needs further investigation. The future research efforts also must target identifying ideal biological markers reflecting the meat quality under different testing environmental conditions which may help to identify species/breed which may survive and produce optimally in the adverse environmental condition.

(Reference will be available from author)



Session-I - Lead Paper-02

SHEEP AND GOAT PRODUCTION APPROACHES AND STRATEGIES TO ENHANCE MEAT PRODUCTION AND PRODUCTIVITY

P. Baswa Reddy

ICAR- National Research Centre on Meat, Hyderabad

In India, livestock sector is an integral part of agriculture and rural economy and it is one of the potential regular income and full time employment generating activity in the rural and peri-urban areas. The nutritional security provided by livestock rearing is enormous. Further, the net output from the unit of investment is comparatively high in livestock farming even under adverse seasonal conditions like severe droughts. Agriculture farming taken up in smaller land holdings is becoming unproductive in recent years, due to lack of assured market/ fluctuation of prices for produce and other adverse seasonal conditions. Therefore, in order to double income of farmers as emphasized by the government of India, it is important to focus on the allied enterprises viz., dairy, sheep & poultry sector. When compared to crops, the price volatility in case of milk, poultry & sheep meat is very less. Poultry sector is already an organized sector in India and the dairy sector is also partly organized through dairy cooperatives. The sheep and goat sector in the country is still unorganized and is vulnerable to exploitation. Therefore, there is a need to mobilize more people and investments into this sector and make it more glamorous and profitable through commercialization. Financing by commercial banks can be encouraged. Market is not a problem for these allied enterprises. While India itself has a large market, neighbouring countries which are deficit in sheep and goat meat can be tapped as well. For this, farmers need to be supported with professional inputs, finances and markets.

Sheep and Goat Rearing in India

Small ruminants play an important role in Indian economy and it provides livelihood to two-third of rural community. Sheep and goats are important species of livestock for India. They contribute greatly to the agrarian economy, especially in areas where crop and dairy farming are not economical, and play an important role in the livelihood of a large proportion of small and marginal farmers and landless labourers. (DAHD 2016)

Sheep and goat are multi-purpose animals raised for their meat, milk, wool, hides and skins. In spite of a number of small ruminant development activities in operation in different states of the country, sheep and goat rearing still continues to be a nomadic/backward proposition and thus mostly concerned to poor and landless people. For scanty suitable grazing lands in most of the states, the shepherds keep on migrating their flocks over extensive areas within or even in the neighboring states. Sheep and goat rearing is thus practiced in a diversified form depending upon the region and the location.

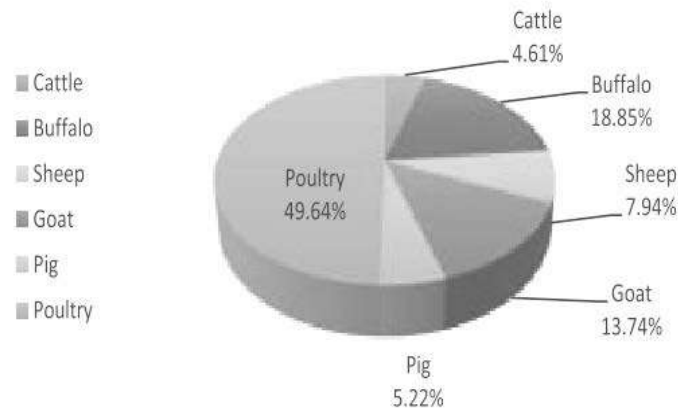
Demand and supply of small ruminant meat:

Small ruminants contributed around 21.5% of meat produced in India during 2017-18 while poultry meat accounted for almost half of the total meat produced (DAHD, 2018).

46.22 million sheep and 93.92 million goats were slaughtered in India during 2017-18 to produce 6.03 lakh tons of sheep meat and 10.43 lakh tons of goat meat. West Bengal leads the list in goat meat with 2.54 lakh tons of production amounting to 24.3 % of total goat meat production. Andhra Pradesh and Telangana together produced 56.72 % of the country's sheep meat with 3.42 lakh tons of production during

2017-18. This trend clearly indicates that goat meat is produced more in eastern region of the country while sheep meat is produced more in the southern states particularly the telugu states of Andhra Pradesh and Telangana(DAHD, 2018).

Fig. : Species wise meat contribution in India (2017-18)



The average lamb consumption in the world is around 2 kg per capita per annum(FAOSTAT, www.fao.org) with large variations between geographical regions (e.g. 17 kg in Australasia vs. 0.7 kg in North America), between countries and even between regions within the same country.

Meat production in India is far below the level of demand from the huge population. Moreover, by 2050, it is expected that the population in India would increase by 34% and to fulfil the dietary recommended levels of the livestock products by Indian Council of Medical Research (ICMR) for a population of 1.7 billion people, the livestock sector should produce 3-4 times more meat than the current production. Further, in order to attain the national goals of doubling the farmers income by 2022, the ICAR data and the BAHS specify a short term CAGR of 5% in mutton and chevon production till 2022. To achieve this, the sheep and goat production sector which is yet to take off on scientific lines has to grow in leaps and bounds to meet the huge demand for meat in India.

Table: Short term targeted projections for sheep and goat meat production by 2022

	2015-16	Projection -2022
Sheep population (Million)	65 (2012 LC)	82
Mutton production (thousand tons)	482.52	724
Goat population (Million)	135 (2012 LC)	249.55
Goat meat production (thousand tons)	940	1260

Export Potential for Sheep And Goat Meat

During 2017-18, India exported 21,906 metric tons of sheep and goat meat worth Rs 835.74 crore (129.67 million USD) realizing an average price of Rs 382 per kilogram of meat which is far less than the price prevailing in many states of the country. The top five destinations for Indian sheep and goat meat were UAE, Saudi Arabia, Qatar, Kuwait and Oman. In the world, during 2017, the export trade of sheep and goat

meat was 1.05 million metric tons worth 5883 million USD. The top exporting countries of sheep and goat meat were New Zealand, Australia, UK, Ireland, Spain and Netherlands. The major importing countries were China, USA, France, UK and Germany. State wise data of sheep and goat meat export from India reveals that the major sheep meat production and consumption states of Andhra Pradesh and Telangana as well as major goat meat centric state of West Bengal have negligible share in the export of small ruminant meat from India. This implies that these states have huge demand and the local price is more than the export price inferring that we need to focus more on meeting the local demand and once we become surplus in sheep and goat meat production by adopting scientific approaches for improving the productivity, we can tap the potential for exporting to other countries.

Table: Export of Sheep and Goat meat from India to different countries (Source APEDA)

Country	2014-15		2015-16		2016-17		2017-18	
	Qty	Rs. Crore	Qty	Rs. Crore	Qty	Rs. Crore	Qty	Rs. Crore
U A E	11439.11	408.49	12449.84	472.59	13003.17	500.25	12619.7	466.5
Saudi Arabia	6925.56	255.7	4700.95	188.11	4550.69	194.29	4239.58	177.54
Qatar	2003.65	70.49	2173.64	84.17	2102.87	82.44	2119.43	80.02
Kuwait	1741.99	63.5	1680.44	66.38	1612.95	65.11	1925.7	74.89
Oman	480.69	15.16	318.29	11.14	363.87	13.09	539.39	20.31
Baharain Is	178.96	6.61	211.53	8.53	274.91	11.6	296.69	11.7
Maldives	31.94	0.98	84.75	2.44	80.98	2.39	143.48	4.09
Seychelles	9	0.26	6.2	0.18	16	0.45	17.11	0.51
Nepal	0	0	3.76	0.13	0.64	0.02	0	0
Other Countries	16.87	0.35	6.3	0.22	2.5	0.09	5.43	0.18
Total	22827.77	821.54	21635.7	833.89	22008.58	869.73	21906.51	835.74

Table: State wise export of Sheep and Goat meat from India (Source, APEDA)

State	2014-15		2015-16		2016-17		2017-18	
	Qty (MT)	Rs. Crore	Qty (MT)	Rs. Crore	Qty (MT)	Rs. Crore	Qty (MT)	Rs. Crore
Delhi	13612.14	502.6	13079.12	526.99	12115.94	496.56	12284.56	480.1
Maharashtra	7769.38	277.19	7095.37	259.4	8004.71	308.32	7608.09	287.52
Uttar Pradesh	1215.5	35.29	1222.75	39.96	1510.9	51.6	1887.36	64.42
Haryana	208	5.88	198	5.96	137	4.2	99	2.63
Bihar	0	0	2.76	0.1	0.6	0.02	0	0
Andhra Pradesh and Telangana	0	0	31.84	1.19	238.41	8.99	27.13	1.07

Kerala	7.49	0.38	4.86	0.28	0.99	0.06	0.36	0.01
Uttarakhand	0	0	0	0	0.03	0	0	0
West Bengal	13.28	0.19	1	0.04	0	0	0	0
Tamil Nadu	1.98	0.02	0	0	0	0	0.02	0
Total	22,827.77	821.55	21,635.70	833.92	22,008.58	869.75	21,906.52	835.75

TECHNOLOGICAL CONSIDERATIONS TO ENHANCE SHEEP AND GOAT MEAT PRODUCTION:

To achieve the projected targets of sheep and goat meat production in the country and to exploit the huge export potential, the production and productivity need to be increased by implementing a two pronged approach i.e.,

1. Supporting the livelihoods of traditional shepherds by educating and providing incentives to them to adopt new technologies in small ruminant rearing.
2. Simultaneously encouraging the unemployed youth to take up sheep & goat rearing on large scale with modern rearing technologies.

Though sheep and goat rearing is a profitable venture, the new generation youth are not willing to continue in the profession because of the age old way in which the farming is being done in the country ignoring the advanced technologies coming up in sheep and goat rearing worldwide.

Due to poor husbandry practices being followed and less productivity of the animals, more and more sheep and goats are being slaughtered to meet the growing demand for small ruminant meat leading to decrease in the population of these animals in the country over the years. Between 2007 and 2012, though there was a meagre 3.8% increase in goat population in the country, sheep population drastically decreased by 9% in five years. This throws an alarming situation to look into the issue of making sheep and goat meat available to the future generations both qualitatively as well as quantitatively.

There are two different way in which the issue can be addressed. The first one is by increasing the number of animals and the second one is by increasing the productivity of the animals. The second approach addresses the issue scientifically by increasing the meat yield per animal through scientific approaches in feeding, health care and management practices. In this approach, the burden on existing feed resources is less in comparison to increasing the number of animals.

Some state governments where there is huge demand for sheep and goat meat like Telangana have already started to address the issue of increasing the number of animals through distribution of sheep to the shepherd community of the state by procuring them from neighbouring states. But mere distribution of sheep may not yield the desired results unless all the stake holders involved in the chain are adequately educated on different aspects of sheep value chain like management, feeding, health care, marketing, hygienic slaughter, value addition, quality control etc., At the same time, the addition of these huge numbers of animals in a short span is likely to increase the pressure on the existing feed and fodder resources in the days to come and alternative methods should be looked into to meet the feed and fodder requirement. Likewise breeding as well as healthcare programmes need to be meticulously planned and implemented to make the initiative of the



government successful in achieving the target of making the country self-sufficient in the short term and net exporter in the medium to long term.

Increasing the productivity of the animals by following scientific methods of breeding, feeding, health care and management without numerically increasing the number of animals is the right approach to increase the meat production in the country. The average carcass yield of small ruminants in India is 10-12kg. Increasing this to 16-18kg is possible through scientific rearing practices and it is equivalent to increasing the numbers of animals by 50%. This approach is not likely to add the burden exponentially on the existing feed and fodder resources.

Productivity enhancement is a key factor to augment the competitiveness of the sheep and goat meat industry. But, this comes with huge challenges like scientific breeding & breed selection, feeding, health care, management, marketing, capacity building of every stake holder involved in the value chain and creation of infrastructure facilities.

Breed and breeding

As per the breed survey-2013, in India there are 36 million sheep belonging to one of the 37 specific indigenous breeds (pure plus graded) and 25 million sheep of nonspecific breed. Nellore, Deccani, Marwari and Bellari are the major breeds accounting for 19.17, 10.15, 6.70 and 3.79 percent of sheep population respectively. Rambouillet breed with 2.7 lakh population contributes to 7.16 % of total exotic/ crossbred sheep in India. Among goats, 61.26% of the total goats in India are non-descript while only 38.74% are of specific indigenous breed (pure plus graded). Black Bengal, Marwari and Barbari breeds account to 15.28, 5.31 and 4.65 % respectively of the total goat population in India. The number of exotic breeds of goat in India is almost negligible.

While the indigenous breeds are well acclimatized to the native condition, the average carcass yields of these animals are around 10-12kg per animal only. The last few decades of research efforts and interventions to improve the breed performances and development of crosses for increasing the meat productivity have met with very little success and poor adoptability throughout the country. At this juncture, to meet the huge increase in demand for meat, it is essential to introduce and rear exotic sheep breeds with high meat productivity. In the context of climate controlled farming becoming the order of the day, the best performing breeds of the world can be reared in India by creating conducive environment to tap their potential. This kind of approach can be encouraged under commercial lines and the local indigenous breeds may be continued and preserved parallelly with scientific interventions to improve their performance gradually.

Feeding

Providing feed and fodder accounts to more than two thirds of the total cost and efforts in small ruminant production. Any effective intervention in feeding is likely to influence the productivity as well as profitability in this sector. It is an established fact that cost of feeding for production of meat per kilogram is more if more number of less productive animals are reared when compared to that of rearing less number of high productive animals. Fulfilling the feed requirement of huge number of less productive animals from same resource base of land and water is going to be a huge challenge. Since there is very little scope for allocation



of additional land for fodder production, it is suggestible to use the resources judiciously to attain more productivity from high yielding animals.

To improve productivity and transform sheep and goat rearing from subsistence to a market oriented systems, the feed issue should be addressed in different ways in different contexts. The resource poor farmers may be advocated to shift to semi intensive system of rearing and the educated youth may be supported to establish commercial sheep breeding units under intensive system of rearing. Again, under intensive system of rearing, different approaches can be advocated depending upon availability of resources with the farmers.

- i. Feeding Green fodder under cut and carry system along with concentrate supplementation if the land and water facility to grow fodder throughout the year is available.
- ii. If the fodder cannot be grown throughout the year due to scarcity of water, excess fodder can be produced during rainy season and it can be conserved either in the form of Hay or Silage and they can be used to meet the feed requirements during lean seasons.
- iii. If there is no possibility of fodder production due to lack of water or land, the farmers who have financial capability and want to go for rearing of large number of animals can adopt the concept of rearing animals with complete feeds (Total Mixed Rations, TMR) by effectively utilizing locally available crop residues as feed resources for sheep rearing.

A study by the 'ICAR- National Research Centre on Meat' on rearing ram lambs under stall feeding with complete feeds (Total Mixed Rations, TMR) is given here under.

A study on broiler ram lamb production with complete feeds (Total Mixed Rations, TMR) -Economics of production

In the recent times due to increasing demand for quality mutton, many enthusiastic farmers and entrepreneurs are showing interest in taking up sheep rearing on a large scale in commercial lines. But, unorganized nature of sheep rearing and marketing in addition to the shrinking grazing lands and hardships associated with traditional systems of rearing are averting them from venturing into this sector. Alternative systems of rearing wherein one can have complete control over the production system can encourage people to undertake sheep rearing in a professional and commercial manner.

To address this issue, ICAR-National Research Centre on Meat (NRCM), Hyderabad has conducted study on rearing of ram lambs under stall feeding with 'Complete Feeds' (Total Mixed Rations, TMR) under National Agricultural Innovation Project. For this purpose a Rural Feed Processing Unit was established at Chennur village of Gudur mandal in Nellore dist. of A.P. From the feed produced in this plant, field trials were conducted under farmers' field conditions to rear weaned ram lambs up to market weight under stall feeding covering 20 villages of 4 mandals in Nellore district involving 48 farmers. Under this, weaned ram lambs of 3-4 months age were reared under complete confinement in sheds/thatches in the farmers' premises and the animals were never allowed to go out for grazing till they attain market weight. In the stalls, ram lambs were offered with complete feed in the feeders to meet all the nutrient requirements in dry mash form as seen in the case of broiler poultry rearing. The ram lambs attained market weight in 120 days of feeding. (The details are given in the table)

Complete feed comprises of roughage and concentrate ingredients grinded and mixed in definite predefined proportions to meet the maintenance and growth requirements of lambs. The roughage component



here may comprise of cheaply available crop residues and agro-industrial by-products like maize straw, ground nut straw, maize cobs etc. Depending on the palatability, nutrient content and anti-nutritional factors present in them, certain limitations are specified for the level of inclusion of these residues in the complete feeds. The remaining portion of complete feed comprises of concentrate ingredients like grains, millets, oil seed cakes, brans, molasses, mineral mixture, salt, vitamins etc., as per the formulation. The overall level of inclusion of each ingredient in the complete feed depends on the level of nutrients required in the final complete feed. Depending on the availability of different crop residues and agro industrial by- products in different localities, the composition can be changed accordingly with the advice of the animal nutritionist.

The cost economics of rearing ram lambs under stall feeding with complete feeds is given here under. The prices mentioned pertains to the years 2011 and 2012

Table: Cost economics of rearing ram lambs under stall feeding with complete feeds

	If farmer purchases complete feed	If farmer uses his own crop residues	If reared for breeding ram purpose
Avg. Cost of Ram lamb (Rs)	2700	2700	2700
Avg. Wt.of Lamb(Kg)	13	13	13
Avg. no. of days in feeding	120	120	165
Avg. Complete feed consumed (Kg)	105	105	160
Cost of complete feed/kg(Rs)	13	9.25	9.25 / 13
Total cost of feed (Rs)	1365	971.25	1480 / 2080
Other Misc. costs/ animal	300	300	350
Total inputs /animal (Rs)	1665	1271	1830 / 2430
Avg. Market wt. of animal (kg)	28	28	35
Avg sale price (Rs)	5480	5480	7200
Profit / Animal in four months (Rs)	1115	1508	2670 / 2070

Health care

Concerted efforts of the central as well as state governments in the last three decades helped in educating the farmers about the importance of preventive health care in livestock farming and its economic implications. Still, sheep and goats which move on migration are susceptible to various diseases through contaminated feed, water etc., Stall feeding of sheep and goats can reduce this risk to a greater extent as the animals are not exposed to vulnerabilities and a good care can be taken to avoid the spread of diseases through feed and water. Strengthening the institutional mechanisms for animal health care at field level and development of suitable preventive health care methods for all the diseases for which effective vaccines are not available will improve the health status of the flocks and there by income to the farmers.



PROMOTIONAL AND POLICY LEVEL REQUIREMENTS

Commercial farming

The prevailing production system for sheep and goats in India is extensive in nature wherein the animal are dependent on natural pasture and farmers go on migration with the flocks to far off places in search of feed. Most of the times, this leads to negative energy balance and the animals go down in condition leading to poor productivity.

In response to the increasing demand for sheep and goat meat in the domestic market and to reduce the demand supply gap and to develop the sector as a whole, special attention should be given to promote commercial sheep and goat farming. Progressive farmers, interested entrepreneurs, and educated youth willing to invest in this business may be provided with infrastructure support and production incentives to rear sheep and goats as a commercial business enterprises. They may initially start with small flock size and then increase the size after gaining experience. These farmers should be provided with low cost credit, knowledge and market intelligence. The initial investment towards housing, breeding stock etc. should also be supported to attract investors in the sector.

Marketing Infrastructure

The most important thing in any commercial activity is a market for the produce. Today in many states there are no regulated markets for sheep and goats. The farmers do not have the first hand information on the prevailing price for their animals in the market. Many times farmers sell their animals to the middle men or butchers based on the price fixed by those people following unscientific methods. To avoid this, markets and marketing facilities should be provided in all the reasonable locations and strict measure should be implemented to sell the animal on body weight basis only. For this, provisions should be made for weighing balances in the markets.

Establishment of rural and municipal slaughter houses

In rural areas and small town small scale slaughter facilities should be created to slaughter animals, prepare meat and sell it fresh. In major towns, the existing slaughter houses should be upgraded with modern facilities. The butchers should be mandated to use these facilities by paying a small fee which can be used for maintaining the facility. The live animals brought for slaughter should be mandatorily certified by competent authorities. Awareness programmes on meat quality and clean meat production should be conducted for the benefit of the consumers.

Organic sheep production

Organic livestock production is another activity which can be encouraged to cater to the niche market of health conscious consumers of meat, milk and eggs. Organic meat and meat products are likely to fetch 30 to 50 percent premium which translates into higher income to the farmers with a very little additional cost in the form of organic certification charges. Even these certification charges can also be done away with if the state organic certification agencies take initiative in this regard.

Supporting Research and Capacity building

As it is imperative to improve the productivity of the animals through breed improvement, feeding, health care and management, liberal funding and priority should be given for focussed research to address these issues. The research efforts of ICAR- CSWRI located in Rajasthan with focus on wool and meat may



not be sufficient to fully address the meat specific requirements of southern states in general and Andhra Pradesh and Telangana in particular. Likewise, research efforts on improving the meat productivity of goats in the eastern parts of the country should also be strengthened. State agricultural and veterinary universities, state animal husbandry departments, ICAR and government of India should establish need based research setups to address the local issues. Research on alternative feeds and feeding methods under controlled rearing systems, development and stabilization of breeds or crosses in sheep with twinning capabilities through breeding or biotechnological methods, standardization and popularization of artificial insemination in sheep and goats are some of the immediate researchable issues along with capacity building of all the stake holders of this sector to increase small ruminant meat production and productivity in the country and also increase the income to the farmers.

(Reference will be available from author)



Session-I - Lead Paper-03

**NATURAL BIOSCAFFOLDS FROM ABATTOIR CO-PRODUCTS:
DEVELOPMENT, CHARACTERISTICS AND APPLICATIONS**

Vasudevan V N

Assistant Professor, Dept of Livestock Products Technology and
Meat Technology Unit, College of Veterinary and Animal Sciences,
KVASU, Mannuthy, Kerala

India has a total livestock population of 512.05 million and poultry population of 729.2 million as per the 19th livestock census 2012 (DAHD,2017).According to various statistics, 107 million livestock and more than 650 million poultry birds were slaughtered annually in India leading to production of 6.3 million tonnes meat. It leaves huge loads of by-products. The load is further increased by dead and fallen animals. The value of unprocessed by-products from buffalo and sheep in India was reported to be quite high. If these by-products are properly utilized, the returns will be almost equal to the value of the meat derived from an animal. Many of the animal byproducts are converted into medicinal/surgical materials which are commercially used in human and veterinary medicine. One such product is the surgical sutures, which are expensive and marketed by commercial firms.

Tissue engineering and regenerative medicine is a rapidly advancing interdisciplinary field that combines the principles of life sciences, materials sciences, and engineering to construct tissue engineered grafts, which are transplanted to the body as replacements for the missing or severely damaged tissues and/or organs (Langer and Vacanti, 1993). A typical tissue engineered graft consists of a scaffold (or called a template) and biochemical cues that are furnished by support cells and growth-stimulating signals (including growth factors, cytokines and chemokines) (Atala *et al.*, 2012). A biomaterial-based scaffold plays a fundamental role in tissue engineering because it provides mechanical property and structural support for cell attachment and tissue development, creates a permissive environment for cell survival, proliferation and differentiation, and eventually promotes tissue regeneration (Hendow *et al.*, 2016).

An ideal scaffold needs to have many specific architectural, mechanical, physicochemical, and biological properties. Firstly, the scaffold should have a porous spongy structure to facilitate cell adhesion and migration and to stimulate angiogenesis and metabolic exchange. Secondly, the scaffold should have a certain shape stability and intrinsic mechanical property that are similar to that of defective tissues. Thirdly, the scaffold needs to be biocompatible to the body and biodegradable with a controllable rate in the body. Fourthly, the scaffold needs to show no or low immunogenicity. Finally, the scaffold needs to be able to include biological and/or physical cues that affect cell phenotype and promote directed cellular regrowth (Chan and Leong, 2008). Extracellular matrices (ECM) developed from mammalian tissues like dermis, pericardium, small intestine and



urinary bladder are used as surgical mesh materials and as scaffolds for regenerative medicine applications. These tissues are harvested from different species including pigs, cows, horses and buffaloes.

Bovine and porcine pericardium

Bovine pericardium (BP)-derived biomaterials, first introduced into clinical practice in bioprosthetic heart valves (Ionescu *et al.*, 1982), are now widely used (Chang *et al.*, 2002). Furthermore, it is used in cardiac and thoracic surgery as a material for repairing intracardiac and diaphragmatic defects (Cunanan *et al.*, 2001). Overcoming the aggressive recipient graft-specific rejection response is critical to utilizing such xenogeneic biomaterials in clinical practice. Although glutaraldehyde fixation prevents hyperacute and acute immune responses towards BP by masking xenoantigens from immediate recognition, persistence of xenoantigens in the biomaterial elicits chronic immune-mediated degeneration and subsequent calcification (Dahmet *et al.*, 1990).

Porcine pericardium can be used in tissue engineering, as a biomaterial for the construction of heart valves, vascular grafts and patches (Bender *et al.*, 1989). It is known, that pericardial tissue acts as a protective barrier of the mammalian heart, containing pericardial fluid, contributing to the physiological function of the heart.

Small intestinal submucosa

Small intestinal submucosa (SIS) has proved considerable regenerative capacity for repair of bowel wall defects at different locations. Small intestinal submucosa (SIS) is a biodegradable, commercially available, acellular, immunologic inert collagen matrix, which is extracted from the submucosal layer of porcine small bowel. SIS remains biologically inert graft material without provoking immune-mediated inflammatory reactions (Allman *et al.*, 2001). In recent years, experimental studies showed considerable success for the use of SIS as a tissue graft in blood vessels, bladder, ureter and tendon (Badylac *et al.*, 1989).

Different experimental studies have been carried out to evaluate SIS in substitution and remodeling of gastrointestinal defects. Biliary duct, small bowel, stomach, and esophagus have been investigated. Rosen *et al.* (2002) reported that SIS promotes the regeneration of native gastrointestinal tissue with normal architecture consisting of mucosa, muscularis, and serosa and also he suggested that SIS can be placed successfully as a patch or as an interposition graft in the canine common bile duct.

Wang *et al.* (2017) in their study demonstrated that the SIS-Mesenchymal Stem Cells scaffold significantly improved pancreatic islet function and islet survival *in vitro* and *in vivo* and explained that the improvement may be associated with the upregulation of insulin expression, the improvement of islet microcirculation and the secretion of cytokines.

Crapo and Wang (2011) demonstrated that SIS gel-based cardiac tissue can be engineered *in vitro* with contractile rates and durations and contractile protein expression comparable to tissue containing Matrigel. Advantages of engineered myocardium based on SIS gel include: (1) the

absence of tumor-derived biomaterials; (2) in vitro contraction rate closer to that of myocardium in vivo; and (3) increased expression of troponin T, a key intracellular protein in the contractile machinery of cardiomyocytes.

A scaffold material composed of porcine small intestinal submucosa was fabricated into a 3-dimensional shape and implanted into a canine model of musculotendinous junction repair (Turner *et al.*, 2010). In this model, the distal third of the gastrocnemius and musculotendinous junction were completely removed and replaced with the ECM implant. The results of this study showed that the implant promoted the formation of vascularized, functionally innervated skeletal muscle that was nearly indistinguishable from native muscle by 6 months post-implantation. These findings have now been translated into a treatment for human patients who have suffered volumetric muscle loss (Maseet *et al.*, 2010)

Cholecyst

Karthika *et al.* (2018) in their study indicated that the cholecyst-derived scaffold (CDS) prepared by a non-detergent/enzymatic method from porcine gall bladder could be used as a wound healing matrix for treating full thickness lacerated wounds in dogs. They explained that cholecystic extracellular matrix has lower load of immunogens than the extracellular matrices of jejunum and urinary bladder. Therefore, a scaffold prepared from porcine cholecystic extracellular matrix is likely to be less immunogenic than those prepared from jejunum and urinary bladder.

Nair *et al.* (2017) prepared abionanocomposite scaffold by modifying a cholecystic extracellular matrix scaffold by conjugating amine-functionalised gold nanoparticles and the biomaterial properties of this novel scaffold were subsequently evaluated. They found that scaffold may be a potential biomaterial for cardiac tissue repair.

Suvaneeth *et al.* (2018) studied about Gross and histopathologic changes of porcine cholecyst assisted full thickness skin wound healing in rabbits. They found that the graft assisted healing technique, as a whole, appeared more visually acceptable and the gross observations itself were vital evidences of improved healing compared to open wound. Graft assisted wounds were devoid of inflammation, seroma formation and ulcerations, suggesting better acceptance of the scaffold in vivo.

Porcine skin and adipose tissue

Porcine skin is the most common source of xenograft skin because of its similarity to human skin. Of the non-primate species, porcine dermis is probably the most structurally and immunologically similar to human dermis (Srivastava *et al.*, 1999). There exists the potential for cross-species transmission of pathogens, especially Mmes and prions, when xenografts are used. Xenograft dermis can be treated with ionizing radiation, freeze-dried or soaked in glycerin for sterilization (Berthod and Rouabhia, 1997). Pig skin can be used to adress second degree burns, especially after early excision (Gao *et al.*, 1992). In addition, pig skin provides a suitable overlay to cover widely meshed (1:8 to 1:12) autografts.



The decellularized ECM derived from porcine adipose tissue could serve as a xenogeneic biomaterial and has a great potential for use in regenerative medicine. Decellularized xenogeneic ECM provided a suitable substrate for the adhesion and proliferation of human cells *in vitro* and also showed potential as a biocompatible material for *in vivo* tissue reconstruction (Choi *et al.*, 2012).

Collagen dressings formulated from bovine, porcine, or avian sources are recommended for the treatment of partial-thickness and full-thickness wounds with minimal-to-moderate exudation, but contraindicated for third-degree skin burns (Ruszczak, 2003). Pigs have the most similarities to human skin in that it is firmly attached, has sparse hair follicle distribution, has similar epidermal and dermal thickness, and heals through the process of re-epithelialization (Summerfield *et al.*, 2015). On top of these structural and wound healing similarities, porcine skin also has a similar blood supply and immunological function.

Pig skin-derived ECM gel composed of various ECM components was developed and tested as an efficient filler for wound treatment and found that this gel together with human peripheral blood cells can effectively promote the neovascularization and collagen deposition due to compositional properties, leading to improved wound healing (Kuna *et al.*, 2017). Permacol Surgical Implant is a decellularized porcine dermal layer containing collagen and elastin fibres. Material is cross-linked with diisocyanate by a patented technology. It is used mainly for abdominal wall hernia reconstruction (Parker *et al.*, 2006).

EZ Derm is a reconstituted collagen of porcine origin which is cross-linked with aldehyde to increase its tensile strength. The product does not incorporate into the wound and has to be removed (Bello *et al.*, 2001). It is therefore marketed as a bioactive wound dressing.

Bladder submucosa / acellular urinary bladder matrix

The most used decellularized natural matrices in urology are derived from the bladder tissue or small intestinal submucosa (Brehmer *et al.*, 2007). A successful regeneration of a mouse bladder by implanting a decellularized bladder matrix scaffold impregnated with fibroblast growth factor was obtained (Kanematsu *et al.*, 2003). A number of human studies have used cadaveric bladder submucosa: 2 studies in patients with urethral stricture and one in hypospadias (El-Kassaby *et al.*, 2003). In a comparative study of 30 patients with urethral stricture, bladder submucosa graft was as successful as buccal mucosa in patients with a healthy urethral bed, no spongiofibrosis, and good urethral mucosa (El-Kassaby *et al.*, 2008).

The study performed on beagle dogs compared the effects of the use of allogeneic acellular matrices obtained from bladder submucosa that were seeded with urothelial and muscle cells obtained from the cystotomy material of five beagle dogs with the unseeded matrices of the same origin. Fluoroscopic and urodynamic tests performed after 2–3 months showed normal bladders and adequate compliance in all cases (Oberpenning *et al.*, 1999).

In one study, a heterologous and homologous bladder acellular matrix graft and the influence of collagen ratio on the regeneration of function in a dog model was compared. The homologous



graft led to more complete regeneration, whereas collagen seemed not to be replaced in the heterologous model, but changed over time. It is possible that the ratio of collagen types seemed to influence smooth muscle regeneration (Sievert *et al.*, 2006).

Eweida *et al.* (2011) showed positive effects of a urinary bladder matrix (UBM) seeded with keratinocytes in wound healing in the urinary bladder. In the study performed in beagle dogs, keratinocytes seeded on the UBM were transplanted into the urinary bladder of the dogs with full-thickness excision wounds. The positive effects of this treatment on preventing early wound contraction and promoting vasculogenesis were reported.

Remlinger *et al.*, (2013) reported that Urinary Bladder Matrix (UBM) scaffolds may provide a more viable option for myocardial reconstruction than a scaffold derived from a cardiac location. The ability for the UBM patches to completely and rapidly degrade, while being replaced with newly formed site-appropriate tissue is a significant finding.

Omentum

The omentum is a double sheet of peritoneum that extends from the greater curvature of the stomach overlying most abdominal organs. This tissue is highly vascularized and its fibrillar ECM is rich with collagens, adhesive proteins and GAGs. Since GAGs bind a variety of protein ligands, they can serve as growth factor depots and regulate a wide variety of biological activities, including developmental processes, angiogenesis, and cardioprotection. Due to its unique composition, the omentum also serves as a depot for adult stem cells with regenerative potential. These stem cells are based in the omentum matrix and upon signals migrate to heal injured organs. The overall regenerative capacity of the omentum, its ability to maintain progenitor cell viability, absorb large amounts of edema fluids and limit the formation of scar tissue at the site of injury, has long been demonstrated. Collins *et al.* (2009) reported that omentum was frequently been used as a peduncled or free flap because of its antigenic and regenerative properties. It was used to cover colonic or colorectal, esophageal or esophagogastric and tracheal or bronchial anastomosis, to manage perforated gastric or duodenal ulcers and to control bleeding in hepatectomy or pancreatico-deodenectomy.

Yang *et al.* (2009) described methods for defatting omentum and the process for preparing decellularized omentum for implantation into mammalian system. Decellularization protocols involved physical, chemical or biological methods. Physical methods included direct pressure, agitation, sonication or snap freezing. Chemical agents included hypotonic and hypertonic solutions, acids and bases, detergents and alcohols. Enzymes usually employed in decellularization were nucleases, collagenase, trypsin and lipase. Non enzymatic agents were ETA and EGTA.

According to dos Santos Costa *et al.* (2010), the greater omentum has been employed in various surgical procedures due to its rich vascularity with high capacity for absorption, pronounced angiogenicity supporting ischemic or hypoxic tissues, ability to adhere to local tissues, innate immune function, and high concentration of growth factors and factors promoting hemostasis. Brown *et al.* (2011) suggested that the allogenic omentum obtained from both living and deceased donors

were used as a decellularized biological scaffold or a further step was tried by in vitro recellularization with seeding of autologous adipose derived stem cells for soft tissue reconstruction.

Shadmaniet *al.*, (2014) concluded that transportation of omental pedicle was effective on the healing process of an injured eye in an animal model of severe ocular surface alkaline burn. Thajunnisa (2018) reported that decellularized omentum was effective in early epithelialization of the corneal ulcers in canines as an extracellular graft.

Steps in the processing of acellular matrices

Decellularization

The process is carried out to make the scaffolds free of any cellular and nuclear material as the same can elicit adverse immune reaction in the recipient. Various methods and agents are used to achieve cell removal, which are briefly outlined below.

Acids and bases

Acids and bases cause hydrolytic degradation of biomolecules. Peracetic acid is a common disinfectant that doubles as a decellularization agent by removing residual nucleic acids with minimal effect on the extracellular matrix composition and structure. Bases like calcium hydroxide, sodium sulphide and sodium hydroxide are commonly used to remove hairs from the dermis during early stages of decellularization, but they completely eliminate growth factors from the matrix and decrease mechanical strength. Hypotonic and hypertonic saline solutions can readily cause cell lysis by simple osmotic effects with minimal changes in the matrix molecules and architecture.

Detergents

Ionic, non-ionic and zwitterionic detergents solubilise cell membrane and dissociate DNA from proteins, and thus are effective in removing cellular material from biological tissues. However they also disrupt and dissociate proteins from the ECM. TritonX-100 can effectively remove from thicker tissues such as valves where enzymatic and osmotic methods are insufficient. Sodium dodecyl sulfate (SDS) appears more effective than Triton X-100 for removing nuclei from dense tissues and organs such as the kidney and temporomandibular joint while preserving tissue mechanics. The addition of a detergent such as SDS to a decellularization protocol can make the difference between complete and incomplete cell nuclei removal but has the associated drawback of ultrastructure disruption and growth factor elimination (Yang *et al.*, 2010). SDS is typically more effective for removing cell residues from tissues compared to other detergents but is also more disruptive to ECM.

Biologic agents

Enzymes reported in tissue decellularization protocols include nucleases, trypsin, collagenase, lipase, dispase, thermolysin, and α -galactosidase. Enzymes can provide high specificity for removal of cell residues or undesirable ECM constituents. However, complete cell removal by enzymatic treatment alone is difficult and enzyme residues may impair recellularization or evoke an

adverse immune response. Removal of cells and ECM constituents by trypsin is time-dependent, and complete decellularization by trypsin alone may require lengthy incubation even for thinner tissues such as valve leaflets. Trypsin can be used effectively to disrupt tissue ultrastructure and improve penetration of subsequent decellularization agents; therefore, exposure to trypsin as the initial step in a tissue decellularization protocol may be desirable or even necessary, particularly for complete removal of cell nuclei from dense tissues. Chelating agents such as ethylenediaminetetraacetic acid (EDTA) and ethylene glycol tetraacetic acid (EGTA) aid in cell dissociation from ECM proteins by sequestering metal ions. It is likely that chelating agents contribute to subtle disruptions in protein-protein interactions by the same mechanism. Chelating agents alone are insufficient for superficial cell removal even with agitation, and they are therefore typically used in combination with enzymes like trypsin.

Assessing the efficiency of decellularization

Residual cellular material within scaffold may contribute to cytocompatibility problems in vitro and adverse host responses in vivo upon reintroduction of cells. Although decellularization techniques cannot remove 100% of cell material, it is possible to quantitatively assay cell components such as double-stranded DNA (dsDNA), mitochondria, or membrane-associated molecules such as phospholipids. The threshold concentration of residual cellular material within matrix sufficient to elicit a negative remodeling response has not been investigated in detail and may vary depending upon matrix source, tissue type into which the matrix is implanted, and host immune function.

The following minimal criteria suffice to satisfy the intent of decellularization:

- < 50 ng dsDNA per mg matrix dry weight
- < 200 bp DNA fragment length (Nagata *et al.*, 2010)
- lack of visible nuclear material in tissue sections stained with 4',6-diamidino-2-phenylindole (DAPI) or H&E

Crosslinking methods

- Employed to control the mechanical strength and rate of degradation
- Less important for acellular matrices as the collagen is already crosslinked
 - Physical methods
 - UV irradiation
 - Increases the enzymatic resistance
 - Effective only for thin transparent scaffolds
 - Chemical techniques
 - Glutaraldehyde
 - Carbodiimide family



- Isocyanate family
 - Hexamethylene diisocyanate
- All the chemicals leave potentially cytotoxic residues
- Enzymatic cross-linking
 - Transglutaminases

Sterilization of scaffolds

It is necessary to sterilize biologic scaffolds composed of ECM prior to implantation or in vitro use, including depyrogenation to eliminate endotoxins and intact viral and bacterial DNA that may be present (Crapo *et al.*, 2011). Biological scaffolds may be sterilized by simple treatments such as incubation in acids or solvents, but such methods may not provide sufficient penetration or may damage key matrix constituents. However, sterilization methods such as ethylene oxide exposure, gamma irradiation, and electron beam irradiation are known to alter scaffold ultrastructure and mechanical properties, including properties of clinical products composed of acellular matrix. Of these, ethylene oxide may substantially change scaffold mechanical properties or leave them unaltered, and ethylene oxide treatment can cause undesirable host immune responses that impair proper function of the biologic scaffold after implantation. Matrix degradation during irradiation is at least partially attributed to denaturation of key structural proteins such as collagen, a process which cannot be mitigated by exposure rate and occurs even at relatively low doses. Gamma irradiation causes residual lipids to become cytotoxic and accelerates enzymatic degradation of scaffold.

Conclusions

Fatal burn injuries and other traumatic wounds are significant in developing countries. Conventionally treated third degree skin wounds (using split-thickness skin grafts; autologous or allogenic) result in contraction, scarring, reduced functionality, and deterioration in quality of life. Acellular scaffolds can minimize scarring, but the materials currently available are expensive and less affordable to the people of the developing world. Abattoir co-products can serve as valuable raw materials for acellular matrices and more investment in infrastructure and research is needed for the development of affordable dermal substitutes from these raw materials.

(Reference will be available from author)



Session-I - Lead Paper-04

GRADING AND QUALITY OF MEAT IN DOMESTIC MARKET

R. Narendra Babu

Professor, Department of Livestock Products Technology (Meat Science)
Madras Veterinary College, Chennai

Agriculture and Animal Husbandry are the important sectors of Indian economy. It contributes about 14% to the GDP of India and 11% of its total exports. Food security has been the fundamental concern of the mankind over the millennia. Food and Agriculture Organisation reported that about 1.3 billion tons of food are globally wasted or lost per year. A reduction in these losses would improve food security by increasing the real income of all the consumers. During past 30 years 95% of the research investments focused on increasing productivity and 5% directed towards reducing losses. Meat production has not received adequate attention by the entrepreneurs, policy makers, scientists, politicians although it is linked with economic condition of poor farmers and backward communities. The major constraints being faced by the meat industry are lack of scientific approach to rearing of meat animals, unorganized nature of meat production and marketing, inadequate infrastructure facilities and poor post-harvest management.

Meat consumption practices vary based on geographical disposition, availability of animals, religious practices, and rituals and customs of the population. Pork has been the most widely consumed kind of meat globally. The most commonly consumed meat in the world include beef, pork, chicken meat, mutton, chevon and those from sea food. In our country, there is increased demand for chicken, mutton, chevon, followed by beef and pork. Even beef production in our country is more, major portion is being exported.

As the meat consumption pattern differs Animal husbandry practices, slaughter, processing and meat distribution to the consumers also differ from country to country. Indian consumers till date they are preferring pre-rigor meat, so the concept of centralized meat production, processing and distribution of chilled/ frozen packed meat to consumer is not possible. It is not justifiable to evaluate and grade our Indian animals as being practiced in other countries. So to improve the quality of domestic meat, it is must for us to understand the means of animal husbandry activities, how the livestock products reach the consumers first and develop suitable means of assessing the quality for domestic meat.

Quality and Post Harvest Technology

Quality is the standard of something as measured against other things of a similar kind; the degree of excellence of something. Meat quality is normally defined by the compositional quality (lean to fat ratio) and the palatability factors such as visual appearance, smell, firmness, juiciness, tenderness, and flavour. The nutritional quality of meat is objective yet "eating" quality, as perceived by the consumer, is highly subjective.

Information on the extent of the losses during post harvest operations is important to the scientists and policymakers to work out research programmes and strategies to curtail these losses and to help ensuring food security. The annual value of post harvest losses in India during the year 2013-14 has increased three fold when compared to 2005-06, which was about Rs 92,651 crore. The loss in livestock produce was about Rs 18,987 crore. The post harvest loss in meat sector was estimated to be 2.71%, in which 1.9% is during farm operations and 0.72% during storage and preservation.

Post-harvest losses are the measurable quantitative and qualitative loss of a specific food product after harvest. Quantitative losses include decreased weight or volume, due to poor handling, whereas qualitative losses include adversely altered physical condition or characteristics, such as undesirable color changes and reduced nutrient value. Hence post-harvest loss includes natural shrinkage (e.g., moisture loss), loss from



mold, pests or inadequate climate control and food waste. Post harvest losses could occur anywhere in the post-harvest chain of interconnected phases or associated activities, from the time of harvest on the farm all the way through the food manufacturing, processing, marketing (e.g., retail) and consumption chain to the final decision by the consumer to eat or discard the food..

Meat production potential

The total meat production in India accounted to about 7.4 million tonnes in 2016-17. (India agristat, 2018). Poultry is one of the fastest growing segments among the components of agricultural sector in India. The broiler meat production in India is around 3,725 thousand metric tonnes (USDA 2015) and the contribution of Southern states in total meat production of India is significant (DAH&D, 2012). Tamil Nadu stands second in poultry meat production of India with 350 thousand MT just behind Andhra Pradesh (2012-13).

India ranks 2nd in goat population and also ranks 2nd in chevon production (next to China). India has about 5% of world sheep population and ranks third in the world. Mutton and Lamb meat together contribute 4% (203,000 MT) of total meat production in India and ranks 4th in mutton production (next to China, Australia and New Zealand).

India is the largest exporter of sheep and goat meat to the world. Apart from export, mutton and chevon is consumed by most of the sections of society without any religious and social taboos hence; it serves as a main source of red meat in the country.

During the period 2007 to 2012 the pig population in the country had decreased by 7.54% over the previous census. Though pork consumption has religious taboos in India, the population of exotic breeds (2.4 millions) has increased by 2.8% whereas, the population of indigenous breeds (7.8 millions) has decreased by 10.3% to the total pig population (Ministry of Agriculture, Department of Animal Husbandry, Dairying & Fisheries, 2014).

Present scenario of domestic meat market

Today's poultry industry is characterized by vertical integration (also known as contract farming) whereby a single company controls the breeding, hatching and processing of broilers but contracts with private poultry farmers for raising of chicks. The increase in integration system of rearing broiler chickens at different geographical locations has made it imperative to transport these birds from the farms to the market over a distance of approximately 200-300 kms. Mostly the birds are handled by the wholesalers, shifting the birds from the farm and distributing them to retailers.

The producers/farmers involvement in the supply of sheep and goats to the slaughter house is very low. Most of the animals are mainly handled by the middle man so, the malpractice is begun with supplying low quality and low graded animals for slaughter. The animals in lesser age, older age and low meat quality are forced to procure by the middle men to the retailers. The major economic issue in the Indian sheep and goat meat industry is the loss during transit of live animals to slaughter house in terms of weight, injuries and mortality from the geographically separated rearing area to the slaughter points. After slaughter, the carcasses are transported to the retail outlets in unrefrigerated vehicles from the slaughter houses.

Presently, the pig meat industry is in an unorganized form. Pork production in India is limited, representing only 7% of the country's animal protein sources. Indian pork consumption can be divided into two segments: The vast majority takes place in the informal sector in the form of locally raised fresh pork meat. This meat is not widely distributed in the organized retail sector. The second segment of the pork

market deals with high-value imported products. These products include cured meats such as sausages, ham, bacon and canned meat products, as well as small quantities of frozen meat. They are typically found in most leading Indian hotels catering to international business travellers and tourists.

The middlemen play a major role in marketing, pricing of such animals/ birds with their own system of animal evaluation, which is biased and the producers could not get the price they deserve. Indirect involvement of farmers and domination of middle man in the slaughter activities hinder the development of grading system for our animals/carcasses.

In addition, after slaughter to enable easy handling, processing and distribution, the carcasses are cut into retail cuts without proper infrastructure, leading to evaporative loss and quality deterioration of meat at retail outlet. Due to lack of awareness among the consumers about the chilled and processed meat, there is a high demand for fresh meat through wet market. The present day wet market is leading to huge economic loss by under utilisation of the leftover meat and by- products, in turn increasing the post harvest losses.

Indirect involvement of farmers and domination of middle man in the slaughter activities hinders the development of grading system for our animals/carcasses. So the grading system prescribed by BIS follows in the line with USDA grading system. But this system cannot be adapted for marketing animals and carcasses in India as well as for export.

Pilot study to understand the post harvest losses and Quality deterioration in domestic meat Chicken:

A study was carried out to assess the post-harvest losses during marketing chicken in Chennai by documenting the present day practices followed from lifting the birds in the farms till the carcass / meat reached the consumer through wholesale / retail outlets in both winter and summer season. Twenty four trips each twelve in winter and summer season were made for documenting the present study. During transportation (about 250 km) number of birds, weight of birds, live weight loss, mortality per centage, total weight loss, tissue shrinkage, injury, time consumption for transport, and weight loss per bird were recorded. In retail outlet, the practices followed was documented and the time taken to sell the bird after slaughter, the weight loss in carcass / meat and the microbial quality of the carcasses were evaluated at different time interval up to 6 hours. The most of the carcasses in retail outlet were sold within six hours after slaughter. In simulation study, six trials were carried out as in the retail chicken shop in each season in the Department of Livestock Products Technology (Meat Science), Madras Veterinary College, Chennai. Chickens were slaughtered by standard procedure and fifteen carcasses were kept under different conditions in each trial viz., room temperature, display cabinet (0-4°C) packed ice and ice bank tank (khan chicken centre, Perambur, Chennai-11). During storage the meat sample was assessed for loss in weight, Extract Release Volume (ERV), and Microbial quality (Total Viable Count)

The observations and the results are presented in the tables.

Weight loss in birds during transportation from farm to wholesale / retail outlet

Season	Weight of (kg) of live birds in truck				Per cent weight loss (%)				Weight loss per bird(%)
	At loading	At unloading	DOA	Excreta	After unloading	DOA	Tissue shrinkage	Total weight loss	
Winter (N = 12)	4434.37	4329.75	18.26	7.34	2.36	0.43	0.25	2.77	2.75
Summer (N = 12)	4431.39	4296.12	23.76	8.20	3.01	0.53	0.33	3.53	3.60

N= number of trips

Weight loss in chicken carcasses kept at ambient temperature in retail outlet (n=30)

Retail outlet	WINTER	SUMMER
	Weight loss in percentage	Weight loss in percentage
30 min	2.82	3.03
1 hr	4.12	4.58
2 hr	5.46	6.07
4 hr	6.74	7.55
6 hr	8.16	9.09

Weight loss / gain (kg) of chicken carcasses after slaughter under different storage conditions at different intervals (n=30)

	Weight loss (%) in Room temperature	Weight loss (%) in Display cabinet	Weight loss (%) in Ice box	Weight gain (%) in Ice bank tank
0 hour	-	-	-	-
30 mins	2.70	2.42	2.73	1.91
1 hr	4.16	2.65	2.66	6.83
2 hr	5.31	2.70	2.64	11.63
4hr	6.90	2.55	2.37	-
6 hr	8.47	2.36	2.11	-

Weight loss of chicken carcass in simulation study

The per cent loss of weight in carcasses from the time of slaughter to 6 hours of storage ranged from 2.7 to 8.47 in room temperature, 2.36 to 2.42 in display cabinet and from 2.11 to 2.73 in ice box. However an increase in per cent weight was observed in carcasses stored in ice bank tank for two hours (1.91 to 11.63 %)

The significant decrease in carcass weight at room temperature may be attributed to loss of surface moisture due to evaporation on exposure to external environment. However, carcasses in ice bank tank gained weight due to absorption of water when they are immersed in cold water.

It is recommended that if ice bank tank or ice box method of storage is adopted for distribution of meat at retail outlets, the quality of water used for preparation of ice should be potable with lower microbial and chemical load.

Retail outlet

TVC of chicken carcasses ranged from 4.67 to 6.86 log cfu/g of meat at 0 and 6 hours respectively at ambient temperature. High levels of bacterial cross-contamination in the retail outlets may occur especially during defeathering and water chilling, with intestinal contamination apparently being the only source. However, these levels may also increase during evisceration of the carcasses, washing and processing due to contamination by personnel.

Weight loss in retail outlet at ambient temperature

Weight loss was observed in chicken carcasses at ambient temperature in retail outlet both during winter and summer season. The weight loss during summer was comparatively higher than winter and irrespective of seasons with the increase in time between slaughter and sale the loss of weight in the carcasses also increased. This increase in weight loss during summer may be attributed to higher environmental temperature to which the carcasses are exposed resulting in higher evaporative losses.

SHEEP AND GOATS

A study was carried out to assess the post harvest losses in marketing of sheep and goats by documenting the present day practices followed from purchasing of the animals in the shandies till the carcass/ meat reaches the consumer through retail outlets in both winter and summer season. A total of twenty four trips each twelve during short distance (<20kms) and long distance (>150 kms) were made for documenting the present study. During transportation the following observations including the number of animals, weight of animals, live weight loss (tissue shrinkage), mortality percentage, total weight loss, time consumption for transport, and weight loss per animal were recorded.

The major observation which might be the factor responsible for the non significance was that smearing of animal tongue and lips with salt, so that it takes more water or forceful administration of water into the animal's mouth.

In case of sheep and goats, a total of 24 trips were made, in which 12 were short distance (<20kms) and 12 were long distance (>150kms) from the shandies to slaughter house and retail outlet to document various parameters pertaining to various practices followed at shandies, slaughter house, retail outlet and samples were collected from retail outlet to assess the physicochemical characteristics and microbial quality of meat. Simulation work was carried out in the department of Livestock Products Technology (Meat Science), Madras Veterinary College, Chennai.

The most of the carcasses in retail outlet were sold within six hours after displaying in the retail outlets.

In addition six simulation trials were carried out in the Department of Livestock Products Technology (Meat Science), Madras Veterinary College, Chennai. Carcass cuts of the animal were purchased from wholesaler in a slaughter house and transported to the department hygienically and were maintained under four different conditions viz., room temperature (simulating the retail outlet), in chiller, in display cabinet (0-4°C) and in thermocol boxes with packed ice. The samples were stored under these condition for a period of 8 hours and samples were drawn at 30 minutes, 1, 2, 4,6 and 8 hours and were assessed for change in weight, Extract Release Volume (ERV) and Microbial quality (Total Viable Count).

Weight loss in animals during long distance transportation from shandies to slaughter house

Season	Weight of live animals (kg)			Per cent weight loss	
	At loading	At unloading	DOA	Live animals	Excreta
Winter (N = 6)	8286.66	8033.41	3.54	2.90	0.11
Summer (N = 6)	7743.33	7497.08	3.32	3.05	0.13

Weight loss in sheep and goat carcass kept at ambient temperature in retail outlet (n=15)

Retail outlet	Weight loss in percentage	
	Winter	Summer
30 min	1.08	1.17
1 hr	1.64	1.75
2 hr	2.43	2.62
4 hr	3.35	3.67

Weight loss (kg) of sheep and goat carcass cuts after slaughter under different storage conditions at different intervals (n=6)

	Weight loss (%) in Room temperature	Weight loss (%) in Chiller	Weight loss (%) in Display cabinet	Weight loss (%) in Ice box
0 hour	-	-	--	-
30 mins	1.66	1.68	1.59	1.64
1 hr	3.05	2.81	2.52	2.67
2hr	4.25	3.80	3.14	3.55
4hr	4.97	4.31	3.45	3.91
6 hr	5.70	4.84	3.76	4.27
8 hr	6.37	5.08	3.83	4.58

Quality of domestic meat

Extract Release Volume (ERV) (ml) of chicken carcasses stored at different storage conditions (N=30)

	Room temperature	Display cabinet	Ice box	Ice bank tank
0 hr	39.17	39.83	38.50	35.00
30 min	33.00	35.50	31.50	31.67
1hr	25.50	28.50	26.83	27.83
2 hr	22.00	25.83	22.50	24.67
4 hr	17.33	23.17	20.50	-
6 hr	13.67	20.67	18.67	-

Total viable count (log cfu per g) values of chicken carcasses stored at different environment temperature conditions (n=30)

	Room temperature	Display cabinet	Ice box	Ice bank tank
0 hr	3.21	3.38	3.29	3.41
30 min	5.19	4.68	4.72	4.8
1hr	5.35	4.72	4.75	4.81
2 hr	5.79	4.82	4.90	4.93
4 hr	6.21	4.90	5.03	-
6 hr	7.19	5.24	6.10	-

Extract Release Volume and Total Viable Count of chicken carcasses in retail outlet at ambient temperature (24.3 °C – 28.2 °C) during winter (21.6 °C – 29.2 °C) and summer (26.03 °C – 34.5 °C) season (N=30)

	WINTER		SUMMER	
	ERV (ml)	TVC (log cfu per g)	ERV (ml)	TVC (log cfu per g)
30 min	25.13	4.67	22.13	4.82
1hr	22.33	4.92	20.99	4.83
2 hr	20.72	5.13	20.61	5.24
4 hr	17.43	5.21	17.62	5.70
6 hr	14.94	6.86	12.16	7.13

Extract release volume (ml)

Extract release volume as a rapid test for detecting spoilage in meat and opined that a mean ERV values of 24.6 ml correlated with log 8 bacterial number/ gram and concluded that ERV value of 25 ml was supported as a divider between acceptable and unacceptable.

A rapid decrease in ERV was observed at room temperature followed by ice box storage, whereas ERV values were similar in ice bank and display cabinet stored carcasses. The decrease in ERV values at room temperature below 21 ml at 4 hours of storage could be due to exposure of meat surface to bacterial contamination, whereas carcasses stored under controlled environment had better ERV due to the preservative effect of low temperature since it extends the lag phase of microbes.

Total viable count

Total viable count (TVC) of carcasses increased with increase in storage period and higher counts were observed at room temperature followed by ice box, ice bank and display cabinet. Total viable count significantly increased during longer storage period and the samples stored at room temperature revealed significantly higher counts compared to meat stored at refrigerated conditions.

The first indication of spoilage in fresh chicken meat was the production of off-odours, which become apparent when microbial numbers reaches to 10^7 CFU per cm^2 . In the present study the TVC of carcasses stored at room temperature only exceeded the limit of log 7 only at 6 hours of storage. The microbial quality was superior in carcasses stored in display cabinet followed by ice bank tank and ice box. The reduced microbial load may be attributed to lower temperature which delayed the multiplication of microorganisms.

Sheep and goats

Samples were collected from retail outlet to assess the physicochemical characteristics and microbial quality of meat. Simulation work was carried out in the department of Livestock Products Technology (Meat Science), Madras Veterinary College, Chennai.

The current practices prevailing in marketing of carcasses at the retail outlets to the consumers including the waste generated were also documented.

Six trials of simulation work were carried out in the Department of Livestock Products Technology (Meat Science), Madras Veterinary College, Chennai. Carcass cuts of the animal were purchased from wholesaler in a slaughter house and transported to the department hygienically and were maintained under four different conditions viz., room temperature (simulating the retail outlet), in chiller, in display cabinet (0-

4°C) and in thermocol boxes with packed ice. The samples were stored under these condition for a period of 8 hours and samples were drawn at 30 minutes, 1, 2, 4,6 and 8 hours and were assessed for change in weight, Extract Release Volume (ERV) and Microbial quality (Total Viable Count).

Extract Release Volume, Total Viable Count (TVC) of sheep and goat carcass in retail outlet at ambient temperature during summer and winter season (N=12)

	WINTER		SUMMER	
	ERV (ml)	TVC (log cfu per g)	ERV (ml)	TVC (log cfu per g)
30 min	39.08	4.62	38.12	4.75
1hr	32.83	4.92	31.62	5.08
2 hr	28.04	5.32	27.33	5.54
4 hr	23.50	5.71	22.12	5.91
6 hr	19.70	6.34	18.16	6.61

Extract Release Volume (ml) of sheep and goat carcass cuts stored at different storage conditions (n=6)

	Room temperature	Chiller	Display cabinet	Ice box
30 min	39.91	40.83	40.33	39.75
1 hr	31.75	36.00	34.66	33.41
2 hr	26.33	32.25	30.50	28.33
4 hr	22.33	27.50	26.83	24.83
6 hr	20.66	25.58	24.58	23.00
8 hr	17.58	24.08	22.75	21.00

Total viable count (log cfu per g) values of carcass cuts stored at different environment temperature conditions (n=6)

	Room temperature	Chiller	Display cabinet	Ice box
30 min	2.82	2.83	2.84	2.84
1 hr	4.24	3.74	3.83	3.88
2 hr	4.84	4.23	4.27	4.30
4 hr	5.31	4.41	4.57	4.65
6 hr	5.74	4.82	4.92	4.98
8 hr	6.22	5.14	5.22	5.57

Due to lack of scientific processing

Cost and Economic loss involved in transport of sheep and goats from shandies to slaughter house

	Short distance (N=12) (Rs)	Long distance (N=12) (Rs)
Average Transport cost per animal	10.64	69.96
Average Transport cost per kg	0.68	3.29
Average loss due to mortality of animals	-	135.61
Average loss due to transport of animals	9.36	836.60

Economic loss in retail outlet of processing of chicken carcasses during winter and summer season

Time interval	WINTER		SUMMER	
	Weight loss per bird (g)	Cost of weight loss per bird (Rs)	Weight loss per bird (g)	Cost of weight loss per bird (Rs)
30 minutes	41	4.84	46	5.88
1 hour	61	7.90	69	8.83
2 hour	81	9.55	92	11.77
4 hour	100	11.8	114	14.59
6 hour	121	14.28	137	17.53

Economic loss in retail outlet of processing of sheep and goat carcass during winter and summer season

Time interval	WINTER		SUMMER	
	Weight loss per carcass (g)	Cost of weight loss per carcass (Rs)	Weight loss per carcass (g)	Cost of weight loss per carcass (Rs)
30 minutes	94	47.00	100	50.00
1 hour	142	71.00	148	74.00
2 hour	210	105.00	221	110.50
4 hour	290	145.00	310	155.00

Economic loss during storage of sheep and goat carcass cuts at different storage conditions

Time interval	Room temperature	Chiller	Display cabinet	Ice box
	Economic loss per carcass cut (Rs)	Economic loss per carcass cut (Rs)	Economic loss per carcass cut (Rs)	Economic loss per carcass cut (Rs)
30 minutes	9.50	9.50	9.00	9.00
1 hour	17.50	16.00	14.00	14.50
2 hour	23.00	20.50	17.00	18.50
4 hour	28.00	24.25	19.00	21.00
6 hour	32.25	27.25	20.75	23.00
8 hour	35.75	28.25	22.00	24.50

Economic loss in storage of chicken carcasses at different storage conditions

It was evident from the observation of the present study that the economic loss (Rs) to the processor due to loss of weight in chicken carcasses stored at different condition viz., room temperature, display cabinet, thermocol ice box (packed ice) ranged from Rs. 4.13 to 4.48 at 30 minutes, 4.01 to 6.96 at one hour, 3.89 to 8.96 at 2 hours, 3.54 to 11.56 at four hours and 3.18 to 14.16 at 6 hours. The trend clearly indicates that economic losses due to loss of weight can be minimized by adopting either placing the carcasses immediately after slaughter in display cabinet or ice box as compared to room temperature.



However, in carcasses stored in ice bank tank there was a gain in weight resulting in profits in the range of Rs. 3.54 to 21.71 during different times of storage. This increase in weight could be due to absorption of water by the carcasses during chilling. Carcasses chilled by water immersion gained about 11.5 per cent of its original weight.

Transport charges of birds:

The cost of transportation was calculated taking to consideration the charges for food, refreshment, loading, toll fee (for vehicle), fuel charges and wages for driver, loadman per trip, salary for driver and miscellaneous cost. In total the charges incurred for transportation for one kg of bird during summer and winter was Rs. 1.96 and 1.78 respectively.

The cost of transportation is one of the major factors that determine the cost of meat at the domestic market. Hence, establishment of central processing units near the production area in near future may pave way for better regulation of market price of chicken meat round the year.

POINTS TO BE CONSIDERED TO MINIMISE POST- HARVEST LOSSES AND IMPROVE QUALITY OF DOMESTIC MEAT

1. The current practices adopted by the processors for transport of birds from farms to wholesale / retail outlets have been found to cause losses in weight as well as injuries. This can be effectively reduced by either setting up of central processing facilities near the major production sites or by proper designing of crates and vehicle so as to minimize losses and increase profitability.
2. Major economic losses to the processors have been documented at the processing site. Hence, it is recommended that carcasses instead of being held at ambient temperature may be stored under chilled condition before distribution.
3. Display cabinet, Ice bank tank and ice box storage of carcasses have been found to be efficient in maintaining the quality of carcasses and at the same time with minimal losses. However, if ice bank tank or ice box method of storage is adopted for distribution of meat at retail outlets, the quality of water used for preparation of ice/chilling should be of good quality, potable with lower microbial and chemical load

If the above suggestions are adopted it will pave way for establishing uniform market price for chicken, mutton and chevon round the year.

In addition to the above, evolving a grading system suitable to our animals is more important in improving the quality of domestic meat. As an initiative, a study has been carried over to grade ,sheep, goats and pigs and their carcasses in Tamil Nadu.

A pilot study was carried out to evolve a suitable live and carcass grading system for Indian goats (*Capra hircus*) and Indian sheep (*Ovis aries*) by documenting the present day condition and practices followed in slaughter houses in Tamil Nadu. A total of 8 district corporations/municipal slaughter houses, were visited for a period of 5 months for documenting the present study. In live animal data collection the following parameters which influence the marketing of goat, viz. age, sex, breed, weight, size (frame), muscling, shape, body length (BDL), hip width (Pin Bone width) (HW), height at withers (HAW), chest girth and fore cannon bone length (CB) were recorded and in carcass data collection the following parameters which influence the quality of carcass, viz. live weight, carcass weight, carcass length, dressing percentage,

colour, fat thickness (12th rib), rib eye area , body wall thickness, marbling, maturity, muscling, leg score, kidney fat, pelvic fat, heart fat and flank streaking were recorded.

Goats

In present study 1893 goats and 533 carcasses data were collected from slaughter houses of 8 different districts of Tamil Nadu. Most of the goats slaughtered were of Salem black, Kanni breeds and Non-descriptive which were less than 1-year age with average body weight of 14-15 Kg and carcasses weight was 6-7 Kg with dressing percentage of 44.6 %.

Based on the observations different grades were evolved for live animals namely grades G-1 (6-15 months), G-2 (15-24 months), G-3 (25-36 months) and G-4 (Above 36 months) which denotes that grade G-1 has the ideal age for good meat yield and the other age groups are not having that much quality meat because of the age, G-2, G-3, and fourth one is very old animal so this meat was low quality and being tougher, very young below six months and above 42 months were not considered for grading.

GRADES EVOLVED FOR LIVE GOATS

Parameters	Grades			
	G-1	G-2	G-3	G-4
Age (months)	6-15	15-24	25-36	Above 36
Weight (kg)	15-20	18-24	20-25	Above 25
Muscling	Heavy	Heavy	Average to heavy	Average to heavy
Body condition score	3-4	3-4	3	3
Neck	Muscular	Muscular	Moderate to muscular	Moderate to muscular
Top view	Long and wide	Long and wide	Long and wide	Long and wide
Rump	Long leveled	Long leveled	Long leveled	Long leveled
Width and length of loin	Long and wide	Long and wide	Long and wide	Long and wide
Leg structure	Normal	Normal	Normal	Normal

GRADES EVOLVED FOR GOAT CARCASSES OF INDIA

Parameters	Grades			
	Gc-1	Gc-2	Gc-3	Gc-4
Live weight (Kg)	15-20	18-24	20-25	Above 25
Carcass weight (Kg)	8-11	8-12	9-11	10-13
Muscling	Heavy	Average to heavy	Average	Average
Dressing percentage	45-47	43-45	42-44	40-42
Leg score	4	3-4	4	4
Maturity	Immature	Mature	Mature	Mature
Kidney, pelvic and heart fat	Abundant	Moderate	Moderate	Moderate



Based on the observations different grades were evolved for carcass as grades Gc-1, Gc-2, Gc-3 and Gc-4 which denotes that grade Gc-1 has the ideal dressing percentage for good meat yield and the other weight groups are not having that much quality meat because of the dressing percentage and maturity, Gc-2, Gc-3 having the medium quality meat, and fourth grade (Gc-4) is of old animals aged above 42 months hence the meat will be tougher and low in quality, young goats below 6 months will be immature hence both the categories (Below 6 months and above 42 months) were not considered for live and carcass grading.

Sheep

A total of 2522 live animals and 515 carcasses were subjected for data collection to evolve grade for live sheep and their carcasses.

Most of the sheep slaughtered were less than 1 year age with average body weight of 17.4 Kg and carcasses weight was 8 Kg with dressing per centage of 46.5 %. Numbers of animals slaughtered in authorized slaughter house were almost same as number of animals slaughtered in unauthorized road side local shops. Based on the research findings it was concluded that male uncastrated sheep of less than one year age and medium sized (15 to 20 Kg) sheep are slaughtered more in Tamil Nadu. The carcasses weight ranged between 6 to 9 Kg and dressing per centage was 46.28% for sheep were slaughtered in different districts of Tamil Nadu.

The parameters for live animals grading viz., body weight, muscling, body condition score, neck, top view, rump, loin width and length were considered for evolving grades as the composition of muscle is prominent in these locations in live animal.

So keeping in view of the above points five types of grades (A, B, C, D and E) are evolved for Indian live sheep and their carcasses based on age (quality) and size (yield) to suit to the Indian condition.

Grade A and grade B have the same age group, size and other parameters which are considered for grading, but the difference between grade A and grade B being grade A had high body weight and tender meat whereas grade B had low body weight. The grade C and D had higher body weight and tougher meat. The animal which does not fit into any of the above grades was classified as E grade.

Grades evolved for live Indian sheep

Parameters	Grade -A	Grade- B	Grade-C	Grade- D
Age (months)	6 to 20	3 to 20	20 to 30	Above 30
Size	Medium, large	Small, medium	Heavy	Heavy
Body weight	16 to 25 Kg	10 to 15 Kg	26 to 30 Kg	Above 30 kg
Muscling	Average, heavy	Light, average	Heavy	Heavy
Body condition score	3, 4	3	4,5	3,4
Neck	Muscular	Moderate, Muscular	Muscular	Muscular
Top view	Long wide without bony contours	Short narrow with bony contours	Long wide without bony contours	Long wide without bony contours

Rump	Long and leveled	Short and steep	Long and leveled	Long and leveled
Loin width and length	Long and wider	Short narrow	Long and wider	Long and wider
Legs	Normal	Normal	Normal	Normal

In the present study grading of sheep carcass based on two general considerations quality and yield. Palatability indicating characteristics of the lean here in referred quality and estimated per cent of closely trimmed, boneless, major retail cuts to be derived from the carcass herein referred yield. (USDA 1984).

The parameters for carcass grading viz., carcass weight, muscling, leg score, dressing percentage, maturity, kidney fat, pelvic fat, heart fat and flank streaking were taken into consideration as these parameters can be easily measured to distinguish between different carcasses.

Grades evolved for Indian sheep carcass

Parameters	Grade -A	Grade- B	Grade-C	Grade- D
Age (months)	6 to 20	3 to 20	21 to 30	Above 30
Carcass weight (Kg)	8 to 12	6 to 8	12 to 15	More than 15
Muscling	Average, heavy	Average	Heavy	Heavy
Leg score	4	3, 4	4	3, 4
Dressing percentage(%)	46 to 50	44 to 46	46 to 50	43 to 46
Maturity	Mature	Immature	Mature	Mature
Kidney, pelvic and heart fat	Moderate, abundant	Slight, moderate	Moderate, abundant	Slight, moderate
Flank streaking	Moderate, abundant	Slight, moderate	Moderate, abundant	Moderate, abundant

Pigs

A study was carried out to evolve a suitable live and carcass grading system for pigs by documenting the existing practices and collecting data from live animals and carcasses in different districts of Tamil Nadu. The live animal particulars and measurements were collected in the government/private pig farms and the carcass particulars were collected in the government/private slaughter units/retail outlets for present study. The parameters which influence the marketing of pigs and their carcasses were recorded and analysed statistically.

In the present study, the data were collected from 621 live animals and 297 carcasses in different districts of Tamil Nadu. Mostly, the exotic pigs were slaughtered at the age of 7- 9 months (40.6%) followed by pigs of more than 12 months (22.7%) age with an average body weight of 79 kg and 98 kg respectively. Most of the carcasses weighed 59-75 kg with the dressing percentage of 73 - 75%.

Based on the research findings it was observed that gilt (39%) and barrow (32%) of less than one year age and medium sized (80 to 100 kg) pigs were slaughtered more in Tamil Nadu. The carcasses weighed between 67 kg and 81 with dressing percentage of 74% for pigs was marketed for consumption in different districts of Tamil Nadu.



The parameters for live animals grading of exotic pigs viz., body weight, body length, chest girth, muscling (ham, loin and neck), body condition score, top view, body length, height at withers, chest girth and hip width were considered for evolving grades. The parameters for carcass grading of exotic pork carcasses viz., age, carcass weight, carcass length, dressing percentage, back fat thickness, loin eye area and yield of lean cuts were taken into consideration as these parameters can be easily measured to distinguish between different carcasses.

GRADES EVOLVED FOR LIVE PIGS

Parameters	Grade - A	Grade - B	Grade - C	Grade - D	Grade - E
Age	7 to 9 months	7 to 9 months	10 to 12 months	12 to 24 months	Very young (below 7 months) and very old (above 24 months)
Weight	81 to 100 kg	50 to 80 kg	101 to 120 kg	120 to 180 kg	Below 50 kg (young) 180 kg (very old)
Body Ondition Score	3 (Ideal)	2 (Thin)	4 (Fat)	5 (Obese)	1 (Emaciated) and 5 (Obese)
Muscling	Heavy	Average	Heavy	Heavy	Thin to average
Body Legth	73.1 to 85 cm	65.1 to 73 cm	85.1 to 95 cm	95.1 to 100 cm	Below 65 and above 100 cm
Chest Girth	85.1 to 90 cm	70.1 to 85 cm	90.1 to 105 cm	105.1 to 120 cm	Below 70 and above 120 cm
Neck	Muscular	Thin	Muscular	Muscular	Thin and moderate
Top View	Uniform and regular	Uniform and regular	Uniform and slightly irregular	Irregular and long wide	Irregular
Leg Structure	Normal	Normal	Normal and abnormal	Abnormal	Any abnormality

Grade- E: The animal which does not come under first four grading parameters was classified as grade-E.

GRADES EVOLVED FOR PORK CARCASSES

Parameters	Grade - A	Grade - B	Grade - C	Grade - D	Grade - E
Age	7 to 9 months	7 to 9 months	10 to 12 months	12 to 24 months	Very young (below 7 months age) and very old (above 24 months)
Carcass Weight	60 to 70 kg	50 to 60 kg	81 to 100 kg	101 to 180 kg	Below 40 kg (young) and above 180 kg (very old)
Carcass Length	73.1 to 78	68.1 to 73	78.1 to 83	83.1 to 90	Below 68 kg and above 90 kg
Dressing Percentage	66 to 70 %	60 to 65 %	71 to 75 %	76 to 78 %	Less than 60 % and more than 78%



Back Fat Thickness	2.6 to 3 cm	2.0 to 2.5 cm	3.1 to 3.5 cm	3.6 to 4.0 cm	Less than 2.0 and more than 4.0 cm
Yield of Lean Cuts	Above 60 %	55 to 60 %	50 to 55 %	Below 50 %	Less than 50 %
Muscling	Heavy	Average to heavy	Heavy	Heavy	Thin and Very thick
Ham Score	Average to thick	Thin to average	Thick	Thick	Thin and Thick

Grade- E: The animal which does not come under first four grading parameters was classified as grade-E.

(Reference will be available from author)



Oral Presentations

TPL-1

EXTRACTION OF KERATIN BY MICROBIAL DEGRADATION OF CHICKEN FEATHERS – AN ATTEMPT TO CONVERT WASTE INTO WEALTH

**T.G.Prabhavathi, R. Ramani, V. Appa Rao, R. Narendra Babu,
J.Ramesh and S.Ezhilvelan**

A study was conducted to standardize the procedure for extraction of keratin from chicken feathers by microbial degradation. A novel *Bacillus licheniformis* was bought from MTCC (Microbial Type Culture Collection and Gene Bank) for the extraction. Extra cellular keratinase was produced in the production medium. Keratin was extracted by microbial degradation. The molecular characteristics of the extracted keratin was studied by using SDS – PAGE, FTIR and Scanning Electron Microscopy. Molecular weight of the extracted substance was found to be 50kDaby SDS – PAGE. On FTIR spectroscopy analysis of the extracted substance, the transmittance peaks for amide I (1665 cm^{-1}) and amide II (1533 cm^{-1}) indicated the presence of α –helix structure in the extracted substance, moreover the amide I (1638 cm^{-1}) and amide II (1515 cm^{-1}) peaks indicated the presence of β – sheet type in the extracted substance. Peaks that appeared between 1200 and 1000 cm^{-1} (1078 cm^{-1}) were attributed to S-O vibration. The peaks that appeared in the range of $480 - 560\text{ cm}^{-1}$ represented disulphide bonds in the extracted substance. The Scanning electron microscopic picture of the lyophilised extracted substance showed the adherence of micro particles together indicative of presence of keratin. These characteristics confirmed that the extracted substance was keratin and thus the study paves way for the utilization of waste (chicken feather) to be convert into a wealthy by product – keratin by microbial degradation which will also alleviate environmental pollution.

TPL-2

LIVE ANIMAL AND CARCASS CHARACTERISTICS OF LARGE WHITE YORKSHIRE PIGS REARED UNDER INDIAN CONDITIONS AT MARKET AGE TO EVOLVE REGRESSION EQUATION FOR PREDICTION OF THEIR LIVE AND CARCASS WEIGHT

**A.Muthukumar, R.Narendra Babu, P.Tensingh Gnanaraj, V.Appa Rao, K.Sudheer*,
R.Jayanthi and Robinson.J.J.Abraham**

Department of Livestock Products Technology (Meat Science), Madras Veterinary College, Chennai-07.
Tamil Nadu Veterinary and Animal Sciences University.

A study was carried out to evolve the regression equation to predict the live weight and carcass weight of Large White Yorkshire pigs reared under Indian conditions by measuring the live animal characteristics viz., body weight, body length, height at withers, chest girth and hip width and carcass characteristics viz., live

weight, carcass weight, dressing percentage, carcass length, loin eye area, back fat thickness and yield of lean cuts respectively. A total of 185 live pigs and 107 carcasses were covered under this study. The mean $\pm$ SE values of body weight (kg), body length (cm), height at withers (cm), chest girth (cm) and hip width (cm) were found to be 92.06 ± 2.16 , 92.27 ± 1.25 , 65.73 ± 0.96 , 102.71 ± 1.10 and 31.11 ± 0.38 respectively. The mean $\pm$ SE values of live weight (kg), carcass weight (kg), dressing percentage (%), carcass length (cm), loin eye area (cm^2), back fat thickness (cm) and yield of lean cuts (%) in Large White Yorkshire pigs were 67.54 ± 2.67 , 48.80 ± 1.95 , 71.41 ± 0.55 , 67.62 ± 0.99 , 24.96 ± 0.54 , 3.35 ± 0.12 and 63.07 ± 0.47 respectively. Regression equations evolved for predicting the body weight and carcass weight of Large White Yorkshire pigs were.

$$\text{Live weight, } Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \mu$$

$$Y_{\text{LWY}} = -85.850 + 0.460X_1 + 0.268X_2 + 0.367X_3 + 2.576X_4$$

Where, Y = dependent variable (body weight), LWY- Large White Yorkshire, α - constant, β - Parameter estimates ($\beta_1, \beta_2, \beta_3$ and β_4), X_1 - body length, X_2 - height at withers, X_3 - chest girth, X_4 - hip width, μ - Error

$$\text{Carcass weight, } Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \mu$$

$$Y_{\text{LWY}} = 0.483X_1 + 0.301X_2 + 2.025X_3 + 1.781X_4 + (-0.67) X_5$$

Where, Y = dependent variable (carcass weight), LWY- Large White Yorkshire, α - constant, β - Parameter estimates ($\beta_1, \beta_2, \beta_3$ and β_4), X_1 - dressing percentage, X_2 - carcass length, X_3 - loin eye area, X_4 - back fat thickness, X_5 - Yield of lean cuts, μ - Error

The recorded observations of live weight and carcass parameters can serve as a standard for establishing suitable grades for Indian conditions. The evolved equations will facilitate to measure the live weight and carcass weight of animals without much instrumental intervention under field conditions.

TPL-3

LIVE ANIMAL AND CARCASS CHARACTERISTICS OF CROSS BREED PIGS REARED UNDER INDIAN CONDITIONS AT MARKET AGE TO EVOLVE REGRESSION EQUATION FOR PREDICTION OF THEIR LIVE AND CARCASS WEIGHT

A. Muthukumar, R.Narendra Babu, P.Tensingh Gnanaraj, V.Appa Rao, K.Sudheer*, R.Jayanthi and Robinson. J.J. Abraham

Department of Livestock Products Technology (Meat Science),
Madras Veterinary College, Chennai-07.
Tamil Nadu Veterinary and Animal Sciences University.

A study was carried out to evolve the regression equation to predict the live weight and carcass weight of Cross breed pigs reared under Indian conditions by measuring the live animal characteristics viz., body weight, body length, height at withers, chest girth and hip width and carcass characteristics viz., live weight, carcass weight, dressing percentage, carcass length, loin eye area, back fat thickness and yield of lean cuts respectively. A total of 279 live pigs and 144 carcasses were covered under this study. The mean $\pm$ SE values of body weight (kg), body length (cm), height at withers (cm), chest girth (cm) and hip width (cm) were 96.19 ± 2.07 , 86.30 ± 0.93 , 71.02 ± 0.57 , 104.41 ± 0.85 and 32.48 ± 0.20 respectively. The mean $\pm$ SE values of live



weight (kg), carcass weight (kg), dressing percentage (%), carcass length (cm), loin eye area (cm²), back fat thickness (cm) and yield of lean cuts (%) in cross bred pigs were 92.19±2.23, 70.65±1.88, 75.80±0.38, 79.17±0.58, 32.01±0.82, 3.82±0.06 and 56.60±0.48 respectively. Regression equations evolved for predicting the body weight and carcass weight of Cross breed pigs were.

$$\text{Body weight, } Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \mu$$

$$Y_{CB} = -105.265 + 1.568X_1 + 0.594X_2 + 0.401X_3$$

Where, Y = dependent variable (body weight), CB- Crossbred pigs, α - constant, β - Parameter estimates (β_1 , β_2 , β_3 and β_4), X_1 - body length, X_2 - height at withers, X_3 - chest girth, X_4 - hip width, μ - Error.

$$\text{Carcass weight, } Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \mu$$

$$Y_{CB} = 0.871X_2 + 0.349X_3 + (-0.924X_5) + 9.508 X_6$$

Where, Y = dependent variable (carcass weight), CB- Crossbred pigs, α - constant, β - Parameter estimates (β_1 , β_2 , β_3 and β_4), X_2 - carcass length, X_3 - loin eye area, X_5 - Yield of lean cuts, X_6 - muscling, μ - Error.

The recorded observations of live weight and carcass parameters can serve as a standard for establishing suitable grades for Indian conditions. The evolved regression equation will facilitate to measure the body weight of animals without much instrumental intervention under field conditions.

TPL-4

LIVE ANIMAL AND CARCASS CHARACTERISTICS OF MADRAS RED SHEEP AT MARKET AGE TO EVOLVE PREDICTION EQUATION TO ESTIMATE THE LIVE WEIGHT AND CARCASS WEIGHT

**R.Tamilselvan, R.Narendra Babu, V.Appa Rao, T.M.A. Senthil Kumar,
Robinson J.J Abraham, R.Jayanthi, K.Sudheer and A.Serma Saravana Pandian**

Department of Livestock Products Technology (Meat Science),
Madras Veterinary College, Chennai- 600 007
Tamil Nadu Veterinary and Animal Sciences University

A study was carried out to evolve the prediction equation to estimate the live weight and carcass weight of Madras red sheep by documenting the practices followed in slaughter houses in Tamil Nadu. Prediction equation using stepwise multiple regression equation analysis to estimate the live weight by measuring the live animal body measurements viz. body length, height at withers, hip width, chest girth and fore cannon bone length and for carcass weight the following carcass measurements viz. carcass length, dressing percentage, rib eye area, body wall thickness were taken. A total of 173 live Madras red sheep and 34 carcasses were covered under this study. The mean $\pm$ SE values of body weight (kg), body length (cm), hip width (cm), height at withers (cm), chest girth (cm) and fore cannon bone length (cm) were found to be 14.69±0.29, 54.59±0.38, 13.68±0.18, 55.75±0.33, 58.31±0.38 and 14.21±0.73 respectively. The mean $\pm$ SE values of live weight (kg), carcass weight (cm), carcass length (cm), dressing percentage (cm), rib eye area (cm²) and body wall thickness (cm) in Madras red sheep were 12.47±0.31, 5.61±0.16, 50.67±0.35, 44.88±0.22,

5.68±0.11 and 0.81±0.02 respectively. Regression equations evolved for predicting the body weight and carcass weight of Madras red sheep were.

$$\text{Live weight, } Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \mu$$

$$Y_{MA} = -14.987 + 0.044X_1 + 0.832X_2 + 0.031X_3 + 0.241X_4 + 0.006X_5 + \mu$$

Where, Y = dependent variable (body weight), MA – Madras red, α - constant, β - Parameter estimate, X_1 -Body Length, X_2 -hip width, X_3 -height at withers, X_4 -chest girth, X_5 -fore cannon bone length, μ - Error

$$\text{Carcass weight, } Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \mu$$

$$Y_{MA} = -10.068 - 0.004X_1 + 0.232X_2 + 0.001X_3 + 0.022X_4 + \mu$$

Where, Y = dependent variable (carcass weight), MA – Madras red, α - constant, β - Parameter estimate, X_1 -carcass length, X_2 -dressing percentage, X_3 -Rib eye area, X_4 -body wall thickness, μ - Error

The recorded observations of live weight and carcass parameters can serve as a standard for establishing suitable grades for Indian conditions. The evolved equations will facilitate to measure the live weight and carcass weight of animals without much instrumental intervention under field conditions.

TPL-5

EFFECT OF HERBAL V/S SYNTHETIC AMINO ACID SUPPLEMENTATION ON BROILER PRODUCTION AND CHICKEN QUALITY ATTRIBUTES

Naga Raja Kumari K*, Naga Mallika E, Srinivas Kumar D and Anurag Borthakur

NTR College of Veterinary Science, Gannavaram-521102,
Sri Venkateswara Veterinary University, Andhra Pradesh, INDIA
*corresponding author: nkkallam3@gmail.com

A study was conducted to evaluate the efficacy of AV/CAP/18 (herbal amino acid supplement) and synthetic amino acid supplements on broiler growth and performance. Vencobb day old chicks of 156 numbers were randomly distributed into 4 treatment groups with 3 replicates of 13 birds each. Basal diet without any amino acids was prepared (control T1). Basal diet was supplemented with DL-Methionine at 1.25kg/T and AV/CAP/18 at 2kg/T (T2), AV/CAP/18 at 2kg/T (T3), Lysine@1kg/T, MHA at 2.5kg/T, Choline chloride 600g/T, Biotin 150g/T (T4) were prepared and fed ad libitum to the birds (1-38 days). Feed intake (FI), body weight (BW), feed conversion ratio (FCR), economics, serum and blood parameters, carcass yield, were measured. Significantly increased BW, better FCR, more profit and higher carcass yields were observed in T2 followed by T4 group. Increased ($p < 0.05$) carcass weights, cooked yield, dressing percentage with incorporation of amino acids in diets either of the source when compared to control and only AV/CAP/18 supplemented groups. The sensory quality of meat was rated high in herbal amino acid supplemented (T2 & T3) groups when compared to control group. Basing on the results it can be concluded that broiler diets can be supplemented with AV/CAP/18 along with DL-Methionine instead of synthetic amino acids for better performance and can be treated as organic.



TPL-6

**INFLUENCE OF AGE AND DIFFERENT MUSCLE REGIONS ON
INSTRUMENTAL COLOUR AND TEXTURAL
CHARACTERISTICS OF EMU BIRDS**

**R. Ramani, Robinson J.J Abraham, K. Kumanan, V. Appa Rao,
R. Narendra Babu and C.Vasanthi**

A study on the influence of age and different muscle regions (drumstick, thigh and breast) on Instrumental Colour and textural characteristics of emu birds of two different age groups (15 and 18 months) was carried out in sixteen emu birds (8 in each group). The birds were brought from private farm in Salem and slaughtered as per the standard procedure in the Department of Livestock Products Technology (Meat Science), Madras Veterinary College, Chennai. The Colour of the meat samples were analysed by Hunter's Colour lab and textural characteristics were analysed by Stable Microsystems Texturometer. Spectrophotometric assay of meat colour revealed that the younger age groups had higher lightness (L^*), lower redness (a^*) and yellowness (b^*) values. Drumstick region revealed to have minimal lightness (L^*) and intense redness (a^*) and the thigh region was found to be intermediary. The breast region had the highest lightness (L^*) and lowest redness (a^*) values. Hue values were more in drumstick and the breast showed more chroma values. The texture profile values in this study reflected that the younger age groups (15 months) had favourable textural properties pertained to tenderness of meat. The younger age groups (15 months) had decreased hardness, springiness, cohesiveness, gumminess and chewiness values than the older aged (18 months) birds. The values also indicated that the drumstick was the least tender region of all. This study on the whole indicated that emu birds of 15 month age group are best to be selected for slaughter and preparation of value-added products considering their favourable characteristics in Instrumental Colour and textural Properties.

TPL-7

**EFFECT OF FEEDING AMARANTHUS LEAF MEAL ON
CHOLESTEROL AND PROTEIN CONTENT OF BROILER MEAT**

Dr Sireesha K* and Dr Naga Raja Kumari K

Assistant Professor,
NTR College of Veterinary Science, Gannavaram-521102.

A study was conducted in broilers to know the effect of Amaranthus leaf meal (ALM) on cholesterol levels and protein content of meat. The ALM was incorporated into five formulated broiler starter diets at varying inclusion levels (0, 2.5, 5, 7.5, 10 %). All the diets were formulated isocaloric and isonitrogenous and fed to the five experimental groups (n = 150) in three replicates each with 10 birds over a period of 6 weeks. Feed intake (FI), body weight gain (BWG) and FCR, cholesterol in serum, breast muscle and thigh muscle were studied. ALM supplementation had no effect on FI, FCR and carcass yields. A significant decrease in serum cholesterol, LDL-C, breast muscle cholesterol, LDL-c and triglyceride, thigh muscle cholesterol, LDL-



c and triglyceride and thigh muscle fat values, but a significant increase in VLDL-c, breast muscle HDL-c and breast muscle protein values were observed. The profit over the feed cost per bird was high in 7.5 percent ALM inclusion diet compared with other diets. Basing on the study it can be concluded that ALM can be incorporated safely upto 7.5% levels for production of designer meat.

TPL-8

GROWTH PERFORMANCE OF INDIAN PAMPAÑO, (*TRACHINOTUS MOOKALEE*) IN NET CAGES

P. Pravallika, B.Chamundeswari Devi* and P. Sri Dattatreya

Fisheries Research Station,
Sri Venkateswara Veterinary University, Kakinada, India.

The Indian Pampano, *Trachinotus mookalee* is considered as a promising species for mariculture in India. The present study was conducted to evaluate the growth performance of Indian Pampano, *Trachinotus mookalee* in net cages in closed bay. Indian Pampano seed were obtained from Central Marine Fishery Research Institute (CMFRI), Vishakhapatnam. The seed were stocked in 1 x 1 x 2 m cages in closed bay at Suryalanka (15°51' 04.54''N & 80°31'58.87''E) near Bapatla, Guntur District, Andhra Pradesh. Fishes were stocked at 4 different stocking densities i.e., T₁ (4/m³) T₂ (6/m³) T₃ (8/m³) T₄ (10 /m³). The study period was from August to October, 2018 (92 days). Fish feed was given @ 10% of body weight. Fish were fed twice a day, at 6 am and 5 pm; daily ration was divided into two equal halves. A feeding ring (0.5 m) was fixed in the middle of each cage. Feeding rings are enclosures that float at the water surface; they hold floating feed and prevent the escape of feed out of the feeding ring and thus reduce wastage of feed. The size of fish at the time of stocking was 10.1g ± 0.69 (T₁) 10.6g ± 0.56 (T₂) 10.7g ± 0.74 (T₃) 10.2g ± 2.62 (T₄).

Water quality parameters like temperature, D.O, pH, salinity, NH₃, NO₂, NO₃, alkalinity and hardness were analysed at fortnightly intervals and were within the optimum range for culture of Indian Pampano. The fish have attained the size of 52.1g ± 0.24 (T₁) 47.3g ± 0.54 (T₂) 38.5g ± 0.22 (T₃) 32.4g ± 0.14 (T₄) weight. 100% survival was reported at all stocking densities and it was observed that growth reduced with increasing stocking densities.

TPL-9

RED ANT CHUTNEY - A TOURISM ATTRACTION OF BASTAR

Prateek Chauhan, Yugal Kishor Sahu, Dr Lomte D M

Indian Culinary Institute, Tirupati

India is an enormous country embedded with all resources that are absolutely needed for the advancement of a developing country. There is no doubt about that the Indian cuisine and its spices never fails to mesmerize people with an exotic and unique flavour all around the world. The country has rich



culture, traditions, and languages that make the country different from 193 countries present around the globe. The utmost uniqueness that Indian cuisine has, its different taste and texture of food keep on changing with every step within its geographical boundaries, it's continuing the journey to evolve what with the current popularity of western foods and cuisines. There are numerous recipes that are profoundly Intact with the cuisine and are very much popular among the people like the sum of the best example is Punjabi cuisine, some lesser known recipes are also existing on the same piece of land that is not even heard of due to some constraints and awareness amongst the rural communities. Red Ant chutney (*Oecophylla smaragdina*) also known as Chaprah in the local Chhattisgarhi language is an exotic cuisine made up of red ants are popular among the localities of Bastar region of Chhattisgarh state of India, due to its medicinal properties, and formic acid which is present in red ants, it is consumable amongst the rural people at large scale but still, on the other hand, are very much away from the reach of the people all in some parts of Chhattisgarh and around the world. So, in order explore the rich rural cuisine and make the people aware about the hidden exotic flavours of rural households. Researchers have developed questionnaire using 5 point Likert scale to identify the information Known by Tourist about red ant chutney .Data collected have been analysed by using IBM SPSS version 25.0 & One sample T – test has been used to test hypothesis. This research concludes that red ant chutney definitely has a potential and is going to benefit the rural people as well as tribal communities resides in the Bastar district. It also have potential to attract tourist since it has medicinal properties and health benefits; resulting in to socio economic impact on the people of rural areas of Bastar.

TPL-10

EFFECT OF AGE ON THE CARCASS CHARACTERISTICS, CARCASS COMPOSITION AND OFFALS IN LARGE WHITE YORKSHIRE PIGS

V. Appa Rao, A.Vanathi, R.Narendra Babu, C.Vasanthi, S.Ezhilvelan and R.Ramani

Department of Livestock Products Technology (Meat Science)

Madras Veterinary College, Chennai – 600 007

The aim of the study was to evaluate carcass characteristics, composition and offals in Large White Yorkshire pig of three different age groups irrespective of sex and live weight of the animal. The animals were brought from the local and private farms in and around Chennai. A total of 63 number of Large White Yorkshire pigs, were selected and they were divided into three different age groups, viz., group I (5 to 7 months) $n = 14$, group II (8 to 10 months) $n = 35$, group III (11 to 13 months) $n = 14$ were slaughtered as per the standard procedure in the Department of Livestock Products Technology (Meat Science), Madras Veterinary College, Chennai. The live weight (89.36 ± 5.64) was found higher ($P < 0.01$), in group III when compare to other groups. Among the carcass characteristics, group III showed higher significance in hot carcass weight ($P < 0.01$), carcass length ($P < 0.05$) and back fat thickness ($P < 0.05$) when compare to group I and group II. There was no significant difference observed in dressing percentage and skin thickness. with respect to the carcass composition there was no significant difference noticed in Ham, Picnic shoulder and Boston butt percentage, but the loin (29.98 ± 1.64), side and spare percentage (29.98 ± 1.64) showed higher ($P < 0.05$) in group III when compare to group I and group I. Regarding non carcass composition the yield of feet, stomach and intestine, heart and liver was found higher ($P < 0.05$) in group I when compare to other



group. The yield of blood, head, lungs, tail and spleen revealed no significant difference. Hence in conclusion as the age increases the live weight, hot carcass weight and back fat thickness increases and showed an influence on carcass characteristics. An increasing trend was also noticed in the percentage of loin, side and spare ribs. Pertaining to the yield of offals age had a reversal effect on the percentage of feet, stomach and intestine, heart and liver.

TPL-11

CARCASS CHARACTERISTICS OF LARGE WHITE YORKSHIRE PIGLETS FED WITH ALTERNATE PROTEIN SOURCES

S. Durga^{*}, D. Anandha Prakash Singh, S. Sureshkumar S. Ramakrishnan and K. Sivakumar

Department of Livestock Production Management
Veterinary College and Research Institute, Namakkal

A biological experiment was conducted to evaluate the carcass characteristics of Large White Yorkshire piglets fed with conventional concentrate diet incorporated with wet brewer's spent grains (T1), *Moringa oleifera* leaves (T2) and rice gluten meal (T3) at 10, 10 and 5% level, respectively and conventional concentrate diet kept as control (T4). The study was carried out using 24 weaned Large White Yorkshire piglets available at Instructional Livestock Farm Complex, Veterinary College and Research Institute, Namakkal for 120 days period. At the end of the trial, 4 animals from each group were slaughtered and showed that the pigs fed with 10% wet brewer's spent grains recorded significantly ($P < 0.05$) lowest back fat thickness (1.15 ± 0.28 cm). The 5% rice gluten meal (T3) fed pigs registered the highest (60.51 ± 1.24 kg) hot carcass weight followed by conventional concentrate control diet (58.30 ± 1.30 kg) and 10% wet brewer's spent grains (54.88 ± 1.41 kg). The dressing % of the pigs fed with 10% wet brewer's grains, 10% *Moringa oleifera* leaves, 5% rice gluten meal and control diet were 71.50, 71.00, 73.25 and 72.75%, respectively and did not show significant difference. It is concluded that among the treatment groups, 10% wet brewer's spent grains was considered more suitable to reduce the back fat thickness resulting in lean meat production.

TPL-12

LIVE ANIMAL AND CARCASS CHARACTERISTICS OF MECHERI SHEEP AT MARKET AGE TO EVOLVE PREDICTION EQUATION TO ESTIMATE THE LIVE WEIGHT AND CARCASS WEIGHT

R. Tamilselvan, R. Narendra Babu, V. Appa Rao, T. M. A. Senthil Kumar, Robinson J. J. Abraham, R. Jayanthi, K. Sudheer and A. Serma Saravana Pandian

Department of Livestock Products Technology (Meat Science),
Madras Veterinary College, Chennai
Tamil Nadu Veterinary and Animal Sciences University

A study was carried out to evolve the prediction equation to estimate the live weight and carcass weight of Mecheri sheep by documenting the practices followed in slaughter houses in Tamil Nadu.

Prediction equation using stepwise multiple regression equation analysis to estimate the live weight by measuring the live animal body measurements viz. body length, height at withers, hip width, chest girth and fore cannon bone length and for carcass weight the following carcass measurements viz. carcass length, dressing percentage, rib eye area, body wall thickness were taken. A total of 1124 live Mecheri sheep and 190 carcasses were covered under this study. The mean $\pm$ SE values of body weight (kg), body length (cm), hip width (cm), height at withers (cm), chest girth (cm) and fore cannon bone length (cm) were found to be 17.64 ± 0.10 , 56.21 ± 0.11 , 16.03 ± 0.14 , 58.22 ± 0.11 , 59.67 ± 0.12 and 15.42 ± 0.13 respectively. The mean $\pm$ SE values of live weight (kg), carcass weight (cm), carcass length (cm), dressing percentage (cm), rib eye area (cm^2) and body wall thickness (cm) in Mecheri sheep were 18.29 ± 0.25 , 8.68 ± 0.13 , 50.14 ± 0.28 , 47.24 ± 0.11 , 7.51 ± 0.09 and 1.16 ± 0.02 respectively. Regression equations evolved for predicting the body weight and carcass weight of Mecheri sheep were.

$$\text{Live weight, } Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \mu$$

$$Y_{ME} = -26.037 + 0.481X_1 + 0.062X_2 + 0.094X_3 + 0.169X_4 + 0.004X_5 + \mu$$

Where, Y = dependent variable (body weight), ME – Mecheri, α - constant, β - Parameter estimate, X_1 -Body Length, X_2 -hip width, X_3 -height at withers, X_4 -chest girth, X_5 -fore cannon bone length, μ - Error

$$\text{Carcass weight, } Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \mu$$

$$Y_{ME} = -15.328 + 0.025X_1 + 0.307X_2 + 0.100X_3 + 0.568X_4 + \mu$$

Where, Y = dependent variable (carcass weight), ME – Mecheri, α - constant, β - Parameter estimate, X_1 -carcass length, X_2 -dressing percentage, X_3 -Rib eye area, X_4 -body wall thickness, μ - Error

The recorded observations of live weight and carcass parameters can serve as a standard for establishing suitable grades for Indian conditions. The evolved equations will facilitate to measure the live weight and carcass weight of animals without much instrumental intervention under field conditions.

TPL-13

EFFECT OF EARLY WEANING ON CARCASS CHARACTERISTICS OF LARGE WHITE YORKSHIRE PIGS UNDER INTENSIVE SYSTEM

V. Sravanthi, D.Suresh Babu, A. Anitha and Eswara Rao

Dept.of LPM, NTR College of Veterinary Science, Gannavaram.

A study was carried out in 54 Large White Yorkshire pigs to find out the effect of early weaning on carcass traits. Three weaning groups namely group 1 (25 days), group 2(40 days) and group 3(56 days) were compared. Each group consisted of 18 piglets from three litters. Five months after weaning, six pigs from each group were slaughtered and the carcass traits studied included pre slaughter weight, carcass length, hot carcass weight, average back fat thickness, dressing percentage, meat-bone ratio and whole sale primal cuts. A highly significant variation was observed between group 2 and the other two groups with respect to pre slaughter weight ($64.99 \pm 0.30\text{kg}$), carcass length ($26.42 \pm 0.38\text{kg}$), dressing percentage ($75.2 \pm 0.39\%$), meat –bone ratio(4.16 ± 0.00), ham($27.63 \pm 0.22\%$) and belly($8.69 \pm 0.15\%$). Whereas group 3 has higher in boston butt and loin and a highly significant variation ($p < 0.01$) than that of group 2 while picnic shoulder in group 1 was significantly ($p < 0.01$) higher than that of 2 and 3.



TPL-14

PHYSICO-CHEMICAL AND MOLECULAR CHARACTERISTICS OF COLLAGEN EXTRACTED FROM CHICKEN SKIN

G. N. Nithin Kumar, V. Appa Rao, R. Narendra Babu, S. Ezhilvelan and A. Sindhura*

Department of Livestock Products Technology,
Madras Veterinary College, Chennai- 600 007.

A study was carried out to extract collagen from chicken skin and evaluate its physical chemical properties. Collagen was extracted from chicken skin after defatting and removing the non-collagenous protein. The collagen was solubilized by using 0.5 M acetic acid and 1 % pepsin. The solubilized collagen was precipitated out by adding 2.6 M NaCl and collected by centrifugation at 4°C. Then the extracted collagen was purified by dialysis and stored as liquid collagen at -18°C to evaluate physico-chemical characteristics such as pH, yield, instrumental colour analysis, proximate composition and for SDS-PAGE. Hydroxyproline content of extracted collagen was determined. The results of the study revealed that the pH and yield of collagen extracted from chicken skin was 3.66 ± 0.05 and 22.60 ± 0.33 . The Lightness (L), Redness (a) and Yellowness (b) of extracted collagen was 92.11 ± 1.22 , 0.086 ± 0.18 and 14.45 ± 2.44 respectively. The moisture, protein, fat, ash and hydroxyproline content of the extracted collagen was $7.09 \pm 0.25\%$, $57.23 \pm 0.90\%$, $28.32 \pm 0.55\%$, $5.89 \pm 1.14\%$ and $7.76 \pm 0.72\%$ respectively. The SDS-PAGE showed bands in lane 1 representing the high range protein marker in four bands with the molecular weight of 202, 116, 98 and 47kDa in sequential order; whereas the collagen extracted from chicken skin in lane 2 depicted two bands with a molecular weight of around 202kDa (β - chain) and 116kDa (α - chains). In the present study, collagen from chicken skin contained two distinct α chains ($\alpha 1$ and $\alpha 2$) and one β chain. Based on the results of the present study it can be concluded that collagen can be extracted from chicken skin which was a byproduct of poultry slaughter house.

TPL-15

PRODUCTION OF SELENIUM ENRICHED FUNCTIONAL MEAT THROUGH SUPPLEMENTATION OF DIFFERENT SOURCES OF SELENIUM IN TOTAL MIXED RATIONS (TMR) OF SHEEP

P Baswa Reddy, DBV Ramana¹ and M Muthukumar

ICAR- National Research Centre on Meat, Chengicherla, Hyderabad

¹ICAR- Central Research Institute for Dryland Agriculture, Hyderabad

Selenium plays a major role in the protection of body tissues against oxidative stress, maintenance of defence against infection and modulation of growth and development in humans as well as animals. Recently, there is growing interest in the dietary supplementation of livestock with selenium. Selenium concentrations in the muscle of the meat animals can be increased by dietary selenium supplementation in livestock feeds and the meat obtained from such animals could be beneficial for human health. With this concept, animal experiments were carried out in sheep to produce selenium enriched functional meat through nutrient supplementation in sheep. Thirty two weaned Nellore ram lambs of 5-6 months age were randomly divided



into four groups with eight animals in each group. Four complete feeds (Total Mixed Rations, TMR) were prepared and animals in different groups were offered with respective TMR *ad-libitum* for 120 days. Except in the first group (control), supplementary selenium was added @ 500ppb in the other three feeds. The source of Selenium varied between groups. There was no supplementation of Selenium in Group-1 (control) whereas Sodium Selenite, Seleno-methionine and Selenium-Yeast were added as source of Selenium in TMRs of group 2,3 and 4 respectively. After the feeding trail, animals were slaughtered to study the carcass characteristics and selenium content in different muscles and edible organs. The average daily weight gain, feed intake, feed conversion efficiency, dressing yield were similar ($p>0.05$) between the groups. The selenium content in LD muscle was four times higher ($p<0.001$) in Seleno-methionine supplemented group (group-3) when compared to control group (175.66 ppb vs 44.33ppb). Similar trend was observed in thigh muscle also. Breast muscle contained relatively higher ($P=0.06$) selenium in the third group. Selenium content of liver and kidney were similar ($p>0.05$) between the different treatment groups whereas the seleno-methionine supplemented group had significantly higher ($p<0.05$) selenium content in heart muscle and testicles. Based on the results it was concluded that seleno-methionine supplementation in sheep diets could effectively enrich the muscles with selenium.

TPL-16

COMPARATIVE CARCASS CHARACTERISTICS OF RAJASRI BIRDS WITH BROILERS

**S. Shakeela, G.V. Bhaskar Reddy, B.V.Vivekananda Reddy,
E. Nagamallika and B.Eswara Rao**

Department of Livestock Products Technology, College of Veterinary Science,
Sri Venkateswara Veterinary University, Tirupati-517 502.

The present study was investigated on comparative carcass characteristics of Rajasri male birds with broiler birds by conducting experimental trials at the Department of Poultry Science, College of Veterinary Science, Tirupati. A total of 6 birds were slaughtered at 24 weeks age for Rajasri birds and 6 weeks age for broiler birds each at Department of Livestock Products Technology, College of Veterinary Science, Tirupati. Carcass traits such as pre-slaughter weight, carcass weight and dressing percentage were significantly ($P<0.05$) higher in broilers than Rajasri chicken. Yield of edible and inedible offals viz. liver, gizzard, heart, giblet, blood and feather were significantly ($P<0.05$) lower in broilers than Rajasri birds. Percent inedible offal yield viz. blood, feather, head and feet were significantly ($P<0.05$) higher in broilers than Rajasri birds. Percent edible offal yield viz. liver, gizzard, heart and giblet were significantly ($P<0.05$) lower in male Rajasri birds than broiler chicken. Yield of cutup parts and percentage yield were calculated based on carcass weight in present study. Cutup parts viz. neck, wings, breast, back, thigh and drumstick yield were significantly ($P<0.05$) higher in broilers than Rajasri birds. Based on the results, it can be concluded that broilers at the age of 6 weeks having superior carcass characteristics than Rajasri male birds slaughtered at 24 weeks of age.



TPL-17

VALUE ADDITION IN BUFFALO MEAT

R.Narendra Babu, K.Dushyanthan, C.Vasanthi and V.Appa Rao

Department of Livestock Products Technology (Meat Science),

Madras Veterinary College, Chennai-7

Tamil Nadu Veterinary and Animal Sciences University.

Buffalo meat is the major meat produced in India accounting for about 43% of the world buffalo meat production. Buffalo meat has a lower fat content, and its fat is milky white, compared to the yellow-white fat of beef. Buffalo meat is darker in color with a lower muscle pH of 5.6 ± 0.4 whereas beef muscle has a pH of 6.4 ± 0.7 . Most of the export oriented meat industries in our country are exporting buffalo meat and so the amount of meat trimmings and the low value cuts like cheek meat and offals like heart and tongue generated is a huge volume and the same may be collected hygienically from such industries, the above meat can be utilised effectively for processing emulsion based meat products. Further, the low value cuts like cheek meat and offals like heart and tongue were underutilised for human consumption. Hence, this study envisages the utilisation of low value meat and offals @ 25 parts in the ratio of 50:25:25 of cheek meat: heart: tongue as it is presented in the same ratio in live animal. Skeletal meat was incorporated @ 75 parts for the formulation consisting of 90 % of meat (75:25 of skeletal meat: low value meat) and 10% of fat (5% buffalo fat and 5% refined sunflower oil). Emulsion products like sausages, nuggets, loaves and patties were prepared by different cooking methods like smoking (sausages), steaming (nuggets and loaves) and hot air oven cooking (patties). The cooked emulsion products were subjected to evaluation like product characteristics (emulsion stability and yield), physico-chemical (pH, shear force value, Hunters colour, Texture profile analysis) and sensory evaluation (appearance, flavour, juiciness, texture and overall acceptability). The results of the study revealed that all the treatment emulsion products were statistically similar to the control emulsion products and were organoleptically acceptable as that of control emulsion products. This confirms the hypothesis that value addition of buffalo meat could be done by preparing emulsion meat products with the effective incorporation of underutilised low value meat (meat trimmings) and offals @ 25% of meat with acceptability of the product as that of control products.

Poster Presentations

TPL-18

DEVELOPMENT OF FERTILIZER BRIQUETTES FROM SLAUGHTER HOUSE WASTES

**Arun Sankar K J*, V N Vasudevan, Sathu T, Irshad A, Vandana Sasidharan,
Yazhinidevi R and B Sunil**

Department of Livestock Products Technology
College of Veterinary and Animal Sciences, Mannuthy. * Email: arunsankarkj@gmail.com

Service slaughter houses in the country generate large quantities of animal blood, manure and rumen contents as waste materials. Eco-friendly disposal of such waste often requires long time or expensive equipments. The objective of the current study was to develop fertilizer briquettes using the biomass originating from slaughter houses. Partially dried rumen contents (RC) were mixed with fresh blood collected after bleeding of animals in different proportions. The blood was thoroughly mixed with RC and dried in tray drier at 70°C for six hours. The dried blood-rumen content mixture was further mixed with commercially available coir pith block in 20 different proportions. The final mixture was formed into a fertilizer briquette using a hydraulic biomass briquetting machine. Each fertilizer briquette was 5cm in diameter, 2cm thick and had an average weight of 30-40 grams. Each briquette was analysed for pH, electrical conductivity (EC), organic carbon (OC), moisture, nitrogen, total P₂O₅, total K₂O and carbon/nitrogen (C/N) ratio. Sample with RC and coir pith added in the ratio 40:60 respectively in which blood was added at 80% by weight of RC had desirable properties to be used as a fertilizer. This sample possessed a pH of 6.5, 4.7dS/m of EC, 48.72% of OC, 2.19% of nitrogen, 0.9% by weight of total P₂O₅, 2.04% by weight of total K₂O and C/N ratio of 22.25. The study highlights the promising potential for development of fertilizer briquettes using slaughter house wastes which are compact, easy to transport and market, and ideal for grow bag cultivation and garden nurseries. It could be a feasible eco-friendly process minimising the adverse environmental impact of slaughter house waste materials.

TPL-19

IN VITRO MEAT PRODUCTION- BENEFITS OVER CONVENTIONAL MEAT PRODUCTION

Vivek Sahu*, Sahil KR. Angurana¹, Sanjay Singh, Varun KR. H. Mehta Surajkumar

Department of LPT, ¹VPH, Duvasu Mathura

The world population is rising day by day at higher rate and will be rising to a whopping 9.8 billion by the year 2050. Our current food system is ruled by big dairy and meat industry is not sustainable and will not be able to meet the current demand. So promising and sustainable alternative is in-vitro meat production.



cultured meat is an animal product produced that has been never part of a complete living animal. Necessity of in-vitro meat production, Prevent animal suffering and cruelty, Prevents Global warming, No risk of meat borne diseases, The most important and useful objective is to supply continuously meat for long term manned space mission in the far future, Optimum use of resources, Prevents extinction of animal species. Techniques Adopted for in-vitro Meat Production, Self-organizing technique given by Benjaminson (2002), Scaffold technique discovered by Van Eelen, embrace a Dutch patent for this general approach to producing cultured meat. New startups, Mosa meat- by Dr. Mark Post, Super meat- by Israeli company, Memphis meat- silicon valley startup by cardiologist. Controversies, U.S. Cattlemen's Association submitted a petition to USDA (2018), Issues raised by Friends of the Earth. Work in INDIA. Humane Society International India and the Centre for Cellular and Molecular Biology in Hyderabad have joined together in an effort to create clean meat in India by 2025. Being advantageous it is costly, there is need of highly trained professionals, Technical unemployment, Variability in sensory attributes. Conclusion, Better for sustainable approach, Current meat production methods are associated with many problems, This in vitro technique can solve these hurdles but still this technology is in infancy stage so require more research

TPL-20

EXTRACTION OF BIOACTIVE PEPTIDE FROM CHICKEN INTESTINE

**E. Vimal Raj, R. Ramani, V. Appa Rao, M. Parthiban, R. Narendra Babu and
Bhagyashree Ojha**

Department of Livestock Products Technology (Meat Science),
Madras Veterinary College, Chennai.
Tamil Nadu University of Veterinary and Animal Sciences (TANUVAS)

The study was conducted to extract the bioactive peptides from chicken intestine by enzymatic hydrolysis followed by ultra filtration. The protein rich sediment was separated from clean intestines and subjected to enzymatic hydrolysis by using protease P. The hydrolysate was filtered and separated into small molecular weight fractions by ultra filtration using 10 kDa and 3 kDa molecular weight cut-off to enrich specific hydrolysate fractions. These were assessed for bioactivity by DPPH radical scavenging assay for anti-oxidant activity and by α -amylase assay for anti-diabetic activity. The results of DPPH radical scavenging assay between hydrolysate and extracted peptides were compared with standard butylated hydroxyl toluene (IC_{50} value- 0.23 ± 0.3 mg/ml). The bioactive peptides of <10 kDa (IC_{50} value- 0.15 ± 0.0 mg/ml) exhibited better activity than hydrolysate (IC_{50} value- 1.45 ± 0.0 mg/ml) and the peptides of <3 kDa (IC_{50} value- 1.90 ± 0.8 mg/ml). This indicated that lower the IC_{50} value higher was the potency of the peptides to exhibit better antioxidant activity. Thus the extracted peptides of <10 kDa were found to have better antioxidant activity than standard butylated hydroxyl toluene, which is a commercially used antioxidant in the food industry. The results of α -amylase inhibitory activity assay between hydrolysate and extracted peptides were compared with standard acarbose (IC_{50} value- 158.42 ± 10.1 μ g/ml) which was drug for type 2 diabetes mellitus. The hydrolysate exhibited better activity (IC_{50} value- 273.04 ± 23 μ g/ml) than peptides of <10 kDa (IC_{50} value- 959.0 ± 8.1 μ g/ml) and <3 kDa (IC_{50} value- 362.0 ± 23 μ g/ml). This indicated that lower the IC_{50} value higher was the potency of the peptides to exhibit better antidiabetic activity. This study concludes that by-products like chicken intestines can be effectively utilized for extraction of bioactive peptides and further utilisation in nutraceuticals and therapeutic industry.



TPL-21

COMPARISON OF PHYSICOCHEMICAL PROPERTIES OF KERATIN EXTRACTED FROM CHICKEN AND TURKEY FEATHERS

**G. Pardhu, D. Santhi, V. Appa Rao, T.A. Kannan,
R. Narendra Babu and C.Vasanthi**

Department of Livestock Products Technology (Meat Science),
Madras Veterinary College, Chennai-7, (TANUVAS)

A study was conducted to standardize a viable protocol for keratin extraction from chicken and turkey feathers by chemical method, and study the physicochemical properties of the extracted keratin. The highly cross-linked structure of feather with numerous di-sulphide bonds were hydrolyzed by alkaline hydrolysis using sodium hydroxide (2.5% for chicken feathers and 5% for turkey feathers) for keratin extraction. The keratin extracts were dried and evaluated for physicochemical characteristics such as pH, yield, protein, instrumental color analysis, solubilization time and isoelectric pH. The yield of keratin extracted from chicken feathers was significantly ($P<0.05$) higher (40.34%) than from the turkey feathers (22.97%). The protein content of keratin extracted from chicken feathers was significantly ($P<0.01$) higher (81.24%) compared to turkey feathers (70.82%). The pH was significantly ($P<0.01$) higher and the isoelectric pH was significantly ($P<0.01$) higher for keratin from chicken feathers than that from the turkey feathers. The solubilization time of chicken feathers were significantly ($P<0.01$) lower than turkey feathers. In hunters colour analysis, lightness (L^*) and hue values were significantly ($P<0.01$) higher in keratin extracted from turkey feathers, whereas redness (a^*), yellowness (b^*) and chroma values were significantly ($P<0.01$) higher in keratin extracted from chicken feathers. The results of the study revealed that keratin prepared from chicken feathers had higher yield and higher protein content than the keratin from turkey feathers. Also, the time taken for solubilization is lesser for hydrolyzing chicken feathers compared to turkey feathers. Hence, it is concluded that the chicken feathers will serve as a viable source for keratin, a protein which has numerous commercial applications. In addition, keratin extraction will also be a solution for the disposal of chicken feathers.

TPL-22

PHYSICO-CHEMICAL AND MOLECULAR CHARACTERISTICS OF CHONDROITIN SULPHATE EXTRACTED FROM BOVINE TRACHEA

**G.N. Nithin Kumar, V. Appa Rao, R. Narendra Babu, A. Vanathi, A. Munavara Sulthana,
Rongsensusang and S. Lidhiya***

Department of Livestock Products Technology (Meat Science),
Madras Veterinary College, Chennai- 600 007, (TANUVAS).

A study was carried out to extract the chondroitin sulphate from Bovine Trachea and evaluate its physical chemical and proximate composition. Chondroitin sulphate was extracted from Bovine Trachea using



0.25 % papain. The extracted chondroitin sulphate was dialysed, lyophilized and stored in refrigerator at 4⁰ C for analysis. The physico-chemical characteristics such as pH, yield, instrumental colour analysis, proximate analysis, SDS-PAGE were determined in lyophilized chondroitin sulphate. The concentration of chondroitin sulphate was estimated in lyophilized chondroitin sulphate by di-methylmethylene blue assay. The results of the study revealed that the pH and yield of the extracted chondroitin sulphate was 6.53±0.11 and 3.78±0.14% respectively. Lightness (L), Redness (a) and Yellowness (b) of the extracted chondroitin sulphate was 88.56±1.27, 3.89±0.34 and 15.90±0.70 respectively. The Hue and Chroma of extracted chondroitin sulphate was 76.37±1.43 and 16.37±0.76 respectively. The moisture, protein, fat, ash and concentration of extracted chondroitin sulphate was 6.13±0.13%, 55.83±1.31%, 21.74±0.14%, 6.58±1.15% and 37±5.13% respectively. The SDS-PAGE showed bands in lane 1 representing the protein marker in eight bands with the molecular weight of 196, 103, 58, 41, 28, 20, 15 and 6kDa in sequential order; whereas the extracted chondroitin sulphate in lane 2, lane 3 depicted a band with molecular weight of 6 kDa to 15 kDa. In the present study, the extracted chondroitin sulphate had the molecular weight between 6 kDa to 15 kDa. The extracted chondroitin sulphate can be used to prepare scaffold to use as a dressing material for wound healing.

TPL-23

INNOVATIVE TECHNOLOGY FOR COMPOSTING OF POULTRY FEATHER WASTE

Pavan M, Sathu T, Irshad A, Vasudevan VN, Athira P, Silpas S, Sunil B

Department of Livestock Products Technology
College of Veterinary and Animal Sciences, Mannuthy, Kerala.

Poultry industries produce a lot of feathers which are considered as waste and needs to be managed properly. Poultry feathers are rich with keratin protein and therefore they could be a source for good nitrogen fertilizer. Proper treatment of poultry feather waste might be an environmental friendly solid waste management tool and a good source of Nitrogen rich organic fertilizer. A drum of 180 kg capacity was taken, 2cm diameter holes were put with a gap of 7-10cms. The feather waste produced out of poultry slaughter at Meat Technology Unit was collected and weighed. Around 24 Kg of feather was mixed with chopped green grass (8Kg) along with 2kg cow dung was put into the aerobic composter. The compost was rotated at 3 days interval for 60 days. Feathers were examined for physical changes during composting. The feathers lost its strength by 20th day. The feathers were brittle and loose at 40th day and by 60th day, the compost turned black in colour. On 6th day of composting a characteristic reduction in volume of raw material loaded was noted and volume reduction around 50-60% of its initial volume and no much further reduction of volume was noted upto the 60th day of the study. The pH during composting period upto 60th day ranged 6.8-7.3 with moisture 30.33%. Different parameters like pH (6.8 – 7.3), Bulk density (0.16), Moisture (15-25%), Electric conductivity (0.055dSm⁻¹), Nitrogen (0.16%), Phosphorus as P₂O₅ (0.663%), Potassium as K₂O (1.11%), Organic Carbon (9.97%) and C/N ratio 1.46:1 were evaluated. The values were in agreement with the specifications of organic fertilizers (Schedule- IV Part- A of Fertilizer (Control) Order 1995).



TPL-24

**COMPARATIVE PHYSICO-CHEMICAL MEAT QUALITY
CHARACTERISTICS OF RAJASRI BIRDS WITH BROILERS**

G.V. Bhaskar Reddy, S. Shakeela, J. Indumathi, B.V.Vivekananda Reddy and Z. Naveen

Department of Livestock Products Technology, College of Veterinary Science,
Sri Venkateswara Veterinary University, Tirupati-517 502.

The present study was investigated on comparative physico-chemical, proximate and sensory characteristics of Rajasri male birds with broiler birds by conducting experimental trials at the Department of Poultry Science, College of Veterinary Science, Tirupati. A total of 6 birds were slaughtered at 24 weeks age for Rajasri birds and 6 weeks age for broiler birds each at Department of Livestock Products Technology, College of Veterinary Science, Tirupati. Physico-chemical, proximate and sensory characteristics were estimated in breast muscle of in both group of birds. It was observed that pH at 24 h and per cent water holding capacity (WHC) was significantly ($P<0.05$) higher in broiler birds meat than Rajasri birds meat. Breast muscle obtained from Rajasri birds recorded significantly ($P<0.05$) higher cooking yield and shear force value than muscle from Broiler birds. Muscle fiber diameter was significantly ($P<0.05$) higher in breast muscle of Rajasri birds than broiler birds. Moisture and crude fat percent were significantly ($P<0.05$) higher in broiler birds muscle than Rajasri birds. Crude protein and total ash percentages were found to be significantly ($P<0.05$) higher in Rajasri birds muscle than broiler birds muscle. Sensory scores viz., colour, flavour, juiciness, tenderness and overall acceptability varied significantly ($P<0.05$). Rajasri birds muscle scored significantly ($P<0.05$) higher colour and flavour scores than broiler birds. Broiler birds muscle scored significantly ($P<0.05$) higher juiciness, tenderness and overall acceptability scores than Rajasri birds muscle. Based on the obtained results in this study, it can be concluded that the physico-chemical and proximate characteristics and sensory scores were comparable in breast muscles from both Rajasri and Broiler birds.

TPL-25

**EXTENSION METHODOLOGY IN CREATING AWARENESS
TOWARDS CONSUMPTION OF MEAT AND MEAT
PRODUCTS**

K.Vijay Prakash, Debashis Ganguly and Arunasis Goswami

Department of Veterinary and Animal Husbandry Extension Education, WBUFAS, Belgachia

The livestock sector is poised for revolution in developing countries where the major increase on meat and milk are anticipated. They provide milk, meat, draft power, hides and skins and other valuable by-products. They significantly contribute to sustainable human nutrition and economy of the nation. The majority of meats consumed in India are fish, bovine, mutton, goat, pig,



and poultry. In Indian context, culture, traditions, customs, and taboos influence meat consumption to a great extent. International competitiveness in livestock products will be influenced considerably by the preparedness of individual countries to take advantage of the opportunities opened up by the agreements under Uruguay round. Surplus male and unproductive animals end up as meat animals. Meat production in India, except in case of broiler industry and the meat from culled layers in organized farms, are all in the traditional production systems with little investment. Extension at Producer/Farmer Level are: training of farmers and entrepreneurs on export quality standards and phytosanitary requirements, training on Fair Average Quality Standards (FAQ) for livestock products, sensitization training to middle level extension functionaries to improve their technical and professional knowledge and skills. Thus, consumers who purchase fresh or frozen non-processed meats such as beef, pork, chicken and fish normally rely on personal dietary knowledge. For many, meat is the main course of each meal. The US tops the world in per capita consumption of meats.



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Key Note Addresses

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VALUE ADDED MILK PRODUCTS : A BOON FOR RURAL UNEMPLOYED YOUTH

Y. Kotilinga Reddy¹ and G. V. Bhaskar Reddy²

¹Associate Dean and Dairy Technology Specialist, College of Dairy Technology
Sri Venkateswara Veterinary University, Tirupati-517502. A.P, India.

²Assistant Professor and Head, Department of Livestock Products Technology,
College of Veterinary Science, Tirupati, Andhra Pradesh-517 502.

I. Introduction

India is the highest milk producing nation in the world. The milk production has been increased from 24 million metric tons in the year 1950 to 176.35 million metric tons in the year 2017-18 with annual growth rate of 6.6% by reaching an enormous growth in milk production to cater to the needs of the Indian population and become self sufficient, surprisingly becoming the exporter of SMP. The per capita availability of milk is 359 grams in the year 2017, slightly greater than the world's average. The share of milk and milk products in food expenditure is 17% and is after that of cereals. The maximum growth for milk in demand for food products among all others during the year 2000-20 is 159%, this indicates that preparation and marketing of milk and milk products is having a very good scope for dairy entrepreneurs in India.

Milk as it is or milk with value addition by converting them into milk products which can be easily marketable to get better price for the produce. The dairy producers especially rural women, unemployed rural youth or as such the milk producing farmers can establish a small dairy as an enterprise for getting more profits utilizing available technology. The reasons for the unemployed youth to take up preparation and marketing of milk and milk products as dairy business are:

- Availability of surplus milk during the flush season at reasonable cost
- Crop failure alternatively the best is the milk business
- Regular income like an employee's unlikely agriculture as annually
- Low capital
- Self-employment
- Value addition for the milk products
- Local available materials can be used for production of milk products
- Locally available fuel can be used for production of milk products
- Good market potential

II. Availability of milk: A prior survey can be conducted about the excess availability of milk in a village and has to be identified. It is better to form a cooperative society, collectively can purchase one Bulk Milk Cooler (BMC) which can utilized for preservation of milk immediately to prevent multiplication of bacteria by chilling milk to 4°C and can extend the shelf life of milk to 24 hours. Mean while the milk can be transported to the place where sufficient price is going to obtain. Otherwise milk can be sold on retail basis at local market or and be converted in to value added milk products.

III. Bulk Milk Cooler: Bulk tank coolers are run by mechanical refrigeration system which cools the milk rapidly. These coolers maintain the temperature automatically during storage. Milk can be poured directly from milking pails into the tanks. This method is suitable for handling 500-2500 lit milk/day. It is widely used at village level milk collection centers in India. From the Bulk milk cooler (BMC), the milk is pumped to the insulated tankers for transportation to dairy plants. The BMC may be horizontal or vertical cylindrical tanks with inner jacket and insulated body on the other side. There is provision of inner shell of the tank or direct expansion refrigerant coil for cooling. Milk is directly poured into the tank or pumped into the tank. Milk remains in contact with the inner shell of the tank cooling it to 4°C. The agitator is provided for uniform cooling. The cost of 500 liter capacity is Rs.4,50,000 of Venture steels Pvt. Ltd. Pune.



Fig. 1. Storing milk in Bulk Milk Coolers

A. Sale of Whole Milk : The milk as such whole milk as cow (4% fat and SNF 8.5%) or buffalo milk (5% fat and SNF 9%) can be sold by packing in the sachets using hand sealing at farmers house or in established milk depot or centre at local market place which is highly profitable or the milk can be standardized for production of toned, standardized or full cream milk then pasteurised, packaged, chilled and marketed industrially using cream separator, BMC, pasteurization plant, cold store and organised marketing system.



Fig.2 Selling Raw Milk



Fig.3. Selling Pasteurized milk sachets

After the local sales the left over milk, normally the fresh surplus milk or milk preserved in bulk milk cooler can be utilized effectively by converting into value added products.

B. Cream: The surplus milk left over even after selling the fresh milk or sub-standard milk or returned milk can be subjected for cream separation for recovery of milk fat in the form of cream using cream separator. Further, during the standardization in the production of toned and double toned milk some amount of excess fat can removed from milk by cream separation process will be utilized for the production of consumer cream products or butter or ghee used for culinary preparations (Cream separator capacity of 165 liters per hour the approximate cost is Rs: 23,000 and is available at M/s. Suryoday Engineering Co. Ahmadabad, Gujarat).

Fig.4. Cream separator



Fig. 5. Cream and Skim milk



Fig.6. Cream



Procedure:

- Clean all parts of the cream separator and assemble the bowl
- Place the bowl over the spindle and cover the system
- Switch on the separator and allow to attain maximum speed
- Take hot water (at 80°C) in to the supply tank
- Allow the hot water to run through the bowl to clean and pre-heat the bowl
- Heat (warm) the milk to 45 to 50°C and transfer to the supply tank
- Open the valve and allow the hot milk to enter the bowl
- Collect the cream and skim milk in separate containers (cream:skim milk is 10:90)



- At the end of the operation allow hot water to run through the bowl
- Dismantle the bowl and clean all parts with detergent solution, rinse with hot water and allow to air dry

Uses of cream: Cream for making ice-cream factories; Cream for dressing and decorating cakes in baking shops; Cream for preparation of butter; Butter can be converted into ghee and can sell.

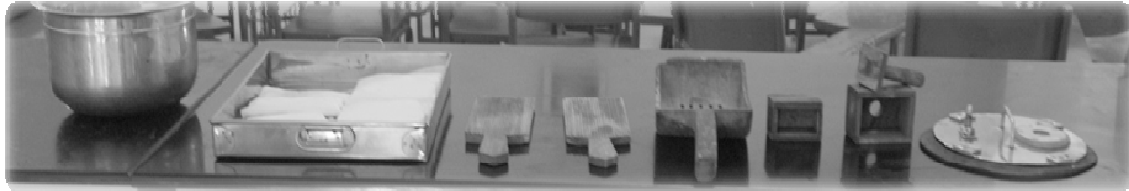
C. Preparation of butter (cooking butter / unsalted butter): The basic raw material for the preparation of butter is cream.

- Standardize the cream to 35-40% fat and pasteurize (heat) at 80-82°C for 5-8 minutes
- Cool cream to 7-10°C and store overnight at refrigerator
- Transfer the cooled cream in to the butter churn and fill the churn to 1/3rd of its capacity
- Lock the door and allow the churn to rotate at speed of 45 revolutions per minute
- Stop the churn and press the air vent valve for few times (5 minutes intervals) during the early stages of churning
- Allow the churn to until the watch glass appears clear. This indicates that the emulsion is broken and fat granules are separated from the serum.
- Stop the churn and add break water (10-15% of cream) at 2°C lower than butter milk into the churn
- Allow the churn to rotate for few minutes to develop the butter grains to suitable size
- Stop the churn and drain the butter milk using strainer.
- Add chilled water (wash water) equal to the quantity of butter milk removed in to the churn
- Allow the churn to rotate at slower speed (15 rpm) for 5 minutes to wash the butter grains of excess butter milk
- Stop the churn and allow the wash water to drain
- Allow the churn to rotate at the speed of 6-8 rpm for working of butter for about 20-30 minutes
- Stop the churn open the door and collect butter in plastic tubs.
- Butter is usually filled into the butter moulds contained printing facility immediately after being removed from the churn and then printed and wrapped in polyethylene, butter papers, vegetable parchment paper or plastic cups or tubs with lids or metal cans may be used for marketing
- Normally the butter can store the butter at -6 to -8°C. However, the temperature of commercial storage of butter ranges from -23 to -29°C for one year.

D. Preparation of ghee : Ghee is the pure clarified butter fat prepared chiefly from cream or desi butter to which no coloring matter is added. Ghee is characterized by its pleasant, cooked and rich flavor. The preferred texture is of large uniform size grains having non-greasy consistency. One of the best and easy method to prepare ghee at households by utilizing the surplus milk, converting into curd there by churning the curd to get butter which in turn converted into ghee by melting in a vessel at controlled conditions and the left over butter milk is utilized for the household purpose and may distributed to the neighbors. This can be achieved when the surplus milk is up to 10 liters. If the quantity of milk is more than this quantity the milk will be

subjected to cream separation and obtained cream can directly converted into ghee of by converting into butter and then to ghee.

Fig. 7. Preparation of butter with cream using S.S Churn of 5 liters capacity



Procedure:

- Ensure the gas operated multipurpose vat is clean and dry
- Place either cream or butter in the vat and heat at low flame with continuous stirring
- Allow the content to boil slowly and avoid over flowing due to foaming
- Observe for first foaming and second foaming
- Notice the crackling sound. As soon as it subsides reduce the heating process
- Continue heating the contents until second foam subsides and residual content start browning
- Control the temperature in the range of $114^{\circ}\text{C} \pm 2^{\circ}\text{C}$
- Allow the contents to cool to $75-80^{\circ}\text{C}$
- Decant the clarified fat in to a clean and dry container
- Filter the contents through dry filter cloth
- Hang the cloth cover the container to collect remaining ghee from the ghee residue

- After some time squeeze the cloth to recover entrapped ghee
- The ghee obtained is subjected for cooling and granulation to get large size granules by keeping the ghee at 30°C by slow cooling
- The ghee is packed in non transparent metalized polyester packs or polyethylene packs or in laminates or in tins or glass bottles



Fig. 8. Preparation of Ghee in multipurpose vat and packing in glass bottles

Storage : Ghee should not be store in refrigerator it leads to loss of granularity and develops the waxy or pasty consistency. A storage temperature around 21°C is usually recommended

E. Utilization of skim milk: The skim milk obtained after cream separation of surplus fresh milk is utilized for preparation of low fat curd, low fat butter milk and low fat flavored milk. Further, the little sour milk (Stored milk or morning milk used at afternoons) can be utilized for preparation of kalakhand a milk sweet with grainy texture with little sour taste.

F. Utilization of unsold milk for value added milk products: The whole fresh surplus milk can be converted into the various value added milk products like Doodhpeda, Gulabjamun, Rasogolla, Panner, Kulfi, Badam milk, Spiced butter milk, Lassi, Dahi (curd), Basundi, Rasamalai and Milk agar cake etc..for more profits.

1. Doodh Peda / Khoa / Palgoha : The most common delicious milk sweet of South India highly appreciated having and good marketing both in rural and urban areas is doodhpeda commonly called as khoa. The basic raw materials are fresh raw milk preferably buffalo milk and sugar.

Description : Khoa is obtained by boiling (buffalo milk preferable) in large open bowl-shaped metal frying pan with two handles called karahi, resembling the Chinese work. The liquid milk is stirred at first and later its solidified portion is constantly scraped with a long-handle flat-edged metal scraper called 'Khunti' to prevent caramelization. The light brown mass is finally shaped into a large ball or small pats. Though naturally sweet, khoa is sometimes further sweetened with sugar (one-fourth of its weight) to yield burfi and flavored with cardamom to make peda. Khoa from batch sizes 200-500 kg milk is produced in the countryside where milk is plenty is available at relatively low cost. It is then shipped to urban centers for use in making sweets.

1. Iron karahi (pan) and khunti: To market 5 to 10 kg khoa ordinary iron pan with Khunti is sufficient and fuel may be LP gas or husk challa. The obtained khoa may be packed and the labels may be pasted on the lids and product is sent for marketing. The normal shelf life at room temperature under hygienic production will have 7 days.

2. Khoa making machine (Multi-purpose vat): This is a gas operated machine with a hot base plate, Teflon scraping assembly for scraping of milk for concentration without browning and run with a motor. The capacity is 20 litres milk per batch. However, the obtained doodhpeda has found to be gummy due to continuous scraping for longer time. The time taken for production of Khoa is 1½ hrs by using 20 litres of milk. The cost of equipment is Rs.49,000/- and address for availability is M/S. Solar Arks, Kolhapur.

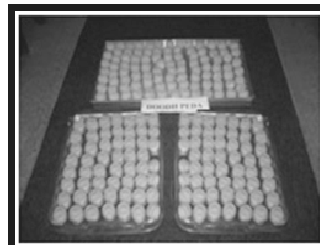


Fig.9. Khoa preparation by multipurpose vat with 20 liters of milk as small scale industry

3. Steam operated khoa pan: Steam operated Khoa pan is more economical compared to gas operated Khoa machine by utilizing less energy. Further, it is observed that the time taken for conversion of 25 liters of milk into Khoa is only 20 minutes and the Khoa is grainy in texture without any gumminess with acceptable flavour and colour. The production of steam is brought out by using a boiler either it may work with diesel or coal or fire wood. It is a saucer type khoa pan. 120 liters capacity tilting type 'Khoa' making machine made out of inner surface (pan) SS 304 6 mm thick plate, steam jacket pan made out of MS 6 mm plate and insulated cover made out of MS 2.5mm thick sheet along with accessories. The pan would be resting on 4 numbers of fabricated frames. The cost of equipment is Rs. 1,25,000/- and address for availability is Autec Industries, Adambakkam, Chennai.

2. Gulabjamun:

Introduction : Dhap khoa having 40-45% moisture is normally used for its preparation. Like over sweets, the manufacture of gulabjamun is also largely in the hands of halwais who adopt small scale batch method. The most liked gulabjamun should have brown colour, smooth and spherical shape, soft and slightly spongy body free from lumps and hard central core, uniform granular texture, mildly cooked and oily flavor, free from doughy feel and fully succulent with sugar syrup. It shall have optimum sweetness.

Method of preparation:

1. By using dhap khoa: The method of making gulabjamun from dhap khoa involves proper blending of 750g khoa, 250g maida and 5g baking powder to homogenous and smooth dough. Small amount of water can be added in case dough is very hard and do not roll into smooth balls. The mix should be prepared fresh every time. The small balls formed from the dough are deep dried in ghee to golden brown colour and subsequently transferred to 60% sugar syrup maintained at about 60°C. It takes about 2 hrs for the ball to completely absorb the sugar syrup.

2. By using skim milk powder based gulabjamun mix: This formulation consists of skim milk powder 43.4%, maida 25%, suji or ravva 15%, butter-fat/vanaspati 15%, baking powder 1.5% and powdered cardamom 0.1%. All the ingredients are mixed uniformly in a power driven mixer or mixed by hand. Fat, after melting, is incorporated slowly to ensure thorough mixing. The mix is packaged in printed polyethylene bags



or laminated pouches and stored in a dry place. To make gulabjamun, 100 grams of the mix powder is mixed with 50-55 ml of water or milk to make dough, and the rest of the procedure is the same as for traditional gulabjamun.

Conclusion: For startups dairy business is having a lot of scope with good expansion. This business can be taken up at any level of capital investment by the unemployed youth and rural women. Conversion of milk into value added milk products at farmers level with available infrastructure one can earn a high amount of income. For doubling the income of the farmers utilization of surplus milk by getting supporting price is the current demand for all. To meet the challenge, on one way to develop the technical skill for production and marketing of value added milk products to the rural youth and women, at the same time better utilization of milk by getting supporting price to the farmers for the produce. Value added milk products are playing crucial role for prevention of poverty and improve the rural economy.

(Reference will be available from author)



Session-II : Key Note Address-02

**INNOVATIVE AND READY TO EAT PRODUCTS
FROM FISH AND SHELLFISH**

K. Dhanapal¹, T.V. Ramana², K. Sravani³, P. Hari Babu⁴ and G.V. Bhaskar Reddy⁵

¹ Professor and University Head, Department of Fish Processing Technology,
College of Fishery science, SVVU., Muthukur, Nellore (Dist), A.P

² Dean, Faculty of Fishery Science, Sri Venkateswara Veterinary University, Tirupati

³ Assistant Professor, Department of Fish Processing Technology,
College of Fishery science, SVVU, Muthukur, Nellore (Dist), A.P

⁴ Associate Dean, College of Fishery Science, SVVU, Muthukur, Nellore (Dist), A.P

⁵ Assistant Professor and Head, Department of Livestock Products Technology,
College of Veterinary Science, Tirupati-517 502, Andhra Pradesh.

Fisheries make an important contribution to the world population by providing quality animal protein which is of great nutritional significance. The demand for fish is expected to exceed all available supplies in near future, owing to revolutionary changes taking place in the dietary habit of people all over the world and the consumers look at the fishery products as healthy foods. Further, fishery products have also become a major commodity in international trade and are a source of foreign exchange. Nowadays in fish processing industry Value addition is the most talked about word because of the increased opportunities and also for foreign exchange. A large number of value added and diversified fish products both for export and domestic market based on fish, shrimp, lobster, squid, cuttle-fish, bivalves.

Introduction

Consumer demand is a dynamic process that changes based on several factors. Recent changes include a gradual disappearance of conventionally processed products and their emergence in new forms and styles; processed products in ready-to-consume forms in consumer packs and products which can be made for the table with minimum preparation (ready-to-cook). Value addition is the enhancement added to a product or service by a company before the product is offered to customers. Products processed as 'Ready to eat', 'Ready to cook', 'Ready to fry', 'thaw & eat', 'Heat & Serve' and 'retail raw branded products' and other fishery pharmaceutical and cosmetic products of high unit value in export market are considered as Value Added Products.

During the financial year 2017-18, export of marine products reached an all-time high of US \$ 7081.55 million. Marine products crossed all previous records in quantity, rupee value and US \$ terms. Export for aggregated to 1377244T valued at Rs. 45106.80 Crores. In the first nine months of 2018, Indian shrimp exports to US were 175,838 tonne, against 151,010tonne in the corresponding period the previous year, and marked a growth rate of 16%.

Product Diversification

Product diversification always promotes price discrimination and enables us to realize maximum foreign earning. It further helps us to enhance the employment opportunities of coastal rural women. The emergence of value added products are accelerated by the current demand pattern of the major seafood markets in exporting countries. People have become more selective in their food choices and they are ready to spend more on food. All over the world the tendency now is to take convenience foods such as assembled



meals rather than preparing from basic ingredients. Heat and eat type of value added products have got considerable demand at retail level to the consumers who resist seafood because of its smell and cumbersome to clean and cook.

Besides exports, the internal demand for value added products is increasing in India. The introduction of microwave oven also helped to pick up markets for value added products. Today the affluent society has started switching over to value added products. Such a change is due to the result of fast food concept and general trend to move from deep fry to oven able packs. Some diversified seafood products which are of recent origin and have commercial acceptance both in export and domestic market are listed below:

1. Fillet and Fillet Blocks : Large sized conventional fishes could be filleted, glazed, individually frozen and wrapped. Some of these are good skinless fillets also. In the case of small fillets where individual freezing cannot be restored to, laminate blocks can be made for further processing into fish finger. The demand for fish fillets in preparing composite fillets, a number of small fillets are placed in a large fillet shaped mould and then compressed with low pressure to mould it to a single fillet piece. After freezing; battering and breading can also be done.

2. Fish steaks : Large sized fish could be sliced into thin steaks of uniform individually frozen and vacuum packed. The export of fish steaks are in increasing trend in recent years.

3. Ready to serve fish curry : Fish curry in ready to consume form, packed in metal cans or three-layer configuration flexible pouches is a value added product. Sardine, seer fish, mackerel, herring etc., usually serve as raw materials for this product.

4. Fish Soup Powder : Fish soup powder is a specialty product containing partially hydrolysed fish protein, carbohydrates, fat and several other seasonings including salt. It is prepared by blending processed fish meat with fried onion, coriander, starch, sugar, pepper, ascorbic acid, CMC, MSG to a thick paste. The paste is dried at 70°C and powdered.

5. Minced Fish Meat : Minced meat is the fish separated in comminuted from the skin, bones, scales and fins from the fish. Minced meat can be the base material for the preparation of number of products like fish sausages, cakes, cutlets, patties, fingers, balls, paste, Surimi textured products etc. The product has good domestic market. This is marketed as "Kheema" locally. Minced meat can be used for the preparation of fish fingers, fish balls, fish cutlets and can be coated with battering and bread crumbs. The products are flash fried at 175°C for 20 seconds, frozen and packed. Fish flakes is another product prepared from minced fish by blending minced fish meat with starch, salt and water and spreading the homogenised mass uniformly in aluminum trays in thin layer of 2 mm thickness and steamed for 3-5minutes, cooled to room temperature and cut to desired shape and dried to moisture content below 10%.

a. Surimi and Extruded products: Surimi is a Japanese term for mechanically deboned fish flesh that has been washed with water and mixed with cryoprotectants for good frozen shelf life. Surimi is used in the preparation of various products viz., Kneaded Products, Kamaboko products, Imitation products \ analog products (eg. crab leg, scallop and shrimp), Fish sausages.

b. Battered and Breaded Products: This is the most important class of value added products very much relished by the consumers as convenience food. These products are included in the value added products, because the process of coating with batter and bread crumbs increases the bulk of the product and thereby reduce the cost element. According to requirement, seasonings and spices can be added to the batter. To set



the batter, the products have to be flash fried, frozen immediately and held in frozen condition till it is taken out for cooking and serving. These products have high demand in the export as well as domestic market. Eg: Battered and breaded- peeled shrimp, fan tail, round tail on, battered and breaded - fish fillets, fish fingers, fish cutlets and fish patties.

6. Individually Quick Frozen Products: This innovation allowed the processor to supply the customer with frozen items in small ready to cook pieces instead of solid blocks, which had to be cut or thawed prior to use. High initial investment, maintenance, staff and skilled operation are the disadvantages. This product is suitable and convenient for the growing market in semi prepared ready to eat products. Different IQF products available in our country are a) shrimp – whole, peeled and deveined, cooked, headless shell on, butterfly fan tail; b) lobster - cooked lobster, lobster tails, lobster meat; c) squid – rings, tubes; d) Cuttle fish – fillets; e) Clam – boiled clam meat; f) fish fillets – skin less fillets. IQF products fetch better price than conventional block frozen materials in foreign market.

7. Heat processed products: Tremendous development has taken place in canning industry especially in the design and development of containers, canning equipment and nature and type of the products. Some of the containers of recent origin are retortable pouches, rigid plastic containers, aluminum cans, drawn and wall ironed (DWI) as well as easy- open cans with pull/ring tabs is carried out in overpressure autoclave of which many models are now available. Employment of hydrostatic cooker-sterilizer for heat processing high temperature short time process etc. is other innovation in the field of equipment / machinery for heat processing seafood. The product mix up in the heat process category of sea food includes several convenience ready- to- serve products such as fish curry, fish-in-rice etc the products are conveniently be processed in retort pouches using an over-pressure autoclave. Because of the smaller cross section profile of retort pouch such products need to be maintained only for a shorter time in the retort and hence temperature induced changes on the quality parameters of the product are minimum.

8. Extruded products: Extruded products like noodles, wafers, flakes, etc. from vegetable sources are well established in the consumer market. But fish based extruded products are yet to gain popularity. Extrusion is a process in which combination of shear, pressure and temperature leads to molecular transformation in the constituents and involves denaturation of the protein, fragmentation of the starch molecules and changes in the non- covalent bonds between protein, lipid and carbohydrate. Fish based extruded products have got very good marketing potential. Formulation of appropriate types of products using fish mince, starch etc, attractive packaging for the products and market studies are needed for the popularization of such products. The technology can be employed for profitable utilization of by catch and low value fish providing ample generation of employment opportunities.

9. Fish Sauce and Fish Salad: These are high value convenience foods packed in ready to heat and eat form. Fish fillets, tuna steaks, cuttle fish tubes, squid rings, cooked shrimp and clams are suitable for the preparation of such products and the sauces used include lemon butter sauce and Spanish tomato sauce. The main ingredients used in the fish salad are cooked fish, salad dressings, cooked macaroni and small quantities of onion, capsicum, celery, pepper and lime juice. These products are preserved by freezing. Since, it is a heat and eat product, it is desirable to pack such products in containers that can be heated in microwave ovens.

10. Accelerated Freeze-dried Products: Freeze drying in fish preservation is a recent development in fish processing and it is becoming very popular inspite of high cost of production, because of several other advantages associated with the product.



11. Fish Pickles: It is prepared by mixing fish meat (cut to consumable size) fried in oil, with the prepared gravy, allowed to mature for overnight in closed containers and packed in sterile glass bottles and sealed air tight, with a layer of oil floating on the surface of pickles. The gravy is prepared by mixing fried ingredients like green chilli, ginger and garlic with chilli powder, turmeric powder, at low flame.

12. Smoked masmin flakes: An innovative value added product has been developed using a new processing method by smoking and drying skip jack tuna meat which is similar to the commercially available masmin flakes. Major ingredients used for the product preparation are skipjack tuna and salt. Minced tuna meat is mixed with salt and liquid smoke, made into a paste and stuffed inside a stainless steel mold after which blocks are cooked and dried till the moisture reaches below 15%. Using a flaking machine masmin flakes are produced and dried again to get the product of moisture content below 10%. Flakes are then packed in polyester/polythene laminated pouches and stored at room temperature. Masmin flakes prepared by improved method have superior biochemical qualities compared to traditional masmin flakes.

13. Fish Kure: Fish Kure is a fish based extruded food product and have application as snack food. Usually, extruded products are prepared using cereal flour, which have less protein content and are limited in some essential amino acid. By incorporating protein-rich fish mince instead of cereal, the product is protein enriched snack food. The production process involves fish meat is mixed with cereal flours, spices and salt and extruded using a twin screw extruder. The dried and coated products are then packed in metalized polyester polyethylene pouches using nitrogen gas filling and the product is acceptable up to 3 months at ambient temperature.

14. Fibreized products: Fibreized products are the greatest in demand among the surimi based imitation shellfish products. The ingredients used in the formulation of fibreized products include, besides surimi, salt, starch, egg white, shellfish flavor, flavor enhancers and water. All the ingredients are thoroughly mixed and are ground to a paste. The paste is extruded in sheet form on the conveyor belt and is heat treated using gas and steam for partial setting. A strip cutter subdivides the cooked sheet into strings and is passed through a rope corner. The final product is formed by steam cooking of the colored and shaped material.

15. Shrimp products:

a. Breaded shrimp: Shrimp in different forms such as peeled and deveined, butterfly, round tail-on and cooked and peeled are coated with batter and bread crumbs and flash fried for 20 seconds at 180°C in refined vegetable oil. They are then frozen and packed in IQF form, preferably in thermoformed containers.

b. Stretched shrimp (nobashi): Increasing the length of peeled and deveined shrimp and minimizing its curling by making parallel cuttings at the bottom, and applying pressure using simple mechanical devices is a new technology adopted by the seafood processing industry in recent years. Increasing the length by about 1-2 cm depending on the size of the shrimp is possible by this method.

c. Barbecue: Bamboo stick is pierced into the meat from head portion to tail. It is packed in thermoformed trays under vacuum and frozen at -40°C.

d. Sushi: Cooked butterfly shrimp packed in thermoformed trays under vacuum and frozen at -40°C.

e. Skewered shrimp : 4-5 shrimps are arranged in a skewer in an inverted "U" shape. It is then packed in thermoformed trays under vacuum and frozen at -40°C.



16. Cephalopods and Molluscan Products

a. Squid Rings : Cleaned squid tubes are cut in the form of rings, cooked for 1-2 minutes in boiling brine (3%), cooled, battered, breaded and flash fried for 20 seconds.

b. Stuffed Squid : It is prepared from squid tubes. The tubes are filled with stuffing mixture prepared using cooked squid tentacles, potato, fried onion, spices, etc. The stuffed squid is then battered, breaded and flash fried.

c. Cuttle Fish Products : This is an important product where the dressed tube is opened, battered and breaded, frozen and stored.

d. Clam products : Clam meat is obtained from depurated clam which is blanched in brine, battered, breaded and flash fried.

Quality Control Aspects: In the light of HACCP regulations, the Government as well as the Industrialists have started paying proper attention to the quality standards of the export products. However quality maintenance in the internal distribution system of fresh and processed fish is much essential. Some of the simple quality control aspects which can be easily taken care to improve internal and external marketing systems are:

1. Fish and shellfish should be preserved properly immediately after catch.
2. Ice should be prepared from good quality water and used in proper ratio.
3. Handling areas and containers should be properly disinfected.
4. Proper drainage should be provided in markets and landing centres.
5. Fish should be protected from flies, rodents, insects, birds and animals..
6. Immediately after catch, fish should be sorted species wise. Shrimps shall be graded, deheaded, peeled and deveined as soon as possible.
7. The quality standards like fixing limits for heavy metals and microbial limits should be imposed.
8. The bivalves as far as possible should be depurated before shucking.
9. Sun drying on sandy beaches should be strictly stopped. While salting, only good quality salt should be used.
10. Quality of fish sold in domestic market should be assured.
11. Proper cost effective preservation facilities should be provided at all retail outlets.
12. Educate public as well as fisher folk about the need of sea food safety norms through proper extension strategies.

Recommendations

- Realization of the importance of Fish processing and value addition through training and demonstration.
- Establishment of pilot Fish processing plant with requisite infrastructural facilities at production centers of Fresh water fishes.



- Introduction of efficient transportation like refrigerated and insulated Trucks and wagons for rapid disposal of harvest to distant destinations of demand places.
- Strengthening of marketing infrastructure with development of new fish markets in the near and around areas of catchments.
- Avenues of finding viable markets at metropolitan and urban township of national importance.

Conclusion

Marketing of value added products is completely different from the traditional seafood trade. It is dynamic, sensitive, complex and very expensive. Marketing surveys, packaging and advertising are a few of the very important areas, which ultimately determine the successful movement of the innovative product. Most of the market channels currently used is not suitable to trade value added production. A new and an appropriate channel would be the super market chain. Appearance, packaging and display are all important factors leading to successful marketing of any new value added product. The retail pack must be clean, crisp and clear and make the contents appear attractive to the consumer. The consumer must be given confidence to experiment with the innovative product launched in the market. Packaging requirements change with product form, target group, market area, species used and so on. The latest packaging must also keep abreast with the latest technology.

(Reference will be available from author)

Lead Papers

Session-II : Lead Paper - 01

APPLICATIONS OF HIGH PRESSURE PROCESSING IN FOOD INDUSTRY

Dr. Sudheer K.P

Professor & ICAR National Fellow

Project Coordinator, Centre of Excellence in Post-harvest Technology

College of Horticulture, Kerala Agricultural University, Vellanikkara, Kerala-680 656

Introduction

The increased demand for high quality, natural and fresh foods free from preservatives and additives necessitates the development of alternative processing technologies that offer safe food to consumers. High pressure processing (HPP), also known as high hydrostatic pressure, is a non-thermal food preservation technique that has the potential to meet all these demands. It is an opportunity to preserve food, by applying intensive pressure in the range of 300-900 MPa, without adversely affecting organoleptic, textural and nutritional qualities as thermal processing like pasteurization and sterilization may do.

HPP was discovered in 1899 and has been used since in chemical, ceramic, carbon allotropy, steel/alloy, composite materials, crystal, diamond and plastic processing industries. Its use in the food processing area dates back over a century to the research of Hite in 1899 for the preservation of milk and later on fruits and vegetables. It was not until early 1990s, that the first commercial high pressure processed food were available with the launch of jellies and jams by the Japanese industry in Tokyo. In U.S., the first successful commercial high pressure processed product application was a guacamole dip manufactured by Fresherized Foods in Texas. Currently, other HPP products on the international markets are fruit juices, jams, jellies, rice cakes, and raw squid in Japan; fruit juices in France, Italy, United Kingdom and Portugal; and ready-to-eat meats and in-shells oysters in the USA; apple sauce in Canada etc. It is yet to be introduced in the Indian food industry sector which shows a booming growth trend.

Basic High Pressure Principles

Two main principles control the behavior of food under high pressure:

1. *Isostatic Principle*
2. *Le Chatelier's Principle*

Pressure is instantaneously and uniformly transmitted throughout the sample, independently of size and shape of the food, which is a major advantage compared to thermal processing (Smelt, 1998).

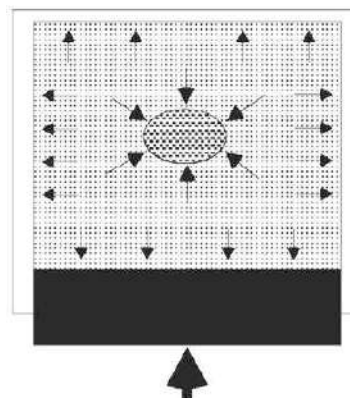


Figure 1. Isostatic Pressure

A uniform pressure will be applied uniformly in all directions of the sample, thus the pressure will not damage the product which will return to its original shape when the pressure has been released (Fig.1). This is known as isostatic pressure (Balasubramaniam *et al.*, 2008).

The fundamental effect of high pressure transmission is based on Le Chatelier's principle, which explains that when a constraint is placed on a system, the system will respond to minimise the effect of that constraint. This means that the application of high pressure will impose a volume constraint and enhance reactions with negative volume changes or negative activation volumes; this marks the distinction between high pressure and heat where free energy or activation energy are the more familiar terms (Johnston, 1995).

High Pressure Processing Equipment

Although the principles of HPP of food have been known since the late 1800s, it is not until relatively recently that the developments in engineering equipment design have permitted the use of HPP at the industrial level.

The primary components of a HPP system include the following:

- A pressure vessel of cylindrical design
- Two end closures for sealing the vessel
- A device for restraining the end closures (yoke, threads, and pin)
- A low pressure pump
- An intensifier which uses liquid from the low pressure pump to generate high pressure process fluid for system compression



Fig 2. A batch type HPP system under operation

- A system for controlling and monitoring the pressure and temperature and
- A product-handling system, usually perforated baskets, for transferring product to and from the pressure vessel (batch system).

High pressure vessels may operate in a vertical (Fig. 2), horizontal, or tilting mode. The pressure vessel can be built with two or more concentric cylinders. The cylinders should be made of stainless steel to avoid corrosion.

Current industrial HPP treatment of food is done using a batch or semi-continuous process; solid food can only be treated in a batch mode and need to be prepackaged, whereas liquid food can be treated in a batch (packaged food) or semi-continuous process (unpackaged food). The key components of a high-pressure system are the pressure vessel, pressurizing system, and ancillary components.

Pressure Vessel

A high-pressure vessel, in which products under treatment are subjected to pressure, is the key component of this technology. Pressure vessels are generally made of low alloy steel and are routinely used in the ceramic and metal industries. However, in the case of food applications, a unique requirement for the high-pressure vessel is that it must undergo several thousand processing cycles per year to process large volumes of foods. The large number of required pressurized and depressurized cycles increases metal fatigue and reduces the life of the vessel. Furthermore, the vessel itself must be protected from any corrosion due either to the food material itself or to any liquids used for cleaning, and must be easy to clean.



Pressurizing Systems

Two types of pressurizing systems defined as indirect and direct are commonly employed in the industry. In an indirect pressurizing system, the pressurizing medium (e.g., water) is first pumped through an intensifier, into the pressure vessel. An intensifier is a high-pressure pump used to increase the pressure to desired levels. The intensifier is separate from the high-pressure vessel. This system requires high-pressure tubing and appropriate fittings to convey the pressurized medium to the pressure vessel. In a direct pressurizing system, the pressure intensifier is located within the pressure vessel. In this system, both pressure intensifier and the vessel are fabricated as a single unit, and the total size of the vessel can be quite large. A piston is used to deliver the high pressure to the product. This system requires heavy-duty seals that must withstand repeated opening and closure without leakage. A major limitation of this method is the need for efficient seals between the pressure vessel and the piston.

In HPP, inert gases or water are the most commonly used pressure media. The relative incompressibility of water compared with gases makes it the preferred pressure medium in many applications. The decrease in volume of water is about 5 percent when its pressure is increased from 0 to 4000 Pa at 22°C. This volume reduction is much smaller compared with inert gases, where high volume reductions can make operations more hazardous. When water is used as a pressure medium subjecting food materials to high pressure, there is instantaneous and uniform transmission of the pressure throughout the product being treated. Typically, small amounts of oil may be added into the water for anticorrosive and lubricant purposes.

HPP time

HPP time is the total time required to undergo the processing of the food commodity taken into concern. In a typical HPP cycle, the food is loaded into a perforated basket that goes into the pressure vessel. The pressure is then increased to the processing target pressure (come-up time) and the product is held at the desired pressure for 3 to 10 minutes (pressure holding time). After this the pressure is released in usually few seconds (decompression time) and the product can be unloaded at this point (Balasubramaniam *et al.*, 2008).

Come-up time

It is the time required for the pressure of the treated sample to increase from the atmospheric pressure P_s (0.1MPa) to the processing pressure P_1 and corresponding temperature change from T_s to T_m (Figure.3). This time depends on the sample rate of compression, transmitting fluid rate of compression, power of the high pressure pump and target process pressure. Most high pressure equipments use one to three minutes pressure-come-up time to reach the process pressure. HPP is usually accompanied by a moderate temperature increase called adiabatic heating which depends on the composition of the food product being processed. The temperature of the water in the food increases by 3°C per 100 MPa, whereas the temperature of fats and oils increases about 8-9°C per 100 MPa.

Pressure holding time

The pressure holding time is the time between the end of the come-up time and the beginning of decompression i.e., from P_1 to P_2 and temperature T_m to T_2 . High pressure holding time is usually around three to ten minutes. For an economically effective commercial high pressure process, the industry should target reduced pressure holding times to maximize productivity. Other options that may help to reduce the processing time could be pulsed pressure processing (multiple compression-decompression cycles), combination of high pressure with temperature treatment or other processing technologies, or increasing the processing pressure.

Decompression time

The decompression time is the time required to bring the sample from process pressure, P_2 back to atmospheric pressure, P_s (0.1 MPa) and the temperature at this will be T_2 to T_f . Most high pressure equipments need just few seconds to depressurize.

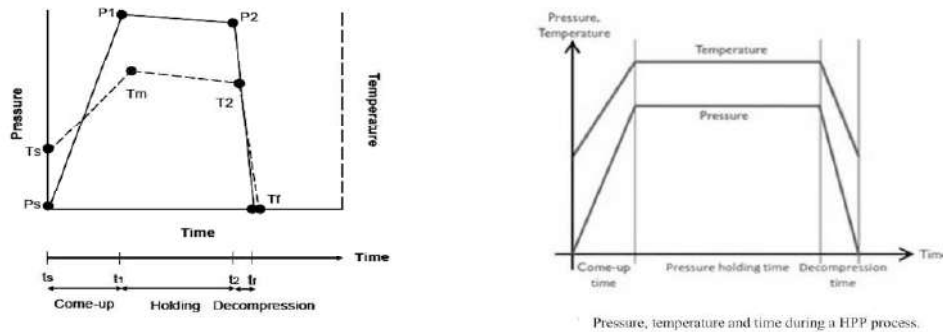


Fig 3. Pressure-Time-Temperature Curves for a Batch HPP Treatment

Effect of HPP on Safety

Processed / fresh foods have recently been associated with food borne disease outbreaks as per the centers of disease control and prevention such as cantaloupe *Salmonella* outbreaks in 2011 and 2008; alfalfa sprouts *Salmonella* outbreaks in 2010 and 2009. The effect of HPP on microbial safety, quality and sensory characteristics of these foods has therefore been widely investigated as an alternative to traditional food processing and preservation methods.

Microorganisms vary in their response to high pressure and indeed there can be vast high pressure sensitivity among bacterial species and even strains. Compared to vegetative cells, endospores tend to be extremely HPP resistant, requiring a combination of high pressure treatment at pressure exceeding 1000 MPa and heat treatment with a temperature of more than 80°C. Yeasts and molds are relatively sensitive to HPP. Most vegetative yeast and molds are inactivated within a few minutes by 300-400 MPa at room temperature. However, yeast and mold ascospores may require treatment at higher pressures. Viruses show a wide range of sensitivity in response to high pressure. The critical parameters which influence the microbial inactivation under HPP include both primary as well as secondary factors.

Primary factors

Besides type of microorganism, composition of suspension media or food, pressure level and treatment time, the critical parameters for high pressure induced microbial inactivation are pH, water activity (a_w) and the treatment temperature. Various combinations of these parameters have been investigated and the general rules are as follows:

- Microorganisms become more susceptible to pressure at lower pH and recovery of sub lethally injured cells is reduced. Further, sub lethally injured microorganisms induced by HPP can be reactivated in a nutrition-rich environment, but fail to repair at acidic conditions.
- A reduction of water activity exerts protective effect for microorganisms against pressure treatments.
- The treatment temperatures above or below room temperature tend to increase the inactivation rate of microorganisms.



Secondary factors

- The redox potential of the pressure menstruum.
- The medium of composition in which microorganisms are dispersed.

Packaging of HPP products

The most common packaging materials used for HPP food are polypropylene (PP), polyester tubes, polyethylene (PE) pouches, and nylon cast polypropylene pouches. PP materials are the best suited for HPP use because of their reversible response to compression, their flexibility and resiliency. Packaging materials for HPP must be flexible to withstand a 15% increase in volume followed by a return to original size, without losing physical integrity, sealing or barrier properties. The headspace must be minimized as much as possible in order to control the deformation of packaging materials and ensure efficient use of the package and space in the pressure vessel. Vacuum packaging is the most common method usually followed since it helps in reduced product destruction.

Advantages of HPP

- High pressure is not dependent of size and shape of the food.
- High pressure is independent of time/mass, that is, it acts instantaneously thus reducing the processing time.
- It does not break covalent bonds; therefore, the development of flavors alien to the products is prevented, maintaining the natural flavor of the products.
- It can be applied at room temperature thus reducing the amount of thermal energy needed for food products during conventional processing.
- Since HPP is isostatic (uniform throughout the food); the food is preserved evenly throughout without any particles escaping the treatment.
- The process is environment friendly since it requires only electric energy and there are no waste products.

Limitation of HPP

- Food enzymes and bacterial spores are very resistant to pressure and require very high pressure for their inactivation.
- The residual enzyme activity and dissolved oxygen results in enzymatic and oxidative degradation of certain food components.
- Most of the pressure-processed foods need low temperature storage and distribution to retain their sensory and nutritional qualities.
- The use of intense pressure in the range of 600-900 MPa may cause risk to the operators.
- Initial investment of the HPP equipment is huge due to its heavy mechanical parts for pressure generation etc.

Application of HPP in Meat Industry

The shelf life of fresh meat is increased with increase in pressure; however the meat takes a cooked appearance as the actomyosin denatures at about 200 MPa and the myoglobin denatures and/or co-precipitates

with other proteins at about 400 MPa. In addition, at pressures of 400 MPa and above the unsaturated lipids in the meat become more susceptible to oxidation, probably due to the release of iron from complexes present in meat and/or changes in the lipid membrane. Thus it is unlikely that many consumers would be prepared to buy such meat. However if pre-rigor meat is subjected to pressures of about 100–150 MPa, below those necessary to cause colour changes, it becomes significantly more tender than its untreated counterpart and this may now be a commercially viable process, given the decreasing cost of high pressure rigs. When treated at 100–200 MPa while the temperature is raised from ambient to around 60°C post-rigor meat also yields a tender product and this may also be a commercially attractive process to parts of the food industry, for example those involved in catering.

High Pressures of 101 MPa to 1013 MPa have been explored as potential food safety treatments for meat (Hugas *et al.*, 2002). The effects of extreme pressure on microorganisms are not fully understood, but substantial reductions (> 5 log cycles) in numbers of *Pseudomonas fluorescens*, *Citrobacter freundii* and *Listeria innocua* in ground beef have been demonstrated (Carlez *et al.* 1993), and high pressure treatment slowed the development of spoilage organisms during subsequent storage of ground beef (Carlez *et al.* 1994). Microbial reductions are enhanced when high pressure treatment is combined with mild heating or chilling, but colour changes were observed after 10 minutes of treatment. The use of pulsed high pressure could be more effective than continuous single application (Hayakawa *et al.* 1994). High pressure processing is a very promising technology for ready-to-eat (RTE) meats due to less/ no chemical addition and high retention of texture and flavour of the product.

Application of HPP in Dairy Industry

Hite (1899) was the first to report the effect of HHP on food borne microorganisms by subjecting milk to a pressure of 650 MPa and obtaining a significant reduction in the number of viable microbes. HHP improves rennet or acid coagulation of milk without any detrimental effect on flavour, body and texture and nutrients.

Application of HPP in Dairy Industry

Conditions	Product and Salient results	References
200-250 MPa	The combination of high pressure with bacteriocin such as lacticin resulted in synergistic effect in controlling microbial flora of milk without significantly influencing the cheese making properties	Morgan et al., (2000)
100-600 MPa/ 0-30 min at 20°C	Rennet coagulation time of heated milk decreased with increasing pressure and treatment time. The strength of the pressure treated coagulum from heated milk was considerably greater and the yield of cheese curd also found 15% greater than that from unheated /unpressurized milk; the protein content of the whey was 30% lower	Huppertz et al.,(2002)
200-400 MPa	Pressure treatment of cheese milk increased the yield of lowfat cheese by improving protein and moisture retention. Pressurization of pasteurized milk improved its coagulation properties. Cheese made from pressurized and pasteurized milk showed increased protein and moisture retention as well as improved coagulation properties. The protein degradation and development of texture and flavor was also rapid and the product had lower hardness and cohesiveness and higher sensory scores	Molina et al., (2000)
200-500 MPa/ 60 min, 20°C	Periodic oscillation of pressure was very effective for the destruction of pathogen such as <i>Listeria monocytogenes</i> , <i>Escherichia coli</i> and <i>Salmonella enteritidis</i> .	Vachon et al., (2002)
300-600 MPa	Increase in cheese yield by high-pressure treatment of cheese milk due to denaturation of whey proteins and increased moisture retention was also found. Higher moisture content of cheese made from high-pressure treated milk due to the fact that casein molecules and fat globules may not aggregate closely and may allow moisture to be trapped or held in cheese.	Drake et al., (1997)



Extended shelf-life and a "fresh-like" product presentation emphasize the need to take full account of food safety risks, alongside possible health benefits to consumers. These characteristics offer the dairy industry numerous practical applications to produce microbiologically safe and minimally processed dairy products with improved characteristics. Some studies in the dairy sector are briefed in the table given below. This shows that HHP is a powerful tool to develop novel dairy products of better nutritional and sensory quality, novel texture and increased shelf-life.

HPP effects on Microbial Efficacy

High-pressure treatments, in general, are effective in inactivating most vegetative pathogenic and spoilage microorganisms at pressures above 200 MPa at chilled or process temperatures less than 45°C, but the rate of inactivation is strongly influenced by the peak pressure (Patterson, 2005; Lau and Turek, 2007). Commercially, higher pressures are preferred as a means of accelerating the inactivation process, and current practice is to operate at 600 MPa, except for those products where protein denaturation needs to be avoided. The pressure resistance of vegetative microorganisms often reaches a maximum at ambient temperatures, so the initial temperature of the food prior to HPP can be reduced or elevated to improve inactivation at processing temperature (*i.e.*, temperature at pressure). Mechanisms of bacteria inactivation have shown that HPP can interrupt cell reproduction and functions by membrane damage and cellular effects on the fluid transport of nutrients (Torres and Velazquez, 2005). Furthermore, microbial enzymes can be denatured due to structural damage or activated given the appropriate conditions. The extent of inactivation also depends on the type of microorganism, food composition, pH, and water activity. Gram-positive bacteria are more resistant than gram-negative, and generally speaking the larger and more complex the organism, the easier it is to inactivate. HPP causes damage to cell membranes and denatures some intracellular proteins leading to cell death.

Reduced water activity, however, tends to inhibit pressure inactivation with noticeable retardation as the water activity falls below ~ 0.95. Depending upon the pressure temperature dose delivered, the process can also sub-lethally stress or injure bacteria. When validating an HPP pasteurization process, sufficient time after treatment should be allowed to confirm that sub-lethally injured organisms do not recover, and a nonselective microbiological media should be used to detect all viable organisms of concern during post-treatment storage.

Most yeast are inactivated by exposure to 300–400 MPa at 25°C within a few minutes, however, yeast ascospores may require treatment at higher pressures. Pressure inactivation of molds follows a pattern similar to yeast. Among viruses, the high degree of structural diversity is reflected in their wide range of pressure resistances (Smelt, 1998). While some human viruses appear more pressure-sensitive, other viruses such as polio virus are pressure resistant. Most viruses can be eliminated by pressure treatments designed for eliminating bacteria of concern, but virus inactivation has not been as extensively researched as microorganisms. Bacterial spores can be difficult to inactivate using HPP, and require higher pressures, process temperatures, and holding times as compared to vegetative cells. Bacterial spores are often resistant to pressures above 1,000 MPa at ambient temperatures. *Clostridium botulinum* strains have been identified as the most pressure-temperature resistant pathogenic spores. Among the nonpathogenic spores studied, *Bacillus amyloliquefaciens* spores have been reported to have high pressure-heat resistance (Ahn *et al.*, 2007). More research is needed to characterize the combined pressure-thermal resistance of pathogenic and spoilage microorganisms as a function of the food matrix, pH, and water activity. Standardized reporting of process conditions, equipment, and microbial techniques utilized are needed in developing a comprehensive database of inactivation kinetics (Balasubramaniam *et al.*, 2004).



HPP effects on proteins

A protein structure can be defined at four levels: the primary structure is characterized by the amino acid sequence joined by covalent peptide bonds, which determines the specific function of the protein in the metabolism (Fennema, 1996). The secondary structure is the three dimensional configuration of the secondary structures generally formed with non-covalent bonds between amino acid side chains. Finally, the quaternary structure is the spatial arrangement of the tertiary subunits, also held together by non-covalent bonds (Hendrickx *et al.*, 1998). Protein functionality can be modified by the surrounding environment and external factors.

At low pressures, covalent bonds are not affected and therefore nor is the primary structure of the protein. At high pressures, hydrogen bonds can be broken and therefore secondary structures can be affected (Cheftel, 1995). Pressure levels of 200 MPa or higher caused significant changes to tertiary structures, while quaternary structures are affected by pressures of 150 MPa or higher (Hendrickx *et al.*, 1998). Similarly Cheftel (1995) after applying pressures between 100 and 200 MPa concluded that in this region there could be partial unfolding or protein denaturation, aggregation or gelation, depending on the protein concentration.

HPP effects on enzymes

Enzymes are proteins with three-dimensional structures and active sites. Small changes in the active site can cause loss of their activity or functionality (Fennema, 1996). It has been found that high pressures can either activate or inactivate enzymes. A pressure activation effect can be described by decompartmentalization of intact tissues, resulting in the leakage of enzyme and substrate and increasing their contact. The result of this contact can induce catalysis or reaction depending on the pressure levels, types of enzymes, pH, medium composition and temperatures. For some enzymes a maximum pressure level at which they became inactive has been observed. To achieve greater enzyme inactivation, pressure should be applied in numerous cycles. (Hendrickx *et al.*, 1998)

HPP effects on nutrients and pigments

Most fruits and vegetables have been shown to retain quality attributes such as colour as well after pressure treatments as observed after blanching. This is because most covalent bonds are not affected by pressure, so pigments are preserved (Basak and Ramaswamy, 1998). Modeling of water soluble vitamins showed high retention (100% and 102%) of vitamin B1 and B6, respectively when treated to 600 MPa for 30 minutes at 20°C (Sancho *et al.*, 1999). Overall, Vitamin C levels in a multivitamin model appears to be more susceptible to degradation during high pressure processing, with 87.83% retention at 200 MPa and 88.58% at 600 MPa (Sancho *et al.*, 1999). Levels of vitamins were claimed to be fully maintained after high pressure treatments during 2 months of storage at 3°C (Donsi *et al.*, 1996). Furthermore, vitamin C, antioxidative capacity, sugar and carotene content etc. were highly preserved during high pressure treatments (500-800 MPa, 5 minutes). Similarly, no changes in the total concentration of lycopene or β - carotene in tomatoes were observed after 60 minutes of high pressure treatment at 600 MPa (Butz *et al.*, 2002).

Effect of HPP on colour, texture and flavour of fruit and vegetable based food products

Colour, flavour and texture are important quality characteristics of fruits and vegetables and major factors affecting sensory perception and consumer acceptance of foods. HPP could preserve nutritional value and the delicate sensory properties of fruits and vegetables due to its limited effect on the covalent bonds of



low molecular-mass compounds such as colour and flavour compounds. During HPP, different pressure and temperature combinations can be used to achieve desired effects on texture, colour and flavour of foods. The quality of high pressure processed fruits and vegetables can, however, change during storage due to coexisting chemical reactions, such as oxidation, and biochemical reactions when endogenous enzymes or microorganisms are incompletely inactivated. In addition, special attention is given to the possible impacts of HPP combined with elevated temperatures on those sensory properties.

The effect of HPP on Bioaccessibility

Sudheer *et al.*, (2011) studied the effect of HPP and thermal processing on the bioaccessibility of lycopene in tomato puree at various process pressures (450 MPa, 550 MPa and 600 MPa) and temperatures (20, 45 and 117°C). This was compared with the conventional thermal processing methods like high pasteurization (90°C for 10 min) and sterilization (117°C for 19.5 min). The results showed that increasing the duration and pressure of HPP decreased the bioaccessibility of lycopene content. HPP at 117°C and 600 MPa for 2.5 min decreased the bioaccessibility by 27.90%, followed by HPP at 45°C and 550 MPa for 20 min (16.44%), compared to the non processed puree. However bioaccessibility of high pressure treatment at 20°C and 450 MPa showed an increase in bioaccessibility of lycopene content. In contrast to this, thermal sterilization (117°C for 19.5 min) increased the bioaccessibility of lycopene by 26.59%, followed by strong pasteurization (90°C for 10 min), which was 12.75% compared to the non processed tomato puree. The results of the present study demonstrate that HPP of tomato puree is accompanied by both positive and negative effects. Increasing the pressure level resulted in a decrease in bioaccessibility of lycopene. It was hypothesized that the fibre network entrapped the lycopene present in high pressure tomato pulp, making it less approachable for digestive enzymes and bile salts.

Shelf life studies

Cloud loss is considered to be a major quality defect in orange juice. The effect of HPP (700 MPa, 1 minute) on cloud preservation and shelf life of freshly squeezed orange juice showed a 90 days shelf life under refrigeration conditions considering cloud preservation and microbiologically stable product. The odour and flavor of HPP navel orange juice was acceptable to trained sensory panel and consumer acceptance panel after storage at 10°C for up to 12 weeks.

Researchers found that in RTE meats pressure treated at 600 MPa at 20°C for 180 s, there was no deterioration in sensory quality, no difference in consumer acceptability, a 4 log reduction in *Listeria monocytogenes* in inoculated product and the refrigerated shelf life was extended (Hayman et al. 2004). Hugas *et al.* (2002) reported that HPP treatment (600 MPa for 10 minutes at 30°C) could extend the shelf-life of food including cooked ham, dry cured ham and marinated beef loins.

Houska *et al.*, (2006) evaluated HPP (500 MPa for 10 minutes) of apple- broccoli juice and noted that pressure inactivates more than 5 logs of the microbial population and preserves the content of sulforaphane, a compound that exhibits anticancer, antidiabetic and antimicrobial properties to broccoli. They also reported that the vitamin C content is independent of the pressure level but depends on the holding time and the sensory quality of the treated juice was similar to the frozen juice for up to 70 days of storage. The processing of orange juice with thermal as well as HPP showed good vitamin C retention during HPP than thermal processing with appreciable shelf life during storage.



Conclusion

The application of any new technology presents significant challenges to food technologists and food researchers. HPP offers the food industry a technology that can achieve the food safety of heat pasteurization while meeting consumer demand for fresher-tasting minimally-processed foods. In addition, other favourable organoleptic, nutritional and rheological properties of foods have been demonstrated following HPP, in comparison to heat processing. The retention of colour and aroma and the preservation of nutritive components offer enormous benefits to both the food processing industry and consumers. Also, from a food processing/engineering perspective, key advantages of high-pressure applications to food systems are the independence of size and geometry of the sample during processing, possibilities for low temperature treatment and the availability of a waste-free, environmentally-friendly technology. Application of HPP can inactivate microorganisms and enzymes and modify structures, while having little or no effects on nutritional and sensory quality aspects of foods. HP food processing is today being used on an ever-increasing commercial basis. Opportunities clearly exist for innovative applications and new food product development. Therefore, HPP allows the optimization of food manufacturing processes and also the production of novel foods.

(Reference will be available from author)



Session-II : Lead Paper - 02

BIOACTIVE PEPTIDES : FROM SCIENCE TO APPLICATIONS

Manish Kumar Chatli, S N Rindhe, R V Wagh, Amanpreet Kaur and Nitin Mehta

Department of Livestock Products Technology
Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana

1. Introduction

Recently, various reports suggested that there is a surge in the incidence of several common life style diseases; that are basically the NCD's i.e. the Non- Communicable Diseases; like that of the hypertension, cardio-vascular diseases, Obesity etc; These diseases have now become a serious concern globally. Health specialist emphasized on balanced diet and regular exercise. Diet is a very important component to combat life style diseases. Famous philosopher Hippocrates also postulated "Let food be thy medicine and medicine be thy food". This has brought the concept of Functional Foods and nutraceuticals. Functional foods are any food or food ingredient that may provide a health benefit beyond the traditional nutrients it contains.

Bioactive peptides are basically protein fragments consisting of 2-20 amino acid residues; with various biological activities including antioxidant, antimicrobial, antihypertensive, immunomodulatory, anticarcinogenic, anticoagulant effect. These peptides also play an essential role in the enhancement of mineral absorption & prove to be beneficial in the field of nutraceuticals & therapeutics too. Peptides within the sequence of their parent proteins are usually inactive, but can be liberated during enzymatic digestion or fermentation. Applying enzymes to modify protein is an efficient way to recover potential bioactive peptides. Once bioactive peptides are liberated they act as regulatory compounds with hormone like activity. Bioactive peptides are considered the new generation of biologically active regulators that not only prevent the mechanism of oxidation and microbial degradation in foods but also enhanced the treatment of various diseases and disorders, thus increasing quality of life.

Livestock products (milk, meat and eggs) are important component in human diet due to its known nutritive value. These are a rich source of proteins, conjugated linoleic acid, antioxidants, vitamins such as riboflavin, niacin, vitamin B₆, pantothenic and folic acid and numbers of minerals including iron, zinc, selenium and phosphorus. The proteins of animal products are of high quality and contain all the essential amino acids and high biological value.

These high quality proteins are a source of multifunctional bioactive peptides.

2. Motivations for bioactive peptide research

The increasing consumer awareness about functional food and their health promotion have motivated governments, researchers, health professionals, and the food industry to find solutions (Daliri and Lee, 2015). The high selectivity, efficacy, stability, safety, bioavailability and tolerability of bioactive peptides from food proteins is propelled by the readily available and inexpensive protein raw materials as therapeutics for human disease treatments and prevention. The essential properties of peptides like easy synthesis, optimization and evaluation as potential therapeutics for many diseases have attracted the attention of developing peptide based therapeutics in recent years. In line with this, there is remarkable increase in the number of approved therapeutic peptides on the market as researchers continue to develop new peptides using novel strategies.



3. Sources

3.1 Peptides from animal sources

Blood disposal is a severe problem for meat processors, serum albumin, and the main blood protein has received little attention. Blood is a valuable source of proteins (circa 20%) and represents a promising source of BP. Peptides derived from animal proteins have been attributed to different health effects (Bhat et al. 2015^b). In a recent study, serum albumin was hydrolyzed using different concentrations of trypsin and the peptide sequences in the hydrolysates presented the following activities: angiotensin-converting enzyme (ACE) inhibition (antihypertensive activity), DPP-IV inhibition (glucose regulation), and antioxidation (Arrutia et al., 2016). After in vitro GI digestions of bovine haemoglobin, 75 unique peptides were identified using low-resolution (LR) liquid chromatography (LC)-MS/MS analysis as well as 950 unique peptides by using high-resolution (HR) liquid chromatography (LC)-MS/MS (Caron et al., 2016).

3.2 Peptides from vegetal sources

Bioactive peptides found in soy milk samples could be formed during food processing (Capriotti et al., 2015). In vitro GI digestion of soybean seeds and soy milk were produced bioactive peptide (Singh et al., 2014). Cereal grains that have been used in human diets for a long time such as wheat, barley, rice, rye, oat, millet, sorghum, and corn, are rich source of bioactive peptides (Malaguti et al., 2014). The processing of fruits and vegetables generates a significant amount of waste material. Stones of fruits such as plum (*Prunus domestica* L.) are rich in proteins and may be a cheap source of bioactive peptide that could be useful for the food and pharmaceutical industries. González-García et al. (2014) developed a method for the extraction of proteins from a residual material from plum involving the use of high intensity focused ultrasound. The resultant extracted proteins were digested using alcalase, thermolysin, flavourzyme, and protease P enzymes and antioxidant and ACE inhibitory capacities of the hydrolysates were assayed. Alcalase was the enzyme showing the most promising extract for the isolation of antioxidant and potential antihypertensive peptides.

3.3 Peptides from food sources

3.3.1 Milk

Milk proteins have a range of biological activities like immunoprotective effect of immunoglobulins and antibacterial activity of lactoferrin (Lf) an iron-binding glycoprotein. The role of milk proteins is to supply amino acids and nitrogen to the young mammals and important part of dietary proteins for the adult (Sharma et al., 2011). Raw milk as well as dairy products like cheese are the greatest sources of bioactive peptides (Lemes et al., 2016 and Mohanty et al., 2016). Consumption of fermented milk containing BP has a blood pressure—lowering effect in hypertensive subjects. Milk proteins fermentation using lactic acid bacteria (LAB) is an innovative approach to generate bioactive peptide with low cost and positive nutritional image associated with fermented milk products (Hayes et al., 2007). Donkey milk is a valuable product for the food industry due to its nutraceutical, nutritional, and functional properties. Endogenous peptides derived from donkey milk have been investigated for their antioxidant and ACE inhibitory activities (ZeneziniChiozzi et al., 2016).

The most potent bioactive peptide originated from non-digested colostrum, which had only been subject to endogenous protease activity. Peptides from the permeate of bovine colostrum after dialysis or those generated by a simulated GI digest have been characterized and tested for bioactivity using murine intestinal (mICc12) cells and their bioactivities compared with the bioactivity of intact colostrum (Jorgensen et al., 2010).

Table 1: Milk Bioactive peptide with their amino acid sequence and bioactivity.

Sr. No.	Source	Peptide (AA sequence)	Bioactivity
1	<i>Lactobacillus rhamnosus</i> + digestion with pepsin	Asp-Lys-Ile-His-Pro-Phe, Tyr-Gln-Glu-Pro-Val-Leu	ACE inhibitory
2	<i>Lactobacillus helveticus</i>	Val-Pro-Pro, Ile-Pro-Pro	ACE inhibitory
3	<i>Lactobacillus GG</i> enzymes + pepsin and trypsin	Tyr-Pro-Phe-Pro, Ala-Val-Pro-Tyr-Pro-Gln-Arg, Thr-Thr-Met-Pro-Leu-Trp	Opioid, ACE inhibitory, immune-stimulatory
4	<i>Lactobacillus delbrueckii subsp., bulgaricus</i> . IFO13953	Ala-Arg-His-Pro-His-Pro-His-Leu-Ser-Phe-Met	Antioxidative
5	<i>Kluyveromyces marxianus</i> var	Tyr-Leu-Leu-Phe	ACE inhibitory
6	β -Casein derived peptides	Lys-Val-Leu-Pro-Val-P(Glu)	ACE inhibitory

(Source: Sanchez and Vazquez, 2017)

3.3.2 Meat

Bioactive peptide isolated from meat products has the potential for incorporation into functional foods and nutraceuticals. However, a limited number of food products containing meat derived bioactive peptide are commercially available (Ryan et al., 2011). Ryder et al., 2016 observed that bioactive peptide derived from meat shown to exhibit antihypertensive effects in vivo, along with antioxidant capabilities and other bioactivities such as antimicrobial and anti-proliferative activities in vitro. Pork meat constitutes a source of bioactive compounds that could be utilized in functional foods or nutraceuticals (Escudero et al., 2012).

3.3.3 Egg

Eggs which may find applications in medicine and food industry is an important source of many bioactive peptide may have potential applications for maintenance of dermal health and treatment of skin diseases as well as a source of valuable proteins in human nutrition (Sun et al., 2016). Bioactive peptides from egg proteins were identified, characterized and released in vitro or in vivo and the results have contributed to change the image of the egg as a new source of biologically active ingredients for the development of functional foods with specific benefits for human health and the treatment and prevention of diseases (Bhat et al., 2015^a). The Arg-Val-Pro-Ser-Leu Bioactive peptide obtained from egg white protein was chemically synthesized and bio assayed to show ACE inhibitory activity, as well as good stability in a simulated GI digestion (Yu, 2011).

4.1. Gastrointestinal digestion (in vivo)

Bioactive peptides may be released in vivo during gastrointestinal digestion by the action of digestive enzymes like pepsin, trypsin or chymotrypsin. Dietary proteins undergo denaturation in the presence of hydrochloric acid (HCl) secreted by the parietal cells of the stomach. This acid activates pepsinogen and converts it into its active form, pepsin. Pepsin acts on proteins to metabolize them to amino acids. Gastrointestinal digestion permits the consequent action of the enzymes present in the small intestine such as pepsin, trypsin or chymotrypsin, which are responsible for protein hydrolysis (Korhonen and Pihlanto, 2003). Several bioactive peptides viz., antibacterial (Mohanty et al., 2014), immunomodulatory (Gauthier et al., 2006), anti-hypertensive (Vermeirssen et al., 2004) and opioid peptides (Pihlanto-Leppala et al., 1996) are known to be released from casein and/or whey proteins by gastrointestinal digestion.



4.2 Microbial fermentation (in vitro)

Several lactic acid bacteria (LAB) (e.g. *Lactococcus lactis*) have been reported to release bioactive peptides by the process of fermentation. This system consists of a number of distinct intracellular peptidases including endo-peptidases, amino-peptidases, di-peptidases, and tripeptidases (Christensen et al., 1999). Recent studies have reviewed the production of various bioactive peptides including antimicrobial, immunomodulatory, antioxidative and ACE-inhibitory through microbial proteolysis (Gobbett et al., 2004).

4.3 Enzymatic activity

The most common way to produce bioactive peptides from milk is through enzymatic hydrolysis of the whole protein molecules. Digestive enzymes and combinations of different proteinases including alcalase, chymotrypsin, pepsin and thermolysin as well as enzymes from bacterial and fungal sources have also been utilized to generate bioactive peptides from various proteins.

5. Types of bioactive peptides and their role in human health

5.1 Antimicrobial peptides

Antimicrobial bioactive peptides derived from milk have been reported to inhibit many Gram positive and Gram negative pathogens including *Escherichia coli*, *Aeromonas hydrophila*, *Salmonella typhi*, *Bacillus cereus*, *Salmonella typhimurium*, *S. enteritidis*, *Staphylococcus aureus* (Mohanty et al., 2014) and control many microbial infections.

5.2 Immunomodulatory peptides

Recently many cyto-chemical studies indicate that the immunomodulatory bioactive peptides derived from both casein and whey proteins are related to the stimulation and proliferation of human lymphocytes, macrophage phagocytic activity, antibody synthesis and cytokine regulation (Clare et al., 2003)

5.3 Anti-hypertensive peptides or angiotensin-converting enzyme (ACE)

ACE inhibitors are di- or tri-peptides containing proline, lysine or arginine at their C-terminal end. Bioactive amino acid sequence displaying antihypertensive activity is mainly isolated from bovine and human caseins. ACE is a peptidyl di-peptidase enzyme having the capacity to cleave the carboxyl terminal end of the substrate that may regulate an increase in blood pressure by converting angiotensin I to an active peptide hormone angiotensin II. This stimulates the release of aldosterone, as a result of which sodium concentration becomes high and blood pressure goes up. But antihypertensive peptide is able to inhibit ACE to control increase of blood pressure (Korhonen and Pihlanto, 2007).

5.5 Antioxidant peptides

Several milk peptides also play a regulatory role in oxidative metabolism which is essential for the survival of cells and causes oxidative changes by producing free radicals. But when an excess of free radicals is released, they oxidize cellular protein, membrane lipid, DNA, and enzymes that cause shutting down of cellular respiration and mediate injuries including atherosclerosis, diabetes, rheumatoid arthritis and oxidative DNA-damage leading to cancer (Halliwell and Whiteman, 2004)

Milk-derived anti-oxidative peptides are comprised of five to eleven hydrophobic amino acids including proline, histidine, tyrosine or tryptophan in sequence which are widely distributed among caseins, soybean and gelatine in hydrolysis by proteolytic enzymes (Korhonen and Pihlanto, 2003). They may function by scavenging or preventing the formation of radicals (Wong and Kitts, 2003)

Table 2 : Anti-oxidative peptides derived from milk proteins

Sr. No.	Protein source	Enzyme	Peptide sequence	Antioxidative activity
1	Casein	Trypsin	Val-Lys-Glu-Ala-Met-Ala-Pro-Lys	Inhibition of enzymatic and non-enzymatic lipid peroxidation
2	Casein	Pepsin	Tyr-Phe-Tyr-Pro-Glu-Leu	Radical scavenging activity
3	β -Lactoglobulin (β -lg)	Corolase	Trp-Tyr-Ser-Leu-Ala-Met-Ala-Ala-Ser-Asp-IleTrp-TyrSer-Leu-Ala-Met-Ala-Ala-Ser-Asp-IleTyr-Val-Glu-Glu-Leu	Radical scavenging activity

6. Production and functionality of bioactive peptides

6.1. Enzymatic hydrolysis

The most common way to produce bioactive peptides is through enzymatic hydrolysis of whole protein molecules. The most prominent enzymes are pepsin, trypsin and chymotrypsin that have been shown to release a number of bioactive peptides both from different casein and whey proteins.

6.2 Microbial fermentation

Many dairy starter cultures are highly proteolytic. Formation of bioactive peptides can, thus, be expected during the manufacture of fermented dairy products. In fact, the release of different bioactive peptides from milk proteins through microbial proteolysis is now well documented (Gobbetti et al., 2007). Fermentation of milk with a commercial starter culture mixture of five lactic acid bacteria (LAB) strains followed by hydrolysis with a microbial protease increased ACE inhibitory activity of the hydrolysate (Chen et al. 2007).

6.3. Chemical synthesis

The main chemical methods for peptide synthesis are solution phase synthesis (SPS) and solid phase peptide synthesis (SPPS). SPS is usually carried out by coupling single amino acids in solution. Synthesis of long peptides is possible by first synthesizing short fragments of the desired peptides and condensing them to yield long peptides (Chandrudu et al., 2013). This method of SPS is called the fragment condensation method. In SPS, intermediate products can be deprotected and purified to obtain a high purity of the desired peptide (Carpino et al., 2003). SPS is inexpensive and can easily be scaled up, however, the long reaction time remains a drawback. It involves the synthesis of a peptide using resin as a support for the growing peptide chain. The reactive side chain and the alpha amino group of an amino acid are first protected and the C-terminus of the amino acid is attached to the resin (Stawikowski and Fields, 2012)

7. Applications of bioactive peptides

Bioactive peptides have attracted increasing interest as prominent candidates for various health-promoting functional foods. At present, milk proteins are the best known source of such ingredients but until recently the commercial production of milk derived bioactive peptides has been limited by alack of suitable large-scale technologies. Membrane separation techniques seem to provide the best technology available for the enrichment of peptides with a specific molecular weight range (Pouliot et al., 2006). Nanofiltration and



ultrafiltration techniques are now employed industrially to produce ingredients which contain specific bioactive peptides based on casein or whey protein hydrolysates. Such preparations are commercially available and are being introduced into different consumer products, such as dairy and fruit based drinks, confectionery, chewing gum, pastilles and capsules. Currently marketed products contain peptides with anticariogenic, antihypertensive, mineral-binding, stress relieving and satiety inducing properties.

8. Future outlook

Novel technologies, such as chromatographic and membrane separation techniques seem to be appropriate means to enrich active peptide fractions from the hydrolysates of various food proteins. Production of bioactive peptides from protein-rich raw materials may be scaled up to industrial level using controlled fermentation in bioreactors with known LAB. Recombined enzyme technology and specific production strains or peptidases isolated from suitable microorganisms are likely to be employed industrially in the future. In addition to enzymatic hydrolysis, microbial fermentation provides a natural technology applicable for the production of bioactive peptides either from animal or plant proteins. The stability of chemical structures and biological activity of peptides in different food matrices and subsequent fate during the digestion process are to be taken into account in formulation of products containing bioactive peptides. Again, new emerging technologies, such as micro and nano-encapsulation may offer feasible solutions for improving stability of peptides in various food products and during digestion. Molecular studies are needed to assess the mechanisms by which bioactive peptides exert their activities. For this approach, it is necessary to employ new nutrigenomics techniques, for example proteomics and metabolomics.

The potential health benefits of bioactive milk peptides have been a subject of growing commercial interest in the context of health-promoting functional foods. So far, antihypertensive, mineral-binding and anti carcinogenic peptides have been most studied for their physiological effects. A few commercial products have been launched on the market and this trend is likely to continue alongside with increasing knowledge about the functionalities of the peptides. In view of the current global trend of increasing prevalence of obesity and related diseases, type two diabetes, in particular, more experimental research should be focused on natural dietary bioactive peptides which can induce satiety and reduce insulin resistance. Other new areas where more research about bioactive peptides is warranted are impairment of cognitive functions, memory-related diseases and mood control. In this context, antioxidative and opioid properties of many milk peptides may be worth further investigations.

9. Conclusion:

Being unique in their characteristic and due to their biophysical and biochemical properties these bioactive peptides are valued a lot among the potential ingredients which regulate oxidative stress and food intake, reduce the risk of diseases in living organism. Although, there is still a small number of studies, especially *in vivo* studies, which should be conducted in order to confirm safety and beneficial effects of bioactive peptides, scientific, technological and consumer interest for these peptides and their potential use in controlling and promoting health increases, and results remains to be seen. The important step for new bioactive products is in providing consumers with accurate, not misleading information about the health benefits of these products. The vast potential for such product will not be achieved without extensive scientific research to ensure the safety and efficacy.



Session-II : Lead Paper - 03

FUNCTIONAL MEAT PRODUCTS – SCOPE AND SIGNIFICANCE

K. Manjula*, G.V. Bhaskar Reddy, C. Suneetha, D. Jhansi and B. Kalyani**

*Assistant Professor and Coordinator, Division of Food Technology,

Department of Home Science, Sri Venkateswara University, Tirupati

**Assistant Professor and Head, Department of Livestock Products Technology,

College of Veterinary Science, SVVU, Tirupati-517 502.

Introduction

Functional foods are the foods which affect the body systems in a better way by providing nutrition more than required in a manner to improve health and prevention from diseases and some more on functional food products. Functional foods are one of the fastest-growing segments of the food industry. In some countries, functional foods have already become part of the dietary landscape. Consumers are now more concerned about the health issues and demand more nutritious food products with increased health promoting factors. Increasing awareness about the effect of diet and specific food ingredients on health has initiated studies on the impact of food components on health. There is an increase in the production of such functional foods on large scale due to growing awareness about effects of diet for a healthy living. Meat is a major source of food proteins and also of some valuable nutrients like minerals and vitamins. Nutrients like iron, vitamin B12 and folic acid have inferior bioavailability in food other than meat. However, there are increased health concerns due to relationship of some meat constituents with major chronic diseases. Meat food industries are now in pressure to produce healthier meat products. Functional food provide an incomparable opportunity for meat industry to provide meat products with enhanced health promoting factors and reduced disease causing components. Through different techniques, meat can be processed to produce a large variety of products with health beneficial properties.

Functional Foods

Functional foods are one of the fastest-growing segments of the food industry. In some countries, functional foods have already become part of the dietary landscape. Generally speaking all foods are functional as they have nutritional value and are fundamental for survival. However, the term "functional food" defined as foods having disease preventing and/or health promoting benefits in addition to their nutritive or processing value. Functional foods are foods or dietary components that may provide a health benefit beyond basic nutrition. Functional foods can be divided into two broad categories. The first category consists of functional foods that naturally contain a component that offers additional benefits to the consumer. The other category of functional foods consists of processed foods in which a component is added to the food to give the additional benefits. Today's science and technology can be used to provide many additional functional foods, and future scientific and technological advances promise an even greater range of health benefits for consumers. Functional foods can provide health benefits by reducing the risk of chronic disease and enhancing the ability to manage chronic disease, thus improving the quality of life. Functional foods also can promote growth and development and enhance performance.

Functional Ingredients / Components

Functional components in food will play an important role in health maintenance in the future as a result of their medicinal properties. Functional components of food can be effectively applied in the treatment and prevention of diseases. They act simultaneously at different or identical target sites with the potential to impart physiological benefits and promotion of wellbeing. Functional components include phytochemicals,

Non-starchy carbohydrates like dietary fibre, Antioxidants such as Carotenoids, Polyphenols, Phytosterols, Tocopherols and tocotrienols and Organo-sulphur compounds, Probiotics and prebiotics. Different types of functional components in food, their medicinal properties, functions and sources are overviewed in Table 1.

Table 1: Foods with Functional Components

Functional Food	Functional Component	Potential Benefit
Tomatoes, Watermelon	Lycopene	Prostate health
Broccoli	Lutein	Reduced risk of macular degeneration
Citrus	Flavanones	Neutralizes free radicals, reduced risk of some cancers
Soybeans	Isoflavones	Lowers LDL and total cholesterol
Cranberries	Proanthocyanidins	Improves urinary tract health
Fish oils	Omega-3 fatty acids	Reduced risk of cardiovascular disease
Insoluble fiber	Wheat bran	Reduced risk of breast and colon cancer

Functional meat products

Scientific progress in understanding the relationship between nutrition and health has an increasingly profound impact on consumer's approach to nutrition which has resulted in the development of the concept of functional foods. Consumer's increasing interest for maintaining or improving their health by eating these specific food products has led to the development of many new functional foods. Most of these new formulations are dairy products, vegetable based products, specific fats, etc., but so far the functional food formulations based on meat products are very limited. Meat and meat products can be modified by adding ingredients considered beneficial for health or by eliminating or reducing components that are considered harmful. The use of these ingredients in meat products offers the opportunity to improve the nutritional and health qualities of meat products.

Foods of animal origin including meat are required to maintain the health of a human body. Meat is specifically valuable as a source of omega-3 fatty acids, vitamin B12, protein and highly bioavailable iron. The consumption of meat and other animal products can alleviate nutritional deficiency, which is still widespread in developing countries and secure a better child physical and mental development. Population growth, urbanization, economic growth and flourishing markets all lead to the increasing demand for meat and animal products. Also, changing nutritional needs, driven by growing incomes and demographic transitions, there is an increased need for livestock products including meat on a global scale. Apart from the nutritional status, meat and other animal products play an important social role in the modern society. Until 2020, meat demand is expected to increase highly in developing countries and slightly in developed countries.

Being a major source of Saturated Fatty Acids (SFA) in the diet, meat has been implicated in diseases associated with modern life, especially in developed countries. The n-6:n-3 ratio of polyunsaturated fatty acids (PUFA) is another risk factor associated with cancers and coronary heart disease. Thus, one of the functional modifications done in meat is change in its fatty acid and cholesterol levels observed that n-3 PUFA levels in pigs fed on linseed diet produced higher levels of thiobarbituric acid reactive substances (TBARS) without altering the sensory attributes of meat.



Another functional modification that can be done in meat products is the addition of fiber that produces a diminution in caloric content as studies have proven a relationship between a diet containing an excess of energy-dense foods and the emergence of a range of chronic diseases, including colon cancer, obesity, cardiovascular diseases and several other disorders.

In meat processing, certain problems envisaged like colour instability and fat oxidation due to disruption of muscle membrane structure, to control these negative effects, various synthetic antioxidants i.e. butylated hydroxy anisole (BHA), butylated hydroxy toluene (BHT), tertiary butyl hydroquinone (TBHQ) and propyl gallate and combination of these with citric acid and alpha tocopherol and ascorbyl palmitate were used successfully, but their usage was restricted owing to toxicity. Consumer preferences for "natural" products have resulted an increased interest in the use of natural antioxidants from various plants, vegetables, cocoa products, oil seeds, herbs, fruits, berries etc. viz., grape seed, grape peel, fenugreek, green tea, black tea, rosemary, sage, aloe vera, mustard, tea catechins, whey protein concentrate and cottonseed meals. Because of these reasons, a splendid approach of replacing them with natural antioxidants to extend the shelf life of meat products during refrigerated storage.

Although meats are sources of other vitamins, strategies have been employed to incorporate antioxidants in meat to produce healthier products. These compounds have been used in product formulation either in isolated form or may be added from some other sources. Dietary fibre plays important role in metabolic effect in terms of reduction in chronic diseases. Many studies have been undertaken and support a protective role for fibre in the prevention and management of chronic diseases. Dietary fibre intake provides many health benefits. A generous intake of dietary fibre reduces risk for developing diseases like coronary heart diseases, stroke, hypertension, diabetics, obesity and certain gastrointestinal disorders. Furthermore, increased consumption of dietary fibre improves serum lipid concentrations, lowers blood pressure, improves blood glucose control in diabetes, promotes regularity, aids in weight loss and appears to improve immune function. Unfortunately, most persons consume less than half of the recommended levels of dietary fibre daily.

Among various dietary fibres, Psyllium/ Psyllium husk (Isabgol/Ispaghula) obtained from *Plantago ovate* plant are a common source of soluble fibre used in functional food processing industries. There are various commercial uses of psyllium in food, pharmaceutical and their industries. Psyllium is most frequently added to breakfast cereals, meal replacements, bread, biscuits, wheat flour and other bakery and meat products to improve the fibre content of the food. It is also added to juices, shakes, soups, etc.

Guava powder is an extensively used functional ingredient in various food products as health foods for medicinal purposes besides its use as preservative for foods. Guavas are rich in dietary fibre and vitamin C, with moderate levels of folic acid. Having a generally broad, low-calorie profile of essential nutrients, a single common guava (*P. guajava*) fruit contains about four times the amount of vitamin C as an orange. The main phytochemicals found in guava are ascorbic acid, antioxidant-containing dietary fiber, carotenoids, and polyphenolics. Due to their antioxidant properties, carotenoids have shown beneficial health effects in cancer inhibition, immuno-enhancement, and prevention of cardiovascular diseases (Wilberg and Rodriguez-Amaya, 1995). The most important carotenoids which provide oxidative protection are α -carotene, β -carotene, lutein, lycopene, zeaxanthin, and β -cryptoxanthin (Veris, 2000). A well-established function is the vitamin A antioxidant activity of some of carotenoids, including α -carotene, β - carotene, β -cryptoxanthin. Polyphenols are the most abundant phytochemicals in our diets, and fruits are the main contributors (4). Currently, limited studies exist on the identification and quantification of guava polyphenolics. Moreover, Guava is high in concentrations of gallic acid (0.374 mg/100g), total phenolics (4.95 mg/100g), and the highest total and



soluble dietary fiber of the fruits investigated. Guava are somewhat unusual in their flavonoid polyphenolic content as well, with significant levels of myricetin (55 mg/100g) and apigenin (58 mg/100g) present in edible tissues, but do not contain the more commonly found flavonoids quercetin and kaempferol (Miean and Mohamed, 2001) that are abundant in some vegetables. Hence Guava powder can be used as a source of antioxidant dietary fibre in meat products. Guava powder is rich in dietary fibre, phenolics and possesses good radical scavenging activity as well as reducing power. Incorporation of guava powder can decrease the pH, emulsion stability, cooking yield and moisture content of meat products. Guava powder can be used as source of antioxidant dietary fibre in meat foods without much effect of sensory characteristics.

V. Scope and future of functional meat products

With growing understanding of the relationship between diet and health has come the emergence of so-called functional foods. The idea of using food for health purposes and not merely as a source of nutrients opens up a whole new field in the meat industry. In addition to traditional presentations, there a number of ways in which the meat sector can modify the qualitative and quantitative composition of meat and meat product components and produce designer foods with specific properties. This entails addressing quality factors associated with different product properties (sensory and technological properties, hygiene, convenience, stability etc.), nutritional value (balanced composition and bioactive substances) and their effects on physiological function and health.

A growing number of consumers perceive the ability to control their health by improving their present health and/or hedging against aging and future disease. These consumers create a demand for food products with enhanced characteristics and associated health benefits. The development of functional meat products provides a unique opportunity to contribute to improvement of the quality of the food offered to consumers who want to benefit their health and well-being. However, before being considered an economic challenge, it is and must remain a scientific challenge the food industry.

VI. Conclusion

Over the last several decades, meat products have come under increasing scrutiny by medical, nutritional and consumer groups because of the associations established between their consumption (or that of a number of their constituents—fat, cholesterol, etc.) and the risk of some of the major degenerative and chronic diseases (ischemic heart disease, cancer, hypertension and obesity). Therefore, meat-based functional foods are being seen as an opportunity to improve the image of meat and address consumer needs, and also to update the nutritional and dietary goals. The importance of meat in the diet is as a concentrated source of protein which is not only of high biological value but its amino acid composition complements that of cereal and other vegetable proteins. It is also a good source of iron and zinc and several B Vitamins, and liver is a very rich source of vitamin A, possessing excellent palatability and satiety value and has become a status symbol in the dietary menu of human beings. Population growth, urbanization, economic growth and flourishing markets all lead to the increasing demand for meat and animal products. Also, changing nutritional needs, driven by growing incomes and demographic transitions, there is an increased need for livestock products including meat on a global scale. Both meat and its associated products can be modified by adding ingredients considered beneficial for health or by eliminating or reducing components that are considered harmful. Emerging science clearly indicates that the functional foods currently on the market represent a small fraction of the possible products. Health-conscious consumers are increasingly seeking functional foods in an effort to control their own health and well-being.

(Reference will be available from author)

Session-II : Lead Papers - 04

SLAUGHTER HOUSE FOR PROCESSING OF SMALL AND LARGE ANIMALS FOR MEAT

G.D Arlene-Christina¹ T.R. Shanmukha² and P.K Ravindiran³

Senior Engineer¹, Managing Director² and Senior Consultant³

Ahara Technology Group Pvt Ltd, Hyderabad

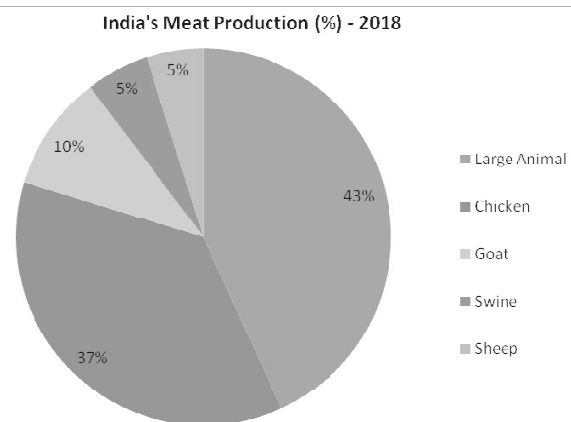
1.1 Need for slaughter house modernization

Meat industry is one of the growing food industries globally. A slaughter house or abattoir is a facility where animals are killed for consumption as food products. In India, the rate of meat consumption is on an increasing trend and therefore there is a need to develop this poorly developed sector. The reasons for the meat industry not expanding to its full potential can be attributed to socio- religious factors. Lack of finance, poor private participation and environmental problems are some of the other constraints felt.

Modern slaughter house is required to be established in all Local Self Government Institutions (LSGIs) for ensuring slaughtering of animals in a scientific way, for producing hygienic meat and ensuring recovery of resources. Scientific slaughtering, maintenance of hygienic conditions in slaughter houses and maximum utilization of byproducts are the three most important requirements for sustaining our meat industry. Quality and hygiene levels in slaughter house are low due to imperfect bleeding, primitive and crude slaughtering, lack of infrastructure facilities for water, electricity and facilities for hanging carcass / flaying. This has resulted in increase of waste contamination / deterioration of meat. Qualitative and quantitative capacities of abattoirs need to be upgraded and these are required to be linked with commercial processing of meat, both for domestic consumption and exports. It will ultimately results in discouraging unauthorized slaughtering.

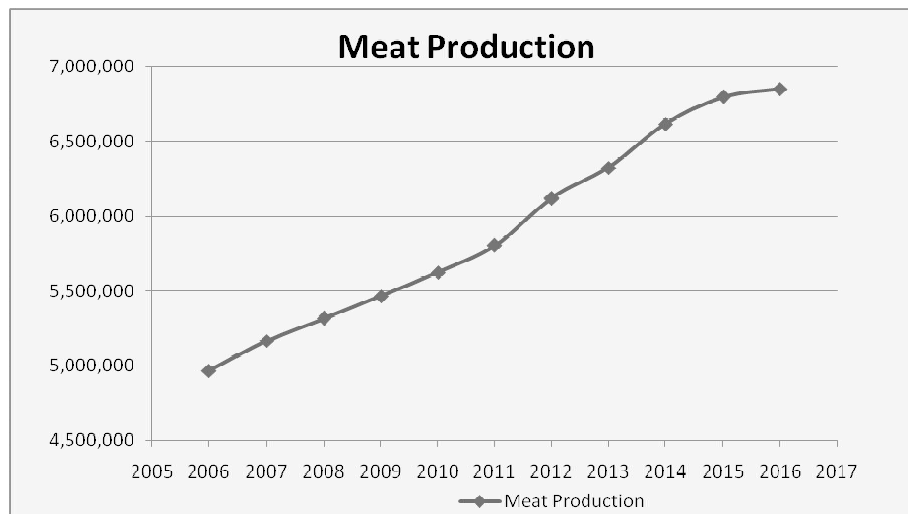
1.1.2 Meat Production in India

There are nearly 3,600 municipal slaughter houses in India, but most of them are very old and have already outlived their utility (working group on Animal Husbandry and Dairying 12th Five year plan (2012-2017)). They lack the essential amenities required such as water, light and drainage. Apart from these, there are numerous unauthorized slaughterhouses which are also working in several cities of India. About 36.5% of Goat, 32.5% of Sheep, 28% of Pigs, 1.9% of Buffaloes and 0.9% cattle are slaughtered every year. The reported per capita availability of meat in India is about 1.4 kg per annum, which is rather low compared to 60-90 kg in European countries.



Source : FAOSTAT

Figure 1: Animals used for meat purpose in India (%) – 2018



CAGR= 3.27%; Source: FAOSTAT; India's Meat Production for 2017 (estimate): 6.85 Million Tonnes

Figure 2: India's Meat Production 2006-2017

As per data provided by FAOSTAT, India's meat production has shown a growth at a CAGR of 3.27% between 2005 and 2017 to approximately 6.85 Million Tonnes. India's meat production in 2018 was estimated to be approximately 6.98 Million Tonnes. The majority of the production (97%) comes from the livestock basket comprising of the large animals, chickens, goats, swine and sheep.

Although, India's livestock population offers tremendous potential as far as meat production is concerned, the sector hasn't received adequate attention from entrepreneurs, policy makers, politicians and scientists to harness its potential. The livestock sector is intimately linked with the economic conditions of farmers and other socio-economically backward communities and provides for a multitude of revenue streams for them through the various stages of the animals' life.

1.2. Details of Slaughtering in India

The methods of slaughtering for the small animals are the Jhatka and Halal. Jhatka is a method of slaughtering of animals adopted by the Sikh/ Hindu community in India which required the decapitation of the animal by a swift single cut using a sword. It is proposed to develop the plant for goat (Jhatka) meat with a capacity of slaughtering 50 goat/ sheep per hour.

The Mohammedan ritual slaughter is known as "Halal". This method stipulates that the animal brought for slaughter should be healthy and alive at the time of slaughter and 'the slaughter operations has to be performed by a Muslim who has been authorized by the community for the purpose'. The Halal method of slaughter does not forbid the practice of stunning. Bleeding is performed by severing the carotid arteries and jugular vein while prayers are offered and the head of the animal is drawn directed to Mecca. The machines and equipments will be installed in the suitably designed building.

The process of producing finished product from live animals/goat/sheep is of intrinsic and takes place in series.

Generally the steps are defined in following sequence: -

- Step I - Receiving and ante-mortem inspection of animals in open lairage
- Step II - Checked and passed animals are put to covered lairage /holding pen with fasting



- Step III - Forwarding the animals to abattoir through raceway
- Step IV - Abattoir, where slaughtering is carried out
- Step V - Post mortem inspection
- Step VI - Butcher Centric slaughtering system / or mechanical could be followed by removal of head, horn, hoof and de hiding Splitting of the animals' abdomen to remove various organs/viscera/offal.
- Step VII - The products are dispatched by means of Refrigerated Containers or as hot carcass.

1.2.1 Building area specifications

The different construction of a slaughter house shall be built and maintained by its owner in the manner as specified below, namely:

- a) Plant Building –
 - i. Materials used shall be impervious, easily cleansable, and resistant to wear and corrosion.
 - ii. Materials such as wood, plaster board, and porous acoustic-type boards, which are absorbent and difficult to keep clean shall not be used.
- b) Floors - The floors shall be non-absorbent and non-slippery with rough finish and shall have suitable gradient for drainage.
- c) Coves - Coves with radii sufficient to promote sanitation shall be installed at the juncture of floors and wall, in all rooms and which shall not be less than 100 mm
- d) Interior Walls –
 - i. interior walls shall be smooth and flat and constructed of impervious materials such a glazed brick, glazed tile, smooth surface Portland cement plaster, or other non-toxic, non-absorber material applied to a suitable base.
 - ii. Walls shall be provided with suitable sanitary type bumpers to prevent damage by hand trucks, carcass shanks, and the like. (iii) The interior walls shall have washable surface up to the height of 2 meters from the floor so that the splashes may be washed and disinfected.
- e) Ceilings –
 - i. Ceilings shall be of the height of 5 mts or more in workrooms and so far as structure conditions permit, ceilings shall be smooth and flat
 - ii. Ceilings shall be constructed of Portland cement plaster, large size cement asbestos boards with joint sealed with a flexible sealing compound, or other acceptable impervious material and finished so as minimize condensation, mold development, flaking and accumulation of dirt.
 - iii. The walls above glazed type portion and ceiling shall be painted with water resistant paint to maintain them clean.
- f) Window Ledges - Window ledges shall be sloped 45 degrees to promote sanitation and to avoid damage to glass in windows from impact of hand trucks and similar equipment, the windowsills shall be 1200 mm above the floor level with proper ventilation through mechanical venting or through working vents shall be provided in the roof structure.
- g) Doorways and Doors –
 - i. Doorways through which product are transferred on rails or in hand trucks shall be at least 1500 mm high and shall be at least 1500 mm wide.



- ii. Doors shall either be of rust-resistant metal construction throughout, or if made with rust resistant metal having tight softwood, they shall be clad on both sides with soldered or welded seams.
- iii. Doorjamb shall be clad with rust-resistant metal securely affixed so as to provide no crevices for dirt or vermin and the juncture at which the door joins the walls shall be effectively sealed with a flexible sealing compound.
- h) Screens and Insect control - All windows, doorways and other openings that may admit flies shall be equipped with effective insect and rodent screens and 'Fly chaser' fans and ducts or air curtains shall be provided over doorways in outside wall of food handling areas that are used for dispatch or receiving.
- i) Rodent-Proofing-Except in the case of solid masonry, walls constructed of glazed tile, glazed brick, and the like, expanded metal or wire mesh not exceeding 12.5 mm mesh, shall be embedded in walls and floor at their junction and such mesh shall extend vertically and horizontally to a sufficient distance to exclude the entrance of rats and other rodents.
- j) Vehicular areas for Trucks –
 - i. Concrete paved areas, properly drained and extending at least 6 meters from building, loading docks or livestock platforms shall be provided at places where vehicles are loaded or unloaded.
 - ii. Pressure washing jets and disinfection facilities for trucks carrying animals shall also be provided at such places.
- k) Drainage –
 - i. All parts of floors where wet operations are conducted shall be well drained and as far as possible, one drainage inlet shall be provided for each 37 meter square of floor space
 - ii. A slope of about 20 mm per meter to drainage inlets shall be provided for usual conditions and it shall be ensured that the floor slopes uniformly to drains with no low spots, which collect liquid.
 - iii. Floor drains shall not be provided in freezer rooms or dry storage areas and when floor drains are installed in rooms where the water seal in traps is likely to evaporate without replenishment, they shall be provided with suitable removable metal screw plugs.
- l) Lighting and ventilation –
 - i. Unrefrigerated work rooms shall be provided with adequate direct natural light and ventilation or ample artificial light and ventilation by mechanical means.
 - ii. Uncolored glass having a high transmissibility of light shall be used in skylights and windows
 - iii. The glass area shall be approximately one fourth of the floor area of a workroom and such ratio shall be increased where there are obstructions, such as adjacent buildings, overhead catwalks, and hoists, which interfere with the admittance of direct natural light.
 - iv. Distributed artificial lighting of much quality and at such distances as may be specified by the Central Government shall be provided at all places where adequate natural light is not available or is insufficient.
- m) the following materials shall not be used in an abattoir, namely :
 - i. Copper and its alloys in equipment used for edible products.
 - ii. Cadmium in any form in equipment handling edible products
 - iii. Equipment with painted surface in product zone



- iv. Enamel containers or equipment is not desirable and
- v. Lead
- n) All permanently mounted equipment shall either be installed sufficiently away from walls (minimum 300 mm) to provide access for cleaning and inspection.
- o) All permanently mounted equipment shall either be installed sufficiently above the floor (minimum 300 mm) to provide access for cleaning and inspection or be completely sealed (watertight) to the floor area.

1.3 Slaughtering details

No animal shall be slaughtered in a slaughter house in sight of other animals. No animal shall be administered any chemical, drug or hormone before slaughter except drug for its treatment for any specific disease or ailment. The slaughter halls in a slaughter house shall provide separate sections of adequate dimensions sufficient for slaughter of individual animals to ensure that the animal to be slaughtered is not within the sight of other animals. Every slaughter house as soon as possible shall provide a separate space for stunning of animals prior to slaughter, bleeding and dressing of the carcasses

The complete details of the Small & Large Animal Line is given below

1. **Arrival and Inspection:** Trucks/tempo bringing live goats from the farms are carefully scheduled to ensure steady supply, with movement commencing very early in the morning till the relatively cooler hours of the day. Here Sheep and goat are held before slaughtering for 24 hours and no feed is provided to them to keep the internal system clear.
2. **Stunning :** The modern mechanical of stunning is by shooting, consisting of two forms:
 - Use of a captive bolt pistol which delivers a force (concussion) into the head of the animal to make it unconscious.
 - Use of a penetrating free-bullet gun of firearm. Compression stunners with or without penetrating heads, using air (not cartridges) are also employed in immobilizing animal. Older method in which a knocking or striking hammer was wielded on the head of the animal is now disallowed in humane practices in some countries, but in extreme and needy cases the hammer can be used to stun small ruminants by a quick blow at the back of the neck.

The simplest mechanism consists of electrodes or probes built in the form of tongs with insulated handles and applied between the ear and eye of the animal for 1-4 seconds. About 5-7 seconds must elapse before the animal starts bleeding. The level of voltage used for sheep and goats is between 60 and 70 volts/AC 50-60 cycles.

In strict Halal practice, stunning is ruled out since technically it puts the animal in a state of unconsciousness before bleeding. Nevertheless some Islamic communities accept electrical stunning as cattle, for instance, are known to recover from this application and lead normal lives-an indication that they still remain alive after stunning. Other Islamic groups in parts of Africa and Asia employ the hammer method of stunning.

3. Shackling And Bleeding

Stunned animal are then positioned for shackling. A vertical or hanging position is achieved by shackling below the hock of one hind leg and hoisting the animal (head down) to a convenient height. Alternatively, Animals are placed horizontally on a concrete slab or a sturdy plastic pallet for bleeding.

The actual bleeding operation is made by sticking or inserting the sticking knife through the neck behind the jaw bone and below the first neck bone. The objective is to sever the blood vessels of the neck and let the blood ooze out. If the knife is inserted is at a lower position than indicated, then the esophagus might be cut and the viscera may get contaminated.

The bleeding should be complete within the usual time for the animal and it is 2 minutes in case of sheep and goat. Insufficient bleeding and slow death could mean that the separation of the neck vessels is incomplete or specifically the arteries leading to the head have been missed, having only cut the veins during sticking.

Hoist bleeding is more hygienic and is recommended. It also facilitates collection of blood for further use.

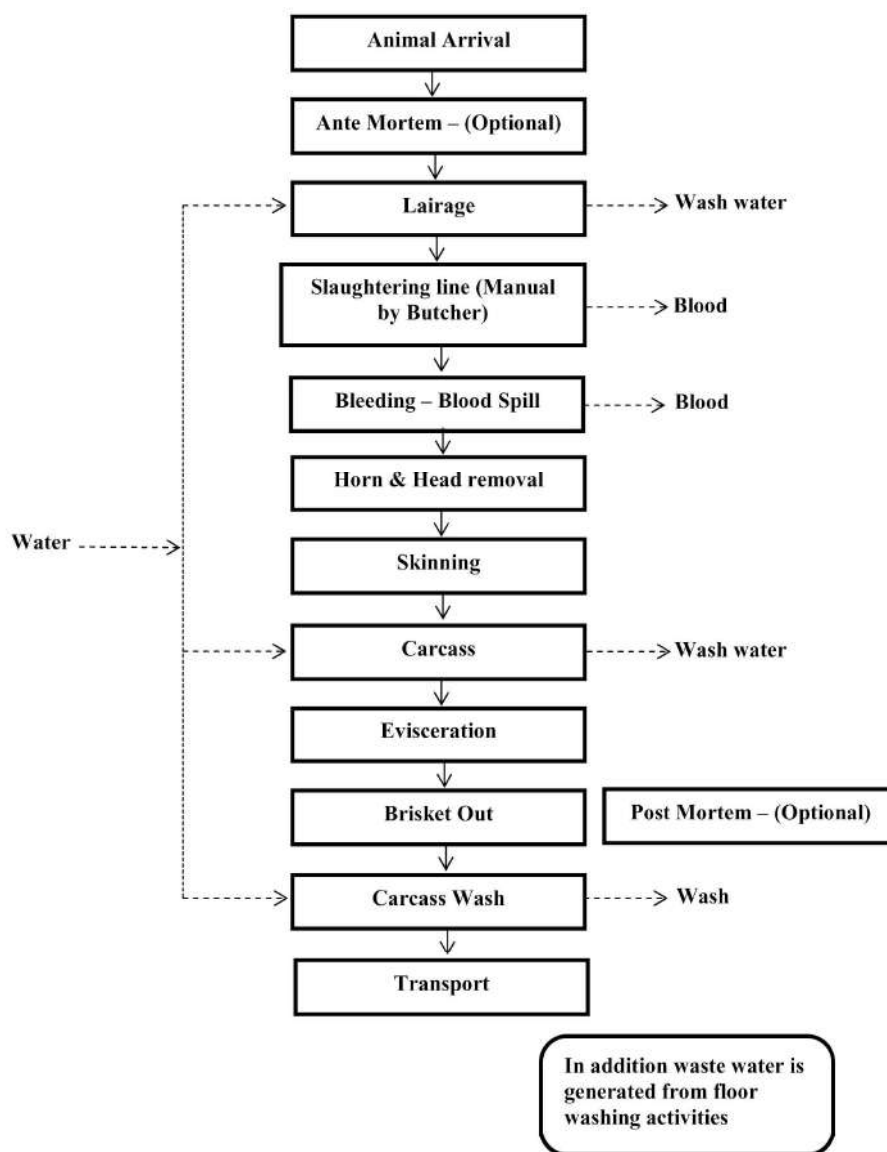


Figure 3 : Process flow diagram



4. Skinning and Dehiding

Legging: In removing the skin, Initial cutting of the skin is done around the leg to expose and loosen the tendon of the hock and using as a means of hanging the carcass. This process is called legging.

Pelting: A second step called pelting (after the term pelt normally applied to the skins of lambs and other wool or fur-bearing animals) involves the removal of the entire skin and preparation of the animal body for evisceration. Tropical sheep and goats have hair not wool on their bodies, thus the term skinning is more appropriate for them. Skinning, like stunning, can be done either in the horizontal or hanging position, the former being more suited to small slaughterhouses and the latter for larger premises with bigger orders and with facilities or equipment for railing the individual carcasses one after another.

Hoist Skinning: With the animal body in the hoist position, using the skinning knife, legging is commenced at the back of the free (unsuspended) leg by removing the skin around the hock and working towards the toes. This exposes the tendon on the back leg and the smooth joint just above the toe. The foot is cut off at this joint and the tendon gets loosened. The animal is then hung on a hook to suspend the leg. The process is repeated for the other leg while the cuts are continued on the inside of both legs towards the naval region.

The next step involves removal of body skin. First an opening is made in the front legs, cutting towards the jaw and continuing over the brisket to the naval. Using the knife, the brisket is skinned, but from this stage onwards, the knife is normally not used further. This is to protect the 'fell', a fine membrane occurring between the skin and the carcass which helps to improve the appearance of the carcass and reduce surface shrinkage.

Horizontal Skinning: The animal is placed on its back on a flat raised surface, such as sturdy plastic pallet or a concrete slab. Cutting and fisting then begin at the forelegs, working toward the belly and sides of the animal, ending at the hind legs. The tendon between the hock and the toes is exposed and loosened. At this point, feet, bung and head are cut at the designated points

4. Evisceration

With the external structures like skin, feet and head removed, the next step is to cut open the animal body to dislodge the contents and produce the carcass. To avoid contamination of the carcass through accidental cuts or punctures of the stomach and intestines, simple but well-directed steps are followed. For this, it is important that the carcass remains or is placed in the hanging position.

- The first step in evisceration is to cut around the tied bung or rectum and free it completely from all attachments and drop it in the pelvic cavity.
- The breastbone is cut or chopped along the midline up to its tip. Another cut is made from the cod or udder using the skinning knife down the midline into the breast cut. By practice, the pelvis (or lower part of the abdomen) is left uncut.
- Then the body cavity is entered to separate the urethra connections from the kidneys. While the intestines are loosened up further, the stomach and intestinal mass are pushed slightly out of the midline opening. (In some countries, the kidneys and spleen are often left in the sheep carcass.). At this stage, liver is held out and then pulled out together with the freed contents of the abdominal cavity and dropped into an intestinal mass truck.



- The final stage in evisceration is the removal of the contents of the chest cavity. By cutting the thin muscle sheet or diaphragm separating this cavity from the belly, the pluck (i.e. heart, lungs, trachea and esophagus) can be pulled out as a unit. The fore shanks (i.e. the upper and lower arms) are fastened together using a tendon or a thick rubber band to plump the shoulders. The carcass is then washed and railed to the inspection bay.

5. Postmortem Inspection

Aside from the carcass, parts of the animal body which are assembled for inspection are the tongue, head, and pluck, liver and intestinal mass. The carcass is held still in the suspended position. However, the visceral organs including the head and tongue are placed on hooks in a separate bay while the stomach and intestines remain in the truck.

Each carcass is identified with its set of organs for inspection. Inspection is normally carried out by professional veterinarians but some parts of the world trained public health inspectors are employed. Their duty is to examine the slaughter products for evidence of disease and abnormality and eliminate them from the public meat supply.

6. Offal Handling

Offal handling is an important part because a substantial weight of sheep's and goat are discharged during de hidding and evisceration. The foot rail and sit – stand stool are designed in such a way that workers can vary their position while working and workflow system are redesign as that the masses are automatically transferred from the end of the viscera table to respective offal conveyor.

7. Stamping

The wholesome carcass-meat and the organs and parts thereof would be stamped with the specific Meat Inspection stamps provided for, with the specific ink. Stamping mark or impressions would be applied properly and legibly at the specific region or parts of the carcass-meat and organs, as per stamping process in vogue or as per International Meat Industry Concept, practice and procedure followed would be as laid down in the code of regulations in this regard.

8. Weightment

The record of weight of carcass would be maintained for the benefit of the butchers or the administration as the case may be, for statistical purpose.

9. By product utilisation

There is dynamic scope of processing of meat products and the by-products utilization from abattoirs/livestock and its multifarious benefits are generally not realized by industries, govt. agencies, farmers and the public. Now a major part of such byproducts are considered as waste, which cause environmental pollution, and its potential to enhance the financial viability of such projects are neglected. By-products from livestock should therefore be considered as wealth. India is considered as the largest producer of milk in the world and the major producer of buffalo meat in the world. The scope and potential of byproducts utilization comprises of newer industries, employment generation, increased revenue generation, better returns to the farmer and environmental protection and safety. Some of the probable by - products and its scope on resource recovery is given below.

Table 1: Byproduct Utilization in abattoir

By-product	End Product
Blood	Pharmaceutical products, leather finishing agent, plywood adhesive, feed and fertilizer
Bone Gellatine	Hotographic, pharmaceutical, explosives, printing and food
Tallow	Soap, cosmetics, food and feed
Hide/Skin	Leather, collagen: cosmetics, glue and gelatin.
Intestine	Food, surgical sutures, musical strings, sports guts, Prosthetic materials-collagen sheets, burn dressing, heparin and feed.
Horn & Hoof	Horn meal, manure, neats foot oil, fire extinguishers and protein hydrolysate
Hair/Wool	Carpets, felt, upholstery, amino acid and brushes
Stomach	Rennin for dairy industry
Fat	Fatty acids, Tallow, Pharmaceuticals, feed food, cosmetics grease, lubricants and soaps
Vitreous humour intestinal content & Stomach contents	Biogas and manure

1.4 Conclusion

The paper comprises of all the details needed for a modern slaughter house and processing of animals for meat. Presently, a majority of the existing slaughterhouses have outdated facilities and follow unhygienic practices for the production of meat for the end consumers. Where the export oriented slaughterhouses have adopted standard practices and technologies in order to meet international regulatory requirements, the prominently disorganized domestic meat production industry continues to operate under status quo since monitoring is virtually non-existent despite existence of standards. There is a huge need of Modernization of Slaughter house to provide safe and hygienic cold chain management in order to deliver the meat hygienically to the end consumers.

(Reference will be available from the Author)



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**TRADITIONAL PROCESSING OF MEAT AND POULTRY PRODUCTS OF
SOUTHERN INDIA WITH EMPHASIS ON TELANGANA AND
ANDHRA PRADESH**

M. Shashi Kumar¹, N. Anitha² and V. Kesava Rao³

¹ Professor & Univ. Head, Dept. of LPT, C.V.Sc., Rajendranagar, Hyderabad.

² Ph. D. Scholar, Dept. of LPT, C.V.Sc., Rajendranagar, Hyderabad.

³ Former Professor & Head, Department of LPT, RIVER, Pondicherry.

Introduction

Meat has been consumed as a part of diet by man since pre-historic times and is an excellent source of high quality proteins and various micronutrients. In spite of religious taboos and socio-economic constraints, it still finds a prime place in the diet of over seventy percent Indians. Though the meat industry in our country is yet to become a part of organized sector, its contribution to the national exchequer is significant. In terms of financial contribution at present meat and meat products accounts to around Rs.17,260 crores annually to the Indian economy (Rao, 1998). Most of the meat produced in India is for domestic consumption and only a small part of it is exported. The export and processing of meat and meat products are still to gain momentum.

Diversity in tradition and culture among different communities in India has resulted in large variety of traditional meat products. Moreover, Arabs, Mughals, Portuguese and Persians have brought many interesting products, particularly different varieties of kababs and tandoori chicken. These products have become traditional products over the passage of time and they are being widely consumed all over the country. Traditional processing of various meat and poultry products has resulted into development of products with unique sensory attributes. Based on the availability of raw materials, people have developed taste to particular commodities and in the process various specialty products have developed traditional to their regions because of this reason these products vary from region to region and place to place.

Recently the demand for the traditional meat products is increasing day by day due to rapid urbanization and industrialization in the country. In the recent past, some attempts were made by the researchers at CFTRI and NRC Meat for standardization of traditional products profiles. However no systematic efforts were made to describe the indigenous and traditional meat and poultry products at one place. Many have described different culinary practices for different products. In this article an attempt has been made to project the salient features of traditional processing of some popular indigenous meat products of the country.

Some specialty traditional meat products of Southern Region

Meat curry is one of the most preferred meat product of the southern part of the country followed by meat dopiaza, meat fry, Biryani, meat pokora, meat balls in the second line of preference and kabab, korma, kofta and tikka in the third line of preference (Singh et al., 1995). Meat fry, mutton and chicken curry and biryanies are the popular products of southern region of the country. However, a dry salted meat similar to Biltong (dry salted meat) is very popular in parts of Andhra Pradesh and Tamil Nadu.

Meat curry: For meat curry generally bone in meat chunks (Chevon or mutton) are preferred. In this region meat curry is prepared adopting two methods. 1. Marination followed by shallow frying in oil and then moist cooking, 2. Shallow frying of meat along with spices and condiments in oil followed by moist cooking. In the first method, meat is cut into medium size pieces and marinated with salt, spices, condiments and sour curd for 1/2 to 1 hour. These are then fried in heated oil till all the visible moisture is lost. Then water is added to immerse the meat pieces, the cooking vessel is covered with a lid and cooked on a low flame till the meat is sufficiently done. In the second method, the spices and condiments are fried in oil and then the washed and drained meat pieces are added to it and fried. After frying, water and salt is added and remaining process is same as previous one.

Gongura chicken curry: Gongura chicken is a very common dish in some regions of Andhra Pradesh and is consumed often. These leaves are also called as puntikura in some regions of Andhra. pulicha keera in Tamil Nadu. It is a rich source of iron and few other essential nutrients. So it is widely used in Andhra cuisine. *Ingredients:* 1/2 kg chicken, 1 ^{1/2} cups gongura leaves (using too much can make curry very sour), 3 to 4 green chilies, 1 cup onions chopped finely, 1 to 1/2 tsp garam masala (adjust to suit your taste), 2 tbsp poppy seeds paste or 10 cashew nuts, 2 tbsp oil. *Dry spices:* 1 bay leaf or 1 sprig of curry leaves, 2 green cardamoms, 4 cloves, 1 inch cinnamon piece, 1 pinch cumin or jeera, *Marination:* 1 tsp lemon juice, 3/4 tsp ginger garlic paste, 1/8 tsp turmeric, 1/8 tsp red chili powder, salt as needed. Dry roasted poppy seeds paste or cashew nut paste can be used for gravy. *Preparation:* Clean the leaves and wash them in water several times. Drain off and keep aside. Saute the leaves in a tsp of oil along with green chilies. Cool and blend coarsely or smooth paste to suit your taste. Marinate chicken with ingredients mentioned under marination. Set this aside. Saute the spices in hot oil in a pan, add onions and fry until golden brown. Add ginger garlic paste and fry till the raw smell wards off. Add chicken and fry on high till the chicken turns white in color. Pour enough water to cover the chicken and sprinkle garam masala. Cover and cook till the chicken is tender and soft cooked. Add poppy seeds paste and then ground paste both. Mix well and cook for about 4 minutes or till it reaches the desired consistency. Serve gongura chicken curry with rice. ghee and onions.

Mutton Korma: Medium size meat pieces are washed and the water is drained off. It is then marinated with salt, spices, condiments and curd for around four hours. Sufficient quantity of ghee, chopped onion, bay-leaves and whole garam masala are fried. Then the marinated meat pieces are added and mixed covered with lid and cooked under slow heat till the visible moisture from the meat is lost. Then it is added with curd and little sugar and placed under low flame till meat is completely cooked.

Dry salted meat: In the preparation of dry salted meat, meats from both small and large ruminants are used. In case of meat from large ruminants, the meat is cut into long strips of about 1/2 to 1 inch breadth, whereas, meat from small ruminants are cut into small chunks. These meats are mixed with salt and turmeric powder and sun dried. These dried products have considerable shelf life. Before cooking, these dry salted products are rehydrated and then cooked as usual.

Hyderabad Chicken Dum Biryani: *Ingredients:* 1 kg chicken, 2 large onions, 2 tbsps chopped coriander leaves, 1 tsp saffron, 1/2 cup luke warm milk, salt, 2 tbsps ghee + 5 tbsps oil; *For Marination:* 3/4 cup thick curd/yogurt, 1 ^{1/2} tbsps ginger garlic paste, 1 tbsp red chili pwd (adjust), 1/4 tsp turmeric pwd, 3/4 tsp coriander pwd, 1/2 cup chopped coriander leaves. 3/4 cup pudina leaves. Juice of 1 lemon, 1 ^{3/4} tbsps salt.; *Biryani masala(pwd):* 8 cloves, 1" cinnamon stick, 4 elaichi/cardmom, 3/4 tsp shah jeera, 12 pepper corns. *Ingredients to cook irce:* 4 cups basmati rice, 6 cloves, 3 cardamoms, 1" cinnamon stick, 3 bay leaves, 1 marathi mogga, 1 star anise, 10 mint leaves, 1 tbsp oil, 1 1/2 tbsp. salt, water as required. *Method:* Marinate



chicken with the ingredients by adding biryani masala pwd for 2-4 hours. Cook basmati rice in water along with bay leaves, cloves, cinnamon, cardamom, marathi mogga, elaichi, oil, salt till its half cooked, strain the water and cool. Heat 1 tbsp oil + 1 tbsp ghee in a vessel, add sliced onions, saute for 8-10 min till caramelized and keep aside. Add the saffron to the lukewarm milk and combine well, keep aside. Take a wide deep vessel, add 3 tbs oil, spread out marinated chicken then cook on high flames for 2 min, add a tbsp of oil over the chicken pieces then reduce flame. Spread half of the rice over the chicken layer, pour tbsp. of ghee all over the rice, add half of the caramelized onions, spread tbs coriander leaves, pour half of saffron milk over the rice, then repeat same spreading. Cover with the lid and seal the edges with wheat dough and cook on high flame for 2 min. Remove the vessel from the stove and place on a iron tawa, expose to low flames and cook for 20-25 min. Turn off heat and do not remove lid for 10 min, after 10 min, remove lid, combine gently and serve hot with raita and curry of your choice.

Hyderabadi Kacha Biryani: *ingredients:* 1 kg Lamb, 750 g Semi cooked rice, Sauted brown onions to taste, 1 tbsp Ginger garlic paste, 1 tbsp Red chili paste, 1 tbsp Green chili paste, 1/2 tbsp Cardamom powder, 3-4 Cinnamon sticks, 1 tbsp Cumin seeds, 4-5 Cloves, 2 tbsp Lemon juice, 250 g Curd, 4 tbsp Clarified butter, A pinch Mace, Mint leaves to taste, 1 tsp: Saffron. *Method:* Clean the meat. Now in a pan add meat, salt, ginger garlic paste, red chili powder, green chili paste, sauted brown onions, cardamom powder, cinnamon, cumin seeds, cloves, mace, mint leaves and lemon juice. Mix it well. Add curd, clarified butter, semi cooked rice, saffron, water and oil and mix it well. Now apply sticky dough on the sides of the pan. Cover with lid to seal it and cook for about 25 minutes. Hyderabadi Biryani is ready to eat. Garnish with boiled eggs, sliced carrot and cucumber. Serve hot.

Haleem: *Ingredients:* 1/2 Wheat Daliya Known as Haleem ka daliya, 1kg Boneless mutton, 350 g Curds, 4 tablespoons Ginger and Garlic paste, 2 big sized Onions for cooking, 3 big sized Onions for garnishing, 6 cloves, 6 elaichi, 1/2 teaspoon of caraway seeds, all powered as garam masala, 3 bunches (coriander leaves) Kothmir, 3 bunches (mint leaves) Pudina, 250 g Oil, 1 tsp Chili powder, 1 tsp Haldi. *Preparation:* First wash and soak the cracked wheat for at least 1/2 hour. Then wash and clean the lamb thoroughly, trimming off any excess fat. Mix the Iamb with 1 tbsp of Ginger-Garlic paste, 1/2 tsp of salt, red chili powder 1/2 tsp garam masala powder and 1/4 tsp turmeric. Pressure cook the lamb on high flame for 8-10 min (or until 3 whistles) and then simmer for another 15-20 min. After it cools down, shred and keep aside. Boil the cracked wheat along with the mixed lentils, 1 tbsp ginger-garlic paste 1/4 tsp turmeric powder, 3-4 green chilies, 1/2 tsp black pepper corns in 8-10 cups of water until it is cooked completely and the water is almost absorbed by the wheat. Put this wheat in a blender and pulse for a few seconds [in 2-3 batches]. Remove and keep aside. Heat the oil in another container add the whole spices, the cooked and shredded lamb, remaining green chilies, 1/2 cup fresh coriander and sauté for a 2-3 min. Add the Yoghurt and sauté for another 10-15 min or until oil starts to float on top. Add 3 cups of water and bring it to a boil, Add the cooked Wheat and mix well...adding a little bit of Ghee at a time. Do Check the salt and add if needed, let it simmer for at least 1/2 hour...keep stirring in between. Serve hot Garnished with fried onions, cashew nuts and fresh Coriander. It can also be enjoyed with fresh naan.

Butta Haleem: This is one of the most popular meat products of Hyderabad and its adjoining area. Beef, mutton and chicken are the meat commonly used for preparation of Haleem. Deboned meat is cut into one inch cubes. Meat cubes (approx.1 kg) together with the corn are cooked with four cups of water till the meat becomes tender. Cooked meat is mashed with wooden spoon till soft. Grated coconut and poppy seeds are roasted separately for garnishing later on. Garlic and ginger paste is now added to the remaining part of onion and fried. Ground coconut and poppy seed mix is now added along with chili powder. Further curd is added

and cooked till the oil floats on top. Meat and corn mixture is added to the curry and cooked by simmering. Milk is added to give the preparation a creamy consistency and again cooked till it gets thickened. The final dish is garnished with chopped mint, coriander leaves and fried onion and slices of lemon and served hot with rice or chapati.

Paya Nahari: *Ingredients:* Paya 10 pieces (Head and legs), Onion 200 g, Vegetable oil 100 g, Yogurt 100 g, Cumin seeds (roast and make a paste) 1 tsp, Coriander seeds 1 tbsp, Coconut (grated) 2 tsps, Ginger-garlic paste 2 tbsp, All-purpose flour 2 tsps, Red chili powder 1 tsp, Turmeric powder ½ tsp, Fennel powder 1 tsp.; *Method:* Dissolve the all-purpose flour in 150-ml, Water and set aside. Wash and clean meat and set aside. Peel and slice onion sautéed in oil and add ginger-garlic paste, garam masala, cumin powder, coriander powder, turmeric, salt to taste and yogurt. Cook well. Boil paya with 100 g onion, 1/2 tsp turmeric powder, 4 green chilies till the meat becomes tender. Add meat to the cooked gravy along with the stock and add fennel powder, chopped fresh coriander. When it is boiling add all-purpose flour mixture. Cook for 2 minutes and remove from heat. Garnish with brown onion, chopped coriander, chopped mint and lemon. Serve with Indian breads such as roti/sheermal/naan.

Hyderabad Dalcha: *Ingredients:* 250 g mutton cut into pieces, 3/4 cup chana dal soaked for half hour, 2 tsp ginger-garlic paste, 1 ½ tsp, dhania powder, 1/2 tsp haldi, 1 tsp chili powder, 2 green chilies, 2 onions, sliced fine, and fried crisp, 2 tbsp oil. *Procedure:* To the chana dal add 1/4 teaspoon haldi add enough water to cook till tender. Then mash well and set aside heat add the slice onion and fry till brown. Add the ginger-garlic paste and haldi and fry till pink, then add the mutton and fry till oil separates. Put it in the chili powder, dhania powder and 2 cups water and cook till the mutton is tender. To the mutton add the mashed dal, crushed and fried onion, warm water and salt to taste. Simmer gently, serve hot.

Hyderabad Tahari: *Ingredients:* 500 g fatless kheema, 500 g Basmati rice washed & soaked for 15 mins 2 tsp garam masala, 1 cup beaten curd, A handful of chopped kothmir, A handful of chopped pudina, 4 onions, sliced fine, 1/2 tsp haldi, 1 tbsp ginger-garlic paste, 6 green chilies, 4 tbsp ghee or refined oil, 2 egg, boiled. *Procedure:* To the washed kheema, add a little of the sliced onion, and squeeze the kheema so that each grain of kheema separates. Heat the ghee and add the sliced onions, then fry till crisp. Add the ginger-garlic paste and haldi, then fry till the raw smell disappears: Now add the curd and kheema along with salt to taste. Cook till nearly dry and add green chilies. Fry a little. Add the drained rice and fry adding warm water-1 1/2 inches above the rice level. Add in the garam masala and allow to cook till the Tahari is tender and moist. Serve hot, garnished with 2 boiled eggs cut in half, chopped pudina and kothmir.

Shawarma: *Ingredients:* 1 ½ lbs boneless, skinless chicken thighs or breasts (thinly cut), one cup plain yoghurt, ¼ cup vinegar, 2 cloves garlic, crushed, 1 teaspoon pepper, 2 cardamom pods, 1 teaspoon all spice, Juice from 1 lemon. For sauce: 1 cup tahini, 2 cloves garlic crushed, ¼ cup lemon juice, 2 tablespoon yoghurt. Pita fillings: 8 loaves of pita bread or 4 large thinly slice cucumbers, thinly sliced onions, ½ teaspoon sumac, thinly slice tomatos, ½ cup fresh parsley, finely chopped pickle slices(optional); *Method:* Combine all ingredients except for chicken, fillings, and sauce ingredients to make marinade. If it seems a little dry, add a little olive oil (a tablespoon at a time). Add chicken, cover and refrigerate at least 8 hours, preferable overnight. In a stockpot or large saucepan, cook chicken over medium heat for 45 minutes or until done. Be sure not to overcook! If chicken becomes a little dry, add a few tablespoons of water throughout cooking duration. While chicken is cooking, prepare the sauce. Combine sauce ingredients and mix well. Set aside. Take the onions, tomatoes, cucumbers and sprinkle with sumac. Add other filling ingredients in a large bowl and combine well. When the chicken is done, you can shred it, slice it, or leave into large pieces. *Prepare the*



Pita: Place enough chicken on pita that cover 1/4 of the loaf. Add veggies and pour sauce. Roll like a soft taco or burrito and you have shawarma! **Serving Shawarma:** You can serve shawarma with fries, falafel, hummus, or with a salad like tabouleh.

Marag: *Ingredients:* 2 kg mutton with bone, 1/4th kg onion, 1/2kg curd (beaten), 1/4th kg coconut powder (dry roasted for 3 min), 200 g cashew nut (ground to paste), 1 tbsp garam masala powder, 1 tsp zeera powder, 1 tsp dhania powder, 1 tbsp ginger garlic paste, 1 pathar ka phool (optional), 1 tsp black pepper powder, a few Peppercorns, 1 piece of Cinnamon (1 inch), 3-4 small Cardamom whole, Oil; *Preparation:* In meat add half of ginger garlic paste, little salt and pressure cook till tender. Grind onions and coconut together to a thick paste. Heat oil in a vessel, add cardamom and dalcini. Saute onion, coconut paste & ginger garlic paste and keep stirring it. Add cashew nut paste and stir till oil separates. Now add jeera powder, dhania powder, garam masala powder & the beaten curd. Keep stirring for 15 min. The more you keep stirring the better taste it gets. Now add the mutton and peppercorns. Mix well. Add water according to consistency you wish to have for soup. Cook well for 10 min. At the end put the pathar ka phool in it & cook for 2 min. Remove from fire and serve hot with stuffed paratha

Boti Curry: Boti curry is prepared using stomach and intestines of sheep and goats. Sometimes the stomach and intestines of small animals are also utilized. Stomach and intestines are collected and subjected to repeated washing with portable water to wash off the contents. The washed stomach (Rumen, reticulum and intestines) are scalded in boiling water added with salt and the mucous lining is removed/ peeled off. Then they are washed again and cut into smaller pieces of 1-2" sized. The meat pieces are mixed with one tsp each of salt, turmeric, red chili powder and ginger-garlic paste and marinated for about one hour. After marination the boti curry is prepared in the similar way as meat curry. The boti curry requires more quantity of oil (about 3-4 tsp), condiments and spices. This is a delicacy in the parts of Telangana and Andhra Pradesh regions. Boti curry is served hot with rice or chapathi.

Meat products which are commonly consumed throughout the country

There are certain traditional meat products which are commonly consumed in most parts of India irrespective of region. These are meat samosa, meat balls or kofta, kababs, tikka etc. Processing and preparation of such products are briefly, discussed.

Meat Samosa: Meat samosa is an important Indian cuisine. Samosa can be prepared as a protein based food product using meat of old animal or culled chicken along with vegetable extenders. Raw meat from leg and breast and partially cooked meat from neck, wing and back may be separated and minced through a grinder. Dry spices mixture and green condiments, mashed potato are fried with meat and stuffed into dough made of maida. Deep fat frying until the external cover becomes golden yellow and crispy. In addition to mashed potatoes, bengal gram or black gram can also be used as binder. Sharma et al., (1988) beneficially utilize- black gram and bengal gram at 10% improving the protein content of samosa.

Meat Tikka: Tikka is an indigenous processed product which is served hot as fast food, usually consumed alone or with tomato ketchup, like fish cutlets. The minced meat, salt, fat, seasonings, binder, green curry stuff, egg and tomato are hand mixed thoroughly and moulded into tikkas with the help of a metallic mould. The raw tikkas are fried in vegetable fat till brown colour and desirable doneness. Meat tikkas should have a crispy surface and somewhat less springy texture than patties, burgers and other comminuted products. Singh and Bawa (1990) studied the preparation, processing and sensory properties of meat tikkas from culled hens and breeder males.



Meat Ball/Kofta: Meat ball or Kofta are being prepared using coarsely ground meat obtained from old animals or culled chickens. Coarsely minced meat and fat are added with salt, maida, seasonings, condiments and whole egg liquid and hand mixed. The course emulsion or mix is moulded into ball shape manually. The meat balls may be cooked in boiling water containing 1% salt and 0.2% polyphosphate (Wani et al., 1994) or fried in vegetable oil to a desirable doneness (Mandal et al., 1996; Mandal and Pal, 1998). Recipes and processing techniques for kofta has been standardized by Padma et al (1988a). The addition of extenders significantly improved the texture, juiciness and overall acceptability. Flavour and overall acceptability scores of goat meat balls could be significantly improved by incorporating different levels of onion, garlic, ginger paste (Padma et al, 1988b). Attempts have also been made to develop low fat meat balls utilizing different binders viz. carrageenan, milk co-precipitate etc. with varying degree of success (Rao et al., 1994a)

Chicken Curry: Chicken curry is one of the major chicken product prepared throughout the country with considerable variation in the spice contents (Kondaiah, 1996). The basic preparation includes cutting the chicken into cubes or suitable size and marinade with appropriate quantities of salt, turmeric and chili powder and kept for few minutes. Small quantity of oil is heated and the paste of condiments (onion, garlic and ginger) is fried to light brown colour and chicken pieces are added and fried till golden brown and allowed to cook with lid-on or pressure cooked. The cooking time varies from 10 to 20 minutes depending upon the quality of chicken used. Dry spices powder (consisting of cloves, cinnamon, coriander, cumin, pepper etc.) is added and stirred and finally suitable quantity of water is added depending upon the gravy desired. A variety of thickeners or fillers such as coconut milk, curd, tomatoes, vegetables, mushroom flour etc are added. Dry type of chicken curry is prepared when the chicken pieces are cooked in their own juices or with little water.

Chicken Korma: Ingredients and preparation are similar to chicken curry except that curd and grated coconut is added as filler at the final stages and allowed to cook for 2-3 minutes.

Chicken Fry: Two types of preparation can be made for chicken fry. Chicken pieces are cooked in water and then spices added and fried in oil to golden brown colour. In other preparation raw chicken pieces are marinated and then fried in oil with spices to golden brown colour.

Shemi Kebab: *Ingredients:* 2 ^{1/2} kgs lamb cubes 1 ^{1/2}", ¼ cup caramelized onions, 1 raw yellow onion, very finely chopped, 2 teaspoons ginger garlic paste, 1 teaspoon coconut powder, 1 teaspoon poppy seeds, 1 teaspoon cumin seeds, 1/4 teaspoon turmeric powder, 1 bay leaf, torn in half, ½ teaspoon paprika, 1/2 teaspoon red chili powder, 2 tablespoons ghee (clarified butter), melted, 1/2 teaspoon garam masala, 2 tablespoons almonds, 2 tablespoons cashew nuts, 2 tablespoons peanuts, 1-1/2 teaspoons jalapeno green chili peppers, 1/3 cup chana dal, 2 tablespoons lemon juice, 1-1/4 cups water, ½ teaspoon black pepper, freshly ground, 1 ^{1/4} teaspoons salt, 3 tablespoons fresh mint leaves, chopped, 1/3 cup canola oil, as needed. *Preparation:* To the washed and drained kheema, add the chana dal, sabut masala, 1 cup warm water, salt to taste and then cook till dry. Remove from heat and add ginger, garlic, pepper, chilli powder, dhania and jeer powder. Grind to a fine paste and then form into a dough. To the minced onion, add the finely chopped pudina, kothmir, lime juice and salt to taste. Beat the egg lightly. Divide the dough into lemon-sized balls. Flatten each ball in the palm of your hand and stuff with a little of the onion mixture. Shape into a kabab and dip in the beaten egg. Shallow fry till it turns pink. Serve hot.

Malai Kebab: *Ingredients:* 500 g breast of the chicken, cut into 1 ^{1/2}" cubes, 6-8 green chillies, A handful of kothmir and pudina, chopped, 12 flakes garlic, 8-10 almonds or cashew nuts, 3/4 cup beaten cream, 1" piece ginger, Juice of 1 lemon, Oil for basting, Salt to taste. *Preparation:* To the washed and dried chicken cubes, apply the lemon juice. Grind the following to a fine paste: green chillies, almonds, adrak-lasan, pudina and



kothmir. Apply this paste to the chicken. Next add the cream and mix well before adding salt to taste. Allow the mixture to then marinate well for 6 hours. Thread on skewers and grill over charcoal, basting with oil or ghee. Serve hot with dahi chutney.

Boti Kebab: *Ingredients:* 500 gms boneless mutton, 3 tbsp beaten curd, 2 tsp ginger-garlic paste, 2 tsp khus khus, 2 tsp chironji, 2 tsp dhania, 1 tsp jeera, 8 black pepper, 4 lavang, 1 onion, sliced and made into paste, Salt to taste. *Preparation:* To the mutton cubes apply the ginger-garlic paste, beaten curd and onion paste. Lightly roast and powder the khus khus, chironji, dhania, jeera, kalimiri and lavang. Sprinkle the powder over the mutton, mix well and add salt to taste. Allow the mutton to marinate for 6 to 8 hours. Thread the mutton cubes on skewers, baste with oil and roast over charcoal. Serve hot with onion rings.

Kamli Kebab: *Ingredients:* Chicken legs 4 nos, Garam masala powder - 1/2 tspn, Chaat masala powder - 1 tspn, Yogurt-4 tbsps, Asafoetida - a pinch, Salt, Garlic - 3 flakes, Ginger - 1 tbspn chopped, Black pepper powder - 1/2 tspn, Kashmiri red chilly powder - 1 tspn, Red cabbage - 1 cup grated, Lime juice -2 tbsps. *preparation:* In a basin mix the chicken legs with the yogurt, chili powder, pepper powder, garlic ginger paste, asafoetida, garam masala powder, chaat masala powder, one tbspn of the lime juice and salt. Allow to rest for 3 hours. Put on skewers and cook in a tandoor oven till cooked, (or you can use a griller). Remove and keep aside. Spread the cabbage leaves on the edges of a flat plate. Place the chicken legs on the center of the plate. Serve hot sprinkled with the remaining lemon juice.

Tangri Kebab: *Ingredients:* Chicken drumsticks 4; For Marinade I: Ginger garlic paste - 1 tsp, White pepper powder a pinch, Salt 1 1/2 tsp, Vinegar - 1 1/2 tsp, Marinade II: Curds - 1 1/2 cup, Cream -1/3 cup, Ginger garlic Paste - 1 tsp, White pepper powder - 1 1/2 tsp, Garam masala - 1 tsp, Salt -1 1/2 tsp, Saffron – little, Oil for basting; For Coating: Egg 1 large, Cashew powder - 2 tsp. *Preparation:* Prepare the first marinade by mixing the respective ingredients. Make deep cuts on drumsticks and rub with first marinade and keep aside for 15 minutes. Mix all the ingredients for second marinade and pour over the drum sticks and again keep aside for 1 to 2 hours. Pick out the drum sticks from the marinade and place on a grilling rack. Place the rack on the middle shelf of the oven. Grilled the entire drumsticks with basting with oil. When cooked, dip in beaten egg mixed with cashew powder and grill again till the coating is set.

Tikka Kebab: *Ingredients:* Lean steak 600 g, yogurt-1 tbsp, finely chopped onion 1 tbsp, finely chopped ginger 1 tbsp, finely chopped garlic 1 tbsp, finely chopped green chili-1 tbsp, crushed peppercorn 1 tbsp, turmeric powder 1 spoon, egg 1, salt. *Preparation:* Chop the meat into manageable pieces and process in a mixer to obtain a smooth paste. Add the remaining ingredients and mix well. Divide the mixture into small portions and roll into lemon sized balls and press lightly to make a disc. Put the kebabs on an oven tray, and bake in a preheated oven at 190 °C /375 °F/ Gas 5 for 10 to 12 minutes. Alternatively, grill them on medium heat. Line the grill pan with foil (to collect the drips and save on cleaning). Put the kebabs on the pan rack and slide the pan to the midway position. Grill for 10 to 12 minutes turning once. If barbecuing them, cover them with foil to prevent them drying up too much.

Though the meat products discussed above are more common in Telangana and Andhra region, they are popular throughout the country. Thorough and full-fledged scientific research need to be under taken on each product so as to develop data base on the traditional meat products popular in different geographical region of the country to develop a universal acceptance and to preserve the tradition.

(References will be available from the Author)

Oral Presentations

FPT-1

NUTRITIONAL AND MICROBIAL CHARACTERISTICS OF SALT DRIED MUTTON PRODUCT

**R.Jayanthi^{*}, V.Appa Rao, R.Narendra Babu, Robinson J.J Abraham,
S. Ezhilvelan and A.Munavara Sulthana**

Department of Livestock Products Technology (Meat Science),
Madras Veterinary College, Chennai-600 007
Tamil Nadu Veterinary and Animal Sciences University

The objective of the study was to evaluate the nutritional and microbial characteristics of salt dried mutton product which was prepared by dry salting method. Sodium chloride (NaCl) salt was added at different levels viz. 0% (Control), 2.5% (T1), 5%(T2) and 7.5%(T3) to the meat. Dry salting method was done by rubbing the salt over the meat pieces manually, followed by a rest period. The salt treated mutton samples were then oven dried at 70°C for 24 hours. The end product was subjected to analyse the proximate composition (moisture, protein, fat, ash, carbohydrate and energy) and microbial quality. The results of the study revealed that there was a highly significant ($P<0.01$) difference in moisture (5.58%), protein (51.96%) and carbohydrate (6.92%) content between the control and treatments. Fat and energy levels had a significant difference ($P<0.05$) when there was no significant difference ($P>0.05$) in ash level (2.10%). The results of total viable count had a highly significant ($P<0.01$) difference between the control and treatments on the storage period of 0, 3 and 5 days. Hence, based on the results the study has been concluded as salting with 5% NaCl can be used in mutton in order to maintain the proximate and microbial characteristics of the final end product.

FPT-2

PROCESS OPTIMIZATION FOR THE DEVELOPMENT OF VALUE ADDED CHICKEN MEAT SAUSAGES

**D. Maheswara Reddy¹, B. Eswara Rao¹, A. Jagadeesh Babu², PRS Moorthy¹,
RSD Gupta¹ and S. Vani³**

¹ Department of Livestock Products Technology, CVSc, Proddatur, SVVU, India

² Department of Veterinary Public Health, CVSc, Tirupati, SVVU, India

³ Department of Animal Genetics & Breeding, CVSc, Proddatur, SVVU, India

Repeated trials were conducted to incorporate the appropriate binder at right percentage for the development of value added chicken meat sausages. Three different binders viz. sorghum, oat and barley flours each at three different levels viz., 3, 6 and 9 percentages were added to prepare the value added chicken



meat sausages to select a binder at its optimum desirable level. The prepared sausages were subjected to quality analysis i.e., cooking loss, emulsion stability, water-holding capacity, hardness, proximate analysis and organoleptic evaluation. Among the different treatments chicken meat sausages incorporated with Oat flour at 9 % level recorded significantly ($P<0.05$) higher cooking yield, water holding capacity, penetration values, flavor, juiciness, tenderness and overall acceptability than the rest of the formulations and control. Further oat flour at 9 percent level recorded significantly ($P<0.05$) higher percent of moisture as well as crude fiber and lower percent of crude fat. Hence incorporation of oat flour at 9 % level in chicken meat sausages was considered to be optimum with all the desired qualities of value added chicken meat sausages.

FPT-3

EFFECT OF BINDERS ON THE QUALITY TRAITS OF VALUE ADDED VARIETY MEAT INCORPORATED CARABEEF LOAVES

**C. Vasanthi, V. Appa Rao, K. Dushyanthan, R.Narendra Babu, S.Ezhilvelan,
R.Ramani and A.Vanathi**

Department of Livestock Products Technology (Meat Science),
Madras Veterinary College, Chennai.

Utilization of tough spent meat and underutilized offals and low value meat is facilitated by addition of binders as functional ingredients and improved processing technologies in the development of emulsion based meat products. The research work envisages development of carabeef loaves incorporated with low value variety meat and offals @ 25% of meat and different binders like Refined wheat flour (T1), Whole egg liquid (T2), Soya flour (T3) and Liquid whey (T5) and quality assessment by subjecting to Physico-chemical analysis like pH, Shear Force Value (SFV), Hunter's colour L^* (lightness), a^* (redness), and b^* (yellowness) values, Texture profile analysis; Microbial quality analysis (Total viable count, Anaerobic count and Yeast and Mould count) and Organoleptic assessment to study the effect of value addition (low value meat and binder incorporation) on the quality and acceptability of the loaves. Egg treated loaves recorded more brightness (54.78 ± 2.51) and redness (11.88 ± 0.40) values than other treatments. However, statistical similar values were observed between control and treatment loaves for pH, SFV and Hunters colour values which indicates that the incorporation of low value meat and binders did not affect the quality of the product. Significant differences ($P<0.01$) in hardness, gumminess, cohesiveness and chewiness was observed between overall treatments, however, the values were found to be statistically similar between egg, soya flour and liquid whey treated loaves which reflects that binders incorporation did not affect the textural quality of the product. Similarly, the comparable hardness values and lower gumminess, cohesiveness and chewiness values recorded in Refined wheat flour incorporated (T1) loaves and control loaves indicates that the addition of low value meat did not affect the textural quality of the product. The products were also observed to be microbiologically safe for consumption. Further, the similarity in organoleptic scores between treatments confirms and derives conclusion that variety meat incorporated loaves irrespective of binders were found to be acceptable and ensures value addition.



FPT-4

QUALITY AND ACCEPTABILITY OF CHICKEN MEAT CUTLETS INCORPORATED WITH CHICKEN MEAT EMULSION

M. Anna Anandh

Tamil Nadu Veterinary and Animal Sciences University (TANUVAS),
Department of Livestock Products Technology,
Veterinary College and Research Institute, Tirunelveli, Tamil Nadu, India.

Chicken meat cutlets with 25, 50 and 75 % levels of chicken meat emulsion were prepared and their quality evaluated. Chicken meat cutlets prepared with 100% minced chicken meat were used as control. Significant ($p < 0.05$) increase was observed in chicken meat emulsion incorporated chicken meat cutlets for breading pickup, product yield and moisture retention. pH, diameter shrinkage and water holding capacity values were differed significant ($p < 0.05$) from control and the values non significantly increased with increasing level of chicken meat emulsion in the chicken meat cutlet formulation. Moisture, protein and fat content values between control and chicken meat emulsion incorporated chicken meat cutlets did not differed significantly between them. Sensory evaluation scores for appearance and colour, flavor, texture, juiciness, binding and overall acceptability on 9 - point hedonic scale were highest for 50% chicken meat emulsion incorporated chicken meat cutlets followed by 75% and 25% chicken meat emulsion incorporated chicken meat cutlets. Thus, it can be concluded that 50% chicken meat emulsion can be effectively used for preparation of chicken meat cutlets of an acceptable quality without affecting quality and acceptability.

FPT - 5

QUALITY ATTRIBUTES AND STORAGE STABILITY OF SPENT HEN MEAT PICKLE PREPARED USING DIFFERENT ACIDULANTS

A. S. Khade, M. Raziuddin and A.A. Devangare

Department of Livestock Products Technology, MAFSU, COVAS, Udgir,
Maharashtra, INDIA

The present study was carried out to evaluate the effect of incorporation of different acidulants viz. 1% acetic acid (control), 0.5% lactic acid and 0.5% citric acid on quality of spent hen meat pickle prepared from deboned spent hen. The pickle was evaluated for changes in physico-chemical, microbial and sensory attributes at an interval of 0, 15, 30, 45 & 60 days of storage at ambient temperature ($37 \pm 1^\circ\text{C}$). Results revealed that pH valued did not differ significantly up-to 45 days of storage of pickle but on 60th day of storage, the pH of pickle significantly differed ($p < 0.01$). TBA values of product decreased significantly ($p < 0.01$) up-to 30 days of storage for control and different acidulants although TBA values increased significantly ($p < 0.01$) from 45 to 60 days of storage. Microbial count and sensory quality did not show any appreciable changes in spent hen pickle and remained satisfactory throughout the storage period. It could be concluded that 0.5% citric acid and 0.5% lactic acid levels were more suited as an acidulants in the preparation of spent hen meat pickle and could be stored safely up to 60 days of storage at ambient temperature.



FPT - 6

**RECOVERY AND UTILIZATION OF RUMEN PROTEIN
ISOLATES FROM SLAUGHTERED BUFFALO IN
BUFFALO MEAT PATTIES**

**Jagannatha Rao. B^{*}, Kondal Reddy. K², Basawaraj Awati³, Kulkarni.V.V⁴,
Madhava Rao.T⁵ and Sarjan Rao.K⁶**

^{*}Department of Livestock Products Technology, Veterinary College, KVAFSU, Bidar

² College of Veterinary Science, Rajendranagar, Hyderabad

³ Dept.of Veterinary Microbiology, Veterinary College, Bidar.

⁴ National Research Centre on Meat, Hyderabad

^{5,6} College of Veterinary Science, Proddatur, Kadapa

The experiment was aimed at preparation of protein isolates from by products such as buffalo rumen, and to identify suitable levels of incorporation of these protein isolate in buffalo meat patties without any loss in quality and acceptability of the product. Protein isolates were recovered as per the method suggested by Darine Selmane *et al.*(2010) was standardized in laboratory. The percentage recovery of protein isolates from rumen protein isolates were 32.00 percent. The protein content of rumen protein isolate was found to be and 14.32 ± 0.38 percent as per (AOAC, 1995). The in- vitro protein digestibility of rumen protein isolate were 79.3 ± 16.00 percent as per (ICONTEC, 1994). The standard plate counts and psychrotrophic plate counts of rumen protein isolates were significantly lower than raw rumen tissues respectively. The counts are estimated as per (APHA, 2001) method. No counts were observed for coliforms and staphylococcus in both the raw tissues and derived protein isolates. The findings of the present study also indicated that the protein isolates may have retained their functional properties and have role in improving the water holding capacity as well as emulsion stability of the meat in which they have been incorporated, on cooking. The emulsion stability was estimated as per the method by Baliga and Madaiah (1970). Shear force value increased significantly with increase in incorporation levels of protein isolates in buffalo meat patties.

This might be due to better emulsion stability leading to better texture of patties. The collagen content of patties was estimated as per the procedure of Neuman and Logan (1950). In the present study, the rumen protein isolate has shown superior digestibility and buffalo meat patties containing rumen protein isolate at 20% incorporation level have shown increased available lysine to rest of the patties containing isolates at different incorporation levels. The available lysine was estimated as per the method by Carpenter (1960). The sensory evaluation scores for general appearance, flavour, texture, mouth coating, juiciness and overall acceptability of patties incorporated up to 20% level of rumen protein isolate were given higher scores and rated as very good to excellent. The patties with 30% levels of protein isolates were given lower scores and rated as fair to good. It was observed that panelists preferred patties incorporated up to 20% level of protein isolates. Results from this study indicated that meat could be replaced up to 20% with rumen protein isolate in patties formulations without adversely affecting quality and reduction in cost of production up to Rs 27/kg in treated meat patties in comparison with control.



FPT - 7

ANTIOXIDANT AND ANTIMICROBIAL PROPERTIES OF *CAPSICUM ANNUUM* EXTRACT IN RESTRUCTURED BUFFALO MEAT PRODUCTS

**Irshad A^{*1}. Sharma B.D²., Om Prakash Malav³., Suman Talukder² and
Rajiv Ranjan Kumar²**

Indian Veterinary Research Institute, Izatnagar

¹Assistant Professor, Department of LPT & MTU, KVASU., ²Division of LPT, IVRI.,

³Department of Livestock Products Technology, GADVASU, Ludhiana, India.

Restructuring of meat products enables the use of less valuable meat components to produce high quality meat products at reduced cost. One of the major causes of deterioration in colour and flavour of restructured meat product is lipid oxidation. The aqueous extract of dried *Capsicum annuum* (CAE) was evaluated for antioxidant and antimicrobial properties in restructured buffalo meat steak (RBMS) under refrigerated storage ($4\pm1^{\circ}\text{C}$). Total phenolics, DPPH radical scavenging activity and TBARS values were measured as indicators of antioxidant properties during storage ($4\pm1^{\circ}\text{C}$) of RBMS. Antimicrobial activity of dried *Capsicum annuum* aqueous extract was evaluated against total plate count (TPC), psychrophilic count, anaerobic count and Yeast and Mould count (YMC) using spread plate methods. The experiment was done with pre-standardized control and three levels viz. 2%, 4% and 6% of *Capsicum annuum* aqueous extract. In aqueous CAE, the average total phenolic content was $864\mu\text{g/g}$ Gallic acid equivalents and free radical scavenging activity was 46.8%. After nine days storage of control and RBMS, the TBARS increased by 168% in control product, 110% in RBMS with 2% CAE, 86.2% in RBMS with 4% CAE and 58.6% in RBMS with 2% CAE. In control RBMS, TBARS reached above 2 mg/kg meat on the 12th day whereas TBARS remained constant (0.6–0.8 mg/kg) in RBMS with CAE during storage. Further, a negative correlation between total phenolic contents and TBARS values was also observed. Results of sensory evaluation indicated that addition up to 4% (v/w) of CAE in RBMS did not have adverse effect on colour, flavour and acceptability scores. Antimicrobial activity of CAE was demonstrated by decrease in TPC, psychrophilic count, anaerobic count and YMC with increase in percentage of CAE. It was concluded that dried *Capsicum annuum* aqueous extract could be explored as a natural preservative in restructured meat products.

FPT-8

DEVELOPMENT OF READY TO COOK CHICKEN CUTLET MIX AND ITS SHELF LIFE ASSESSMENT DURING STORAGE UNDER AMBIENT CONDITIONS

Tomar S, Chauhan G, Chand S, Das A and Meshram S

Division of Livestock Products Technology, IVRI, Izatnagar, Bareilly, Uttar Pradesh

The present study was conducted to develop a ready to cook chicken cutlet mix and study the quality changes during its storage at ambient temperature for a period of 90 days. The dehydrated mix was prepared using optimized quantities of meat from spent hen, spices, condiments, refined wheat flour, corn starch, curd powder, textured soya protein, blanched and shredded potatoes and dried vegetable mix (beans, carrot and peas), packaged in ALP, sampled at 15 days interval and evaluated for various physico-chemical and microbiological quality analysis. Cutlets prepared from the mix were evaluated for their sensory attributes.



Hunter colour values, hue, chroma and colour change (ΔE) did not show any significant change during the storage period thereby indicating the colour stability of mix. A significant ($p < 0.05$) decline in pH was observed during the storage period while the moisture content, water activity, TBARS, FFA content, PV followed an increasing trend during the storage period. The mix was microbiologically stable as indicated by low SPC, YMC and absence of coliforms. Cutlets prepared from the stored mix were sensorially acceptable with no significant changes in colour and appearance, juiciness, meat flavour intensity while the overall acceptability of the cutlets ranged from 6.83-6.60 during the storage period. Nutritive value of optimized RTCCM indicated the mix to be a dense source of energy, with high protein, total dietary fibre and essential minerals.

FPT - 9

PHYSICO-CHEMICAL AND SENSORY PROPERTIES OF RESTRUCTURED BUFFALO MEAT STEAKS

**Tejas M. Natekar, V. Appa Rao, R. Ramani, R. Jayanthi,
C. O. Vinayananda and Bhagyashree Ojha***

Department of Livestock Products Technology (Meat Science),
Madras Veterinary College, Chennai. (TANUVAS)

A study was undertaken to develop restructured meat steaks from low value buffalo cheek meat and evaluate the optimum level of inclusion of salt, sodium tri polyphosphate (STPP) and transglutaminase (T.G.). Six different combination levels of salt, STPP and T.G. were deliberated to prepare restructured buffalo meat steaks. The combination of incorporation of salt, STPP and T.G. were 1: 0.2: 0.5 (T_1); 1: 0.2: 0.75 (T_2); 1: 0.2: 1 (T_3); 2: 0.1: 1 (T_4); 2: 0.2: 1 (T_5) and 2: 0.3: 1 (T_6) respectively. The optimum inclusion level of salt, STPP and T.G. were assessed by subjecting the developed restructured buffalo meat steaks for physico-chemical analysis (shear force, drip loss, cooking yield, instrumental binding strength and texture profile analysis) and sensory analysis. Results revealed that 2% salt, 0.2% STPP and 1% T.G. (T_5) had significantly ($P < 0.01$) higher cooking yield ($78.35 \pm 0.13\%$), shear force (5.22 kg/cm^2), instrumental binding strength, texture profile parameter values and sensory scores. The drip loss (1.52%) had highly significant ($P < 0.01$) decrease in T_5 as compared to control and other treatments. Based on the results obtained 2% salt, 0.2% STPP and 1% T.G. (T_5) level of incorporation were found to be the optimum and can be recommended for production of restructured meat steaks from low value buffalo cheek meat. The prepared restructured buffalo meat steaks is not only cost-effective but also comparable to intact muscle in terms of physico-chemical and sensory qualities.

FPT - 10

QUALITY ASSESSMENT OF PORK PATTIES INCORPORATED WITH DIFFERENT TOMATO PRODUCTS

S Tomar¹ and Chatli M K²

¹ College of Veterinary Science and A.H., NDVSU, Jabalpur

² College of Veterinary Science., GADVASU, Ludhiana

The present study was conducted with an objective to evaluate the comparative efficacy of pork patties incorporated with different tomato products namely, 10% tomato puree-TP (T_1), 12.5% tomato pulp-

TPP (T₂) and 6% lyophilized tomato peel-LTP (T₃). These patties were compared with control patties for various physico-chemical, sensory and microbiological parameters during refrigerated storage of 20 days. Changes in pH followed a decreasing trend during the storage with the lowest pH being in T₃. The pH was recorded significantly ($p<0.05$) higher in control than all the treatments. T₃ showed the highest concentration of the active compounds (β -carotene and lycopene). PV, FFA content and TBARS values followed an increasing trend and were significantly ($p<0.05$) lower in treated products as compared to the control. The DPPH radical scavenging activity was significantly higher in treatments as compared to the control which decreased during advancement of storage period. However, the products except T₃ were microbiologically stable upto the 20th day as revealed by SPC, Coliforms, Psychrotrophs and YMC. Sensory evaluation of the patties revealed that patties incorporated with tomato products except T₃ were acceptable upto 20 days of refrigerated storage whereas the control product was unacceptable. Thus it can be concluded that tomato products can be successfully utilized as efficient sources of natural antioxidants in meat and meat products so as to minimize the lipid oxidation without hampering sensory attributes.

FPT-11

DEVELOPMENT AND EVALUATION OF CHICKEN NOODLES USING EXTRUSION TECHNOLOGY

**Pavan M, Sathu T, Vasudevan V N, Irshad A, Sunanda C, Silpa S,
Kiran Kumar S and Sunil B**

Department of Livestock Products Technology
College of Veterinary and Animal Sciences, Mannuthy, Kerala.

The rapid urbanization, fast life style and change in socio-economic status of the population in India, has increased in the demand for ready-to-cook food products. Noodles because of its variety, mouthfeel, versatility, convenient to use, is widely accepted throughout the world and is relished by the people of all age group. Available literature shows no study have been done on noodles incorporated with chicken. Extrusion is a process of shaping by forcing softened and plasticised materials through dies or holes by pressure. The present study is undertaken to develop ready-to-cook chicken noodles at different levels of chicken using extrusion technology. Control Noodle was formulated by conducting preliminary studies with different ratios of flours and other ingredients required for extrusion of noodles. The cooked minced spent chicken was added over and above the standardised control formulation of flours at 40% (T₁), 50% (T₂), 60% (T₃) and 70% (T₄) as four different treatments. The noodle samples were evaluated for pH, water activity and sensory attributes of the chicken incorporated noodles. The pH was significantly (<0.05) higher for control (8.0033 ± 0.18204) and significantly lower for T₄ (6.8050 ± 0.07224). The water activity for samples ranged between 0.49533 ± 0.006339 – 0.57583 ± 0.033736 and can be considered as the low moisture food which was significantly (<0.05) higher for T₄. The sensory attributes for control, T₁, T₂, T₃ did not significantly vary. However, T₄ incorporated with 70 % chicken showed significantly higher values for taste, appearance, colour and overall acceptability. 70% chicken can be efficiently used in noodles over and above the formulation as animal protein substitute ensuring value addition.



FPT - 12

DEVELOPMENT OF CHICKEN MEAT PATTIES BY USING POMEGRANATE PEEL POWDER

Priyanka Sharma, Sajid Hussain and Sanjay Yadav

Department of Livestock products Technology

College of Veterinary Sciences

Lala Lajpat Rai University of Veterinary and animal Sciences, Hisar, India

The study was conducted with an objective to evaluate the effect of Pomegranate (*Punica granatum*) peel powder on quality characteristics of chicken meat patties. The chicken meat patties were prepared with incorporation of 1% 2% 3% & 4% Pomegranate peel powder and after sensory evaluation selected level of pomegranate peel powder in chicken meat patties is 2% and the nutritional and physico-chemical characteristics of product is studied. Pomegranate peel powder addition showed significantly higher moisture and lower fat content as compared to control chicken meat patties at selected level. The incorporation of Pomegranate peel powder also decreased the cholesterol and free fatty acid content as compared to control sample. However, the emulsion stability and cooking yield were higher in Pomegranate peel powder chicken patties. The addition of powder in the products resulted lower thiobarbituric acid content as compared to control product. The pH values are less affected in treated products compare to control. The shear press value was lower for Pomegranate peel powder chicken meat patties as compared to control. It is concluded that addition of Pomegranate peel powder at 2% levels improved the nutritional and physico-chemical properties of chicken meat patties.

FPT-13

DEVELOPMENT OF CHICKEN MEAT KABABS BY USING ASHWAGANDHA ROOT POWDER

Sajid Hussain, Priyanka Sharma and Ashok Malik

Department of Livestock products Technology

College of Veterinary Sciences

Lala Lajpat Rai University of Veterinary and animal Sciences, Hisar, India

The study was conducted with an objective to evaluate the effect of Ashwagandha (*Withania somnifera*) root powder on quality characteristics of chicken meat kabab. The chicken meat kabab were prepared with incorporation of 2% Ashwagandha root powder and the nutritional and physico-chemical characteristics of product are studied. Ashwagandha root powder addition showed significantly higher moisture and lower fat content as compared to control chicken meat kabab. The incorporation of Ashwagandha root powder also decreased the cholesterol and free fatty acid content as compared to control sample. However, the emulsion stability and cooking yield were higher in Ashwagandha (*Withania somnifera*) root powder chicken kababs. The addition of Ashwagandha root powder in the products resulted lower thiobarbituric acid content as compared to control product. The pH values are less affected in treated products compare to control. The shear press value was lower for Ashwagandha (*Withania somnifera*) root powder chicken meat kabab as compared to control. It is concluded that addition of Ashwagandha root powder at 2% levels improved the nutritional and physico-chemical properties of chicken meat kabab.

FPT-14**PHYSICO-CHEMICAL AND SENSORY EVALUATION OF
SALT DRIED MUTTON CHUKKA**

**R.Jayanthi^{*}, V. Appa Rao, R.Narendra Babu, Robinson J.J. Abraham,
A.Vanathi, Bhagyashree ojha and A. Sindhura**

Department of Livestock Products Technology (Meat Science),
Madras Veterinary College, Chennai
Tamil Nadu Veterinary and Animal Sciences University

The objective of the study was to evaluate the physico-chemical and sensory parameters of salt dried mutton product prepared by dry salting method. Sodium chloride (NaCl) salt was added at different levels viz. 0% (Control), 2.5% (T1), 5%(T2) and 7.5%(T3) to the meat. Dry salting method was done by rubbing the salt over the meat pieces manually, followed by a rest period. The salt treated mutton samples were then oven dried at 70°C for 24 hours. The end product was subjected to analyse the physico-chemical parameters viz. pH, shear force value, hunter colour analysis, texture profile analysis and sensory evaluation. The results of the study revealed that there was a highly significant ($P<0.01$) difference in shear force value (7.55kg/cm^2), colour and texture profile analysis between the control and treatments. The results of sensory evaluation had a highly significant ($P<0.01$) difference between the control and treatments. 5% level of sodium chloride treated mutton sample had the higher score for the overall acceptability. Based on the results of sensory evaluation it can be concluded as the 5% NaCl can be used in mutton to improve the physico-chemical properties without affecting the sensory parameters.

FPT-15**EVALUATION OF KABAB DEVELOPED USING COCKTAIL
EMULSION AND MINCED MEAT**

**Yazhinidevi R*, Sathu T, V N Vasudevan, Irshad A, Vandana Sasidharan,
Arun Sankar K J, Silpa Sasi and Pavan M**

Department of Livestock Products Technology
College of Veterinary and Animal Sciences, Mannuthy

Among the various convenience ready to eat meat products kabab enjoys a popular place and are available in food outlets worldwide. Kababs are usually made either from minced meat or chunks of meat along with other ingredients to improve the appearance and flavour. Emulsion technology has been developed to make kabab with good odour and taste but it did not give consumer preferred meat bite feeling. Thus the present study was envisaged to evaluate the effects of levels of meat batter and minced meat on the sensory quality of kababs. Standardised cocktail emulsion was prepared using chicken and duck meat in the ration 3:1. Three levels of standardised cocktail emulsion 25%, 50% and 75% were incorporated in the formulation as three different treatments, T1- 75% minced chicken meat + 25 % emulsion, T2- 50% minced chicken meat + 50% emulsion, and T3- 25% minced chicken meat and 75% emulsion. Chicken meat was minced in a meat mincer with 13mm plate. The common salt, condiments, spice mix were added to the weighed minced meat equally in all treatments as per the formulation. Standardised cocktail emulsion was prepared in Mado bowl chopper (Germany) as per the standard procedure. The kababs were moulded on metal skewers. Then steam



cooked for 10 minutes to attain an internal temperature between 70-75°C, then cooled and kababs were individually weighed and packed in HDPE packs and stored under refrigeration temperature for analysis. The kababs were shallow fried and served hot for sensory evaluation. The steaming or cooking losses were 17.02 ± 2.39 , 11.71 ± 1.29 and $10.44 \pm .48$ for T1, T2 and T3 respectively. T1 significantly showed higher cooking loss compared to other two treatments. The frying loss were 19.27 ± 1.73 , 16.62 ± 3.30 and 12.49 ± 2.67 for T1, T2 and T3 respectively and there was no significant difference between the treatments. Appearance and colour scores for T1, T2 and T3 were 7.15 ± 0.10 , 7.14 ± 0.08 , 7.2 ± 0.10 respectively. Flavour scores for T1, T2 and T3 ranged from 6.92 -7.1833. Juiciness scores for T1, T2 and T3 ranged between 6.78- 6.97. Texture scores for T1, T2 and T3 were 6.72 ± 0.11 , 6.83 ± 0.12 and 7.04 ± 0.13 respectively. Saltiness and mouth coating scores for T1, T2 and T3 ranged between 6.99 -7.10 and 6.95 - 7.11 respectively. Overall acceptability scores for T1, T2 and T3 were 6.85 ± 0.11 , 7.03 ± 0.12 and 7.16 ± 0.010 respectively. The sensory scores of kababs for all treatment did not show significant difference, however T3 showed higher sensory scores for most of the sensory attributes.

FPT-16

STUDIES ON EFFECT OF MEAT PARTICLE SIZE ON QUALITY CHARACTERISTICS OF RESTRUCTURED MUTTON SLICES

G.V.Bhaskar Reddy, A.R. Sen¹, E. Nagamallika, B. Eswara Rao,
S. Lakshmi Narasaiah and B.V. Vivekananda Reddy

Department of Livestock Products Technology, College of Veterinary Science, SVVU, Tirupati-517502

¹ICAR-National Research Centre on Integrated Farming, Patna, Bihar

The influence of meat particle size on quality characteristics of restructured mutton slices (RMS) processed by hot-set binding system was evaluated. The treatments were T1 (RMS formulated with 0.5 cm particle size), T2 (RMS formulated with 1.0 cm particle size), T3 (RMS formulated with 1.5 cm particle size) and T4 (RMS formulated with 2.0 cm particle size) and the remaining ingredients are same for all treatments. The developed RMS were analyzed for physico-chemical, proximate, textural and sensory characteristics. T1 had significantly ($P<0.05$) higher cooking yield, batter stability, water-holding capacity than remaining formulations. Highest per cent diameter shrinkage (12.61) was observed in T4 than other formulations. Small particle size formulations (T1 and T2) showed significantly ($P<0.05$) more protein extractability values than big particle size (T3 and T4) formulations. The particle size did not significantly ($P>0.05$) influenced the per cent collagen content but collagen solubility was influenced by particle size. Meat particle size significantly ($P<0.05$) influenced various proximate composition (moisture, protein and fat) of RMS. Meat particle size significantly ($P<0.05$) influenced the chewiness values of RMS. T1 and T2 had significantly ($P<0.05$) less chewiness and hardness, more cohesiveness and gumminess than T3 and T4. Both meat particle size differently affect the various sensory attributes of RMS. Among all treatments, T1 showed highest quality characteristics than remaining formations.



FPT - 17

**A STUDY ON EFFICACY OF NATURAL ANTIOXIDANTS ON
PHYSICO-CHEMICAL AND MICROBIAL STABILITY OF GOAT MEAT
(CHEVON) PATTIES DURING STORAGE.**

**Y.R. Ambedkar¹, Anurag Pandey¹, Ashish Saini¹, Y.Babji.²,
Sarita Kumari¹ and Neha Thakur¹**

¹ Department of Livestock Products Technology, PGIVER, Jaipur, RAJUVAS

² National Research Centre on Meat, Hyderabad

The comparative antioxidant and antimicrobial efficacy of green tea (*Camellia sinensis*) extract and grape seed (*Vitis vinifera*) at % with synthetic antioxidant butylated hydroxyl anisole (BHA) at 0.01% was studied in cooked chevon patties under anaerobic packing conditions during refrigerated storage. The chevon patties treated with GSE had significantly ($p<0.05$) lower thiobarbituric acid reactive substance (TBARS) value and free fatty acids (FFA) content compared to control (C) and other samples in aerobic packaged conditions. A significant ($P<0.05$) lower anti-microbial counts were noted in the chevon patties added with natural anti-oxidants. The GSE treated chevon patties rated significantly ($P<0.05$) superior scores of color flavor tenderness juiciness and overall acceptability than control. BHA and GTE have excellent antioxidant and anti-microbial properties compared to control. BHA and GTE treated chevon patties during refrigerated storage under anaerobic conditions.

FPT - 18

**ASSESSMENT OF QUALITY ATTRIBUTE AND STORAGE STABILITY OF
MUTTON PATTIES INCORPORATED WITH DIFFERENT
LEVELS OF CORN FLOUR**

**Y.R.Ambedkar¹, Anurag Pandey¹, Ashish Saini¹, Sarita Kumari¹,
Neha Thakur¹ and Shrawan Kumar Meel**

Postgraduate institute of Veterinary education and Research, Rajuvas, Jaipur

This study was carried out to evaluate emulsion stability cooking loss, physico-chemical properties, sensory attributes and storage stability at refrigeration temperature at $\pm 4^{\circ}\text{C}$. The mean percent emulsion stability of mutton patties of control, 5, 10 and 15% corn flour formulations were 9.50 ± 0.29 , 14.65 ± 0.42 , 11.81 ± 0.39 and 7.01 ± 0.12 respectively. Emulsion stability of 15% corn flour was significantly ($P<0.01$) higher than other treatments. The mean $\pm$ S.E of colour scores of 15% level of corn flour was significantly ($P<0.01$) higher than control and other levels. The mean $\pm$ S.E of flavour scores of chicken meat patties of control, 5, 10 and 15% corn flour formulations were 5.87 ± 0.12 , 5.52 ± 0.08 , 5.74 ± 0.07 and 6.15 ± 0.08 respectively. The mean $\pm$ S.E of flavour scores of 15% corn flour was highly significantly difference ($P<0.01$) than other levels. The mean values of juiciness scores of 15% corn flour was significantly ($P<0.01$) higher than control and other levels. The mean values of cooking has no significance difference between control and other treatments except 15% level. TBARS value increased with increase in storage period. TPC and yeast and mould count increased along with storage period. Overall mean percent of total ash has no significant



difference has been noticed between various levels of the corn flour during the storage period. The protein content of mutton patties increased while decreasing fat content. Overall mean values of fat percent differed significantly ($P<0.05$) during refrigerated storage period. Overall mean $\pm$ S.E values of pH of mutton patties significantly increased ($P<0.05$) during refrigerated storage period.

FPT - 19

EVALUATION OF ANTIOXIDANT POTENTIAL OF BETEL (*PIPER BETEL*) AND ROSEMARY (*ROSMARINUS OFFICINALIS*) LEAVES EXTRACT COMBINATION AND ITS EFFECT ON PHYSICO-CHEMICAL PROPERTIES OF CHICKEN POWDER INCORPORATED SNACKS

**Ashish Saini, Anurag Pandey, Y.R. Ambedkar, Neha Thakur, Sarita Kumari,
Priyanka Meena and Vilshan Chauhan**

Department of Livestock Products Technology, PGIVER, Jaipur

The present study was undertaken to evaluate the antioxidant potential of betel (*Piper betel*) and rosemary (*Rosmarinus officinalis*) leaves extracts through different kind of biochemical test (Total phenol content (TPC), Total flavonoid content (TFC), DPPH free radical scavenging assay, 3-ethylbenzothiazoline-6-sulfonic acid (ABTS) and Nitric oxide radical scavenging assay) and its effect on physico-chemical properties of chicken snacks at room temperature up to 60 days of storage. The result showed that test sample exhibited high TPC (196.55 ± 4.63) mg of Gallic acid (GAE) per g, TFC (23.31 ± 4.93 mg rutin/g) and IC_{50} value of combination sample for DPPH, ABTS and Nitric oxide radical scavenging assay was found 28.39 ± 2.17 , 53.97 ± 5.46 and 57.74 ± 2.47 respectively. Product treated with combination had significantly ($P<0.01$) lower thiobarbituric acid value (mg malonaldehyde/kg), tyrosine value and free fatty acid (oleic acid/100 g) as compared to control during storage. It can be concluded that betel leaves extract had good antioxidant activity and it significantly improve the physico-chemical properties of product at room temperature storage.

FPT - 20

EVALUATION OF ANTIOXIDANT POTENTIAL OF BETEL (*PIPER BETEL*) LEAVES EXTRACT AND ITS EFFECT ON PHYSICO-CHEMICAL PROPERTIES OF CHICKEN POWDER INCORPORATED SNACKS

**Ashish Saini, Anurag Pandey, Y.R. Ambedkar, Neha Thakur,
Sarita Kumari and Shrawan Kumar Meel**

Department of Livestock Products Technology, PGIVER, Jaipur

The present study was undertaken to evaluate the antioxidant potential of betel (*Piper betel*) leaves extracts (BLE) through different kind of biochemical test (Total phenol content (TPC), Total flavonoid



content (TFC), DPPH free radical scavenging assay, (3 ethylbenzothiazoline-6-sulfonic acid (ABTS) and Nitric oxide radical scavenging assay) and its effect on physico-chemical properties of chicken snacks at room temperature up to 60 days of storage. The result showed that BLE exhibited high TPC (174.71 ± 13.74 mg of Gallic acid (GAE) per g), TFC (42.07 ± 4.82 mg rutin/g) and IC_{50} value of BLE for DPPH, ABTS and Nitric oxide radical scavenging assay was found 32.62 ± 0.68 , 57.74 ± 2.05 and 53.24 ± 2.39 respectively. Product treated with BLE had significantly ($P < 0.01$) lower thiobarbituric acid value (mg malonaldehyde/kg), tyrosine value and free fatty acid (oleic acid/100 g) as compared to control during storage. It can be concluded that betel leaves extract had good antioxidant activity and it significantly improve the physico-chemical properties of product at room temperature storage.

FPT-21

STUDY OF PHYSICOCHEMICAL PROPERTIES OF MANGO SEED STARCH AND ITS APPLICATION AS THICKENER AND STABILIZER IN CHILLI SAUCE

Pavan m Gundu¹, Sachin g¹, Amar Shankar^{2#}

¹ Department of Food Technology, School of Engineering and Technology, Jain Deemed to be University, Bengaluru.

¹ Post Graduation student, M. Tech. Food Technology,

² Asst Professor, Department of Food Technology

The mango seed kernels were utilized to extract starch which in turn reduces the industrial waste in mango processing. Here, we studied the physicochemical properties like functional and morphology of extracted starch granules and its application as thickener and stabilizer in chilli sauce with comparison to widely used CS. The yield of starch extracted was about 24%, swelling power and solubility was found to be 19.161 g/g and 12.709% at 90°C. MSS showed highest water binding capacity of 96.3%. The SEM and XRD analysis were carried out for starch granules and found that the granules morphology and internal structures are similar to cereal starches with A-type crystalline structures. The MSS was added in different proportion to chilli sauce to study its thickening and stabilizing property in comparison to CS. The stabilizing property was analysed by storage studies carried out for duration of four weeks. The pH, titratable acidity, TSS, flow consistency and serum separations were analysed for chilli sauce with MSS, CS and control before and after four weeks and found that the pH of chilli sauce decreased after four weeks whereas TSS of chilli sauce had increased with decrease in consistency of sauce. The chilli sauce with MSS showed lowest serum separation compared to CS. Sensory analysis was also carried out to check the quality of chilli sauce and found that sample will 3 grams of MSS was of higher score. Further, it can be enhanced with fortification of essential micronutrients.



Poster Presentations

FPT-22

EFFECT OF INCORPORATION OF CARROT AND RADISH PASTE IN VACUUM PACKAGED TURKEY MEAT SAUSAGES UNDER REFRIGERATION STORAGE

**M. Naveen Kumar Reddy, M. Shashi Kumar, G.V. Bhaskar Reddy, N. Krishnaiah,
D. M. Reddy and N. Anitha**

Department of Livestock Products Technology,
College of Veterinary Science, Rajendranagar, 500 030, Hyderabad.

The present study was investigated to evaluate the shelf life of vacuum packed turkey meat sausages incorporated with raw vegetables i.e., raw carrot paste (RCP) and raw radish paste (RRP) each at 10 % level under refrigeration ($4\pm1^{\circ}\text{C}$) for a period of 25 days. The sausages were developed as per the standardized protocol with addition of RCP and RRP thus packed and stored at refrigerated temperature and evaluated for physico-chemical, microbiological and organoleptic quality at an interval of 5 days. The quality parameters were significantly ($P<0.05$) affected due to the incorporation of raw carrot paste (RCP) and raw radish paste (RRP) and also due to refrigeration storage. The results revealed that there was significant ($P<0.05$) increase in the physico-chemical qualities viz., Tyrosine value, TBARS value, as storage progressed from 0 to 25 days. However, the values were well below the threshold level of spoilage. Gradual decrease of pH observed in control and treated products under vacuum packaging. As the progressing of storage period, a gradual and significant ($P<0.05$) decrease in sensory scores was observed. Flavour and overall acceptability scores were significantly ($P<0.05$) higher; texture and juiciness scores were non-significantly higher for radish incorporated turkey meat sausages than carrot incorporated turkey meat sausages and control. Standard plate counts increased significantly ($P<0.05$) as storage period progressed from 0 to 25 days. Psychrophilic counts were not detected in the control and treated sausages at 0th day, afterwards the psychrophilic counts increased significantly ($P<0.05$) as storage period progressed from 5 to 25 days. Yeast and mold counts were not detected in any of the products throughout the entire storage period. Considering the results obtained in the study, it may be concluded that addition of RCP and RRP each at 10 % level extends the shelf life and vacuum packaged turkey meat sausages shelf stable up to 25 days during refrigeration period without any quality deterioration.

FPT - 23

EFFECT OF MUTTON EMULSION AND GROUND MUTTON ON QUALITY AND ACCEPTABILITY OF SEASONING FRYUMS (*MEAT VADAM*)

M. Anna Anandh

Department of Livestock Products Technology, VCRI, Tirunelveli.
Tamil Nadu Veterinary and Animal Sciences University (TANUVAS)

Left over rice vathals or vadams is a sun - dried product which can be stored for over a year. Vadam is traditionally made using left over rice. Most of the vadam available in the market are mainly based of cereals



which are high in calorie and low in protein contents. Incorporation of animal proteins in such snack type food products can improve the nutritional quality especially with respect to amino acid composition, flavor, odor and taste. In this perspective, meat based seasoning fryums (meat vadam) with 25 % mutton emulsion and 25 % ground mutton were prepared and their quality were evaluated. The corresponding level of rice flour was 75%. Control seasoning fryums contained 100% rice flour. Other ingredients used in the formulation ie., common salt, green chili paste, onion paste, cumin powder, spice mix, asafetida powder and curd were added over and above rice flour and goat meat combination. Significantly ($P<0.05$) increased values were observed in mutton emulsion incorporated seasoning fryums for pH, product yield, bulk density, hydratability, water absorption index, water solubility index, moisture, protein and fat contents as compared to ground mutton incorporated seasoning fryums. Results of sensory evaluation on 9 - point hedonic scale showed appearance and colour, flavour, texture, crispness, after taste, meat flavour intensity and overall palatability were higher for 25 % mutton emulsion incorporated seasoning fryums as compared to 25% ground mutton incorporated seasoning fryums. Sensory evaluation results indicated that mutton emulsion incorporated seasoning fryums were rated "very palatable" whereas ground mutton incorporated seasoning fryums rated "moderately palatable". Thus, it can be concluded that, 25 % mutton emulsion can be successfully used preparation of meat based seasoning fryums of acceptable quality.

FPT-24

INFLUENCE OF PROCESSING METHODS ON QUALITY CHARACTERISTICS OF RESTRUCTURED BUFFALO MEAT SLICES

**B.V. Vivekananda Reddy, G.V. Bhaskar Reddy, S. Lakshmi Narasaiah,
E. Nagamallika and B. Eswara Rao**

Department of Livestock Products Technology, College of Veterina Science,
SVVU, Tirupati-517 502, A.P.

The effect of various processing methods like hand mixing (H), tumbling (T), massaging (M) and tumbling and massaging (TM) on quality characteristics of restructured buffalo meat slices (RBS) was evaluated. The treatments were H (RBS manufactured with hand mixing of 1 hour) T (RBS manufactured with continuous tumbling of 4 hours), M (RBS manufactured with 2 hours of massaging) and TM (RBS manufactured with 2 hours of tumbling and 1 hour of massaging) and the remaining ingredients are same for all treatments. The developed RBS were analyzed for physico-chemical, proximate, textural and sensory characteristics. TM had significantly ($P<0.05$) higher cooking yield, batter stability, water-holding capacity than remaining formulations. RBS manufactured by TM processing showed significantly ($P<0.05$) more protein extractability values than hand mixing, tumbling and massaging formulations. The processing method did not significantly ($P>0.05$) influenced the per cent collagen content but collagen solubility was influenced by various processing methods. Different processing methods did not significantly ($P>0.05$) influenced various proximate composition (moisture, protein and fat) of RBS. The RBS manufactured with TM had higher textural and sensory scores than remaining formulations. Based on the results, it can be concluded that RBS processed by tumbling and massaging had superior quality attributes than hand mixing, tumbling and massaging.



FPT - 25

**EFFECT OF GUAVA POWDER ON PHYSICO-CHEMICAL PROPERTIES
AND SENSORY EVALUATION OF CHICKEN MEAT NUGGETS**

**R.Jayanthi*, V.Appa Rao, Robinson J.J Abraham, C.Vasanthi,
K.Sudheer and GarimellaPardhu**

Department of Livestock Products Technology (Meat Science),
Madras Veterinary College, Chennai,
Tamil Nadu Veterinary and Animal Sciences University

A study was carried out to evaluate the optimum level of inclusion of guava powder for the development of functional chicken meat nuggets. Chicken nuggets were prepared with three different levels of guava powder viz., 0.5, 1.0 and 1.5 per cent and were evaluated for physico-chemical characteristics. Results revealed that nuggets incorporated with 1.5 per cent guava powder had a significantly ($P < 0.01$) higher emulsion stability (96.38%), cooking yield (97.85%) compared to other treatments and control. No significant difference was observed in pH, colour, texture profile analysis and cholesterol between treatments and control. However, nuggets incorporated with 1.5 per cent guava powder had higher sensory scores compared to other treatments and control. Hence, 1.5 per cent of guava powder was selected as optimum level for the development of functional chicken meat nuggets.

FPT - 26

**INCIDENCE OF PALE SOFT EXUDATIVE PORK IN
PIGS IN AND AROUND GANNAVARAM**

K.Haritha¹, T.Venu², E.Naga Mallika³, B.Eswara Rao⁴

^{1&2}M.V.Sc. Scholar, ³Associate Professor, ⁴Professor and University Head
Department of Livestock Products Technology, NTR College of Veterinary Science, Gannavaram, AP.

Data from 40 randomly selected Large White Yorkshire carcasses, sourced from different farms in and around Gannavaram slaughtered at experimental abattoir at Department of Livestock Products Technology, CVSc, Gannavaram were collected over 40 days. The pH of the longissimus dorsi muscle was measured at standard 15 minutes intervals after evisceration of the carcass. Two published PSE definitions by Gajana *et al.* (2013) and Offer (1991) were selected to test the incidence of PSE pork in the samples collected. The carcasses that fell outside these thresholds were considered PSE and are presented as a proportion (%). Determination of PSE using an ultimate pH threshold of pH 5.5 according to Category 1 had resulted in 60% of carcasses being classified as PSE. However, ultimate pH is independent of the rate of pH decline the rate of fall of pH was considered. The percent of animals which were considered for the rate of pH decline greater than or equal to 0.02 units per minute at 45 minutes (Offer 1991) was 10%. The colour of fresh meat is pale in all situations and is not associated with eating quality of meat. The meat was well acceptable in terms of palatability. Lactate values were estimated in all animals and the average values were 110.43 ± 0.36 exhibiting a possibility of stress.



FPT-27

**INFLUENCE OF COOKING ON THE COLOUR AND TEXTURE PROFILE OF
DIFFERENT MUSCLE REGIONS OF DUCK MEAT**

**T.Nandini Devi, R.Ramani, R. Narendra Babu, J. Ramesh,
V.Appa Rao and Bhagyashree Ojha**

Department of Livestock Products Technology (Meat Science),
Madras Veterinary College, Chennai.
Tamil Nadu University of Veterinary and Animal Sciences (TANUVAS)

A study was carried out to assess the influence of cooking on the colour and textural characteristics of different muscle regions (thigh and breast) of duck meat. Eight meat samples of duck were procured from retail meat outlets. The meat samples were moist cooked with pressure cooker (121°C, 15 lbs psi) and analysed. The colour of cooked meat samples were measured using Hunter lab Mini scan plus Spectrocolorimeter. Texture profile analysis was carried out using a Stable Microsystems Texturometer plus texture analyser. The results for yellowness (b^*) and chroma values showed significant difference ($P>0.05$) between breast and thigh regions in cooked duck meat. No significant difference ($P>0.05$) was observed in other parameters like brightness (L), redness (a^*) and hue values between the breast and thigh regions of cooked duck meat. It was also observed that the breast region of cooked meat of duck had higher hardness (10.3 ± 0.34), springiness (0.69 ± 0.03), cohesiveness (1.12 ± 0.5) and chewiness (7.5 ± 0.11) values while thigh region of cooked meat of duck had higher values for gumminess (9.3 ± 0.07). Hence it can be concluded that cooking produces highly significant changes in different regions of meat and these results can be useful for meat scientists for preparation of innovative and value-added meat products.

FPT-28

**STATISTICAL SURVEY ON AGE WISE CONSUMER PREFERENCE FOR
MEAT AND MEAT PRODUCTS FROM FIVE DIFFERENT
REGIONS OF KERALA**

**¹Sruthi C*, ¹Swetha P T, ¹Afsal S, ¹Athulya T R, ¹Murugavelu M, ²Vrinda K Menon,
²Sethulekshmi C, ³B Sunil and ⁴C Latha**

¹MVSc Scholars, ²Assistant Professors, ³Professor, ⁴Professor and Head
Department of Veterinary Public Health
College of Veterinary and Animal Sciences, Mannuthy, Thrissur
Kerala Veterinary and Animal Sciences University

The paper stems from an interest in understanding the preferences of population with respect to meat and meat products and their implications. A statistical survey was conducted in three different age groups from five different regions of Kerala (Nilambur, Irinjalakkuda, Kizhakkencherry, Mullurkara, and Edakkara) with a well structured questionnaire. The age groups were in the ranges of 20-30, 30-40 and 40-50 years with 60 sample units each. The study encompassed preferences of consumers on the type of meat and value added products, consumer's awareness on availability of good quality meat and religious taboos on meat consumption. The result of the survey showed an increased preference to chicken meat in 43.33% of people



among 20-30 years of age group and 50 % from 40-50 years, while 51.7% of the 30-40 years of age group preferred beef meat. Out of the 180 population, 96 % people preferred cutlet over other meat products. Among the total population 87.2% preferred buying meat from road side slaughter houses where as the rest 12.8% preferred buying meat produced in modern slaughter houses. Among the people of 20-30 years of age, 18.2% have religious aversion for pork whereas 12% have an aversion for beef. In the group of 30-40 years of age, 19% people have an aversion to pork and 12.5% have an aversion to beef. In the age group of 40-50, 22% have an aversion to pork consumption and 13% have an aversion to beef consumption. From the data obtained, it is evident that age has a major impact on meat preferences which could influence the meat and meat product marketing.

FPT-29

A SURVEY OF MEAT BORNE ZONOTIC DISEASES AMONG THE PUBLIC IN KADAPA DISTRICT, ANDHRA PRADESH, INDIA

**C. Venkata Sesha Reddy^{1*}, B. Sujitha¹, D. Maheswara Reddy², RSD Gupta²,
M.Naveen Kumar Reddy² and S. Vani³**

¹V BVSc & A.H., College of Veterinary Science, Proddatur, SVVU, A.P.

² Department of Livestock Products Technology, CVSc, Proddatur, SVVU, A.P.

³ Department of Animal Genetics & Breeding, CVSc, Proddatur, SVVU, A.P.

Diseases that are transmitted to human beings through the consumption or handling of meat are known as meat borne diseases. Zoonotic pathogens are present in meat, offals, meat products and slaughter environment but are often difficult to diagnose. Meat borne zoonoses are of both public health and economic importance. A study was conducted to assess the awareness about meat borne zoonotic diseases among livestock farmers, agricultural workers, butchers, students and employees. The questionnaire was prepared to get the information about zoonotic diseases, source of infection, modes of transmission and hygienic practices followed by the respondents. A total of 650 people were selected randomly from Kadapa district of Andhra Pradesh, India and their responses were collected, tabulated and analyzed using percentage analysis. Some of the respondents know about the dangerous meat borne zoonotic diseases like Bird flu (56%), Tuberculosis (20.3%), Anthrax (10%), Salmonellosis (4.5%), Taeniasis (3.5%), Listeriosis (3.2%), Leptospirosis (3.02%), Hydatid disease (2.5%) and Erysipelas (1.5%). None of the farmers and agricultural workers was aware about disinfectants. Awareness about transmission of meat borne zoonotic diseases among the respondents was 6.64%. Continued education and creating awareness by conducting training programmes and collaboration between veterinary and human health care professionals were considered to be important to combat meat borne zoonotic diseases.



FPT-30

**STANDARDIZATION OF VALUE ADDED EGG PONGANALU
AND CHICKEN PONGANALU**

**K.Vidyadhara Reddy DVG¹, N.Ranga Rao¹, R.Sai Dilip Gupta²,
D. Maheswara Reddy², M.Naveen Kumar Reddy².**

¹ IVth BVSc & A.H., College of Veterinary Science, SVVU, Proddatur, A.P.

² Department of Livestock Products Technology, CVSc, Proddatur, SVVU, A.P, India.

The present study was intended to standardize the recipe and procedure of traditional ponganalu with egg and chicken. Ponganalu is a well known traditional food item consumed as snack and breakfast especially in Rayalaseema region of A.P. prepared using fermented rice and lentil blended with onions, green chilly and curry leaves using a mould. Ponganalu mix is prepared using egg liquid, chicken and Bengal gram flour which give value addition by increasing proteins, vitamins and minerals. Consumers are demanding new products with quality, stability, safety and better health. But some of the present modern food technologies often leading to loss of basic nutrients from processed raw materials necessitate finding a new way to improve the nutritional value. As our Indian food is as diverse as its culture and climate there is a scope for innovation of new traditional products. Hence, the present study was designed to standardize the procedure for preparation of value added egg ponganalu and chicken ponganalu by modifying the traditional recipe of ponganalu by replacing batter made of lentils and rice with Egg liquid, Chicken (20%), Onions (40%), Green chilly (4%), Bengal gram flour (2%), Salt (1.5%), Turmeric powder (0.125%), Red chilly powder (0.75%), Pepper powder (0.11%), Ginger garlic paste (5 %) which are consumer preferable, easy to prepare, ready to eat, delicious and cost effective. Further serving of egg and chicken ponganalu with bread slices gives good appeal. These two products are prepared as a part of our entrepreneurial training programme and there is a good demand for these products among the consumers.



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Key Note Addresses

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THE ROAD TO NABL (ISO / IEC 17025 : 2005) LABORATORY ACCREDITATION : EXPERIENCES OF ICAR-NRC ON MEAT WITH A NOVEL SCOPE

Vaithyanathan, S and Vishnuraj, M. R

Meat Species Identification Laboratory (MSIL), ICAR-National Research Centre on Meat,
Chengicherla, Hyderabad-92, Telangana, India.
ISO/IEC 17025:2005 NABL Accredited Laboratory

1. Introduction

The high price of animal derived proteins in market make this commodity (meat) highly vulnerable to adulteration. Moreover mislabelling of food products is done to cover up the food fraud committed while making food preparations in the form of ingredient substitution and has been observed globally (Amaral et al., 2017). One of the worst outcome of meat authenticity issue can be elucidated from the "Horse meat scandal" of Ireland in January, 15, 2013 (Walker *et al.*, 2013). The issue had its origin when the press release from the Food Safety Authority of Ireland (FSAI), declared the presence of horse and pig DNA in beef burgers. It begins with merely two meat processing plants, but on a two month laboratory investigations, it evolved on to a pan-European food fraud incident. This fraud exposed mainly in the cheaper end of frozen beef market and as on consumer confidence in processed meat products in the European Union has been significantly damaged. This is a lesson for the meat food industry that, any such incidence may leads to sharp decline in trade of ready meal sector. Anecdotal evidence of such meat admixture episode can also be traced from the "great meat substitution scandal" unfolded in 1981 in Australia (Grabosky and Sutton, 1989). In this case, horse meat were detected in beef shipped from Australia to a plant in San Diego in US. Another devastating picture of meat fraudulency can be read out from the article of Walker *et al.*, (2013). In his own words it is explained as "*Considerable quantities of pet food were illegally diverted into the human food chain. The pet food included the flesh of donkeys, (feral) goats, kangaroos, buffaloes and horses, killed in the field without regard to hygiene*".

Consumption of meat and meat products in India is growing rapidly due to higher disposable income and rapid urbanization. Being a country with diverse geography and religiously and seasonally adaptable food habits, the possibilities of adulterations are various. Unlike the developed countries, the offending factors in meat trade in India is multifactorial and the need to establish a meat species identification laboratory at an Institutional level is explained further in this article. This article is prepared in such way to discuss some of the many aspects of establishing an ISO/IEC 17025 compliant laboratory in an institutional set-up with the goal of strengthening the testing competitiveness/analytical capabilities of the FSSAI referral laboratory (ICAR-National Research Centre on Meat) per se and of providing guidance to other institutional and private laboratories to travel down the same road.

2. Why the country need a Meat Species Identification Laboratory (MSIL)

From the experiences of MSIL, which started analysing meat samples for species identification in 2010-11, and from the information/evidences received from the authorities who forwarded all the 216 samples



to MSIL till date (Jan-2019), the need to establish a laboratory for meat species identification is explained in a fivefold facets.

At first, the distinctiveness of Indian meat industry is that, slaughter of cow and sale of beef is prohibited in several states of India through enactment of law (National Commission on Cattle, 2002). Vaithyanathan et al. (2018) published a comprehensive report on application of DNA techniques in forensic food analysis through analyzing 139 field/evidence samples submitted to MSIL, and the issues posed by various law enforcement agencies. According to 19th Livestock census conducted by Department of Animal Husbandry, Dairying and Fisheries, Government of India, except for buffaloes, the population has reduced by 4.10, 9.07, 3.82 and 7.54% for *cattle*, sheep, goat and pigs respectively during the period from 2007 to 2012. There was a marginal increase in buffalo population from 105.34 to 108.70 million (3.19%) during 2007 to 2012. During the period from 2007 to 2012 the meat production has increased in India by 7.33, 7.84, 11.66, 10.34 and 20.81% for *cattle*, buffalo, goat, sheep and chicken, respectively. Slaughtering of male buffalo calves is banned in several states. India has around 4000 registered slaughterhouses, whereas 25,000 unregistered premises were functioning and animals are slaughtered.

Secondly, the issues of food fraud/economically motivated adulterations (EMA) especially in processed/prepared meat products, and this is largely a mysterious area in the Indian context. The U.S. Food and Drug Administration (FDA) has defined economically motivated adulteration (EMA) as the "fraudulent, intentional substitution or addition of a substance in a product for the purpose of increasing the apparent value of the product or reducing the cost of its production, i.e., for economic gain." The driving force behind any adulteration is the revenue maximization, either by using a low cost ingredient to substitute a more expensive one, or to remove the valued component (Ioannis and Nikolaos 2005). Singh and Neelam (2011), reported that approximately 25-30 % of meat sold in India is adulterated and adulteration will be more in case of comminuted meat products. In one of the study conducted by MSIL on Haleem during a period of two years (2016 & 2017) on 100 samples collected from retail outlets, the incidence of occurrence of undeclared species were established with a relatively higher frequency (unpublished data).

EMA, apart from affecting the freedom of choice, generates considerable concerns from multiple perspectives: company brand protection, criminality, public health and consumer fraud. Ongoing EMA-related research at the Food Protection and Defence Institute (FPDI) focuses on the vulnerabilities in the food system, drivers that create an opportunity for EMA and the impact of EMA with an emphasis on public health consequences. While EMA perpetrators do not intend to cause illness or death, as that will reveal the adulteration, EMA may still result in public health harm. Illnesses in both human and animals have occurred due to fraudulent adulteration, typically when the adulterant is toxic or allergenic. This results in EMA not only being an economic crime but also a public health threat. The adulteration of high value commercial meat such as mutton with low value meat such as chicken, pork and beef is done for financial gains which results in high motivation to the trader (Nischella et al., 2016). Once the taxonomic features are removed from the meat, it is difficult to identify the species of the meat visually. This is further complicated by the similarity in the texture between closely related species used for adulteration.

Third, The ever increasing demand for meat due to increasing trend in consumption make the fraudster to search for unconventional meat to adulterate with high quality meat. In India and some of the African countries, one of the unconventional meat receiving the latest attention of adulteration is camel meat. However, the slaughter of camel and sale of camel meat is prohibited in India (FSSAI, 2011). The total number of camel in the world is 25 million, and India possess 0.4 million camels mostly in Rajasthan,



Haryana, Gujarat (Indian Livestock Census 2012). The population of camel in India is dwindling at 22.48% in a span of 6 years. Hence, conservation of this animal is important to maintain proper ecosystem in the desert. One of the conservation system is the detection of illegally slaughtered and sold camel meat in the Indian market. Moreover, the issue became more imperative considering the fact that consumption of wild/unconventional meat may lead to emerging zoonotic diseases or entry of banned drugs in human food chain. Therefore, test are a risk based assessment and generally tend to be for the highest risk groups only.

Fourth, Indian meat export industry is mainly dominated by buffalo meat and the demand for Indian buffalo meat in international market has sparked a sudden increase. India is producing 2.08% of the global meat (302 MT) and has the distinction of producing largest amount of buffalo meat in the world (42.61%). Only export of buffalo meat is permitted from India by rule, and not the beef, so adequate testing facilities needed to establish that the beef is not entering in to the export chain to safeguard the exporter's interest. Halal authentication to test the presence of porcine DNA covering a wide range of finished products and raw meat including food by both qualitative and quantitative methods may improve the present halal certification procedures in the country.

Fifth, being a member country in WTO and under the new food regime of Food Safety and standards act (FSSAI), it is mandatory to develop robust and state of the art techniques to detect such meat adulteration in a cost effective manner. Moreover, ISO has already set up its technical committee (ISO/TC 34/SC 16) to develop methods to analyse the presence of buffalo meat in meat and meat products (ISO/AWI 20147) and to develop multiplex PCR methods (ISO/NP 20148) to detect species origin of meat and meat products. The initial impetus for the creation of a standard for meat came from Iran. The Iranian Govt. was concerned that donkey meat was being substituted for halal meat and realized that they could not monitor the meat satisfactorily without international support. And there is currently a move away from targeted testing, from looking at a particular species and asking is there or not, to a method that establishes what kind of meat the product consist of.

3. Why should an institutional laboratory have a quality system?

Top management of ICAR-NRC on Meat wanted to know whether entering the accreditation process was self- motivated by the laboratory management, recognizing the significance and advantages of accreditation, when standards like GLP (Good Laboratory Practices from Organization for Economic Cooperation and Development, OECD) were available for adoption, or was reluctantly adopted as a result of external pressure, applied by external bodies such as a regulating authority or corporate management, or by market necessity, and interestingly our answer was both. The outside pressure was definitely there, which was from the Food Safety and Standards Authority of India. In India, the species identification from the suspected meat samples/meat products is not commercially performed in the biological testing laboratories. But the demand for species identification of meat samples is increasing day by day and the FSSAI has identified the MSIL (NRC on Meat) as referral laboratory for meat species identification.

The ICAR-National Research Centre on Meat is the constituent unit of Indian Council of Agricultural Research (ICAR), established in Hyderabad with a vision to make National Research Centre (NRC) on Meat as a premiere institute of meat research to solve the problems and face challenges of meat and allied sectors development in the country. The Centre has developed its new campus at Chengicherla (10 km from Uppal towards Warangal high way) in April 2007. The Meat Species Identification Laboratory (MSIL) of NRC on Meat is coming under the Quality Control Division of the institute.



The FSSAI has also made it mandatory to all the referral laboratories to get their laboratories accredited as per NABL policy and following ISO 17025:2005 standards. The ICAR-NRC on Meat completed its registration on Indian Food Laboratory Network (InfoLnet), the online platform under FSSAI for laboratories, food safety officers and standards in the country, which further demands the need for adoption of an internationally acceptable quality system. Besides, meat exporters, animal husbandry departments, police departments and customs department also request MSIL to perform species identification of meat samples. The MSIL has adequate facilities and technical competence to carry out the tests as mentioned in the scope of accreditation, i.e. meat species identification by DNA based techniques.

Main benefits from adoption of a new quality system in MSIL

- An improvement was measured in most of the parameters we were observing. Laboratory managers are especially pleased with the marked improvement in personnel professionalism and skills, in planning and executing more precise, reliable and efficient measurement processes, in clearer and more detailed documentation and in better maintenance of the equipment.
- Organizational learning is improved, mainly through corrective and preventive activities, with data and information assembled from internal and external sources alike.
- Inter-laboratory proficiency tests were noted as very beneficial.
- Improvement is noted in the practice of listening to customer needs, ideas and types of information needed in test reports. Customers were more involved in defining work methods. It is not surprising that customer satisfaction has improved.

4. General guidelines for NABL Accreditation process

National Accreditation Board for Testing and Calibration Laboratories (NABL) is a Constituent Board of Quality Council of India. NABL has been established with the objective to provide Government, Industry Associations and Industry in general with a scheme for third-party assessment of the quality and technical competence of testing and calibration laboratories. In order to achieve this objective, NABL provides laboratory accreditation services to laboratories that are performing tests / calibrations in accordance with ISO/IEC 17025:2005 and ISO 15189:2012 for medical laboratories. These services are offered in a non-discriminatory manner and are accessible to all testing and calibration laboratories in India and abroad, regardless of their ownership, legal status, size and degree of independence. NABL accreditation system complies with ISO/IEC 17011:2004 and Asia Pacific Laboratory Accreditation Cooperation (APLAC) MR001. Based on evaluation of NABL operations by APLAC in 2000, NABL has been granted signatory member status by APLAC and International Laboratory Accreditation Cooperation (ILAC) under their Mutual Recognition Arrangements (MRAs). Under these MRAs, the reports issued by NABL accredited laboratories are considered to be equivalent to reports issued by laboratories accredited by (currently) 76 accreditation bodies in 64 economies (<https://www.nabl-india.org>).

Preparation & Eligibility for Accreditation

- Once the CAB decides to seek NABL accreditation, it should make a definite plan of action for obtaining accreditation and nominate a responsible person to co-ordinate all activities related to seeking accreditation who should be familiar with CAB's existing quality system.
- The CAB should get fully acquainted with relevant NABL documents and understand the assessment procedure and methodology for filing an application.



- A CAB wishing to be accredited by NABL must have a Quality Manual on its Quality System satisfying the requirements as described in various clauses of ISO/ IEC 17025:2005 and requirements of relevant NABL specific criteria (NABL 102) and needs to ascertain the status of its existing quality system and technical competence.
- The proposed Quality manager shall have undergone 4-days formal training on management system and internal audit based on relevant standard.
- The CAB must ensure that the procedures described in the Quality Manual and other documents are being implemented.
- The applicant CAB must have participated satisfactorily in the proficiency testing program, wherever applicable, conducted by NABL/ APLAC or any other national or international accredited/ recognised PT provider. If no suitable PT program is available the CAB can initiate an inter-laboratory comparison with adequate number of accredited laboratories.
- The minimum stipulated participation for laboratories is one parameter/ type of test/ calibration per discipline, prior to grant of accreditation and an on-going program as per NABL 163.
- The satisfactory performance shall be defined in term of z-score and En number respectively or any other acceptable internationally accepted method.
- For unsatisfactory performance, the CAB is to take corrective action and inform NABL. ISO/ IEC 17043, NABL 163 and NABL 164 give details of proficiency testing.
- The applicant CAB must have conducted at least one internal audit and a management review before the submission of application (<https://www.nabl-india.org>).

5. General process of Accreditation and practical experiences of the laboratory in implementing the ISO/IEC 17025.

The process of accreditation starts with the appointment/authorization of the following key personnel in MSIL.

❖ **Top Management** (Director, ICAR-National Research Centre on Meat)

Top Management is the overall in-charge of the MSIL, he is also responsible for effective implementation of the quality policies of the lab and to ensure that the objectives are met. As Head of the organization, he nominates the Quality Manager (QM) and the Technical Manager (TM), and their deputies.

The MSIL management, that comprises Director, ICAR-NRC on Meat, QM and TM has decided to establish, implement and maintain a quality management system in conformance with ISO/IEC 17025: 2005 requirements for the accreditation of the laboratory. And the scope of this quality management system (QMS) related to testing of meat samples for species identification. For the effective implementation of the this quality management system in MSIL to carry out the test mentioned under the scope, a detailed documentation comprising four levels of document have been prepared by the active participation of this team and are made accessible to the concerned laboratory personnel.

- ✓ Level 1: Quality Manual (QM)
- ✓ Level II: Quality Management System procedure manual (MSP)
- ✓ Level III: Standard Operating Procedures (SOP), Standard Testing Procedures (STP) and Data Sheet (DS)

- ✓ Level IV: Forms, formats and records used in the lab

The management system documentation of the laboratory is communicated to, understood by, available with and implemented by those personnel who are responsible for maintaining the quality of test results.

Scope and field of application

The Meat Species Identification Laboratory (MSIL), ICAR-National Research Centre on Meat, is indented to provide quality services in the field of meat species identification through *DNA Macro array method*, under the category: Biological testing, as per the NABL policy of testing and calibration laboratories. In MSIL, the lab authorizes specific personnel to perform test, to issue test reports, give opinions and interpretations and to operate particular type of equipment. And MSIL maintains the records of the relevant authorizations, competence, educational and professional qualifications, training, skills and experience of all technical personnel, including contracted personnel.

Both the Quality Manager and Technical manager in MSIL has undergone the mandatory 4 days training for "Laboratory Quality Management System & Internal Audit as per ISO/IEC 17025: 2005" which were organized by the National Institute for Training on Standardization (NITS) through BIS and the technical personnel were trained internally for the relevant scope of testing by the technical manager.

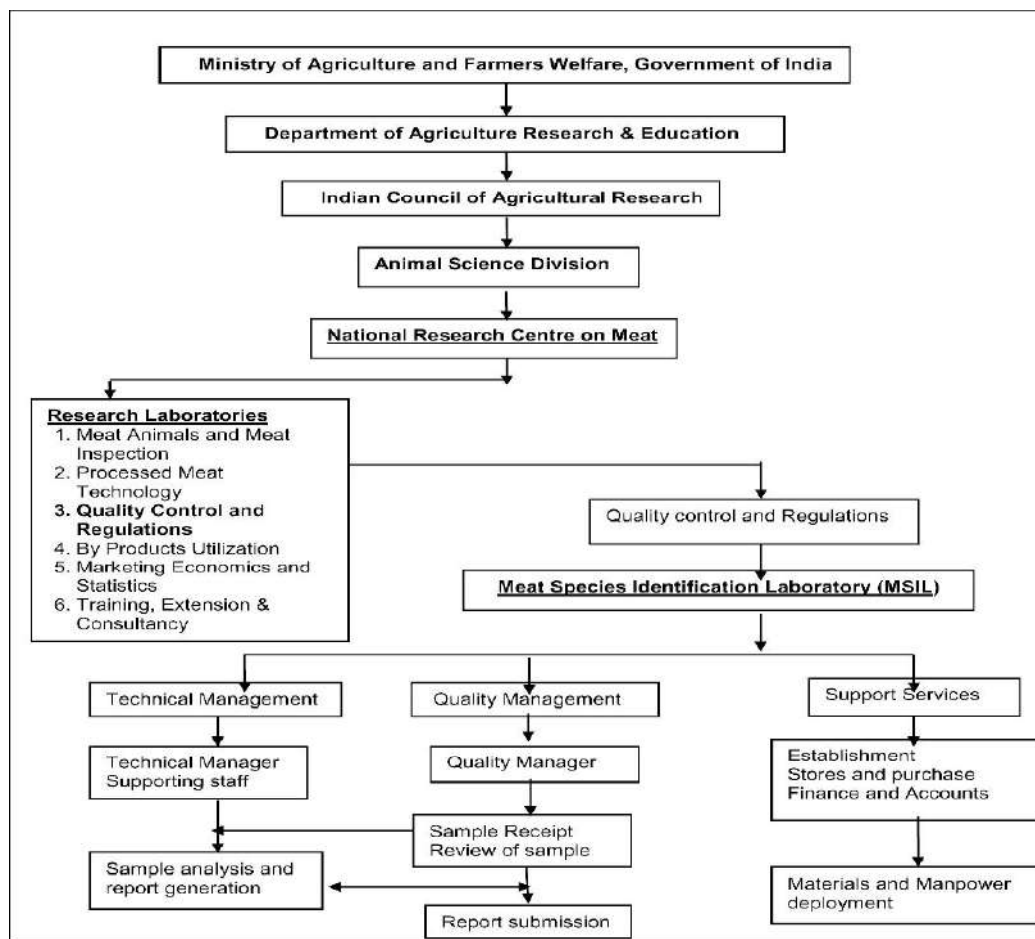


Fig 1: Organogram of MSIL, ICAR-National Research Centre on Meat.



The MSIL has submitted its application after completing the first internal audit and Management review meeting in the prescribed application form (NABL 151 for testing laboratories), in three copies along with two copies of the quality manual of the CAB that should describe the management system in accordance with ISO/ IEC 17025: 2005 on 23/05/18. The application is to be accompanied with the prescribed application fee as detailed in NABL 100. After completion of adequacy auditing of the documents of MSIL and since there are no inadequacies in the quality manual a pre -assessment visit of the CAB is organised by lead assessor appointed by NABL on 14/07/18. The pre-assessment of the CAB is conducted to evaluate non-conformities (if any) in the implementation of the quality system, to assess the degree of preparedness of the CAB for the assessment, to determine the number of assessors required in various fields based on the scope of accreditation, number of key location to be visited etc. The lead assessor submitted a pre-assessment report to NABL Secretariat with a copy to the CAB. The CAB took corrective actions on the non-conformities raised on the documented management system and its implementation and submitted a report to NABL Secretariat.

After the MSIL has taken satisfactory corrective actions, NABL finalized the constitution of assessment team in consultation with the CAB. The team includes one lead assessor and one technical assessor for the scope of accreditation sought. Assessment was conducted for two days dated 11 & 12th of August-2018 and the team reviewed the CAB's documented management system and verified its compliance with the requirements of ISO/ IEC 17025: 2005 and NABL 102, the relevant specific criteria and other NABL policies. The CAB's technical competence to perform specific tasks was also evaluated through retesting of retained samples. The assessment team has submitted the recommendation towards grant of accreditation to NABL. The assessment report was examined by NABL Secretariat and the follow up action as required were initiated. MSIL has taken necessary corrective actions on non-conformities and submitted a report to NABL Secretariat within 15 days.

6. Accreditation certification by National Accreditation Board for Testing and Calibration Laboratories (NABL), Quality Council of India (QCI).

NABL Accreditation of Meat Species Identification Laboratory (MSIL) in the field of Biological Testing as per the Laboratory Quality Management System (ISO/IEC 17025:2005) were achieved as on 10/10/2018. The grant of accreditation from NABL is for a period of two years in the field of biological testing which mainly covers the meat species identification based on DNA macro array technique for nine species of meat/food animals. The accredited CABs at all times shall conform to the requirements of ISO/ IEC 17025: 2005 and relevant specific criteria and NABL Policies. The accredited CABs are required to comply at all times with the terms and conditions of NABL given in NABL 131 "Terms & Conditions for obtaining and maintaining NABL Accreditation". The NABL accreditation certificate is valid for a period of 2 years. NABL conducts annual Surveillance of the CAB at intervals of one year which is aimed at evaluating continued compliance to the requirements of ISO/ IEC 17025: 2005 relevant specific criteria and NABL Policies. The accredited CAB is subjected to re-assessment every 2 years. The CAB has to apply 6 months before the expiry of accreditation to allow NABL to organise assessment of the CAB, so that the continuity of the accreditation status is maintained.

National Accreditation Board for Testing and Calibration Laboratories
(A Constituent Board of Quality Council of India)

CERTIFICATE OF ACCREDITATION

MEAT SPECIES IDENTIFICATION LABORATORY (MSIL)

has been assessed and accredited in accordance with the standard
ISO/IEC 17025:2005
'General Requirements for the Competence of Testing & Calibration Laboratories'

for its facilities at
ICAR-National Research Centre on Meat, Chengicherla,
Boduppal PO, Hyderabad, Telangana
in the field of
TESTING

Certificate Number TC-7992
Issue Date 10/10/2018 Valid Until 09/10/2023

This certificate remains valid for the Scope of Accreditation as specified in the annexure subject to continued satisfactory compliance to the above standard & the relevant requirements of NABL.
(To see the scope of accreditation of this laboratory, you may also visit NABL website www.nabl-india.org)

Signed for and on behalf of NABL

Anil Reda
Chief Executive Officer

National Accreditation Board for Testing and Calibration Laboratories
(A Constituent Board of Quality Council of India)

SCOPE OF ACCREDITATION

Laboratory Meat Species Identification Laboratory (MSIL), ICAR-National Research Centre on Meat, Chengicherla, Boduppal PO, Hyderabad, Telangana

Accreditation Standard ISO/IEC 17025: 2005 Page 1 of 1
Certificate Number TC-7992 Last Amended on --
Validity 10.10.2018 to 09.10.2023

Sl.	Product / Material of Test	Specific Test Performed	Test Method Specification against which tests are performed	Range of Testing / Limits of Detection
BIOLOGICAL TESTING				
I. MOLECULAR ANALYSIS				
1.	Meat and Meat Products	Animal Species Identification Cattle Buffalo Equine Sheep Goat Pork Turkey Chicken Camel	DNA micro array method based on NRC/MSE/STP-001 dated 23.05.2018	Qualitative LOD < 5 %

Manoj Kumar
Convener

Anuja Prasad
Program Manager

Fig 2 : NABL Accreditation certificate & Scope of Accreditation for MSIL.

Lead Papers

Session-III : Lead Paper - 01

ROLE OF EGGS IN HUMAN NUTRITION AND HEALTH : AN OVERVIEW

B. Eswara Rao, E. Naga Mallika and M. Sahitya Rani

Department of Livestock Products Technology
NTR College of Veterinary Science, Gannavaram, A.P

Introduction

Essential dietary nutrients including micro nutrients (vitamins and minerals), amino acids and essential fatty acids are needed by the human body to stay healthy. In addition, the body needs trace elements and energy providing compounds such as sugars and non essential fatty acids. These compounds along with non nutritive substances such as fibre are provided by the food we eat. Most foods contain more than one nutrient but are particularly good source of one or two nutrients. Eggs are unique and contain balanced distribution of nearly every nutrient essential to human. Eggs are one of the nature's most perfectly balanced foods, containing all the nutrients, vitamins except Vitamin C and minerals known to be essential for good health. Eggs are economical source of high quality protein and contain moderate amount of fat, mostly unsaturated fatty acids. Eggs are low in the more dangerous saturated fat.

Nutritive value of Edible egg

The egg is recognised as a rich source of nutrients that are essential for maintaining human health. Eggs when laid, are either sterile and are naturally packed in a containers, the shell not only facilitates handling, but also protects from outside contamination. The nutritive value of eggs varies with regard to vitamin content. A good hatching egg is of best nutritional value. Vitamin and trace mineral content can be influenced by the hen's diet. Therefore, a well fortified diet gives the best nutritional value in eggs.

Protein

It contains all ten essential amino acids. It is known as balanced protein, if it is added to other foods, which are having unbalanced protein, improves their nutritive value. The quality of egg protein is taken as standard against which the proteins of other foods are measured. Protein account 11% of energy. It has a very high biological value (BV), Net protein Utilisation (NPU) and protein efficiency ratio (PER) (Krishnappa and Ramachandra, 1984) compared to other foods.

TABLE: 1 Amino Acid Composition of Egg (Nutrients per 100g)

AMINO ACIDS (G)	WHOLE EGG	WHITE	YOLK
Alanine	0.69	0.64	0.81
Arginine	0.77	0.6	1.14
Aspartic acid	1.18	1.06	1.44
Cystine	0.28	0.28	0.27
Glutamic acid	1.54	1.36	1.94

Glycine	0.40	0.36	0.49
Histidine	0.29	0.24	0.41
Isoleucine	0.66	0.56	0.87
Leucine	1.04	0.88	1.39
Lysine	0.82	0.66	1.17
Methionine	0.39	0.39	0.39
Phenylalanine	0.64	0.60	0.69
Proline	0.48	0.40	0.65
Serine	0.91	0.71	1.36
Threonine	0.59	0.47	0.85
Tryptophan	0.19	0.17	0.24
Tyrosine	0.51	0.41	0.73
Valine	0.70	0.72	0.96

Source : Cotterill and Gilbert, 1979.

FAT

The average egg of 60g contains approximately 6g of lipid, which is almost wholly confined to yolk (Gilbert, 1976a). Egg fat is in an emulsified form readily digestible, not only by adults but also by children of 3 months age. Fat acts as a carrier for Vitamin A, D, E and K. Egg fat is rich in phosphorus and essential fatty acids.

Almost all lipids in yolk exist in lipoprotein form, which may readily be separated into distinct classes by a range of physical and chemical methods (Cook, 1968, Gornall and Kuskis 1973). The overall lipid; protein ratio of the yolk is about 2:1. Extractable lipid contents are far about 33% of the total weight of the yolk. The proportions of the major individual lipid fractions are listed in table 2.

Table: 2. Proportions of Major Lipid in Yolk (% weight of total).

LIPID		PHOSPHOLIPIDS	
Cholesterol esters	1.3	Phosphotidy ethanol amine	23.9
Triglycerides	63.1	Phosphotidyl serine	2.7
Free fatty acids	0.9	Phosphotidyl choline	69.1
Free cholesterol	4.9	Sphingomyelin	1.0
Phospholipids	29.7	others	3.2

(Source : Rhods and Lea, 1957, Privette et.al. 1962; Noble and Moore 1964, 1965, 1966, cook and Martin 1969, Gornall and Kuskis, 1973).

The major yolk lipid fraction is triglyceride, which is accompanied by substantial quantity of phospholipid, the only other major component is free cholesterol. Other extractable lipid like substances e.g. pigments, may be present in the yolk but in very low proportions only. Phosphotidyl choline and phosphotidyl ethanol amines are the major phospholipid components.

The fatty acid composition of the major lipid fractions are given in Table 3.

Table: 3. Fatty Acid Composition (Major fatty acids, % by weight of total phospholipid fractions of the yolk).

Fatty Acid	Cholesterol esters	Triglycerides	Phospholipids
Palmitic	29.1	24.5	28.4
Palmitoleic	1.0	6.6	1.9
Stearic	9.5	6.4	14.9
Oleic	40.1	46.2	29.5
Linoleic	18.0	14.7	13.8
Arachidonic	0.9	0.3	6.2
Decosahexanoic	0.5	0.2	4.1

Source: Rhods and Lea, 1957, Privette et.al. 1962; Noble and Moore 1964, 1965,1966, cook and Martin 1969, Gornall and Kuskis, 1973).

The oleic acid is the major fatty acid in the lipid fraction with palmitic and stearic acids accounting for up to half of the total. Substantial level of linoleic acid is also present. The phospholipids fraction contains a high level of poly unsaturated fatty acids (Table 4). Cholesterol and fatty acid content of yolk: The relative composition of the yolk in relation to cholesterol and fatty acid content are given in Table-5.

Table: 4. The Average Fatty Acid Composition of Egg Lipids

Lipids (g)	Whole egg	White	Yolk
Total Fat	10.5	-	28
I Total saturated fatty acids	3.0	-	8
8:0 Caproic acid	0.05	-	0.16
10:0 Caprylic acid (octanoic)	0.15	-	0.47
12:0 Lauric acid	0.05	-	0.15
14:0 Myristic acid	0.70	-	-
16:0 Palmitic acid	25.2	-	31.8
18:0 Staeric acid	4.1	-	7.5
20:0 Arachidonic acid	0.04	-	0.12
II Total unsaturated fatty acids	6.0	-	16
(a) Mono - unsaturated acids			
14:1 Tsuzuic acid	0.01	-	0.03
16:1 Palmitoleic acid	0.39	-	1.24
18:1 oleic acid	4.2	-	13.4

Linoleic acid	0.90	-	2.40
(b) Poly unsaturated			
18:2 Linoleic acid	1.20	-	3.82
18:3 Linolenic acid	0.20	-	0.08
20:4 Arachidonic acid	0.10	-	0.30

TABLE: 5.

CHOLESTEROL AND FATTY ACID CONTENT OF YOLK. (a)	
Cholesterol esters (b)	1.3
Free Cholesterol (b)	4.9
Poly unsaturated fatty acid content (c)	15.9
Linoleic acid	1.0
C20+C22 poly unsaturated acid	3.2
Total poly unsaturated acid(c)	20.1
Mono unsaturated fatty acids (c)	45.1
Saturated fatty acids (c)	34.2

About 5% of the yolk is free cholesterol and it is accompanied by 1% of cholesterol in an esterified form.

The level linoleic acid in the yolk is 16% of the total fatty acids. With the addition of C₁₈, C₂₀ and C₂₂ poly unsaturated fatty acids gives a total polyunsaturated content of some 20%. If the reminder of the fatty acids in the yolk, monounsaturated account for 46% and saturates to 34% (Table 4&5). Thus yolk can be considered as predominantly unsaturated.

MINERALS, TRACE MINERALS AND VITAMINS

Egg is a rich source of these nutrients, yolk is the richest portion of the egg. The minerals, trace minerals and vitamin contents of an egg are shown in tables 6, 7 and 8.

Table: 6. Mineral Content in the Egg (Per 100g)

	WHOLE EGG	WHITE	YOLK
Minerals (Ash) (g)	1.00	0.7	1.6
Calcium (mg)	54.0	10.0	148.0
Chloride (mg)	175.0	174.0	171.0
Iron (mg)	2.10	0.30	6.00
Magnesium (mg)	11.5	11.0	13.0
Phosphorus (mg)	210.0	22	599.0
Potassium (mg)	149.0	150.0	110.0
Sodium (mg)	129.0	175.0	78.0
Sulphur (mg)	233.0	163.0	214.0

Source: Cotterill and Gilbert (1979)

The egg is a good source of calcium, chloride, potassium and sulphur. The iron content of an egg, especially in the yolk is higher than many of the foods.

TABLE: 7.

TRACE ELEMENTS IN HEN'S EGG (mg/g)		
ELEMENT	YOLK	WHITE
Aluminium	2.7	0.1
Arsenic	0.2	Trace
Boron	Trace	1.2
Copper	9.2	0.3
Flourine	4.3	0.2
Iodine	2.7	0.4
Lead	8.1	6.1
Manganeese	0.5	Trace
Molybdenum	Trace	0.1
Silicon	31.00	21.00
Strontium	Trace	Trace
Titanium	0.2	0.1
Vanadium	0.1	0.2
Zinc	45	0.2

TABLE : 8. VITAMINS IN THE EGG.

VITAMINS	WHOLE EGG	WHITE	YOLK
A(IU)	1140	-	3210
B(mcg)	0.28	0.01	0.83
Choline (gm)	0.53	-	1.49
Biotin (mcg)	22.5	7.0	52.0
D (IU)	50	-	150
Folic acid (mg)	9.4	1.6	23.2
Niacin (mg)	0.1	-	-
Pantothenic acid (mg)	2.7	0.13	6.0
Pyridoxine (mg)	0.29	0.26	0.35
Thiamine (mg)	0.10	-	0.27

SOURCE : Cotterill and Glauert, 1981.

THE PLACE OF EGGS IN HUMAN DIET

Eggs provide a unique, well balanced nutrients for all ages. The egg is considered, low sodium and low caloric food for humans. Due to these virtues, egg is an incredible edible food for humans of all ages.

The egg has high quality proteins compared to other foods. The quality of a food protein can be determined by its Biological value (BV), Net protein Utilisation (NPU), Protein efficiency ratio (PER) and chemical score.

Table:9. Nutritive Value of Eggs per Serving Size.

Nutrient	Eggs		Percentage of daily requirement for average adult by	
	One	Two	One egg	Two eggs
Calories	80	160	2-3	
Protein (g)	6	13	10-15	30
Carbohydrates (g)	1	1		
Fat (g)	6	12		
Cholesterol (mg)	260	520		
Sodium (mg)	70	140		
Vitamin A	200-800 IU	-	6	10
Vitamin D	10-50 IU	-		
Thiamine (B ₁) (mg)	60-120	-	2-5	
Riboflavin (B ₂) (mg)	100-150	-	5-23	
Niacin (mg)	760		-	5-11
Vitamin E			2	6
Vitamin B ₆			4	6
Folic acid			8	15
Biotin			4	8
Pantothenic acid			8	15

Source : Cotterill and Glauert, 1981.

Table : 10. Energy Values of an Egg

Method of cooking	Energy Value
Boiled egg	80 Kilo calories
Fried egg	135 K.cal
Omelette	135 K.cal
Poached	80 K.cal
Scrambled	145 K.cal
White (albumen)	15 K.cal
Yolk	65 K.cal

Table: 11. Quality of Selected Foods in Comparison with Eggs.

Quality	Egg	Beef	Fish	Cow Milk	Whole Wheat Flour	Beans
Digestibility	97.0	99.3	85.0	96.9	90.9	72.8
Biological value	93.7	74.0	76.0	84.5	65.7	58.0
NPU	93.5	66.9	79.5	81.6	40.3	38.4
PER	3.9	2.3	3.5	2.1	1.5	1.5
Chemical score	100.0	69.0	70	60	44	34.0

Source: Amino acid contents of food FAO, 1970.

The egg contains useful proteins up to 95%; where as other foods like rice have 80%, and meat only 67%. The quantity of proteins present in eggs is 15-30%, cereals, 8-15% and dehusked pulses, grams like "Tur" Masoor, Urad and chhana contain 21-28%.

The superiority of animal protein is because of their high content of two essential amino acids namely lysine and methionine. Usually, the Indian vegetarian meal is deficient in lysine/ methionine.

Eggs Re also good source of unsaturated fatty acids mainly oleic, iron, phosphorus, trace minerals, vitamins A, E and K and the B, D group. As a natural source of vitamin, eggs rank second only to fish liver oils. Eggs are low in calcium and contain very little or no Vitamin C.

Home prepared hard cooked egg yolks are practical and desirable supplement for infants. By the time baby is one year old, it may also be fed with the egg whites. Eggs contribute significantly to the body's nutrient needs during rapid growth, and are an excellent food for young children and teenagers. Sometimes egg proteins cause allergy in very young children, especially, infants at weaning period.

Table: 12. Egg Gastric Digestion Times

METHOD OF COOKING	TIME REQUIRED FOR DIGESTION
Parboiled egg	1 hour 45 minutes
Raw egg	2 hour 15 minutes
Poached (with 5g butter)	2 hours 30 minutes
Hard boiled	3 hours
Omelette	3 hours

The drawback of egg is the property of creating allergic symptoms affecting the skin, the respiratory, gastric and intestinal organs, which are caused by the egg protein. Non vegetarian foods like eggs will produce more uric acid i.e. 14-16 grams per 0.45 kg egg. Human kidney can remove only less than 7 grams per day.

EGG COMPARISON WITH OTHER FOODS

According to the nutritional survey of top ten foods with respect of nutrients, the rank of the egg is shown in Table 13.

Table: 13. Nutritional Survey Rank For Eggs Among Top Ten Foods.

NUTRIENT	RANK FOR EGG
Vitamin A	3
Riboflavin	5
Iron	4
Phosphorus	7
Caloric source	9
Protein	7
Fat	7
Saturated fatty acids	7
Mono unsaturated fatty acids	8

High nutrient content of egg, low caloric value and easy digestibility make eggs valuable in many therapeutic diets for adults. Eggs are valuable and readily acceptable in diets for older people, whose caloric needs are lower and who have difficulty in chewing certain types of food. The nutritionists divide foods into four groups, milk, meat, vegetable, fruit and cereals.

Two or more servings per day are recommended from meat group, which includes eggs, poultry, beef, veal, lamb and fish. Most young children and older adults can meet their nutrient needs from meat group with less than two servings. Two eggs, 57 to 86g lean boneless cooked meat, poultry or fish, 1 cup cooked dry beans, dry peas or lentils or 4 peanut butter, counted per serving for the meat group.

As far as nutrient principles are concerned a couple of eggs can compare to 100g meat and more over cost is $\frac{1}{4}$ less. The egg doesnot contain substantially a larger fat quantity than meat, but supplies quite large amounts of Vitamin A, B, B₂ and niacin 50mg, calcium and several mineral. The quantity of iron is same in meat and egg. The egg can be compared to meat with respect to protein, although egg's content is 13% in comparison to 20% in meat. The egg protein quality is due to conalbumen in the albumin, vitelline in the yolk and others rich in phosphorus and sulphur and their relative amino acid compounds have a much higher amount of lysine and methionine. Biological value of an egg is 93.7 and 74.7 for beef.

Eggs are considered as protective foods for humans because they:

- Provide better support for the mother and better start in life for the young.
- Speed up maturity and produce better development
- Produce high level of adult vigour.
- Extend the average useful span of life.

(Reference will be available from author)



Session-III : Lead Paper - 02

**ANTIBIOTIC RESIDUES IN FARMED SHRIMP :
FOOD SAFETY IMPLICATIONS AND MITIGATION
INTERVENTIONS**

Dr. B. Madhusudana Rao

Principal Scientist

ICAR-Central Institute of Fisheries Technology (ICAR-CIFT)
Visakhapatnam Research Centre, Ocean View layout, Pandurangapuram,
Andhra University, P.O., Visakhapatnam

Consumer safety driven food quality regulations are being enforced worldwide. India exported 1.37 million tonnes of seafood worth US\$ 7.08 billion in 2017-18. Frozen shrimp constituted the major item of the export, both in terms of quantity (565,980 tonnes) and export value (US \$ 4.85 billion). The presence of residues of antibiotics or their metabolites in food is potentially harmful to the consumers. Residues of antibiotics or their metabolites in shrimp exported from India to the European Union, United States and Japan has resulted in rejection of several shrimp consignments. Residues of antibiotics/metabolites reported in shrimp exported from India during 2010-2018, were predominantly due to the presence of furazolidone-AOZ followed by chloramphenicol, oxytetracycline and nitrofurazone-SEM. Andhra Pradesh is the leading producer of farmed shrimp in India but on the flip side, the state's share of antibiotic based rejections ranged from 31 to 89% of Indian shrimp rejections. Interventions need to be made at shrimp farms, shrimp processing units, approved testing laboratories and research needs for ensuring antibiotic free shrimp products or else the 'huge volumes' of shrimp farmed and processed in Indian would be worth 'nothing' if they fail to meet the quality standards vis-a-vis antibiotic residues.

1. Status of shrimp in Indian fishery exports:

Indian fishery products exports have witnessed phenomenal growth earning sizeable foreign exchange. In terms of quantity the increase was from 37, 175 tonnes in 1970 to 13,77,244 tonnes in 2017-18 and in terms of value the increase was from Rs. 33.54 crores (USD 47.38 million) to Rs. 45,107 crores (USD 7,082 million). India exported several fish items such as frozen finfish, frozen shrimp, frozen cuttle fish, frozen squid, dry fish, chilled fish and live fish. Of these, frozen shrimp constituted the major item of the export (Fig. 1), both in terms of quantity (41.09%; 5,65,980 tonnes) and value (68.4%; \$ 4848.19 million; Rs 30,868.2 crores). The substantial increase in the quantity of frozen shrimp exports of India can be squarely attributed to the introduction of pacific white shrimp, *Penaeus vannamei* in 2009-10 into India and its exponential farming by the Indian farmers; particularly in the state of Andhra Pradesh. The area under *P. vannamei* farming in India increased from 283 ha (2009-10) to 50,240.77 ha (2015-16). Taking cue from Andhra Pradesh, other states namely Tamil Nadu, Odisha, Gujarat, West Bengal, Maharashtra, have taken up *P. vannamei* farming. Farmed *P. vannamei* after harvest is processed and exported to the US, EU, South-east Asian countries, Japan, West Asia and China. In 2016-17, the US (1, 65,827 tonnes), South-East Asia (1,05,763) and the EU (77,718 tonnes) were the largest importers of shrimp from India.

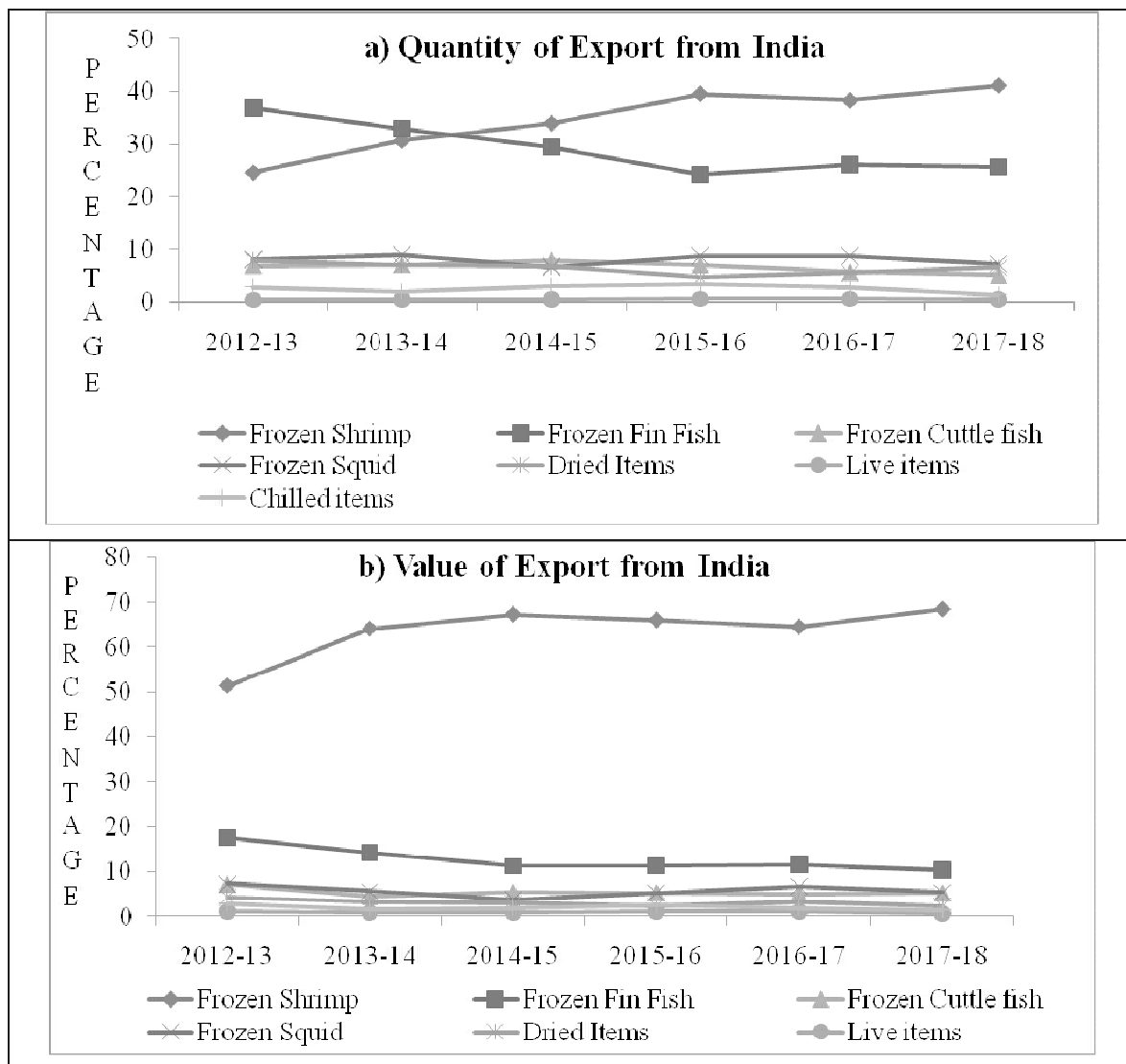


Fig. 1: Trends in the export of different fishery products from India.

a) Quantity wise; b) Value wise

2. Role of antibiotics in infection control:

Antibiotics are life saving magic potions that revolutionized human medicine and have been playing preeminent role in health care saving precious lives. Antibiotics are detrimental for the growth and survival of bacteria. Antibiotics act by inhibiting bacterial cell wall synthesis (penicillin, ampicillin, cefotaxime, ceftazidime, cefazolin, meropenem, imipenem, vancomycin), disrupt bacterial cell membrane (daptomycin, polymyxin, clistin), inhibit protein synthesis (gentamicin, kanamycin, amikacin, tobramycin, tetracycline, doxycycline, linezolid, chloramphenicol, azithromycin, clarithromycin, fusidic acid) or inhibit nucleic acid synthesis (ciprofloxacin, ofloxacin, norfloxacin, sulfamthoxazole, trimethoprim and rifampin). Worldwide, between 2000 and 2010, consumption of antibiotic drugs increased from 54,083,964,813 standard units to 73,620,748,816 standard units and India was the single largest consumer of antibiotics in the world in 2010 (Van Boeckel *et al.*, 2014).

3. Antibiotic use in fisheries and regulatory restrictions:

Antimicrobials find use in aquaculture for the prevention and treatment of aquatic animal diseases, mainly bacterial diseases. The major bacterial diseases affecting aquaculture worldwide, in tropical and temperate regions are as follows

Vibriosis	:	<i>V. anguillarum</i> , <i>V. harveyi</i> , <i>V. parahaemolyticus</i> , <i>V. vulnificus</i>
Aeromoniasis	:	<i>Motile Aeromonas spp.</i> , <i>Aeromonas caviae</i> , <i>A. hydrophila</i> , <i>A. sorbia</i> , <i>A. veronii</i> , <i>A. jandaei</i> , <i>A. salmonicida</i>
Edwardsiellosis	:	<i>E. anguillarum</i> , <i>E. ictaluri</i> , <i>E. piscicida</i> , <i>E. tarda</i> , <i>Yersinia ruckeri</i>
Pseudomoniasis	:	<i>P. anguilliseptica</i> , <i>P. fluorescens</i>
Flavobacteriosis	:	<i>F. branchiophilum</i> , <i>F. columnare</i> , <i>F. psychrophilum</i>
Infection with Intracellular bacteria	:	<i>Piscirickettsia salmonis</i> , <i>Hepatobacter penaei</i> , <i>Francisella noatunensis</i> , <i>Chlamydia spp.</i>
Mycobacteriosis	:	<i>M. fortuitum</i> , <i>M. marinum</i> , <i>Nocardia asteroides</i> , <i>N. crassostreae</i> , <i>N. seriolae</i>
Streptococcosis	:	<i>S. agalactiae</i> , <i>S. iniae</i> , <i>Lactococcus garvieae</i> , <i>Aerococcus viridians</i>
Renibacteriosis	:	<i>R. salmoninarum</i>
Anaerobic bacteria	:	<i>Clostridium botulinum</i> , <i>Enterobacterium catenabacterium</i>

Antibiotics gain entry into the aquaculture system by a number of ways. The shrimp farmer in order to control bacterial diseases may add the antibiotic directly to the water or apply the antibiotic as a coating to the feed pellets. Sometimes, antibiotic may be inadvertently added through the use of feed supplements of unknown composition and quality. Effluents from terrestrial animals and humans may end up in the aquatic environment as the sanitary barriers used in terrestrial food animal production are difficult to establish in aquaculture.

On the regulatory front, India has listed 20 antibiotics/pharmacologically active substances that are prohibited for use in shrimp aquaculture. The antibiotics banned for use in aquaculture are Nitrofurans (including furaltadone, furazolidone, nitrofurantoin, nitrofurazone), chloramphenicol, sulphamethoxazole, sulfanamide drugs (except approved sulfadimethoxine, sulfabromomethazine and sulfaethoxypyridazine) and glycopeptides. Other compounds prohibited for use in aquaculture are chloroform, chlorpromazine, colchicine, dapsone, *Aristolochia spp.*, dimetridazole, metronidazole, ronidazole, ipronidazole and other nitromidazoles, clenbuterol and diethylstilbestrol. However, it is pertinent to note that the regulations governing export of fish (EIC of India) and sale of fish in domestic markets (FSSAI) have established maximum residual levels (MRLs) for four antibiotics viz., tetracycline at 0.1ppm; oxytetracycline at 0.1 ppm; trimethoprim at 0.05 ppm and oxolinic acid at 0.3 ppm but is not clear whether these antibiotics are permitted for use in aquaculture.

USFDA has approved only the use of oxytetracycline, Sulfadimethoxine/ormetoprim and florfenicol for the control of bacterial diseases such as Enteric septicemia of catfish caused by *Edwardsiella ictaluri*; furunculosis in freshwater-reared salmonids, streptococcal septicemia in freshwater-reared warm water finfish, columnaris disease in freshwater-reared finfish.



4. Food safety risks and trade implications:

- a) **Antibiotic residues and human health:** The presence of residues of antibiotic or their metabolites in food are potentially harmful to the consumers. Nitrofurans are not authorised for use in food-producing animals in the European Union, USA, Australia, Philippines, Thailand, Brazil, India as they are genotoxic and carcinogenic. Reduction of the nitro group of nitrofurans leads to the formation of reactive intermediaries. In studies on spermatogenesis, furazolidone, furaltadone, nitrofurantoin and nitrofurazone caused toxic effects on the testes in rats and mice. In chronic toxicity and carcinogenicity studies, furazolidone induced malignant mammary tumours in rats, bronchial adenocarcinomas in male and female mice and neural astrocytomas in male rats. Similarly, another antibiotic chloramphenicol is also not authorised for use in food-producing animals as it is implicated in the generation of aplastic anaemia in humans and causes reproductive/hepatotoxic effects in animals. Nitroreduction of chloramphenicol to nitroso-chloramphenicol and the production of reactive oxygen species leading to DNA damage seem to be crucial factors in the induction of aplastic anaemia. Panel on Contaminants in the Food Chain (CONTAM) of the European Food Safety Authority concluded that it is unlikely that exposure to food contaminated with nitrofurans marker metabolites at or below 1.0 µg/kg and chloramphenicol at or below 0.3 µg/kg is a health concern (EFSA, 2014; 2015).
- b) **Antimicrobial resistance (AMR) and human health implications:** Emergence of antibiotic resistance in bacterial pathogens is recognized as a major public health threat affecting humans worldwide and World Health Organization has named antibiotic resistance as one of the three most important public health threats of the 21st century. Bacteria owing to their genetic plasticity have developed resistance mechanisms and have become masters in acquiring resistance in the antibiotic-driven adaptive bacterial evolution process. Antibiotic resistance is a natural process but anthropogenic practices have hastened the process of selection of antibiotic resistant strains of bacteria. Newer resistant phenotypes of pathogenic bacteria are surfacing at frequent intervals thereby limiting therapeutic options. The emergence and spread of resistant and multi drug resistant bacteria have enormous implications for human health. AMR has direct impact on human and animal health but also carries huge economic costs. Globally, AMR is responsible for 700,000 deaths annually. Report from Britain predicts that AMR might cause 10 million deaths per year by 2050 and might cause \$ 100 trillion loss to the global economy by 2050. It is estimated that AMR might cause 3.5% reduction in GDP in 2050.
- c) **Trade implications for Indian shrimp exports:** The presence of residues of veterinary medicinal products (commonly known as antibiotic) in frozen shrimp exported from India was reported by the European Union, United States and Japan leading to rejection of shrimp consignments. During the last seven years (2011-2017) a total of 597 quality defects were reported from frozen shrimp exported from India to the European Union, United States and Japan, of which 27% (ranging from 12 to 40%) were due to the presence of antibiotics/metabolites. Andhra Pradesh is the leading producer of farmed shrimp in India. However, on the flip side the state's share was 61.5% of antibiotic based rejections (ranging from 31 to 89%) of shrimp exported from India (Fig. 2). It is pertinent to note that the complaints due to antibiotic residues in farmed shrimp from Andhra Pradesh dictated the trend of total antibiotic related rejections from shrimp exported from India.

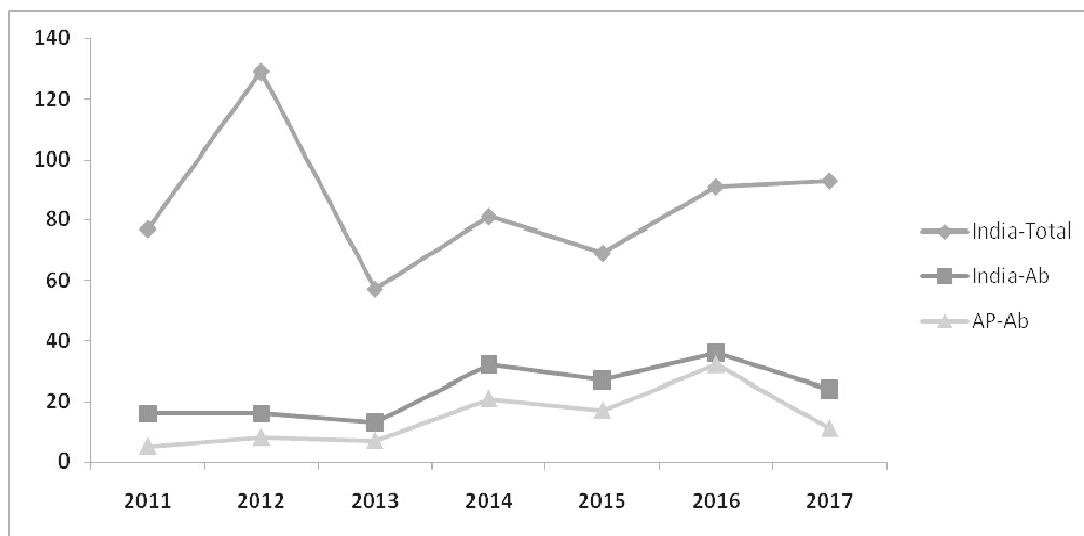


Fig 2. Trends in the rejection of shrimp exported from India to European Union, USA and Japan

The European Union employs a tool known as Rapid Alert System for Food and Feed (RASFF) to avert food safety risks in food and feed before they can harm consumers. When a serious health risk such as presence of antibiotic residues is detected in the food, RASFF alert notifications are sent to all member countries and the concerned food consignments get rejected. The EU has established a minimum required performance limit (MRPL) of 1 µg/kg for nitrofurans metabolites and 0.3 µg/kg for chloramphenicol in aquaculture products (EU, 2003). However, EU has 'zero tolerance' to nitrofurans and chloramphenicol which means 'any confirmed concentration of any of the metabolites is a non-compliance'.

A total of 78 RASFF notifications were issued for the presence of different antibiotic residues in shrimp exported from India during the period 2010-2018. The RASFF notifications due to antibiotic residues were relatively higher in the last two years (Fig. 3a) i.e. 2017 (15 rejections) and 2018 (13 rejections) compared to the preceding years (5 rejections in 2015 and 5 rejections in 2016). European Union has decided to strengthen its mandatory testing of farmed shrimp consignments to deter shrimp producers in India from misusing veterinary medicinal products and to minimize risks to human health in the European Union and accordingly has decided (2016/1774/EU) that samples are to be taken from at least 50% of consignments presented for import at border inspection posts on EU territory instead of the previous sampling plan of 10% (2010/381/EU). Four antibiotics namely furazolidone (metabolite-AOZ; 3-amino-2-oxazolidinone), nitrofurazone (metabolite-SEM; semicarbazide), chloramphenicol and oxytetracycline have been reported in the RASFF alerts.

Among these antibiotics, predominant RASFF rejections (Fig. 3b) were due to the presence of the nitrofurans drug, furazolidone(77%) followed by chloramphenicol (13%), oxytetracycline (5%). The trend in the furazolidone (AOZ) based alerts had a profound influence on the total RASFF alerts reported in shrimp exported from India. There was wide variation in the quantity of antibiotic residue reported under RASFF from shrimp exported from India. The level of AOZ ranged from 1.05 to 300 ppb with a median value of 3ppb; SEM in shrimp ranged between 1.1 and 170ppb with a median value of 4.8 ppb; oxytetracycline residues ranged between 210 ppb to 382 ppb and Chloramphenicol residue ranged between 0.11 to 2 ppb.

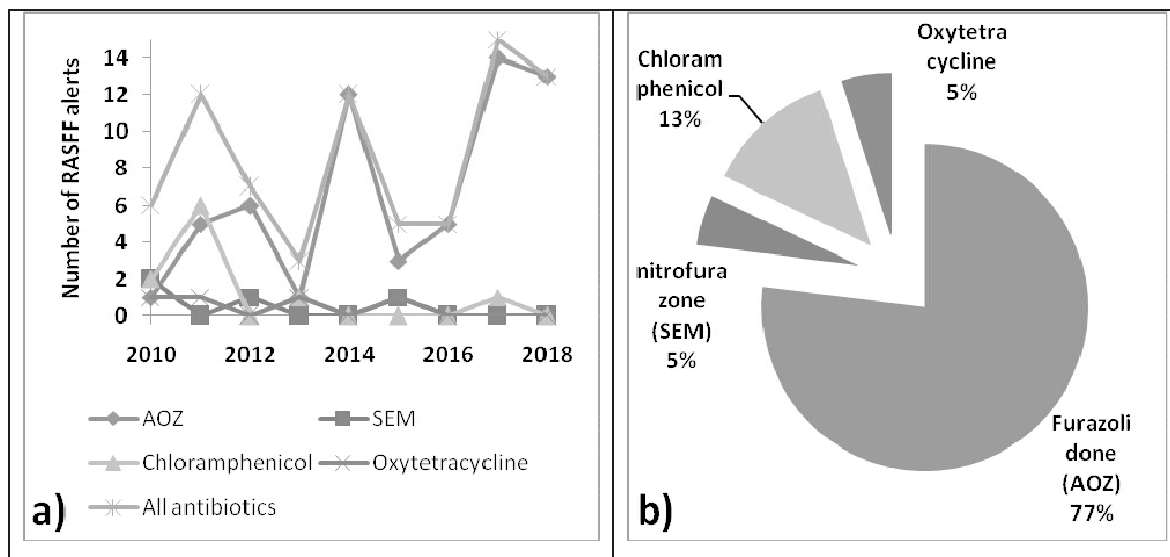


Fig. 3. Antibiotics / antibiotic metabolites responsible for RASFF alerts of Indian Shrimp

- d) National Residue Control Plan (NRCP) of India:** NRCP is a system for monitoring residues of Aquaculture drugs/Veterinary Medicinal Products shrimp and fish, seed and feed used in India aquaculture. Marine Products Export Development Authority (MPEDA) draws the samples on behalf of Export Inspection Council (EIC) of India. NRCP sampling tests a large number of samples from shrimp farms viz., 1109, 1355, 1390 and 1720 shrimp samples were tested during 2015, 2016, 2017 and 2018, respectively. The NRCP results indicate that 16%, 0.4%, 1.5% and 0.9% of the shrimp samples tested were positive for the presence of antibiotics/ antibiotic metabolites in 2015, 2016, 2017 and 2018, respectively, indicating greater progress in addressing the issue at the shrimp farm level but at the same time alerting that the problem still persists. However, the NRCP results of hatchery samples portray an entirely different picture. The NRCP results of hatchery samples reveal that in 2015, 2016, 2017 and 2018 the number of shrimp seed positive for the presence of antibiotic/ antibiotic metabolites were 44%, 39%, 38% and 32%, respectively indicating imminent concerns at the shrimp hatchery level.
- e) The menace of the drug Furazolidone on frozen shrimp exported from India:** Nitrofurans are a group of synthetic antibiotics that were chemically derived from furans and contain a characteristic 5-nitrofuranyl ring. Nitrofurans include furazolidone, furaltadone, nitrofurazone and nitrofurantoin. Furazolidone is a broad spectrum antibiotic that is active against both gram positive and gram-negative bacteria and has been used in human and veterinary medicine to treat intestinal infections. Nitrofurans were also used in aquaculture to control a number of bacterial diseases of fish (e.g. edwardsielliosis, vibriosis, branchiomycosis, columnaris and tail rot disease) and bacterial infections of shrimp (shell disease, appendage rot, septicaemias, bacterial fouling, gill diseases and necrotic hepatopancreas (Liao *et al.*, 2000). Nitrofurans parent compounds metabolize rapidly after ingestion by the shrimp to form corresponding tissue bound metabolites. Furazolidone metabolizes to 3-amino-2-oxazolidinone-AOZ; Furaltadone metabolizes to 3-amino-5-morpholinomethyl-1,3-oxazolidinone-AMOZ; nitrofurazone metabolizes to semicarbazide-SEM and nitrofurantoin metabolizes to 1-aminohydantoin-AHD). These metabolites bind to proteins and DNA, thereby persist for several weeks in edible tissues and hence serve as excellent marker metabolites for the illegal use of nitrofurans in food producing animals. The



metabolites are stable during frozen storage and are not destroyed by cooking, frying, grilling, roasting and microwaving of meat. Owing to these attributes, nitrofurans metabolites are the preferred compounds for monitoring compliance. The residues of nitrofurans detected in farmed shrimp exported from India to EU during the period 2010-2018 were furazolidone (77%) and nitrofurazone (5%). The trend in the furazolidone (AOZ) based alerts had a profound influence on the total RASFF alerts reported in shrimp exported from India. Similarly, furazolidone in frozen shrimp was also reported by other importing countries such as United States and Japan. The data indicates that stringent measures have to be adopted to control all the prohibited antibiotics in farmed shrimp but utmost priority has to be given to furazolidone. Information from the drug manufacturers on production and distribution and sale of furazolidone would be helpful in understanding the inadvertent use/ misuse of furazolidone in aquaculture.

5. Mitigation interventions for ensuring antibiotic free shrimp products:

- a) **Disease prevention through scientific farming:** Shrimp hatchery operators and shrimp farmers need to adopt scientific farming practices with stringent biosecurity measures and Good Aquaculture Practices so as to avoid infection in the aquatic animals thereby preventing the necessity for antibiotics usage. Importantly, shrimp hatchery operators and shrimp farmers should ensure that use only antibiotic free aquaculture inputs. Coastal Aquaculture Authority (CAA) has initiated a process of registering antibiotic free inputs that can be used in aquaculture in India. The antibiotic free products that are listed on the CAA website (<http://www.caa.gov.in/>) belong to different categories such as larval feed, adult feed, feed additives, probiotics, chemicals, disinfectants and immunostimulants. All the registered products are labelled as antibiotic free. All the shrimp hatchery operators and shrimp farmers should be made aware of all the antibiotics prohibited for use in shrimp rearing and advised to use only the CAA registered antibiotic free aquaculture inputs. A record of all the inputs (feed, feed supplements, sanitizers, disinfectants, fertilizers, probiotics and medicines) used should invariably be maintained by shrimp hatchery operators and shrimp farmers. Inputs without labels or extra label use of drugs must be avoided. Feed and other input (probiotics, disinfectants, supplements) manufacturers must test their products, batch wise for the presence of prohibited antibiotics, and label them as free from banned antibiotics. Awareness programmes by government agencies and farm audits by the shrimp processors have to be conducted at regular intervals to sensitize the farmers and suppliers on non-usage of banned antibiotics. Personnel (technicians), presently involved in shrimp disease diagnosis and drug prescription have to be registered by a regulatory/statutory agency with unique identification number for better accountability.
- b) **Effective Testing of farmed shrimp to avoid antibiotics residues:** Shrimp intended to be processed for human consumption have to be invariably tested for the presence of harmful residues. Testing has to be performed at two stages i.e. pre-harvest (live shrimp sampled from shrimp farms for analysis) and pre-shipment (finished shrimp product after processing in seafood processing units). Pre-harvest testing to ensure that antibiotic residue free raw material is processed for export. The pre-harvest ELISA testing for the presence of chloramphenicol and all four nitrofurans metabolites (AOZ, AMOZ, AHD and SEM) has to be performed by the shrimp processors in their in-house laboratories or by the shrimp farmers in MPEDA ELISA laboratories. Shrimp processors need to establish necessary infrastructure for in-house testing for antibiotic residues and providing adequate training to the quality assurance personnel for ensuring accuracy of test results. Pre-shipment testing of the processed shrimp product for the presence of antibiotics / antibiotic metabolites has to be performed by employing LC-MS-MS (Liquid



chromatography – tandem Mass Spectrometry) or HPLC methods in EIC approved laboratories. Presently, the maximum residue level (MRL) or the minimum required performance limit (MRPL) adopted for different antibiotics in shrimp meat are as follows..

Antibiotic / antibiotic metabolite	MRPL / MRL
Chloramphenicol	0.3 ppb
Nitrofurantoin metabolites (AOZ, AMOZ, AHD, SEM)	1 ppb
Oxolinic acid	100 ppb
Difloxacin	300ppb
Sparfloxacin	30 ppb
Enrofloxacin (sum of enrofloxacin and ciprofloxacin)	100 ppb
Flumequine (fin fish)	600 ppb
Flumequine (other species)	200 ppb
Tetracyclines (sum of parent drugs and its 4-epimers) (Tetracycline, Oxytetracycline and Chlortetracycline)	100 ppb
Sulfonamides (Sulfadiazine, Sulfamethoxazole, Sulfamethoxypyridine, Sulfamethazole, Sulfamethazine, Sulfamerazine, Sulfapyridine, Sulfadimethoxine, Sulfachloropyradizine, Sulfathiazole-free acid (Sum of all substances)	100 ppb

Testing laboratories approved by the competent authority for testing antibiotic residues in pre-shipment products should adhere to strict sampling protocol. The approved laboratories should participate in inter-laboratory proficiency testing with analytical laboratories in India and abroad. This is vital, as the frozen shrimp consignments rejected by imported countries, have been tested in India prior to export in EIC approved laboratories and the results were found negative for the presence of antibiotic residues. The discrepancy in the results of foreign laboratories and the Indian laboratories has to be addressed by participating in inter-laboratory proficiency testing between Indian labs and importing country labs.

- c) **Research interventions to search for alternatives to antibiotics:** Research is necessary to develop natural, organic (GRAS) alternatives for antibiotics to control disease in shrimp farms and hatcheries. Bacteriophages, bacteriocins, probiotics, organic acids, quorum sensing inhibitors, essential oils and vaccines are potential candidates for research. Research efforts are necessary to establish withdrawal period of different antibiotics in shrimp for timing shrimp harvest after therapeutic use of approved drugs so that no harmful residues of the antibiotic would be present in the finished product.

Conclusion:

The problem of antibiotic residues in farmed shrimp has to be addressed on priority basis to protect human health and avoid economic losses. The stakeholders involved in shrimp production, processing, distribution, promotion and regulation should take appropriate measures to mitigate the menace of residues of veterinary medicinal products (antibiotic residues) in shrimp.

(Reference will be available from author)



Session-III : Lead Paper - 03

**INTERVENTION TECHNOLOGIES FOR ENHANCED MEAT
QUALITY AND SAFETY**

Dr. V. Appa Rao

Professor and Head,

Department of Livestock Products Technology (Meat Science),
Madras Veterinary College, Chennai – 600 007

Introduction

Now-a-days, globally consumers demand high-quality food products which are easy-to-handle, nutritious and possess improved taste with extended shelf life. One of the most significant challenges in the food industry is to apply efficient technologies in the production chain to fulfil these demands. In this respect, application of new innovations in health-promoting food manufacture has been fascinating and exciting topic of major public concern, while at the same time it confers multiple advantages in the industrial sector. In response to demands from increasingly health conscious consumers, the global new trend focuses on meats not only with superior sensory appeal but also of improved nutritional attributes in meat and meat products. Current innovations in meat production have resulted in the development of novel products with specific functional ingredients, reduction or removal of undesirable components, modification of meat composition, and overall improved quality and safety.

Methods that are used today in the meat industry, such as packaging, application of antimicrobials (natural or chemicals), pasteurization, high pressure processing, or combinations of these technologies (hurdle technologies), have been widely explored and introduced in the management of meat quality and safety. Microbial safety is among the imperative challenges that prevail in meat products because they provide an ideal medium for the growth of microorganisms particularly pathogenic bacteria. The incidence of these microbes can result quality deterioration of products leading towards food borne diseases when consumed by peoples. Several preservation technologies like chemical and biological interventions are effective to retard or inactivate the growth of micro-organisms most commonly related to food-borne diseases.

Amidst increasing demands from the industry, more advanced alternative technologies are required to meet meat safety requirements and consumer expectations. Some of these are still under investigation. Among them, the demand for more innovative packaging such as intelligent packaging is increasing. Physical interventions, such as high pressure processing (HPP), Pulse Electric Field (PEF) processing, pulsed light (PL) technology, ultrasonic and oscillating magnetic field pulses (OMP) have been studied as novel meat intervention technologies in recent years. Moreover, adding natural antimicrobial agents to meat products or packaging has become a new trend in the meat industry. However, these technologies have several limitations to be overcome before commercialization such as increase in cost, quality and sensory changes, and lack of validation studies. The objective of this topic is to describe the current approaches and developing technologies for enhancing quality and safety of meat and meat products.

I. Physical intervention technologies

Physical intervention plays a vital role in the decontamination of meat products because no chemical residues are produced /developed in meat products and the meat quality parameters such as nutrients, flavor, appearance, and tenderness are highly preserved. Physical intervention can be applied throughout all processing stages of meat, from pre-slaughter (animal washing), slaughter (trimming and hot-water washing),



processing (steam pasteurisation, refrigeration, super-chilling), post-packaging (irradiation, high-pressure processing, and so on).

Steam pasteurization is a fast, cost-effective method which is suitable for almost any size of meat products. The treatment time for better appearance and quality, however, is limited. **Irradiation** is one of the most efficient physical preservation technique with minimum meat quality changes. Consumer acceptability, however, becomes one of the limiting factors for its application. **High frequency heating technology** is still under investigation for its ability to produce safer and higher-quality meat products.

(i) Steam pasteurization: Steam pasteurization, as a commercial antimicrobial carcass intervention process, which is being widely adopted in the beef slaughter industry. The industrial process was developed in the United States and steam-pasteurization of carcasses was approved by the FDA in 1995 for whole carcasses as well as parts of carcasses that are to be further processed.

Normally, the treatment involves 3 steps: **water removal, steam pasteurization, and rapid chilling.** The equipment is a stainless steel tunnel encompassing the facility's overhead rail system and is situated immediately prior to the point where carcasses enter the holding cooler ("hot box"). Carcasses are sent into the tunnel at normal line speeds and are exposed uniformly to saturated water steam at atmospheric pressure for 8-10 s, bringing the surface temperature up to 85° to 90°C. The second section of the unit applies a chilled water spray to quickly decrease the surface temperature of carcasses and minimize unfavourable color effects. The technology has been placed in a favourable position to provide a fast and cost-effective solution to decontaminate small and large pieces of meat. However, McCann and others (2006) reported that a cooked appearance could show up after a prolonged treatment exceeding 10s. Another drawback of the technology is if there is no uniform temperature distribution of the steam could result in an improper treatment of the food product, but this weakness can be overcome by applying a continuous monitoring system to ensure that the entire surface, especially the neck, is properly treated.

(ii) Irradiation: Food irradiation is one of the developed food preservation technologies. It is a physical process that exposes meat to an ionizing radiation source, which is a form of electromagnetic energy. Only γ - rays produced from cobalt-60 and cesium-137, and X-rays generated from a machine operated at or below 5 MeV and electrons from a machine at or below 10 MeV are permitted to be applied for food irradiation. Irradiation energy, which is applied to food products, ejects electrons from the atoms or molecules and produces free radicals and ions. The primary target of highly energized electrons is water molecules in meat products. The production of ions and free radicals in food is higher in liquid form than in the crystalline form (frozen product) or limited free-water form (dried products). The hydroxyl radical, the product of water found during irradiation, is a highly oxidizing agent and thus can form stable products with large molecules and compounds, such as DNA, protein, and others. In addition, irradiation may also damage living cell membranes and cause other changes leading to cell damage.

Irradiation applied to meat products, including red meat, poultry, and so on, is mainly used in US to control illness-causing microorganisms and the dose is strictly regulated by the U.S. Food and Drug Administration (FDA). An irradiation dose of up to 4.5 kGy is applied for refrigerated red meat, up to 7 kGy for frozen meat, and up to 3 kGy for poultry is allowed in the United States. In addition, 3 kGy is permitted for poultry for the control of pathogens. Restrictions are strict in the EU. So far, products allowed for irradiation within the whole EU contain only one single food category: "dried aromatic herbs, spices and vegetable seasonings". The actual energy to be applied depends on the microorganisms to be killed in the meat product. The *D*-value of the most resistant serotype of the Gram-negative pathogens of public health



significance, such as *E. coli*, *Yersinia enterocolitica*, *A. hydrophila*, *Campylobacter*, and *Salmonella* is 0.6 kGy. For frozen poultry, recommended doses for the reduction of *Salmonella* by 3 to 5 logs is 3 to 5 kGy and 1.5 to 2.5 kGy for chilled poultry. The dose can be further reduced if other intrinsic or extrinsic factors are combined, such as MAP or low water activity, because the generation of highly active free radicals and other toxic products becomes lower. Compared to other meat preservation methods, such as thermal inactivation and preservatives, the advantages of irradiation include:

1. No residual problems occur as with chemical preservatives.
2. Effective on pathogenic species.
3. Meat product can be processed in the package due to the high penetrative ability of γ -rays, which can avoid further contamination.
4. Lower energy consumption.
5. Irradiation can reduce certain food losses and complement other meat processes.
6. Highly efficient inactivation of bacteria (Zhou *et al* 2010).

As irradiation is always linked with nuclear technology, any food that is treated with irradiation may be erroneously considered as radioactive. Thus, the biggest challenge related to irradiation applications is consumer acceptability. Risk perception studies have indicated that the public deems food irradiation as moderately or even highly dangerous. Although the adverse effect of irradiation on the wholesomeness and quality of meat products is very low compared to some other preservation methods, still certain quality changes occur during this process, which are limiting the adoption of irradiation technology by the meat industry:

(1) Lipid oxidation: Irradiation can generate oxidative chemicals. Hydroxyl radicals are the most reactive oxidative products which can result in lipid oxidation in meat, especially in liquid systems. Because there is 75% or more water in meat, the oxidation induced by irradiation is not negligible. It is, however, also dose-dependent. For example, vacuum-packaged pork exhibited significant surface discoloration at 4.5 kGy.

(2) Off-odor: A set of unpleasant odors, described as "metallic" or "burnt," can be produced in irradiated turkey breast fillet, and was different from non-irradiated fillet, and consumers could easily differentiate easily. It is suspected to be mainly caused by the radiolytic degradation of amino acid side chains.

(3) Color changes: The color changes in irradiated meat differ significantly. They depend on factors such as dose, animal species, muscle type, and packaging type. The color change in irradiated chicken breasts may result from the deamination of myoglobin.

(4) Water holding and texture: Irradiation-induced water loss and higher shear force could be due to the destruction in the membrane of muscle fibers or denaturation of muscle proteins.

(5) Nutrient loss: Some vitamins, such as B₁ and C, are sensitive to irradiation. Losses can be reduced through lowering irradiation dose, temperature, oxygen, or changing packaging materials. It has been calculated that only 2.3% of vitamin B₁ would be lost in the American diet if all the pork in the United States were to be decontaminated by irradiation (Cast, 1996).

(iii) High-frequency heating

High-frequency heating, which includes radiofrequency (RF) and microwave (MW) heating, has gained increased industrial interest and shown great potential to become the alternatives to conventional methods for heat processing. The drawback of conventional steam and hot water treatments in meat



processing lies in the slow heat conduction from heating medium to the thermal center. This, in turn, requires longer cooking time and leads to much more severe treatment of the outer layer of meat, which then can potentially result in quality reduction of the product. However, RF and MW heating are modern techniques that rely on electromagnetic energy and are able to provide rapid and uniform heat distribution within a food. Therefore they have become promising heating techniques in the meat industry. High-frequency heating, unlike other heat transfer modes, can convert electrical energy to heat directly within the food itself, which then absorbs the generated heat. Therefore, better efficiency and uniform cooking can be achieved. Both MW and RF have designated frequencies authorized by the U.S. Federal Communication Commission (FCC) for industrial heating, with 13.56, 27.12, and 40.68 MHz for the radiofrequency range, whereas it is 433, 915, 2450, and 5800 MHz for microwave heating.

The main difference between RF and MW is wavelength. The wavelength at the RF-designated heating frequencies is 22 to 360 times as great as that at the designated MW heating frequencies, which allows greater penetration depth in a product. In this sense, RF is more suitable and effective for large-diameter foodstuffs such as meat. The application of RF heating in the food processing industry has been tried for decades and can be traced back to the 1940s. It was initially used to thaw frozen eggs, fruits, vegetables, and fish. Later, RF heating was widely used in the dehydration of biscuits. Recently, the application of this technology has gained attention in the pasteurization of meat products. Of course, the quality of heated products by RF becomes the critical factor. Investigations on the capability of RF on the pasteurization and sterilization of meat products are still underway because of its potential use in producing shelf-stable meat products with a short heating time and uniform heating.

II. Chemical intervention technologies

Chemical interventions engage a wide variety of food-grade chemicals, usually applied to the meat surface, to inhibit or kill microorganisms. The antimicrobial effect of chemicals is mainly due to their ability to disrupt cellular membranes or other cellular constituents and interrupt physiological processes. However, the usage of chemical treatments poses the problems of possibly inducing resistance in foodborne pathogens and selecting resistant organisms over other microorganisms. Currently, at the international level, the Codex Alimentarius has adopted a list of approved food preservatives and their maximum levels allowed in meat. Regulatory authorities in the EU have issued strict restrictions on the use of chemicals on fresh meat.

(a) Chlorine: Chlorine is one of the most investigated chemical interventions for meat decontamination in the beef and poultry industries. Advantages of chlorine are ease of application, sound economics, and effectiveness against most microbial forms such as Gram-positive and Gram-negative bacteria. The antimicrobial activity of chlorine is mainly due to its strong oxidative effect on bacterial cell wall, causing the inactivation of enzymes or DNA. Chlorine is known to reduce total bacterial counts and kill some foodborne pathogens such as *Escherichia coli* O157:H7 and *Salmonella* during washing of beef and poultry carcasses. Reasonably good reduction in microbial counts have been reported using 200 to 500 ppm chlorine solutions, though such high levels of chlorine are prohibited in the food industry. While solutions of 200 ppm chlorine gave 1.5 to 2.3 log reductions in total aerobic bacteria counts on beef carcasses, the success achieved by solutions of up to 250 ppm chlorine have been highly inconsistent. However, chlorine is easily neutralized by organic matter; hence, using it before de-hiding is unwise because large amounts of organic material are often attached to hides.

(b) Organic acids and their salts: Solutions of organic acids (1% to 3%), such as lactic and acetic acids, are commonly used for beef and lamb. Other organic acids, including formic, citric, fumaric, propionic, and L-



ascorbic acids, may be used either separately or as a mixture in chemical washes. Organic acids are commonly applied using spray cabinets. Acetic or citric acid was evaluated on inoculated beef carcass surfaces under laboratory conditions. Microbial reductions obtained for inoculated bacteria, including aerobic bacteria, non-pathogenic *E. coli*, *E. coli* O157:H7, and *Salmonella* spp., varied between 0.7 log and 4.9 logs. On the other hand, a commercial 2% lactic acid spray at 42°C onto beef carcasses before evisceration has been reported to reduce aerobic plate counts by 1.6 logs, *Enterobacteriaceae* counts by 1 log, and *E. coli* O157:H7 prevalence by 35%. This could be caused by differences in the acid concentrations, the application methods, and the type of meat used in the various studies. Under a commercial factory environment, spraying acetic acid just after slaughter reduced levels of coliforms, *Enterobacteriaceae*, and *E. coli* on carcasses by 0.6 to 1.4 logs.

Heated carcasses treated with organic acids commonly show some discoloration on their surfaces. Fortunately, this discoloration usually becomes less obvious after chilling. Meat handlers may experience skin or eye irritation when acetic acid is used to treat meat; machinery tends to corrode with usage of acids as well. There are also concerns that organic acids may lead to formation of acid resistant bacteria strains capable of accelerating spoilage or increasing objectionable effects on meat appearance.

(c) Peroxyacetic acid: Peroxyacetic acid, also known as peracetic acid, functions well as an antimicrobial agent due to its high oxidizing potential. It destroys microorganisms by oxidation and subsequent disruption of their cell membranes, causing cell lysis and, ultimately, death. Unlike chlorine, it can be used over a wide temperature range (0° to 40°C), wide pH range (3 to 7.5), and is not affected by protein residues. It is primarily used as a carcass rinse in beef processing plants. It may also be employed during spray-chilling of carcasses, with the assumption that it breaks down to safe and non-polluting products (acetic acid and hydrogen peroxide) so that no unacceptable residues remain on the meat surface. The collective results from these experiments concluded that peroxyacetic acid was not an effective intervention when applied to chilled inoculated carcass surfaces.

(d) Acidified sodium chlorite: The antimicrobial effect of acidified sodium chlorite (ASC) is due to the oxidative effect of chlorous acid, which originates from the conversion of chlorite ion into its acid form under acidic conditions. It has been suggested that the type of acid used, the method of application, and the contact time with the meat surface all play an important role in the success of its antimicrobial capability.

(e) Trisodium phosphate : Trisodium phosphate's (TSP) high alkalinity in solution enables removal of fat films to allow more contact and also destruction of fatty molecules in the bacterial cell membrane, thus causing leakage of its contents. It is approved by the USDA for use in food processing, including meat preservation. Studies have shown that spray-washing with TSP could reduce contamination of beef briskets and prevent bacterial attachment, hence allowing easier removal of bacteria during washing. A 10% TSP solution was used in a trial for application to beef trimmings before grinding. Microbial counts were reported to have been reduced by <1 log but the resultant ground beef possessed better color stability and a more favorable appearance during 7-d storage under simulated retail conditions (4 °C). Disposal of TSP poses an environmental threat as it contributes to eutrophication in ponds and lakes if not treated properly. Recycling should be done wherever possible to reduce environmental damage.

(f) Ozone: Ozone, being a powerful oxidizing agent, kills bacteria by destroying their cellular walls and membranes. Advantages of applying ozone as a meat disinfectant include its high reactivity, penetrability, and eventual natural decomposition to oxygen. However, ozone may also result in increased oxidation of meat pigments and rancidity of fats. Research work on its efficiency as an antimicrobial have been highly variable.



(g) **Activated lactoferrin** : Lactoferrin is an antimicrobial agent and its main sources are milk, saliva, tears, and in trace present in meat tissue. Activated lactoferrin (ALF) can be applied on meat surface during processing or on finished product just before packaging. It is used for poultry meat decontamination at a level of 2%. The mechanistic approach of ALF involves that it can rupture cell membrane of bacteria and binds iron in cell. It is also effective against variety of pathogens including *Listeria monocytogenes*, *E. coli* and *Salmonella*.

(h) **Cetylpyridium chloride**: Cetylpyridium chloride (CPC) is considered as a strong antimicrobial agent and its action mechanism involve the formation of ionic interaction between cetylpyridinium ions with acidic molecules that can interrupt bacterial respiration. Several studies report that washing poultry carcasses with 0.5% CPC can reduce up to 2.5 log of *Salmonella typhimurium*. Likewise, CPC is also effective (5 log reduction) during refrigerated storage of beef carcasses after spray chilling with CPC.

III. Biological intervention technologies

Biological interventions, including bacteriophages and bacteriocins, have shown some promise as decontamination treatments and are, hence, increasingly used in the food industry. Shelf life and food safety may also be enhanced by using natural or controlled microflora, such as lactic acid bacteria (LAB) and/or their metabolic products including lactic acid, bacteriocins, and others. Extensive research has been carried out for the potential application of natural antimicrobial agents in food preservation. Unlike chemical intervention technologies, most biological technologies are still under investigation due to the lack of validation studies. Even though studies have shown varied results, the potential for biological intervention to be widely used remains large. This is especially true with the increasing demand for natural and non-chemical treated foods.

(a) **Plant extracts and essential oils** : Plants and their essential oils, and other isolated compounds, contain a variety of secondary metabolites that have been identified for their ability to inhibit the growth of bacteria, yeasts, and molds (Chorianopoulos *et al*, 2008). The antimicrobial compounds in plant materials are commonly found in the essential oil fraction of various plant parts, including leaves (as in rosemary and oregano), flowers or buds (clove), bulbs (garlic and onion), seeds (fennel and parsley), and fruits (pepper) (Gutierrez *et al*, 2008). These compounds may inactivate bacteria or inhibit the production of undesirable metabolites.

Generally, essential oils are more effective against Gram-positive than Gram-negative bacteria. The exact mechanism of action is not clear. At low concentrations, phenols present in essential oils may affect bacterial enzyme activity, whereas at high concentrations protein denaturation may occur. Phenolic compounds' antimicrobial activity may come from their ability to increase bacterial cell permeability and, hence, allow macromolecules to escape. Investigations on specific essential oils' effectiveness as antimicrobial agents have been conducted. In a recent study, microbial population reductions on lamb meat of up to 2.8 logs were documented, using a combination of MAP and 0.1% of thyme essential oils. Another investigation reported a 1.12 log reduction of *E. coli* O157:H7 populations on whole beef muscles that were coated with bioactive films containing 1% oregano essential oils.

(b) **Bacteriocins**: Bacteriocins are antimicrobial peptides/proteins produced by bacteria (They may be added during the processing of raw meat or cooked meat products, before packaging, to prevent growth of spoilage microorganisms. Furthermore, they can destroy bacterial membranes swiftly, hence, minimize the time available for bacterial mutation which may solve the problem of antibiotic resistance. A recent study had

concluded that there are variations in strain sensitivities and that development of antibiotic resistance is possible. There are several limitations when employing nisin as an antimicrobial in meat due to its interaction with phospholipids, emulsifiers, or other food components, low solubility at pH above 6, and inactivation by formation of nisin glutathione adduct.

(c) Bacteriophages: Bacteriophages are progressively more frequently used for inactivation of *L. monocytogenes* in food. Bacteriophages are generally considered as safe for use in food and highly host-specific. This specificity, however, also means their application is limited in that a phage against one bacterial strain might not be effective against another. Their antimicrobial effectiveness is still limited by factors such as potential resistance development by bacteria. Bacteriophages are a natural product, so environmental issues due to disposal would be nominal.

IV. Hurdle technology

Hurdle technology refers to the use of a combination of suboptimal growth conditions in which each hurdle factor alone is insufficient to prevent the growth of spoilage and pathogenic bacteria, but hurdles used in combination provide effective control. This technology not only ensures the safety but maintains high quality of foods. Based on the hurdle concept, a number of meat product manufacturers have used a combination of intrinsic or extrinsic factors affecting bacterial growth to effectively control the outgrowth of pathogens. Numerous investigations have been done on the efficiency of combining natural antimicrobials with other non-thermal processing technologies so as to optimize antimicrobial activity. Chemical or physical intervention technologies, including carbon dioxide (CO₂), ultrasound, pulsed electric field (PEF), ultra-high pressure (UHP), and ozone (O₃), may have synergistic effects with natural antimicrobials. Bacterial cell membranes are weakened and, hence, become more susceptible to natural antimicrobial agents after these non-thermal treatments.

The application of bacteriocins together with other interventions have shown the ability to enhance antimicrobial effects, such as when applied in combination with chelating agents or with preservative treatments such as high hydrostatic pressure (HHP) or PEF. The effectiveness of nisin against Gram negative bacteria and fungi have been reported; nisin was used in combination with organic acids and chelating agents. The combinations of nisin and nitrite reportedly inhibited *Clostridium botulinum* toxin formation in meat systems and growth of *Leuconostoc mesenteroides* and *L. monocytogenes*. Combining bacteriocins with organic acids and their salts may enhance the antimicrobial activity of bacteriocins greatly (Stiles 1996). The increased net charge and solubility of bacteriocins under acidic conditions aids diffusion of bacteriocin molecules through the bacterial cell wall.

Some researchers have investigated the irradiation and vacuum packaging combination effects on meat quality. Irradiation introduces an off-odor by sulfur compounds such as dimethyl sulfide, dimethyl disulfide, and dimethyl trisulfide. When irradiation was combined with MAP (CO-MAP) microbial loads were reduced and shelf life was extended.

ADVANCED TECHNOLOGIES

I. Intelligent packaging

Intelligent packaging is defined as packaging which monitors the condition of foods to give information about its quality during transport and storage. The use of sensor technology (such as gas sensor, fluorescence based oxygen sensor, bio-sensor) and indicators (such as integrity indicators, freshness indicators, time-temperature indicators, and so on) have been demonstrated to be of potential future use with



meat and meat products. For fluorescence-based oxygen sensors, fluorescing dyes that are encapsulated in a solid polymer matrix are involved. This kind of sensor has been tested with vacuum-packaged and modified atmosphere-packaged meat products (cooked chicken and beef) to monitor the headspace molecular oxygen. Thus, lipid oxidation and microorganism outgrowth can be observed. Biosensors function by converting the biological signals (enzymes, antigens, microbes, hormones, and others) to quantifiable electrical responses.

Freshness indicators are designed for detecting microbial metabolites (such as organic acids, ethanol, biogenic amines) that are produced during product storage. Time-temperature indicators (TTIs) can continuously measure time and temperature-dependent historical change in a products and therefore is particularly suited to monitor distribution chains. Recently, several prototypes of microbiological TTIs have been developed and tested for monitoring microbial quality of modified atmosphere packaged meat products. Unlike other TTIs, microbiological TTIs are based on the temperature-dependent growth of the TTI microorganisms which induces a pH drop in the sensor tags, leading to an irreversible color change of the medium's chromatic indicator. Although cost and other factors such as the need of validation studies for various food matrixes may limit their applicability, this technology is very promising.

II. High pressure processing

High pressure processing (HPP) is an emerging and assuring technology for meat safety, including boneless meat products, cured meat products, and RTE meat. It is a novel technology used to damage pathogens in meat products while enhancing tenderness. HPP is generally applied at the post-packaging stage so that it will avoid further contamination during later food processing. At ambient temperatures, vegetative microorganisms and enzymes can be inactivated by applying a pressure of 400 to 600 MPa. Similarly, HPP at 400 to 600 MPa was effective in controlling most major foodborne pathogens (*E. coli* O157:H7, *L. monocytogenes*, *Salmonella* spp. *S. aureus*, and so on) present in various meat products such as vacuum-packaged ground beef, cooked ham, and dry cured ham. It has been reported that in RTE meat treated with 600 MPa at 20°C for 180 seconds no significant deterioration in sensory quality was perceived. Since the U.S. Dept. of Agriculture-Food Safety and Inspection Services (USDA-FSIS) issued a letter-of-no-objection (LNO) for the use of HPP as an effective post-packaging intervention method in controlling *L. monocytogenes* in RTE meat and poultry products in 2003, HPP technology has been employed by many meat processors with great potential in terms of ensuring meat safety after.

III. Pulsed electric field

PEF refers to the application of a short burst of high voltage to food products at ambient or refrigeration temperature. The cell membrane is then damaged by the application of high voltage. During this process, little heat is generated because of the short time. Thus the quality of meat may be well-preserved. However, applying PEF technology still has limited applicability on solid foods such as meat products due to the nature of the food. This is due to low conductivity and high protein and fat contents of the meat and meat products.

IV. Pulsed light

PL technology involves applying a short-duration pulse of light within the range of 170 to 2600 nm. Its photo-dynamic effect (toxicity is generated through light absorbing molecules) is the main reason for its antimicrobial ability. Unlike PEF, PL technology has been developed to improve microbiological quality and safety of meat products. PL treatment at 8.4 J/cm² reduced approximately 1 to 2 log CFU of *L. monocytogenes* on cooked meat products. Similarly, various foodborne pathogens including *Campylobacter*



jejuni and *Salmonella* spp. were also inactivated by 1 to 2.5 log when PL was treated on the surface of chicken meat. Additionally, PL treatment on *S.typhimurium* in vacuum-packaged chicken breasts with longer exposure time appeared to have similar effectiveness on its surface, indicating the potential applicability of PL technology on packaged meat products. There are no significant changes in quality and sensory characteristics of treated meat compared with control when PL was treated under mild conditions. However, several factors including treatment time, intensity of PL, and treatment distance could influence the chemical and physical quality of meat products; therefore, it is necessary to explore an optimum condition ensuring microbial safety without deterioration before its successful commercialization.

V. Ultrasound technology

With ultrasound technology, high pressure, shear, and a temperature gradient are generated by high power ultrasound (20 to 100 kHz), which can destroy cell membranes and DNA, thus leading to cell death. Since the product should be immersed in an ultrasound bath for treatment, the technology is suitable for small carcasses such as chicken and pork. Recent literature has shown that ultrasound treatment alone reduced about 1 log CFU/cm² of Gram-negative bacteria including *Salmonella* spp, *E. coli* and *Pseudomonas fluorescens* on the surface of chicken wings, while ultrasound with lactic acid inactivated more than 1.5 log CFU/cm². Pressurized steam was also tested to investigate the synergistic effects of ultrasound in combination with steam. These studies suggest that ultrasound could be combined with antimicrobials such as chemical sanitizers and organic acids to enhance the bactericidal effect.

VI. Oscillating magnetic field

Oscillating magnetic field (OMF) destroy pathogens by loosening bonds between ions and proteins (such as calcium and calmodulin). Some reviews discussing OMF as an emerging technology have been published since the technology was patented in 1985. The major advantages of OMFs are avoiding post-processing contamination as OMFs are applied to packaged products precluding non-thermal processing and maintaining high product quality. However, OMF treatment requires special packaging materials, which severely limits its commercialization.

VII. Natural antimicrobials

Another emerging preservation technology is the concept of natural antimicrobial agents, which are likely to become popular because of consumer demands for minimally processed foods and natural preservatives. In particular, the use of natural antimicrobials dramatically increased in the processing of organic meats due to restriction on the use of chemical preservatives. Bacteriostatic or bactericidal effects of active compounds based on plant, animal, and bacterial origins have been well studied, while little study has been done on the change in the quality of meat after treatment with these additives. Quality changes of meat products by the addition of natural antimicrobials would be influenced by not only concentration but also different kinds of active compounds. Thus future studies are needed to evaluate the physicochemical property of meat with natural antimicrobials to find the optimum treatment conditions.

Conclusion

In summary, microbial hazards and associated issues continue to be the major challenges to meat safety well into the future. Chemical residue related issues also continue to be a major concern and some of them need attention from time to time. It is important to realize that management of meat safety risks should be based on an integrated effort and approach that applies to all sectors, from the producer through the processor, distributor, packer, retailer, food service worker and consumer. We should also keep in mind that most of the food borne illnesses are due to mishandling of foods in ways we know we should avoid, while



animal-borne pathogens introduced into the environment lead to illness associated with consumption of water or other foods. Thus, consumer education and environmental pollution issues should be major targets in our efforts to improve meat and food safety.

Methods for decontamination of meat products are in use today, such as packaging, application of antimicrobial chemicals and bacteriocins, steam pasteurization, HPP, PEF, and combinations of these technologies (hurdle technologies), have been widely investigated and proven as effective control measures in reducing bacterial contamination levels. Implementation of some technologies such as chemical sanitizing and irradiation in meat processing facilities has led to significant improvements in the microbiological safety of fresh meat. This does not, however, mean that meat products are free from foodborne pathogens, since raw meat products are still main vehicles known to cause foodborne illness outbreaks. Researchers continue to identify novel technologies for the preservation of commercialized meat products, which could enhance safety without deteriorating quality. Future approaches should focus more on exploring hurdle technologies for synergistic effects, as well as maintaining freshness and high quality of meat.

(Reference will be available from author)



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**MEAT SAFETY ASSURANCE MICROBIAL RISK ANALYSIS
ACROSS THE SUPPLY CHAIN**

**Dr. Y. Babji, Dr. G. Kandeepan, Dr. Y. R. Ambedkar*, Dr. S. Kalpana,
Dr. S. Vaithiyanathan and Dr. S. Girish Patil**

National Research Center on Meat, Hyderabad

*Department of Livestock Research Station, SVU, Garividi, Andhra Pradesh

Introduction

India possessed a huge livestock population of 512.05 millions of which total bovines population was 299.6 million (cattle 190.9 millions and bovine 108.7 millions); sheep 65.07 millions; goat 135.2 millions; pigs 10.3 millions; poultry 729.2 millions, yak 0.1 millions, mithun 0.3 million respectively, the other animals were 1.48 millions, poultry was 729.2 millions, producing 2.3 million tonnes of meat at the end of tenth five year plan (2006-07) to 5.5 million tonnes at the end of the eleventh five year plan (2011-12) whereas in the beginning of twelfth plan (2012-13) it was 5.95 million tonnes and it increased to 7.0 million tonnes in 2015-16 and 7.4 million tonnes in 2016-17. Of the total meat of 7020 thousand tonnes, poultry had a share of 46% (3246 thousand tonnes), buffalo 23% (1611 thousand tonnes), goat 13% (943 thousand tonnes), sheep 7% (485 thousand tonnes), pig 5.5% (388 thousand tonnes) respectively during the year 2015-16. Fish production increased from 5.66 MMT in 2000-01 to 11.41 MMT in 2016-17. India is the largest producer of milk in the world producing 155.5 million tonnes in the year 2015-16 and 165.4 million tonnes during 2016-17 while the egg production was 82.92 billions in 2015-16 and 88.14 billions during 2016-17.

India has exported 13,14,158.05 MT of buffalo meat products worth Rs. 2,6681.56 crores to the world during 2015-16 and 13,30,660.47 MT worth Rs. 26,30,793.15 lakhs during 2016-17. India is the largest exporter of sheep & goat meat to the world. The country has exported 21,950.71 MT sheep and goat meat worth Rs. 837.76 crores during the year 2015-16 whereas during 2016-17, exports were to the tune of 22,060.16 MT worth Rs. 87108 lakhs. Indian Poultry products to the tune of 659304.15 MT worth Rs. 76871.61 were exported during 2015-16 whereas during 2016-17, the exports were to the tune of 449527.49 MT worth Rs. 53164.74 Lakhs

Despite extraordinary increases in animal populations, meat production, meat exports and incoming foreign currency, India did not carve out a niche in the international markets due to foodborne illnesses.

In India, the exact estimates of the burden of food-borne disease is not known. Most food-borne diseases go unreported, only a few are reported by the media, usually those with high morbidity when they occur in urban areas but in a 2006 nationwide study 13.2 % households reported to have experienced foodborne illness in India (Koli and Garg 2015). According to 2015 global estimates of foodborne diseases, "the risk of foodborne diseases is most severe in low-and middle-income countries, linked to preparing food with unsafe water; poor hygiene and inadequate conditions in food production and storage; lower levels of literacy and education; and insufficient food safety legislation or implementation of such legislation" (World Health Organization, 2016). During 2010, 5.82 crore cases of food-borne diseases were reported besides 3.51 lakh food related deaths of which more than 70 % of are meat related ones in India and annually 3-5 billion infectious diarrhoea cases and nearly 1.5 million deaths occur mainly in young children, due to contaminated food and water. India is the most awful food safety violator in the world followed by China and Mexico, based



on the data analysis of 3400 food safety events by global food monitoring service food sentry. The main causes of food borne illness are bacteria (66%), chemicals (26%), virus (4%) and parasites (4%).(Addis and Sassy, 2015).

As per the data provided by the Integrated Disease Surveillance Programme (ISDP) of the Ministry of Health, Government of India, the number of food poisoning outbreaks and acute diarrhoeal disease outbreaks recorded were 2555 and 4366, respectively, during 2008-2017, while in 2017 alone, a total of 242 and 312 food poisoning and acute diarrhoeal diseases, respectively, were reported.(Kristkova et al., 2017).It is estimated that the FBD burden in India is about 100 million cases per year (about 1 in 12 people) caused by various diarrhoeal, infectious, parasitic and chemical agents. Kristkova et al., (2017) reported FBD as 'food poisoning' and it is forecasted that by 2030 around 176 million Indians likely to suffer from FBD with a projected cost Rs. between 7.0- 8.4 billion USD (Kristkova et al., 2017).

In a cross-country study, for every additional metric ton of meat consumed per 100 people, FBD mortality increased by 6% (Hanson et al. 2012) and 30% FBD are due to consumption of fruits, vegetables and aflatoxins.USA each year experience more than 40% percent of all bacterial foodborne illnesses due to consumption of contaminated meat and poultry products (Painter 1998; Painter 2008) and the annual cost of illness due to consumption of meat and poultry products has been estimated at nearly \$2.5billion for poultry, \$1.9 billion for pork, and \$1.4 billion for beef. (Batz and Morris 2017).

Food-borne diseases remain an authentic and dreadful problem in the globe including India causing great human suffering and significant economic loss. The changing food safety milieu due to superior scientific knowledge of the hazards should enable competent authorities to significantly reduce meat related risks. Nevertheless, the links between hazards in foods and foodborne illnesses in humans have sometimes been difficult to establish, let alone quantify and, where they have been identified, interventions have not always been technically, economically or administratively realistic. Therefore, regulators face serious challenges globally and nationally.

Besides improving public health, effective food safety systems maintain consumer confidence in supply chain and provide a sound regulatory foundation for domestic and international food trade. International trade agreements developed under the World Trade Organization (WTO) emphasize the need for regulations governing international trade in science based foods and risk assessment. The Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) permits countries to take legitimate measures to protect the life, health and well being of consumers without impeding trade among nations.

Article 5 of the SPS Agreement directs countries to ensure that their sanitary and phytosanitary measures are based on an assessment of the risk to human, animal or plant life or health, taking into account risk assessment techniques. Article 9 of the SPS Agreement defines the obligation of developed countries to provide technical assistance to developing countries for improving their food safety systems.

Food safety assurance is a shared responsibility by everyone involved in supply chain. Nevertheless, government and FSSAI should provide continually an enabling institutional and regulatory environment for food control incorporating and enforcing food laws, policies, regulations and standards, institutions with clearly defined responsibilities for food control management and public health; augmenting scientific capacity, integrated management approach, inspection and certification, diagnostic and analytical laboratories, standard setting, infrastructure and equipment, monitoring structures and capabilities, surveillance of human health problems related to food intake, capacity building for emergency response, training, public information, education and communication.



FAO and WHO have been working, in collaboration with national governments, scientific institutions, food industry, consumers and others, to improve the safety and quality of food in developing countries but food safety issues are still rampant in developing nations. In recent years, FAO/WHO global fora of food safety regulators have focused attention on mechanisms and strategies for building effective national food safety systems, which includes risk analysis.

Despite progress of national food control systems, a wide range of factors such as increasing volume of international trade, expanding international and regional bodies' legal obligations, increasing complexity of food types and geographical sources, intensification and industrialization of agriculture and animal production, increasing travel and tourism, changing food handling patterns, changing dietary patterns and food preparation preferences, new food processing methods, new food and agricultural technologies, increasing resistance of bacteria to antibiotics, changing human/animal interactions with potential for disease transmission, greater public demands for health protection, changing agricultural practices and climate change, changing human behaviour and ecology, sophisticated technology and detection and management of hazards, rapidly changing dimensions of the global and local food safety factors and food control principles such as increasing reliance on science, production to consumption approach, cost-effectiveness and efficiency of government control functions, increasing role of consumers in decision making, epidemiologically based food source attribution, adopting a more "integrated" approach to working with animal and plant health, adopting risk analysis, an abundant array of hazards such as biological, chemical and physical hazards have potential to cause adverse health effects due to mutant protein (technically called a prion) that causes "mad cow disease" or bovine spongiform encephalitis (BSE), acrylamide residues in baked and fried starchy foods, methylmercury in fish, and campylobacter in poultry, antimicrobial agents as feed additives are pressing competent authorities for further improvement in food safety and quality assurance.

Currently, governments and other parties involved in food control are developing new methods and applying and enhancing a wide variety of existing administrative systems, infrastructures and approaches to ensuring food safety, including risk analysis. In the present poor food safety scenario of national importance, adopting microbial risk analysis is indispensable for ascertaining and mitigating occurrence of microbiota across the supply chain.

Risk analysis

Risk analysis is comprised of three components: risk management, risk assessment and risk communication. Each of these components has been applied across supply chain, collectively known as "risk analysis." Risk analysis is used to develop an estimate of the risks to human health and safety; to identify and implement appropriate measures to control the risks; to communicate with stakeholders about the risks and enforced measures; to support and improve the development of standards; to address food safety issues that result from emerging hazards or breakdowns in food control systems; to provide food safety regulators with the information and evidence that they need for effective decision-making; contributing to better food safety outcomes and improvements concerning public health; contributing as a tool significant gains to competent authorities in food safety and quality assurance.

Components of risk analysis

The three main components of risk analysis defined by Codex is as follows:

(i) Risk assessment : A scientifically based process consisting of i) hazard identification; ii) hazard characterization; iii) exposure assessment; and iv) risk characterization.



(ii) **Risk management:** The process, distinct from risk assessment, of weighing policy alternatives in consultation with all interested parties, considering risk assessment and other factors relevant for the health protection of consumers and for the promotion of fair trade practices, and, if needed, selecting appropriate prevention and control options.

(iii) **Risk communication:** The interactive exchange of information and opinions throughout the risk analysis process concerning risk, risk-related factors and risk perceptions, among risk assessors, risk managers, consumers, industry, the academia and other interested parties, including the explanation of risk assessment findings and the basis of risk management decisions.

2. Risk Management

It is comprised of four major phases and one of which is preliminary risk management activities that has several steps.

Step 1: Identify and describe the food safety issue

Identifying and articulating the nature and characteristics of the food safety issue is an essential first task for risk managers that needs formal risk assessment and the other times, such issues can be resolved without risk reduction through a risk management frame work(RMF) such as a new or emerging potential hazard(s) that constitutes an unknown level of risk; for example, Shiga toxin producing *E. coli* (STEC) from mammals, an indication of a high level of risk to consumers from a specific pathogen in a specific food; for example *Listeria monocytogenes* in delicatessen meats, a need to rank and prioritize risks posed by a group of similar hazards; for example, enteric pathogens, for risk management, an indication of a high level of risk to consumers associated with a category of foods; for example, imported spices.

Step 2: Develop a risk profile

A typical risk profile includes a brief description of the situation, product or commodity; information on consumer exposure to a hazard; possible risks associated with that exposure; consumer perceptions of the risks and risks among different segments of the population; information on initial statement of the food safety issue, description of the hazard and food(s) ,how and where the hazard enters the food supply, which foods expose consumers to the hazard and how much of those foods are consumed by various populations, frequency, distribution and levels of occurrence of the hazard in foods; identification of possible risks from the available scientific literature; nature of values at risk (human health, economic, cultural, etc); implications of risk management in terms of international agreements (e.g. SPS Agreement) for risk profiles of *salmonella* and *campylobacter* in poultry, *listeria* in ice creams and ready-to-eat meats.

Step 3: Establish broad risk management goals

Risk management goals include developing specific regulatory standards or other risk management measures in order to reduce risks associated with a specific food-hazard combination to an agreed acceptable level (e.g. for an emerging microbiological hazard), for a veterinary drug that leaves residues in foods to ensure that exposure to the residue is limited to levels that do not exceed the acceptable daily intake, ranking risks for risk management of *Listeria monocytogenes* in different food categories, and analysing the risk reduction impacts a particular food safety issue.

Step 4: Decide whether a risk assessment is necessary

After deciding whether risk assessment is necessary or not, questions like how a risk assessment might be approached, what questions it might try to answer, what methods might yield useful answers, and where data gaps or uncertainties might likely preclude clear-cut answers, are significant issues. In certain cases, risk assessment is not required but issues can be solved by GMP, for instance *Listeria monocytogenes*.



Step 5: Establish a risk assessment policy

Risk assessment policy is developed to provide an agreed framework for the conduct of risk assessment which provides guidance to appropriate level of protection and scope of the risk assessment.

Step 6: Commission the risk assessment

The nature of the commissioning risk assessment method may vary, based on the nature of the risk, the institutional context, resources and other factors. In general, risk managers must assemble an appropriate team of experts to carry out the task, to interact with the risk assessors so as to instruct them to perform the work. Functional separation should be remembered which means separating out the tasks that are carried out as a part of risk assessment or risk management at the time when they are being performed. Risk assessment should be done by adopting codex standards for chemical hazards in foods whereas for microbial hazards it ought to be done by using available FSIS risk assessments.

Step 7: Consider the results of the risk assessment

In judging the risk assessment, risk managers need to be fully informed about the strengths and weaknesses of the risk assessment and its outputs; be sufficiently familiar with the risk assessment techniques, sources, uncertainties, variability in risk estimates to explain it to the stakeholders.

Step 8: Rank food safety issues and set priorities for risk management

The criterion for ranking is the perceived relative level of risk to consumers, so that risk management resources can be optimally applied to reduce overall food-borne public health risks; food safety issues prioritized based on serious restrictions in international trade resulting from different food safety control measures; relative ease or difficulty of resolving the issues; pressing public or political demand for attention to a particular problem or issue. The risk ranking exercise with *Listeria* in food illustrates a case in which the relative risk per food category is totally different from the absolute risk.

A. Selection of risk management options

It involves the identification, evaluation and selection of risk management options.

Step 1: Identify available management options

Bearing in mind the risk management goals and outcome of the risk assessment, risk managers should resolve to identify a range of risk management options such as (1)elimination of potential for risks (e.g. ban sales of an imported food with a history of high levels of microbial contamination), prevention or limiting initial levels of hazards in raw materials (e.g. select pasteurized ingredients, ensuring good veterinary practice (GVP) in use of veterinary drugs in food animals); (2) identification of CCPs across supply chain (e.g. mandate environmental hygiene controls, food processing controls, storage temperature controls);(3)reducing hazard levels in foods through various means (e.g. physical inspection regimes, pasteurization standards, decontamination processes, use of preservatives).

Step 2: Evaluate the identified management options

A clear link must be established between the risk management option being evaluated and the level of risk reduction and/or consumer protection that is provided in terms of appropriate level of protection" (ALOP) , implementation of HACCP and development of specific quantitative microbiological metrics – such as food safety objectives (FSOs, the maximum frequency and/or concentration of a hazard in a food at the point of consumption that provides, or contributes to, achievement of the ALOP.), performance objectives (Pos, the



maximum frequency and/or concentration of a hazard in a food at a specified step in the food chain that provides, or contributes to, achievement of the ALOP.) and performance criteria (PCs, the effect in frequency and/or concentration of a hazard in a food that must be achieved by the application of one or more control measures to provide or contribute to a performance objective) (FAO/WHO, 2006).

Step 3: Select a risk management option(s)

Through various approaches (notional zero risk approach, where risks are negligible ;ALARA approach ("as low as reasonably achievable, where hazards are limited, residual risks remain ,ex. enteric pathogens), (threshold" approach, where risks kept below a specific numerical level-ex. carcinogens) and benefit-cost approach, where risk-based measures to control campylobacter in chickens) and decision-making frameworks, select quantitative microbiological metrics as risk management options where POs and/or PCs as a basis for establishing practical standards, such as risk-based microbiological criteria (MC), process criteria or product criteria to reduce foodborne pathogens to an optimum level and an FSO established at the point of consumption of the food provides a reference for developing microbiological targets at other points in the food production chain. (FAO/WHO, 2006).

B. Reaching a decision on the preferred risk management option(s).

The decision-makers aim to achieve the "best" level of consumer protection in a manner that is cost-effective, technically feasible, sensitive to consumer rights and other cost-risk benefit analysis requires information on both risks and the consequences of different risk management decision options.

C. Dealing with uncertainty

When making risk management decisions, FSSAI need to take into account uncertainty transparently and conduct sensitivity analysis to determine how perturbations in model supply chain inputs affect the results, and an uncertainty analysis to determine the consequences of all the uncertainty.

D. Implementation of the risk management decision

These decisions are implemented by government officials, food industry and consumers through GMP, GHP, HACCP systems, microbiological testing, sampling plans and microbiological criteria. FSSAI through its single authority can eliminate duplication of efforts, overlap of responsibilities, and improve the food safety across supply chain efficiently.

E. Monitoring and review

Risk management decisions should be reviewed when new scientific data or insights, experience available during inspection and monitoring; databases for notifiable diseases, disease registries, death certificate databases, time-series data, targeted human surveys (active surveillance), analytical epidemiological studies, outbreak investigation data for food-borne illness events and food source attribution purposes.

3. Risk Assessment

It should take in to account any measure that is applied for protecting human health and wellbeing with a higher "appropriate level of health protection as per Codex risk assessment procedure and WTO SPS Agreement.

F. Basic components of a risk assessment for risk microbiological hazard :

(i) Hazard identification

Biological hazards such as microbes, viruses, parasites and toxins of biological origin, *E. coli* O157:H7, prion agent of BSE, and multi- antibiotic resistant strains of *Salmonella* cause FBD. (FAO/WHO, 2006).



(ii) Hazard characterization

A wide range of hazard factors (e.g. infectivity, virulence, antibiotic resistance) and host factors (e.g. physiological susceptibility, immune status, previous exposure history, concurrent illness) affect hazard characterization and its associated variability. Epidemiological information is essential for full hazard characterization.

(iii) Exposure assessment

The degree of human exposure depends on many factors including the extent of initial contamination of the raw food, characteristics of the food and the food processes in terms of the hazard organism's survival, multiplication or death, storage and preparation conditions before eating and transmission pathways, for instance those for *Campylobacter* in poultry, may involve cross-contamination at retail or in the home.

(iv) Risk characterization

It should explicitly consider the dynamics of microbiological growth, survival, death in foods, complexity of the interaction (including sequelae) between human and risk agent following consumption as well as its potential for further risk.

(v) Biotechnology risk assessment

Risk analysis principles and food safety assessment guidelines have recently been elaborated by Codex for foods derived from "modern biotechnology", i.e. those containing, derived from or produced using genetically modified organisms. The safety assessment for these foods should include a comparison between the whole food derived from modern biotechnology (or component thereof) and its conventional counterpart, taking into account both intended and unintended effects.

(vi) Sensitivity analysis

It is a scientific process that shows the effects of changes in various inputs (data or assumptions) on the outcomes of a risk assessment, estimates how much the uncertainty or variability associated with each input factor and contributes to the overall uncertainty and variability in the risk estimate.

(vii) Validation

It is the process of evaluating a simulation model used in a risk assessment for its accuracy in representing a food safety system, e.g. by comparing model predictions of food-borne disease with human surveillance data, or by comparing model predictions on hazard levels at intermediate steps in the food production chain with actual monitoring data.

(viii) Establishment of "targets" in the food chain as regulatory standards

Develop and evaluate specific quantitative microbiological metrics such as performance objectives and performance criteria; practical risk-based metrics such as process criteria, product criteria and microbiological criteria in HACCP plans as targets

(ix) Integrating risk assessment and economic assessment

Integrate risk assessment (health impacts, economic costs and other costs into units, dollars, rupees, "disability-adjusted life years", DALYs, or "quality-adjusted life years", QALYs) for reducing microbiological contamination in supply chain. For instance, contamination levels reduced, health risk averted (DALY) in broiler chicken supply chain when risk assessment and economic assessment done on control measures. Scald tank, cooking (prepared meat) and good kitchen hygiene contributed to it. (FAO/WHO, 2006).



4. Risk Communication

It is an integral part of risk analysis and an inseparable element of the RMF. Successful risk communication is a prerequisite for effective risk management and risk assessment, contributes to transparency of the risk analysis process and promotes broader understanding and acceptance of risk management decisions.

G. Key communication elements of food safety risk analysis

Key components include as below:

(i) Identifying a food safety issue

Open communication among all parties with information to contribute can be invaluable for accurately defining the issue.

(ii) Developing a risk profile

Experts developing the risk profile need to establish their own communication networks with the external scientific community and industry to build up a sufficient body of scientific information.

(iii) Establishing risk management goals

Communication with risk assessors and external stakeholders is essential; the risk management goals should not be established in isolation and which should be communicated to all stakeholders.

(iv) Developing a risk assessment policy

It involves risk assessors and risk managers to consider, resolve complex issues in a time bound manner with patience to agree on a risk assessment policy.

(v) Commissioning a risk assessment

The quality of face-to-face meetings and communication between the two groups at the outset often contributes significantly to the quality of the resulting risk assessment product. Discussions should be iterated until clarity is achieved by all participants.

(vi) During the conduct of a risk assessment

Traditionally, risk assessment has been a comparatively "closed" phase of risk analysis, in which risk assessors do their work largely out of the public eye. Interested parties who have essential data, such as manufacturers of chemicals and food industries whose activities contribute to exposure may also be invited to share scientific information with the risk assessment team and frank communication.

(vii) When the risk assessment is completed

Risk managers need to make sure they understand the results of the risk assessment, its implications, and uncertainties. The results also need to be shared with interested parties and the public, and their comments and reactions may be obtained.

(viii) Ranking risks and setting priorities

Risk managers should ensure a participatory process that encourages dialogue with relevant stakeholder groups. Priority judgements are inherently value-loaded and ranking risks in priority for risk assessments and risk management attention is fundamentally a political and social process, in which affected stakeholder groups should participate.



(ix) Identifying and selecting risk management options

Decisions on issues such as risk distribution, equity, economics, cost-effectiveness and arriving at an ALOP are often the crux of risk management. Effective risk communication during this stage is fundamental to the success of the risk analysis. Involving food safety risk managers from various stakeholders yield great outputs in addressing food safety issues.

(x) Implementation

When implementation is carried out primarily by government and it also works with the industry to develop an agreed plan for putting food safety controls into effect, then monitors progress and compliance through the inspection, verification and audit process.

(xi) Monitoring and review

Risk managers need to arrange for the collection of relevant data needed to evaluate whether the implemented control measures are having the intended effects. The importance of integrating scientific information from all aspects of monitoring hazards throughout the food chain, risk assessments and human health surveillance is paramount importance.

H. Some practical aspects of risk communication

Communication does not occur automatically and it has not always been easy to achieve. Communication elements of a risk analysis need to be well organized and planned, just as risk assessment and risk management elements.

I. Goals of communication

Goals of communication should be to establish what the subject of the communication is, for example, risk assessment policy understanding outputs of a risk assessment, identifying risk management options; knowing who needs to participate, both *generically* i.e. risk assessors, affected industry) and *specifically* (i.e. which individuals); and when during the risk analysis process each kind of communication should take place.

J. Communication strategies

A great many specific strategies for effective risk communication have been developed for use in various contexts including for food safety from farm to fork. Ensure openness, transparency and flexibility in all communication activities, identify and use a range of tactics and methods to engage in an interactive dialogue involving risk analysis team members and stakeholders, evaluate the quality of information received from stakeholders and assess its usefulness for the risk analysis.

K. Identifying stakeholders

Potential stakeholders include farmers, ranchers, fishermen and other food producers, food processors, manufacturers, distributors and their vendors, food wholesalers and retailers, consumers and consumer organizations, other citizen advocacy groups (environmental, religious, etc.), community groups (neighbourhood associations, co-operatives, etc.), public health community and health care providers, universities and research institutions, government (local government, state and central regulatory agencies, elected officials, importing countries etc.) with suitable criteria for them to participate in food safety risk analysis. (FAO/WHO, 2006).

L. Methods and media for communication

Methods of communication would be detailed written documents, scientific reports, meetings, briefings and workshops, panel discussions on the latest advances in food safety risk analysis.



Summary

Food safety is an elementary public health concern and achieving a safe food supply poses major challenges by an array of food-borne hazards which must be assessed and managed to meet growing and increasingly complex sets of national objectives. Risk analysis is a powerful tool for carrying out science-based analysis for attaining sound, reliable solutions to food safety problems. Risk Management manages food-borne risks to consumers, requires extensive communication, coordination and collaboration between risk managers, risk assessors and external stakeholders. Risk assessment deals with risk assessment methodologies and their essential characteristics. The responsibilities of risk managers in commissioning and administering a risk assessment are described and differences between risk assessment approaches for chemical compared with microbiological hazards. The relative merits of qualitative and quantitative approaches are examined, using probabilistic models of risks. Risk communication is a powerful element of risk analysis, requires thoughtful planning and resources, infrastructure for risk communication.

Conclusion and recommendations:

The basis of a science-based system of food safety is the incorporation of the results of risk analysis in to all decisions regarding resource allocation, programmatic priorities, and public education activities. Risk assessment integrates data on exposure to harmful agents and dose response relationships to estimate the risk of developing illness from eating specific foods. The growing acceptance of the principles of risk assessment has also led to its use beyond regulatory standard setting. It is now possible to use comparisons of risk to inform and set priorities for risk management. Risk based priorities enable resources to be so allocated as to ensure food safety assurance and protect public health. Develop a comprehensive national food safety plan and implement it under one health approach for India; funds should be allocated in accordance with science-based assessments of risks for meat safety research projects-- provide adequate and identifiable support for research and surveillance to monitor changes in risk or potential hazards in the supply chain, consumption patterns and new hazards. The superseding conclusions that (1) an effective and efficient food safety system must be science based, (2) to achieve a science based food safety system, current statutes governing food safety regulation and management must be continually revised and implemented in its entirety pan India and (3) to implement a science based system, reorganize central government and food safety authority of India's (FSSAI) food safety efforts. FSSAI should focus on hands on trainings in the area of meat safety and quality assurance engaging participation of various relevant ministries with focus on microbial risk analysis.

FSSAI ought to hold a long-term commitment to continuously re-evaluate, change any policies, legislation and ineffective strategies that prevent it from achieving its vision and mission of ensuring meat safety assurance through risk analysis, across the farm-to-table continuum, protecting invaluable meat with the goal of preventing foodborne illnesses, protecting and preserving public health and wellbeing.

(Reference will be available from author)



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ARTIFICIAL FOOD COLOURS : A POTENTIAL THREAT TO HUMAN HEALTH

Dr A. Jagadeesh Babu¹ and Dr. G. V. Bhaskar Reddy²

¹Professor, Department of Veterinary Public Health & Epidemiology
College of Veterinary Science, SVVU, Tirupati-517 502, Andhra Pradesh

²Assistant Professor and Head, Dept. of Livestock Products Technology,
College of Veterinary Science, SVVU, Tirupati-517 502, Andhra Pradesh

The addition of colorants to make food more attractive is not a recent invention. Extracts from spices and vegetables were used as early as 1500 BC, in India and China for coloring skin. Wine was colored as early as 400 BC, and spices and condiments were being colored by AD 1400. Colorants derived from naturally occurring minerals, plants, and animals were prepared along with the spices that played such a prominent part in the development of early civilizations (Tannahill, 1973). The use of food colorants aids in the production of food of preferred color values and provides significant functional advantages in a variety of situations colorants. It corrects for variation and irregularities resulting from storage, processing packaging, and distribution, assuming greater uniformity in appearance and hence acceptability. Color also, help preserve the identity or character by which foods are recognized (Hall, 1958). Food colours are commonly used for

- To make food more attractive, appealing, appetizing, and informative
- Offset color loss due to exposure to light, air, temperature extremes, moisture and storage conditions
- Correct natural variations in color
- Enhance colors that occur naturally
- Provide color to colorless and "fun" foods
- Allow consumers to identify products on sight, like candy flavors or medicine dosages

The advent of the use of food colorants in the late 1800s and early 1900s was unfortunately accompanied by their misuse in food adulteration. Before the development of synthetic colorants, dangerous mineral extracts were often used to colour foods, frequently to disguise food of poor quality. Some of these deceptive practices included colouring of pickles with copper sulfate, cheese with vermilion and red lead, tea with copper arsenate, lead chromate, and Indigo, and Candy with lead chromate, red and white lead, and vermilion (NAS/NRC 1971). In 1956, the discovery of the first synthetic dye, mauve, by Sir William Henry Perkins prompted a search for other dyes. Further development of synthetic colorants then became attractive to the food industry because these colorants were superior to natural extracts in tinctorial strength, hue, and stability and was readily available in many hues. The addition of synthetic colorants to food in the United States was first legalized for butter in 1885, followed by the authorization to add colorants to cheese in 1896 (Newsome, 1986).

Historically, synthetic colorants, also known as aniline dyes, were manufactured from coal tar derivatives. Although the colorants were highly purified before they were added to foods, the negative connotation of their association with coal tar resulted in much unfavourable publicity. As a result, synthetic colorants are no longer manufactured from coal tar derivatives but instead are developed from highly purified petrochemicals. The U.S. Department of Agriculture began to investigate the use of colorants in foods to establish principles for their regulation in the early 1900s. The first comprehensive regulation regarding food colorants was the Federal Food and Drug Act of 1906. Previously, 80 different colorants had been used in



foods. Following establishment of the Federal food and Drugs Acts, the U.S. Department of agriculture eliminated all but seven of these colorants, on the basis of known composition and purity. This act and a series of food inspection decisions lead to establish of a voluntary certification program for food colorants with the food inspection decision of 1907. Subsequently, seven more colorants were added to the approved list. In 1938, The Federal Food, Drug, and Cosmetic Act established mandatory certification (21 CFR parts 73-74, 81-820) requiring submission of samples from each batch of colorant for evaluation of purity. Synthetic colorants that had previously been known by common names were there given specific names to ensure distinction of those for use in foods from those for use in drugs or cosmetics. Three categories for designating colorant names. FD & C (Suitable for use in foods, drugs and cosmetics), D & C (suitable for use in drugs and cosmetics), and external D & C (Suitable for use in externally applied drugs and cosmetics) were defined (Branen *et al.*, 1990).

In 1960, the color additive amendments to the FD & C act were established, defining the term "color additive" as any dye, pigment or other substances made or obtained from a vegetable, animal or mineral or other source capable of coloring a food, drug or cosmetic or any part of the human body. Included in the two part amendments was a Delaney-type clause. Part (1) of the clause prohibited addition to food of any colorant found to induce cancer in human or animals. Part (2) of the clause permitted the use of current color additives under a provisional list in pending the completion of scientific investigations needed to determine their safety for permanence listing. Synthetic colorants were thus required to undergo premarketing safety clearance, and previously authorized colorants were reevaluated (Newsome, 1986).

The Certified Color manufacturer's Association (CCMA) has petitioned the FDA for approval of Carmoisine, a colorant similar in shade to FD and C Red No. 2. Carmoisine is widely used in food in Central and South America and Europe. However, colorants considered safe in one country may not be considered safe in other parts of the world. In the U.S. the toxicity of a colorant is tested under conditions similar to those under which it will be used. Therefore, since it is important that food colors be safe when ingested, animal feeding studies play a key role in their evaluation (Marmion, 1984). Present day toxicological testing, as suggested by the FDA, is listed in the RDA "Red Book" (FDA, 1982). Scientists in many other parts of the world, however, place emphasis on the effects of subcutaneous injection of the colorant. Because of the different mechanisms involved, the results of the studies conducted under these different test conditions vary and have resulted in much scientific and political debate.

Many color additives had never been tested for toxicity or other adverse effects. Historical records show that injuries, even deaths, resulted from tainted colorants. In 1851, about 200 people were poisoned in England, 17 of them fatally, directly as a result of eating adulterated lozenges.^[7] In 1856, mauveine, the first synthetic color, was developed by Sir William Henry Perkin and by the turn of the century, unmonitored color additives had spread through Europe and the United States in all sorts of popular foods, including ketchup, mustard, jellies, and wine.^{[11][12]} Originally, these were dubbed 'coal-tar' colors because the starting materials were obtained from bituminous coal.^{[13][5]}

Many synthesized dyes were easier and less costly to produce and were superior in coloring properties when compared to naturally derived alternatives.^[9] Some synthetic food colorants are diazo dyes. Diazo dyes are prepared by coupling of a diazonium compound with a second aromatic hydrocarbons.^{[14][15]} The resulting compounds contain conjugated systems that efficiently absorb light in the visible parts of the spectrum, i.e. they are deeply colored. The attractiveness of the synthetic dyes is that their color, lipophilicity, and other attributes can be engineered by the design of the specific dyestuff. The color of the dyes can be controlled by selecting the number of azo-groups and various substituents. Yellow shades are often achieved by using acetoacetanilide. Red colors are often azo compounds.^[15] The pair indigo and indigo carmine exhibit the same



blue color, but the former is soluble in lipids, and the latter is water-soluble because it has been fitted with sulfonate functional groups

Permitted Food Colours:

E numbers 102-143 cover the range of artificial colors. For an overview of currently allowed additives see here. Some artificial dyes approved for food use in the EU include:

- E104: Quinoline Yellow
- E122: Carmoisine
- E124: Ponceau 4R
- E131: Patent Blue V
- E142: Green S

In the US, the following seven artificial colorings are generally permitted in food (the most common in bold) as of 2016. The lakes of these colorings are also permitted except the lake of Red No. 3.

FD & C Blue No. 1 – Brilliant Blue FCF, E133 (blue shade),

FD & C Blue No. 2 – Indigotine, E132 (indigo shade)

FD & C Green No. 3 – Fast Green FCF, E143 (turquoise shade)

FD & C Red No. 3 – Erythrosine, E127 (pink shade, commonly used in glacé cherries)^[24]

FD & C Red No. 40 – Allura Red AC, E129 (red shade)

FD&C Yellow No. 5 – Tartrazine, E102 (yellow shade)

FD&C Yellow No. 6 – Sunset Yellow FCF, E110 (orange shade)

Two dyes are allowed by the FDA for limited applications:

Citrus Red 2 (orange shade) - allowed only to color orange peels.

Orange B (red shade) - allowed only for use in hot dog and sausage casings (not produced after 1978, but never delisted)

Many dyes have been delisted for a variety of reasons, ranging from poor coloring properties to regulatory restrictions. Some of these delisted food colorants are:

FD & C Red No. 2 – Amaranth, E123

FD & C Red No. 32 was used to color Florida oranges.

FD & C Orange Number 1 was one of the first water-soluble dyes to be commercialized, and one of seven original food dyes allowed under the Pure Food and Drug Act of June 30, 1906.

FD & C Orange No. 2 was used to color Florida oranges.

In India only 8 coal tar food colours are permitted to use in certain food products under provisions of PFA. They include 3 red shades namely Carmosine, Ponceau 4R, Erythrosine; 2 yellow shades namely Sunset yellow FCF, Tartrazine; 2 blue shades i.e. Brilliant Blue FCF and Indigo Carmine and 1 green shade i.e. Fast Green FCF. The unpermitted food colours are Metanil yellow, Rodamine B, orange G, Blue VRS, Auramine and some water soluble and oil soluble food colours. Now-a-days, both industrial and non-industrial sectors in



most of developed as well developing countries are involved in different food processing activities (Padmaja et al. 2004). Though the industrial sector is subjected to quality checks but the non-industrial sector is outside of quality checks, statutory controls (Padmaja et al. 2004) resulting in increased production of substandard food products which is affecting human health and leading to indirect financial burden on national economy (Nida Saleem et al., 2013). Because of rapid urbanization, consumption of food products including milk products, meat products and bakery products like cakes, confectionaries is increasing and the production of these products in non-industrial sector is two to three times more than the industrial sector (Sharma 7 Sharma 2004).

Effects on health:

Many studies and surveys have revealed that food colours are the major source of food intoxication (Ashfaq et al., 2002). Even though some synthetic food colours are permitted, the indiscriminate consumption is not safe which may lead to higher incidence of gastrointestinal diseases like cholera, enteric fever, TB etc. The other non-permitted food colours may pose serious health hazards as they are mutagenic and potential carcinogens (Ashfaq et al., 2002). The maximum limit of permissible colours to be added in any food shall be 0.1gm/kg of food. To evaluate safe level usage of food colour, the Joint FAO/WHO Expert Committee of Food Additives (JECFA) has set an Acceptable Daily Intake (ADI) for each food colour (Pratima Rao et al., 2004). The ADI has defined as the amount of substance that can be consumed everyday throughout the lifetime of an individual without any appreciable adverse health effects (JECFA 1996). Many studies have been reported on the use of permitted and non-permitted colours in foods in India and revealed the fact that use of non-permitted colours are known to cause adverse effects in experimental animals and humans (Padmaja et al. 2004)

(Reference will be available from author)

Oral Presentations

FQS-1

DEVELOPMENT OF GREEN SYNTHESIZED GOLD NANOPARTICLE ENABLED SMART INDICATOR FOR MONITORING THE QUALITY OF REFRIGERATED CHICKEN MEAT

Kandeepan.G., Swaroopa. G., Gouthami. B., Babji. Y., Shivaji. A

ICAR-National Research Centre on Meat
Chengicherla, Boduppal Post, Hyderabad-500092, Telangana

The research was aimed to develop a smart indicator label using colorimetric method for monitoring the freshness of chilled chicken meat. The indicator sensor was made from the combination of curcumin-gold nanoparticles and anthocyanin extract of red cabbage which was immobilized on nitrocellulose membrane by dip coating method through centrifugation. In this experiment, the chicken meat was packaged in polypropylene trays wrapped with polypropylene film and the indicator was attached to the inner side of the overwrap film. The colour changes of the indicator label was observed using digital photography during the storage of meat at 0, 3, 5, 7 and 9 days at $4 \pm 1^\circ\text{C}$ in a refrigerator. The colour changes that occurred were quantified and analysed using the Image program. The colour of the indicator label was dark pink when the meat was in fresh state while the colour of the indicator label showed discoloration when the meat quality deteriorated. The colour change in the indicator sensor was monitored and compared with the meat quality parameters such as total volatile basic nitrogen, standard plate count and tyrosine value to correlate the ability of indicator sensor for its suitability to predict the meat quality and storage life. The results indicated that chemical, microbial and sensory quality changes corroborated with the color changes produced in the indicator due to its reactivity with the volatile amines. Therefore it is concluded that the indicator sensor made up of curcumin-gold nanoparticle-anthocyanin can be successfully used as smart packaging indicator for monitoring the freshness of refrigerated chicken meat.

FQS-2

DEVELOPMENT OF DYE BASED COLORIMETRIC INDICATOR FOR ACCESSING FRESHNESS OF STORED CHICKEN MEAT

**Arvind Soni^{1*}, S.K. Mendiratta², S. Talukder², S. Chand², R. K. Jaiswal²,
Y.P.Gadekar¹ and A.K. Shinde¹**

¹Livestock Products Technology Section, ICAR-Central Sheep and Wool Research Institute,
Avikanagar, Tonk, Rajasthan, INDIA

²Division of Livestock Products Technology, ICAR-Indian Veterinary Research Institute,
Izatnagar, Bareilly, Uttar Pradesh, INDIA

In current scenario, packaging is the key tool of commercialized meat sector to ensure its safety in supply chain. A new dye based quality indicator has been fabricated for real-time monitoring of refrigerated ($4 \pm 1^\circ\text{C}$) stored chicken meat. Cresol red is chemo-responsive dye, which was selected as quality indicator



based on their ability to react with package head space gases such as carbon di-oxide. On-package indicator strip changed its colour from initial dark pink to final yellow during storage at 4 ± 1 °C, which was easily detectable with naked eye. The changes in colour of indicator strip was compared with chicken meat quality parameters. pH, Thiobarbituric Acid Reacting substance (TBARS), Total Volatile Basic Nitrogen (TVBN), Ammonia level, Free amino acid (FAA) and microbial counts increased ($P < 0.05$) significantly during storage. At initial stage, pH, TBARS, TVBN, Ammonia and FAA value was 5.78, 0.33, 7.64, 25.9 and 61.53, which increased to 6.34, 1.52 mg malonaldehyde/Kg, 20.9, 56.0 and 126.93 mg/100g, respectively on 7th day of storage. Total plate and Pseudomonas count also increased significantly ($P < 0.05$) to final count of 7.07 and 6.41 log₁₀cfu/g, respectively. Head space carbon di-oxide gas concentration increase significantly ($P < 0.05$) from 0.36 % on 0th day to 1.66 % on 7th day. Results have indicated that indicator colour response correlated well with the change in physico-chemical and microbial parameters of chicken meat enable to real-time monitoring of stored chicken meat.

FQS-3

HALAL AUTHENTICATION OF BONE CHIPS BY SIMPLEX POLYMERASE CHAIN REACTION

Appa Rao, V., R. Narendra Babu, V. Govind, Robinson.J.J.Abraham and A. Vanathi

Department of Livestock Products Technology (Meat Science)

Madras Veterinary College, Tamil Nadu Veterinary and Animal Sciences University, Chennai-7.

Degreased crushed bones are normally used as raw material in the manufacture of edible grade and food grade gelatine. Samples from different gelatine industries screened for halal authentication in this study. Screening of raw materials for authenticity of species is an imperative need for gelatine manufacturing industries to preclude the possibility of their product being rejected by importers or end users due to inadvertent presence of species considered inappropriate in the final product. Keeping in view the above facts it was planned to screen the degreased bone chips which is raw material in gelatin manufacturing for species of origin by adopting a rapid suitable and sensitive method of identification. Crushed bone chips in eighteen batches have been received from gelatine manufacturing industries and screened for authentication of species. Three species buffalo, porcine and cattle primers were used for screening the samples. DNA was extracted from bone chips of unknown origin marketed in Chennai city using a FavorPrep[®] tissue genomic DNA extraction Mini kit. Selected primers were custom synthesized targeting mitochondrial cytochrome b gene and used for PCR amplification. All samples indicated positive for buffalo DNA. Three samples were detected positive for Cattle and none of the samples detected positive for porcine DNA. The DNA extracted by commercial tissue genomic extraction kit used in this study have given adequate DNA yield and purity for further PCR amplification. In summary, simplex PCR designed in this study which target PCR amplification of mitochondrial cytochrome b gene reliable and suitable technique in routine species authentication and can be successfully used for authentication of species of origin in commercial bone meal samples.



FQS-4

DETECTION OF PRESENCE OF RAT SPECIES ON GELATIN SAMPLES BY SIMPLEX POLYMERASE CHAIN REACTION

Robinson.J.J.Abraham, R.Narendra Babu, V. Appa Rao, V. Govind and R.Ramani

Department of Livestock Products Technology (Meat Science)
Madras Veterinary College, Tamil Nadu Veterinary and Animal Sciences University, Chennai-7.

Accidental inclusion of Rodent species or rodent droppings in food products is quite often encountered in food processing industries if adequate measures are not taken for pest control. The Islamic law prohibits Muslims from eating pork and ingredients derived from animals having canine teeth or fangs such as dog, cat, monkey and rat and consumption of products considered non-halal is strictly forbidden. Most of the Muslim countries made halal certification compulsory for gelatine importers and producers and also authentication of declared components in food pack labels is an ever increasing public demand. The present study aimed to develop simple species specific conventional PCR technique for detection of rat species DNA in gelatine and to investigate the source of gelatine in commercial samples marketed in Chennai city, India. Eight batches of gelatin powder prepared from known buffalo sources received from local manufacturing industry suspected for inclusion of rat species. DNA was extracted from samples using a FavorPrep[®] tissue genomic DNA extraction Mini kit. Selected primers were custom synthesized and used for PCR amplification. PCR amplification was carried out using a master thermal cycler (Eppendorf, Germany). Species specific bands of mitochondrial cytochrome b gene (422bp) and ATPase 6 gene (108bp) for buffalo and rat respectively were used for identification. Two batches are contaminated with rat species. Inadequate pest management practices is the factor might be responsible for inclusion of rat species in gelatine samples. Establishing procedures for pest control is an important component of GMPs. DNA extraction procedure employed in the study, primers used and PCR cyclic conditions are optimum for identification of source of gelatine.

FQS-5

APPLICATION OF CHLORINE DIOXIDE AS A DECONTAMINANT FOR BROILER CHICKEN CARCASSES

Irshad, A., Lakshmi, A.T., Vasudevan, V. N., Sathu, T. and B.Sunil

Department of Livestock Products Technology and Meat Technology Unit
Kerala Veterinary and Animal Sciences University

A study was conducted with the objective of assessing the effect of carcass washing as decontaminant with chlorine dioxide solution as well as hot water treatment on the physico-chemical, microbiological and sensory quality of broiler chicken carcasses. 120 broiler chicken carcasses were collected from the poultry processing line of Meat Technology Unit, Mannuthy after slaughter and dressing, were divided into four groups and they were subjected to various decontaminant treatments like: C-Control (untreated broiler chicken carcass), T1-Washing of broiler chicken carcass with hot water at 80°C for 20 seconds, T2- Washing of broiler chicken carcass with 100 ppm chlorine dioxide solution for 5 minutes, T3- washing of broiler chicken carcass with 200 ppm chlorine dioxide solution for 5 minutes. After treatment, microbial quality, physicochemical attributes and sensory quality of the samples were analyzed. The results in the current study have thus



highlighted that the broiler chicken carcasses can be effectively decontaminate after processing by washing with chlorine dioxide solution at 200 ppm concentration for 5 minutes as well as hot water treatment at 80°C for 5 minutes. Since hot water treatment at 80°C for 5 minutes affecting consumer sensory parameters like acceptability and colour scores due to the epidermis damage and subsurface cooking, it cannot be advocated to processors and consumers. Hence, 200 ppm level of chlorine dioxide solution improve the microbial quality of broiler chicken carcass without affecting the physico-chemical and sensory characteristics, it can be advisable to the poultry processor for decontaminating the carcasses after processing.

FQS - 6

VALIDATION OF DNA MACRO ARRAY CHIP (CHIPRON MEAT 5.0) FOR FORENSIC MEAT ANALYSIS

Vaithiyanathan, S, Vishnuraj, M. R, Sowmya, M and Uday Kumar, R

Meat Species Identification Laboratory (MSIL), ICAR-National Research Centre on Meat,

Chengicherla, Hyderabad-92, Telangana, India.

ISO/IEC 17025:2005 NABL Accredited Laboratory

Prior to using a procedure for forensic analysis applications, the laboratory shall conduct internal validation studies as per the requirement of ISO/IEC 17025:2017 (clauses 7.2.2 & 7.8.1.2) and as per Scientific Working Group on DNA Analysis Methods (SWGDM) guidelines, internal validation is an accumulation of test data within the laboratory to demonstrate that established methods and procedures perform as expected. In MSIL, we performed validation of Chipron Meat 5.0 version (that can detect 24 animal species) for species-specificity and limit of detection (LoD), using meat admixtures for both beef and carabeef. The identity of the species origin of meat samples used were pre-confirmed using nucleotide sequencing of mitochondrial 12S r-RNA amplicons and mitochondrial D-loop species specific PCR. To check the LoD for both beef and carabeef, different meat admixtures were prepared to a final weight of 50 g, by adding specified weight i.e., 0.5 g and 1 g of adulterant species to a matrix species to obtain admixture concentration of 1% and 2% (w/w), respectively. For method specificity, meat from both adulterant species and matrix species were prepared to a final weight of 200mg. From all the samples in triplicates, DNA was extracted by spin column method and PCR assay (target gene, 16S rRNA) and hybridization were performed as per manufacturer kit. In result interpretation, LoD as low as 1% for beef in carabeef and carabeef in beef were observed. The specificity study using 100% beef and carabeef showed that the species specific probes in the chip were robust and any chance of cross reactivity were excluded. The repeatability were analysed in triplicates and concluded that the technique provides a fool proof tool for forensic meat analysis at MSIL, ICAR-NRC on Meat. Further, the Chipron test kit can be validated with other meat admixtures like sheep/goat/chicken/turkey/pork/camel/horse as per stakeholder's requirement.



FQS-7

DETECTION OF ENROFLOXACIN AND CIPROFLOXACIN RESIDUES IN PRESSURE COOKED CHICKEN BY LIQUID CHROMATOGRAPHY ELECTRON IONIZATION SPRAY TANDEM MASS SPECTROMETRY

Govind.V, R. Narendra Babu, V. Appa Rao, P. Sriram, T.M.A. Senthil Kumar and Robinson. J.J. Abraham

Department of Livestock Products Technology (Meat Science)
Madras Veterinary College, Tamil Nadu Veterinary and Animal Sciences University, Chennai-7.

The objective of this study is to develop an analytical method capable of screening and confirming the residue level of Enrofloxacin and its metabolite Ciprofloxacin which is common quinolone compound used in poultry production in tissue matrices by Liquid Chromatography Tandem Mass Spectrometry (LC-MS/MS). Presence of residue levels Enrofloxacin and Ciprofloxacin in pressure cooked chicken meat were evaluated using a validated LC-MS/MS (Agilent) method. Targeted analytes were extracted following liquid-liquid extraction method from meat matrix with phosphoric acid added acetonitrile: water as solvent. Analytes were separated using Zorbax® (Agilent) Eclipse plus C18 3.0 x 150mm, 5 microns column. Good linearity over the investigated concentration range was observed, with mean values of correlation coefficients higher than 0.99 of two analytes studied. Recoveries for the analytes based on matrix-matched calibration in tissue matrices were in acceptable range. Limit of detection (LOD) and Limit of quantification (LOQ) obtained with this method for Enrofloxacin were 0.22 ppb, 0.85 ppb and for Ciprofloxacin were 0.47 ppb, 1.44 ppb respectively. This method has been successfully applied for analysis of sixty chicken meat samples from the local market and residues were detected in all samples, which ranges from 2 µg/kg to 24 µg/kg and are below the range of MRLs specified by Export inspection council of India.

FQS-8

ESTABLISHMENT OF CRITICAL CONTROL POINTS WITH REGARD TO *CAMPYLOBACTER* SPP. IN PORK PROCESSING LINES

¹Muralikrishna P*, ²Sunil B, ³Latha C, ⁴Deepa Jolly, ⁴Binsy Mathew, ⁵Vasudevan V N, ⁶Ashok Kumar and ⁷Nithya K R

¹MVSc. Scholar, ²Professor, ³Professor and Head, ^{4,5}Assistant Professors,
⁶Assistant Director General (Animal Health), ⁷Senior Research Fellow
^{1,2,3,4,7}Department of Veterinary Public Health,
⁵Department of Livestock Products Technology,
⁶Indian Council of Agricultural Research, Pusa, New Delhi
College of Veterinary and Animal Sciences, Mannuthy, Thrissur, Kerala.

Campylobacteriosis is one among the universal causes of bacterial foodborne illness. Pork could be considered as potential source of *Campylobacter* infections in humans and is considered to have a major impact on food safety. Carcass contamination could occur at any point in pork processing line at slaughter house and it is important to find out the points which could reduce or eliminate the hazard. A total of 484 samples were screened from various points in pork processing line from M1 and M2 and critical points were established for pork processing in both processing plants. Major contamination points in both plants were



animals brought for slaughter, with sows (66.67 per cent) having higher occurrence than boars (33.33 per cent). Animals carried the organisms before scalding, where neck and belly swabs were also contaminated with *Campylobacter coli*. After scalding, none of carcass swabs were positive for *Campylobacter* spp. So scalding at a temperature of 62°C for five minutes proved as control point in both processing lines. In M1, *C. coli* could be detected in carcass swabs after evisceration (11.11 per cent) from two points (jowl and belly) and these samples were positive till final splitting of carcass and separation of meat. The reappearance could be attributed to possible sources of contamination, especially the knife which was found positive for *C. coli*. After freezing at -20°C for 24 hours, the organisms could not be detected on any meat samples. Scalding followed by polishing could be pointed as Critical control point. Since no organisms could be detected after freezing, indicated storage at -20°C for 24 hours could be CCP2, as no organisms could be detected after the process in M1. In M2, *Campylobacter* spp. could not be detected after scalding followed by polishing, and hence, scalding at proper time-temperature combination can be marked as CCP2. Establishment of critical control points at which a control could be applied, helped to eliminate the organism from the final product in pork processing units.

FQS-9

OCCURRENCE OF *LISTERIA* SPECIES IN MEAT PROCESSING PLANTS IN KERALA

B. Sunil, Nithya K. R., C. Latha, Vrinda Menon K., Deepa Jolly and Ashok Kumar

Department of Veterinary Public Health, College of Veterinary and Animal Sciences, Mannuthy

Introduction : *Listeria*, a food-borne pathogen causes outbreaks worldwide, thus posing serious public health problems in pregnant women, newborns, and adults with a weakened immune system. The organism being ubiquitous in nature are psychrotrophic. Most of the listeriosis cases caused by *Listeria monocytogenes* are the result of the consumption of contaminated food including meat, meat products and dairy products. The occurrence of *Listeria* spp. in meat processing plants in Kerala was investigated in the present study.

Objective : The present study was conducted with the objective of isolating *Listeria* spp. from various meat processing plants in Kerala and its confirmation by polymerase chain reaction.

Methodology : Meat samples, swabs from meat cutting equipments, meat contact surfaces and environmental samples including fresh water and effluent water as well as handwash of workers were procured from the meat processing plants. Pre-moistened swabs were firmly rubbed over the surface to be examined by using parallel strokes and rotation of the swab. These swabs were transferred to 25 ml of peptone water immediately after collection, as per the procedure of United States Department of Agriculture (McClain and Lee, 1998) with modifications. In the primary enrichment phase, 25 ml of the initial dilution was transferred to 225 ml of University of Vermont Medium I (UVM I, Himedia, India), incubated at 30°C for 24h and 0.1 ml of UVM I was transferred to UVM II (Himedia, India) and further incubated at 30 °C for 24 h. Then it was streaked on Polymyxinacriflavin lithium chloride ceftazidime aesculin mannitol (PALCAM, Himedia, India) agar plates and incubated at 37°C for 48h. Colonies with a greyish green glistening appearance surrounded by a black zone of aesculin hydrolysis were selected for further confirmation by biochemical tests. The isolates obtained by culture methods were subjected to PCR. DNA isolation was carried out by boiling and snap chilling methods (Lee *et al.*, 2009). The *iap* gene encoding p60 protein was used as target which is common to all members of the genus *Listeria*.



Results and Conclusion : A total of 1240 samples (103 dung, 133 knife swabs, 100 carcass swabs before evisceration, 131 carcass swabs after evisceration, 138 cutting table surface swabs, 5 plastic storage containers, 144 handwash, 125 meat, 112 air, 5 soil, 118 water and 126 effluent) from five slaughter houses were examined. *Listeria* spp. was reported from all the five slaughterhouses. Of the 1240 samples, 4.68% (58 Nos.) were found to be positive for *Listeria* spp. Highest occurrence was reported from knife swabs (7.8 per cent), followed by cutting table surface swabs (7.24 per cent), hand wash (6.25 per cent), dung (5.83 per cent), meat (4.8 per cent) and effluent samples (4.76 per cent). Less than four per cent occurrence was noted in water (3.39 per cent), carcass swab after evisceration (3.05 per cent) and carcass swab before evisceration (1.00 per cent). *Listeria innocua* was the most commonly isolated species (61 isolates) followed by *L. ivanovii* and *L. welshmeri*. *Listeria ivanovii* was obtained from knife swabs, carcass swab after evisceration, cutting table surface swabs, water and effluent samples, while *L. welshmeri* was present on cutting table surface swabs, handwash and water samples. Air samples were negative for the organism. The highest occurrence was reported from slaughter house 2 (4.92 per cent) and lowest from slaughter house 1. The study gave an insight into the source of contamination in the plant from equipments and other contact surfaces which points to the importance of sanitation that is critical for ensuring that ready-to-eat products do not become contaminated. In this study, the organism, having been recovered from food contact surfaces points to the possibility of biofilm formation on equipment surfaces and processing surfaces. Listeriosis is fatal in vulnerable population. The organism is, not only more resistant than most disease causing foodborne bacteria to freezing, drying, high salt levels, nitrite and acid, but can also grow at low temperature and with low oxygen level such as those found on vacuum packaged meats. The study brings out the importance of hygienic practices to be exercised in processing plants and recommends improved sanitation for prevention of listerial contamination.

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FQS-10

QUALITY EVALUATION OF CHICKEN NUGGETS IN TRAY PACKAGING USING DIFFERENT WRAP FILMS AT 4±1°C

**Dipak Kumar Banerjee, I Prince Devadason,* R. K. Agrawal, R. R. Kumar,
Safier Ahmad Ganiee**

Division of Livestock Products Technology, ICAR-IVRI,
Izatnagar, Bareilly, U.P, India

Packaging is the last step of processing chain and first step of marketing food products. A study was conducted to evaluate the influence of different packaging materials namely low density polyethylene (LDPE), high density polyethylene (HDPE), linear low density polyethylene (LLDPE) and polyvinyl chloride (PVC) on various quality and safety attributes of chicken nuggets stored at 4±1°C. The physico-chemical (pH, instrumental colour, water activity, thiobarbituric acid reactive substances (TBARS), tyrosine value (TV), Warner-Bratzler shear force (WBSF) and free fatty acid (FFA)), sensory and microbiological (total plate count (TPC), yeast and mold count (YMC), coliform count (CC) and psychrophilic count (PC) parameters were studied at 5 days interval until spoilage. The pH and FFA values raised continuously whereas colour (L,a,b), water activity and WBSF values decreased from 0 to 20th day for all the treatments. The initial TBARS value (0.018±0.012) increased to 0.71±0.020, 0.99±0.025, 1.09±0.018 and 1.02±0.019 mg malonaldehyde/kg and TV (initially 0.20±0.009) increased to 0.35±0.009, 0.44±0.014, 0.49±0.018 and 0.43±0.012 mg/g for HDPE,



LDPE, LLDPE and PVC films respectively after 20 days of refrigeration. TPC increased from 1.86 ± 0.02 to 3.59 ± 0.07 , 5.69 ± 0.05 , 5.52 ± 0.05 and 5.24 ± 0.09 $\log_{10}$ cfu/g and overall acceptability reduced from 7.63 ± 0.058 to 5.90 ± 0.058 , 5.72 ± 0.069 , 5.74 ± 0.068 and 5.81 ± 0.087 on an eight-point hedonic scale for HDPE, LDPE, LLDPE and PVC packaged nuggets respectively. The PC and YMC were detected on 10th and 15th day respectively and gradually increased up to 20 days within acceptable limits for all the treatments. Chicken nuggets sealed with HDPE, LDPE, LLDPE and PVC were acceptable for a period of 20, 15, 15 and 15 days respectively at $4 \pm 1^\circ\text{C}$. The chicken nuggets packed in food grade polypropylene trays sealed with HDPE film exhibited better eating and keeping qualities compared to other films.

FQS-11

DETECTING ADULTERATION OF CHEVON WITH VEAL USING ATTENUATED TOTAL REFLECTANCE-FOURIER TRANSFORM INFRARED SPECTROSCOPY

**Sreejith, Vasudevan V.N., Kiran Kumar S*, ShalimaShukoor A., Sathu T., Irshad A.,
Prajwal S., Pavan M., Silpa S. and Muralikrishna P.**

Department of Livestock Products Technology
College of Veterinary and Animal Sciences, Mannuthy, Thrissur

The consumption of meat and meat products in the state shows an increasing trend and the higher demand for meat and meat accompanied by their escalating cost makes them prone to fraudulent adulteration, substitution and mislabelling. The regulatory authorities need to find simple, reliable and low-cost techniques to analyse the products and control the manufacturers by law. Attenuated Total Reflectance-Fourier Transform Infrared Spectroscopy (ATR-FTIR) is a non-destructive method for spectral analysis of compounds that requires minimum sample preparation. The study sought to determine the infrared (IR) spectra of chevon, veal and their blends by ATR-FTIR spectroscopy. Male goats aged 10-12 months and culled male calves aged 6-12 months ($n = 10$ for each) were utilized in the study. The *Longissimus dorsi* muscle samples were collected from the goat and veal carcasses following scientific slaughter procedures. The harvested chevon and veal samples were blended at eight different proportions. The blends were prepared by replacing chevon with veal at two, five, ten, thirty, forty and fifty percent levels of the total blend. The FTIR spectra of chevon, veal and their blends were obtained. Around 14 predominant peaks were taken for analysis. The peak at wavenumber $3070-3072\text{ cm}^{-1}$ appeared only with respect to pure unadulterated chevon and veal samples, whereas none of the blends showed a peak at this wavenumber. Similarly, an absorption peak at wavenumber $1116 \pm 1\text{ cm}^{-1}$ was a unique observation in all the blended samples. A peak at $700 \pm 1\text{ cm}^{-1}$ was also a unique observation in the FTIR spectrum of blended meat samples. The principal component analysis (PCA) score plot which illustrated the arrangement of the samples in relation to the attributes revealed a significant separation between pure and blended meat samples. The study revealed that ATR-FTIR spectroscopy, combined with PCA regression, can be used to determine the adulteration when chevon is blended with veal. Further works to validate the procedure and to determine the sensitivity of the technique are suggested.

Poster Presentations

FQS-12

ASSESSMENT OF WATER QUALITY IN FLOOD AFFECTED VENKITANGU PANCHAYAT OF THRISSUR, KERALA

¹Afsal S*, ¹Athulya T R, ¹Murugavelu M, ¹Sruthi C, ¹Swetha P T, ²Vrinda K Menon, ³B Sunil and ⁴C Latha

¹MVSc Scholars, ²Assistant Professors, ³Professor, ⁴Professor and Head
Department of Veterinary Public Health
College of Veterinary and Animal Sciences, Mannuthy, Thrissur
Kerala Veterinary and Animal Sciences University- 680651

Water is the basic requirement of the body and thus life. Water quality testing is important because it identifies contaminants and prevent water borne diseases. The impact of 2018 Kerala flood on the ground water quality in Venkitangu Panchayat of Thrissur district was assessed. Forty samples were collected from different areas of the Panchayat and pH, turbidity and coliform count were assessed. All the samples revealed the presence of coliform above the permissible level (10MPN/100 ml). The mean pH of 95% of the water samples was found to be 5.6, which was much lower than the permissible level (6.5-8.5). However, (62.5%) of the samples had turbidity within permissible level (1 – 5 NTU). Highest turbidity of 60.86 NTU was observed in one of the well water. Although chlorination of the well water was done by the people after floods, the increase in coliform count may be attributed to reduced pH and increased turbidity of water, which reduces the efficiency of bleaching powder. Testing the water allows a knowledgeable approach to address the specific problems of a water supply. It helps to ensure that the water source is being properly protected from potential contamination and an appropriate treatment system is selected and is operating properly.

FQS-13

CROSS SECTIONAL SURVEY ON CONSUMER PREFERENCES OF MEAT AND MEAT PRODUCTS IN URBAN AREAS OF MALAPPURAM AND THRISSUR

¹Athulya T R*, ¹Murugavelu M, ¹Sruthi C, ¹Swetha P T, ¹Afsal S, ²C Latha, ³Vrinda K Menon and ⁴B Sunil.

¹MVSc Scholars, ² Professor and Head, ³Assistant Professor, ⁴ Professor
Department of Veterinary Public Health
College of Veterinary and Animal Sciences, Mannuthy, Thrissur
Kerala Veterinary and Animal Sciences University.

Meat and meat products represent an important source of protein in the human diet. The meat preferences, consumer behavior and their perception of meat and meat products in the urban population are



changing constantly. Since consumers are the final step in the production chain, it is useful for the producers to identify the factors that affect their food preferences. The survey was conducted to assess the preferences of people in urban area towards meat and meat products. A total of three urban localities, two from Thrissur and one from Malappuram were selected and 180 households were surveyed with the help of a well structured questionnaire. From the data it was found that 38% of the people preferred chicken and 35% preferred beef and the rest 27% preferred other meat types. Freshly cut meat was preferred by 68% of the people to stored frozen meat. Majority (62.1%) preferred purchasing meat from local meat stalls whereas only 23.8% preferred packaged meat from supermarkets and the rest (14.1%) preferred other purchasing options. Religious aversions were also a factor governing preferred meat type (23% showed aversion to pork and 18% to beef). 88% of the people were aware of value added meat products and among that, 53% preferred cutlet, 28% preferred fried roll, while the rest 19% preferred products like kebab, sausages, nuggets etc. The upper middle class communities preferred to purchase value added meat products (95.5%) while only 56% of the lower middle class community preferred value added meat products. Storing meat in the refrigerator was practiced by 93.7% of the population, while the rest (6.3%) used other means of storage. From this data, it was evident that visual inspection of meat, cultural and religious influences, method of storage of meat and economic status of the family are some of the important buying behavioral drivers in the urban population of Malappuram and Thrissur.

FQS-14

NUTRITIONAL QUALITY OF READY-TO-EAT CHICKEN MEAT PRODUCTS SOLD IN CHENNAI CITY

R.Jayanthi*, V.Appa Rao, R.Narendra Babu, Robinson J.J Abraham, R.Ramani and S.Lidhiya

Department of Livestock Products Technology (Meat Science),
Madras Veterinary College, Chennai-600 007
Tamil Nadu Veterinary and Animal Sciences University

The objective of the study was to analyse the nutritional quality of Ready-To-Eat chicken meat products sold in different zones of Chennai city. Totally 144 samples (72 numbers of Chicken 65 and 72 numbers of Tandoori chicken) were collected and analysed for the proximate composition (Moisture, Protein, Fat, Crude Fibre, Ash, Carbohydrate and Energy), fatty acid and amino acid profile. The standard AOAC (1995) procedure was used to analyse the parameters. The results revealed that there was a highly significant ($P<0.01$) difference between zones in moisture (58.91%), carbohydrate (19.4%) and a significant difference ($P<0.05$) in the energy values (223.29 kcal) were observed in the chicken 65 products. In case of tandoori chicken there was no significant ($P>0.05$) difference in the proximate composition between the zones. Tandoori chicken had a highly significant ($P<0.01$) difference in moisture (61.32%), protein (18.14%) and fat (10.14%) content when compared to Chicken 65 in all the zones. Fatty acid profile and amino acid profile had a highly significant ($P<0.01$) difference between the products. Hence, it can be concluded as the collected samples had the standard nutritional values which fulfil the human recommendations.



FQS-15

DETERMINATION OF HAAS CONTENTS OF DIFFERENT CHICKEN MEAT PRODUCTS COLLECTED FROM DIFFERENT ZONES OF CHENNAI

J.K. Aswini Durga, V. Appa Rao, R. Narendra Babu, C. Vasanthi, S.Lidhiya, A.Sindhura and Bhagyashree Ojha*

Department of Livestock Products Technology (Meat Science),
Madras Veterinary College, Chennai- 600 007.
Tamil Nadu University of Veterinary and Animal Sciences (TANUVAS)

A study was under taken to detect the presence of HAAs(Heterocyclic aromatic amines) viz.MeIQx (2-amino-3,8 – dimethylimidazo[4,5-f] quinoxaline) and PhIP (2- amino -1- methyl -6- Phenylimidazo[4,5-b] pyridine) in ready-to-eat chicken products such as grilled chicken, tandoori chicken, chicken-65 and chicken shawarma collected from hotels and fast food outlets in 3 zones of Chennai. Totally seventy-two samples of chicken meat products (6 samples/product/zone) were analysed using LC-MS/MS and the levels of HAAs were assessed as per the standard procedures. In 72 samples of chicken meat products, the average detection levels of MeIQx and PhIP in grilled chicken were 5.85 and 1.90 ppb; in tandoori chicken were 9.93 and 1.55 ppb; in chicken-65 were 7.02 and 2.31 ppb and in chicken shawarma were 9.17and 2.12 ppb respectively. The chicken shawarma collected from three different zones (North: 1.91 ± 0.25 , Central: 3.07 ± 0.48 and South: 1.40 ± 0.52) had significant difference ($p < 0.05$) for PhIP and no significant difference observed for MeIQx when compared to other chicken meat products. Similarly, MeIQx had significant difference ($p < 0.05$) between the chicken meat products (grilled chicken: 5.62 ± 1.20 , tandoori chicken: 13.63 ± 3.38 , chicken-65: 8.23 ± 0.72 and chicken shawarma: 6.51 ± 1.68) collected within the south zone. However, PhIP had no significant difference between the products within the zones. The concentrations of HAAs in commercial chicken meat products collected in Chennai city were low in comparison with other findings. However, more samples have to be analysed to evolve standards for HAAs in ready-to-eat chicken meat products. These results will form basis for public education towards cooking methods that minimize formation of mutagenic and potentially carcinogenic substances in cooked meat products.

FQS-16

PREVALENCE OF POTENTIAL PATHOGENIC AEROMONADS SPECIES IN SEA FISH, CRAB AND PRAWNS IN CHENNAI, INDIA.

Rongsensusang^{1*}, Vinayananda C.O.¹, Deepak S.J.², Elango A.², Appa Rao V.¹ and Porteen K.²

¹Department of Livestock Products Technology (Meat Science),
Madras Veterinary College, TANUVAS, Chennai, INDIA.

²Department of Veterinary Public Health and Epidemiology,
Madras Veterinary College, TANUVAS, Chennai, INDIA.

A study was undertaken to assess the prevalence of Aeromonads and their antimicrobial resistance and virulence genes potentials among isolated Aeromonas species from seafood such as fish, crab and prawns in Chennai, India. A total of 270 fresh sea foods samples, which includes 30 samples of each sea foods viz., sea fish, prawn and crabs from each of 3 fish markets i.e., Marina beach, Chintadripet and Purasaiwakkam.



Aeromonas were isolated by cultural method using *Aeromonas* selective agar- Bile salts Irgasan brilliant green (BSIBG) agar and duplex PCR was performed to detect the 16S rRNA and aerolysin (aerA) gene in the isolates. Among 270 samples investigated, 172 samples were found to be positive by cultural method of which 160 samples were confirmed by PCR assay, targeting 16S rRNA, which includes 68 (75.56%), 42(46.67%) and 50(55.56%)samples of fishes, crabs and prawns, respectively, and 57/160(35.53%) showed positive for a pathogenic marker i.e.,aerolysin gene,which includes 27 (36.90%), 16 (34.42%) and 14 (24.85%)samples of fishes, crabs and prawns, respectively. The antimicrobial resistance pattern of *Aeromonas spp.* isolates showed complete resistant against ampicillin, penicillin and cephalothin whereas sensitive against enrofloxacin, gentamicin and tetracycline. The increased prevalence of aeromonads in sea food may be attributed to cross contamination during post-harvest processing. The detection of potential pathogenic aeromonads and multiple antimicrobial resistances in *Aeromonas* species isolated raise serious public health concern worthy of further investigation.

FQS-17

EVALUATION OF CHICKEN EGG QUALITY COLLECTED FROM DIFFERENT MARKETING CHANNELS IN PRODDATUR, KADAPA DISTRICT, A.P.

**K.Venkatesh¹, G.Navya¹, R. Sai Dilip Gupta², D. Maheswara Reddy² and
M. Naveen Kumar Reddy²**

¹ Vth BVSc & A.H., College of Veterinary Science, SVVU, Proddatur, A.P.

²Department of Livestock Products Technology, CVSc, Proddatur,
SVVU, A.P., India.

The present study was designed to know the quality of chicken eggs collected from different marketing channels viz., Wholesale shops, Retailers and Interior Vendors in Proddatur town of Kadapa district, Andhrapradesh. A total of 240 eggs were collected randomly and evaluated for external and internal quality parameters viz., egg weight, volume, specific gravity, shape index, cleanliness, shell soundness, shell texture, color, shell thickness, Albumen index and Yolk index. Data obtained through measuring external and internal quality parameters were expressed in percentage analysis. The results showed that, 33.63% eggs were under weight, 27.2% eggs were under volume, 17.27% eggs have lower specific gravity, 50.41% were spherical shaped, 4.54% were elongated, 35.83% were dirty with fecal stains, 15.41% have poor shell quality with cracks and leakers, 30.41% have rough texture, 3.75 % eggs have lower shell thickness, 27.5 % eggs have lower Albumen index and 31.25% eggs have lower Yolk index. Based on the results it is concluded that the interior vendors in proddatur has poor external and internal quality when compared to wholesalers and retailers.



FQS-18

DISEASE CONDITIONS OF SHEEP AND GOAT CARCASSES SLAUGHTERED IN TAMIL NADU IN DIFFERENT SEASONS

**S.M. Dhishonin, R. Narendra Babu, K. Porteen, R. Ramani, V. AppaRao,
Robinson J.J Abraham and R. Jayanthi**

Department of Livestock Products Technology (Meat Science),
Madras Veterinary College, Chennai-600 007, Tamil Nadu Veterinary and Animal Sciences University

A total of 2867 sheep and goat (1763 in winter and 1104 in summer) meat for were subjected to ante-mortem and post-mortem examination in eight districts viz. Kancheepuram, Trichy, Coimbatore, Nilgris, Salem, Madurai, Kanyakumari and Villupuram in both seasons. Out of 2867 animals none of the animals exhibited any clinical symptoms for contagious or infectious diseases in ante-mortem inspection. In post-mortem examination 843 (29.40%) small ruminant carcasses were identified with parasitic and pathological conditions. Totally 2024 (70.60%) small ruminant carcasses were found healthy and not exhibited any parasitic and pathological conditions. Incidence of disease conditions in Kanchipuram, Villupuram, Trichy, Salem, Coimbatore, Nilgris, Madurai and Kanyakumari in winter and summer were 2.15%, 2.26%; 1.70%, 1.63%; 5.05%, 5.25%; 0.91%, 3.08%; 8.1%, 7.25%; 4.54%, 4.44%; 7.15%, 3.89% and 0.5%, 0.45% respectively. The analysis of data revealed there was a highly significant difference ($P < 0.01$) observed between winter and summer seasons.

FQS-19

DETERMINATION OF BEEF ADULTERATION BY POLYMERASE CHAIN REACTION TECHNIQUE

**T. Deepak, V. Appa Rao, R. Narendra Babu, Robinson J.J. Abraham,
A. Raja, R. Jayanthi* and Rongsen Susang**

Department of Livestock Products Technology (Meat Science),
Madras Veterinary College, Chennai-600 007
Tamil Nadu Veterinary and Animal Sciences University

Meat species identification is an important field of quality control management in meat industry. The present study has been undertaken to detect beef from other meat by polymerase chain reaction in a short time. The beef samples used in this study was subdivided in to fresh samples ($4 \pm 1^\circ\text{C}$), frozen samples ($-18 \pm 2^\circ\text{C}$), cooked samples (pressurecooked at 6.8kg/cm^2 for 30 minutes) and processed samples. The sensitivity (detection limit) of PCR for beef was found to be $0.02\text{ng}/\mu\text{l}$ and the specificity of primer was confirmed by PCR amplification of chicken, beef, pork, mutton and chevon DNA with each primer set. Direct sequencing of purified PCR products 12s rRNA gene of beef samples were carried out and the sequences obtained were analyzed using BLAST at NCBI to observe the level of homology (identity) of the amplified PCR products. These sequences were found to be matching well with the published sequences available in the NCBI. It was found that beef specific PCR developed in the present study was highly sensitive to identify meat adulteration up to 5% level.



FQS-20

CROSS SECTIONAL SURVEY ON CONSUMER PREFERENCES OF MEAT AND MEAT PRODUCTS IN RURAL AREAS OF PALAKKAD AND THRISSUR

¹Swetha P T*, ¹Afsal S, ¹Athulya T R, ¹Murugavelu M, ¹Sruthi C, ²Binsy Mathew, ²Vrinda K Menon, ³B Sunil and ⁴C Latha

¹MVSc scholar, ²Assistant Professor, ³Professor, ⁴Professor and Head
Department of Veterinary Public Health
College of Veterinary and Animal Sciences, Mannuthy, Thrissur
Kerala Veterinary and Animal Sciences University- 680651

The socio economic and socio demographic variation among rural people considerably influences the meat and meat product consumption. With the rising income levels of the consumer and their changing taste and preferences, the demand for meat is undergoing a change both in qualitative and qualitative terms. The present study was undertaken to assess the preferences of meat consumption in rural localities of Palakkad and Thrissur districts of Kerala. Two rural areas each were selected and 120 households were assessed under each area, using a well structured questionnaire. Majority of the rural population preferred chicken (55%) followed by beef (21.5%) and mutton (8%). Fresh meat was preferred by 82% of the population. Religious aversions play a major role in meat preference among rural populations. Aversion to pork consumption in rural areas was shown by 20% whereas 21 % showed aversion to beef consumption. The people were mostly ignorant about the availability of various value added meat products and very few had a practice of purchasing them. 36.6% of the population were aware of value added meat products. Among this, majority (90.5%) of rural population preferred cutlet. The results of the analysis are not solely interesting from a scientific point of view, but also important for decision makers of the meat chain who are confronted with new challenges caused by societal and demographic changes.

FQS-21

ASSESSMENT OF ENVIRONMENTAL EXPOSURE OF BUFFALO MEAT USING ENTOMOLOGICAL TECHNIQUES

Vandana Sasidharan*, V N Vasudevan, Sathu T, Irshad A, Arun Sankar K J, Yazhini Devi R and B Sunil

Department of Livestock Products Technology
College of Veterinary and Animal Sciences, Mannuthy

In the current retail meat marketing conditions in the country, carcasses are usually exposed to ambient environmental conditions resulting in deteriorative changes in the wholesomeness and safety of meat sold to the public. Hence, determining the freshness of meat and period of environmental exposure are major challenges faced by law enforcement authorities. Though various laboratory techniques and microbiological evaluation can tentatively indicate wholesomeness of meat, assessment of environmental exposure of carcasses remains still elusive to a great extent. When fresh meat is exposed to the environment, various flies invade meat in different chronological successions. The objective of the current study was to correlate the appearance of larvae of flies colonising on meat with the time elapsed since the slaughter of the animal and exposure of the carcass to the environment. Buffalo meat samples (n=8) collected from Corporation slaughter



house, Thrissur were utilised for the study. Immediately after slaughter and dressing, approximately 500 g of *biceps femoris* muscle were harvested, packed in HDPE pouches and carried in insulated boxes to the Meat Technology Unit, Kerala Veterinary and Animal Sciences University, Mannuthy. At the laboratory, each muscle sample was divided into five equal portions. Each portion was placed in petriplates and was kept uncovered to get exposed to the environment. The petriplates were exposed in the large animal slaughter hall of the Meat Technology Unit. After the designated period of exposure, larval development on meat surface was monitored by keeping samples under rearing conditions inside beakers covered with muslin cloth to prevent any further fly attack. The samples were examined thrice a day for the presence of any visible fly larvae. The sample was processed in 10% KOH and observed under high power objective of microscope and the larvae were definitively identified. Two of the samples which had been exposed for 9 hours and six samples exposed for 12 hours showed presence of larvae within 48 hours of rearing. The larvae were identified as *Chrysomiamegacephala* and *Sarcophaga* species by gross and microscopic characteristics. This study revealed that, in the specific environment where the meat has been exposed, occurrence of fly larvae on meat after 48 hours of rearing indicated a minimum exposure period of 9 hours. However, as the fly types and burden in different meat market premises differ, absence of any larvae on the meat surface after rearing cannot rule out prolonged environmental exposure of meat. Further studies in different climatic conditions, geographic locations and meat handling environments of different degrees of hygiene can potentially yield valuable indications about the freshness of meat.

FQS-22

MEDICINAL AND NUTRACEUTICAL PROPERTIES OF JACKFRUIT

Ajay Durge and Preeti Birwal

Food Technology Department, SET, Jain University, 562112

The Indian Ayurveda has medicinal and nutraceutical importance of jackfruits "the fruit of the poor" because of its antibacterial, anti-inflammatory, anti-diabetes, to increase immunity, as an antioxidant property which help in to reduce fever, constipation, and as a remedy for a snake bites. Unripe fruits are astringent and contain trypsin inhibitors. Which helps humans' body to digest food while suffering from stomach pain, nausea, vomiting or diarrhea. Jackfruit is rich source of carbohydrate, calcium and potassium. Many studies have been reported on anti-diabetic properties as it increases glucose tolerance and also having a hypoglycemic effect, helps in stomach also cardiovascular diseases, reduce osteoporosis. Jackfruit is also helping in physical and mental fatigue, muscle weakness because of presence of thiamine and niacin. Jackfruit is also a good source of anti-skin cancer components. The utilization of jackfruit bear seed good source of starch and protein (lectin that has adverse effect in the digestive tract). The jackfruit sap utilizes to develop all-natural glue which does not contain any toxic chemical, to explore the possibilities of the jackfruit sap as an alternative adhesive. Investigations carried out to study the utilization of jack fruit waste as a cattle feed showed the non-edible portion (perianth meal, rind and core meal) of the fruit. Use of each part in form of direct consumption, powders, purees, concentrates, extracted essential compounds chunks etc in food in half or partial replacement in baking, cooking, pickling, fermentations process will definitely give higher nutritional aspects to consumers.



TECHNICAL SESSION - IV

Food Preservation and Packaging



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Key Note Addresses

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BIOACTIVE PEPTIDES IN FOOD OF ANIMAL ORIGIN : A POTENTIAL MARKET FOR THE MEAT INDUSTRY

George T. Oommen

Former Professor and Head, Meat Technology Unit & Dept. of Livestock Products Technology
KVASU, Mannuthy, Thrissur

Introduction

Bioactive peptides (BP) have been identified in a range of foods, including plant, milk meat (beef, pork, chicken), egg, fish and other marine organisms. BP from food proteins offer major potential for incorporation into functional foods and nutraceuticals. Meat industry in India can take advantage of the potential of the BP in the formulation of meat based functional foods, the revolution that is sweeping across all food sectors. Growing food consumer awareness and global competition among meat producers put pressure on creating novel healthier meat products incorporating BP. Because of the number of bioactive compounds and the diversity of biological effects, diverse experimental approaches must be initiated to increase our understanding of these peptides. Considering the complexity of this biology, sophisticated experimental designs and analytical methodologies must be employed to advance the field. Advanced knowledge on health benefits of BP will provide the scientific basis for future efforts to improve public health. Many academic, scientific and regulatory bodies have developed, or are developing, guidelines to establish the scientific evidence base needed to support and further validate claims for functional components. Assessment of the economic and market potential, consumer acceptance of the developed functional foods and evolution of cost effective technology for BP isolation are to be developed.

Bioactive Peptides

BP are short amino acid sequences joined by covalent peptide bonds. Bioactive peptides have been defined as food derived components (genuine or generated) that, in addition to their nutritional value exert a physiological effect or bioactivity in the body. These BP are usually 2–30 amino acid residues in length, although, some have been reported to be >20 amino acid residues. Bioactive peptides may be absorbed through the intestine where they subsequently enter the circulatory system intact to exert various physiological effects, or they may produce local effects in the digestive tract (Ryan J. T *et al*, 2011). Dietary Proteins have nutritional, physiological/functional and biological properties. Food derived bioactive peptides have been shown to display a wide range of physiological functions, also known as tertiary functions, viz., antihypertensive, antioxidative, opioid agonistic, immunomodulatory, antimicrobial, prebiotic, mineral binding, antithrombotic, antimutagenic, antiaging, antiproliferative and hypocholesterolemic effects (Arihara K, 2006). Depending on the amino acid sequence of the BP, they affect the nervous, immune, cardiovascular and endocrine systems.

Although some BP exist free in its natural source while majority of them are in the structure of the parent proteins and latent until released and activated by enzymatic proteolysis, either during gastrointestinal



digestion or food processing. Methods employed in the proteolytic digestion of parent proteins, *in vitro* and *in vivo*, include hydrolysis by digestive enzymes, plant and bacterial proteases, endogenous enzymes in raw food and by microbial fermentation.

Isolation and Identification of Bioactive Peptides from Food Proteins

Among the numerous methods used in the release of BP from food proteins, enzymatic hydrolysis is widely used. Pepsin, trypsin, chymotrypsin and proteases from bacterial, animal and plant origin have been used for the isolation of BP from meat. Although bacterial fermentation of milk with lactobacilli has been commonly used for the isolation of BP, it has not been successful in meat yet. Peptic digestion of pork produced angiotensin -1-converting enzyme (ACE) inhibitory peptides. The crude protein hydrolysates are fractionated by ultrafiltration based on peptide size and bioassayed. The fraction with highest bioactivity is further purified by RP-HPLC or gel permeation chromatography. Individual peptide moiety is identified by MS and protein sequencing. Once the structure of bioactive peptides is known, a synthetic version of the BP is synthesized and assayed to verify bioactivity (Arihara K and OhataM, 2006). Three main methods of synthesis of BP are (1) chemical (2) recombinant DNA technology and (3) enzymatic synthesis.

Bioactive Peptides Derived from Meat and Meat Products

There are several meat based BP, *viz.*, ACE inhibitory peptides (antihypertensive peptides), Coenzyme Q10, histidine dipeptides, *viz.*, carnosine and anserine, taurine, creatine, L-carnitine, and glutathione. Studies revealed that modifying animal feed can increase the content of bioactive compounds in the meat. As a result of food processing such as aging, enzyme treatment, tenderization, fermentation and during digestion BP are released. The content of peptides in meat increases during postmortem aging and changes in oligopeptide levels occur during the storage of beef, pork and chicken. Proteolytic reactions occur during fermentation of raw sausages and dry-cured ham during when BP are formed. Meat proteins are degraded into peptides by endogenous enzymes during fermentation of meat products.

Antihypertensive Peptides

Among the bioactive peptides derived from meat proteins, ACE inhibitory peptides have been studied most extensively. One of the best studied BP is one that inhibits Angiotensin I- Converting Enzyme (ACE). ACE is a dipeptidyl carboxypeptidase that converts an inactive form of decapeptide, angiotensin I to a potent vasoconstrictor, octapeptide angiotensin II, and inactivates bradykinin, a depressor. ACE is responsible for creating angiotensin II, which constricts arteries, resulting with higher blood pressure. Though pharmaceutical ACE inhibitors are effective in decreasing mortality due to myocardial infarction, numerous side effects have been reported (Ryan, J. T *et al*, 2011). It has been reported that muscle proteins from animals are a viable source of ACE inhibitory peptides *in vitro* and may potentially be incorporated into nutraceutical products to exert antihypertensive effects *in vivo* (Jang A and Lee M, 2005). ACE inhibitory peptides of the true inhibitor group and pro-drug type reduce the systolic blood pressure. Majority of the ACE inhibitory peptides found in meat are true inhibitor type peptides. Detailed investigations on the intestinal absorption of the ACE inhibitory peptides and its bioavailability have demonstrated a significant systolic blood pressure lowering effect in hypertensive patients. Inhibition of ACE is brought about by hydrophobic peptides only which are compatible with the active sites of ACE. The presence of hydroxyproline is critical for the binding of peptides to the active sites of ACE, in the case of peptides greater than three amino acids in length. Further studies are required to identify bioactive peptides *in vitro* which can enter the circulatory system intact and remain active at their target site.

ACE Inhibitory Bioactive Peptides from Myosin and Troponin

ACE inhibitory peptides have been identified in the hydrolysates of actin, myosin and troponin in cardiac and skeletal muscle fibres. On thermolysin digestion of pork skeletal muscle, Arihara, *et al.*, (2001) identified myopentapeptide A and B, from two different positions in myosin heavy chain which are found to be potent antihypertensive peptides *in vivo*. On hydrolysis of Crude myosin heavy chain in pork skeletal muscle with pepsin evolved a peptide M6. The bioactivity of M6 is retained even after thermal processing at 98°C for 10 min prior to hydrolysis. Similarly, crude myosin light chain on digestion with pepsin generated another ACE inhibitory octapeptide.

Another ACE inhibitor peptide of nine amino acids are released from the regulatory protein Troponin C from pork skeletal muscle. The pepsin hydrolysate of crude porcine Troponin T also released another ACE inhibitory peptide. The ACE inhibitory peptides generated by digestion of pork with a combination of pepsin and pancreatin are found to be homologous to the amino acid sequence of the cytoskeletal protein titin.

Antihypertensive Peptide from Collagen

ACE inhibitory peptides were purified from hydrolysate of bovine skin gelatine. Five proteases, *viz.*, Alcalase, Chymotrypsin, Neutrase, PronaseE and trypsin were employed for sequential hydrolysis and three steps ultrafiltration. Two peptides with ACE inhibitory activity were isolated from the low molecular weight fraction. The purification of ACE inhibitory peptides from *Aspergillus* protease and gastric protease hydrolysed chicken breast muscle resulted in the identification of four peptides displaying strong ACE inhibitory effects. The peptide expressing the strongest ACE inhibitory activity referred to as P4 is not along term vasodepressor *in vivo* (Saiga A, 2006). The amino acid sequence of these four peptides were homologous to that of collagen.

The hydrolysate obtained on hydrolysis of chicken collagen by *Aspergillus oryzae* protease was further hydrolysed with four proteases, *viz.*, protease FP, Protease A, amino g and protease N. The resulting low molecular weight four peptides had long term ACE inhibitory activity, *in vivo*. This shows their potential as antihypertensive therapeutic agents.

ACE inhibitory peptide from hydrolysate of sarcoplasmic proteins of beef was reported to be a hexapeptide. Feeding this hexapeptide resulted in a significant reduction in systolic blood pressure in addition to lower total and LDL cholesterol blood concentrations. Four peptides were found to exhibit strong ACE inhibitory activity, the strongest of which was from the Alcalase hydrolyzed hydrolysate.

Antihypertensive Peptides from Fish Sources

Fish byproducts which are generally discarded is hydrolysed with pepsin, papain, bromelin, thermolysin, alkalase, *etc.*, and separated into five fractions from the frame protein depending on molecular weight. The fraction with < 1kDa is found to be the most active ACE inhibitory peptide, especially that hydrolysed with bromelin. Frame protein hydrolysate of tuna, sole, Alaskan Pollock, salmon, shark, dark meat of tuna, *etc.*, are good sources of antihypertensive peptides.

Antioxidant Peptides from Meat Sources

Antioxidants protect the body against reactive oxygen species (ROS), which can attack membrane lipids, protein and DNA which in turn can cause cardiovascular disease, diabetes type II, cancer and Alzheimer's disease, lipid peroxidation and deterioration of food quality and consequent reduction in shelf life.



Several endogenous antioxidants tocopherols, ubiquinone, carotenoids, ascorbic acid, glutathione, lipoic acid, uric acid, spermine, carnosine, anserine in skeletal muscle have been studied.

Papain hydrolysate of the porcine myofibrillar proteins resulted in the identification of five peptides with antioxidant activity from myosin heavy chain, actin and tropomyosin. BP which inhibited peroxidation of linoleic acid, DPPH scavenging and metal chelating activities. A mixture of pepsin, papain, proteases from bovine pancreas and proteases from *Streptomyces* and *Bacillus polymixa* were used to hydrolyse porcine collagen. Plasma proteins are underutilized protein source for antioxidants. Alcalase hydrolysis of porcine plasma proteins yielded antioxidant BP. Increasing the degree of hydrolysis increased antioxidant activity and most of the fractions were <3 kDa. Two BP with antioxidant activity were identified in the traditional chicken essence. Hydrolysate of venison with papain produced two peptides with antioxidant activity.

Histidine Dipeptides

Both carnosine (b-alanyl-L-histidine) and anserine (b-alanyl-1-methyl-L-histidine) are antioxidative histidine dipeptides and the most abundant antioxidants in beef, chicken, pork and fish. In general, carnosine and anserine contents of chicken breast muscle are higher than those of thigh muscle. Anserine is contained at higher levels than carnosine in both muscles, at a ratio of approximately 3:1. On the other hand, the content of carnosine is higher than anserine in pork and beef. Also, the content ratio differs depending on the type of muscle or animal species. These peptides can withstand high temperature processing.

The concentrations of carnosine in meat range from 500 mg/kg of chicken thigh to 2.7g per kg of pork shoulder. On the other hand, anserine is especially abundant in chicken muscle. Their antioxidant activities may result from their ability to chelate transition metals such as copper. These antioxidative peptides have been reported to play many roles, such as prevention of diseases and aging related to oxidative stress. Carnosine is abundant in beef and shows its therapeutic value as anti-inflammatory agent. Anserine is more in goose flesh and in chicken. These peptides have direct and indirect antioxidant properties. The former is for removal of peroxyl radical and singlet oxygen, while the latter to chelate metal ions which are prooxidants. Carnosine and anserine are antifatigue and antiglycating agents, as well. Both dipeptides are water-soluble components and are therefore easily extracted and found more in soup.

L-Carnitine

L-carnitine is supplied to the body by endogenous biosynthesis in kidney, heart, brain and to a lesser extent in testes and lung and by dietary origin. Humans can synthesise L-carnitine from lysine and methionine with cofactors iron and vitamin C, in a multistep process. It is seen in tissues that metabolise long chain fatty acids as their primary dietary fuel, such as skeletal and cardiac muscle. Animal products like meat, fish, poultry, and milk are the best sources. The redder the meat, the higher its carnitine content. L-carnitine can help energy production in muscle, during hard exercise and has antifatigue effect on oral administration to mice. It is detected in skeletal muscle of various animals (Shimada *et al.*, 2005), especially abundant in dairy products which contain carnitine primarily in the whey fraction. Different methods of cooking and freezing did not deteriorate the quality of L-carnitine in meat, milk and fish. L-carnitine plays an important role in energy production by chaperoning activated fatty acids (acyl-CoA) into the mitochondrial matrix for metabolism and chaperoning intermediate compounds out of the mitochondrial matrix to prevent their accumulation. It is also found to have hypocholesterolaemic effect. Calcium absorbing property of L-carnitine improves skeletal strength. L-carnitine retarded apoptosis and skeletal muscle myopathy in heart failure. Corned beef in Japan is being marketed with L-carnitine and carnosine as functional food.

Coenzyme Q₁₀

Coenzyme Q₁₀ (CoQ₁₀) is a fat-soluble ubiquinone that plays a critical role in both cellular energy metabolism at the mitochondrial level and as an antioxidant for cell membranes and lipoproteins. Approximately half of the body's CoQ₁₀ is obtained through diet and the remainder is endogenously synthesized via the cholesterol metabolic pathway. Rich sources of dietary coenzyme Q₁₀ include meat, poultry, and fish, while eggs and dairy products are moderate sources. Its presence is more in organ meat and fatty fish like herring, trout, sardine and mackerel. The CoQ₁₀ content of these foods did not change on boiling.

CoQ₁₀ is a member of the ubiquinone family of compounds which refer to the ubiquitous presence of these compounds in living organisms and their chemical structure, which contains a functional group benzoquinone. Ubiquinones are fat-soluble molecules with 1 to 12 isoprene (5-carbon) units. The ubiquinone found in humans, ubiquinol has a "tail" of ten isoprene units (50 carbon atoms) attached to its benzoquinone "head". The biosynthesis of CoQ₁₀ involves three major steps: 1) synthesis of the benzoquinone structure from either tyrosine or phenylalanine, which requires vitamin B6. 2) synthesis of the isoprene side chain from acetyl CoA and 3) condensation of these two structures. CoQ₁₀ can exist in three oxidation states, fully reduced, fully oxidized and radical state. CoQ₁₀ in its reduced form is a potent fat soluble cellular antioxidant inhibiting lipid peroxidation.

Glutathione

Red meats and organ meats, from grass-fed animals, contain plenty of alpha lipoic acid which is known to generate glutathione and support the sustained activity of vitamin C and vitamin E in the body. Alpha Lipoic acid increases the levels of intra-cellular glutathione, and is a natural antioxidant with free radical scavenging abilities. ALA is also known to enhance glucose uptake and may help prevent the cellular damage that comes with the complexities of diabetes. Glutathione is made of glycine, cysteine and glutamic acid, which are present in high quality lean protein sources such as lean beef, yogurt and poultry. Whey protein boosts production of glutathione by enhancing cysteine. Whey protein is the ideal food to help naturally increase glutathione, increasing metabolism, strengthening the immune system and reducing appetite. Processed whey protein or protein isolate lack glutathione. Whey protein contains proteins like alpha-lactalbumin which is rich in sulphur-containing amino acids. It should not be overheated or pasteurized as this destroys the delicate disulphide bonds that give these proteins their bioactivity. Native whey protein contains bioactive amino acids like cysteine and highest level of naturally-occurring glutathione components: immunoglobulins, active peptides, cysteine, and lactoferrin.

Taurine

Taurine (2-aminoethanesulfonic acid) is mainly obtained from diet. The main biological actions of taurine include its ability to conjugate bile acids, regulate blood pressure and act as a potent antioxidant and anti-inflammatory agent. These actions suggest that high levels of taurine may be protective against CHD. However, data from epidemiologic and intervention studies in humans are limited. The identification of taurine as a preventive factor for CHD may be of great public health importance. Taurine is found in cow milk, veal, beef, pork and fish. The highest amounts of taurine can be found in sea foods like shellfish, especially scallops, mussels, and clams. High amounts of taurine can also be found in the dark meat of turkey and chicken, and their products. Cooking has been shown to have no adverse effect on taurine levels.

Synthesis of taurine begins in the liver with a magnesium-catalyzed methylation of methionine to form homocysteine, a process which can be reversed by the vitamin B12 and the folate dependent enzyme



methionine synthetase. Homocysteine donates its sulfur group to form cystathionine and under the influence of pyridoxal-5'phosphate (P5P) cystathionine is broken down to cysteine. Cysteine, catalyzed by cysteine deoxygenase, combines with dioxygen to become cysteine sulfinic acid, which is then decarboxylated by cysteine sulfinic acid decarboxylase (CSAD) and P5P to hypotaurine. Hypotaurine is oxidized to taurine by hypotaurine dehydrogenase. Alternatively, taurine is formed following the oxidation of cysteine sulfinic acid to cysteic acid and the decarboxylation of cysteic acid by P5P.

Antioxidant Peptides from Fish Source

The strongest antioxidant fraction of mackerel protein hydrolysate with Protinase N contained small peptides and free amino acids and had a molecular weight of 1400 Da. Studies in Alaskan Pollack frame protein, Tilapia, silver carp, tuna dark muscle and salmon showed that the peptides with greater antioxidant activity was associated with peptides of low molecular weight of <1 kDa. The antioxidant ability of peptides *in vitro* depends on peptide size, amino acid composition of the peptide and presence of free amino acids within the hydrolysate. The peptide from Alcalase and Flavourzyme digested Trevally was shown to prevent oxidative damage to DNA. Seven antioxidant peptides in the hydrolysate of proteins recovered from sardine processing plant waste were <600 Da. The peptides from tuna dark muscle by-product are effective *in vitro* antioxidants with potential for incorporation into foodstuffs as natural antioxidants. (Ryan, J.T, *et al.*, 2011).

Antimicrobial and Antiproliferative Peptides

Several Antimicrobial peptides have been identified from milk proteins especially from casein and lactoferrin. One peptide from beef has been found to inhibit the growth of certain pathogenic gram negative and positive bacteria. Oyster muscle hydrolysed with Alcalase and Bromelin produced a cysteine rich antimicrobial peptide which inhibited the growth of pathogenic *E. coli*, *P. aeruginosa*, *B. subtilis*, and *S. aureus*. Antimicrobial peptides from beef were found to have cytotoxic effect and inhibited the proliferation of stomach adenocarcinoma cell lines. Peptides isolated from anchovy sauce induced apoptosis in human lymphoma cell line. The hydrolysate of tuna dark muscle by-product contained two peptide fractions within the range of 400 and 1400 Da which exhibited the strongest antiproliferative activity by exposure to the human breast cancer cell line. This shows the potential of meat products and meat by-products as valuable sources of bioactive peptides for incorporation into functional foods.

Opioid Peptide Activity

Opioid peptides are defined as peptides that have an affinity for an opiate receptor as well as opiate-like effects (Pihlanto A and Korhonen H, 2003). Basically, opioid peptides have effects on the nerve system as well as on gastrointestinal functions. In some meat products, such as blood sausage, hemoglobin is a major component. Investigation of hemoglobin peptic hydrolysate has revealed the presence of biologically active peptides with affinity for opioid receptors.

Immunomodulating Peptides

Immunomodulating peptides have been discovered in enzymatic hydrolysates of proteins from various foods, such as milk, eggs, soybeans, and rice. However, to date, meat protein-derived such peptides have not been reported.

Occurrence of Bioactive Peptides in Egg

Avian egg white contains a number of proteins with antimicrobial activities, bacterial cell lysis, metal binding, and vitamin binding. Enzymatic hydrolysis of lysozyme has been found to enhance its

activity by exposing antibacterial portions of the protein and producing peptides with antibacterial activity. Peptides corresponding to amino acid residues 98–112, 98–108, and 15–21 possessed antimicrobial activity against *E. coli* and *S. aureus*. Furthermore, peptides produced by the enzymatic digestion of ovalbumin, and their synthetic counterparts, were found to be strongly active against *Bacillus subtilis* and, to a lesser extent, against *E. coli*, *Bordetella bronchiseptica*, *Pseudomonas aeruginosa*, and *Serratia marcescens*, as well as *Candida albicans*.

Several egg white proteins and peptides have demonstrated immunomodulating activity. The phagocytic activity of macrophages was increased by the addition of ovalbumin peptides, derived from peptic and chymotryptic digestions, respectively.

A vasorelaxing peptide, ovokinin was isolated by the peptic digestion of ovalbumin. Additionally, a peptide produced by chymotrypsin digestion was also found to possess vasorelaxing activity. Both peptides significantly lowered the systolic blood pressure. Two ACE-inhibitory peptides were also identified in ovalbumin by peptic and tryptic digestions.

Hen's egg white lysozyme-derived peptides showed moderate inhibitory activities against calmodulin-dependent phosphodiesterase and free-radical scavenging properties. Egg lysozyme hydrolysates have potential as functional foods and nutraceuticals, although bioavailability studies are required to confirm their health benefits in humans.

Milk Derived Bioactive Peptides

Fermented milk products and milk caseins are good sources of BP. BP can be produced from milk proteins through different pathways involving indigenous enzymes, digestive enzymes, and microbial enzymes from starter and non-starter cultures acting during milk secretion, milk storage, milk processing, and milk digestion. Proteolytic activity in fresh raw milk is attributed to indigenous and microbial enzymes. Among the indigenous enzymes, milk contains at least two main proteinase systems, the plasmin-plasminogen system and lysosomal enzymes, as well as possibly other proteolytic enzymes. Indigenous enzymes play a role in the liberation of bioactive peptides during milk secretion and storage. Pepsin, trypsin and chymotrypsin have been shown to release a number of antihypertensive peptides, calcium-binding phosphopeptides (CPPs), antibacterial, immunomodulatory and opioid peptides both from different casein and whey proteins.

Almost 90% of the peptides from casein and β -casein are able to exert ACE-inhibitory, antihypertensive and antioxidant activities. At least three ACE-inhibitory peptides were released by purified proteinase of *L. helveticus* and antihypertensive and antioxidant peptides were found in ovine sodium caseinate incubated with *Bacillus* sp. P7. Many dairy cultures are highly proteolytic, leading to bioactive peptide accumulation in ripened dairy products like cheese. The fermented milks, viz., yoghurt, sour milk and dahi are a source of bioactive peptides with anticarcinogenic, antihypertensive, mineral binding, and stress relieving activities due to the action of probiotic strains such as *L. casei*, *L. helveticus*, and *S. cerevisiae*. Yoghurt bacteria, cheese starter bacteria and commercial probiotic bacteria have been demonstrated to produce different bioactive peptides in milk during fermentation.

Functionality of Milk Protein Derived Bioactive Peptides

Biologically active peptides can be produced from precursor milk proteins by 1) enzymatic hydrolysis by digestive enzymes, 2) fermentation of milk with proteolytic starter cultures, 3) proteolysis by microbial or plant enzymes. A combination of above methods has proven effective in generation of short functional peptides. Six different functionalities and potential health targets are 1) Weight Management –



satiety inducing glycomacropeptide, opioid, 2) Heart Health – ACE inhibitory, antithrombotic, anticholesterolemic, antioxidative, 3) Bone Health – Calcium Binding Phosphopeptides, Lactoferricin, 4) Dental Health – antimicrobial, calcium binding (ccp) 5) Digestive Health – antimicrobial, satiety inducing, immunomodulatory, glycomacropeptide, opioid 6) Immune Defence – Immunomodulatory, glycomacropeptide, cytomodulatory, 7) Mood Memory and Stress Control – Casomorphins and other opioid related.

Summary and Future Research

Bioactive peptides from milk, meat, chicken, egg and fish with a spectrum of bioactivities, viz., ACE inhibitory, antihypertensive, antioxidative, opioid agonistic, immunomodulatory, antimicrobial, prebiotic, mineral binding, antithrombotic, antimutagenic, antiaging, and hypocholesterolemic have been discussed. Although information on BP generated from meat proteins is still limited, here is a possibility of utilizing such components for developing novel functional meat products and food ingredients. BP derived from meat proteins are promising candidates for ingredients of meat based functional foods. Such activity could open a new market. Developing functional fermented meat products could be another good strategy in the meat industry, especially traditional fermented meats are attractive targets for finding new functional meat products. The potential health benefits of bioactive milk peptides have been a subject of growing commercial interest in the context of health-promoting functional foods. More peptide-based products are to be developed to manage various risk factors of the metabolic syndrome, e.g., hypertension, serum lipid levels, glucose balance and body mass index. In view of the current global trend of increasing prevalence of obesity and related diseases, diabetes Type II, in particular, more experimental research should be focused on natural dietary BP which can induce satiety and reduce insulin resistance. Other new areas where more research is warranted are impairment of cognitive functions, memory-related diseases and mood control. In this context, antioxidative and opioid properties of many milk peptides may be worth further investigations. Also, potential to reduce oxidative stress in the body via oral administration of antioxidative peptides may be of considerable interest in view of the inflammatory events caused by ROS in the living cells.

(Reference will be available from author)



Session-IV : Key Note Address - 02

AGRINANOTECHNOLOGY

Dr. T. N. V. K. V. Prasad*

Principal Scientist, Nanotechnology laboratory, Institute of Frontier Technology,
Regional Agricultural Research Station, Acharya N G Ranga Agricultural University,
Tirupati - 517 502, Andhra Pradesh. *tnkvprasad@gmail.com

Introduction

FAO predicted that (2009) the global grain production is required to increase by 70% to meet the food demands of 9.6 billions of population by 2050 (UN, 2013). To increase food production, it is necessary to use the different technologies in agriculture. Nanotechnology has been described as a set of technologies relating to materials, systems and processes which operate at a scale of 100 nanometers or less (Ditta, 2012; Mousavi and Rezai, 2011). Nanoscale materials show novel physical, chemical and biological properties, which are completely distinct from their bulk counter parts and individual molecules (Li et al., 2001). Nanoparticles have large surface to volume ratio and possess strong affinity to biological targets such as proteins (Kumar et al., 2010). With the limited natural resources such as land, water and soil fertility, demand for food has increased tremendously as it is required to feed the population of 9 billion by 2050. The cost of chemical fertilizers, pesticides and other production inputs has been drastically increased due to limited reserves of natural gas and petroleum (Ditta, 2012). There is a need to overcome these constraints with the help of precision farming practices and effective application of nanotechnology to agriculture (Chowdappa et al., 2013).

It has been conclusively demonstrated that fertilizers contribute to the tune of 35-40% of the productivity of any crop. Keeping in view of the importance of fertilizers, the Govt. of India is heavily subsidizing the cost of fertilizers, urea in particular. The application of nanotechnology to agriculture and food industries is carrying increased weight because of the potential benefits ranging from improved food quality and safety to reduced agricultural inputs and improved processing and nutrition. Agriculture, food and natural resources sector is a part of those challenges like sustainability, vulnerability, human health and happy living. The aim of nanomaterials in agriculture is to reduce the amount of spread chemicals, minimize nutrient losses in fertilization and increased yield through water and nutrient management. Nanotechnology has the potential to develop the agricultural and food industry with novel tools for the molecular management of rapid disease detection, enhancing the ability of plants to absorb nutrients among others. The significant interest of using nanotechnology in agriculture includes specific applications like nanofertilizers and nanopesticides to track products and nutrients levels to increase the productivity without decontamination of soils and waters and protection against pest and diseases. The new chemical and physical properties of nanoparticles provide useful functions that are being rapidly exploited in medicine, biotechnology, electronics, material science and energy sectors among others. The nanoparticles like Ag, ZnO and CuO are relevant in the growth of agriculture by bioactivity and bio-modification. It has been suggested by the researchers that the carbon nanotube (CNT) fused mesh can remove water-borne pathogens, heavy metals like lead, uranium and arsenic. This sophisticated filtering machine removes microbial endotoxins, genetic materials, pathogenic viruses, and micro-sized particles. The carbon nanotubes play a beneficial role in mustard plant growth and the TiO₂ treatment by Nitrogen Photo-reduction leads to an improved growth of spinach. From many different technological innovations including hybrid varieties, synthetic chemicals and biotechnology nanotechnology seeks a new source of agricultural improvements benefitting from food processing, distribution, packaging and functional food.



The aim of nanoparticles in agriculture is to reduce the amount of sprayed chemicals to deliver active ingredients, minimize nutrient losses in fertilization and increase yield through optimized water and nutrient management. The delivered nanotechnology devices are also being explored in the field of plant breeding and genetic transformation. For the crop production and plant protection the nano-capsules nano-particles and nano-emulsion act as a smart delivery system of active ingredients for disease and pest control. Also these particles are used in fertilizers for the enhancement of nutrients adsorption by plants and delivery of nutrients.

Plant Production

Plant-based agricultural production is the basis of broad agriculture systems providing food, feed, fiber, fire (thermal energy), and fuels through advancements in materials sciences, and biomass conversion technologies. While the demand for crop yield will rapidly increase in the future, the agriculture and natural resources such as land, water and soil fertility are finite. Other production inputs including synthetic fertilizers and pesticides are predicted to be much more expensive due to the constraints of known petroleum reserve. Precision farming is hence an important area of study to minimize production inputs and maximize agricultural production. Outputs for meeting the increasing needs of the world sustainability. Given that nanotechnology may allow for the precise control of manufacturing at the nanometer scale, a number of novel possibilities in elevating the precision farming practices are possible (Chen et al., 2011).

Many nanoscale carriers, including encapsulation and entrapment, polymers and dendrimers, surface ionic and weak bond attachments and other mechanisms may be used to store, protect, deliver and release by control of intended payloads in crop production processes. One of the advantages of nanoscale delivery vehicles in agronomic applications is its improved stability of the payloads against degradation in the environment, thereby increasing its effectiveness while reducing the amount applied. The nanoscale delivery vehicles may be designed to "anchor" to plant roots or the surrounding soil structures and organic matter if molecular or conformational affinity between the delivery nanoscale structure and targeted structures and matters in soil could be utilized (Johnson et al., 2010).

Nanofertilizers

In the process of achieving the sustainability in agriculture, applying innovative technologies, nanotechnology in particular, in agriculture including fertilizer development is considered to be one of the promising approaches to significantly increase crop production. It is evident that the efficiency of conventional fertilizers is as low as 30-50% and leaving a few management options to enhance the productivity necessitates the application of nanotechnology to fertilizer research and development. A few reports are available in the literature on nanofertilizer research but directly-related research is a draw back. (Ghormade et al., 2011; Nair et al., 2010). Huge quantities of macronutrient fertilizers (mainly N P and K fertilizers) are used for increasing the production of food, fiber, and other essential commodities. Total global macronutrient fertilizer ($N + P_2O_5 + K_2O$) consumption was 175.7 million ton (Mt) in 2011 and is projected to increase to 263Mt in 2050 (Alexandratos and Bruinsma, 2012). It was estimated that N fertilizers have contributed a roughly 40 percent increase in per-capita food production in the past 50 years, indicating the critical role of these macronutrient fertilizers in global food production (Smile, 2002). Moreover, due to the low efficiency (30–50%) and heavy application of these macronutrient fertilizers, significant amounts of these nutrients (N and P) are transported into surface and groundwater bodies, disrupting aquatic ecosystems and threatening health of human and aquatic life. Therefore, an urgent and practically essential research direction is to develop highly efficient and environmentally-friendly macronutrient (N and P) nanofertilizers to replace



the conventional N and P fertilizers and to ensure the sustainable food production while protecting the environment. A brief discussion on some promising macronutrient nanofertilizer is given below (Ruiqiang Liu et al., 2015).

Nanotechnology and agricultural production developments

In the near future, nanostructured catalysts will be available which will increase the efficiency of pesticides and herbicides thus allowing lower doses to be used. An agricultural system widely used in the USA, Europe and Japan, which efficiently utilises modern technology for crop management is called Controlled Environment Agriculture (CEA). CEA is an advanced and intensive form of hydroponically based agriculture. **Controlled-environment agriculture (CEA)** is any agricultural technology that enables the grower to manipulate a crop's environment to the desired conditions. CEA technologies include greenhouse, hydroponics, aquaculture, and aquaponics. Controlled variables include temperature, humidity, pH, and nutrient analysis. Plants are grown within a controlled environment so that agricultural practices can be optimized. The computerized system monitors and regulates localised environments such as fields of crops and irrigated water. CEA technology provides an excellent platform for the introduction of nanotechnology to agriculture. Nanotechnological devices for CEA that provide "scouting" capabilities which could tremendously improve the grower's ability which will help in determining the best time to harvest the crop and the vitality of crop along with food security issues, such as microbial or chemical contamination. One area in particular is that of the cotton industry where current techniques of spinning cotton are quite wasteful. From harvesting the cotton to finalizing the fabric it's made into, over 25% of the cotton fiber is lost to scrap or waste. Margaret Frey, an assistant professor of textile science at Cornell University, has developed a technique called electrospinning that makes good use of the scrap material otherwise to make low-value products like cotton balls, yarn, and cotton batting.

Nanosensors for monitoring soil conditions and plant growth hormone

The proficient use of agricultural natural assets like water, nutrients and chemicals during farming as nanosensors is user friendly. It makes use of nanomaterials and global positioning systems with satellite imaging of fields and might make farmers to detect crop pests or facts of stress such as drought. Nanosensors disseminated in the field are able to sense the existence of plant viruses and the level of soil nutrients. They also minimize fertilizer consumption and environmental pollution. Nano-encapsulated slow- release fertilizers have been widely used. To check the quality of agricultural manufacture, nanobarcodes and nanoprocessing could be used the idea of grocery barcodes for economical, proficient, rapid effortless decoding and recognition of diseases. They created nanobarcodes that may tag perhaps multiple pathogens in a farm, which may simply be detected using any fluorescent based tools. Nanotechnocrates are capable of studying plant's regulation of hormones such as auxin, which is accountable for root growth and seedling organization. Nanosensors that react with auxin have been developed. This is a step forward in auxin research, as it helps scientists to know how plant roots acclimatize to their environment, particularly to marginal soils for the improvement of soil retention of water or liquid by Nanomaterials, e.g. zeolites and nano-clays, for retention of water or liquid agrochemicals in the soil for their slow release to the plants.

Conclusion and perspectives

Nanotechnology has great potential as it can enhance the quality of life through its applications in various fields like agriculture and the food system. Around the world it has become the future of any nation. But we must be very careful with any new technology to be introduced about its possible unforeseen related



risks that may come through its positive potential. However, it is also critical for the future of a nation to produce a trained future workforce in nanotechnology. In this process, to inform the public at large about its advantages is the first step, which will result in tremendous increase in the interest and discovery of new applications in all the domains. However, the future of nanotechnology is uncertain due to many reasons, such as negative reaction of the public towards genetically modified crops, lack of many of the requisite skills in public agricultural research organizations for this type of research and ill-equipped and somewhat hesitant regulatory structures to deal with these new technologies. There is a dire need to tear down the sharp boundary present between the social and natural sciences and if we succeed in discarding this boundary, we may be able to develop a more desirable and more democratic socio-technical future.

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(Reference will be available from author)

Lead Papers

Session-IV : Lead Paper- 01

BIOBASED PACKAGING FOR FOODS

E. Naga Mallika and B.Eswara Rao

Department of Livestock Products Technology
NTR College of Veterinary Science, Gannavaram

The quality of food depends on the changes that occur due to exchange between food and its surroundings. Synthetic packaging materials are much appreciated for their efficacy to reduce mass transfer between food and storage medium. Composite copolymers or multilayered film packaging can significantly reduce gas and solute transfers.

Different materials like metals, glass, wood, paper, pulp and plastics are used as packaging materials. Most of these enter the municipal streams at the end of their service life. Discarded packaging is a menace posing a major challenge to waste management. On an average we use plastics for 12 minutes in a day and that takes nearly 500 years to get decomposed. Even though recycling can be done, different additives such as fillers, colorants, and plasticizers used for packaging applications and other compositional complexities together with contamination during use, often render recycling uneconomic compared with disposal in landfill. Although, the proportion of waste being land filled has fallen, percent of municipal waste that ends up in landfill is still high.

In India, on an average about 25,940 tons of plastic is utilized per day and more than 97,000 tons of solid waste is generated per day according to Ministry of Environment, forest and climate change. The use of plastics in world is estimated to be 260MT.

Biodegradable plastics made from renewable raw materials like starch or cellulose have been developed for packaging applications. This type of packaging arises primarily from the use of raw materials like crops instead of crude oil. These are biodegradable polymers that are capable of undergoing decomposition into carbon dioxide, methane, water, inorganic compounds, or biomass. These can be either biobased or petrochemical based. But due to the additives added in these petrochemical based products these may create another menace.

In consequence, a number of biodegradable materials such as naturally occurring polymeric materials, have been investigated as alternative to plastics. Biopolymers from agricultural food stocks, food processing waste and other resources have the ability to form biopolymers packaging material upon processing. (Davis and Song 2006). But, so far the use of biodegradable films for food packaging has been strongly limited, because of the weak mechanical properties of natural polymers. Further these cannot meet the requirements of a cost- effective film. Several strategies to enhance barrier properties of these films were investigated like blending of polymers, coating with high barrier materials and use of multilayered films, in order to improve the quality of these films. These polymers are edible sometimes.



The use of edible films in food products appears new, but food products were first covered by edible films and coatings many years ago. Wax has been used to delay dehydration of citrus fruits, since 12th & 13th centuries (Guilbert and biquet 1986). Application of coatings to meats to prevent shrinkage was the usual practice since at least the 16th century, where meats were coated with fats. (Kester and Fennema 1986). In the 19th century, sucrose was applied as an edible protective coating on nuts, almonds, and hazelnuts to prevent oxidation and rancidity during storage. Most of the times, an emulsion of waxes and oil in water was spread on fruits to improve their appearance.

A number of edible polysaccharide coatings, including alginates, carrageenans, cellulose ester, pectin, and starch derivatives have been used to improve stored meat quality. Edible packaging consists of edible films, sheets, coating and pouches. Edible films and sheets are stand-alone structures that are preformed separately from the food and then placed on or between food components or sealed into edible pouches. Edible coatings are thin layers of edible materials formed directly onto the surface of food (Janjarasskul and Krochta, 2010). The edible films comprise of thickness of <254 μm , whereas edible sheets include up to thickness of 254 μm .

The advantages of edible films over traditional petrochemical-based polymeric packaging materials were they can be consumed with packaged product, even if the films are not consumed, they are biodegradable. These can enhance the organoleptic properties of packaged foods with incorporation of various food additives such as flavorings, colorings, sweeteners. They can be carriers of nutrients like vitamins, minerals and also function as carriers for antimicrobial and antioxidants agents and be used at the surface of foods to control the diffusion rate of preservative substances from surface to the interior of the food. They can be applied inside heterogeneous foods at the interfaces between different layers of components and tailored to prevent deteriorative intercomponent moisture and solute migration in foods such as pizzas, pies and candies. They can be very conveniently used for microencapsulation of food flavoring and leavening agents to efficiently control their addition and release into the interior of foods. They could be used in multilayer food packaging materials together with inedible films, in which case the edible films would be the inner layers in direct contact with the food.

Majority of edible films and coatings contain at least one component which is a high molecular weight polymer. Long-chain polymeric structures are required to yield film matrices with appropriate cohesive strength when deposited from a suitable solvent. Increased structural cohesion generally results in reduced film flexibility, porosity and permeability to gases, vapours and solutes. As polymer chain length and polarity increases cohesion is enhanced. A uniform distribution of polar groups, along the polymer chain increases cohesion by increasing the likelihood of inter chain hydrogen bonding and ionic interactions. A variety of polysaccharides, proteins and lipids derived from plants and animals have been utilized, either alone or in mixtures, to produce edible films and coatings.

A variety of polysaccharides (cellulose, starch, chitin etc.) and their derivatives have been evaluated for potential use as edible packaging because they are abundant, low cost and easy to handle. Polysaccharides possess good film forming properties. Polysaccharide films exhibit good mechanical as well as gas barrier properties and are efficient barriers against oil and lipids. However, the films offer little resistance to water migration and their functional properties are greatly affected by humidity. Various polysaccharides such as Starch, Cellulose, Hemi cellulose, Chitosan, gums like carrageenan, pectin and agar are used.

Starch

Starch is the main polysaccharide energy storage material in the plant kingdom. It is a mixture of amylose and amylopectin. Due to its linear nature, amylose forms coherent, relatively strong, free standing films in contrast to amylopectin films that are brittle and non-continuous. To enhance water solubility, partial etherification of high-amylose starch with propylene oxide can be performed to yield hydroxypropylated derivatives. Amylose, high-amylose starch and hydroxypropylated high-amylose starch have been used as protective edible coatings on foods and encapsulating agents to provide an O₂ or lipid barrier and to improve appearance, texture and handling. Edible starch films and coatings are commonly used in bakery, confectionary and meat products. Dextrins are a group of low-MW carbohydrates produced by the hydrolysis of starch are often used to make various types of coatings on confections as well as edible glues and sealants. The dextrin products can be soluble in cold water and have fair film formation properties and good adhesive properties. An aqueous coating of dextrins is applied as chocolate coatings to retard flavour spoilage.

Cellulose

Cellulose is the most abundant, naturally occurring polymer. To produce plastic materials from cellulose, a chemical modification involving substitution of cellulose hydroxyl functions by acetate or methyl functions (etherification) need to be performed. The objective of modification is to decrease the intensity of the hydrogen bonds. The degree and type of substitution and polymer chain affect permeability, mechanical properties and solubility. The most common cellulose ethers are methyl cellulose (MC), hydroxypropyl cellulose (HPC), hydroxypropyl methylcellulose (HPMC) and carboxymethyl cellulose (CMC) and all have good film forming properties. MC has excellent film-making properties, high solubility, efficient O₂ and lipid barrier properties. They have been used commercially to form edible films that provide barriers to O₂, oil and moisture, with MC and HPMC finding use as batter ingredients to lessen oil uptake and moisture loss during deep-fat frying.

Hemicellulose

Hemicellulose have been used for edible food coatings based on β -glucan extracts from hulled barley, hull-less barley and oats, and corn hull or maize bran arabinoxylan, xylans from birchwood, grass and corncob have been used as additives in wheat gluten to form potentially edible composite films.

Chitosan

Chitin, after cellulose is one of the most abundant polysaccharides produced in nature and is abundant in the cell walls of insect cuticles. Chitosan is a versatile, nontoxic, nonantigenic hydrophilic polysaccharide derived from chitin by deacetylation with alkalis; typical commercial chitosan is about 85% deacetylated. Chitosan films can be formed by casting acidic aqueous solutions, the film properties is strongly dependant on molecular weight and degree of acetylation. Chitosan has broad antimicrobial activity, is most effective against yeast and molds, followed by gram-positive and gram-negative bacteria. The antimicrobial activity of is due to release of protonated glucosamine fractions from the biopolymer into the food. Chitosan can bind trace metals, thus preventing microbial growth and toxin production. Some workers (Friedman and Juneja, 2010) suggested that low molecular weight chitosans below pH 6.0 present optimal conditions for achieving desirable antimicrobial and antioxidative-preservative effects in liquid and solid foods. The effects of chitosan coatings on fresh cut products such as strawberries, carrot, mango, cantaloupe, pineapple and mushroom have been observed to retard microbial growth and enhance their shelf life (Tamer and Copur, 2010).



Gums

Alginates are extracted from brown seaweeds, the film produced by the evaporation of water from the alginate solution are impervious to oils and greases, good barrier to O₂ but have high water vapour permeabilities. Alginate coatings effectively lessen desiccation in enrobed meats by acting as a sacrificing agent and because of their good O₂ barrier properties, can protect foods against oxidation.

Carrageenan is a collective term for polysaccharides extracted from certain species of red seaweed, it has been applied to a variety of foods to carry antimicrobials and reduce moisture loss, oxidation and disintegration.

Agar is a galactose polymer and is derived from red seaweeds. It forms strong gels, agar coatings containing water- soluble antibiotics and the bacteriocin nisin have been used on fresh foods.

Pectin are water soluble, anionic polymers. Pectinate coating can retard water loss from enrobed food by acting in a sacrificial manner when moisture evaporates from their gel matrix rather than dehydrating the food. Pectin coating have been observed to retard lipid migration and improve handling and appearance of foods.

Lipids

Lipid compounds can be used as protective coatings rather than forming coherent films. However, they can provide gloss and can act as a moisture barrier due to their low polarity. Waxes (esters of a long chain fatty acid with a long-chain alcohol) including natural waxes such as carnauba wax, candelilla wax, rice bran wax, bees wax and synthetic waxes such as paraffin and petroleum wax, as well as mineral and vegetable oils, have been used commercially as protective coatings for fresh fruits and vegetables. Wax coatings are more resistant to moisture transfer than other lipid and non-lipid edible coatings. Wax, fat and oil based coatings are difficult to apply due to their thickness and greasy surface, may confer waxy or rancid taste. Mono, di and triglycerides are the mono, di and trimesters of glycerine with fatty acids and have been used as coatings. Acetylated glycerol monostearate coatings are slightly more permeable to water vapour than PA and PS films and significantly more permeable than LDPE films; they are less permeable to O₂ than PS films. Certain problems have been observed with acetylated monoglyceride edible coatings, including a tendency to crack and flake during refrigerated and frozen storage, to pick up foreign odours and exhibit an acidic or bitter aftertaste. Unsaturated glycerides and acetylated glycerides may be susceptible to oxidation. Edible resins such as shellac, terpene resin and wood resin are used to impart gloss to foods. Shellac has been extensively used as an edible coating for confectionary and fresh produce.

Proteins

Films and coatings are made from animal and plant proteins including collagen, gelatine, wheat gluten, corn zein, soy protein, whey protein (WP) and casein. Due to their inherent hydrophilicity and incorporation of hydrophilic plasticizers such as glycerin and sorbitol (for flexibility), they have limited resistance to water vapour. Protein based films generally have good mechanical and optical properties, are good barriers against the transport of O₂, CO₂, aroma and lipids but have high WVP. Physical, chemical and enzymatic cross-linking treatments can be used to improve the barrier as well as mechanical properties. When used as coatings on fresh foods, protein materials are susceptible to proteolytic enzymes present in these foods. Some people are allergic to specific protein fractions of milk, egg, peanut, wheat etc., so use of protein films and coatings must be clearly indicated on the label.



A. Animal Protein

Collagen

Collagen sausage casings are made from regenerated corium layer of beef hides; gelatine is derived from partial hydrolysis of collagen. Collagen film overwrap on refrigerated and thawed beef reduces exudation without significantly affecting colour or lipid oxidation. Collagen based films have been proposed for processed meats to reduce shrink loss, increase juiciness, allow for easy removal of nets after cooking or smoking and absorb fluid exudates for a variety of cooked meat products. Gelatin coatings can O₂, moisture and oil migration or carry bioactive ingredients. Gelatin is widely used as an encapsulating agent in hard and soft gel capsules for moisture or oil based food ingredients and dietary supplements.

Milk protein

Milk proteins used as edible films and coatings are made from casein as well as WP. WP films and coatings have been used as protective barriers to reduce O₂ uptake and rancidity in roasted peanuts and frozen salmon, as well as disintegration of fragile freeze-dried foods. Incorporation of ascorbic acid into WP films confers an O₂- scavenging function and such films reduce OTR and retard lipid oxidation in coated peanuts, baby formula, peanut butter and mayonnaise (Janjarasskul and Krochta, 2010). WP isolate reduced fat uptake in fried chicken breasts by 30%.

Other animal protein

Animal proteins other than collagen and milk protein used for development of edible films and coatings are fish myofibrillar protein, egg white protein, keratin etc.

Plant Protein

Cereal proteins used to form edible films include corn zein (made from prolamin) and wheat gluten (a mixture of prolamin and glutenin). Zein is one of a few proteins used as a commercially successful finishing agent imparting surface gloss and acting as an O₂, lipid and/or moisture barrier for nuts, candies, confectionary products and other foods. Edible films and coatings have also been made from globulin protein fractions of soybeans and peanuts, rice protein, sorghum protein.

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Multicomponent or edible composite packaging materials have been developed by blending bio-components for specific applications with the aim of taking advantage of complementary functional properties or to overcome their respective flaws. Multicomponent films are formed by two basic techniques. The coating technique involves casting or laminating a lipid onto a dried edible base film to form a bilayer or laminated film. The emulsion technique involves adding a lipid to a film-forming solution prior to casting and creating an emulsified film.

Plasticizers are generally added to edible films to improve film flexibility and durability. These include mono, di, or oligosaccharides such as glucose, fructose-glucose syrups and sucrose; polyols such as glycerol,



sorbitol, lipids and derivatives such as phospholipids, fatty acids etc. Emulsifiers are essential to achieve sufficient surface wettability to ensure proper surface coverage and adhesion to the coated surface as well as for the formation and stabilization of well-dispersed lipid particles in composite emulsion films. Common emulsifiers include acetylated monoglyceride, lecithin, glycerol monopalmitate, glycerol monostearate, polysorbate 60, polysorbate 65, sodium laurylsulphate, sorbitan monostearate etc.

At present, improving the performance of these polymeric materials can be done through incorporation of certain nanoparticles that have the ability to interact with food and environment and package and confer antimicrobial properties, while some continuously monitor and detect changes in the package environment. Such nano composites have applications in active and smart packaging systems. The primary advantage of antimicrobial edible films is that it can reduce post-processing contaminations on food surface. Edible films or coatings can act as carriers of antimicrobial and antifungal agents and can enhance the shelf life of foods. The most commonly used antimicrobials are organic acids, chitosan, nisin, Lactoperoxidase, some plant extract and their essential oils. In selecting an antimicrobial, its effectiveness against target microorganism and possible interactions among the antimicrobial, the film forming biopolymer and other food components present must be considered. Controlling the antimicrobial release from edible films is very important, and, therefore, measurement of diffusion coefficients of the antimicrobials in edible films is necessary prerequisite.

Antioxidants can also be added to edible films to delay the start or slow the rate of oxidation reactions. Primary antioxidants are free radical acceptors that delay the initiation or propagation of autoxidation. Secondary or preventive antioxidants retard oxidation by several different actions including chelating pro-oxidant metals, deactivating singlet O_2 , absorbing UV radiation, Scavenging O_2 or promoting antioxidant activity of primary antioxidants, for example, citric acid, ascorbic acid etc. Numerous plants have been identified as sources of natural phenolic compounds with antioxidant activity like rosemary, thyme, sage etc. The antioxidant containing edible films and coating could enhance shelf life of fatty foods by retarding or delaying oxidation.

The properties of materials are magnified in their nanoforms due to their huge surface- to- area ratio. Nano composites concept represents a stimulating route for creating new and innovative materials. The nano composite materials obtained by mixing natural polymers and sheets of crystalline solid layered offer a great variety of property profiles. The application of nano composites promises to expand the use of edible and biodegradable films. Starch-clay nano composite was investigated for various applications (Tang et.al 2008). Cellulose nano fibers and MMT, jute nanofibril reinfused starch, polyvinyl alcohol bio composite films were developed. (Das et al.2011, Azereds et al.2009). Clay, silicate nano particles, carbon nano tubes, grapheme, starch nano crystals, cellulose based nano fibers, nano whiskers, chitin or chitosan nano particles, silver nano particles, and titanium nano particles, magnesium nano particle, copper and zinc nano particle are experimented. Among all layered inorganic solids, clay had attracted attention by packaging industry. Montmorillonite, hectonite, saponite and kaolinite are the commonly used layered silicates.

The combination of biopolymers with nano particles, results in bio-nano composites which exhibit good mechanical properties, dimensional stability, and solvent or gaseous mixture.

Conclusion

The use of edible films or coatings on various food products continues to expand. The many potential benefits of edible films and coatings as carriers of antimicrobial agents, flavors, antioxidants, coloring agents, vitamins, probiotics and nutraceuticals justify continued research in this arena of active packaging. However,



the application of edible films and coatings in India is still at infancy. There exists huge scope for use to get benefited in India with this type of packaging as such applications are at nascent stage. Edible films, gels or coatings are considered biopolymers with numerous desirable properties and may be needed for variety of polysaccharides, lipids, proteins, alone or in combination with other components. When these are applied to foods, this can not only enhance the quality and safety of the food but slows down deterioration and extend the shelf life. New legislations and standards in favour of edible materials seem to be very helpful to spur market growth.

(Reference will be available from author)



Session-IV : Lead Paper - 02

CURRENT TRENDS IN THE PACKAGING OF MEAT AND MEAT PRODUCTS

Dr. I. Prince Devadason

Senior Scientist, Division of Livestock Products Technology
ICAR- Indian Veterinary Research Institute, Izatnagar, Bareilly, UP

Introduction

Packaging of meat and meat products are an essential part of meat processing and a dynamic link between the producer and the consumer for the safe supply of the product through the various stages of processing, storage, transport, distribution and marketing.

All over the globe, the consumers are showing larger consciousness towards food packaging as it provides information on the quality, quantity, value and the hygienic standards. The central aspect of meat preservation is the suitable packaging for the specific meat product (Fresh, Processed, Cured, Smoked etc). The main objective of packaging is to protect meat/meat products from microbial contamination, external factors like light, oxygen or any physical damage or chemical agents. The choice of the packaging material has to be done very prudently to protect the different physico-chemical properties like the kind of pigments, sensory attributes and mainly the microflora. The aim is to block and prevent the main deteriorative changes and make the products available to the consumers in the most appealing form. The initial quality of the meat however has to be very good because packaging can only maintain the current quality of meat or suspend the onset of spoilage by controlling the factors that responsible to it. The product, therefore, is only protected for a specific period determined by the method that is used. Thus, meat and meat products require a dedicated package profile depending upon the kind of meat, method of processing, state of storage and distribution. This paper elaborates the different packaging materials which are developed over a period of time and the different packaging methods evolved for different kinds of meat and meat products.

Advancements in packaging methods of meat and meat products:

1. Vacuum Packaging:

Vacuum packaging is a method to increase the shelf-life of meat products. Here the meat product is placed in an air-tight pack, the air is sucked out and the package sealed creating the internal environment vacuum. By creating vacuum around the product, the levels of oxygen in the packaging are reduced, impeding the ability of oxygen-breathing microorganisms to grow and spoil the product. The lack of oxygen also reduces the amount of spoilage due to oxidation thereby facilitates extension of shelf life. This is a cost effective and easy method of packaging but the life is limited.

2. Modified Atmosphere Packaging:

MAP is certainly a more versatile process than vacuum packaging. Vacuum packaging is essentially a 'one size fits all' technology – it depends mainly on removing air. MAP on the other hand can be tailored to the particular meat product, with different gases and different proportions of gas in the mixture used to give the maximum shelf life for the particular meat product and to retain the quality and appearance of the product.

For example for packaging of meat, the proportion of carbon dioxide and oxygen in the modified atmosphere can be varied depending on the type of meat. The gas mixture used for red meat is different to that used for white meat.

One aspect where MAP does perform well when compared with vacuum packaging is in the presentation of the product. In vacuum packaging, as the pressure within the packaging is reduced the packaging material collapses and forms itself tightly around the product. For some products, such as fresh meat, this can distort the appearance of the product..

Another aspect in which the two processes differ is in the ease of quality control of the packaging process. In MAP packaging, air is flushed from the package and replaced with the gas mixture, making it possible to constantly monitor the gas content of the package during the packaging process. Once the package is sealed, any leakage of the modified atmosphere can be detected, enabling the integrity of the seal to be assured. For vacuum packaging, because there is no gas present in the package, leak testing is typically done through manual inspection, making quality control less straightforward.

3. Controlled Atmosphere Packaging

The storage life of chilled meat can be extended by packaging product under a preservative gaseous environment to inhibit growth of spoilage bacteria. The maximum storage life is attained by packaging in a gas-impermeable pouch under an atmosphere of oxygen-free CO₂, with the gas added in sufficient quantity to fully saturate the meat at the optimum storage temperature (-1.5°C) and atmospheric pressures. In such controlled atmosphere packaging (CAP), the storage life of meat is between 8 and 15 times that of the same product stored in air. The CAP environment assures retention of good raw meat colour, and development of good eating qualities in cooked product. CAP packaging is being used commercially for shipment of chilled lamb to distant markets. Continuing studies indicate that it could be applied equally effectively to prolonging the storage life of a wide range of other perishable food products.

4. Active / Smart Packaging

Active packaging systems are developed with the goal of extending shelf life for foods and increasing the period of time that the food is high quality. Active packaging technologies include some physical, chemical, or biological action which changes interactions between a package, product, and/or headspace of the package in order to get a desired outcome (Yam et al., 2005). The most common active systems scavenge oxygen from the package or the product and may even be activated by an outside source such as UV light (Gander, 2007). Active packaging is typically found in two types of systems; sachets and pads which are placed inside of packages, and active ingredients that are incorporated directly into packaging materials.

Active Packaging: Sachets and Pads

In order to absorb or emit gases to a package or headspace, sachets and pads are very commonly used. Sachets were developed in the late 1970s in Japan. For oxygen scavenging, the sachets essentially utilize the process of rusting, or the oxidation of iron compounds in the presence of oxygen and water. Oxygen scavengers can also be made based on enzyme technology. Oxygen absorbers are usually made of powdered iron or ascorbic acid. Iron based scavengers typically do not pass the metal detector inspections on most packaging lines, and in these incidences ascorbic acid is advantageous. Oxygen absorbers in sachets are commonly found in meat and poultry products, coffee, pizzas, baked goods and dried foods. Sachets that absorb carbon dioxide along with oxygen are also available and are most commonly found in roasted or ground coffee packages. Some sachets are capable of emitting ethanol as an antimicrobial agent to extend the shelf life of high moisture bakery products. Drip absorbent pads may be used in packages containing meats that are likely to leak after temperature fluctuations. These pads prevent the growth of molds or bacteria by absorbing water into super-absorbent polymer granules placed between two layers of microporous non-woven polymer. Although sachets work well in many applications, they are not appropriate for every situation.



Sachets cannot be used in liquid foods. They may not be used in a package made of flexible film, as the film will cling to the sachet and prevent it from performing its function. Sachets have the risk of accidental ingestion by consumers and this may account for their limited commercial success in North America and Europe (Yam et al., 2005).

Active Packaging: Materials Containing Active Components

More recent attempts at active scavenging have focused on incorporating the scavenger into the packaging material itself. This method has potential for use in polyethylene terephthalate (PETE) bottles and can be included in many plastic containers and closures. Adding scavengers to the plastic rather than a sachet can save many problems.

Active Packaging: Anti-microbial Systems for Food Packaging

An exciting innovation in active packaging is the potential for the controlled release of antimicrobials from packaging materials. Antimicrobials incorporated in packaging materials could extend shelf life by preventing bacterial growth and spoilage. In one system, known as "BioSwitch" (de Jong et al., 2005), an antimicrobial is released on command when bacterial growth occurs. The basic concept is that a change in the environment such as pH, temperature, or UV light occurs and the antimicrobial responds accordingly. The external stimulus results in a release of the antimicrobial component of the package.

In this system, the antimicrobial is released on command, and the system is active only at specific conditions. This system could potentially increase the stability and specificity of preservation and reduce the amount of chemicals needed in foods. A common example of release on command antimicrobials in food packaging is the inclusion of polysaccharide particles that encapsulate antimicrobial compounds. Many bacteria will digest polysaccharide when they grow, and so if a bacterial contamination occurs, the growth of bacteria will release the antimicrobial compounds and should inhibit subsequent microbial growth.

5. Intelligent Packaging:

Intelligent packaging systems exist to monitor certain aspects of a food product and report information to the consumer. The purpose of the intelligent system could be to improve the quality or value of a product, to provide more convenience, or to provide tamper or theft resistance (Robertson, 2006).

Intelligent packaging can report the conditions on the outside of the package, or directly measure the quality of the food product inside the package. In order to measure product quality within the package, there must be direct contact between the food product or headspace and the quality marker. In the end, an intelligent system should help the consumer in the decision making process to extend shelf life, enhance safety, improve quality, provide information, and warn of possible problems.

Intelligent packaging is a great tool for monitoring possible abuse that has taken place during the food supply chain. Intelligent packaging may also be able to tell a consumer when a package has been tampered with. There is currently work being developed with labels or seals that are transparent until a package is opened. Once the package is tampered with, the label or seal will undergo a permanent color change and may even spell out "opened" or "stop". Perhaps intelligent packaging will be able to inform a consumer of an event that occurred such as package tampering that may save their life.

6. Aseptic packaging:

Aseptic processing can be defined as the processing and packaging of a commercially sterile product into sterilized containers followed by hermetic sealing with a sterilized closure in a manner that prevents viable microbiological recontamination of the sterile product. The benefits of aseptic processing over



conventional canning include longer shelf life, wider packaging sizes, wider container materials and improved nutritional and sensory properties.

7. Nano-packaging:

Nano-enabled packaging is the fruit of revolution in the packaging industry. Nano-enabled packaging utilizes nano materials, with diameter less than 100 nanometers, to manufacturing packaging materials. Nano-enabled packaging is extensively employed in food & beverage and pharmaceutical packaging and has exhibited strong acceptance in the market. Nano-enabled packaging provides longer shelf life to perishable food and beverages. Nano-enabled packaging has been found to improve attributes such as taste, texture, color and consistency of the packaged food. It increases absorption and the bio availability of nutrients in foodstuffs. Among the various nano particles used in this industry, nanoclay, silver and titanium nitride have the largest applications. Nanoclay is the most used material owing to its cheap availability and utility in popular thermoplastics such as polypropylene, PET, nylon and thermoplastic polyolefin.

8. Retort pouch processing:

Retort pouches combine the advantages of the metal can with the frozen boil-in-the-bag. The attributes of flexible containers offer benefits for the consumer, retailer, and manufacturer alike (Coles & Kirwan, 2011):

1. The thin profile of the pouch or container provides rapid heat transfer for both preparation and for sterilization during processing. A 30–40% reduction in processing time is possible, with energy savings.
2. Reduced heat exposure results in improvements in taste, colour, and flavour; there are also fewer nutrient losses.
3. Preparation of products that need to be heated to serving temperature can be accomplished in 3–5 min by immersing the pouch in boiling water or placing the plastic container in a microwave oven.
4. Storage space of the retort pouch or container in a paperboard carton is no larger than that for cans; disposal space is less.
5. Shelf-life of retort pouch products is equivalent to that of foods in metal cans.
6. Refrigeration or freezing is not required by packers, retailers, or consumers.
7. Pouches and containers do not corrode externally and there is a minimum of product–container interaction.
8. Opening the pouch requires only tearing the pouch across the top at the notch in the side seam, or by using scissors. The container lid may be peeled open or cut with a knife.
9. The flexible container is safer in that a consumer would not be cut as on a metal can or be faced with broken glass as with glass jars.
10. Empty retort pouches and nesting containers offer processors a reduction in storage space and lighter weight. Compared with empty cans, an equal number of retort pouches use 85% less space and are significantly lighter.
11. Advantages for the retailer include savings in shelf space and the shape makes it easier for the retailer to handle and display the product.
12. The use of a flat carton as an overwrap to hold one or two pouches provides for better product identification on the shelf than cans. The pouch also offers the opportunity to market multipacks, e.g., entree in one pouch and accompaniment such as rice in another.
13. Energy requirements for container construction are less than that for cans.



Conclusions:

Being highly nutritious, the Meat and meat products favour the growth and multiplication of spoilage and pathogenic microorganisms, making them easily prone for the deterioration and food safety. The external factors such as oxidation of meat lipids and proteins (e.g. myoglobin) also lead to quality deterioration of meat and meat products. Modern trends in the packaging of meat and meat products should serve as an effective device for maintaining quality and safety, as well as increasing product worth, encouraging sales and conveying information.

Aspects such as price, safety, size of packaging and recyclability are most important, whereas design, convenience and utility must also be taken into account (Duizer, Robertson, & Han, 2009). Therefore, selection of suitable packaging materials, packaging methods/conditions, and storage environments are the key to achieve high quality packaged meat and meat products. Besides, the systems for improving the quality of raw meat before it is packaged are important to ensure the quality of the end packaged meat. For example, vitamin E supplementation to animal feed resulted high vitamin E content in the raw meat which consequently leads to an extension of retail display life by 1.6-5 days (Gray et al., 1996). Currently, application of Vacuum Packaging and Modified Atmosphere Packaging with overwrapped thermoforming films is a routine practice in meat packaging to prolong the shelf life and retain good quality.

Recently, the development of innovative thermoforming films with better mechanical and barrier properties and optimization of the MAP technologies are the major present-day research emphases in this field. Active packaging such as antimicrobial and antioxidant has been introduced to attain longer shelf-life, which clearly change the conditions of the package to efficiently improve the meat safety and quality. According to Realini and Marcos (2014), the major technical challenge for active packaging is to develop active materials that are able to preserve their original mechanical and barrier properties after adding the active substances.

The use of nanoparticles can reduce the amount of active substance required and thus help maintain the original properties of the base packaging material. The application of edible films, especially those with antimicrobial and antioxidant substances has great prospective for meat and meat products through preventing moisture loss, inhibiting microbial growth and lipid oxidation, preventing changes in texture, flavor, and color, and reducing drip loss. Selection of the proper coating and films for a specific meat product depends on its kind, characteristics, behavior, specific needs, price, and uses that this technology can contribute to the processors and the consumers. The challenges are the possible adverse impact on product sensory qualities, increased price, constrains in achieving standardized coating procedures for big measure of commercial operations.

Hence, further research is required to improve the manufacturing and application processes of edible coatings and films for the meat industry to assure that their use is economically viable and perfect for each product. In the last few decades the retort pouch processed meat products are entering in to the market in a big scale. Researches needed to find out the optimum conditions of retort processing and also development different thermal schedules for different meat products. As there is a huge potential in the coming years for retort pouch processing more research emphasis must be given to the thermally processed ready to eat (RTE) meat products.

(Reference will be available from author)

Session-IV : Lead Paper- 03

RECENT DEVELOPMENTS IN PACKAGING FOR PROFICIENT MARKETING OF MEAT AND MEAT PRODUCTS

Kandeepan Gurunathan, Yellamella Babji, Kalpana Starling and Bindu Gouthami Perugu

ICAR-National Research Centre on Meat, Hyderabad

1. Introduction

Packaging has become the third largest industry in the world and it represents about 2% of Gross National Product (GNP) in developed countries. The fundamental reasons for packaging fresh and processed meat products are preventing contamination, delaying spoilage, permitting some enzymatic activity to improve tenderness, reducing weight loss, and retaining colour and aroma. Based on this, the current meat packaging practices range from overwrap packaging for short-term chilled storage and/or retail display, to vacuum packaging, bulk-gas flushing or modified atmosphere packaging (MAP) systems for long-term chilled storage, each with different attributes and applications. Recently, a series of new packaging technologies and materials have been developed including active packaging, intelligent packaging, edible coatings/films, biodegradable packaging, and nanomaterial packaging. These technologies and materials have the potential to improve the quality and safety, prolong the self-life, reduce the environment impact, and increase the attractiveness of the packaged product to the retailers and consumers, outcomes that are favourably welcomed by the food industry.

2. Recent developments in meat packaging

Innovative packaging with enhanced functions is constantly sought in response to the consumer demands for minimally processed foods with fewer preservatives, increased regulatory requirements, market globalization, concern for food safety, and the threat of food bioterrorism. Active packaging, intelligent packaging, edible coatings/films and biodegradable packaging, and nanotechnology are the major recent innovations in the food packaging industry that have shown promising advanced properties in extending shelf life, improving food safety and quality, and protecting our natural environment. The characteristics for selection of suitable packaging material for packaging of a particular product are given in Table 1.

Table 1 : Properties of major packaging materials used for meat and poultry
(Robertson, 2006; Osswald et al., 2006)

Packaging material (0.025 mm thickness)	Water vapour transmission rate, g/m ² /24 h	O ₂ transmission rate, cm ³ /m ² /24h	Tensile strength, MPa	Tear strength, g/mL	Impact strength, J/m	Haze, %	Light Transmission, %	Heat seal temperature range, C
Poly (vinyl chloride) PVC	1.5–5	8–25	9–45	400–700	180–290	1–2	90	135–170
Poly vinylidene chloride (PVdC)	0.5–1	2–4	55–110	10–19	–	1–5	90	120–150
Polypropylene, PP	5–12	2000–4500	35.8	340	43	3	80	93–150
High density Polyethylene, PE-LD	10–20	6500–8500	11.6	100–200	375	5–10	65	120–177

Linear low density polyethylene, PE-LLD	15.5–18.5	200	7–135	150–900	200	6–13	–	104–170
Ionomer	25–35	6000	24–35	20–40	150	–	–	107–150
Ethylene/vinyl acetate, EVAC	40–60	12500	14–21	40–200	45	2–10	55–75	66–177
Ethylene/vinyl alcohol, EVAL	1000	0.5	8–12	400–600	–	1–2	90	177–205
Polyamide, PA	300–400	50–75	81	15–30	50–60	1.5	88	120–177
Poly(ethylene terephthalate) PET	15–20	100–150	159	20–100	100	2	88	135–177
Polystyrene, PS	70–150	4500–6000	45.1	2–15	59	1	92	121–177

2.1. Vacuum skin packaging

Vacuum skin packaging (VSP), is a subset of vacuum packaging technology. This offers advantages for presentation as well as packaging design variety in skin packaging. The process allows the packaging film to conform exactly to the profile of the product. This gives rise to many opportunities for enhanced product presentation as well as further improving the integrity of the pack itself. In a skin pack, the product becomes the die for the thermoform packaging operation. The semi-rigid bottom web may or may not be thermoformed. The top web is heated in an evacuating chamber until it is near its melting point, at which it drapes over the product and forms a skin around all the contours. Upon sealing, it retains its new shape, ensuring intimate contact with the product, irrespective of surface irregularities. Skin packs are prepared with an oxygen barrier plastic film. Heat shrinkable poly (vinyl chloride) (PVC), polypropylene (PP), and poly(vinylidene chloride) (PVdC) are used for vacuum skin packaging of fresh meat.

2.2. Modified atmosphere packaging (MAP)

Modified atmosphere packaging (MAP) can be sub-classified into three broad categories; low oxygen (or anoxic), high oxygen MAP and vacuum-packaging. Low-oxygen MAP involves the exclusion and replacement of oxygen from within the packaging. Vacuum packaging is sometimes classified as low-oxygen MAP, but for the purposes of this study, it is designated as a separate technology. The most common gases used for low-oxygen MAP are nitrogen (N₂) and carbon dioxide (CO₂). The most recent meat packaging technology is anaerobic (essentially no oxygen) MAP with low levels (0.4%) of CO, 20 to 30% CO₂ and the remainder nitrogen (CO-MAP). This packaging method offers several advantages over aerobic packaging with PVC or high-oxygen MAP including prolonged colour stability, no oxidized flavours, no bone darkening, no premature browning during cooking, decreased growth of spoilage organisms and pathogenic bacteria, Increased tenderness, due to less protein oxidation in an anaerobic environment (Lund et al., 2007), and also due to longer shelf life, allowing continuous action of endogenous tenderizing enzymes (Grobbel et al., 2007). The disadvantages of CO-MAP are negative image of CO by consumers because it is a potentially hazardous gas and concern that products might look fresh even though bacterial levels are high and the product is spoiled. High oxygen MAP involves the use of high oxygen atmosphere (typically 80% by volume) for packaging. High-oxygen MAP promotes bright red colour (oxymyoglobin) when raw, although this is sensitive to the type of cut and storage conditions. Disadvantages include potential for grey colouring and early browning and reduced tenderness, juiciness, and flavour (Lagerstedt et al., 2011). Typically, co-extruded

PA/PE films are used for high-oxygen MAP (John et al., 2004). The PA provides strength, and the PE provides gas and water vapour barrier properties and heat sealability.

Typically fresh red meats are stored in modified atmosphere packages containing 80 % O₂: 20 % CO₂ and cooked meats are stored in 70 % N₂: 30 % CO₂ (Smiddy et al., 2002) as in Table 2. The function of carbon dioxide in MAP is to inhibit growth of spoilage bacteria. Nitrogen is used in MAP as an inert filler gas either to reduce the proportions of the other gases or to prevent pack collapse. The major function of oxygen is to maintain the muscle pigment myoglobin in its oxygenated form, oxymyoglobin. Low oxygen concentrations favour oxidation of oxymyoglobin to metmyoglobin. Therefore, in order to minimise metmyoglobin formation in fresh red meats, oxygen must be excluded from the packaging environment to below 0.05 % or present at saturating levels. High oxygen levels within MAP also promote oxidation of muscle lipids over time with deleterious effect on fresh meat colour. MAP applications may have thermoformed base trays made from unplasticized PVC/polyethylene (PVCU/ PE), poly(ethylene terephthalate)/polyethylene (PET/PE), polystyrene/ethylene/ vinyl alcohol/polyethylene (PS/EVAL/PE), or poly(ethylene terephthalate)/ethylene/ vinyl acetate/polyethylene (PET/EVAC/PE) while preformed base trays are often made from PET, PP, or PVC-U/PE. Lidding films are often PVdC coated PP/PE, PVdC coated PET/PE, or polyamide/polyethylene (PA/PE). Flow wrap films may be PA/PE, polyamide/ionomer, or PA/EVAC/PE (Mullan and McDowell, 2003). Antifogging agents are externally applied to the polymer surface by dip coating or spraying or blended into the polymer for migration to the surface. Antifog agents lower the surface tension of water that condenses on the inside surface of films when there is a temperature differential between the film surface and the surrounding environment. Commonly used agents to prevent film fogging are glycerol esters, polyglycerol esters, sorbitan esters and their ethoxylates, alcohol ethoxylates, and nonyl phenol ethoxylates (Osswald et al., 2006).

Future and recent developments in MAP are and will largely be associated with its use in combination with other technologies, e.g. active packaging. This combination of technologies is sometimes referred to as hurdle technology, and is aimed at utilising the advantages of each technology. For example, anoxic MAP (80% CO₂/20%N₂ and 60%CO₂/40%N₂) has been trialled in combination with oregano and thyme essential oils, for packaging of lamb. Thyme oil was found to be more effective than the oregano oil, and it was suggested that using thyme oil could result in a one day extension in shelf life, relative to a baseline 80%CO₂/20%N₂ MAP-packaged product (Karabagias et al., 2011). It has been suggested that the future focus of MAP will be on low-oxygen applications, because the red-colour advantages of high oxygen MAP are offset by oxidation and the need for longer shelf-life (McMillin, 2008). Research into MAP largely focuses on the use of different gas combinations and concentrations. The addition of 0.4-1.0% carbon monoxide in MAP can promote red-colour stability. Regional regulations on the use of different gases vary. For example, carbon monoxide is not permitted as a food additive in Canada, whereas it is acceptable in New Zealand and Australia (Nassu et al., 2010).

Table 2. Gas mixture used in modified atmosphere packaging for meat and meat products
(Smiddy et al., 2002)

Product	Gas composition (%)		
	O ₂	CO ₂	N ₂
Red meat	60-85	15-40	-
Pork steak	80	20	-
Beef/venison portion	80	20	-

Cooked meats	-	30	70
Cooked ham in slices	-	40	60
Chops/Slices	69	20	11
Poultry	-	75	25
Processed meats	-	-	100

2.3. Controlled atmosphere packaging (CAP)

Controlled atmosphere packaging may be used for bulk product or items of irregular shape, such as whole lamb carcasses, or as master packs for retail-ready product. Controlled atmosphere packaging is not suitable for individual trays of retail-ready product because of the undesirable colour of anoxic meat, and because packaging materials that are impermeable to gases is mostly opaque. Readily available films that are essentially gas impermeable are laminates that incorporate a layer of aluminium foil, laminates with two layers of a metallised film, or laminates with unusually thick layers of plastics with high barrier properties. Controlled atmospheres may be of carbon dioxide or nitrogen, or mixtures of the two gases. Nitrogen can provide an anaerobic atmosphere, but does not otherwise affect the muscle tissue or the microflora. Thus, the storage life of meats in a controlled atmosphere of nitrogen is similar to that of meats in vacuum pack; although in a gas impermeable, controlled atmosphere pack there is no oxidation of myoglobin in exudate or muscle tissue, which eventually become evident with meat in vacuum packs as the result of small quantities of oxygen permeating the packaging films.

2.4. Active packaging

Active packaging is an innovative packaging system/technology that allows the product and its environment to interact to extend the shelf life and/or to ensure food microbial safety, while maintaining the quality of the packed food. Active packaging generally describes any packaging system that protects food from contamination or degradation by creating a barrier to outside conditions while interacting with the internal environment to control the atmosphere within the package. The packaging absorbs food-related chemicals from the food or the environment within the packaging surrounding the food; or it releases substances into the food or the environment surrounding the food such as preservatives, antioxidants, and flavourings. The "releasing active materials and articles" are those designed to deliberately incorporate components that would release substances into or onto the packaged food or the environment surrounding the food; and "released active substances" are those intended to be released from releasing active materials and articles into or onto the packaged food or the environment surrounding the food and fulfilling a purpose in the food. Commercially available active packaging devices are given in Table 3.

2.4.1. Antimicrobial packaging

Antimicrobial active packaging is one of the most important concepts in active packaging because meat provides excellent nutrients for the growth of microorganism. Spoilage microorganisms including bacteria, yeast and molds, and pathogenic micrograms, specifically *Salmonella spp.*, *S. aureus*, *L. monocytogenes*, *C. perfringens*, *C. botulinum*, and *E. coli O157:H7* are the major concerns leading to quality deterioration and food safety issues in meat. The aims of using antimicrobial active packaging are to extend shelf-life and to ensure food safety of meat and meat products. Antimicrobial active packaging can take several forms, including addition of sachets or pads containing volatile antimicrobial agents into packages, incorporation of volatile and non-volatile antimicrobial agents directly into polymers, coating or adsorbing

antimicrobials onto polymer surfaces, immobilization of antimicrobials to polymers by ionic or covalent linkages, and use of polymers that are inherently antimicrobial. Antimicrobial additives react with microorganisms, causing a count reduction or inhibition (Lee, 2010). The additives used can be broadly classified into organic compounds and inorganic compounds. Organic additives used for direct incorporation into packaging films include organic acids and their salts (e.g. acetic acid, benzoic acid, potassium sorbate), fatty acids, plant extracts (e.g. silver, zirconium), nitrites and sulphites and salts. (Including essential oils from herbs), peptides.

Table 3 : Commercially available active packaging devices (Modified from Crossin et al., 2015)

Tradename / trademark	Developer	Description
FreshPax®	Multisorb Technologies Inc. USA	Oxygen scavenging / CO ₂ generating sachet
Ageless®	Mitsubishi Gas Chemical Co. Japan	Oxygen scavenging / CO ₂ generating sachet
OxyGuard®	Clariant Ltd. Switzerland	Oxygen scavenging Sachet
OxyCatch®	Kyodo Printing Company Ltd. Japan	Oxygen scavenging sachet
ATCO®	Emco Packaging Systems, UK and Standa Industrie, France	Oxygen scavenging sachet
Oxysorb	Pillsbury Co., USA	Oxygen scavenging sachet
Cryovac® OS2000	Sealed Air Corporation, USA	UV-activated oxygen scavenging film
Enzyme-based	Bioka Ltd. Finland	Oxygen scavenging film
Shelfplus® O ₂	Albis Plastic GmbH, Germany	Oxygen scavenging masterbatch
OxyRx®	Mullinix Packages Inc. USA	Oxygen scavenging container for high temperatures
OMAC®	Mitsubishi Gas Chemical Co. Japan	Oxygen scavenging film for high temperatures
Linpac	Linpac Packaging Ltd. UK	Moisture tray
TenderPac®	SEALPAC,	Dual compartment system
Dri-Loc®	Sealed Air Corporation, USA	Moisture pad
MeatGuard	McAirlaid Inc. Germany	Moisture pad
CO ₂ ® Fresh pads	CO ₂ Technologies, USA	CO ₂ emitting pads
UltraZap® Xtenda Pak pads	Paper Pak Industries, USA	CO ₂ emitting and antimicrobial pads
SUPERFRESH	Vartdal Plastindustri AS	Box system with CO ₂ emitter
Nor® Absorbit	Mondi Group, UK	Microwavable film
MoistCatch	Kyodo Printing Co., Ltd. Japan	Moisture and outgassing scavenger film
AgIon®	AgION Technologies LLC, USA	Antimicrobial substances
Biomaster®	Addmaster Limited, UK	Antimicrobial substances trays and films
Irgaguard®	BASF, Germany	Antimicrobial substances
Surfacine®	Surfacine Development Company LLC, USA	Antimicrobial substances
IonPure®	Solid Spot LLC, USA	Antimicrobial substances
Bactiblock®	NanoBioMatters, Spain	Antimicrobial substances
Nisaplin and Novasin	Integrated Ingredients, USA	Antimicrobial
SANICO®	Laboritories STANDA, France	Antifungal coating
Wasouro®	Mitsubishi-Kagaku Foods Corp. Japan	Antifungal/ bacterial sheets, labels and films

FreshCase®	Bemis Company Inc. USA	Film that activates red colour in meat
Sira-Crisp®	Sirane Ltd. UK	Microwave susceptor
SmarthPouch®	VacPac Inc.USA	Microwave susceptor

2.4.2. Antioxidant packaging

The other class of directly-incorporated active packaging additives is antioxidants. These include substances such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), rosemary extract and α -tocopherol. These additives act by reacting with free-radicals, including oxides, which can detrimentally affect colour and odour.

2.4.3. Oxygen-scavenging packaging

High levels of oxygen present in meat packaging can facilitate microbial growth, lipid oxidation, development of off flavours and off odours, colour changes and nutritional losses. Therefore, control of oxygen levels in meat packaging is important to limit the rate of such deteriorative and spoilage reactions. Antioxidant active packaging can be used as a means of improving product quality and extending shelf life of meat and meat product through controlling the level of oxygen.e.g. iron powder, ascorbic acid.

2.4.4. Carbon dioxide emitting/generating packaging

CO₂ has inhibitory activity against a range of aerobic bacteria and fungi, as well as direct antimicrobial effect, resulting in an increased lag phase and generation time during the logarithmic phase of microbial growth. For most applications in meat and poultry preservation, high CO₂ levels (10–80%) are desirable because these high levels inhibit surface microbial growth; thereby extending shelf-life. The inhibitory action of CO₂ has differential effects on different microorganisms. Whereas aerobic bacteria such as *Pseudomonas* can be inhibited by moderate to high levels of CO₂ (10–20%), lactic acid bacteria can be stimulated by CO₂. Furthermore, pathogens such as *C. perfringens*, *C. botulinum* and *L. monocytogenes* are minimally affected by CO₂ levels lower than 50%. e.g. bicarbonate.

2.4.5. Moisture absorbers

A major cause of food spoilage is excess moisture. Soaking up moisture by using various absorbers or desiccants is very effective at maintaining food quality and extending shelf life by inhibiting microbial growth and moisture related degradation of texture and flavor (Scetar et al., 2010). In addition to moisture absorber sachets for humidity control in packaged dried foods, several companies manufacture moisture drip absorbent pads, sheets and blankets or liquid water control in high a_w foods such as meats, fish, poultry, fruit and vegetables. Basically they consist of two layers of a microporous non-woven plastic film, such as PE or PP, between which is placed a superabsorbent polymer that is capable of absorbing up to 500 times its own weight with water. Typical superabsorbent polymers include polyacrylate salts, carboxymethyl cellulose (CMC) and starch copolymers, which have a very strong affinity for water (Reynolds, 2007). Moisture drip absorber pads are commonly placed under packaged fresh meats, fish and poultry to absorb unsightly tissue drip exudate. Commercial moisture absorber sheets, blankets and trays include Toppan Sheet™ (Toppan Printing Co. Ltd, Japan), Thermarite™ (Thermarite Pty Ltd, Australia), Luquasorb™ (BASF, Germany) and Fresh-R-Pax™ (Maxwell Chase, Inc., Douglasville, GA, USA).

2.5. Intelligent packaging in meat industry

Intelligent packaging can be defined as “systems that monitor the condition of packaged foods to give information about the quality of the packaged food during transport and storage”. An intelligent packaging system contains smart devices which are small, inexpensive labels or tags that are capable of acquiring,

storing, and transferring information about the functions and properties of the packaged food. The most commonly used smart devices in intelligent packaging of meat and meat products are summarized in Table 4 and 5.

2.5.1. Barcode

A barcode is an optical machine-readable symbol relating to the object to which it is attached. The first commercialized barcode was the UPC (Universal Product Code) introduced in the 1970s that has now become ubiquitous in grocery stores for facilitating inventory control, stock reordering, and checkout. The UPC barcode is a linear symbology consisting of a pattern of bars and spaces to represent 12 digits of data containing limited information such as manufacturer identification number and item number. To address the growing demand for encoding more data in a smaller space, new families of barcode symbologies such as Reduced Space Symbology (RSS), two-dimensional (e.g. PDF 417, Aztec code), Composite Symbology (combining a 2-D barcode such as PDF 417 with a linear barcode such as UPC) and GS1 DataBar Family have been introduced. Information including food packing date, batch/lot number, package weight, nutritional information, cooking instructions and the Web site address of food manufacturer can be encoded in the barcodes and they are even readable by smartphones; providing great convenience for both retailers and consumers. Barcodes are also good devices to identify the origin of food products and are widely used in meat and meat product packaging. In Australia, almost all meat and meat products in the retail market are sold with a barcode.

Table 4. Examples of smart devices used in intelligent packaging and their principle of operation (Modified from Hurme et al., 2002)

Smart devices	Principle/reagents	Information given	Application
Barcodes	Symbology	Product and manufacturer information	Product identification, facilitating inventory control, stock reordering, and checkout
Radio frequency identification tags	Radio waves	Product and manufacturer information	Product identification, supply chain management, asset tracking, security control
Time-temperature Indicators	Mechanical, chemical, enzymatic, microbiological	Storage conditions	Foods stored under chilled and frozen conditions
Gas indicators	Redox dyes, pH dyes, Enzymes	Storage conditions, package leak	Foods stored in packages with required gas composition
Freshness indicators (e.g. Microbial growth)	pH dyes; Dyes reacting with (non-) volatile metabolites	Microbial quality of food (i.e. spoilage)	Perishable foods such as meat, fish and poultry
Pathogen indicators	Various chemical and immunochemical methods reacting with Toxins	Specific pathogenic bacteria such as <i>E. coli</i> O157	Perishable foods such as meat, fish and poultry

2.5.2. Radio frequency identification (RFID) tags

RFID technology is a form of electronic information-based intelligent packaging. Compared with barcodes, the RFID tag is a more advanced data carrier for product identification with several unique

characteristics, such as significantly larger data storage capacity (up to 1 MB for high-end RFID tags), non-contact, non-line-of-sight ability in gathering real-time data, and can penetrate non-metallic materials for rapid and automatic multiple product identification. Nevertheless, the RFID tag is not considered as a replacement for the barcode, mainly because of its relatively higher cost and need for a more powerful electronic information network. It is anticipated that both RFID and barcode data carriers will continue to be used either alone or in combination, depending on the situation. RFID tags have the potential to be combined with temperature, moisture and/or chemical sensors, thereby giving the ability to trace environmental conditions within the supply chain. RFID can improve the movement of existing and new information associated with the product and its supply chain, from farming through to distribution, storage and retail. In addition, RFID tags have the potential to include consumer-specific information, such as cooking instructions. Advantages of RFID systems include increased quality control, improved inventory management (e.g. through stock rotation and shelf life algorithms), reduced product recalls, security and anti-counterfeiting.

Table 5. Commercial intelligent packaging devices (Modified from Crossin et al., 2015)

Tradename / trademark	Developer	Description
OxySense	OxySense, USA	Biosensor
Ageless Eye®	Mitsubishi Gas Chemical Co. Japan	Integrity indicator (gas)
Tell-Tab	IMPAK, USA	Integrity indicator (gas)
O2Sense	Freshpoint, Switzerland	Integrity indicator (gas)
Timestrip®	Timestrip Ltd. USA	Integrity indicator (time)
Novas®	Insignia Technologies Ltd. Scotland	Integrity indicator (time)
Best-by®	Freshpoint, Switzerland	Integrity indicator (time)
3M Monitor Mark®	3M, USA	Time-temperature indicator (fatty acid ester)
VITSAB® TTI	VITSAB, Sweden	Time-temperature indicator (enzymatic)
Fresh-Check®	Lifelines Technology Inc., USA	Time-temperature indicator (polymerization)
Keep-it®	Keep-it Technologies, Norway	Time-temperature indicator (chemical)
OnVu®	Freshpoint and Ciba, Switzerland	Time-temperature indicator (photochemical)
TopCryo®	TRACEO, France	Time-temperature indicator (microbiological)
FreshCode®	Varcode Ltd. Israel	Time-temperature indicator (barcode)
Tempix®	Tempix AB, Sweden	Time-temperature indicator (barcode)
Raflatac	VIT and UPM, UK	Freshness indicator (colorimetric)
Easy2log®	CAEN RFID Srl, Italy	RFID
CS8304	Convergence Systems Ltd. Hong Kong	RFID
TempTRIP	TempTRIP LLC, USA	RFID
Intelligent box	Mondi PLC, Austria	RFID

2.5.3. Indicators

Indicators are a form of qualitative intelligent packaging that communicates the quality and/ or state of a product during the food chain. These can include time-temperature indicators (TTIs), integrity indicators and freshness indicators.



2.5.3.1. Time-temperature indicators

TTIs are typically labels which affix to the outside of a food pack, but indicators can also be applied directly to the food. TTI's serve as a proxy for an indication of bacterial activity, and thus can provide indirect information relating to product quality. TTIs work through mechanical, chemical, electrochemical, enzymatic or microbiological changes with time and temperature. These changes are typically indicated visually through deformation of a material, or a change/movement in colour. A key advantage of TTI's is that it allows products to be managed based on remaining shelf life, rather than first-in first-out, thereby reducing waste. In addition, TTI's are low cost, rendering them suitable for individual retail packs. For example, a Vitsab Checkpoint® TTI label is based on a colour change resulting from the controlled enzymatic hydrolysis of a lipid substrate. The TTI can be activated by applying gentle pressure on the "window" to break the seal between the enzyme and substrate mini pouches. A good mixing is recognized by a homogenous green color in the "window". When the dot is green, this represents the packaged foods are under perfect shipping and storage conditions. If the dot is yellow to light orange the product has not been compromised by time/temperature exposure.

2.5.3.2. Integrity indicators

Integrity indicators are small devices in the form of a package label or printed on packaging films that respond to the changes of a gas composition, thereby providing monitoring the quality, safety and integrity of packaged food products. Typically, a gas indicator also induces a color change to reflect the gas composition changes. Integrity indicators range in complexity from simply communicating how long a product has been opened, detecting leaks over the supply chain, to indicating the amount of ingress of a particular gas into a product at a point in time. Stakeholder needs determines the level of sophistication of the indicator and the nature of the communication. For instance if a consumer only needs to know how long an item has been open, a colour label activated on breaking of a product seal suffices. If the nature of the gas interactions after opening or in the case of a leak is required, a range of colour indicators such as redox dyes or tablets, convey these interactions most often in regard to oxygen content.

2.5.3.3. Freshness indicators

Freshness indicators are devices directly indicating the deterioration or loss of freshness of packaged goods. The development of freshness indicators is based on established knowledge of quality indicating metabolites specifically associated with the type of meat product, spoilage flora, packaging type and storage conditions. The major quality-indicating metabolites or chemicals representing meat freshness are glucose, organic acids (e.g. lactic acid), ethanol, volatile nitrogen compounds, biogenic amines (e.g. tyramine, cadaverine, putrescine, histamine), carbon dioxide, ATP degradation products and sulphuric compounds. Most of the freshness indicators change colour due to the presence of these metabolites or chemicals during spoilage.

2.5.4. Sensors

A sensor is a device which can provide signal(s) relating to the detection or measurement of a physical or chemical property. Most sensor systems require a receptor, which translates a detection or measurement into a signal, and a transducer, which reads this signal, which can then be analysed to produce a quantitative value, which can be stored in some instances. Types of sensors include gas sensors, fluorescence-based oxygen sensors and biosensors.



Gas sensors are often used to detect gas levels (either ambient or generated) in MAP systems. Recent advances in gas sensor technologies include non-destructive optical systems, used to detect gases produced from microbial activity (e.g. hydrogen sulphide, amines). Other research has focussed on utilising nanomaterials within packaging to enable gas detection. Fluorescence-based oxygen sensors provide a visual indication of the presence of oxygen. They are typically dyes, incorporated into a polymer film matrix. Package biosensors to detect the contamination by pathogenic microorganisms of meat and meat products have also been developed. These devices consist of a bioreceptor that recognizes a target analyte and a transducer that converts biochemical signals into a quantifiable electrical response. Bioreceptors are organic or biological materials such as an enzyme, antigen, microbe, hormone, or nucleic acid, while transducers include electrochemical, optical and calorimetric, depending on the system. The interaction can occur through the use of antibodies. An example of a biosensor was the Food Sentinel system, which rendered a barcode unreadable by the presence of certain bacteria (Kerry et al., 2006). The pathogen indicators/sensors also change color in the food package to warn consumers/retailers that food must not be consumed.

2.6. Edible coatings, films and biodegradable packaging for meat industry

2.6.1. Edible coatings

Edible coatings are either applied to or made directly on foods while films are independent structures. These coatings and films are located on the food surface or as thin layers between several parts within the product with the aim of improving overall food quality and extending shelf-life by functioning as barriers to moisture, gas and solute transmission. Moreover, they can be used to incorporate functional food substances, such as antimicrobials, antioxidants, flavouring agents and nutrients, to improve safety, stability, sensory, and nutritional properties of foods. Bovine gelatin coatings have been found to extend the shelf life of beef tenderloins, without adversely affecting sensory perceptions, including colour, flavour and aroma (Antoniewski et al., 2007). For the ground beef-patties, chitosan coatings are more effective in maintaining colour when used in combination with carbon-monoxide flushed PVC packaging, compared with a vacuum-packaged system (Suman et al., 2010).

2.6.2. Edible films

Edible films are defined as continuous matrices prepared from edible materials made up of proteins, polysaccharides and lipids. Edible films act through microbial or anti-oxidant reactions, or by affecting gas permeability. While edible films can provide multiple functions for meat and meat product packaging, there is increased interest in the development and usage of antimicrobial edible films to preserve meat quality for longer shelf life and improved food safety. Incorporation of antimicrobial compounds into edible films as an alternative to their direct application onto the meat surface has the advantage of gradual release of the antimicrobial compounds. This permits a reduction in the level of added antimicrobial which in turn reduces any negative antimicrobial-related sensory changes. Thyme essential oil increased the shelf-life of air-packed lamb from 7 days to 9-10 days (Karabagias et al., 2011).

2.6.3. Biodegradable packaging

Biodegradable packaging materials are defined as materials derived primarily from renewable sources, such as replenishable agricultural feedstocks, animal sources, marine food processing industry wastes, or microbial sources, and can break down to produce environmentally friendly products such as carbon dioxide, water, and quality compost. Biodegradation is the process by which carbon-containing chemical compounds are decomposed in the presence of enzymes secreted by living organisms, and requires

appropriate temperature, humidity and type of microbes for a rapid degradation process. There are currently a range of commercially available biodegradable containers for meat and meat products. Among them, Ingeo™ biopolymer by NatureWorks LLC. (Blair, Nebraska, USA) is mostly used to make foam trays. Ingeo™ biopolymer uses dextrose (sugar) from corn as the primary feedstock (PLA), but can be made from any abundantly available sugar. Some commercially available biodegradable packaging for meat and meat products are presented in Table 6.

Table 6. Some commercially available biodegradable packaging for meat and meat products
(Fang et al., 2015)

Products and manufacturer	Description
Back 2 Earth, Ridgeland, SC, USA	Meat trays made completely from wheat stalk and are GMO- and gluten-free.
BASF Co., Florham Park, New Jersey, USA	A new foaming grade of Ecovio biopolymers. Blends of BASF's petrochemical-based Ecoflex biodegradable resin with PLA.
BioMass Packaging™, Richmond, CA, USA	Foam trays made from Ingeo®
Bodin Industries, France	Foam trays made from PLA resin, and used to package meat or fish at the FiniperSpA super-market chain in Italy and organic chicken or duck.
BuyGreen, Irvine, CA, USA	Biodegradable trays made from corn polymers, starches and complementary ingredients to create a blend that is 100% biodegradable and microwave and freezer safe.
Clear Lam Packaging, Inc., Elk Grove Village, IL, USA	Made from Ingeo™ biopolymer to package a variety of meats, cheeses, pastas, egg rolls and other perishable food items.
CoopboxSpA, Reggio Emilia, Italy	The first foam PLA trays, called Naturalbox, in 2005 for meat, fish, or poultry.
Cryovac® Food Packaging Systems, SC, USA	NatureTRAY™, foam trays made from Ingeo™ and used to package meats, fish, poultry, and produce. Fully moisture resistant.
Dyne-A-Pak Inc., Laval, QC, Canada	Use Ingeo™ biopolymer (PLA) supplied by NatureWorks LLC with lightweight and efficiency of a foam packaging for meat, produce and deli.

2.7. Nanotechnology in meat packaging

Nanomaterials have proportionally larger surface area and consequently more surface atoms than their microscale counterpart. When added to compatible polymers, the nanomaterials can dramatically enhance the material properties of the nanocomposites, including improved mechanical strength, enhanced thermal stability and increased electrical conductivity (Uskokovic 2007). Thus, applications of nanomaterials in food and meat packaging are promising for improving mechanical properties, barrier properties, and/or conferring the packaging with new functionalities such as antimicrobial and antioxidant activity, biodegradability and intelligence ability (Bradley et al., 2011), as well as ability to withstand the stress of thermal food processing, transportation, and storage. Current applications of nanomaterials in food packaging include the enhancement of barrier properties through the incorporation of nano-fillers (e.g. nanoclay), 'active' food packaging; with intentional controlled release of active substances such as antibacterials to improve the shelf-life of food (e.g. nanosilver) and, improvement of physical characteristics to make the packaging more tensile, durable, or



thermally stable (e.g. nano-titanium dioxide, titanium nitride). Potential future applications include the use of 'smart' packaging (e.g. nanosensors and labels) (Drew & Hagen, 2016).

Several studies have demonstrated the potential benefits of adopting active packaging for poultry products. Akbar and Anal (2014) reported that zinc oxide nanoparticles film-embedded in active packaging in a challenge study on ready-to-eat poultry meat sausages against *Salmonella typhimurium* and *Staphylococcus aureus* resulted in a substantial reduction in the number of inoculated target bacteria. Dias et al. (2013) reported that antimicrobial packaging incorporating allyl isothiocyanate and carbon nanotubes enabled effective storage of shredded cooked chicken meat for 40 days by reducing microbial contamination, controlling oxidation and reducing colour changes. Morsy et al. (2014) demonstrated that silver and zinc oxide nanoparticles incorporated into pullulan films and applied to fresh or ready-to-eat turkey products can inhibit foodborne pathogens over three weeks of vacuum-packaged, refrigerated storage. Panea et al. (2014) delayed spoilage and lipid oxidation of chicken breasts packaged in low density polyethylene (LDPE) blended with silver and ZnO nanoparticles. Lloret et al. (2012) have reported on the effectiveness of absorbent pads containing silver nanoparticles in reducing the microbial load of poultry exudates.

Nanocomposites are formed when a polymer matrix is reinforced with fillers in the nanoscale, resulting in improved packaging properties (King et al., 2018). Some examples of fillers are clays, silicates, cellulose microfibrils, cellulose whiskers, and carbon nanotubes; while polymers include polyamide, polystyrene, nylon, polyolefins etc. Growing demand for the production of biodegradable packaging has also led to the use of biopolymers that may be natural or synthetic. Nanocomposites can improve the mechanical strength, biodegradability properties, reduce weight, increase heat resistance, and/or improve barrier against oxygen, carbon dioxide, ultraviolet radiation, moisture, and volatiles of food package materials. Better barrier properties can help maintain food quality and increase shelf life without the use of additional chemical preservatives. For example, Bayer (Leverkusen, Germany) produces Durethan KU2-2601 packaging film that is enriched with silicate nanoparticles. These particles are dispersed throughout the film and reduce the entrance of oxygen and other gases, and the exit of moisture, thus protecting food from spoiling. This product is also stronger and more heat resistant than those currently on the market. In another study, Jang et al. (2010) analysed Gelidium Corneum–Gelatin (GCG) film incorporating nano-clay and thymol. It was reported that this packaging material displayed greater tensile strength, reduced water vapour permeability and inhibited growth of *E. coli* O157:H7 and *L. monocytogenes* during storage of packed chicken breasts.

3. Conclusions

Modern meat packaging should serve as an efficient tool for maintaining quality and safety, as well as increasing product value, promoting sales and imparting information. Factors including price, safety, size of packaging and recyclability are most important, whereas design, convenience and utility must also be taken into account. Therefore, selection of appropriate packaging materials, packaging methods/conditions, and storage environments are the key to obtaining high quality packaged meat products. We can imagine that simple traditional packing will be replaced with multi-functional packaging, such as a packaging with biodegradable, active and intelligent functions. To develop successful meat packaging systems, key product characteristics affecting stability, environmental conditions, and consumer's packaging expectations must all be taken into consideration. A sustainable packaging solution can be achieved only if it is socially responsible, economically viable, and environmentally sound.

(Reference will be available from author)



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**CURRENT TRENDS IN ACTIVE AND SMART PACKAGING OF
MEAT AND MEAT PRODUCTS**

Dr. Sathu. T

Assistant Professor, Meat Technology Unit, College of Veterinary and Animal Sciences
Mannuthy, Thrissur, Kerala

Introduction:

Packaging is an integral part of production, physical distribution and an important tool for marketing. The packaging of the meat and meat products is done to protect the meat and meat products from environmental contamination and other factors (such as dust, odours, microorganism, temperature, moisture loss, physical damage). Packaging also plays a key role in ensuring the safety and quality of the meat and meat products and it helps to minimize losses due to spoilage. In the 20th century many innovations in the meat packaging technology has been brought up, including smart or intelligent packaging (time-temperature indicators (TTIs), gas indicators, radiofrequency identification (RFID) and active packaging (such as oxygen scavengers, carbon-di-oxide releaser, moisture absorbers and antimicrobials in packages).

Packaging fresh meat is carried out to avoid contamination, delay spoilage, permit enzymatic activity to improve tenderness, reduce weight loss, and to ensure an oxymyoglobin or cherry-red colour in red meats at retail or customer level (Brody, 1997). When considering processed meat products, factors such as dehydration, lipid oxidation, discoloration and loss of aroma should be taken into account (Mondry, 1996).

To delay oxidation, control food borne pathogens, and meet the growing demands of consumers for safe and high-quality products, food packing scientist are putting up a considerable effort to do in-depth studies of active food packaging and the development of new active food packaging technologies, which includes utilization of antioxidant properties (Brahmi *et al.*, 2016), antimicrobial properties (Choi, Singh, & Lee, 2016). Though active packaging can effectively improve food quality and extend shelf-life (for example, releasing an antimicrobial or antioxidant compound), this packaging technique cannot provide visual information indicative of the shelf-life, safety, or quality of food, and it cannot warn about possible current or future problems. Food packaging innovations have gradually led to the development of intelligent packaging, which could convey detailed information about the condition of a packaged food or its environment throughout a logistical chain, as well as provide an early warning to the consumer from the food manufacturer (Vanderroost, Ragaert, Devlieghere, & Meulenaer, 2014). Thus, currently available intelligent packaging technologies can accomplish diverse functions such as monitoring, identifying, processing, recording, tracing, and communicating. The goals of this paper were to review the current commercial applications of food packaging technology and present an overview of research innovations and present trends regarding active and smart packaging for meat and meat products.

1. Intelligent / Smart packaging (IP)

Smart packaging is capable of monitoring the condition of packaged food or its environment by using sensors or indicators (such as electronic, chemical, and mechanical triggers). Intelligent packaging could be used to monitor, sense, record, trace, and convey information about the quality of food, and it could be used with decisions concerning shelf life, safety, and quality, as well as alert people with possible problems related



to food (Yam *et al.*, 2005). IP systems contain smart devices (small labels or tags), which can be imprinted onto or incorporated into food packaging materials in order to acquire information about the food's quality, storage of information, and transferring it to the stakeholders (manufacturers, retailers, and consumers) (Fang, Zhao, Warner, & Johnson, 2017). The most commonly used smart devices in IP can be classified as indirect or direct indicators of food quality. Indirect indicators cannot provide direct information to help consumers judge the quality and edibility of food. However, they can indirectly evaluate the effects of the environment surrounding the food on the shelf-life and quality of food which could expose the hidden danger for consumers. Foods that have deteriorated or carry small amounts of a toxin, but which do not yet exhibit detectable signs of spoilage, may harm immunosuppressed populations, especially children and the elderly (Wang, Lu, & Gunasekaran, 2017). Direct indicators can directly present some information about the freshness, edibility, quality, and safety of food to consumers. These devices must usually be placed inside the primary packaging so that they have direct contact with the atmosphere surrounding the food or with the food itself. Therefore, direct indicators have become a main future direction of research in this area.

Examples of intelligent packaging applications for use within the food industry

Tamper evidence and pack integrity, Visual oxygen indicator, Indicators of product safety/quality Time-temperature indicators (TTI's), gas sensing devices, microbial growth, pathogen detection traceability/anti-theft devices, radio frequency identification (RFID) labels, tags, chips, product authenticity, holographic images.

Sensors

A sensor is defined as a device used to detect, locate or quantify energy or matter, giving a signal for the detection or measurement of a physical or chemical property to which the device responds (Kress-Rogers, 1998).

An optical sensor approach offers a realistic alternative to Modified Atmosphere Packaging and Vacuum Packaging. Most sensors contain two basic functional units: a receptor and a transducer.

In the receptor, physical or chemical information is transformed into a form of energy, which may be measured by the transducer. The transducer is a device capable of transforming the energy carrying the physical or chemical information about the sample into a useful analytical signal. There are different types of sensors used in meat industry such as Gas sensors, Fluorescence-based oxygen sensors, Biosensors etc.

Gas indicators

The gas composition within meat package changes due to the activity of the food product (such as respiration and transpiration, as well as spoilage due to microorganisms), the nature of the package (such as the gas permeability of the packaging material), and the environmental conditions (temperature or package leaks). It is directly related to the integrity, shelf-life, quality, and safety of packaged food products (Fang *et al.*, 2017). It monitors the changes in gas composition inside the package and thereby provides a means of monitoring the quality and safety of food products. Different types of gas indicators are used in food packaging systems, as in the form of package labels or package printing films that detect oxygen, ethanol, hydrogen sulfide (H₂S), water vapor, carbon dioxide, or other gas components. Gas sensors are devices that respond reversibly and quantitatively to the presence of a gaseous analyte by changing the physical parameters of the sensor and are monitored by an external device.

Systems presently available for gas detection include amperometric oxygen sensors, potentiometric carbon dioxide sensors (Kress-Rogers, 1998). Recently optical oxygen sensors have been developed which is

comprised of a solid-state material, and operates on the principle of luminescence quenching or absorbance changes caused by direct contact with the gaseous analyte. This solid-state sensor is inert and does not consume analyte or undergo other chemical reactions (Wolfbeis, 1991).

Some sensors are developed which senses gaseous analytes such as hydrogen sulphide, carbon dioxide and amines and thus enhances the quality control systems through detection of product deterioration or microbial contamination (Wolfbeis and List, 1995).

Fluorescence-based oxygen sensors

Fluorescence-based oxygen sensors represent the most advanced and promising systems for remote measurement of headspace gases in packaged meat products. The active component of a fluorescence-based oxygen sensor normally consists of a long-delay fluorescent or phosphorescent dye (Pt-porphyrins) encapsulated in a solid polymer matrix (polystyrene). The dye-polymer coating is applied as a thin film coating on a suitable solid support (Wolfbeis, 1991). Molecular oxygen, present in the packaging headspace, penetrates the sensitive coating through simple diffusion and quenches luminescence by a collisional mechanism. Oxygen is then quantified by measuring changes in luminescence parameters from the oxygen-sensing element in contact with the gas or liquid sample, using a predetermined calibration.

This process is reversible and clean; neither the dye nor oxygen is consumed in the photochemical reactions involved, no by-products are generated and the whole cycle can be repeated. The polymers with good gas barrier properties such as polyamide, polyethylene terephthalate and PVC are not suitable for oxygen sensing as oxygen quenching is slow in such media.

Working range: Most of the sensors works within the range from 0 to 100 kPa of oxygen, or at least 0–21 kPa (0–21%) with detection limits of 0.01–0.1 kPa (where, kPa corresponds to percentage oxygen pressure at room temperature and ambient air pressure) Fitzgerald *et al.*, (2001) examined the potential of platinum based disposable oxygen sensors as a quality control instrument for vacuum-packed raw and cooked meat and MA packed sliced ham while O'Mahony *et al.*, (2004) used fluorescent oxygen sensors printed directly onto the packaging material of sous vide beef lasagna. The production cost of the sensor is less (Kerry and Papkovsky, 2002) and has minimal impact on packaged meat production costs.

Biosensors

Biosensors are compact analytical devices that detect record and transmit information pertaining to biological reactions and indicates the freshness of the product (Yam *et al.*, 2005). These devices consist of a bio receptor specific to a target analyte and a transducer to convert biological signals to a quantifiable electrical response. Bio receptors are organic materials such as enzymes, antigens, microbes, hormones and nucleic acids.

Intelligent packaging systems incorporating biosensors have the potential for extreme specificity and reliability. Toxin guard a visual diagnostic system which incorporates antibodies in a polyethylene-based plastic packaging is capable of detecting *Salmonella* spp., *Campylobacter* spp., *E. coli* 051 and *Listeria* spp. (Bodenhammer, 2002; Boden *et al.*, 2004)

Indicators

An indicator may be defined as a substance that indicates the presence or absence of another substance or the degree of reaction between two or more substances by means of a characteristic change, especially in colour. In contrast with sensors, indicators do not comprise of receptor and transducer components and communicates information through direct visual change.



Integrity indicators

These systems provide qualitative or semi-quantitative information through visual colorimetric changes or through comparison with standard references and can be used as non-invasive indicator systems as part of an MA package. The majority of indicators have been developed for package integrity testing which is an essential requirement for the maintenance of quality and safety standards in packaging of meat products. With the exception of high oxygen content MA packaging of fresh meat, many foods are packaged in low (0–2%) oxygen atmospheres. In such cases, leaks normally result in a significant increase in oxygen concentration. Visual oxygen indicators consisting mainly of a redox dyes, which have been tested as leak indicators in MA packaged minced steaks and minced meat pizzas, respectively, and was reported as reliable indicator (Ahvenainen *et al.*, 1997).

Disadvantages of such devices include high sensitivity (0.1% oxygen concentration required for colour change means indicators are susceptible to residual oxygen in MA packs) A visual carbon dioxide indicator system consisting of calcium hydroxide (carbon dioxide absorber) and a redox indicator dye can be incorporated in polypropylene resin which can be applied to certain meat packaging systems (Hong and Park, 2000).

Freshness indicators

Freshness indicators provides with direct product quality information resulting from microbial growth or chemical changes within a food product. Microbiological quality may be determined through reactions between indicators included within the package and microbial growth metabolites (Smolander, 2003). The majority of freshness indicators are based on indicator colour change in response to microbial metabolites produced during spoilage. Dainty 1996 and Nychas *et al.*, 1998 used freshness indicators to determine spoilage of foods and chemical changes in meat during storage.

The formation of different potential indicator metabolites in meat products is dependent on the product type, associated spoilage flora, storage conditions and packaging system. Changes in the concentration of organic acids such as n- butyrate, L-lactic acid, D-lactate and acetic acid during storage could be potential indicator metabolites for a number of meat products (Shu *et al.*, 1993). Colour based pH indicators can be used as indicators of these microbial metabolites.

Ethanol, like lactic acid and acetic acid, is an important indicator of fermentative metabolism of lactic acid bacteria. Randell *et al.*, 1995 reported that an increase in the ethanol concentration of anaerobically MA packaged marinated chicken as a function of storage time. Biogenic amines such as histamine, putrescine, tyramine and cadaverine have been implicated as indicators of meat product decomposition (Kaniou *et al.*, 2001).

Carbon dioxide produced during microbial growth can in many instances be indicative of quality deterioration. Hydrogen sulphide, a breakdown product of cysteine, primarily produced during the spoilage of meat and poultry by a number of bacterial species with intense off-flavours. It forms as a green pigment, sulphmyocin, when bound to myoglobin and this pigment formed the basis for the development of an agarose-immobilised, myoglobin-based freshness indicator for unmarinated broiler pieces (Smolander *et al.*, 2002).

Time-temperature indicators

The shelf-lives of meat and meat products are very sensitive to temperature variation, and it is one among the major cause of deterioration and economic loss during transportation, handling, distribution, storage, and consumption. The time temperature indicators directly or indirectly show if there is no proper



cold chain is maintained. These are commonly used in the food industry because they are relatively small, cost-effective, and user-friendly when compared to other temperature-monitoring devices.

A time-temperature indicator or integrator (TTI) may be defined as a device used to show a measurable, time- temperature dependent change that reflects the full or partial temperature history of a food product to which it is attached (Taoukis, 2001). Operation of TTIs is based on mechanical, chemical, electrochemical, enzymatic or microbiological change and usually expressed as a visible response in the form of colour development or colour movement. The visible responses thus give a cumulative indication of the storage temperature to which the TTI has been exposed. TTIs are small tags or labels that keep track of time-temperature histories to which a perishable product is exposed from the point of manufacture to the retail outlet or end-consumer.

There are 2 types of TTIs namely Diffusion-based TTIs and Enzymatic TTIs. Diffusion-based TTIs are dependent on the diffusion of a coloured fatty acid ester (indicator substance) along a porous wick made of high quality blotting paper while Enzymatic TTIs are based on a colour change induced by a drop in pH resulting from the controlled enzymatic hydrolysis of a lipid substrate.

Radio Frequency Identification tags (RFID)

RFID is based on wireless communication (magnetic field or electromagnetic wave) that can provide real-time information about temperature, relative humidity, and nutritional and supplier information as the product moves through the supply chain, thus increasing traceability and ensuring food safety and quality (Bibi, Guillaume, Gontard, & Sorli, 2017). RFID is more convenient for product identification than traditional labels and barcodes. These has a relatively large data storage capacity, longer reading range (up to dozens or even more than 100 m of distance), and does not require any visual contact. RFID technology does not fall into either sensor or indicator classification but it represents a separate electronic information based form of intelligent packaging. RFID uses tags affixed to assets (cattle, containers, pallets, etc.) to transmit accurate, real-time information to a user's information system.

RFID is one of the many automatic identification technologies (a group which includes bar codes) and offers a number of potential benefits to the meat production, distribution and retail chain. These include traceability, inventory management, labour saving costs, security and promotion of quality and safety (Mousavi *et al.* 2002). RFID tag contains a tiny transponder and antenna that have a unique number or alphanumerical sequence; the tag responds to signals received from a reader's antenna and transmits its number back to the reader.

RFID tags have the advantage over barcoding in that tags can be embedded within a container or package without adversely affecting the data. RFID tags can hold simple information (such as identification numbers) for tracking or can carry more complex information such as temperature and relative humidity data, package date, nutritional information, cooking instructions etc. Common RFID frequencies range from low (125 kHz) to UHF (850–900 MHz) and microwave frequencies (2.45 GHz). Low frequency tags are cheaper, use less power and are better able to penetrate non-metallic objects. These tags are most appropriate for use in meat industry.

2. Active Packaging

Active packaging refers to the incorporation of additives into packaging systems (whether loose within the pack, attached to the inside of packaging materials or incorporated within the packaging materials themselves) with the aim of maintaining or extending meat product quality and shelf-life. Active packaging



has been defined as packaging, which changes the condition of the packed food to extend shelf-life or to improve safety or sensory properties, while maintaining the quality of packaged food (Ahvenainen, 2003).

As per Hutton, 2003, packaging may be termed as active when it performs some desired role in food preservation other than providing an inert barrier to external conditions. Active packaging systems include use of oxygen scavengers, carbon dioxide scavengers and emitters, moisture control agents and anti-microbial packaging technologies. Thus these additives enhance the preservation function of the primary packaging system.

Examples of active packaging applications for use within the food industry

Absorbing/scavenging properties for oxygen, carbon dioxide, moisture, ethylene, flavours, releasing/emitting properties for carbon dioxide, antioxidants, sulphur dioxide, ethanol removing properties food component removal: lactose, cholesterol, temperature control insulating materials, self-heating and self-cooling packaging, microwave susceptors and modifiers, microbial and quality control antimicrobial films.

Oxygen scavengers

High levels of oxygen present in food packages may facilitate microbial growth, off flavours, off odours development, colour changes and nutritional losses thereby causing significant reduction in the shelf life of foods. Therefore, control of oxygen levels in food packages is important to limit the rate of such deteriorative and spoilage reactions in foods. Since vacuum packaging do not always facilitate complete removal of oxygen; these O₂ scavengers helps to absorb the residual O₂ after packaging thus oxygen absorbing systems provides an alternative to vacuum and gas flushing technologies as a means of improving product quality and shelf life (Ozdemir and Floros, 2004) also minimizes quality changes in oxygen sensitive foods (Vermeiren *et al.*, 1999).

Existing oxygen scavenging technologies utilize one or more of the following concepts: iron powder oxidation, ascorbic acid oxidation, photosensitive dye oxidation, enzymatic oxidation e.g. glucose oxidase and alcohol oxidase (Floros *et al.*, 1997). The majority of currently commercially available oxygen scavengers are based on the principle of iron oxidation (Smith *et al.*, 1990)

The oxygen scavengers can be in the form of a sachet, label, film (incorporation of scavenging agent into the packaging film), card, closure liner or concentrate (Suppakul *et al.*, 2003) which can reduce the oxygen levels to less than one per cent. According to Gill and McGinnis (1995) discoloration can be prevented in ground beef if large numbers of oxygen scavengers are used in each pack to bring residual oxygen to <10 ppm within 2 hours at a storage temperature of 1.5°C. The inclusion of oxygen scavengers in master packs flushed with 50% CO₂: 50% N₂ significantly improved the colour stability of muscle longissimus dorsi and psoas major. (Allen *et al.* 1996, Tewari *et al.* 2001).

Cryovac (OS2000) a polymer-based UV light-activated oxygen scavenging film which is structurally composed of an oxygen scavenger layer extruded into a multilayer film,

can reduce headspace oxygen levels from one per cent to ppm levels in 4–10 days and are used in a wide variety of food products including dried or smoked meat products and processed meats (Butler, 2002).

Carbon dioxide scavengers and emitters

Carbon dioxide (CO₂) efficiently inhibits surface growth by a range of aerobic bacteria and fungi by reducing relative oxygen levels and/or exerting direct antimicrobial effects (at concentrations of CO₂ between 10 per cent and 80 per cent) in food packaging. CO₂ is thus often used as a flushing gas in MAP systems to help maintain freshness and prolong shelf-life, especially for fresh meat, poultry, fish, and cheese packaging.



Carbon dioxide emitter systems are based on either ferrous carbonate or a mixture of ascorbic acid and sodium bicarbonate (Rooney, 1995). This package consists of a standard MAP tray but has a perforated false bottom under which a porous sachet containing sodium bicarbonate/ascorbate is positioned. When juice exudates from the packaged meat drips into the sachet, carbon dioxide is emitted, thus replacing any carbon dioxide absorbed by the meat and preventing package collapse. The inhibition of spoilage bacteria utilizing this active packaging technology may reduce bacterial competition and thus prevents the growth and toxin production by non proteolytic *C. botulinum* or the growth of other pathogenic bacteria (Sivertsvik, 2002).

Carbon dioxide absorbers (sachets), consisting of either calcium hydroxide, sodium hydroxide, potassium hydroxide, calcium oxide and silica gel may be used to remove carbon dioxide during storage in order to prevent bursting of the package. They have been used in packs of dehydrated poultry products and beef jerkey (Ahvenainen, 2003).

Moisture absorbers.

If water activity of the product is lowered, microbial growth could be suppressed (Vermeiren *et al.*, 1999). Moisture absorbers are most well known examples of active scavenging packaging and mostly rely on the adsorption of water by incorporating absorbing substances (such as silica gel, molecular sieves, calcium oxide, and natural clays) into a sachet for use with the packaging (Dainelli *et al.*, 2008).

The moisture controlling systems are available in the form of sheets or pads and it consists of a super absorbent polymer located between two layers of a micro-porous or non-woven polymer. Such sheets are used as drip absorbing pads which could be placed under whole chickens or chicken cuts (Suppakul *et al.*, 2003). Some of the commercial moisture absorbers are minipax, dri-loc and moistcatch TM.

Antimicrobial packaging

The main reasons for the deterioration of meat quality is microbial growth, which leads to discoloration, off-flavor development, textural changes, and the loss of nutritive value, and thus reduces the shelf-life of foods and increases the risk of food-borne illness. Incorporation of bactericidal agents into meat formulations may result in partial inactivation of the active compounds by meat constituents and therefore exert a limited effect on surface microflora (Quintavalla and Vicini, 2002). Antimicrobial food packaging materials extends the lag phase and reduces the growth phase of microorganisms in order to extend shelf life and to maintain product quality and safety (Han, 2000).

The classes of antimicrobials listed range from acid anhydride, alcohol, bacteriocins, chelators, enzymes, organic acids and polysaccharides. These antimicrobial agents may be coated, incorporated, immobilized, or surface modified onto package materials (Suppakul *et al.*, 2003). In Japan, Ag-substituted zeolite is the most common antimicrobial agent incorporated into plastics. Ag-ions inhibit a range of metabolic enzymes and have strong antimicrobial activity (Vermeiren *et al.*, 1999). Antimicrobial films can be classified into two types: those that contain an antimicrobial agent which migrates to the surface of the food and, those which are effective against surface growth of microorganisms without migration.

Coating of films with antimicrobial agents

Coating of films with antimicrobial agents could result in effective antimicrobial activity packaging films such as Poly Vinyl Chloride (PVC) and Linear low density polyethylene (LLDPE) coated with nisin were effective in reducing *S. typhimurium* on the surface of fresh broiler skin and drumsticks (Natrajan and Sheldon 2000).



Incorporation of antimicrobial agents

By direct incorporation of antimicrobial additives in packaging films, antimicrobial activity could be effectively achieved. Antimicrobial films were also prepared by incorporating acetic or propionic acid into a chitosan matrix, with or without addition of lauric acid or cinnamaldehyde, and were applied onto bologna, regular cooked ham or pastrami where growth of Enterobacteriaceae and *Serratia liquefaciens* (surface inoculated onto the meat products) was delayed or completely inhibited as a result of film application (Ouattara *et al.*, 2000). Devlieghere and Debevere, 2002 reported that a 1.0 per cent triclosan film had a psychrotrophic and strong antimicrobial effect which could be used in vitro simulated vacuum packaged conditions against the food pathogen *Listeria monocytogenes*. Siragusa and Dickson (1993) demonstrated that alginate coatings containing organic acids were marginally effective on beef carcasses in reducing levels of *L. monocytogenes*, *S. typhimurium* and *E. coli* 0157:H7 by 1.80, 2.11 and 0.74 log cycles, respectively.

Naturally derived antimicrobial agents

Naturally derived antimicrobial agents represent a lower perceived risk to the consumer (Nicholson, 1998). Skandamis and Nychas (2002) studied the effect of volatile oregano essential oil on the sensory, microbiological and physiochemical attributes of fresh beef stored at 5 and 15°C where longer shelf life was observed in samples supplemented with the volatile compounds of oregano essential oil.

Conclusion

Food packaging technologies like active and smart packaging are improving continuously in response to the ever-increasing demand for high-quality safe foods with change in lifestyle. However, the constrain for wider implementation and commercial application of these technologies in the food industries could be high cost and are also associated with some technical constraints. Focus should be therefore made to overcome the existing challenges by application of nanotechnology. Finally, continuous research and development should be performed based on collaboration between government regulatory agencies, industries, consumers, and multidisciplinary experts in order to increase the safety and effectiveness of new food packaging technologies and ensure the sustainable growth of modern societies.

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(Reference will be available from author)

Oral Presentations

FPP-1

EFFECT OF HUMECTANTS ON THE SHELF LIFE OF CHICKEN SAUSAGE STORED AT AMBIENT TEMPERATURE

S.Ezhilvelan, V.Appa Rao, Robinson.J.J.Abraham, V. Balakrishnan and Daniel. Joy Chandran

Department of Livestock Products Technology (Meat Science), Madras Veterinary College, Chennai

Inadequate cold storage facilities is one of the most important factors that has impeded the development of the processed meat sector in developing countries, including India. Hence, there is a need to develop safe, nutritious and acceptable shelf stable meat products with application of milder techniques and can be stored / marketed without refrigeration. Hence, a study on the effect of humectants on the shelf life of chicken sausages stored at ambient temperature was carried out. Sorbitol at 1%, Texturised Soy Protein (TSP) at 2% and a combination of 0.5% Sorbitol and 1% TSP were used as humectants to reduce the water activity of the sausage to 0.93 and they were the treatments, T1, T2 and T3 respectively and the control was sausages prepared using the standard methods adopted at the department. Analysis revealed a significantly higher emulsion pH in T2, lower emulsion pH in T1, ($P \leq 0.01$), higher emulsion stability and cooking yield in the treatments. The pH, and a_w was significantly ($P \leq 0.01$) lower in the treatments. Tyrosine value was significantly different between the treatments at 30 hrs ($P \leq 0.05$) and 36 hrs ($P \leq 0.05$) though overall means did not differ significantly. TBARs values were significantly different between storage periods and in overall storage means only. Hardness, gumminess and chewiness were significantly different between the treatments. Microbial counts were significantly lower in treatments. Treatments secured significantly higher sensory scores. Analysis of variance revealed highly significant difference ($P \leq 0.01$) between the treatments (at 0 day and 30 hours), between the storage periods, between overall treatment means and between overall storage means. Further, the control group was microbiologically stable only at 24 hours of storage, whereas all the treatment groups were microbiologically stable up to 30 hours of storage.

FPP-2

COMPARATIVE EFFECT OF GREEN TEA EXTRACT AND BUTYLATED HYDROXY ANISOLE ON THE KEEPING QUALITY OF VALUE ADDED CHICKEN MEAT SAUSAGES

D.Maheswara Reddy^{*1}, A.Jagadeesh Babu², B.Eswara Rao¹, PRS Moorthy¹, G.V. Bhaskar Reddy and S.Vani³

¹ Department of Livestock Products Technology, CVSc, Proddatur, SVVU, India

² Department of Veterinary Public Health & Epidemiology, CVSc, Tirupati, SVVU, India

³ Department of Animal Genetics & Breeding, CVSc, Proddatur, SVVU, India

The present investigation was designed to know the effect of Green tea extract (*Camellia sinensis*) at 0.2 % level on the keeping quality of value added chicken meat sausages and to compare it's effect with the synthetic antioxidant i.e., Butylated Hydroxy Anisole (BHA) at 0.01 % under refrigeration ($4 \pm 1^\circ\text{C}$) for a period of 8 days. Significantly ($P < 0.05$) lower values for cooking loss, pH, 2-TBARS and free fatty acid content were recorded due to the incorporation of green tea extract at 0.2 % level. However, emulsion stability



and WHC of chicken meat sausages decreased significantly ($P<0.05$) during the course of refrigeration storage. Microbiological quality evaluation revealed that chicken meat sausages incorporated with green tea extract at 0.2 % level had significantly ($P<0.05$) lower standard plate count and coliform count during refrigerated storage as compared to control and other treatment. Organoleptic evaluation indicated that addition of green tea extract at 0.2% level to chicken meat sausages registered significantly ($P<0.05$) higher sensory scores for various eating quality attributes than the control and BHA. However, there was a significant ($P<0.05$) decrease in all the quality and microbial parameters as the storage period increased irrespective of treatment under refrigerated conditions. Hence, addition of Green tea extract at 0.2 % in chicken meat sausages would not only protect the product longer against oxidative rancidity but also had higher acceptability than control and synthetic BHA.

FPP-3

EFFECT OF TURMERIC POWDER ON PHYSICO – CHEMICAL PROPERTIES OF QUAIL CARCASS DURING REFRIGERATION ($4\pm 1^{\circ}\text{C}$) STORAGE

R. Sai Dilip Gupta, D. Maheswara Reddy and M. Naveen Kumar Reddy

Department of Livestock Products Technology, CVSc, Proddatur, SVVU, India

The present investigation was carried out to know the effect of Turmeric powder application on quail carcasses packed under aerobic and vacuum conditions stored at $4\pm 1^{\circ}\text{C}$. Turmeric powder (*Curcuma longa*) at 0.66 % level was added as per weight of quail carcass to check the physico -chemical quality under refrigeration ($4\pm 1^{\circ}\text{C}$) for a period of 6 days. Physico- chemical properties viz., Shrinkage loss, pH, TBARS, free fatty acid and Tyrosine values were evaluated on 0,2,4,6 days of storage. Significant differences in pH, Shrinkage loss, TBARS, free fatty acid, Tyrosine values were noted between treatments. The application of turmeric powder both in aerobic and vacuum packed carcasses showed significantly ($P<0.05$) lower values for shrinkage loss, pH, TBARS, free fatty acid and tyrosine values compared to their control. Turmeric added vacuum packed quail carcasses recorded significantly ($P<0.05$) lower values when compared to turmeric added aerobic packed quail carcasses and their control. However, physico -chemical parameters decreased non- significantly ($P<0.05$) during the course of refrigeration storage. Organoleptic evaluation indicated that there was no significant difference among turmeric treated carcasses and control carcasses irrespective of packaging method but values were decreased as the storage period increased. Hence it was concluded that Turmeric application will improve the quail carcass quality compared to control during refrigeration storage.

FPP-4

EFFECT OF PACKAGING METHODS ON THE KEEPING QUALITY OF RESTRUCTURED CHICKEN CHUNKS

J.Indumathi, M.Shashi Kumar, G.V.Bhasakar Reddy, Z.Naveen, V.Kesavarao and N.Anitha

Effects of packaging on physicochemical, microbiological and sensory properties in restructured chicken chunks were determined. The products were packaged vacuum and aerobically in low density



polyethylene (LDPE) pouches and analyzed at regular interval of 7 days for 35 days during refrigerated storage ($4\pm1^{\circ}\text{C}$). Results revealed that the SPC, Coliforms, thiobarbituric acid-reactive substances (TBARS), pH and tyrosine values obtained were significantly ($P < 0.05$) low in vacuum packaged restructured chicken chunks than aerobically packed and mean values were increased significantly ($P < 0.05$) as refrigerated storage period advances in both control and treatment. Yeast & mould counts were not detected both in control and treatment during entire storage period. The sensory scores of treatment and control for appearance, flavour, tenderness, juiciness and overall acceptability showed a progressive decline with increase in storage period. The treatment retained good acceptability for 35 days without any marked loss of physico chemical, microbiological and sensory quality, whereas control restructured chicken chunks which were packaged aerobically spoiled within 21 days of storage. Therefore, use vacuum packaging would be useful to control the oxidative quality changes of restructured chicken chunks.

FPP-5

QUALITY OF CHICKEN MEAT BALLS COATED WITH NANO EMULSIONS OF CARDAMOM ESSENTIAL OIL

E. Naga Mallika, M. Haritha and B.EswaraRao

Department of Livestock Products Technology,
NTR College of Veterinary Science, Gannavaram

Nano-emulsion based edible coatings containing cardamom essential oil as active ingredient were applied onto chicken meat balls to extend its shelf life. The efficacy of application of active ingredients as nano emulsions instead of coarse emulsion was evaluated. Nano emulsions were formulated with 2% Sodium alginate, 2.5% Tween 80 and with incorporation of 1.5% and 2.5% of CEO as different treatments. Control balls were uncoated and another first treatment group was coated with the above coarse emulsions. The coated balls were fried and analyzed for oil absorption and moisture content throughout the storage period. Sensorial attributes and the physical-biochemical changes were measured during the frying process. The pH was non-significantly different between treatments. Water loss was less in coated samples when compared to uncoated counter parts. Thio-barbituric acid values and peroxide values, total plate counts were lower in nano emulsion coated samples followed by coarse emulsion coated samples and lowest values were recorded in treatment incorporated with high concentration of cardamom essential oil. In the sensorial analysis, the nano emulsion coated samples were much more preferred than those that were coated with coarse emulsion.

FPP-6

ACTIVE TRAY PACKAGING OF GOAT LIVER WITH DIFFERENT WRAP FILMS AT REFRIGERATION TEMPERATURE ($4\pm1^{\circ}\text{C}$)

**Safier Ahmad Ganee, I.Prince Devadason*, S.K.Mendiratta, Rajiv Ranjan Kumar and
Dipak Kumar Banerjee**

Division of Livestock Products Technology
Indian Veterinary Research Institute, Izatnagar, Bareilly, UP

Goat (*Capra hircus*) liver is an important edible meat byproduct. It is highly nutritious but having very low shelf life. The present study was conducted to establish the shelf life of goat liver, stored at $4\pm1^{\circ}\text{C}$,



using different wrap films in food grade plastic tray. Fresh liver chunks were packed using LDPE, HDPE and PVC overwraps with oxygen absorber sachet in polystyrene trays. LDPE overwrap tray without oxygen absorber was kept as control. Shelf-life evaluation was based on color, lipid and hemopigment oxidation, microbial counts, and sensory assessment of odor and color. Headspace analysis was carried out during the storage time. Control samples stored without oxygen absorber showed the highest lipid and hemopigment oxidation rate, which was detected by higher thiobarbituric acid reactive substances values and metmyoglobin percentage and lower heme iron content than livers stored in trays with oxygen absorber. On the basis of aerobic bacteria counts, the shelf life of control liver stored under aerobic conditions would be 4 days, whereas active packaged tray with HDPE overwrap, it would be 9 days. Minimal changes in color perception were also obtained in HDPE wrapped samples at the end of the storage period. In LDPE wrapped tray(with and without oxygen absorber) high levels of off-odors were already perceived during the first 6 days of storage, whereas in livers stored in PVC and HDPE wraps, these levels of off-odor were not yet perceived at that time.

FPP-7

EFFICACY OF DIFFERENT FILMS AS WRAP OF TRAY FOR FROZEN CHICKEN NUGGETS

**Dipak Kumar Banerjee, I Prince Devadason,* R. K. Agrawal,
Saffier Ahmad Ganjee and Dhananjay Kumar**

Division of Livestock Products Technology, ICAR-IVRI, Izatnagar, Bareilly

Proper packaging is one of the major constraints in marketing of poultry products. The objective of this study was to evaluate the effect of different packaging films namely low density polyethylene(LDPE), high density polyethylene(HDPE), linear low density polyethylene(LLDPE) and polyvinyl chloride(PVC) on acceptability of chicken nuggets stored at $-18\pm 2^{\circ}\text{C}$. The physico-chemical (pH, instrumental colour, water activity, thiobarbituric acid reactive substances(TBARS), tyrosine value(TV), Warner-Bratzler shear force(WBSF) and free fatty acid(FFA)), sensory and microbiological (total plate count (TPC), yeast and mold count (YMC), coliform count (CC) and psychrophilic count (PC)) parameters were studied in triplicate at 1 month interval upto 3 months. There was a gradual increasing trend in pH, TBARS, TV, FFA values, sensory scores and PC whereas declining trend in colour (L, a, b), water activity, WBSF values and TPC for all the treatments during storage. The water activity of HDPE packaged nuggets was highest and PVC packaged nuggets was lowest whereas TBARS and FFA values were lowest for HDPE packaged films at the end of storage period. The change in lightness, redness and yellowness were minimum for PVC packaged nuggets during storage. HDPE packaged nuggets showed a significantly higher sensory scores except texture during 2nd and 3rd month of storage. TPC decreased from 2.46 ± 0.078 to 1.97 ± 0.067 , 2.02 ± 0.054 , 2.06 ± 0.065 and 2.06 ± 0.079 $\log_{10}\text{cfu/g}$ for HDPE, LDPE, LLDPE and PVC packaged nuggets respectively. The PC was absent on fresh nuggets and CC and YMC were absent throughout the storage period for all the treatments. Though the chicken nuggets sealed with HDPE, LDPE, LLDPE and PVC were acceptable for a period of 3 months at $-18\pm 2^{\circ}\text{C}$, HDPE packaged nuggets exhibited comparatively better acceptability than other films.

Poster Presentations

FPP-8

DEVELOPMENT AND QUALITY EVALUATION OF SHELF STABLE JAPANESE QUAIL GIZZARD PICKLE

M. Anna Anandh and R. Annal Villi*

Tamil Nadu Veterinary and Animal Sciences University (TANUVAS),
Department of Livestock Products Technology, Veterinary College and Research Institute,
Tirunelveli – 627 358, Tamil Nadu, India.

* Department of Poultry Technology, College of Poultry Production and Management,
Hosur – 635 110, Tamil Nadu, India.

Japanese quails (*Coturnix coturnix japonica*) are slaughtered mainly for meat, the by - products that are emanated from slaughtered Japanese quail are also of good value. Gizzard is one of the important edible offal and yielding about 2.5 to 3.0 % per bird. Texture of quail gizzard is tough and rubbery due to characteristic muscular construction, poor functional properties and shelf life. It is necessary to evolve appropriate technologies to convert the tough and perishable Japanese quail gizzard into convenience and more acceptable novel products. In this perspective, a study was conducted for the preparation of vinegar based shelf stable quail gizzard pickle and assessed their storage stability at room temperature at an interval of 15 days up to 90 days. The mean pH, product yield (%), moisture (%), protein (%), fat (%), ash (%), titrable acidity (% acetic acid), free fatty acid (% oleic acid) and TBA value (mg malonaldehyde / kg meat) of the freshly prepared pickle were 5.53 ± 0.06 , 94.66 ± 0.24 , 47.33 ± 0.70 , 23.43 ± 0.22 , 14.46 ± 0.15 , 2.84 ± 0.10 , 1.53 ± 0.24 , 0.75 ± 0.16 and 1.15 ± 0.32 , respectively. pH, moisture and titrable acidity values were non significantly increased whereas free fatty acid and TBA values were significantly ($p < 0.05$) increased during the storage at room temperature up to 90 days. Total plate, coliform and yeast and mould counts of the quail gizzard pickle remained satisfactory up to 90 days of storage at room temperature and the microbial counts were within the standard stipulated for cooked meat products. Sensory attributes of the quail gizzard pickle such as appearance and colour, flavour, tenderness, saltiness, sourness and overall palatability on 9 - point hedonic scale did not alter and the product remained highly acceptable throughout storage. Therefore, it can be concluded that pickle prepared from Japanese quail gizzard had better physico-chemical and microbial qualities up to 90 days of storage at room temperature. Finding of this study have shown that Japanese quail gizzard can be successfully used for preparation of shelf stable pickle of acceptable quality with substantial value addition to the materials.



FPP-9

EFFICACY OF NANO ENCAPSULATED ROSEMARY ESSENTIAL OIL ON STORAGE STABILITY OF PORK NUGGETS DURING REFRIGERATED STORAGE

**K. Yogeswari, G.V. Bhaskar Reddy, B. Eswara Rao, A. Jagadeesh Babu, TNVKV Prasad,
E. Nagamallika and B. V. Vivekananda Reddy**

Department of Livestock Products Technology, NTR College of Veterinary Science,
Sri Venkateswara Veterinary University, Gannavaram.

The present investigation was carried out to estimate comparative anti-oxidant and anti-microbial efficacy of rosemary essential oil (REO) at 0.05 %, nano encapsulated rosemary essential oil (NREO) at 0.01 per cent added pork nuggets with control and synthetic antioxidant (BHT) at 0.01 % added pork nuggets were determined by evaluating physico-chemical, microbial and sensory quality at 5 days regular interval up to 30 days during refrigeration ($4\pm 1^{\circ}\text{C}$) temperature. Pork nuggets added with NREO had significantly ($P<0.01$) lower pH, 2-TBARS values (mg malonaldehyde/kg of product), tyrosine value (mg/100 g of product) and per cent FFA values than control and pork nuggets added with BHT and REO. Control and pork nuggets added with BHT were spoiled after 15 days of refrigerated storage. Pork nuggets added with 0.01% NREO had significantly ($P<0.01$) lower total plate counts, total psychrophilic count than control and remaining formulations. Coliform counts were not detected up to 5th day in control and all treated nuggets. From 10th day onwards total coliform counts were noticed. Pork nuggets added with 0.01% NREO significantly ($P<0.01$) lower coliform count than control and other formulations. The overall mean $\pm$ S.E value of 0.01% NREO added pork nuggets had significantly ($P<0.01$) lower staphylococcal counts than control, 0.01% BHT and 0.05% REO added pork nuggets. Pork nuggets added NREO had significantly ($P<0.01$) lower total yeast and mould count than control and remaining formulations. Pork nuggets added with 0.01% NREO had significantly ($P<0.01$) higher colour, flavour, juiciness, mouth coating and overall acceptability scores than control and remaining formulations. As storage period progressed, there was significant ($P<0.01$) detrimental effect in sensory scores between control and treated nuggets. Based on the above findings, it was concluded that addition of nanocapsulated rosemary essential oil at 0.01% per cent was an excellent anti-oxidant and antimicrobial agent and protecting sensory attributes during refrigerated ($4\pm 1^{\circ}\text{C}$) storage and maintain the shelf-life of pork nuggets up to 30 days without any significant quality deterioration.

FPP-10

DEVELOPMENT AND EVALUATION OF CHICKEN FILLETS INCORPORATED WITH *LACTOBACILLUS SAKAI*

Pompi R. Boro*, Pragati. H.¹, Kevimese K¹. and Kuleswan Pame*

Department of Livestock Products Technology, College of Veterinary Sciences &
Animal Husbandary. CAU, Selesih, Aizawl – 796014, Mizoram.

*MVSc, ¹Assistant Professor

An investigation was carried out to study the effect of *Lactobacillus sakei* as a protective culture on storage life of chicken fillets, under refrigeration temperature ($4\pm 1^{\circ}\text{C}$) in vacuum packaging. Chicken fillets were allotted to three different treatment groups Treatment 1: Chicken fillets (Control), Treatment 2: (Chicken



fillets treated with *Lactobacillus sakei* @ 10^8 cfu/g), Treatment 3: (Chicken fillets treated with curing ingredients and *Lactobacillus sakei* @ 10^8 cfu/g). Different physico-chemical and sensory parameters were analyzed at a periodic interval. The pH, WHC and moisture content of all the treatments decreased significantly with advancement of storage period. Protein per cent of T1 was significantly higher than T2 and T3. Fat content and Shear force required to cut the samples increased significantly on progressive storage days in all the treatments. The overall sensory attributes and acceptability of T2 was significantly higher than T1 and T3. From the above study it can be inferred that the use of *Lactobacillus sakei* could be effectively used as biopreservative culture for storage life of chicken fillets under refrigeration temperature and was a successful attempt as superior sensory attributes. Combined Treatment of the chicken fillets with curing ingredients and starter culture ensured a longer shelf of the product.

FPP-11

PLASMA TECHNOLOGY IN MEAT PRESERVATION

Priyanka Meena, Anurag Pandey, Ashish Saini, Sarita Kumari, Asman Singh Gurjar,

Ravi Raman, Shrawan Kumar Meel and Vilshan Kumar Chauhan

Department of Livestock Products Technology;

Post Graduate Institute of Veterinary Education and Research, Jaipur

Development of various novel thermal and nonthermal techniques has shown potential applications in meat processing and preservation. Among various preservation processing techniques, plasma technology has also been extensively used to extend shelf life of meat and meat products. Cold plasma technology is also used to inactivate endogenous enzymes which are responsible for browning reactions particularly polyphenoloxidase and peroxidases. This technology also reduced growth of microorganism via different mode of actions by etching phenomenon, cell disruption by electrophoration etc. Plasma technology is considered as modern non conventional technique which is used for the preparation of modified starches, altering its physical and chemical properties. Overall application of cold plasma for microbial destruction on different food substrates like fruits, meat products, cheese etc. It is an eco-friendly process which is used in the preservation of food and other potential applications as an alternative to common techniques. Future prospects regarding the application of plasma technology in meat industry include designing of plasma treatment system that can adjust in the existing processing line, combination of plasma treatment with other hurdles for more effective meat decontamination, and use of plasma activated water in meat industry. Hence, plasma technology can be used as a partial replacement to the conventional techniques for decontaminating meat and meat products.



Technical Session - V

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Key Note Addresses

Session-V : Key Note Address-01

ANTIBIOTIC FREE FOOD PRODUCTION SYSTEMS – STRATEGIES AND CHALLENGES

B. Sunil and Muralikrishna. P

Meat Technology Unit, College of Veterinary and Animal Sciences, Mannuthy,
Thrissur- 680651. E- mail: sunil@kvasu.ac.in, 9497626575

Introduction

Food safety and its association with antimicrobial usage is one of the most critical issues faced by developing and transitional countries. Antimicrobials are used in food production systems to maintain health and productivity of animals. Antimicrobials at sub-therapeutic levels have been used for growth promotion, improved feed efficiency and enhanced performance of animals/birds in production system. Of late, there has been emergence of resistant strains owing to the indiscriminate use of antimicrobials and changes in microbial gene dynamics (Enberg *et al.*, 2001, Phillips *et al.*, 2004). The development and spread of resistance in zoonotic bacteria with its reservoirs in healthy food producing animals and birds has become a global public health problem (EFSA, 2012). Resistant bacteria of animal origin could be transmitted to humans through the environment, food products and to occupational group by direct contact. In low- and middle-income countries, rising incomes have driven an unprecedented growth in demand for animal protein and as a result, the global biomass of animals raised for food now exceeds the global biomass of humans. To meet this demand, India and other developing countries has shifted towards highly cost-efficient and vertically integrated intensive livestock production systems. Since these production systems necessitate the use of antimicrobials to keep animals healthy and maintain productivity, rising incomes in transitioning countries are effectively driving an increase in antimicrobial consumption and thereby antimicrobial resistance. Rapid increase in production is always associated with improper biosecurity measures, necessitating increased use of antibiotics to eliminate infectious pathogens. This misuse and overuse of antimicrobials in food production systems has contributed to emergence of resistant strains of bacteria globally. If the status quo continues, by 2050, it is estimated that the rise of drug resistant infections could cost 10 million lives a year and a cumulative \$100 trillion of economic output (WHO, 2015).

The trend now has shifted towards creating antibiotic free production systems (ABF). The production of antibiotic-free (ABF) food systems have gained further importance since the use of growth promoting antibiotics (GPA) has been restricted according to global action plan. The consumers are also increasingly avoiding food products that contain antibiotics. Transformation towards ABF production systems is challenging and expensive initially because no antibiotics including ionophores should be used in their feed, water, or injection. This strict definition of ABF can certainly make the growing of chickens and the prevention and control of diseases much more inefficient, expensive, and challenging. Farms with a good health status and proper biosecurity measures, has a smoother transition compared to farms with a history of enteric and respiratory problems. Most often, these farms creates a higher firewall for pathogens—signalling



that the foundation of an ABF production system is prevention through implementation of biosecurity measures.

ABF Production Systems – Challenges & Strategies

ABF food production systems, depends on standard ABF programs that allow use of chemical antibacterials, chemical anticoccidials, and ionophores, but no antibiotics. There are numerous challenges faced by farm managers for successful production of ABF systems which typically involve one or more of the following:

- 1) Production challenges (raising ABF, organic, split birds or 100% ABF, separate processing plants, etc.)
- 2) Management challenges (reducing stocking density, increasing down-time, cleaning-out more frequently, maintaining ideal temperature, keeping strict biosecurity, reducing stress, breed selection, etc.)
- 3) Health challenges (increased enteric and systemic diseases)
- 4) Animal welfare challenges (establish when and how to treat, option to divert to conventional program, etc.)

A producer raising ABF production systems, should be prepared to deal with a variety of health challenges particularly intestinal health. Improper biosecurity measures could lead to cross-contamination in food production systems. New strains of pathogenic organisms could be introduced into farms where animals could act as amplifier host with wild life reservoirs. Humans could also acquire infections especially farmers and working groups through contaminated environment and during animal management (Mena, 2008). Improper health management associated with ABF production systems has resulted in establishment of pathogenic organisms in production systems.

Biosecurity Measures

Biosecurity programmes in ABF production systems generally includes access management, animal health management, environmental hygiene, wild reservoir control and general farm structural and operational improvements to reduce disease transmission. Other areas to be taken care of in ABF production facilities are production management, manure management, drainage improvements and reduced personnel movements in barns. Animal health programs and management practices go hand-in-hand in ABF production systems. Muralikrishna and Sunil (2018) reported that the occurrence of *Campylobacter* spp. was higher in swine production facilities where antibiotics usage was not regular and biosecurity measures were not followed. Also from these production facilities, more sensitive strains of *Campylobacter* spp. was isolated. Whereas, in well-established production facilities using antibiotics for therapeutic and prophylaxis, there was occurrence of higher resistant strains of *Campylobacter* spp. Hence, biosecurity interventions should be highlighted along with proper usage of antimicrobials in swine production systems. According to national action plan, control in antibiotic usage should be always supplemented with proper biosecurity measure in order to control infections of public health significance. Animal caretakers must implement and effectively follow health programs outlined by the herd veterinarian. Herd veterinarians should establish vaccine strategies to minimize disease outbreaks and develop sanitation programs to reduce the spread of disease. Animal caretakers must carefully follow these programs as well as establish good biosecurity programs and sound rodent control. In addition, animal caretakers need to evaluate the animal facilities and maintain those facilities as part of routine



maintenance and upkeep. Ventilation needs to be established by phase to reduce drafts on small pigs and also minimize any manure gases that may reduce performance. Selection of robust genetics that can tolerate a variety of environmental parameters will also improve the success of an ABF program.

Nutritional Status

Nutritional programs can have a significant impact on ABF production systems. In addition, ingredients other than antibiotics could be added to diets to help control or mitigate potential health challenges as the animals grows. In order to be effective in developing a nutritional program, nutritionists need to communicate with the farmer or the veterinarian to further understand the health status of the animals and also identify times during the animal's growth phase where health challenges may arise. While there are many ingredients on the market that claim to aid in gut health, digestion, feed efficiency, and feed intake, understanding the mode of action and expected outcome will aid in the nutritionist's decision process.

Dynamics of gut immunity, gut enzymes, and the microflora interactions should be well understood. Establishing a good population of beneficial gut bacteria that aid in digestion and reduce pathogenic bacteria balances around pH and substrates. For example, diets that are high in non-digestible feedstuffs allow significant nutrients to gut microflora, which increases for the potential of pathogens to overtake population and cause disease. Feeding highly digestible starches in early rations have been shown to improve gut health. The use of probiotics to maintain a certain population of microorganisms has been shown to be beneficial.

Final and major step towards ABF production systems and farm biosecurity is proper educational programmes which is also challenging. Educational programmes to farmers and workers should incorporate hygienic practices, better farming practices and proper knowledge on farm biosecurity.

Challenges Towards the Year 2050

Reinvigorating ABF food production systems is essential to sustainably address the global challenge of food security. The demand for food from animal agriculture is anticipated to nearly double by 2050. Increased demand is due, in part, to a predicted increase in world population from 7.2 billion to between 9 and 10 billion people in 2050. The increase in population puts additional pressure on the availability of land, water, and energy needed for animal and crop agriculture. During this period, it is also anticipated that there will be increase in emergence of pathogens of public health significance. Veterinarians also may have a philosophical disagreement with a policy of no use of antibiotics to prevent or treat disease. They will probably not endorse such policy unless steps are taken to ensure that treatment is not withheld from animals that need it regardless of the economic consequences for the company involved in the production of the animals. Additionally, another philosophical problem is likely to emerge when a professional is asked to support a system that is less efficient over benefits that cannot be scientifically documented and are only perceived as such by consumers that have been influenced at times by misleading advertisements. Therefore, the overall impact of ABF production should be carefully considered before making a decision. With the global trade and economy that exists today, food preference trends in one country, the first-world nations may have adverse, unintended consequences impacting the world's population in other countries. For example, by making production of ABF poultry production systems, more cropland (a very scarce and non-renewable resource) must be dedicated to the production of additional feed ingredients to make up for the loss in efficiency. Taking more cropland and natural resources (including water) from the environment to maintain the same meat output is not a desirable position in a world that is expected to add 64 million people each year from 2015 to 2020. Producing more animal waste to maintain the same meat output leads to increase in pollution of the environment and a larger carbon foot-print, so contrary to consumer perception, consuming



ABF meat has a greater environmental impact than consuming conventionally-produced meat. Finally, and more importantly, by making the production of poultry less efficient and requiring additional feed ingredient resources for the manufacturing of feed, ABF production could create additional demand for feed ingredients and, consequently, a rise in feed ingredient prices that impact both ABF and conventional production. Therefore, ABF production could make animal protein less accessible to those who need it most, the undernourished and hungry of the world.

Conclusion

ABF food production systems is likely to result in significant health and production challenges with corresponding adverse consequences on animal welfare. In terms of residues in edible tissues, all ABF animal production systems will meet FDA established tolerances, which are deemed to be safe for consumers. In terms of food safety, there are no scientifically documented benefits derived from producing ABF animals when compared to conventionally raised poultry. When properly cooked, stored and handled, meat will not contain any pathogens of public health significance. ABF production is less efficient than conventional production with antibiotics, and; therefore, its higher consumption of feed, water, and production of animal waste which could result in a larger carbon foot-print making it less sustainable. Despite the negatives aspects of ABF production, it suits well in developed countries and farms with proper biosecurity measures. If diseases are under control, ABF animal production system becomes more realistic and attainable. Incorporating essential oils and probiotics in feed in production systems could improve the economic basis of ABF production systems. However, if there are production problems and health management issues, ABF production becomes much more difficult if not impossible because the animals that you start with on the farm is already compromised and will probably require antibiotic treatment sometime during the grow-out period. Shifting towards antibiotic free production is going to be a challenge as it should be backed with proper health management and biosecurity measures.

(References will be available from Author)

Lead Papers

Session-V : Lead Paper-01

RECENT TRENDS IN ANTIMICROBIAL RESISTANCE OF EMERGING FOOD-BORNE PATHOGENS

***T. Srinivasa Rao** and **M. Soma Sekhar**

* Associate Professor and Head, Department of Veterinary Public Health and
Epidemiology, NTR College of Veterinary Science, Gannavaram,
Sri Venkateswara Veterinary University, Andhra Pradesh

Antimicrobial resistant emerging food-borne pathogens are biological hazards associated with increased human morbidity and mortality and are of public health concern. The use of antimicrobial agents in animals, plant production and the production of other sources of food and feed has adverse public health consequences by creating a reservoir of resistant bacteria and of bacteria-borne resistance genes that can be passed on to humans, both directly or indirectly. Such resistance respects neither geographical nor ecological borders. Mobile genetic elements harbouring resistance determinants can readily be transferred horizontally between bacteria from terrestrial animals, fish and humans; furthermore, such transfer can take place in natural environments such as the kitchen.

The use of antimicrobial agents for the treatment and control of infectious diseases in animals continues because of considerations regarding animal health and welfare. Emergence of antibiotic resistance is attributed to indiscriminate use of antibiotics particularly while treating the animals and humans for infectious diseases. The traditional food production systems could not respond to the increasing food demand as the global population is increasing to reach 8 billion by the end of 22nd century. Application of antibiotics as growth promoters in animal food production systems has been more popular in both developed and developing countries until the emergence of superbugs. With the result antibiotic resistant strains of Verotoxigenic *Escherichia coli* (VTEC), thermo tolerant *Campylobacter* spp., *Arcobacter* spp., *Listeria monocytogens* and *Clostridium difficile* are emerging as resistant food-borne pathogens.

Verotoxigenic *Escherichia coli* (VTEC):

Verotoxigenic *Escherichia coli* (VTEC) has emerged as a public health threat since its identification in 1982 in USA following an outbreak associated with the consumption of contaminated ground beef. Since then VTEC has been increasingly recognized as an important human diarrhoeal pathogen responsible for haemorrhagic colitis (HC) and hemolytic uraemic syndrome (HUS) in humans throughout the world following consumption of contaminated animal derived foods.

Antimicrobial susceptibility testing was performed on a total of 253 (203 STEC and 50 non-STEC), *Escherichia coli* isolates from different raw meat, RTE meat foods, water and human diarrhoeic samples. Among the 20 antimicrobial agents tested, resistance was most frequent for penicillin (253/253, 100%) followed by linezolid (249/253, 98.41%), erythromycin (245/253, 96.83%), streptomycin (232/253, 91.69%),



tetracycline (223/253, 88.14%), ampicillin 123/253, 48.16%), cephalexin (106/253, 41.89%), trimethoprim (93/253, 36.75%), co-trimoxazole (85/253, 33.59%), cefaclor (84/253, 33.20%), amoxycillin (79/253, 31.33%), ciprofloxacin (78/253, 30.83%), kanamycin (76/253, 30.03%), norfloxacin (62/253, 24.50%), ofloxacin (60/253, 23.71%), chloramphenicol (35/253, 13.83%), Polymyxin-B (27/253, 10.67%), colistin (25/253, 9.88%), amikacin (22/253, 8.69%) and gentamycin (17/253, 6.71%). Out of 203 Shiga toxin-producing *Escherichia coli* (STEC) isolates 73 (35.96%) isolates showed resistance to more than 50% of the antibiotics tested (Rao *et al.*, 2011).

The distribution of resistance determinants for tetracycline and streptomycin was assessed by PCR in resistant isolates. The most common resistance determinants were *tetA* (60%) and *tetB* (27%). Forty seven per cent of isolates contained both *strA* and *strB* genes, 33% and 10% isolates carried *strA* and *strB* gene, respectively and 10% of isolates did not carry either *strA* or *strB* or both genes. Cloning and sequencing of *tetA* and *tetB* genes of O69 *E. coli* isolate from buffalo meat showed 99-100% homology with published sequences of related isolates in GenBank. Antibiotic susceptibility studies revealed that meat, meat products, drinking water and human diarrhoeic samples contains multiple drug resistant strains of *E. coli* which may serve as a reservoir for antibiotic resistance genes in the food environment and may transmit to humans through food chain (Rao *et al.*, 2011).

***Arcobacter* species:**

The genus *Arcobacter* is new in the family Campylobacteriaceae. It is a comma shaped Gram negative bacteria and more than twenty species have been proposed under the genus *Arcobacter*, which signifies them as ever evolving pathogens. Of these, *A. butzleri*, *A. cryaerophilus* and *A. skirrowii* have gained consideration as emerging food and waterborne zoonotic pathogens. In addition, *A. butzleri* has been categorized as a "serious hazard" to human health by International Commission on Microbiological Specifications for Foods. An evidence based semi-quantitative method for prioritization of foodborne zoonoses ranked *A. butzleri* as a microbe of significant importance.

A total of 510 samples comprising faecal swabs of livestock (245), raw foods of animal origin (180) and human stools (85) were examined. Overall prevalence of *Arcobacter* species was found to be 11.7% (60/510) by genus-specific PCR. Among faecal samples of healthy livestock, pigs (23.3%) revealed the highest prevalence, followed by chicken (16.6%), turkey (15.0%), cattle (10.0%), duck (10.0%) and sheep (6.6%). Among foods of animal origin, pork samples (15.0%) revealed the highest prevalence, followed by chicken meat (12.5%), milk (10.0%) and mutton (7.5%). Among human stool samples, farm workers revealed highest prevalence (13.3%, 4/30) followed by veterinary students (8.0%, 2/25) and diarrhoeic humans (6.66%, 2/30). Out of 60 genus-specific PCR positive samples, multiplex-PCR assay enabled detection of *A. butzleri* (16/60), *A. cryaerophilus* (10/60), *A. skirrowii* (10/60), both *A. cryaerophilus* and *A. skirrowii* (9/60), both *A. butzleri* and *A. skirrowii* (5/60), both *A. butzleri* and *A. cryaerophilus* (4/60) and all the three *Arcobacter* species (6/60). Using cultural methods, a total of 41 (8.03%) *Arcobacter* isolates were recovered. Multiplex-PCR assay of 41 *Arcobacter* isolates enabled detection of *A. butzleri* (16/41), *A. cryaerophilus* (13/41) and *A. skirrowii* (12/41). All the *A. butzleri* isolates carried all six putative virulence genes. For *A. cryaerophilus* and *A. skirrowii*, the *cadF* gene was detected in 61.5% and 50%, *ciaB* in 84.6% and 91.6%, *cj1349* in 76.9% and 83.3%, *mviN* in 76.9% and 66.6%, *pldA* in 61.5% and 50% and *tlyA* in 61.5% and 50% of isolates, respectively (Sekhar *et al.*, 2017).

Antibiogram of *Arcobacter* isolates revealed sensitivity to tetracycline (100%), ciprofloxacin (95.1%) and gentamicin (82.9%). Higher resistance was observed for vancomycin (100%), co-trimoxazole (87.8%),

chloramphenicol (78%) and erythromycin (51.2%) with remarkable intermediate resistance against kanamycin (68.2%), nalidixic acid (53.6%) and cefoxitin (43.9%). Resistance to β -lactam antibiotics like aztreonam (65.8%), cefotaxime (63.4%), ceftazidime (58.5%) and ceftriaxone (53.6%) was detected. An ESBL phenotype was confirmed in a total of 15 *Arcobacter* isolates. β -lactamase genes were detected in 63.4% of *Arcobacter* isolates, with *bla*_{TEM} being the predominant gene detected (51.2%, 21/41) followed by *bla*_{CTX-M} group 1 (36.5%, 15/41), *bla*_{AmpC} (29.2%, 12/41), *bla*_{OXA} (29.2%, 12/41), *bla*_{SHV} (14.6%, 6/41) and *bla*_{CTX-M} group 2 (14.6%, 6/41). CTX-M beta-lactamase was found to be the most frequent mechanism of ESBL resistance in *Arcobacter* isolates (Sekhar *et al.*, 2017).

***Listeria monocytogenes*:**

Listeria monocytogenes, responsible for listeriosis in man and animals is also an emerging Gram positive food-borne pathogen. In infected individuals, listeriosis is characterized by meningitis, encephalitis, abortions and or septicemia. Unpasteurized milk and milk products, especially made in farms with poor hygiene can act as vehicle for transmission of listeriosis to humans. Foods of animal origin, clinical and human diarrheal samples were collected for detection and molecular characterization of *L. monocytogenes* and to assess their extent of public health significance.

Out of 502 samples examined, 97 (19.32%) were found positive for *Listeria* spp., of which 39 (7.76%) isolates were identified as *L. monocytogenes*. Among 39 isolates, 24 (7.27%) were from foods of animal origin and 15 (13.15%) were from clinical samples and none of the human diarrheic samples revealed *L. monocytogenes* (Pratap *et al.*, 2017). Among foods of animal origin, highest prevalence was noticed in badam milk (20%) followed by ice cream (13.3%), 10% in both butter and chicken and 8% in both raw milk and cheese and among clinical samples highest prevalence was found in buffalo abortions (20%) followed by 10% each from sheep abortions and vaginal swabs of infertility cases of buffaloes. The mPCR detection of virulence genes revealed presence of *hlyA* and *iapA* in all the tested isolates, *actA* in 33 (84.61%) isolates and no isolate was found to contain *prfA* and *plcA* genes. Serotyping of *L. monocytogenes* revealed majority of isolates assigned to serogroup 4b, 4d, 4e (79.48%, 31/39) and 8 (20.51%, 8/39) isolates assigned to serogroup 1/2b and 3b. *L. monocytogenes* isolates from various sources showed 100% resistance towards nalidixic acid followed by erythromycin (94%), fosfomycin (15%) and chloramphenicol (7%). Multidrug resistant strains of *L. monocytogenes* along with predominant serogroup 4b, 4d and 4e in both foods and clinical samples may pose a threat to public health indicating possibility of transfer of the pathogen from animals to foods of animal origin and thereafter to the food chain (Pratap *et al.*, 2017).

***Campylobacter* species:**

Thermo tolerant *Campylobacter* has been the most commonly reported diarrhoeal bacterial zoonotic pathogen. Most of the infections are caused by *Campylobacter jejuni* and *Campylobacter coli*. As food animals (poultry, pigs and cattle) are considered one of the most important sources of *Campylobacter* infections in man, the development of antimicrobial resistance in *Campylobacter* spp., due to the use of antimicrobial agents in food animals, is therefore, a matter of concern.

A total of 513 samples comprising faecal samples of livestock and poultry (174), intestinal contents of livestock and poultry (96), foods of animal origin (185) and human diarrhoeic samples (35) as well as samples of miscellaneous origin (23) were examined. Overall prevalence of *Campylobacter* spp. was found to be 4.87% (25/513) with highest prevalence in poultry intestinal samples (8/36, 22.2%), followed by pig intestinal contents (4/40, 10%), pig faecal samples (5/60, 8.33%), pork samples (3/90, 3.33%), human diarrhoeic samples (1/35, 2.85%), poultry faecal samples (3/114, 2.63%) and chicken meat samples (1/50,



2%). The virulence genes (flaA and cadF) were present in all the isolates (25/25, 100%) followed by iam (23/25, 92%), cdtA (20/25, 80%), cdtB (20/25, 80%), cdtC (17/25, 68%) and virB11 (4/25, 16%). (Srinivas, 2018).

Antibiogram profiling of 25 isolates revealed that a major fraction of the *Campylobacter* isolates showed sensitivity to colistin and co-trimoxazole (64%), chloramphenicol and azithromycin (56%) and ceftazidime (52%). All the *Campylobacter* isolates were resistant to at least one of the antibiotics tested. Higher resistance was observed for vancomycin and tetracycline (76%), cephalothin and ciprofloxacin (68%), erythromycin (56%) and doxycycline (52%). Notable percentages of isolates were intermediately resistant against nalidixic acid and nitrofurantoin (44%), gentamicin and streptomycin (32%) and clindamycin (28%). Resistance to β -lactam antibiotics like aztreonam (40%), cefotaxime (32%), ceftriaxone (40%) and ceftazidime (28%) were detected. ESBL production was confirmed phenotypically in 12 isolates by combination disc method. blaTEM was the only β -lactamase gene detected in 60% of the isolates (Srinivas, 2018).

***Clostridium difficile*:**

Clostridium difficile is a Gram positive spore forming anaerobic bacterium that causes disease in humans and animals ranging from asymptomatic colonization to diarrhea and colitis. Disease caused by *Clostridium difficile* is linked to nosocomial infections in humans, especially when antibiotics eliminate the normal gastrointestinal flora. The symptoms range from uncomplicated mild diarrhea to life threatening toxic megacolon and pseudomembranous colitis (PMC). Now there is increase in community –acquired *C. difficile* infections (CA-CDI) and this organism has been isolated from beef, veal and pork purchased from retail markets. Shedding of *C. difficile* bacteria from clinically normal adult beef cattle, adult dairy cattle and adult swine can occur in the absence of clinical signs.

The major concern in the control and management of these food-borne disease outbreaks is the resistance of these bacteria to antimicrobial agents like penicillin, cephalosporins, macrolides and quinolones there by drastically limiting the therapeutic options. It is therefore, a worldwide emerging public health problem to be addressed at the earliest. The presence of antimicrobial resistance bacteria represents a high risk for humans since these resistant bacteria of animal origin can be transmitted from animals to humans through the food supply, water or by direct contact. Awareness of the prevalence of antimicrobial resistant bacteria in foods of animal origin provides base line data in order to implement an integrated antimicrobial resistant surveillance system and also facilitates the evolution of interventions to control the antimicrobial resistant bacteria.

(References will be available from Author)



Session-V : Lead Paper-02

OVER VIEW OF BRUCELLOSIS AS FOODBORNE PATHOGEN

R. N. Ramani Pushpa

Professor, Department of Veterinary Microbiology
NTR College of Veterinary Science, Gannavaram

Introduction

Milk and milk products are important sources of an infectious food-borne disease. Non-pasteurized dairy products are one of the most significant hosts of many food borne pathogens including *Brucellaspp.* The genus of *Brucella* comprises facultative Gram-negative bacteria that are able to infect a vast variety of mammals such as humans. Brucellosis is a contagious occupational disease caused by *Brucellaspp.* that affects individuals who have close contact with infected animals. The most common way of Brucellosis transmission is ingestion of non-pasteurized milk and dairy products obtained from infected animals. *Brucellaspp.* are accumulated in mammary glands and supra-mammary lymph nodes of infected animals and therefore the milk of these animals will be a source of pathogens. The clinical features of Brucellosis are not disease-specific; but almost every organ can be affected. Infection with *Brucella* can cause a variety of problems in animals; for example, in females, it could be the cause of abortion and in males, usually orchitis and epididymitis are seen. Depending on conditions such as proper temperature, pH, and humidity, *Brucella* can remain in a contaminated environment for several months.

Brucellosis is caused by different species of bacteria of the Genus *Brucella*, which infect a specific animal species. *Brucellae* belong to α -2 subdivision of proteobacteria. They are Gram-negative, partially acid fast, aerobic, facultative intracellular coccobacilli or short rods. They are oxidase, catalase, nitrate reductase and urease positive. Four out of six major identified species of *Brucella* are human pathogens. Human brucellosis is mostly caused by *B. melitensis* while *B. abortus* is the second cause of human brucellosis, mostly infecting cattle, buffalos, elks, yaks, and camels; *B. canis* is the other cause of human brucellosis and *B. suis* that infects domestic pigs and rodents is the last one. *B. abortus* preferentially infects cattle, *B. melitensis* sheep and goats, *B. suis* pigs and *B. canis* dogs. Above species infect humans with *B. melitensis* being the most common. It affects cattle, swine, sheep and goats, camels, equines and dogs. It may also infect other ruminants, some marine mammals and humans. The disease in animals is characterized mainly by abortions or reproductive failure. The animals typically recover, and will be able to have live offspring following the initial abortion, may continue to shed the organisms in their secretions/excretions. Brucellosis in cattle (*B. abortus*) in sheep and goats (*B. melitensis*) and in swine (*B. suis*) are diseases listed in the World Organization for Animal Health (OIE) Terrestrial Animal Health Code and must be reported to the OIE (Terrestrial Animal Health Code-2012) on its status/occurrence. Brucellosis typically spreads when the animal aborts or gives birth. High levels of bacteria are found in the birth fluids of an infected animal. The bacteria can survive outside the animal in the environment for several months, particularly in cool moist conditions. They remain infectious to other animals which become infected by ingesting the bacteria, present in the contaminated feed and water. The bacteria also colonize the udder and contaminate the milk. The disease can also infect animals and humans through cuts in the skin, or through mucous membranes. Brucellosis is an occupational Zoonoses and a potential risk to veterinarians and farmers who handle infected animals and aborted fetuses or placentas. Brucellosis is one of the most easily acquired laboratory infections, and calls for strict safety precautions in



laboratory when handling cultures and heavily infected samples. Movement and mixing of herds and species are probably the main risks for transmission of brucellosis, among animals. The sale of animals along the trade route and contact with local herds can contribute to the spread of infection. Humans acquire infection by consuming the contaminated milk and milk products and contact with the infected animals.

Mode of transmission

Brucellosis is an infection primarily of animals that causes infertility and late-term abortion. *Brucella* bacteria are found in the blood, urine, semen, vaginal discharges, placentas, milk and aborted fetuses of infected animals. It may also be found in the saliva, and nasal, ocular and joint fluids of infected animals. Animals usually become exposed by contact with bacteria contaminated fluids from infected animals through abraded skin or mucous membranes or by ingestion of infected animal products. In laboratories and during butchering of infected animals, *Brucella* may be transmitted in aerosols. It can also be transmitted on fomites as it withstands drying and can survive in contaminated dust and soil. Survival may be prolonged in conditions of low temperature, high humidity and no sunlight. *Brucella* species are also considered potential bioterrorism agents. Person-to-person transmission of brucellosis is very rare. Congenital infection may occur through the placenta, during breast feeding or due to contact with the mother's blood, urine or faeces during delivery. There have also been rare reports of transmission after blood transfusions, bone marrow transplant and sexual contact.

Antigenic determinants

There are two types of smooth lipopolysaccharide (SLPS) surface antigens, designated A and M. A antigen predominates in *B. abortus* and *B. suis*, while M is the major antigen in *B. melitensis*. Numerous outer and inner membrane, cytoplasmic, and periplasmic proteins have also been characterized.

Pathogenicity

The pathogenicity in human brucellosis is attributed to factors like LPS, adenine and guanine monophosphate, virB, 24 kDa protein, and urease enzyme. *Brucellae* may enter the host via ingestion or inhalation, or through conjunctiva or skin abrasions. The *Brucellae* colonize in different organs with predilection for lymphoreticular system.

Host response

Both antibody and cell-mediated immune responses develop in most patients, but the cellular immunity is the essential component.

Clinical presentation

Brucellosis typically begins with acute non-specific flu-like symptoms. These may include fever, headache, weakness, profuse sweating, chills, weight loss, joint pain, muscle pain, and generalised aches. Inflammation of the liver and spleen, and gastrointestinal or respiratory signs may occur. In males, the testicles and epididymis may become inflamed. Suppurative infections of organs and osteoarticular complications may also occur. Where endocarditis occurs, there is a high case fatality rate.

Typically symptoms last for 2-4 weeks and are followed by a spontaneous recovery. Some infected people may develop an intermittent fever and other symptoms that wax and wane at 2-14 day intervals, known as 'undulant fever'. Occasionally symptoms last for a year or more, patients may become chronically ill and symptoms may recur even after successful treatment.



Indian scenario

In India 80% of the population live in approximately 5,75,000 villages and thousands of small towns; have close contact with domestic/ wild animal population owing to their occupation. Hence, human population stand at a greater risk of acquiring zoonotic diseases including brucellosis. The disease has an added importance in countries like India, where conditions are conducive for wide-spread human infection on account of unhygienic conditions and poverty. Species of main concern in India are *B. melitensis*, and *B. abortus*. *B. melitensis* is the most virulent and common strain for man and it causes severe and prolonged disease with a risk of disability. *B. abortus* is the dominant species in cattle. Bovine brucellosis is widespread in India and appears to be on the increase in recent times, perhaps due to increased trade and rapid movement of livestock. The preponderance of natural bull service in rural India, especially in buffalo, is perhaps yet another important factor in the maintenance and spread of infection. Free grazing and movement with frequent mixing of flocks of sheep and goats also contribute to the wide distribution of brucellosis in these animals. Chahota *et al.* (2003) have reported a severe outbreak of brucellosis in an organized dairy farm leading to abortions, retained placenta and still birth in cows. The diagnosis was made by serology employing Rose Bengal plate agglutination test (RBPT) and standard tube agglutination test (SAT) and confirmed by the isolation of *B. abortus* biotype 1. The presence of brucellosis in India was first established early in the previous century and since then has been reported from almost all states, but the brucellosis situation varies widely between states.

Several published reports including recent ones indicate that human brucellosis is quite common disease in India. In a separate study carried out by Mathur (1968) in Haryana, concluded the goats and sheep as the sources of human infection by isolating *B. melitensis* as a predominant strain from human blood as well as milk samples from goats and sheep. As many as 4.2% aborted women were seropositive for the disease. In Gujarat, 8.5% prevalence of Brucella agglutinins was recorded in human cases. The much higher seroprevalence rate has been also noted in specific risk groups such as abattoir workers. These observations support the occupational risk factors. In a separate study by Mantur and colleagues identified 63 cases at Belgaum Institute of Medical Sciences, Belgaum (Mantur BG and colleagues, unpublished work). In a study at Vellore, Koshiet *al* (1971) reported 10 cases of brucellosis diagnosed by serology or by isolation. In another study, 92 patients were reported from Vellore. However, the epidemiological data on this disease is frequently incomplete. This is partly explained by the absence of proper laboratory facilities, lack of awareness of endemicity, under-reporting as well as poor co-operation and exchange of information between veterinary and health services.

Diagnosis

Brucellosis imitates variety of clinical entities. Clinicians practicing in endemic areas must be familiar with this disease and develop a high degree of clinical suspicion based on epidemiological information. Otherwise because of the deceptive nature, the disease may be easily misdiagnosed or diagnosis may be delayed thereby making clinical diagnosis a challenge.

Laboratory diagnosis

Diagnostic tools include isolation and identification of Brucellae from clinical samples, detection of antigen, genome, and antibodies.

Culture : Blood culture provides definite proof of brucellosis but may not provide a positive result for all patients. Lysis centrifugation and blood clot culture techniques have yielded encouraging results in recent reports (Manture *et al* 2007) in terms of sensitivity and rapidity. The modern automated blood culture systems have somewhat improved the speed of detection. Although bone marrow cultures are considered the



gold standard in some studies (Gotuzzo *et al* 1986; Manturet *et al* 2008), results have not been universally reproducible (Shehabiet *et al* 1990). In such cases, bacteremia might also be maintained from other sources of the reticulo-endothelial system (Manturet *et al* 2008).

Antigen detection: There is only one report (AlShamahy and Wright, 1998) suggesting antigen detection by enzyme linked immunosorbent assay (ELISA) as an acceptable alternative to blood culture. Although antigen detection methods are potentially useful but have not been validated.

Genome detection: Polymerase chain reaction (PCR) has been explored for the rapid detection and confirmation of *Brucella*. Molecular characterization techniques described in the literature are very useful tools for differentiating *Brucella* spp., especially follow-up testing of unusual phenotypic results.

Antibody detection: The limitations of aforementioned tools make serology directed against antibody detection the most useful tool. Antibodies usually begin to appear in the blood at the end of the first week of the disease, IgM appearing first followed by IgG.

Agglutination tests: RBPT is of value as a screening test especially in high risk rural areas where it is not possible to perform SAT. Whenever possible, a serum that gives a positive result should be confirmed by a more specific test. SAT remains the most popular and yet used worldwide diagnostic tool. SAT measures the total quantity of agglutinating antibodies (IgM and IgG), and the quantity of specific IgG is determined by 2-mercaptoethanol (2ME). SAT titres above 1:160 are considered diagnostic in conjunction with a compatible clinical presentation. In endemic areas, a titre of 1:320 as cutoff may make the test more specific. The type of antibody is important, as IgG antibodies are considered a better indicator of active infection and the rapid fall in the level of IgG antibodies is said to be prognostic of successful therapy.

Coombs test that detects incomplete antibodies and immunocapture-agglutination tests have shown similar performances with higher sensitivity and specificity in the diagnosis.

ELISA : A comparison with the SAT, ELISA yields higher sensitivity and specificity. ELISA is also reported to be the most sensitive test for the diagnosis of neuro brucellosis.

Newer rapid assays: *Brucella* IgM and IgG lateral flow and latex agglutination assays have been found to be rapid and simple along with high sensitivity and specificity in culture confirmed cases. These tests are ideal for use as field tests in remote areas and as point of care tests in hospitals and health care centres. Alertness of clinicians and close collaboration with the microbiologist are essential. The Data sharing between medical and veterinary practitioners is essential for diagnosis and eradicating this infection from public health point of view.

Prevention and control

Prevention of human brucellosis is dependent primarily on eradication or control of animal brucellosis by vaccination or culling, practice of hygienic measures by those at occupational risk and pasteurization or proper heating of milk produce before consumption.

Control of animal brucellosis is dependent on two main principles:

(a) Prevention of exposure of animals to infection by preventing free grazing and movement along with frequent mixing of flocks of sheep and goats, unrestricted trade, use of local cattle yards and fairs for trading, sending dry animals back to villages for maintenance, use of semen from unscreened bulls for artificial insemination and poor farm hygiene which contribute to the high prevalence and wide distribution of brucellosis in animals in India, and



(b) Elimination of infected animals from the herd. Detection of truly infected animals assumes paramount importance in any brucellosis control programme. The campaign is easy to operate with high success in small farms with control over movement of animals. A test and slaughter of infected animals or extensive vaccination with approved vaccine, depending on the situation, may be used. This requires a quick, cheap and reasonably sensitive screening test besides a good confirmatory test. In cattle, **RBPT** is used as screen test followed by testing positive sera with CFT for confirmation. The **milk ring test** (MRT) could be used for identifying infected dairy herd with good results followed by **sero-testing** individual animals. Its major drawbacks are that this cannot be used on dry animals and its efficacy is doubtful in sheep and goats.

At present, mass immunization with recommended doses of approved vaccines is the only way to bring down the incidence of brucellosis in areas with high prevalence. For cattle, **B. abortus S-19**, a live attenuated vaccine, given at the age of **3 to 6 months** (in certain cases up to 8 months) is recommended. In spite of certain drawbacks, it is used with satisfactory results. When used routinely to attain coverage of $\geq 80\%$ of population, there is a gradual decline in incidence leading to herd immunity. Where eradication is the aim, vaccination should be stopped once the incidence falls below 0.2% and the infected animals must be eliminated.

B. abortus **RB51**, a live attenuated vaccine that was based on a rough strain has replaced strain 19 vaccine in USA. In February 1996, the USDA approved the use of *B. abortus* strain RB51 (RB51) as the official calf hood vaccine for protection against brucellosis. The Brucella RB51 strain lacks S-LPS, has much lower pathogenicity in vaccinates, considered only mildly abortifacient and presumed to have much lower pathogenicity in humans in response to accidental exposure. In addition, the *B. abortus* RB51 vaccine has a substantial advantage in animal disease control programs because it does not elicit an antibody response against S-LPS and does not, therefore, interfere with results of serologic testing. The epidemiology and planning for prevention and control of brucellosis in sheep and goats are similar to that of cattle with minor adjustments.

A live attenuated Brucella vaccine based on a smooth variant of *B. melitensis* **Rev 1** appears to be highly effective and is widely used to vaccinate small ruminants in parts of the world where *B. melitensis* is enzootic, including Mexico. Immunization of young recently weaned rams (weaner rams) with the *B. melitensis* Rev-1 vaccine is also recommended for control of *B. ovis* in some countries. Like the strain 19 vaccine, this vaccine, too, causes abortions in pregnant animals and short-term shedding of the Rev-1 strain in milk (Banai, 2002) leading to human infections with *B. melitensis* Rev-1 in Israel and the Middle East. Allergic test could be used to identify infected herd followed by sero-testing of individual animals.

In swine, control of brucellosis poses difficulty because there is neither a satisfactory test to identify infected individual animal nor a satisfactory vaccine. It is, therefore, advisable to slaughter the herd.

To date, no effective vaccines against *B. canis* have been identified for use in any animal species. Although advances in vaccine safety have been made, even the current animal vaccines possess certain drawbacks such as these are capable of causing both abortion among pregnant vaccinates and persistent infection among vaccinates with the vaccine strain. Thus, development of new vaccine(s) or improvements in existing vaccines, including expansion for use in more animal species, and efficacy against more of the pathogenic Brucellaspp are still needed.

Control of brucellosis in wildlife animals has proved more challenging, which has been much complicated by the movement to protect animal biodiversity. In USA, brucellosis control in elk and bison in the Greater Yellowstone Area currently calls for surveillance and removal of seropositive animals from some populations as well as management actions to limit contact between bison and cattle in selected locations.

(References will be available from Author)

Session-V : Lead Paper-03

ANTIMICROBIAL RESISTANCE IN MEAT VALUE CHAIN : AN OVERVIEW

S. Wilfred Ruban

Associate Professor (i/c)

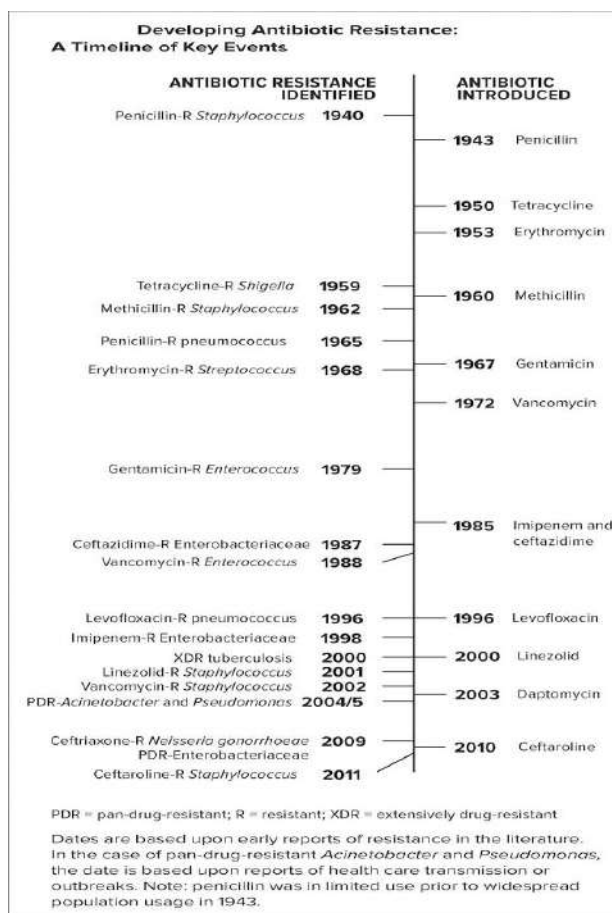
Department of Livestock Products Technology
Veterinary college, Hebbal, Bangalore - 560 043

Antimicrobial resistance (AMR) is a major public health problem globally. While all types of AMR are concerning, antibacterial resistance (ABR) is seen as currently posing the most serious health threat. Bacteria are present everywhere, including in every living being and in the soil, water, and air. With the interconnected ecosystems (humans, animals, the environment), the exchange of bacteria is continuous, and thus the ABR problem is no longer limited to medical science alone. Hence, it requires effective collaboration among several disciplines.

Antimicrobials are administered to animals for a variety of reasons: disease treatment, disease prevention and disease control, and growth promotion/feed efficiency. They are predominantly used to treat respiratory and enteric infections in groups of intensively fed animals, especially during the early part of an animal's life – for example, for flock treatment of broilers, weaning pigs, and calves (Phillips et al., 2004). Antimicrobials are also used to treat infections in individual animals caused by a variety of bacterial pathogens, in particular to treat mastitis in dairy cow

Improper use of antimicrobials in livestock is a potential risk factor for the selection and spread of resistant microorganisms and determinants of AMR from animals to humans through the consumption of foods. However, it is necessary to deepen the impact that the use of antimicrobials in animal husbandry has on human health. In fact, the mechanism by which the resistance can be transferred to humans and the extent of the threat that this poses to human health is still unclear.

The most important factor influencing the emergence and spread of AMR is the use of antimicrobial agents in different hosts with spread of resistant bacteria and resistance genes between hosts of the same or of different species. In the human, veterinary and horticultural spheres there is a variety of ways in which antimicrobials come to be dispensed and applied. In human medicine, antimicrobials are widely used for therapy and prophylaxis both in hospitals and in the community, under varying levels of supervision.

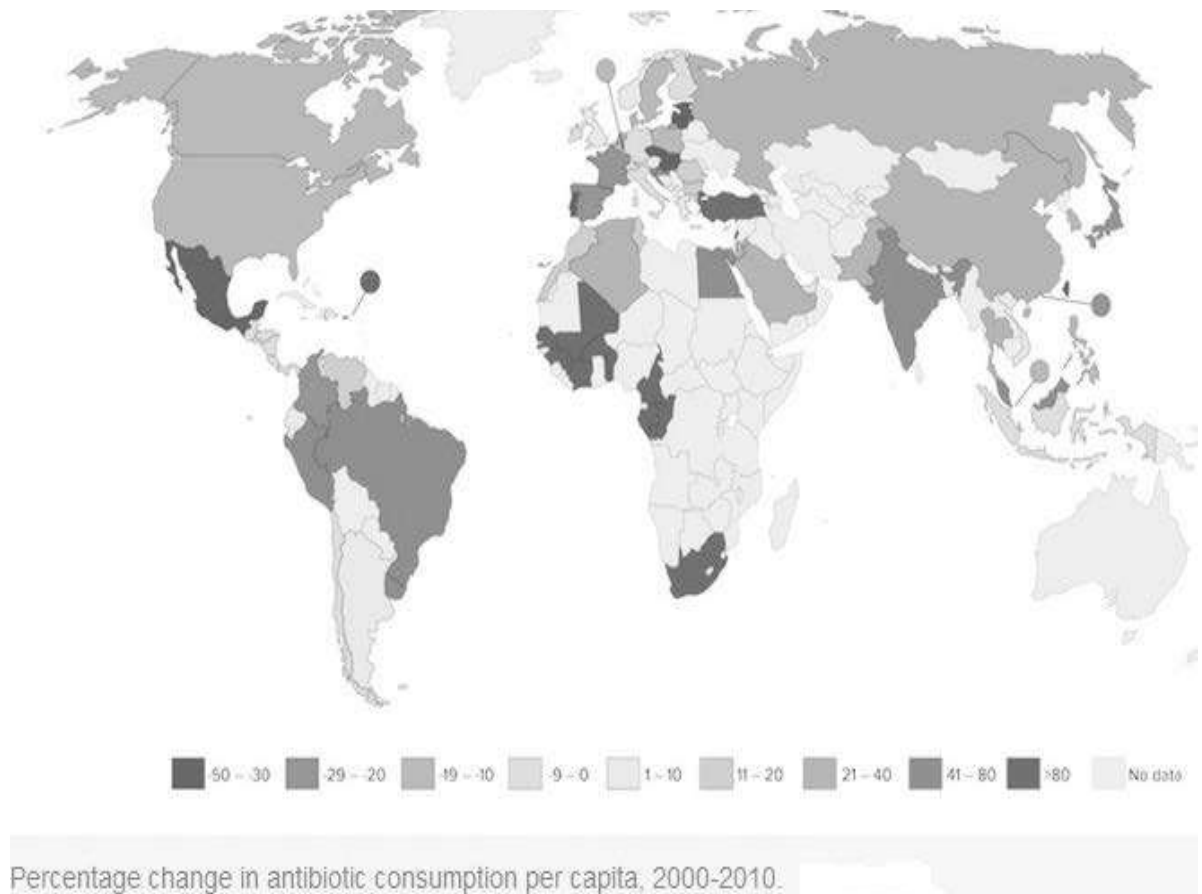


Drivers of AMR emergence in animal production

Although antimicrobial resistance occurs primarily as a consequence of selection pressure placed on susceptible microbes by the use of antimicrobial agents, a variety of other factors also contribute to the emergence and spread of resistance. This section will specifically focus on factors driving AMR in agriculture. Measures such as vaccination, limited co-mingling, adequate ventilation and temperature controls, biosecurity, appropriate nutrition and housing, and quality-assurance programmes are commonly used in modern animal production to reduce the risk of introduction and spread of infections in herds. But it must be recognized that these risk-management practices usually require substantial financial investment, as well as training and incentivizing staff. Even if these measures are implemented properly, however, a residual disease risk will remain. Consequently, antimicrobials are commonly used non-therapeutically in livestock production as a kind of "insurance" in addition to other animal disease risk-management measures

Antimicrobial Use:

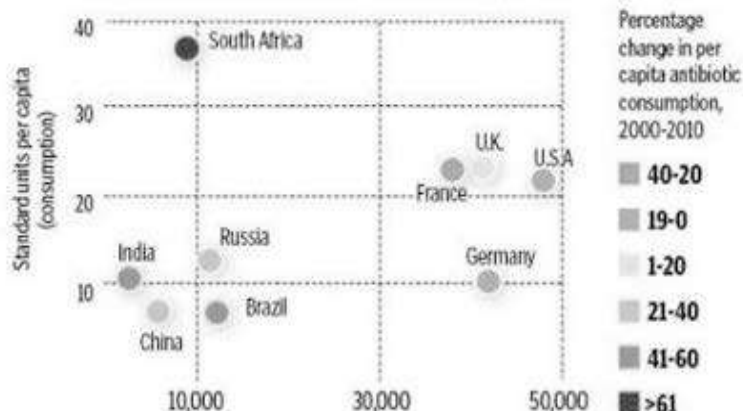
Widespread antimicrobial use is considered to be the main factor associated with resistance in bacterial populations. Excessive use and misuse of antimicrobials are widely recognized as two of the major drivers for acquired AMR, both directly and indirectly, due to the selection pressure imposed on human and animal microbiota (WHO, 2014). Many of the antimicrobial substances licensed for veterinary use belong to antimicrobial classes or groups routinely used in humans.



Antibiotics use per capita by income in selected countries, 2010

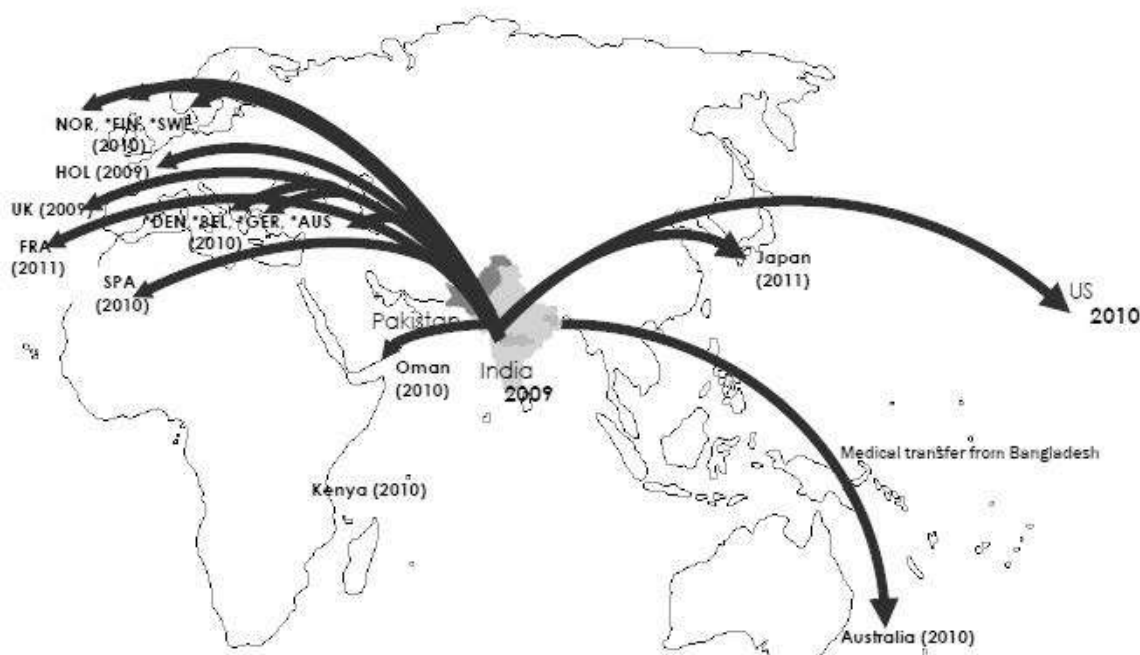
• Per capita consumption is generally higher in high-income countries, but the greatest increase in antibiotic use between 2000 and 2010 was in low and middle income countries.

• Brazil, Russia, India, China, and South Africa accounted for 76% of the increase in antibiotic usage from 2000 to 2010



Animal- Human spread of AMR:

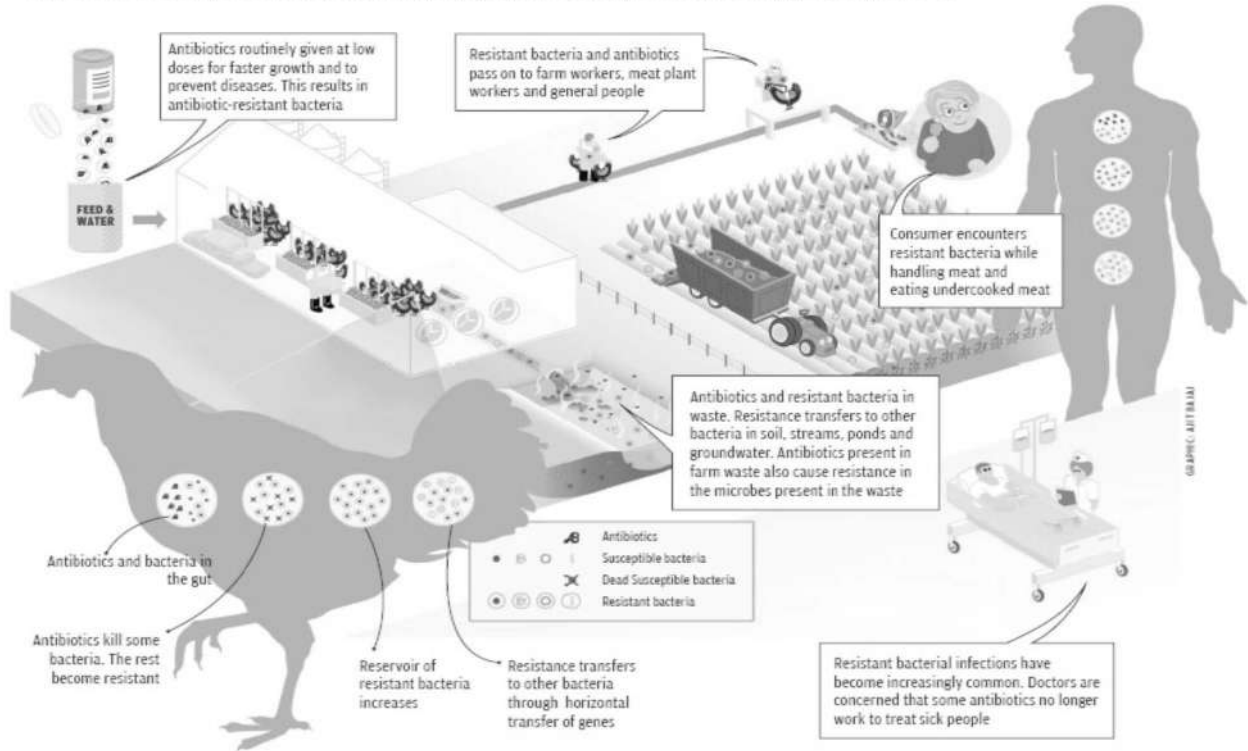
Any use of antibiotics will select for drug-resistant bacteria. Among the various uses for antibiotics, low-dose, prolonged courses of antibiotics among food animals create ideal selective pressures for the propagation of resistant strains. Spread of resistance may occur by direct contact or indirectly, through food, water, and animal waste application to farm fields. It can be augmented greatly by the horizontal transfer of genetic elements such as plasmids via bacterial mating (conjugation). We summarize here the evidence for animal-to-human transfer of resistant bacteria on farms using antibiotics for treatment and/or non-therapeutic use.



NDM spread from India to other parts of the world (2009-2011)

Smart moves of a deadly microbe

As a microbe becomes resistant, it influences other microbes present in the gut of the chicken and then those in the environment, making them resistant to a wide range of antibiotics



Antibiotic Resistance in Food Animals

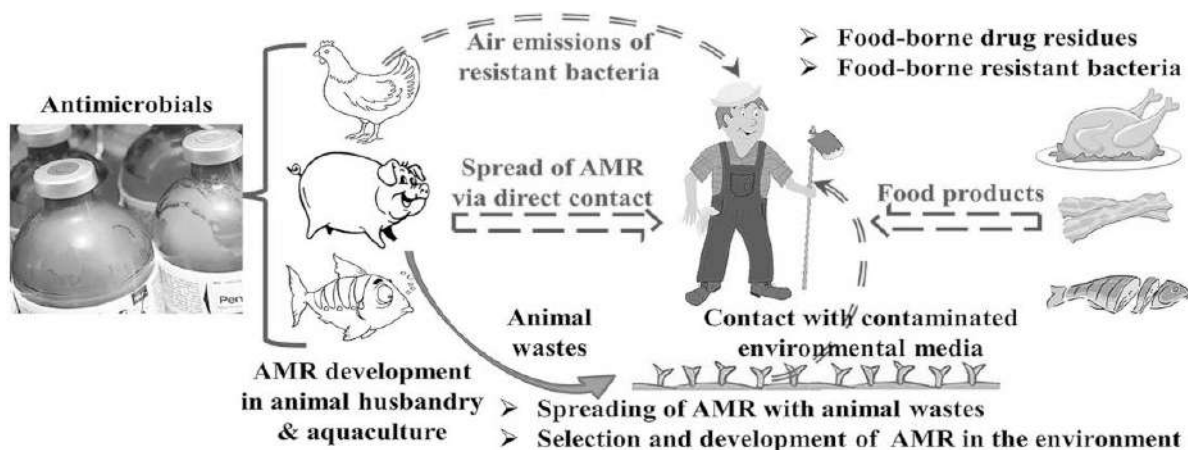
The use of antibiotics in food animals plays a major role in human health, as antibiotic-resistant bacteria can be transmitted between humans and animals through contact, in food products, and from the environment (Landers et al. 2012). The same antibiotics used to treat human infections are commonly used in animals, raising the concern about diminishing the effectiveness of these agents at the expense of human health. With a rise in incomes, there has been an increase in the demand for animal derived protein in India. From 2000 to 2030, it is expected that poultry consumption will increase by 577% in India (Van Boeckel et al. 2015). Similarly, India is the largest producer of milk and second-largest producer of fish, and this production continues to increase (State of Indian Agriculture 2015–16). This is leading to intensive farming with increasing reliance on antibiotics in place of improving hygiene and sanitation. Although a limited number of studies were conducted in food animals, high levels of antibiotic-resistant bacteria were identified.

Antibiotic-resistant bacteria in poultry

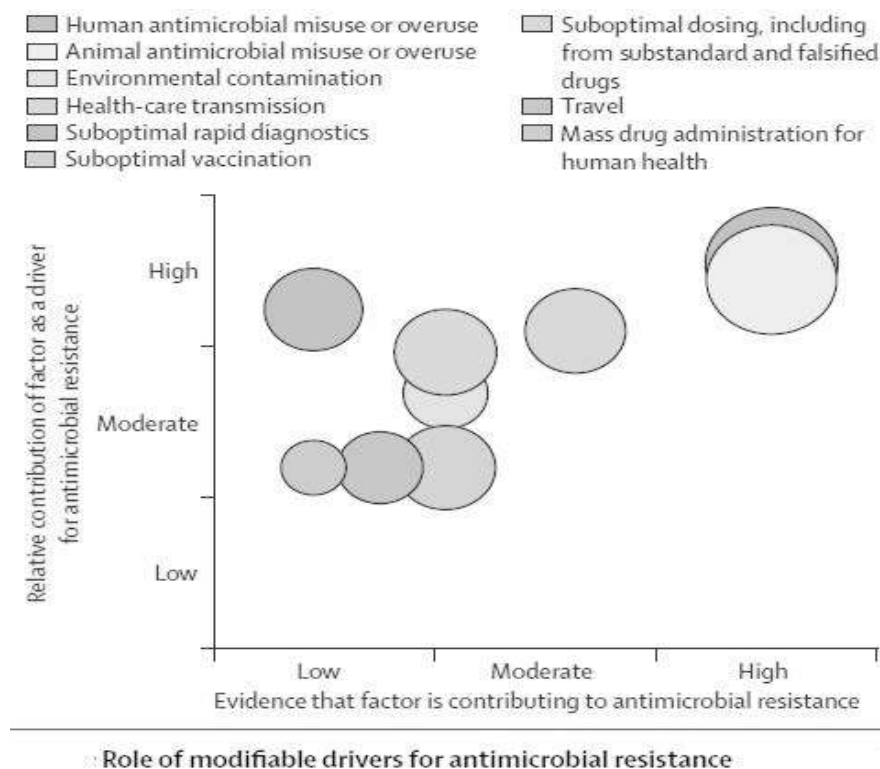
In a recent study involving 18 poultry farms, 1,556 isolates of *E. coli* obtained from cloacal samples of 530 birds were tested for susceptibility to 11 antibiotics (Brower et al. 2017). Resistance profiles were significantly different between broiler and layer farms. Broiler farms were 2.2 times more likely to harbor resistant *E. coli* strains than layer farms. Increased prevalence of ESBL

producing strains was observed in broiler farms (87% compared with 42% in layers). The high resistance in broiler chickens indicates increased use of antibiotics either for growth promotion or for prophylaxis to prevent infection during their short lifespan (Sahu and Saxena, 2014).

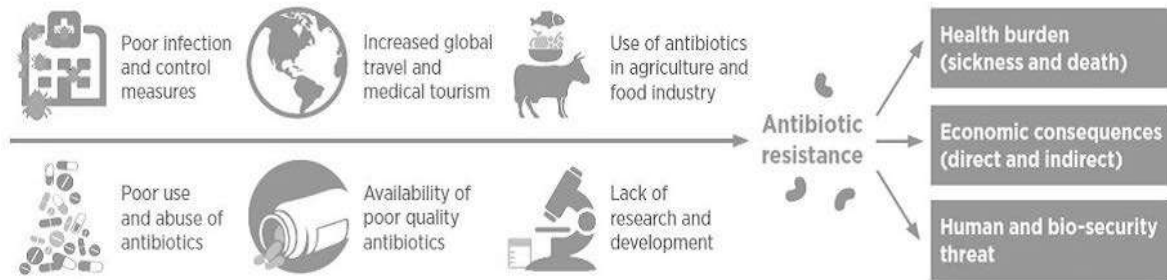
Samanta et al. (2014) found that the prevalence of *Salmonella* species in healthy chickens and their environment was 6.1%, and they were 100% resistant to ciprofloxacin, Gentamicin, and tetracycline. In another study, the prevalence of *Salmonella* species was 3.1%, and they were moderately resistant to various antibiotics (Singh et al. 2013).



The major drivers for increase in Antimicrobial resistance are depicted below:



Consequences of Antimicrobial Resistance:



Conclusion:

Therefore, it would be necessary to:

- Integrate the surveillance/monitoring with data coming from the feed controls
- Strengthen the monitoring of bacteria from the animal food taken at different stages of the food chain (slaughterhouse, detail);
- Improve the cooperation with the authorities/ bodies responsible for animal health in order to share strategies to reduce the use of antimicrobial agents, including the improvement of health and animal welfare (prophylaxis and hygiene protocols, biosecurity measures)
- Monitor the consumption of antimicrobial veterinarian agents throughout the chain.

(References will be available from Author)



Session-V : Lead Paper-04

**ANTIMICROBIAL RESIDUES IN FOODS OF ANIMAL ORIGIN : EXISTING
REGULATIONS AND GUIDELINES FOR RATIONAL USE**

S. Kalpana

(Chemical Residues Laboratory)
ICAR-National Research Center on Meat

Introduction

Time and again it is claimed that, antimicrobial resistance (AMR) associated with the use of antimicrobials for therapeutic and non-therapeutic purposes has led to selection and dissemination of antimicrobial resistant microorganisms with a resulting loss of therapeutic efficacy of the available antimicrobial agents in animal and human medicine. This is a concern of public health importance that cannot be simply wished away. With the intensification of livestock production system for greater economic returns, use of antibiotics in prevention, control and treatment is becoming inevitable. Food animals given antimicrobials contain residues of parent compounds and/or their metabolites which may remain in edible products for a period of time after treatment. In such scenario if withdrawal period of the drug is not observed, then there is every chance for that residue to become a part of the human diet. Subsequently, people consuming such antimicrobial residue-containing foods may suffer from different types of adverse health effects like increasing incidence of antimicrobial resistance, in addition to hypersensitivity and allergic reactions in some sensitive individuals. On the other hand, some antimicrobials like nitrofurans and its metabolites (SEM, AHD, AOH & AMOZ) represents major concern in food due to their carcinogenic nature and their use in food animals have been banned in most countries. Therefore, responsible and prudent use of antimicrobials in food animals is a must to promote animal health and to ensure food safety. On that front, veterinarians who is holding the prescription decision, very much indeed play a crucial role in the mission for attainment of judicious use of antimicrobials in food producing animals and also for complying the regulatory requirement.

Regulations for antimicrobial residues in animal foods

In response to such growing use of antimicrobials in food animal production system internationally and the potential implications for human health and fair trading practices, Codex Committee on Residues of Veterinary Drugs in Foods (CCRVDF) has recommended Maximum residue limits (MRLs) for antibiotic residues in food materials. Stringent regulatory guidelines for antimicrobial residues are in place, therefore it is essential to contain the residue level within the statutory limits in foods. This necessitates use of a suitable analytical technique for compliance monitoring and enforcing their residue limits in foods.

**Table 1 : FSSAI-Food safety and standards (contaminants, toxins and residues) Amendment
Regulations, 2017-Tolerance limit of antimicrobials.**

S.No	Antimicrobials	Food	FSSAI Tolerance limit (mg/Kg)
1.	Amoxicillin	All edible tissue Fats derived from animal tissues milk	0.01
2.	Chloramphenicol	All edible tissue Fats derived from animal tissues milk	0.01

3.	Chlortetracycline/ Oxytetracycline	All edible tissue Fats derived from animal tissues milk	0.01
4.	Enrofloxacin	All edible tissue Fats derived from animal tissues milk	0.01
5.	Zinc bacitracin	All edible tissue Fats derived from animal tissues milk	0.01
6.	Sulphadiazine	All edible tissue Fats derived from animal tissues milk	0.01
9.	Ceftiofur	Cattle muscle Cattle milk	1.0 0.1

Table 2 : Codex Maximum Residues Limit (MRL) for antimicrobials in foods of animal origin

S.No.	Antimicrobials	Target species edible tissue	CAC MRL (µg/Kg)
1.	Amoxicillin	Cattle, Sheep & Pig Muscle	50
		Cattle Milk	4
2.	Benzylpenicillin/Procaine Benzylpenicillin	Cattle, Chicken & Pig Muscle	50
		Cattle Milk	4
3.	Ceftiofur	Cattle & Pig Muscle	1000
		Cattle Milk	100
4.	Chlortetracycline/ Oxytetracycline/Tetracycline	Cattle,Pig,Sheep & Poultry Muscle	200
		Cattle Milk	100
		Poultry eggs	400
5.	Streptomycin	Cattle,Pig,Sheep & Chicken Muscle	600
		Cattle Milk	200
6.	Erythromycin	Chicken Muscle	100
		Chicken eggs	50
		Cattle Milk	100
7.	Gentamicin	Cattle & Pig Muscle	100
		Cattle Milk	200

At national level, FSSAI proposed the tolerance level of antimicrobials in animal foods. For most antibiotics, the FSSAI tolerance level for all edible animal tissue, fats derived from animal tissues and milk has been limited to 0.01 mg/ Kg of food. Some antimicrobials such as chloramphenicol, dapsone, dimetrinidazole, metronidazole, nitrofur, ronidazole and colchicine are enlisted as prohibited substances in foods of animal origin.



Uniform limit

The Uniform limit is the maximum allowed level applied to veterinary drug residues for which official or provisional MRLs are not established. The uniform limit is set at 0.01 ppm based on studies and information by Codex/JECFA/JMPR and other countries including USFDA.

Positive list regulation

In countries like Japan, after the implementation of the positive list regulation, foods of animal origin containing residues exceeding the MRLs on the list, or 0.01 ppm (uniform limit- default tolerance) in cases where there are no MRLs established, are prohibited. Therefore to market our produce in Japan, one has to comply with the currently established official MRLs or the provisional MRLs (together, called the "positive list").

Analytical techniques for detection and confirmation of antimicrobial residues:

EU has laid down its guidelines for testing official samples (Commission Decision 2002/657/EC) that provide a system of Identification Points (IPs) based on the number of fragment ions which is a confirmation requirement. As per the guidelines, IP of minimum 4 is required for substance A compounds which includes forbidden substances like chloramphenicol, nitrofurans, metronidazole etc. and IP of minimum 3 is required for substance B like majority of regulated antimicrobials. Therefore, a definitive mass spectrometric approach only can ensure such confirmation of specific veterinary antimicrobials and quantitate the same (nanogram to picogram range) in various food matrices of animal origin like meat, milk, eggs etc. Of late, tandem MS (MS/MS) detection technique is truly revolutionizing the analytical labs and it is the technique of choice for detection and identification/confirmation of trace-level veterinary antimicrobials completely overcoming any false positive and false negative results. In particular, atmospheric ionization techniques, such as electrospray (ESI-LC-MS/MS) has opened up the avenues for multiclass, multi-residue analysis of more polar, thermolabile and less volatile analytes like veterinary antimicrobials.

Guidelines for judicious use of antimicrobials in livestock production:

- i. Prescribe antimicrobial agents only when necessary (bacterial infections). Choose the appropriate antimicrobial agent. Therapeutic judgment should be based on laboratory test (pathogenic agent isolation, identification and antibiogram) and clinical experience. Right antimicrobial at right time with a right dose and completion of full course of treatment to achieve a positive outcome.
- ii. Comply with the withdrawal (WTD) time of the antimicrobial to protect consumers from violative level exposure in foods of animal origin. It should be borne in mind that antimicrobials after completion of therapy, may remain in tissues for varying times depending on drug elimination kinetics and pharmaceutical formulation.
- iii. Avoid off-label use or extra-label use of antimicrobials. Strictly follow the label indications for target animal species, route of administration, indications etc.
- iv. Ensure rational use of antimicrobials by optimising the dosage regimen (dose, dosing interval and duration of treatment).
- v. Stick on to the label regarding the storage and safe disposal of expired antimicrobial agents.
- vi. Ascertain the pharmacodynamics (PD) of the target antimicrobials in order to know its spectrum of activity, mode of action, minimum inhibitory concentration (MIC), bactericidal concentration,



- whether it has time dependent or concentration dependent activity or co-dependency to access its activity at the site of action.
- vii. Figure out the pharmacokinetic (PK) property of the individual antimicrobial agent to judge its bioavailability at the site of infection, tissue distribution and excretion etc to make precise therapeutic judgements. In-depth insight and understanding on PK and PD is pretty much needed for a rational drug prescribing decision and to optimise antimicrobial therapy.
 - viii. Combine only those antimicrobials which has synergistic effect to increase therapeutic efficacy or to broaden the spectrum of activity.
 - ix. Know the incompatibilities and interactions of your antimicrobial of choice with other drugs co-administered and contraindications if any.
 - x. Take stock of the relevant facts and figures like, species wise /animal sector wise antimicrobial usage, type of antimicrobial use (therapeutic/non-therapeutic), number of animal treated, seasonality and disease conditions etc that will provide tangible inputs to modify treatment strategies and to monitor changes in antimicrobial treatment practices over time.
 - xi. Document and report the incidences of lack of response due to antimicrobial resistance (AMR) for a particular or class of antimicrobials if any, to the concerned authority.
 - xii. Assist in promoting alternative methods of infectious disease management such as vaccination, environmental sanitation, disease containment and management practices like appropriate herd size/stocking density, housing, climate control etc which in turn reduce the incidence for antimicrobial usage.
 - xiii. Strengthen co-operation with all relevant stakeholders like veterinarians, regulatory authorities, pharmaceutical industry, feed manufacturers, and food-animal producers, to have a concerted approach in prudent use of antimicrobials.
 - xiv. Participate in capacity building activities to stay relevant on antimicrobial usage regulations, antimicrobial susceptibility testing methods, AMR monitoring protocols.
 - xv. Promote good veterinary practices (GVP), ensuring compliance with OIE and Codex Alimentarius standards to minimise development and spread of AMR and to contain the antimicrobial residue level below the statutory prescriptions.

(References will be available from Author)



Oral Presentations

FMB - 1

DETECTION OF *BRUCELLA* DNA IN BOVINE RAW MILK BY POLYMERASE CHAIN REACTION

Ramani Pushpa R.N¹ and Lakshmi Kavitha K²

¹ Professor ² Associate Professor

Department of Veterinary Microbiology

NTR College of Veterinary Science, Gannavaram

Sri Venkateswara Veterinary University, Tirupati, Andhra Pradesh

Brucellosis is a neglected zoonosis globally. The shedding of *Brucella* species in milk poses an increasing threat to consumers. This study investigates the presence of *Brucella* DNA in bovine raw milk. A total of 194 milk samples were collected from cattle and buffaloes reared on small farms and organized farms. All the samples were examined by Milk Ring Test and PCR technique to detect *Brucella* agglutinins and *Brucella* DNA respectively. Using MRT, anti-*Brucella* antibodies were detected in 12 samples (6.18%) while PCR amplified *Brucella* specific DNA from 11 samples (5.6%) by 31 kda immunogenic OMP based PCR. *Brucella* DNA was detected in the milk of all MRT positive and seropositive samples. All negative cases were found to be negative in PCR assays.

FMB - 2

OCCURRENCE OF *CAMPYLOBACTER* SPECIES IN CHICKEN AND BEEF MEAT

**B. Sunil, Nithya K. R., C. Latha, Vrinda Menon K., Binsy Mathew,
Deepa Jolly and Ashok Kumar**

Department of Veterinary Public Health, College of
Veterinary and Animal Sciences, Mannuthy

Introduction : Campylobacteriosis is estimated to affect over 1.3 million persons every year and CDC estimates that campylobacteriosis is the second most common forborne illness in the developing countries. It is associated with watery or bloody diarrhoea, abdominal cramps and nausea. Post infection complication include Guillain-Barré syndrome, an acute demyelinating disorder of peripheral nerves. Consumption of undercooked chicken or other foods cross-contaminated with *Campylobacter jejuni* results in Campylobacteriosis.

Objective : The study was performed with the objective of detecting the presence of the organism in chicken and beef meats from the retail shops of Thrissur district.

Methodology : A total of 60 samples, comprising of 30 chicken meat and 30 beef meats from retail shops of Thrissur. The samples were collected aseptically in sterilized polythene bags (100 g each) and transported to the laboratory immediately after collection. Samples were processed for isolation by cultural

method and rapid detection of multiplex PCR for the detection of viable non cultural (VNC) cells. Bacteriological culture was performed in accordance with OIE (2017) to detect *Campylobacter* spp. using selective enrichment medium- Blood Free *Campylobacter* (modified Charcoal Cefoperazone Deoxycholate, mCCD) broth (HiMedia, India) with CCDA selective supplement (FD 135) under microaerophilic conditions at 42°C for 48 h and then plated on to Blood Free *Campylobacter* Selectivity (modified Charcoal Cefoperazone Deoxycholate, mCCD) agar (HiMedia). Colonies which showed grey coloured spreading type shiny, mucoid growth with a tendency to stick and extend when touched with loop were subjected to biochemical tests. DNA isolated from both the enrichment broth after 48 h were performed and subjected to multiplex PCR.

Results and Conclusion : Sixty samples screened and 12 isolates isolated from the meat samples found positive for *Campylobacter* spp. in the Direct PCR assay of Genus specific primer 16SrRNA by Multiplex PCR and five samples found positive for *Campylobacter* spp. in cultural method. Among 12 positive isolates, 11 (11/30) isolates were isolated from chicken meat and one (1/30) isolate isolated from beef meat. Five of the 12 samples were positive for *C. jejuni* specific mapA gene, the Genus specific primer 16SrRNA and virulence specific cadF gene by Multiplex PCR and seven samples were positive for the *C. coli* specific ceuE, the Genus specific primer 16SrRNA and virulence specific cadF gene and confirmed as *C. coli*. One of the isolate isolated from chicken meat showed mixed infection of both *C. jejuni* and *C. coli*. Higher prevalence was showed from the isolates isolated from chicken of 36.67 per cent (11/30). Lowest prevalence was showed from the isolates obtained from beef meat of 3.33 per cent (1/30). Occurrence of *Campylobacter* found in the meat from retail markets were due to poor hygienic conditions maintained in the markets. Implementation of hygiene measures throughout the entire food chain including animal production, transport, lairage, slaughter and dressing operations minimise the potential for contamination and subsequent growth of any contaminating pathogens. The proper sanitation techniques were highly recommended during all steps of food packing and food preparation.

FMB - 3

DETECTION OF BETA-LACTAMASE PRODUCING VIBRIO SPECIES ISOLATED FROM FISH OF MARINE SOURCE

**N. Subhashini*, G. Chaitanya, Ch. Bindu Kiranmayi,
T. Srinivasa Rao and B. Swathi Vimala**

Department of Veterinary Public Health and Epidemiology,
NTR College of Veterinary Science, Gannavaram

Seafood-borne *Vibrio* infections, often linked to contaminated seafood and water, are of increasing global public health concern. Production of extended-spectrum β -lactamases (ESBLs) is a significant resistance-mechanism which is a serious threat to the currently available antibiotic armory. In the present study, out of 50 isolates from 35 sea fish samples, 29 (58%) were found positive for *Vibrio* species. Out of 29, 18 (62%), 8 (27.58%) and 3 (10.3%) isolates were found to be *V. alginolyticus*, *V. parahaemolyticus* and *V. vulnificus* respectively, by mPCR. None of them were positive for *V. cholera*. The 29 different *Vibrio* species were subjected to antibiogram studies including beta-lactamase detection by using mPCR. Antibiotics like tetracycline, chloramphenicol, penicillin, gentamycin, ciprofloxacin, nalidixic acid, kanamycin, cefixime, erythromycin, vancomycin, sulphamethazole and co-trimoxazole were used for antibiogram profile. Out of 29



isolates, 5 isolates were found positive for ESBLs by both phenotypic and genotypic methods. Out of 5 ESBL positive isolates, 4 isolates were positive for TEM gene and one for SHV gene by mPCR. Out of 4 TEM positive isolates, 2 were *V. vulnificus*, one was *V. alginolyticus* and one *V. parahaemolyticus*. SHV gene was seen in one *V. vulnificus* isolate and ACC gene was found in two isolates of *V. alginolyticus*. The occurrence of human pathogenic vibrios, including *V. parahaemolyticus*, *V. alginolyticus* and *V. vulnificus* is of public concern. Even though transmission of fish pathogens to humans may be relatively low, it is a health risk that needs to be considered by fish farmers, fishermen and others who handle fish. Consumption of properly cooked fish is recommended to eliminate these hazards.

FMB - 4

OCCURANCE OF ESBL PRODUCING *KLEBSIELLA* SPP. IN DIFFERENT FOODS OF ANIMAL ORIGIN

**Ch. Bindu Kiranmayi*, N. Subhashini, T. Srinivasa Rao, B. Suresh,
E. Naga Mallika, G. Chaitanya and B. Swathi Vimala**

Department of Veterinary Public Health and Epidemiology,
NTR College of Veterinary Science, Gannavaram

Klebsiella species have been at the centre of attention over recent years due to their role in the evolution of antimicrobial resistance and is not only associated with nosocomial but also with food-borne infections worldwide and has the potential to harbour antibiotic resistance genes. In the present study, a total of 205 samples of foods of animal origin were screened, out of which 95 were khoa, 38 pork, 31 fish and 41 prawn samples. Out of 205 samples, 51 (24.87%) and 8 (3.9%) samples were found positive for *Klebsiella pneumoniae* and *Klebsiella oxytoca* respectively by mPCR. *K. pneumoniae* was found in 28 (29.4%) khoa samples, 7 (18.4%) pork, 6 (19.3%) fish and 10 (24.4%) prawn samples, where as *K. oxytoca* was found in 6 (6.3%) khoa samples, 1 (2.6%) pork and 1 (2.4%) prawn sample and none of fish samples were found positive for *K. oxytoca*. The isolates were subjected to phenotypic antimicrobial susceptibility test using amikacin, aztreonam, cefotaxime, cefpodoxime, ceftazidime, ceftriaxone, gentamicin, imipenem and norfloxacin followed by genotypic confirmation of extended spectrum beta-lactamase (ESBL) production by using mPCR. Highest levels of resistance was observed towards cefpodoxime followed by ceftriaxone, aztreonam, gentamicin, norfloxacin, cefotaxime, ceftazidime and amikacin and imipenem. SHV genes were found in 28 (54.9%) *K. pneumoniae* isolates, of which 23 were from khoa and 5 from prawn samples and CTX-M2 gene was found in one prawn sample. Genetic diversity study among different multidrug resistant *Klebsiella* isolates was done by using ERIC-PCR and REP-PCR. *Klebsiella* species are non-classical food pathogens where faecal contamination and poor personal hygiene of food handlers during food preparation were reported to be the causes for contamination of food with *Klebsiella* species. Their multidrug resistance pattern is a matter of great concern because these bacteria may no longer be treated with conventional therapeutic drugs.

FMB - 5**PREVALENCE AND ANTIMICROBIAL RESISTANCE OF ESBL- *E. COLI* IN CHICKEN RETAIL OUTLETS IN BANGALORE****Rajesh, S., Md. Nadeem Fairoze, S. Wilfred Ruban and Mohan, H.V.**Department of Livestock Products Technology,
Veterinary College, Hebbal, Bangalore- 560024

The present investigation was undertaken to study the prevalence and distribution of *E. coli* and their antimicrobial resistance with special reference to Extended Spectrum Beta-Lactamase (ESBLs) in 100 chicken retail outlet samples of Bengaluru. A total of 400 samples, 100 each of meat, water, cutting board swab and cloaca swabs were subjected to phenotypic study and further confirmation by genotyping using PCR method. Overall prevalence of *E. coli* in the present study was 57.25 per cent (229/400). All the isolates of *E. coli* were confirmed by PCR targeting *uspA* gene. The overall prevalence of ESBL *E. coli* in different samples was 46.25 per cent, whereas prevalence of ESBL in *E. coli* was 80.78 per cent. The results obtained were subjected to statistical analysis using chi-square test. Molecular and genotypic characterization revealed that *bla_{TEM}* gene was carried by 77.83 per cent of the isolates followed by *bla_{CTX-M}* gene in 31.35 per cent and *bla_{SHV}* in 9.19 per cent isolates either alone or in combination. The antibiotic susceptibility pattern of ESBL *E. coli* revealed that all the isolates were resistant to Erythromycin and Penicillin (100 %) followed by Ampicillin, Amoxicillin, Cephalothrin, Cefotaxime, Ciprofloxacin and Cefoxitin, oxytetracycline and Ceftazidime. However, all the ESBL *E. coli* isolates from various sources were sensitive to Meropenem (100 %) followed by Gentamicin and Imipenem (80.52 per cent). The results of Multiple Antibiotic Resistance (MAR) index of ESBL and Non-ESBL *E. coli* indicated that majority of the ESBL *E. coli* had MAR index between 0.7 to 0.9, whereas majority of the non-ESBL *E. coli* had MAR 0.4 to 0.5. In conclusion, correlation between the hygienic condition of the retail outlets, risk factors such as source of water, type of cutting board and butchers hygiene suggested a significant impact on the prevalence of *E. coli* and ESBL *E. coli*.

FMB - 6**EXTRACTION METHOD FOR HPLC ANALYSIS OF ENROFLOXACIN AND CIPROFLOXACIN RESIDUES IN BUFFALO MEAT****S. Kalpana and M. Muthukumar**

Chemical Residues Laboratory, National Research Centre on Meat, Hyderabad.

Enrofloxacin is a synthetic antimicrobial agent exclusive for veterinary use most widely used in bovine therapy by virtue of their relative efficacy in some common bacterial diseases. Although irrational use of fluoroquinolones including enrofloxacin and its active metabolite ciprofloxacin in buffaloes carries the risk of their presence in edible tissues which can be responsible for deleterious effects in consumers, studies related to the quantification of its residues in buffalo meat has received only a minimal attention. For that purpose a simple liquid-liquid extraction method was optimized for monitoring these fluoroquinolone residues in buffalo meat. The extracted samples were analysed using RP-HPLC with fluorescent detector operated at a wavelength of λ_{max} Ex= 280; Em= 450 nm. The limit of quantification for enrofloxacin and ciprofloxacin were 36 and 30 $\mu\text{g/kg}$ with a working range of 10 to 200 $\mu\text{g/kg}$. The repeatability of the recommended analytical



procedure was good and the recoveries of the added fluoroquinolones from the buffalo meat samples ranged from 70-88 %. The inter-day and intra-day variation studied at two levels 100 and 200 µg/kg was below 2 %. Quantitative results at or below the maximum residue limit can be obtained using this simple liquid-liquid extraction method that has high applicability for routine analysis of fluoroquinolone residues in buffalo meat.

FMB-7

MOLECULAR CHARACTERIZATION OF *SALMONELLA SPP.* FROM EGG SAMPLES

Dr. P. Ramya and Dr.L.Venkateswara Rao
College of Veterinary Science, Proddatur, SVVU, Tirupathi.

Objectives: Salmonellosis is a major economic problem for food industry and public health hazard in many countries. In India, Salmonellosis is an endemic and important food borne zoonoses & is primarily due to consumption of eggs, followed by poultry, pork, beef and dairy products. The symptoms in human beings includes diarrhea, nausea, abdominal pain, mild fever, chills, vomition, prostration, headache, malaise etc. and the diarrhea varies from thin vegetable soup like stools to a massive evacuation with accompanying dehydration. Keeping in view of the public health significance of Salmonellosis a small work was designed to detect the presence of *Salmonella spp.* from egg samples that are available from retailers of Proddatur town of YSR Kadapa district, Andhra Pradesh, India.

Methodology: Fifty egg samples were collected aseptically and egg washings have been collected in to sterile test tubes. All the samples have been subjected to pre enrichment for further isolation process.

Results & Discussion: Among the 50 samples 42 isolates were found, *Salmonella spp.* by culture method. Gram's staining of the isolates revealed that they are Gram negative rods. All the 42 isolates were negative for indole and voges-proskauer tests, whereas the same isolates produced bright red color in methyl red test and blue color ring in citrate test. Further all the 42 isolates were subjected to urease test and triple sugar iron agar test. The results revealed that all the isolates were positive for urease test and triple sugar iron agar test the isolates produced acid butt, slant and also gas. All the biochemical reactions confirmed the presence of *Salmonella spp.* The findings of this study revealed that eggs will act as a major vehicle of transmission of food borne zoonoses especially Salmonellosis. Hence by taking proper hygienic measures at farm and retail shop, the public can be saved from this threat.

FMB - 8

SCREENING OF BROILER MEAT FOR ANTIBIOTIC RESIDUES AND ITS PUBLIC HEALTH SIGNIFICANCE

Stella Esther, M. Asokkumar, Annal Selva Malar and M. Priyanka
Madras Veterinary College,
Tamil Nadu Veterinary and Animal Sciences University, Chennai

Large scale production of animal by-products in order to meet the dynamic need of consumers has induced animal husbandry to maximize production globally. This has again encouraged pharmaceutical



industry to manufacture products not only in the forms of drugs to cure disease but also to prevent the spread of diseases in the form of prophylactics. Medicinal additives at very low concentrations as dietary supplement in livestock result in antibiotic residues and indirectly enter the human food chain who subsequently consumes animal products such as meat, milk, eggs *etc.* Toxic effects are, however, unlikely since any residues will be present only at very low concentrations indeed, but allergenic reactions may be produced in sensitive or sensitized individuals. The present study was undertaken to screen 20 broiler meat samples meant for human consumption sold at different retail units in and around Chennai for antibiotic residues using paper strip assay originally validated and patented for screening antibiotic residues in milk (NDRI). The test results were qualitatively analyzed and observed for variation in the colour intensity. Appearance of blue colour on paper strip indicated absence of antibiotic residues in milk while no colour development indicated presence of antibiotic residues in milk at or above MRL.

FMB - 9

SCREENING AND MOLECULAR CHARACTERIZATION OF *ENTEROCOCCI* IN FOODS OF ANIMAL ORIGIN

***Chaitanya Gottapu, Ch. Bindu Kiranmayi, T. Srinivasa Rao, N. Subhashini,
B. Swathi Vimala, Srinivas K, Suresh, Prasastha Ram V, B. Suresh**

Department of Veterinary Public Health and Epidemiology,
NTR College of Veterinary Science, Gannavaram

Enterococci are an emerging foodborne pathogens having worldwide public health concern. The present study was undertaken to characterize *Enterococcus* species of animal origin based on cultural isolation, PCR detection, virulence profile and antibiogram. A total of 119 raw meat samples (38 carabeef, 33 pork, 19 chicken meat, 19 quail meat and 10 mutton) were collected in sterile containers. Overall prevalence of *Enterococcus* species was found to be 67.06% by genus-specific PCR targeting *16S rRNA*. Among meat samples, carabeef (65.78%) revealed the highest prevalence; followed by pork (33.33%), chicken meat (31.57%), mutton (0.2%) and quail meat samples (26.31%). Out of 63 isolates, multiplex-PCR assay targeting *ddl* gene (*E. faecium*), *ddl* gene (*E. fecalis*), GA1,2 (*E. gallinarum*) enabled detection of *E. faecium* (49), *E. fecalis* (6) and *E. gallinarum* (8).

All *enterococci* isolates confirmed by PCR were subjected to molecular characterization by using m-PCR targeting three virulent genes; *gelE*, *ace* and *esp*. Out of 49 *E. faecium* isolates 2 were positive for *gelE* and out of 6 *E. fecalis* isolates 3 were positive for *gelE*, 2 for *ace* and one for *esp* gene positive. No virulent genes were observed in *E. gallinarum*. Vancomycin resistant *Enterococci* (VRE) were detected in 13.3% of the isolates of which *VanC2* was predominant (50%) followed by *VanB* (40%) and *VanC1* (10%). *blaZ* gene mediated β -lactamase genes were detected in 19 (30.15%) of *Enterococci* isolates. *Enterococci* isolates revealed higher resistance against, Aztreonam (100%), Polymyxin (100%), Cefpodoxime (100%), Ceftazidime (85.33%), intermediate resistance against Penicillin (65.33%), Ciprofloxacin (9.33%) and Erythromycin (50.66%) and sensitivity to Gentamicin (66.6%), Ampicillin (81%), Ciprofloxacin (56%) and Tetracycline (62.66%). ERIC PCR and REP-PCR analysis of *blaZ* positive *enterococci* revealed a greater degree of heterogeneity among *Enterococci* isolates.



FMB - 10

APPLICATION OF BIOTECHNOLOGICAL INTERVENTIONS IN IMPROVING CROP PRODUCTIVITY: RESEARCH EXPERIENCES FROM MARKER ASSISTED SELECTION FOR PLANT STATURE IN WHITE YAM

Parvathy Harikumar^{*} and Sheela M N

ICAR-Central Tuber Crop Research Institute, Thiruvananthapuram, Kerala,

White Yam, a tuber crop that satisfies the caloric need of more than 300 million population around the world. Due to its palatability, better yield qualities and nutritional value it is one among the important tuber crop of the state of Kerala, India. On the other hand, studies showed that 30 % of cost of cultivation of this crop is attributed to staking materials for trailing the plant, and this limits the spread of cultivation for this plant. Therefore, a research program was designed to identify any markers, if present, linked with dwarfness in the plant, so that the same can be utilized to modify the plant architecture and further it can be propagated through any *in-vitro* methods for field cultivation. In this context, thirty accessions of white yam, comprising dwarf, semi dwarf and tall varieties, were screened for genetic polymorphism using three commonly used markers namely, ISSR (Inter simple sequence repeat), SSR (Simple sequence repeat) and RAPD (Random amplified polymorphic DNA). A set of 15 primers (A1 to A15) were used to screen ISSR, 10 (B1-B10) for SSR and 8 (C1-C8) for RAPD. The result showed that, ISSR and RAPD showed more number of polymorphic bands compared to SSR and all were efficient in discriminating all the genotypes studied with significant PIC (polymorphic information content) values. Interestingly, it is observed that three SSR markers studied were expressed only in dwarf white yam, and one marker showed a unique band of 1.5Kbp for dwarf gene. The sequence of this product is analysed through NCBI-BLAST and observed a 90% similarity with a gene in *Cocos nucifera* cultivar Chowghat green dwarf. Therefore, it is concluded that the SSR marker identified as linked with dwarfness in white yam can be propagated to the field using *in-vitro* methods for reducing the economic burden associated with cultivation of tall varieties.

FMB - 11

NEUROTOXICITY STUDY WITH TETRACONAZOLE FUNGICIDE IN CHICKEN

**B. Gowtham Prasad¹; Rohit Kumar Jaiswal²; Serlene Tomar³; Annada⁴;
Anitha Nalla⁵ and Anitha Fagoji⁶**

^{1, 2, 3 and 4} Indian Veterinary Research Institute;

^{5 and 6} College of Veterinary Science, Rajendranagar

Neurotoxic potential of tetraconazole technical was tested in twenty four chickens (egg laying White Leghorn hens). The hens were randomly distributed into four groups *viz.*, G1, G2, G3 and G4, each group consisting of six birds. To groups G2, G3 and G4, epoxiconazole was given daily by dietary administration for 21 consecutive days in standard chicken feed at the doses of 500 ppm (low dose), 1000 ppm (intermediate dose) and 2000 ppm (high dose), respectively. Birds belonging to G1 (Control group) were similarly treated, but with standard chicken feed alone. On day 21, 3 birds from each group and on day 42 the remaining birds



from all the groups were sacrificed for gross pathology. Brain, spinal cord and sciatic nerve were isolated from individual bird for histopathological examination. Daily observations were made on neurotoxic behavioural signs, body weight, feed consumption, egg yield and egg weight of individual bird of all the groups. Blood samples were collected from the wing vein of the birds belonging to all the groups on day 0 (pre-exposure), day 21 (on termination of exposure) and on day 42 (at the end of post-treatment period) for haematological and biochemical investigations. The NOEL of epoxiconazole, for Chicken (White Leghorn hens), under the conditions of this neurotoxicity study was considered to be 2000 ppm.

FMB - 12

COMPARATIVE EVALUATION OF PORCINE AND BUFFALO SKIN AND SMALL INTESTINAL SUBMUCOSA FOR THE DEVELOPMENT OF EXTRACELLULAR MATRIX SCAFFOLDS

V. N. Vasudevan, P. Kuttinarayanan and Irshad A.

Department of Livestock Products Technology & Meat Technology Unit
College of Veterinary and Animal Sciences, Mannuthy, Thrissur

Small intestinal submucosa (SIS) and raw porcine skin from 6-8 months old Large White Yorkshire (LWY) pigs and 18-24 months old buffaloes were evaluated for the development of extracellular matrix scaffolds. The thickness of SIS from buffalo and LWY pigs did not differ significantly. Buffalo SIS had significantly higher fat and total collagen contents, and was more resistant to collagenase degradation than that from LWY pigs, but showed a higher content of acid soluble collagen. The buffaloes had thicker skin with a lower yield compared to LWY. Total collagen content was significantly higher in buffalo skin, where as the neutral salt soluble and acid soluble collagen contents in buffalo skin were significantly higher than the LWY skin. The buffalo dermis was found to undergo rapid in vivo enzymatic degradation. Considering the large availability of buffalo skin and SIS as a low-cost abattoir by-product, it can be used for the development of dermal ECM scaffolds after improving the stability to enzymatic degradation by defatting, decellularization, cross linking and sterilization.



Poster Presentations

FMB-13

SEROPREVALANCE OF LEPTOSPIROSIS IN CATTLE OF FLOOD AFFECTED RURAL AREA OF PALAKKAD DISTRICT OF KERALA

**¹Murugavelu M*, ¹Sruthi C, ¹Swetha P T, ¹Afsal S, ¹Athulya T R, ¹Sreekutty S,
²Vrinda K Menon, ²Deepa Jolly and ³C Latha**

¹MVSc Scholars, ²Assistant Professor, ³Professor and Head
Department of Veterinary Public Health
College of Veterinary and Animal Sciences, Mannuthy, Thrissur
Kerala Veterinary and Animal Sciences University

Leptospirosis is widespread and potentially fatal zoonotic disease. Disease is endemic in many tropical regions and causes large epidemics after heavy rainfall and flooding. Infection results from direct or indirect exposure to infected reservoir host animal that carries the pathogen in their renal tubules and shed pathogenic leptospires in their urine. Kerala is endemic to *Leptospira* infection. After the devastating Kerala floods during the monsoon of 2018, there had been an increase in the number of cases of Leptospirosis among both human and animal populations. The present investigation was conducted to analyse the seroprevalance of leptospirosis in cattle in Kuzhalmannam panchayat of Palakkad district. Twenty five serum samples of cattle were screened by Microscopic Agglutination Test (MAT) against 12 reference serovars of *Leptospira interrogans*. In these animals, no clinical abnormalities were observed, no animals were said to have had an abortion. Out of the 25 sera samples tested, two samples (8%) were found positive for MAT; with an antibody titre of 1:200 against *Leptospira interrogans* serovar Hardjo serogroup Sejroe. The present study suggest that the cattle could be a source of infection to humans in the area under study. The farmers were made aware of the situation and advised to take necessary precautions to prevent the spread of the disease.

FMB - 14

ISOLATION OF THERMOPHILIC CAMPYLOBACTERS FROM SAMPLES OF ANIMAL ORIGIN AND THEIR VIRULENCE GENE PROFILES

***Srinivas K¹, T. Srinivasa Rao², Ch. Bindu Kiranmayi³, K. Lakshmi Kavitha⁴,
N. Subhashini³, Y. Suresh¹, V. Prasastha Ram¹, G. Chaitanya¹, B. Swathi Vimala¹
and B. Suresh⁵**

¹M.V.Sc. Scholar, ²Associate Professor and Head, ³Assistant Professor, ⁵Junior Research Fellow,
Department of Veterinary Public Health and Epidemiology,

⁴Associate Professor, Department of Veterinary Microbiology,
NTR College of Veterinary Science, Gannavaram,

Campylobacteriosis is the leading cause of bacterial gastroenteritis worldwide. The important food-borne pathogens are *Campylobacter jejuni* and *Campylobacter coli*. They are commensals of gastro-intestinal tract of animals especially poultry, and occur as pathogens in man. The predominant mode of transmission is



by cross-contamination of food from animal sources. In this study, 455 samples (174 faecal samples, 96 intestinal samples and 185 food samples of animal origin) collected in Krishna and Guntur districts, Andhra Pradesh. The samples were plated directly onto selective agar media i.e., Modified Charcoal Cefoperazone Desoxycholate Agar (mCCDA) with suitable supplements and incubated at 42°C for 48 hours in micro-aerophilic environment. Colonies showing typical morphology were subjected to PCR targeting 16SrRNA gene (*Campylobacter* genus), *mapA* gene (*Campylobacter jejuni*) and *ceuE* gene (*Campylobacter coli*). The overall occurrence rate of *Campylobacter* was found to be 5.27 %. Out of which 79.16% were found to be *C. coli* and 20.84% were found to be *C. jejuni*. All the isolates were screened for presence of putative virulence genes such as *fla*, *cadF*, *iam*, *cdtA*, *cdtB*, *cdtC* and *virB11*. Their occurrence rate was found to be 100%, 100%, 95.83%, 79.16%, 79.16%, 70.83% and 16.67% respectively. Most of these virulence genes code for colonization, invasion and production of toxins. Thus, it is necessary to follow strict hygienic practices during handling of animals and animal products throughout the chain of food production.

FMB - 15

STUDIES ON *SALMONELLA* SEROVARS OF ANIMAL ORIGIN WITH SPECIAL REFERENCE TO *FOODBORNE SALMONELLA* SEROVARS

Yasarla Suresh^{*}, Ch. BinduKiranmayi, T. SrinivasaRao and M. srivani

Department of Veterinary Public Health and Epidemiology,
NTR College of Veterinary Science, Gannavaram

Salmonella is a foodborne pathogen having a worldwide public healthconcern. In the present study,a total of 516 samples comprising poultry cloacal swabs (249) and raw foods of animal origin (118 chicken samples, 65 mutton and 30 pork, 17 poultry liver swabs)and 37 poultry farm water samples were examined for presence of *Salmonella* serovars.Out of 516 samples, 21 were found to be carrying *Salmonella* spp. of which 7 were confirmed to be *S. Typhimurium*, 2 were *S. Enteritidis*, 7 were belonging to the *Salmonella* Group II, 3 were identified as *Salmonella* Group G, one *S. Daytona* and one *S. Linderburg*.All the isolates carried the virulence genes i.e. *invA*, *invH*, *sopB*, *sopE&stn* while *pefA* gene was found only in *S.Typhimurium* isolates and *sefC*gene was found only in *S.Enteritidis* isolates.

Antibiogram of *Salmonella* isolates revealed 100% susceptibility to co- trimoxazole and polymyxin-B, while higher resistance was observed towards amikacin followed by ampicillin, tetracycline, ceftriaxone, gentamicin, sulfamethoxazole,cefepoxime, nalidixic acid, ciprofloxacin, doxycycline, chloramphenicol and streptomycin. Of the 21 *Salmonella*isolates, 15 isolates were foundresistant to β -lactam antibiotics like ceftriaxone, cefotaxime, aztreonamand ceftazidime. β -lactamase genes were detected in a total of 11 isolates,*blaTEM*being the predominant gene detected (9/11), followed by *blaCTX-M* group-2 (2/11), *blaOXA*(1/11) and *blaCTX-M*group-9 (1/11) and no single isolate showed presence of *blaCTX-M* group-1 and *blaSHV*genes.ERIC-PCR genotyping distinguished 7 isolates of *S.Typhimurium* into 6 genotypes whereas REP-PCR distinguished all the isolates into distinct genotypes. The discriminatory power of ERIC-PCR and REP-PCR for *Salmonella* isolates was found to be highly significant (>0.9) i.e. 0.952 and 1.0, respectively.



FMB - 16

**ISOLATION AND IDENTIFICATION OF PATHO-SEROTYPES OF
ESCHERICHIA COLI AND *SALMONELLA ENTERIC* IN TABLE EGGS.**

**Vinayananda C.O*, Md. Nadeem Fairoze¹, Madhavaprasad C.B¹, Appa Rao V²,
Nagappa Karabasanavar¹**

^{*1}Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar-585 401

²TamilNadu Veterinary and Animal Sciences University, Chennai-600 007

The broad spectrum of food-borne infections has changed over time; well-established pathogens are being controlled, and new ones are emerging. New pathogens may emerge as a result of changing ecology or changing technology that connects a potential pathogen to the food chain. This study was conducted to evaluate the occurrence of food borne pathogens (*Salmonella enteric* and *Escherichia coli*) and its patho-serotypes in processed, unprocessed and desi table eggs. The overall occurrence of *E.coli* was found to be 28.57 per cent, with 22.92, 29.17 and 50.00 per cent in the processed, unprocessed and desi table eggs, respectively. *E. coli* isolates obtained were screened for virulence genes viz. STh, SLT1/2 and *invE* genes. Among 24 isolates, 14 isolates were found negative for all 3 targeted genes, nine isolates found to be carrying SLT 1/2, one isolates shown positive for the *invE* gene, three isolates shown positive for both SLT ½ and *invE* genes. None of the isolates was positive for STh gene. Serotyping of 24 isolates obtained in the present study showed that, 10 isolates belonged to O141, O119, O9, O120 and O101 serotypes, while the remaining 14 were untypeable. The overall occurrence of *S. enteric* among the was 5.95 with 2.08, 8.33 and 16.67 per cent in processed, unprocessed and desi table eggs, respectively. Among the isolates obtained, 3.57 per cent was found to be *Sal. Enteritidis* and 2.38 per cent of was *Sal. Typhimurium* serotypes. The result warns an urgent need for applying proper food hygienic practices in retail outlets, in order to reduce the incidence of food-borne diseases.

FMB - 17

**ANALYSIS OF MICROBIAL QUALITY OF THE AIR IN MEAT AND DAIRY
PLANTS BY IMPACTION TECHNIQUE**

**Vinayananda, C O*, Rongsensusang, S.J.Deepak, A.Elango,
V. Appa Rao, K.Portein, and B. Dhanalakshmi**

Department of Livestock Products Technology (Meat Science)
Madras Veterinary College, TANUVAS, Chennai

The air quality in meat processing plants and dairy plant often goes neglected, yet they exert a great influence over the shelf life and quality of final product. The present study was designed to analyze the microbiological quality of air in institutional meat and milk processing plants of Madras Veterinary College. The air sampling was done using impaction technique for meat plant in slaughter hall, processing room, chilling room and further processing room. Similarly, for dairy plant it was done in the milk reception area, pasteurization unit and packaging rooms. The enumeration of aerobic count, psychrophilic count, yeast and mold count and occurrence of *Staphylococcus aureus* in slaughter house and dairy plant was carried using air sampler (impaction method). On analysis the aerobic counts of meat processing plant were found to be



56.67±2.60, 35.67±1.45, 16.00±2.64 and 27.67±2.02cfu/m³ in slaughter hall, processing room chilling room and further processing room, respectively. Yeast and mold counts were found to be 32.00±2.50, 14.33±2.33, 13.33±0.88 and 9.33±2.33 cfu/m³ in slaughter hall, processing room chilling room and further processing room, respectively. In dairy plant, aerobic counts were found to be 58.33±4.9, 27.67±2.40 and 21.0±0.73cfu/m³ in reception pasteurization and packaging section, respectively. Yeast and mold counts were found to be 38.67±2.72, 16.67±2.03 and 28.00±2.51cfu/m³ in reception pasteurization and packaging section, respectively. There was no significant difference in the psychrophilic counts among the different sections of slaughter house and dairy plant units. The occurrence of *Staphylococcus aureus* was observed in slaughter hall and processing section of meat plant and reception section of dairy plant. The results of air microbes obtained in the present study for all the sections of slaughter house and dairy plant by air sampler technique were well within the recommendations given by APHA for food processing plants. With respect to dairy and meat processing industry this study on bio-aerosols mainly helps us to implement the clean room practices for good manufacturing practices.

FMB - 18

THERMOPHILIC *CAMPYLOBACTER* SPP. IN DIFFERENT POULTRY SETTINGS

Vivekanandhan R., Z. B. Dubal*, Balasaheb M. Kale, Anukampa & D K Sinha

ICAR- Indian Veterinary Research Institute (IVRI), Izatnagar, Bareilly

Campylobacter colonizes the intestinal mucus of most of the species especially in chickens. Therefore, consumption and handling of contaminated animal food products, especially poultry meat directly or indirectly contribute to occurrence of gastroenteritis in human. To see the occurrence, a total of 359 samples (caecal, faecal and environmental) were collected from commercial and backyard poultry settings in and around Bareilly region. The suspected colonies of *Campylobacter* spp. from mCCDA (modified Charcoal Cefoperazone Deoxycholate Agar) were subjected to cultural, morphological, biochemical and molecular characteristics for their identification. Out of 15 isolates obtained, two were confirmed as *C. jejuni* and 13 were confirmed as *C. coli* by mPCR. Overall, 4.17% samples found positive for *Campylobacter* spp. with maximum occurrence of 6.09 per cent in commercial poultry settings followed by 1.85 per cent in backyard poultry settings. Further, isolation rate was comparatively more in chicken caecum from commercial poultry settings (15.58 per cent) than chicken caecum (5.55 per cent) from backyard poultry settings. *Campylobacter* spp. could not be detected from chicken faeces and environmental samples from both commercial and backyard poultry setting. Education of farm workers, abattoir workers and food handlers on the principles and application of food hygiene is essential to reduce the incidence and economic consequences of Campylobacteriosis.



FMB-19

OCCURRENCE OF *LISTERIA SPECIES* IN SEAFOODS FROM FISH CATCHMENT AREAS OF KERALA

K Vrinda Menon *, B Sunil and C Latha

Department of Veterinary Public Health
College of Veterinary and Animal Sciences, Mannuthy, Kerala

The study was conducted to find the occurrence of *Listeria* spp in sea foods and to determine the critical control points of the organism in fish catchment areas of Kerala. The seafood samples included fresh fish samples (400), dry fish (100), crustaceans (200) and molluscs (200). The isolates were identified by biochemical methods and then confirmed by molecular characterisation of the isolates. The percent occurrence of *Listeria monocytogenes* in sea foods from Kozhikode and Kollam districts were found to be 2.16 and 0.14 per cent respectively but the organism could not be isolated from Thrissur, Thiruvananthapuram and Allapuzha districts. However, the *Listeria innocua* was isolated from all districts under study with the highest occurrence of 34.59 per cent from Kollam district. The results revealed that the presence of organism in Kollam district was significantly higher compared to others districts ($p < 0.01$). The maximum prevalence of *Listeria* spp. was observed in crustaceans followed by fishes and molluscs. The *Listeria monocytogenes* isolates revealed the presence of all six virulence genes viz., *iap*, *hlyA*, *actA*, *prfA*, *plcA* and *inlA*. Apart from these, five isolates of *L. innocua* were found positive for the presence of *hlyA* gene. Hence, the overall prevalence of *Listeria* spp. in seafoods was found to be 17.33 per cent. The presence of the organism augments the need for regular surveillance for the presence of the organism in seafoods.

FMB - 20

DETECTION OF DIFFERENT *B-LACTAMASES* AMONG *ESCHERICHIA COLI*, *PROTEUS MIRABILIS* AND *KLEBSIELLA* ISOLATES FROM ICE CREAMS SOLD AT DIFFERENT PARTS OF ANDHRA PRADESH

***Chaitanya Gottapu¹, Ch. Bindu Kiranmayi², T. Srinivasa Rao³, N.Subhashini²,
B. Swathi vimala¹, K. Haritha¹**

¹M.V.Sc. Scholar, ²Assistant Professor, ³Associate Professor and Head,
Department of Veterinary Public Health and Epidemiology,
NTR College of Veterinary Science, Gannavaram.

Ice cream is a delicious dairy product commonly consumed by all age groups during all seasons. Due to its composition, it can harbor many potent pathogens. Most ice creams become contaminated with microbes during production, transit and preservation. Such contaminated food product can be responsible for food borne infections in children, elderly people and immune-suppressed patients. Therefore, the study was conducted to evaluate the microbiological quality of street-vended ice creams sold in different areas of Andhra Pradesh. Ninety five street vended/ local made ice cream samples were randomly collected and analyzed for bacterial contamination. The results revealed *Escherichia coli* (40), *Klebsiella pneumonia* (34), *Klebsiella oxytoca* (7) and *Proteus mirabilis* (14) by uniplex PCR method. *Salmonella* and *Pseudomonas* were not detected in any of



the samples. All these isolates were tested for production of different β -lactamase genes responsible for antimicrobial resistance by both phenotypic and genotypic methods. Out of 40 isolates of *E. coli*, 5 showed *bla TEM*, one *blaSHV*, one *bla CTXM* group 9, 2 *blaACC*, 2 *blaIMP* and one isolate showed *blaKPC* gene. Out of 34 isolates of *Klebsiella* (27 *K. pneumonia* and 7 *K. oxytoca*), 23 isolates showed *blashv* and two showed *blaVIM* genes. Out of 14 isolates of *Proteus mirabilis*, 3 isolates showed *blaTEM*, one isolate showed *blaOXA*, one *blaCTX-M* group1, one showed *blaCTX-M* group 9, one *blaFOX* and one *blaACC* gene. It is clear from the current studies that there is a necessity for improving the hygienic status of locally produced ice cream.



Technical Session - VI

Industry - Academecia Meet



IV - AMST - 2019

INTEGRATION OF LIVESTOCK SECTOR TO AUGMENT FARMERS INCOME, ENTREPREUNERSHIP AND SUSTAINABLE MEAT PRODUCTION

Dr. S.P. Fonglan

MVSc(Meat Tech)., PGDABM, MBA.

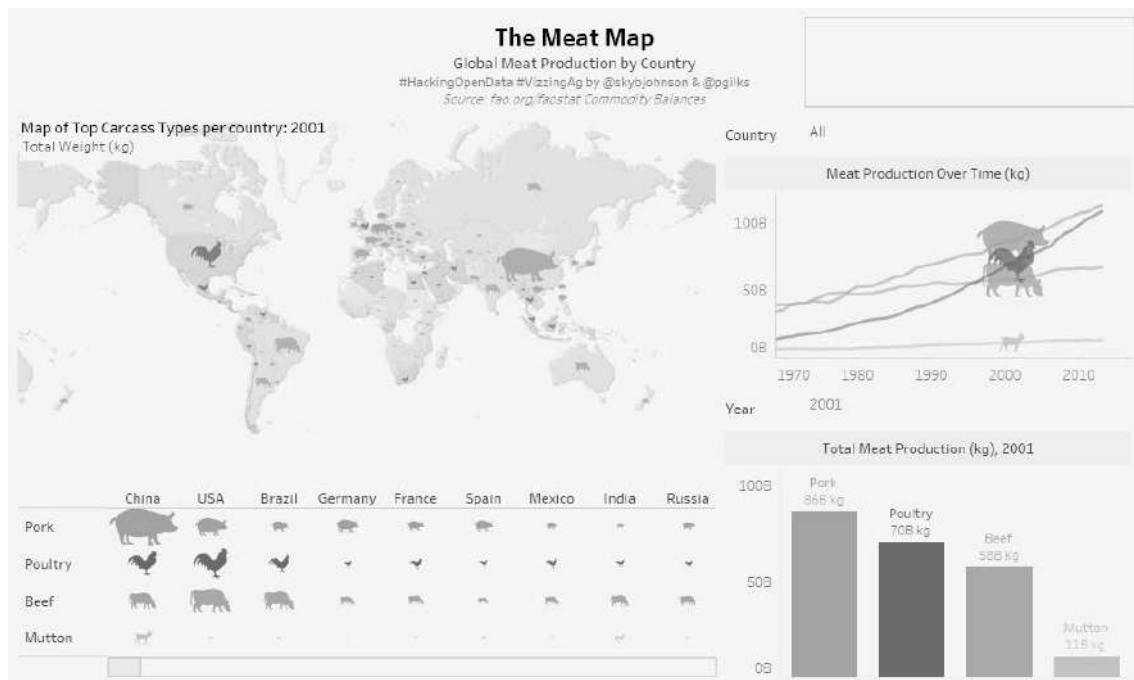
Director, Agrofood Industries (South East),
Vijayawada, AP, India. General Manager, Aov Exports Pvt Ltd.,
C-22/25, Sector – 57, Noida, Up.

Consultant – Slaughter House Waste Management
Regional Centre For Urban And Environmental Studies
(Ministry Of Urban Development, Newdelhi), Lucknow.
Tel : 8081123003, 9935259422
Email : Drspfonglan@aovexports.com

"Agriculture cannot be sustainable without animal agriculture,"
Frank Mitloehner, a UC-Davis animal science professor.

Over view of Global Meat Trade

Fig 1.



Global production is forecast to grow slightly (1 percent) in 2019 to 63.6 million tons, primarily from gains in Brazil, the United States, and Argentina. Brazil's expansion is driven by steady domestic demand and solid export growth to key Asian markets. Argentina's growth is driven by rising weights in response to stronger export demand for heavier animals. Australia's persistent hot and dry weather conditions have led to deteriorating pasture conditions, high grain prices, and low water supplies, forcing more cattle into feedlots. With lower expected cattle numbers at the start of 2019 beef production is forecast lower. To the extent herd rebuilding occurs in 2019 fewer animals may be available for slaughter.

Fig 2 : Global Beef Supplies

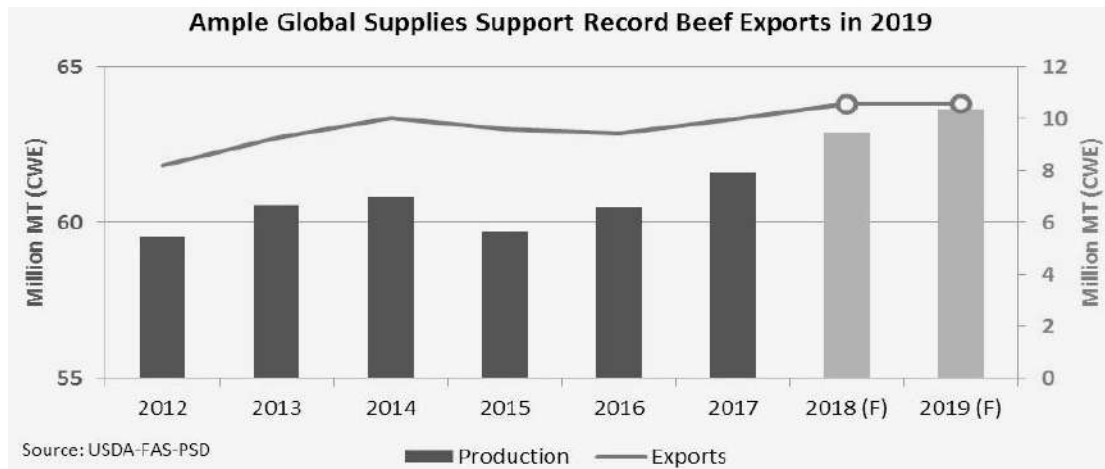


Fig 3 : Global Meat Trade

Beef and Veal Trade - Selected Countries Summary						
1,000 Metric Tons (Carcass Weight Equivalent)						
	2014	2015	2016	2017	2018	2019 Oct
Total Imports						
China	417	663	812	974	1,200	1,320
Japan	739	707	719	817	835	850
Hong Kong	646	339	453	543	560	600
Korea, South	392	414	513	531	560	565
Russia	932	622	524	516	495	470
European Union	372	363	368	338	370	370
Egypt	270	360	340	250	300	330
Chile	241	245	298	281	310	320
Canada	272	269	243	229	240	250
Mexico	206	175	188	196	210	220
Others	2,085	1,969	1,880	1,920	1,927	1,987
Total Foreign	6,572	6,126	6,338	6,595	7,007	7,282
United States	1,337	1,528	1,366	1,358	1,373	1,406
Total	7,909	7,654	7,704	7,953	8,380	8,688
Total Exports						
Brazil	1,909	1,705	1,698	1,856	2,100	2,200
India	2,082	1,806	1,764	1,849	1,665	1,625
Australia	1,851	1,854	1,480	1,485	1,630	1,510
New Zealand	579	639	587	593	603	589
Argentina	197	186	216	293	500	575
Canada	378	397	441	465	500	515
Uruguay	350	372	421	436	440	415
Paraguay	389	381	389	378	380	360
European Union	301	305	350	369	350	350
Mexico	194	228	258	280	305	330
Others	601	685	664	666	650	635
Total Foreign	8,831	8,558	8,268	8,670	9,123	9,104
United States	1,167	1,028	1,160	1,297	1,435	1,472
Total	9,998	9,586	9,428	9,967	10,558	10,576

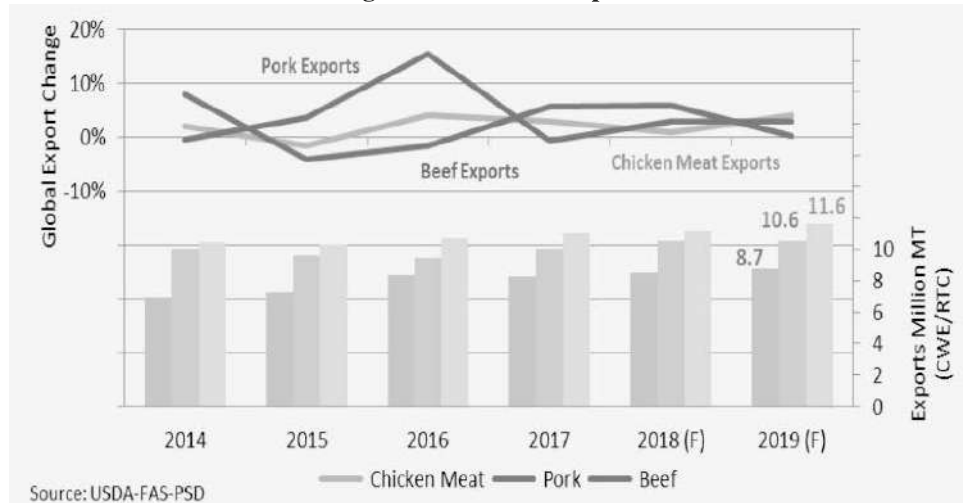
Notes: Includes meat of other bovines for certain countries. Indian exports are carabeef (water buffalo). From 2015, the following countries are excluded: Albania, Azerbaijan, Cote d'Ivoire, Georgia, Ghana, Jamaica, Senegal and Uzbekistan. The notation of a month beneath a year conveys the month in which the forecast for that year was released.

Global exports in 2019 are forecast flat at 10.6 million tons as shipments from Brazil, Argentina, and the United States will offset declines by Australia and India. Australia's herd rebuilding efforts will become its priority in 2019 potentially providing opportunities for major exporters to increase market share on growing global beef demand. China and Hong Kong's ever-rising beef demand will remain strong as stagnant domestic production and looming disease uncertainties in competing meat proteins fuel consumption.

In 2017, Exports by major traders was forecast 3 percent higher to 9.9 million tons on stronger demand. Gains are expected for most major traders including India, Brazil, and the United States. India was

expected to be remaining the top exporter as demand was expected to improve. in Southeast Asia, the Middle East, and North Africa. Brazilian exports will rebound as a weaker real increases competitiveness and the reopening of the Chinese market creates new opportunities.

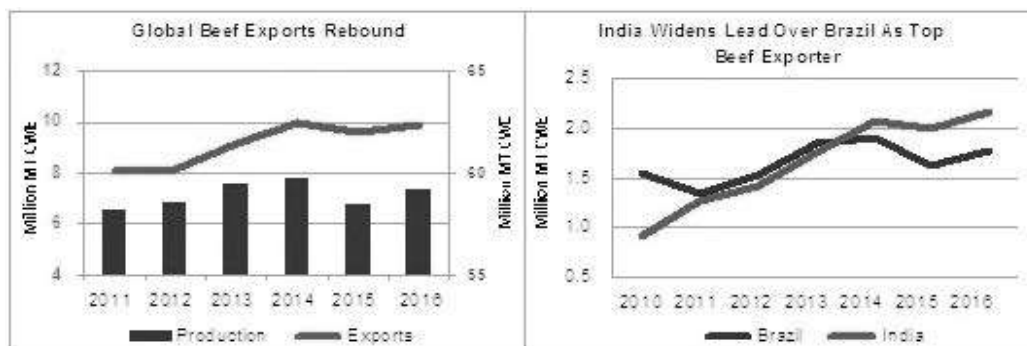
Fig 4 : Global meat exports



Indian Scenario

India's CY 2017-19 cattle and water buffalo population is forecast to increase to 303.6 million heads due to marginally less slaughter in CY 2016-19. The earlier carabeef and beef production forecast of 4.4million tons CWE is lowered to 4.35 million tons CWE on expectation of slow recovery of exports to some of the Southeast Asian and African countries. The estimate of Carabeef and beef production for CY 2016 is revised to 4.2 MMT CWE from previous estimate of 4.3 MMT CWE on sluggish export demand. India's demonetization policy announced on November 8, 2016 also negatively affected export trade once export-oriented slaughter operations depleted funds to make cash payments to the traders and small farmers for the purchase of animals. According to industry sources, export trade was most affected during the month of December 2016. Carabeef production is mainly concentrated in the states of Uttar Pradesh, Andhra Pradesh, Maharashtra, and Punjab, with Uttar Pradesh having the country's largest water buffalo population. The water buffalo population will likely remain strong over the next decade due to strong growth in the dairy sector as more than 50 percent of India's milk production is sourced from water buffaloes and the meat sector primarily uses spent dairy water buffaloes for slaughter.

Fig 5: India Vs Brazil on Beef Exports



Post forecasts CY 2017 carabeef exports at 1.95 million tons CWE, an increase of 5 percent year on year, driven mostly by moderate increases in demand from the Middle East, Africa and Southeast Asia, including the newly opened market of Indonesia. CY 2016 carabeef exports are lowered from 1.95 million tons CWE to 1.85 million tons on the afore-mentioned effect of demonetization. In addition, exports to some of the Middle East and African countries declined in CY 2016 due to economic slowdown and adverse demand conditions, although this slowdown was partly offset by the new exports initiated to Indonesia.

In CY 2018, Indian beef exports stood at 1.665 million tons CWE, a decline of around 15 % compared to the previous year. In CY 2019, India is forecast to export around 1.625 million tons CWE.

Major advantages of Animal Agriculture

- Contribute 40 percent of global value of agricultural output
- Support livelihoods and food security of almost 1 billion people
- Provide food and incomes and consume non-human-edible food
- Contribute 15 percent of total food energy and 25 percent of dietary protein
- Provide essential micronutrients (e.g. iron, calcium) that are more readily available in meat, milk, and eggs than in plant-based foods
- Are a valuable asset, serving as a store of wealth, collateral for credit, and an essential safety net during times of crisis
- Are central to mixed farming systems, consume agricultural waste products, help control insects and weeds, produce manure and waste for cooking, and provide draft power for transport
- Provide employment, in some cases especially for women
- Have a cultural significance, as the basis for religious ceremonies.

Indian Retail Scenario:

India is a multicultural society with varied food habits and preferences. Majority of Indian population i.e. around 75% of the population eat non-vegetarian foods in varied preferences among available non-vegetarian foods. NCR region comprises of 4 crores of population and majority population is in the 15 years to 45 years bracket. This population demographics demand a good market potential for processed non-veg foods in this region.

Fig : 6 Mutton Retail Cuts



Per capita consumption of Chicken in India is 3.6 kg. The NSSO data says 6.4% of rural Indians eat mutton, 21.7% eat chicken, 26.5% consume fish, while 29.2% eat eggs. In urban India, 10% eat goat meat/mutton, 21% eat fish, 27% eat chicken and a 37.6%, eating eggs. Per capita consumption of mutton and fish is less than 100 gm leaving a big gap for growth.

Present Production Trends - Mutton

Mutton production stands at 1.4 million MT as per 2013 -14 statistics of MoFPI. Out of this sheep meat contributes 0.4 million MT. And goat meat contributes 0.9 to 1.0 million MT. India is the second largest producer of goat meat in the world with the finest meat breeds having great potential. Availability of uniform and consistent quality of mutton to Indian customers is still a challenging task and organized players like us play a vital role in fulfilling this gap.

Drivers for Increasing Non-Vegetarian Food demand:

USDA has come out with the following findings for India which will boost/drive the demand for Non-Veg Foods:

Fig. 7 : Modern Abattoir Activities



Rising middle class income, International exposure, overseas employment, wide travel and expansion of fast food restaurant chains has spurred the growth of consumption of convenient non-vegetarian foods. In addition, government policy improvements leading to strengthening of rural and urban infrastructure has made it possible for the availability of hygienic meat and convenient non vegetarian foods to the easy reach of the consumers. The following attributes also favored the growth of convenient meat sector in the urban/rural retail market.

- Expansion of sales and retail distribution
- Spurring growth in rural consumption
- Policy changes in Government of India, thereby modernizing local abattoirs.
- Fastest growing economy in the world.
- India is the second largest consumer market.

Role of AOV Agro in Backward Linkages

Understanding the need and potential we at AOV has geared up to establish strong backward linkages with the primary producers, the farmers. Modern processors like us enable as easy large scale market for the

farmers to sell their produce poultry/sheep/goat/shrimps at reasonable prices benefitting the farmers in the value chain.

Fig: 8 State-of-the-art Meat Packaging Facilities



Strategically located, our processing facilities are at easy reach for the farmers. Our plants are easily connected by road with sheep/goat/buffalo rearing regions and chicken farmers. We shall be providing technical services to those farmers tied up with us so that quality produce is produced with ease.

Role of AOV Agro in Forward Linkages

Fig: 9



**State -of-the-art
processing and packing
facilities.**

- AOV is an established player in the export market as well as the national market.
- With good clientele in the gulf market, chilled mutton is being airlifted and exported in the middle east market.
- We have a well-established market network in the national non-vegetarian meat market
- We sell significant quantities of frozen meat to our prestigious armed forces.
- Thus we at AOV fulfill the FARM to FORK concept giving full benefit the farmers as well as to the consumers.

Fig : 10 Meat Junction



Modern processing infrastructure:

India has developed more than 80 modern integrated buffalo abattoirs with around 15 units having sheep/goat abattoirs along with the buffalo abattoirs. There are around 7 standalone sheep/goat integrated abattoirs and around 15 plus integrated modern poultry processing units.

The chicken plant at our facility is having a capacity of 2000 birds / hour capacity which shall be expandable to 4000 birds/hour to meet the growing demands of the NCR market. We have a full fledged hygienic online poultry processing line to pack chicken primal cut up parts. The plant is equipped with a freezing capacity of 48 MT per day chicken meat. The plant is having a cold storage capacity to store 600 MT of frozen chicken meat. We have two modern integrated sheep/goat abattoirs with a combined capacity of 2500 sheep/goat slaughter per day and an integrated buffalo abattoir with a capacity to slaughter 750 buffaloes per day.

Supply Chain

Our supply chain is equipped with end to end refrigeration facilities to take our chilled/frozen meat to our local as well as our international customers with the promised quality. The proximity of our units to NCR and other metro markets makes us as a leading producer and supply of non-veg products to the NCR and other major metros/markets.

We have a fleet of 16 reefer carriers to cater to our buyers demand in the NCR/metro region under controlled temperatures and hygienic conditions. These reefer carriers are equipped with thermographs to

monitor the temperatures on a continuous basis. We are a leading supplier of frozen mutton and chicken to our prestigious armed forces.



Way Forward:

In these period AOV Agro is being evolved into a leading player and supplier of quality and hygienic non-veg foods to the prestigious Indian armed forces, corporate clients, star hotels, increasing consumers of NCR region, export markets and expanding pan India with our current presence till south in the retail markets of Kerala augmenting the supply of fresh and hygienic meat products nationwide. **Meat Junction** is one such major venture to showcase and take our meat to the retail/corporate customers. This acts as an one stop shop for all the meat requirements of our customers.

Acknowledgement:

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