Scientific Meat Production: Extension Modules and Techniques for Butchers, Meat Handlers and Consumers

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Editors

Vasudevan V.N., Sathu T., Irshad A., Silpa Sasi, Shahaji Phand and Sushirekha Das

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This e-book is a compilation of resource text obtained from various subject experts of Meat Technology Unit, Mannuthy, Thrissur, Kerala Veterinary and Animal Sciences University & National Institute of Agricultural Extension Management (MANAGE), Hyderabad, India on Refresher Course on Scientific Meat Production: Extension Modules and Techniques for Butchers, Meat Handlers and Consumers. This e-book is designed to educate extension workers, students and research scholars, academicians related to Animal Husbandry about Quality Challenges in Meat Sector.

MESSAGE

It is indeed heartening that MANAGE Hyderabad and the Academic Staff College Mannuthy, Meat Technology Unit Mannuthy Thrissur Kerala Veterinary & Animal Sciences University are jointly organising this **Online Collaborative Training Programme on "Scientific Meat Production: Extension Modules and Techniques for Butchers Meat Handlers and Consumers"** in the transformed teaching-learning environment.

In the contemporary meat industry scientific and hygienic practices play a pivotal role in ensuring not only the quality and safety of meat products but also the welfare of animals and the confidence of consumers. Extension professionals, butchers and meat handlers are at the frontline of these processes. Equipping them with updated information and skills is crucial for meeting new demands and adhering to evolving regulatory frameworks.

I trust that this online training programme will empower them to adopt best practices, build awareness among stakeholders and strengthen capacity-building initiatives across all levels of the meat supply chain. I also believe it will foster valuable exchange of knowledge and experiences that will collectively raise standards in the sector.

My sincere congratulations to the organisers and warm wishes for the successful conduct of this training programme and the publication of the compendium.

Prof (Dr) Anil K. S.
Vice Chancellor, KVASU

MESSAGE

Meat is a vital component of human diets across diverse cultures because of its high-quality proteins, vitamins and minerals. In a rapidly evolving food sector, ensuring that meat is produced using hygienic and scientific methods is of paramount importance. Proper handling, humane slaughter and safety-focused production practices do not just secure public health but also enhance consumer trust in meat products.

Extension professionals, butchers and meat handlers carry enormous responsibility for enforcing good practices and regulatory standards from the slaughterhouse to the marketplace. Their ability to understand and address quality challenges remains essential for preserving the nutritional benefits of meat and meeting the ever-growing demand for safe products. By adopting advanced tools and protocols in meat production, we can help reduce foodborne risks, strengthen community health and foster employment opportunities within this sector.

The Directorate of Entrepreneurship, KVASU is delighted to organise the online training **"Online Collaborative Training Programme on Scientific Meat Production: Extension Modules and Techniques for Butchers Meat Handlers and Consumers"** in collaboration with MANAGE Hyderabad and the Academic Staff College Mannuthy, Meat Technology Unit Mannuthy Kerala Veterinary & Animal Sciences University. This initiative comes at a crucial time and I trust it will significantly enhance participants' technical skills enabling them to uphold stringent quality standards throughout the meat supply chain.

My best wishes to everyone involved in this training programme and to all the participants seeking to refine their expertise for the benefit of the meat industry.

Sd/-

Dr. Senthilkumar R.
Director, ASC KVASU

PREFACE

This e-book is an outcome of the **Online Collaborative Training Programme on "Scientific Meat Production: Extension Modules and Techniques for Butchers Meat Handlers and Consumers."** It is specifically designed to equip extension professionals, butchers, meat handlers, processors and other stakeholders with practical knowledge on every stage of meat production from the welfare and scientific slaughter of animals to the hygienic handling storage and retail of meat products.

In recent years, concerns have arisen about the quality and safety of meat due to various contaminants including microorganisms, antibiotic residues and potential environmental pollutants. With meat being a rich source of essential nutrients consumers expect guaranteed wholesomeness and consistent standards in production. Zoonotic pathogens like E. coli O157:H7 and Salmonella also highlight the importance of science-based interventions to prevent foodborne illnesses. Moreover, awareness on antimicrobial resistance underscores the need for judicious antibiotic use and stringent monitoring through the meat supply chain.

The training modules covered in this compendium present updated insights on pre- and post-harvest interventions, processing methods, packaging advances and the scope of extension activities that can elevate practices in the unorganised meat sector. Special emphasis is placed on personal hygiene slaughter hygiene humane handling and the adoption of appropriate equipment to ensure maximum consumer protection and public health benefits.

Together, these contributions offer in-depth technical guidance and operational know-how to empower field officers and industry personnel. They present workable strategies that can be put into practice for improving meat quality while safeguarding the environment and consumer welfare.

We earnestly welcome valuable suggestions to enhance future editions of this compendium.

July, 2024 **Editors**

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Chapter 1

OVERVIEW OF MEAT INDUSTRY IN INDIA – CHALLENGES IN SKILL, GAPS & AWARENESS

Prof. Dr. J. Abraham.
Former Director & Professor, Centre of Excellence in Meat Technology, KAU

The role of meat industry in contributing to the Food Security & Sustainability to provide protein source of food for the 1.44 Billion population of India is well acknowledged. It is a major challenge for India in the current circumstances of unprecedented climatic changes taking place in the country in addition to reduced availability of land, fragmentation of arable land, shortage of water, feed, and various other concerns. However, we possess a very high source of livestock comprising of Cattle, Buffaloes, Goat, Sheep, Pigs and Poultry ranking first in buffalo population in the world, second in cattle and goat population. Our current meat production during 2022-23 was around 9.7 Milliom MT including buffalo meat, beef, mutton,chevon, pork & broiler chicken meat. This is a very impressive growth from 3.6 MMT I 1992-93 to 9.7 MMT during 2022-23. Major contributors among the states are: Maharashtra -12.5%, Utter Pradesh 12.14%, West Bengal 11.63%, Andhra Pradesh 11.01%, Telengana 10.8%. The total export of meat during the same period was to the tune of Rs.32,597.3 Crores /4062.15 USD.(Buffalo meat: 25648.1 Cr, Mutton & Chevon : 537.13 Cr,). The contribution of the Livestock sector is 4.9% of the GDP. It is heartening to note that the meat sector is now growing at a range of 6% CAGR. The overall consumption of meat among the Indian population is 6.82 Kg which is far less than the global average. The current slaughter rates among various species comprise of : Cattle -6.4%, Buffaloes - 11.5%, Sheep – 33.2% & Goat – 38.1%.

Currently we have 76 integrated export abattoirs in the country where all sanitary & phytosanitary procedures are adopted in slaughter & processing as per International Animal Health Code of OIE. They also utilize all the animal byproducts without causing environmental pollution. Majority of the export abattoirs are based at : Aurangabad, Nanded, Mumbai, Medak, Aligarh, Unnao, Ghasiabad, Punjab, Goa, Satara etc. However some of the exporters source their meat from other municipal slaughter houses like; Deonar, Meerut, Jaipur, Saharanpur, Bareilly, Muradabad, Khurja, Gangoh, Hyderabad, Aligarh, Mussafarnagar, Buland Sahar, & Kochi.

The meat sector has a pivotal role in providing nutritional security to our population. In addition to that, the sector provides employment & livelihood support to over 300 million people and contributes to 12% of the household income. 70% of the Indian population now consume 17.5 g of meat, including chicken per day and 79 eggs per annum. Meat provides proteins of high biological value which are readily assimilated in addition to Zn, Fe, Ca, Vit A, Vit B12 and many other micronutrients.

The production of meat for domestic consumption is from most of the municipal slaughterhouses, Panchayat slaughterhouses and even from illegal slaughterhouses. It is really pathetic to see the primitive slaughter facilities in many of those slaughterhouses and the unhygienic practices adopted in such primitive slaughterhouses. Though licenses are required for operation of slaughterhouses, it is not implemented in some of the illegal places. Now, the GOI has implemented the FSSAI regulations for production, processing & marketing of meat. It is a good step towards implementing food safety regulations for production of hygienic & wholesome meat.

It is also disheartening to note that only 1% of the total production of meat is value added. The meat industry would substantially improve and find better financial viability if more value added meat products are produced and marketed. In many of the European countries and in USA, more than 50% of the meat is value added and marketed. Value addition would improve the financial viability in addition to providing tasty, convenient meat products which would be accepted and relished by consumers.

The byproducts of slaughter are only marginally used in most of the slaughterhouses except export abattoirs. Generally only Hide , skin & rarely bones are utilized or sold from such slaughterhouses. Non-utilisation of byproducts result in environmental pollution which in turn causes spread of diseases. Effluent treatment is of major concern in most of such slaughterhouses, since no such facilities are available for them. Such solid and liquid waste are either thrown into rivers or public places.

Consumer awareness is almost at the rock bottom in most of the places. Consumers in general prefer fresh hot meat from carcass and that is one of the reason for the very low value addition. As such, carcasses are exhibited in market places in many states and meat sold to the public. The meat quality is at stake in such places since majority of such sales units do not possess refrigeration facility. The carcasses are generally not kept in cold rooms for conversion of muscle to meat. Such practices are rampant because of lack of cold room facility and poor consumer awareness.

Except pigs all other livestock are mainly reared for milk purpose in India. Though we are exporting a large quantity of meat, we do not have animals reared for meat purpose and we have not so far identified any particular breed as meat animal. However, there are very good breeds among the buffaloe and cattle which could be identified, selected and reared for meat purpose. Many of our Indian breeds of cattle which were previously exported to European countries have been found to be the most excellent meat breeds. Beef being a matter of controversy in India now, we could identify buffaloe breeds for meat purpose. Such a move would elevate our standard and would fetch far better price for our meat in the international market. Currently though we are exporting a large quantity of buffaloe meat, the price structure for our meat in the international market is not reasonably good.

Pork is a delicacy in most of the North-East states. It is also relished well in other states in India. The best meat for value addition is pork and a large number of products could be made

from pork which are well accepted internationally. World over, pork is accepted as the meat of preference in many countries. Therefore if we develop good breeds and process them efficiently, pork & products would become one of the best item which could be exported and also sold domestically.

Mutton & Chevon are well accepted in India and no taboos are existing around such meat. Since the domestic consumption demand is high, the price of mutton & chevon is also very high in most of the places which prohibits their use by average citizen. There is a dire need to identify the best breeds among sheep & goat having best fecundity and survivability with better muscle growth. It is easy for all household to keep such animals without much labour and expenditure.

Major Gaps:

1. Lack of scientific & modern facility in slaughterhouses in India. Requirement includes: Potable water supply, Lairage, Overhead rail system, ETP, Solid waste treatment facility, Cold rooms, Byproducts utilization facility etc
2. Lack of financial support for Modernisation of slaughterhouses.
3. Human Resource Development in all sectors including workers, supervisors, managers, traders, transporters of animals and meat. Byproduct utilization, Effluent treatment,
4. Poor Awareness among consumers regarding nutrition, quality of meat, preparation & storage of meat.
5. Lack of good quality feed and fodder.
6. Lack of Quality control Laboratories
7. Veterinary care for meat animals
8. Need for ante-mortem & post-mortem inspection by Veterinarians.
9. Fluctuation in availability of water & fodder due to climatic changes.
10. Lack of adaptation of technology among the butchers, workers and in the production & processing of meat.
11. Inconsistent rules & regulations in different states in India.
12. Religious fanatism, attack on animal transporters, handlers, butchers, consumers etc.

Challenges

1. How to face the impact of climatic changes that are erupting all over India? There had been severe heat, higher than ever faced by Indians in different states. This affect the availability of water, fodder, feed, management, veterinary services. Several diseases are emerging among animals & birds which affect the productivity, quality, health.
2. Essential need for support for modernization of slaughterhouses. Would the ministry at Central government evolve supporting projects? Would the state governments take initiative for such schemes?
3. Need for identification of Disease-Free Zones and develop Export Abattoirs in such areas?

4. Training needs for skill development among workers, butchers, supervisors, managers, entrepreneurs, Veterinarians, Product manufacturers.
5. Need for cold chain and cold room facilities in slaughterhouses, meat stalls, transport of meat.
6. Cold chain in production, processing and marketing
7. Establishment of solid and liquid waste treatment in all existing slaughterhouses.
8. 8.Establishment of Quality control Laboratories.
9. Identification of meat animal breeds, and establishing meat animal farms.
10. Modern meat stalls for marketing of meat.
11. Vertical integration of Poultry production & marketing.
12. Ensuring potable water supply to slaughterhouses and meat animal farms.
13. Awareness creation among the population regarding meat consumption, quality, storage, benefits, cooking etc.
14. Effective utilization of byproducts of slaughter for improving financial viability of meat production & processing.
15. Better varieties of Fodder cultivation to be encouraged
16. Providing subsidies and incentives for meat exporters.
17. Implementation of Animal Welfare systems in all slaughterhouses.
18. Providing Veterinary services for animal farms and slaughterhouses.
19. Strict implementation of Antemortem and post mortem inspection at slaughterhouses.
20. Genetic improvement of meat animals.
21. Enacting specific rules & regulations for slaughter, processing, transport of animals, storage of meat, & consumption of meat & meat products.
22. Implementation of Food safety standards in production, processing & marketing of meat and meat products.

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Chapter 2

OPTIMISING CARCASS HANDLING, STORAGE AND PACKING: ENSURING MEAT QUALITY AND SAFETY THROUGH SCIENTIFIC PRACTICES

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Introduction

The handling, storage, and packing of carcasses are fundamental components in the meat production process, directly impacting the quality, safety and marketability of meat products. Proper practices in these areas are crucial for maintaining meat's sensory attributes such as texture, flavour and appearance while preventing contamination and spoilage. This document explores the scientific principles and methods underpinning effective carcass management, integrating historical perspectives with modern advancements to provide a comprehensive guide for industry professionals.

Historically, carcass handling involved rudimentary methods like washing with large volumes of water to remove visible contaminants. However, these practices often fell short in preventing bacterial contamination and ensuring hygienic conditions. The shift towards minimal water use and the adoption of dry cleaning techniques, coupled with precise trimming, marks a significant advancement in modern meat processing. Today, the focus is on implementing Good Hygienic Practices (GHPs), utilising advanced cooling and freezing technologies, and employing innovative packaging methods to extend shelf life and maintain meat quality.

A critical aspect of carcass handling is the conversion of muscle to meat, a process influenced by biochemical changes such as pH decline post-mortem. Techniques like electrical stimulation, hip suspension and controlled chilling rates are employed to optimise this conversion, enhancing meat tenderness and flavour. Effective cooling and freezing are paramount to preserving meat quality, with rapid chilling and controlled freezing preventing bacterial growth and physical degradation.

Scientific research has highlighted the limitations of traditional washing methods, showing that spray washing may not significantly reduce bacterial contamination and can even cause cross-contamination. Instead, chemical treatments and precise trimming have proven more effective, though they must complement, not replace, stringent hygiene practices.

Temperature-controlled storage is another cornerstone of meat quality preservation. Properly cooled carcasses exhibit slower bacterial growth and longer shelf life. Factors such as cooler performance, carcass size, air speed, and humidity levels play a critical role in ensuring efficient cooling and preventing spoilage. Freezing, particularly quick freezing, helps retain meat's original quality by minimising physical and biochemical changes.

In retail environments, maintaining optimal storage conditions is essential to prevent temperature abuse and ensure consumer safety. Regular inspections, proper packaging, and adherence to hygienic practices are vital in preventing cross-contamination and preserving meat quality.

Packaging innovations, including vacuum packaging and Modified Atmospheric Packaging (MAP), further extend meat's shelf life by preventing oxidative rancidity and microbial growth. These technologies, combined with comprehensive handling and storage practices, form the backbone of a robust meat quality assurance system. The optimisation of carcass handling, storage, and packing through scientific methods and rigorous hygiene practices is essential for delivering high-quality, safe meat products to consumers. This document serves as a detailed guide for industry professionals, highlighting the best practices and latest advancements in carcass management.

Importance of Proper Carcass Handling and Storage

Improper handling and storage of carcasses can lead to significant issues:

- **Meat Quality Deterioration**: Poor handling can negatively impact the meat's texture, taste and overall quality, leading to consumer dissatisfaction.
- **Contamination**: Unsanitary handling increases the risk of bacterial contamination, which can pose serious health risks.
- **Economic Losses**: Contaminated or spoiled meat results in financial losses as it cannot be sold at premium prices.
- **Spoilage**: Ineffective storage conditions accelerate spoilage, making meat unfit for consumption.

Conversion of Muscle to Meat

The transformation from muscle to meat involves several biochemical processes:

- **pH Changes**: The pH of living tissue is approximately 7. Post-mortem, the depletion of ATP in the muscle cells leads to a drop in pH to around 5.4-5.7. This acidification is crucial for the development of meat's flavour and texture.
- **Key Processes**:
    - **Electrical Stimulation**: Applied to carcasses shortly after slaughter to accelerate the pH decline, reducing the risk of cold shortening and improving tenderness.
    - **Hip Suspension**: Helps in stretching the muscles, thus enhancing meat tenderness.
    - **Chilling Rate**: Rapid chilling helps in preserving meat quality by slowing down microbial growth and enzymatic reactions.
    - **Hanging Time/Maturation**: Proper ageing of meat allows enzymatic processes to break down muscle fibres, improving flavour and tenderness.

Carcass Cleaning Practices

Traditional Practice

Historically, the primary method for cleaning carcasses in the meat industry involved washing them with large volumes of hot or cold water. This practice aimed to remove visible contamination such as blood, dirt and other debris that accumulate on the surface of the carcass during the slaughtering and initial processing stages. The rationale behind using substantial water volumes was to ensure thorough cleaning, making the carcasses appear cleaner and more appealing. However, this approach had several drawbacks:

- **High Water Consumption**: The extensive use of water not only added to operational costs but also posed environmental concerns regarding water waste and management.
- **Limited Efficacy**: While effective in removing visible contaminants, this method often failed to address microbial contamination adequately, leaving bacteria and pathogens on the surface of the meat.
- **Cross-Contamination**: The water used in washing could become a medium for spreading bacteria from contaminated areas to cleaner surfaces, especially if not replaced frequently.

Modern Approach

The contemporary approach to carcass cleaning has shifted towards more efficient and sustainable practices that minimise water usage and focus on targeted cleaning techniques:

- **Dry Cleaning Techniques**: Instead of relying on water, modern practices employ dry cleaning methods such as air knives, dry steam, and brushes to remove surface contaminants. These techniques reduce water usage and the risk of cross-contamination.
- **Effective Trimming**: Trimming involves removing visibly contaminated or damaged sections of the carcass with sterilised knives. This method is more precise and effective in eliminating localised contamination without spreading it.
- **Minimal Water Use**: When water is necessary, it is used sparingly, often in conjunction with controlled pressure sprays that target specific areas rather than washing the entire carcass. This reduces the risk of bacterial spread and conserves water.

Primary Objective

The main goal of carcass cleaning, whether through traditional or modern methods, is to remove visible soiling and bloodstains, thus enhancing the carcass's appearance post-chilling. A clean carcass is not only more visually appealing but also perceived as being of higher quality and safety by consumers and regulatory bodies. Clean carcasses also facilitate better inspection and grading processes, ensuring that any remaining issues can be promptly addressed.

Limitations

Despite advancements in carcass cleaning techniques, several limitations remain:

- **Not a Substitute for GHPs**: Washing or any form of cleaning cannot replace the necessity for Good Hygienic Practices (GHPs) throughout the entire meat processing chain. Ensuring cleanliness and safety at every stage—from slaughter to processing—is crucial.

- **Risk of Bacterial Spread**: If not conducted properly, cleaning processes, especially those involving water, can spread bacteria from contaminated spots to previously clean areas. This highlights the importance of using sterilised equipment and controlled cleaning methods.
- **Incomplete Removal of Microbial Contaminants**: While visible contaminants can be effectively removed, microbial contaminants may still persist. This necessitates the use of additional antimicrobial treatments and stringent hygienic practices to ensure meat safety.

Scientific Research and Findings

Research has highlighted the inefficacy and risks associated with traditional washing methods:

- **Spray Washing**: Studies, such as those by Ellerbroek, Wegener, and Arndt (1993), found that spray washing neither significantly reduces nor increases bacterial contamination. However, it can cause cross-contamination if not managed correctly.
- **Trimming Effectiveness**: Research by Prasai *et al.* (1995) supports trimming as an effective method for removing visible contamination. Yet, Gill (2009) points out that trimming alone may not sufficiently improve the microbiological status of carcasses, underscoring the need for comprehensive hygienic measures.

Modern carcass cleaning practices represent a significant improvement over traditional methods by focusing on targeted, efficient, and sustainable techniques. However, these practices must be integrated with robust Good Hygienic Practices to ensure the overall safety and quality of meat products. By combining effective cleaning methods with stringent hygiene protocols, the meat industry can better control contamination, enhance product quality and meet consumer and regulatory standards.

Scientific Research and Findings

- **Spray Washing Ineffectiveness**: Research by Ellerbroek, Wegener, and Arndt (1993) indicated that spray washing does not significantly reduce bacterial contamination. Instead, it may cause cross-contamination of clean surfaces.
- **Trimming**: Prasai et al. (1995) found trimming to be an effective method for removing visible contamination. However, Gill (2009) argued that trimming might not significantly impact the microbiological status of carcasses.
- **Chemical Treatments**: Various chemicals, such as chlorine, organic acids (acetic, lactic, citric, fumaric), hydrogen peroxide, and antimicrobials (nisin, bacteriocin, lactoferrin), are used to reduce bacterial load. Phosphates like trisodium phosphate are also employed for this purpose.

Good Hygienic Practices (GHP) for Carcass Splitting/Washing

- **Sterilisation**: Ensure that all splitting equipment is sterilised between carcasses to prevent cross-contamination.
- **Potable Water**: Use only potable water for carcass washing.
- **Minimise Washing**: Wash carcasses as little as possible to prevent the spread of contamination.

- **Airborne Cross-Contamination**: Avoid creating aerosols during washing to prevent airborne cross-contamination between carcasses.
- **Trimming Over Washing**: Prefer trimming to remove surface contamination rather than washing.
- **Avoid Wiping Cloths**: Wiping cloths should not be used as they can spread contamination.

Temperature-Controlled Storage Practices

Temperature-controlled storage is essential to maintaining meat quality and safety:

- **Physical and Chemical Changes**: Carcass storage can lead to shrinkage, sweating, loss of bloom, drying, protein breakdown, and changes in odour and flavour.
- **Cooling Practices**:
    - Carcasses should be cooled to specific temperatures (e.g., beef: 6-7°C within 28-36 hours) to prevent bacterial growth and extend shelf-life.
    - **Factors Affecting Cooling Efficiency**: Cooler performance, load, carcass size, and fatness impact cooling rate.
    - **Air Speed and Humidity**: High air speeds (0.5 m/s) and maintaining relative humidity (RH) at about 90% are essential for rapid cooling without causing excessive weight loss due to evaporation.

Freezing and Storage

Freezing is crucial for long-term storage:

- **Freezing Process**:
    - Approximately 80% of meat's water content solidifies into pure ice crystals during freezing.
    - Meat is considered frozen when its core temperature reaches -12°C or lower.
    - **Freezing Speed**: Quick freezing forms smaller ice crystals, preserving meat quality better than slower freezing, which forms larger ice crystals due to water migration.
- **Freezing Techniques**:
    - **Pre-treatment**: Meat is often refrigerated before freezing.
    - **Cutting and Packaging**: Cutting and deboning before freezing reduce mass and increase storage density.
    - **Freezing Equipment**: Blast freezers and plate freezers are commonly used. Blast freezers use high-speed air circulation to achieve rapid freezing, while plate freezers press meat between cooled metallic plates.
- **Quality Assurance**:
    - Protect meat from freezer burn and oxidation with airtight, moisture-vapour resistant packaging.
    - Follow recommended storage durations (e.g., beef: 12 months, pork: 6-8 months).

Retail Meat Cold-Store Maintenance

Proper maintenance of retail meat cold stores is crucial:

- **Chest Freezers**: Commonly used in retail stores for long-term storage, chest freezers operate by convection and conduction, with a slow cooling rate.
- **Inspection Points**:
    - Ensure the entire sensing element is in contact with the food packets.
    - Avoid cross-contamination between raw and ready-to-eat products.
    - Check for abnormal odours, leakage, and sanitary status of the freezer.
    - Monitor for signs of temperature abuse, such as condensed ice crystals inside the packaging.

Packaging of Meat

Packaging plays a vital role in preserving meat quality:

- **Purpose**: Prevent contamination, colour deterioration, moisture loss, odour pickup, and oxidative rancidity.
- **Types of Packaging**:
    - **Aerobic Packaging**: Uses atmospheric air and maintains meat's fresh bloom.
    - **Vacuum Packaging**: Removes air to restrict microbial growth and prevent oxidation.
    - **Modified Atmospheric Packaging (MAP)**: Uses gases like CO_2, N_2, and O_2 to maintain meat colour and quality.

Conclusion

Proper carcass handling, storage, and packing are essential to maintaining meat quality and safety. By adhering to hygienic practices, effective cooling and freezing techniques, and appropriate packaging methods, the meat industry can ensure the delivery of high-quality, safe meat products to consumers.

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Chapter 3

PRESLAUGHTER CARE OF ANIMALS AND ITS IMPACT ON MEAT QUALITY

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Introduction

Preslaughter care of animals is crucial to ensure their welfare, minimise stress and maintain meat quality. Proper handling, transportation and management practices are essential to meet ethical and welfare standards in the meat industry. This unit outlines the key aspects of preslaughter care, focusing on the five freedoms, handling guidelines, transportation best practices and unloading procedures , stunning, slaughtering and sticking.

The Five Freedoms

Ensuring animals are free from hunger and thirst is the first step in preslaughter care. Animals must have access to fresh water and a suitable diet before transportation. The pigs should not be heavily fed just prior to transport to prevent motion sickness and choking; feeding should stop four hours before transport, and a molasses-water mix (1:3) should be provided instead. Providing a comfortable environment in farm, in slaughter house, during transport helps animals avoid discomfort. Vehicles should have non-slip floors and adequate space to prevent overcrowding and ensure animals are protected from extreme heat or cold.

Handling animals gently is essential to prevent pain, injury and disease. Avoid rough handling, yelling or using abusive methods. Regular inspections for signs of injury or illness should be conducted and necessary veterinary care should be provided. Allowing animals to exhibit their natural behaviors by providing enough space and reducing stress factors is also important. Grouping animals with familiar companions can reduce stress and fighting during transportation and in lairage.

Minimizing fear and distress is another critical aspect of preslaughter care. Loud noises, sudden movements and isolation from social group should be avoided. Handlers should use calm approach and avoid deliberate movements to prevent panic and stress among the animals.

Handling of Animals

Proper handling of animals is essential to reduce stress and ensure their welfare during the preslaughter phase. Avoid isolating animals from their group or exposing them to distractions like shadows, flapping cloth or rattling chains. Noisy equipment should be kept away from animals and yelling at them should be avoided, as it increases stress levels and can lead to unpredictable behavior and it ultimately affect the meat quality. Establishing a daily routine helps animals ease handling and reduces stress, as they are creatures of habit. Handlers

should move slowly to avoid frightening the herd. If animals refuse to move, handlers should check for distractions causing them to balk.

Journey from Market to Abattoir

The journey from the market to the abattoir involves several factors that impact animal welfare. Avoid overcrowding to ensure animals have enough space to move and rest comfortably. Transport animals with familiar companions to reduce stress and fighting. Minimise transit and waiting times to reduce stress and fatigue. Ensure good road conditions and well-maintained trucks to provide a smooth journey. Use non-slip ramps for loading and unloading and avoid jumping animals off vehicles higher than 45 cm to prevent injuries. Adjust ventilation and temperature control in trucks to protect animals from heat or cold stress.

Preloading Precautions

Feeding animals before transport is important, but pigs should not be heavily fed to prevent motion sickness and choking. Stop feeding pigs four hours before transport and provide a molasses-water mix (2:50). Premixing different groups of cattle or pigs 24 hours before loading can reduce fighting and stress during transport, as animals become familiar with each other.

Best Practices in Transportation

Vehicles and loading ramps should have non-slip surfaces to prevent slips and falls. Handlers should move animals quietly at a walk or trot, and throwing or rough handling should be prohibited. Educate handlers and drivers about the animals' flight zones and points of balance to ensure proper handling. Avoid overloading trucks to ensure animals have enough space and ventilation and underloading to avoid animal falling leading to fractures and bruises. During hot weather, keep trucks moving to prevent heat buildup and during cold weather, protect animals from wind-chill and frostbite. Ensure minimum deck heights for sheep/goats (0.9 m) and pigs (1 m) in multideck vehicle.

Unloading at the Slaughterhouse

Unload animals as soon as possible after arrival using unloading ramps. Severely injured animals should be slaughtered immediately to prevent further suffering. Allow animals to move slowly and acclimate to their new environment.

Showering with Cold Water in Lairage

Showering animals with cold water lowers their body temperature, providing a calming and cooling effect. This practice reduces the incidence of Pale, Soft and Exudative (PSE) meat and minimises fighting and skin damage. Additionally, showering helps clean the animals. Ensure before slaughter the hide of the cattle is dry so the contamination can be reduced.

At Lairage: Stress Factors

Stress factors at the lairage significantly impact animal welfare. A lack of ramps for unloading can cause unnecessary delays, increasing stress levels. Insufficient holding space, mixing different categories of animals and a lack of shelter from bad weather further exacerbate stress. Deprivation of water and attacks by predators are severe stressors that can lead to panic and injury. Delays in slaughtering and insufficient lighting also contribute to stress. Holding horned, dehorned, animals in oestrus and aggressive animals together can lead to injuries and increased anxiety and stress.

Lairage and Passage

The design of lairage and passageways is crucial for minimising stress. Sharp corners or dead-ends in passageways should be avoided, with curved passageways being ideal. Floors should be non-slip to prevent injuries and a well-functioning ventilation system is essential to maintain a comfortable environment. Playing melodious music can have a calming effect on animals, while the height of the roof should be such that it prevents echoes, which can startle animals.

Effect of Sound on Pigs

Pigs are particularly sensitive to new or sudden noises, including ultrasound. To keep pigs calm, minimising all types of sound is important. Using plastic instead of metal gates and fencing can reduce noise levels, and preventing high ceilings can help reduce echoes and overall noise.

Moving the Pigs

Using a stock board to move pigs is the best method, as it minimizes stress and physical damage. Using an electric goad can increase blood spots in the meat and using sticks can contribute to skin damage in the hind region. Calm handling and minimising noise are crucial for keeping pigs stress-free.

Preslaughter Care in Lairage

Adequate rest is a vital component of preslaughter care in lairage. Animals should rest for a minimum of 4-6 hours, with an ideal range of 18-24 hours before slaughter and a maximum of 48 hours. Ample drinking water must be provided to prevent dehydration. Fasting prior to slaughter is necessary, but animals should be given enough food until the fasting period begins. Without proper rest, animals may not achieve the desired acidity in their muscles, leading to issues like bone taint in cattle and hamsour in pigs.

At Lairage: Stress Factors

Stress factors at lairage significantly impact animal welfare and meat quality. A lack of ramps can cause unnecessary delays in unloading injuries, while insufficient holding space can lead to overcrowding and increased stress. Mixing different categories of animals and a lack of shelter from bad weather further exacerbate stress. Deprivation of water and attacks by predators are severe stressors that can lead to panic and injury. Delays in slaughtering, insufficient lighting, and holding horned, dehorned, animals in oestrus, and aggressive animals together can lead to injuries and increased anxiety.

Fighting in Lairage

Fighting in lairage often results from social dominance behavior and the stress of being mixed with unfamiliar animals. This behavior is most common within the first 15 minutes to 1 hour after mixing the social group and this is more common in pigs. Skin damage due to bite in pigs is typically higher in the front and middle regions of the body, with bites targeting the ears, face, and neck. To prevent fighting, showering animals can be effective or feeding maize grains immediately arriving in the Lairage.

During Slaughter

Proper procedures during slaughter are crucial for animal welfare. Inadequate restraining, lack of proper stunning, and delays in stunning are significant issues that can cause unnecessary suffering. Scientific slaughtering methods must be followed and equipment should be well-maintained and properly applied. The involvement of unskilled persons in slaughtering can lead to mistakes that cause additional stress and pain to the animals.

Before Slaughtering

Pre-slaughter rest, calm handling, and minimising noise are essential to reduce stress in animals. Avoid overcrowding in the alley to stunning box and ensure that no animal is slaughtered in front of another. Additionally, the knife should not be sharpened in front of the animal to avoid causing distress.

During Stunning

Inadequate restraining and improper stunning can cause significant stress and suffering. Effective stunning is crucial and equipment must be well-maintained. Personnel should be trained to ensure that stunning is performed correctly and without delay. Scientific slaughtering methods should be followed, and unskilled persons should not be involved in the slaughtering process to prevent unnecessary suffering.

Welfare Monitoring and Record Keeping

Effective welfare monitoring and record keeping are vital components in maintaining high animal welfare standards during the preslaughter and slaughtering phase. Conducting routine audits and inspections of animal handling stunning, and sticking procedures ensures that practices align with established animal welfare standards. Regular audits help identify any deviations from standard practices and provide opportunities for continuous improvement.

Maintaining detailed records of all procedures is equally important. These records should include logs of stunning and sticking procedures, equipment maintenance records, staff training documentation and any incidents or deviations from standard practices. Comprehensive record keeping allows for better tracking of animal welfare practices, identification of trends or issues, and implementation of corrective actions when necessary.

Effect of Stress on Meat Quality

Hormonal Response to Stress

Understanding the hormonal response to stress is crucial for managing animal welfare and meat quality. Stress can be categorised into short-term and long-term stress, each triggering different hormonal responses. Short-term stress is characterized by the release of adrenaline (epinephrine) and noradrenaline (norepinephrine) from the adrenal medulla, triggered by the activation of the Sympathetic Nervous System (SNS). This immediate response increases heart

rate, blood pressure, and glucose levels, dilates airways and mobilises energy reserves through glycogenolysis. The metabolic effect includes rapid glycogen breakdown in muscles, leading to increased glucose availability for immediate energy. However, this can result in a rapid decrease in muscle pH post-mortem, potentially causing Pale Soft, Exudative (PSE) meat commonly seen in certain breeds of pigs (due to genetic factors-like halothane or napole gene)

In contrast, long-term stress involves the release of cortisol (in mammals) or corticosterone (in some bird species) from the adrenal cortex, triggered by the activation of the Hypothalamic-Pituitary-Adrenal (HPA) axis. This prolonged response mobilises energy stores through gluconeogenesis, suppresses the immune system and promotes protein and fat catabolism. The sustained breakdown of glycogen, proteins and fats can lead to high ultimate muscle pH due to chronic glycogen depletion, resulting in tougher meat texture and DFD meat. Behavioral effects of long-term stress include altered feeding behavior, potential lethargy or depression

Stress experienced by animals during the preslaughter phase can significantly impact meat quality. Common issues related to stress include Pale, Soft, Exudative (PSE) meat, Dark, Firm, Dry (DFD) meat, bruises, and transport mortality.

Pale Soft Exudative (PSE) Meat

PSE meat is often the result of short-term stress, which causes a rapid release of adrenaline and subsequent rapid breakdown of glycogen in muscles. This leads to a rapid decrease in muscle pH post-mortem, resulting in meat that is pale soft and exudative. PSE meat has poor water-holding capacity, making it less desirable for consumers and affecting its quality and market value.

Dark Firm Dry (DFD) Meat

DFD meat, on the other hand, is typically caused by long-term stress, leading to chronic depletion of glycogen stores. This results in a high ultimate muscle pH, making the meat dark, firm, and dry. DFD meat has a tough texture and reduced shelf life, negatively impacting its appeal and marketability and spoils faster due to high pH favouring the microbial growth

Bruises

Bruises are another common consequence of stress and poor handling practices. They result from physical trauma and can occur during transportation, handling or at lairage. Bruises not only affect the appearance of the meat but also lead to trim losses and reduced meat yield, increase the microbial load in the meat.

Transport Mortality

Transport mortality is a severe consequence of stress and inadequate care during transportation. Overcrowding, poor ventilation, extreme temperatures, and rough handling can all contribute to transport mortality. High mortality rates during transport not only raise significant animal welfare concerns but also result in economic losses for producers.

Preslaughter Stress and Microbial Load on Carcass

Preslaughter stress significantly contributes to an increased microbial load on the carcass, affecting meat safety and quality. The following points highlight the critical aspects of this relationship:

Immune Suppression

Chronic stress results in the release of cortisol, which suppresses the immune system. This suppression makes animals more vulnerable to infections, increasing the likelihood of harboring harmful bacteria that can transfer to the carcass during slaughter.

Physical Injuries

Stressful handling and overcrowding can cause physical injuries such as bruises, cuts, and abrasions. These injuries serve as entry points for bacteria, facilitating microbial contamination of the meat.

Increased Pathogen Shedding

Stress can cause animals to shed higher levels of pathogens like E. coli, Salmonella, and Campylobacter. These pathogens can contaminate the carcass, posing serious food safety risks and increasing the incidence of foodborne illnesses.

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Chapter 4

ANIMAL DISEASES AND MEAT QUALITY

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Livestock sector is an important component of India's economy in terms of income, employment and foreign exchange earnings. Following the sustained economic growth and rising domestic income, the demand for livestock products has increased tremendously. This has encouraged the rapid expansion of livestock output during the last few decades. Diseases that affect the health and productivity of food animals directly impact the cost and supply of high-quality protein available for human consumption. In addition to the expense resulting from animal treatments and deaths, diseases also cause economic losses by decreasing meat, milk or egg production, reducing feed conversion, slowing weight gain, and increasing the time the animal must remain on the farm prior to marketing.

Every year almost 1 in 10 people in the world fall ill after eating contaminated food. More than 400,000 die every year because of foodborne diseases . Around 25% of all food produced globally is wasted post-harvest or post-slaughter due to microbial spoilage Contamination of carcass during slaughter happens due to contaminated environment, contamination through the intestinal contents, slaughter house worker and contaminated water. Cross-contamination in meat processing plants and food handlers can also lead to contamination of meat.

Animal farming and diseases:

The backyard farming in developing countries like India, is characterized as a low input/low output system . Backyard production systems (BPS) are a key element of food security in the developing countries as it can lead to better nutrition, which can bolster the immune system in fighting infections . In addition, the BPS have been the source of multiple epidemic outbreaks, even though the data suggest that it may be associated with fewer risks of outbreaks than those in intensified farming . As backyard farmed animals live very close to the human habitation, they are less likely to be monitored and handled than pets that live in the house, leading to lower disease detection rates Lower biosecurity and poor levels of hygiene may also increase the risks of disease transmission . The intensification of animal husbandry has reduced the likelihood that farmed animals come into contact with pathogens, and has thus helped to reduce disease risks. However, it has increased scale of disease impact, led to immunosuppression of intensively farmed animals, The animals raised in intensive farming system have less outdoor access, given specific feed that replaces the foraging crops, remain in highly controlled and confined facilities, receive large doses of antimicrobials. The high animal density in intensive farms leads to a greater spread of pathogens within the facilities as all the animals can be infected within a few days. Moreover, the selection of the most profitable species of farmed animals in intensive farms has led to a high level of genetic similarity which

facilitates the spread of the pathogens as all animals within the farms are immunologically naïve hosts, increasing the chance of catastrophic epidemics. In addition, genetic proximity and high density together offer ideal circumstances for the pathogens to mutate and evolve, which increases the risks of a mutation that is transmissible to humans. To avoid the risk of human contamination, as well as a spread to other facilities, intensive farms in high risk zones usually cull all animals once a case has been detected. For instance, during the highly pathogenic avian influenza epidemic

Meat borne diseases :

Among the numerous microbes interacting with animals, some of these pathogens may become zoonotic and cause illness among humans, posing a threat to public health and the economy. These diseases can be self-limiting or may become fatal depending upon the level of contamination and type of microbial contamination. Meat, red or white, from mammalian, avian, amphibian, aquatic, and reptilian species is consumed by humans as food. It is an excellent source of proteins, vitamins, and minerals and contains essential amino acids. Depending on the animal's health and the hygienic conditions of the meat processing facilities, meat can be a source of many different pathogens. These pathogens can enter the food chain either by direct infection of animals or by contamination during meat handling, processing, and retailing due to poor personal hygiene and sanitary conditions. The importance of meat-borne diseases (MBDs) has been emphasized with the development of the meat industry.

Meat-borne diseases can be caused due to different types of pathogens. Among these types, bacterial pathogens are the most important causative agents. Several bacterial pathogens, including *E. coli, Salmonella, Campylobacter, Listeria monocytogenes, Yersinia enterocolitica, Brucella* species, *Mycobacterium bovis, Bacillus anthracis* or toxin-producing species like *Staphylococcus aureus, Clostridium* species, and *Bacillus cereus*, cause meat-borne disease either by infecting animals or contaminating meat during meat processing or handling . Identification of the correct source of infection is usually hard to establish because of the slow progression of signs and symptoms in these type of diseases. The consumption of contaminated meat can lead to various diseases that can be divided into GIT diseases and extra-GIT diseases.

Escherichia coli :

The organism is normally observed in animal faeces. Many *E. coli* strains, once thought to be harmless, have acquired pathogenic genes and have evolved into potentially harmful pathogens The primary source of this pathogen is the animal population, which is transferred to humans through animal products The contamination of meat with pathogenic *E. coli* serotypes are usually associated with diarrhea or intestinal illnesses, but some strains of *E. coli* can also cause non-intestinal diseases. Among *E. coli* strains, Enterohemorrhagic *Escherichia coli* (*E coli* O157:H7) can cause life-threatening diseases due to hemolytic uremic syndrome and hemorrhagic colitis.

Salmonella :

Non-typhoidal *Salmonella* (NTS) serovars are particularly widespread, infecting a wide variety of animal and human hosts. These include *S*. Enteritidis and *S*. Typhimurium. The

World Health Organization (WHO) has declared that NTS is a major threat to world health, particularly in low-income nations The pathogen can survive in various animals or environments and eventually be transmitted to humans *via* consuming contaminated meat products or *via* direct contact with domestic animals. The organism can lead to severe diarrohoea in humans consuming infected meat. The infection can be controlled in farms by introducing Salmonella free birds, proper biosecurity measures, sanitising water and proper farm waste disposal.

Campylobacter :

Campylobacter, the bacteria responsible for campylobacteriosis, has a major impact on public health. Poultry is a major natural reservoir of *C. jejuni*. Within poultry flocks, they spread through fecal-oral transmission.. It is believed that only a low infectious dose (500–800) of *C. jejuni* is enough to induce GIT disease in humans. *C. jejuni* can contaminate water sources and thrive in domestic animals such as cattle and pork. Consumption of unpasteurized milk or undercooked meat can lead to GIT inflammation caused by *Campylobacter jejuni*, infecting the epithelial cells lining the intestine.

Meat-borne intoxication

Toxins produced by pathogenic bacteria naturally found in or transmitted to meat or meat products can cause meat-borne intoxication. Some bacteria can survive high temperatures or enter food even after it has been cooked or pasteurized. During the food-borne multiplication of these pathogens, they can generate neurotoxins and enterotoxins. Bacterial pathogens like *Staphylococcus aureus, Bacillus cereus*, and *Clostridium perfringens* are examples of this group . *S. aureus* is the most common cause of food poisoning from contaminated meat.

Parasitic infections :

The parasites associated with animals and lead to meat contamination mainly *Taenia* solium, *Taenia saginata*, *Trichinella* spp. *Toxoplasma gondii, Echinococcus granulosus.* Moreover, fish-borne parasites (*Clonorchis* spp., Anisakia spp.,) are also associated with foodborne ilnnesses. The increased popularity of consumption of raw and ready-to-eat meat, fish and vegetables may pose a risk for consumers, since most post-harvest processing measures do not always guarantee the complete removal of parasite stages or their effective inactivation. These diseases often represent complex, multi host life cycles with parasite stages in the hosts, but also in the environment, where parasite stages may survive for many months or even years. Parasite stages may also contaminate other food stuffs such as fruits and vegetables. A human infection risk therefore may occur (even for a single parasite) at several points in different food chains. Proper meat inspection is essential to detect the parasites in meat and prevent its spread to humans.

Foodborne viruses:

Norovirus, Rotavirus, Hepatitis A , Hepatitis E are the mostly related with foodborne illness outbreaks around the world. All these viruses can be transmitted through the fecal/oral route, either by direct contact with infected individuals or by ingestion of contaminated water and foods including meat and meat products. Proper hygiene and sanitation are important to prevent the contamination of meat and meat products with these viruses.

Conclusion:.

The prevention and management of zoonotic diseases spread through meat can be enhanced by collaboration and cooperation under One Health concept. Because meat contamination can occur at various steps of the production and processing of meat, preventing meat-borne zoonotic diseases requires a comprehensive approach spanning from the point of production (at the farm) to the point of consumption (on the table). Given the global threats posed by infectious diseases, it is time to reexamine our regulatory framework, and broadly address health risks at the human–animal–environment interface consistent with the "One Health" approach. Future of fresh meat consumption will be determined by the ability of the meat sector to produce, deliver and guarantee products perceived safe by consumers. Animal welfare , control of diseases, regulated use of antimicrobials and acceptable production methods are key for sustainable production of meat.

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Chapter 5

PERSONAL HYGIENE

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Personal hygiene is (or should be) an integral part of the food quality and safety for each and every food processor. The Codex Alimentarius Food Hygiene document includes guidelines on personal hygiene and include elements on disease control, cleanliness, training and supervision Most of the third-party audits, both those approved by the Global Food Safety Initiative (GFSI) and private audit schemes, also include personal hygiene requirements. Personal hygiene is more than just rules for the workers. Plant management must develop, document and implement the necessary procedures, provide the necessary tools and equipment, set an example and provide the workforce with necessary training so that they understand what is expected of them.

Disease control

Any worker who is sick or has open wounds should not be allowed in a food-handling environment, especially if there is a reasonable possibility of food, food-contact surfaces or food packaging materials becoming contaminated the worker shall be excluded from any operations that may be expected to result in such contamination until the condition is corrected. In other words, food plant workers themselves should not pose a risk of contamination of food. Ideally, enforcement of this should on both management and line workers. Training programs must address this issue. Workers should be instructed to notify management if they are sick or injured, and cannot handle foods. Managers should also have the training and observation skills to notice whether someone is injured or ill. This is one area where plant management can go far toward ensuring enforcement. Worker health is handled differently in other parts of the world. In many countries, especially in India, food handlers are required to undergo medical tests every year.

Health Status

No person suffering from infectious or contagious diseases (like infected wounds,skin infections, sores or with diarrhoea etc.) shall be allowed to work in the slaughter house/meat procession unit. Any person so affected, shall immediately report illness or symptoms of illness to the management.

Annual medical examination of all meat handlers and employees shall be done from a registered medical practitioner; to ensure that they are free from infectious and other communicable disease. A record of these examinations signed by a registered medical practitioner shall be maintained for inspection. All meat handlers shall be inoculated against the enteric group of disease and a certificate thereof shall be kept for inspection. In case of an

epidemic, all meat handlers should be vaccinated irrespective of the yearly vaccination. Employee who come into direct or indirect contact with edible parts of birds or meat in a course of their work, where necessary, have a medical examination prior to employment.

In case of any injury/cut: Any person who is cut or injured should discontinue working with meat immediately (preparation, handling, packing or transportation) should be suitably bandaged. No exposed bandage should be worn. All bandages should be completely protected by a water proof covering, different in colour, and clearly visible and is of such a nature that it cannot become accidentally detached. Only bandage with above mentioned type is allowed to wear inside the slaughter house/Processing Unit. First aid facilities should be provided in the facility.

Clothing

Wearing outer garments suitable to the operation in a manner that protects against the contamination of food, food-contact surfaces or food-packaging materials and wearing, where appropriate, in an effective manner, hairnets, headbands, caps, beard covers or other effective hair restraints. Suitable garments will depend upon the type of processing operation and management's commitment not only to food safety and quality, but also to the safety of the worker. Food plant workers should wear hairnets that contain and cover all the hair and ears. Many operations also mandate that workers wear bump caps. Workers who have beards and/or mustaches should ensure that they are fully covered. The garments that food plant workers wear vary widely. Some plants allow their workers to wear street clothes, whereas others provide complete uniforms. Street clothes are not a good idea, as one can never tell where employees were before coming to work. Ideally, uniforms shall be tight fitting and be equipped with snaps or Velcro closures. There shall be no pockets located above the waist. Sleeves shall be manufactured with elastic bands at the wrist to protect the arms. Many operations color-code uniforms, especially if the plant produces sensitive products. In plants producing ready-to-eat foods, workers on the raw side might wear white uniforms, whereas those on the cooked or finished product side will wear blue. In operations such as these, when moving between these areas, workers must not only change their uniforms but also their shoes or boots. Shoes are an area that management needs to address. For safety purposes, shoes must be close toed and preferably have steel toes and shank. However, since food plant workers are on their feet for a large part of each day, it behooves management to make a commitment to identifying a supplier that produces a comfortable safety shoe. Many plants bring the manufacturer of safety shoes into the plant several times a year to allow their crews to select a shoe with which they are comfortable. Workers should be obliged to change shoes immediately before going into the processing area or to utilize foot baths or boot washers. Anyone entering a food processing area must remove all jewelry, including rings, brooches, watches, pins, earrings, necklaces and visible piercings. In addition, false nails, nail polish, false eyelashes and any other object that may possibly contaminate food should not be allowed in the plant. Additionally, processors must develop a policy of no cellphone.

Personal Cleanliness

Meat handlers shall maintain a high degree of personal cleanliness with adequate and suitable clean protective clothing, head covering, face mask, gloves, gum boots etc. All wares should be washed, unless designed to be disposed, and should be maintained in a clean condition consistent with the nature of the work in which the person is engaged. If wearing gloves during the slaughter and dressing of birds and the handling of meat, it has to be ensured that they are of an approved type for the particular activity, e.g. stainless-steel chain gloves, synthetic fibres, nitrile and they are used according to specifications, e.g. washing before use, changing or sanitizing gloves when contaminated. All meat handlers working in the deboning hall must wash their hands with soap and sanitizer. All persons entering the slaughter house/meat processing unit shall wash their hands step by step as mentioned below: Wet hands with potable water. Apply liquid soap and make a lather for at least 30 seconds. Apply to every part of hands including nails, between fingers and to cover full hands, and on both the sides of the hands. Wash with potable water and disinfect / dry their hands. Hand washing shall be done: At the beginning of food handling activities, immediately after using the toilet, after handling raw food or any contaminated material, tools, equipment or work surface, on coughing/sneezing, smoking; to avoid contamination of other food items and after handling chemicals.

Personal behavior

The slaughter house/processing unit shall implement an effective personal hygiene programme that identifies hygienic behaviour and habits to be followed by personnel to prevent contamination of food. Any behaviour or unhygienic practices which could result in contamination of meat shall be prohibited in meat processing, distribution, storage and handling areas. This includes smoking, chewing or eating, sneezing or coughing over unprotected meat, spitting etc. Personal effects such as jewelry, watches, pins or other items should not be worn or brought into food handling areas if they pose a threat to the safety and suitability of food. Should provide separate lockers/place provided for persons regularly work in slaughter houses/processing unit to keep their personal belongings etc. 5. Food contact tools and equipment shall not be kept in personal lockers.

Visitors

Proper care has to be taken to ensure that food safety and hygiene are not getting compromised due to visitors in the floor area. The facility shall ensure that visitors who visit an area in slaughter house/ meat processing unit where meat is handled should wear protective clothing and head cover and adhere to all personal hygiene provisions as mentioned by the company to maintain food safety. All visitors should provide declaration in written of carrying no infectious disease.

Employee Amenities

One area where management plays a major role in employee hygiene is providing funding for employee facilities and support services. These include lockers and locker rooms,

toilets, handwashing facilities, medical and first aid facilities, lunchrooms and break areas and access points to the plant. Lockers and locker rooms are an often-ignored area. Employees need a place where they can change clothes and feel that their valuables are safe and secure. Having safe and secure lockers is one means of discouraging employees from bringing personal items into the plant. Ideally, the plant should provide employees with lockers that are at least six inches off the ground to allow for cleaning. The tops of lockers should be slanted to preclude storing anything on top. Employees should also be informed that lockers may be inspected at any time and that no food may be stored in the lockers. The plant must provide their employees with an adequate number of toilets and handwashing facilities, and make sure these are kept both clean and well supplied. The rule of thumb is one toilet and handwash station for every 10 employees. Handwashing facilities should include hands-free sinks (knee or foot operated, or an electric eye), soap, a constant supply of warm water and a means to dry hands. There is a need to create policies for how people enter the processing area and establish support facilities. Different methods can help ensure compliance. It is very common to set up a vestibule that includes items such as hairnets and snoods. Many companies also post pictures of both the proper way and the wrong way to wear garments. To ensure that all employees wash before beginning work, management must install an adequate number of sinks to allow all employees to wash without having to line up. If a company provides their employees with uniforms, they need to either contract with a laundry service or install in-house laundry facilities. The laundry facilities, whether they are contracted or done in-house, must be able to properly document their operations. In fact, the same procedures used for selecting vendors should be employed when selecting a laundry service. Uniforms must be inspected for damage and washed at high temperatures. If the uniforms are damaged, they must be fixed or taken out of service. As part of the laundry program, there should be facilities to place dirty laundry and a means of getting the cleaned uniforms back to the workforce. Never rely on workers to properly wash their uniforms. There is simply no way to verify that it is being done properly. There must be dedicated areas for activities like eating, drinking and smoking. Lunch or break rooms must be designed with food storage facilities. One element of the locker policy is that food may not be stored in lockers, so food storage must be part of the lunch or break rooms.

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Chapter 6

ESTABLISHMENT OF MODERN SLAUGHTER HOUSES – TAKING THE LOCAL BODY MEAT TRADERS AND PUBLIC INTO CONFIDENCE

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Livestock plays an important role in Indian economy. The livestock sector grew at a CAGR of 7.9% during 2014-15 to 2020- 21 (at constant prices), and its contribution to total agriculture gross value added [GVA] , (at constant prices) has increased from 24.3% in 2014-15 to 30.1% in 2020-21 and it stood at 4.1% of total GVA of the nation. Besides their monetary benefit and providing a steady stream of food and revenues for households, livestock provide employment to the rural family, act as insurance during crop failures and the number of livestock owned by a farmer determines the social status among the community. Livestock provides livelihood to two–third of rural community. It also provides employment to about 8.8 % of the population in India, (Soumyakant Dash, 2017).

The total meat production in the country is 9.29 million tonnes for the year 2021-22 with an annual growth rate of 5.62%. The per-capita availability of meat is 6.82 kg/annum during 2021-22 increased by 0.30 kg/annum over previous year. India is forecast to be the third-largest beef exporting country in 2022, with sales increasing year over year from 2020 levels. India was the largest global beef exporter from 2014 to 2016 but slowed and declined to a recent low in 2020 before recovering. Beef is the second highest exported commodity from India, after Basmathi rice.

India has about 4000 slaughterhouses, of which only 1,707 have been registered under the Food Safety and Standards Authority of India (FSSAI). These slaughterhouses are maintained by local authorities where animals are slaughtered for domestic consumption, and also utilises service of field veterinarians from the department of Animal husbandry.

These are the bright facets of the meat Industry. But, rather very unfortunately on the flip side there are issues and pitfalls right through the meat value chain–

i. beginning with slaughter of sheep and goats before they attain maturity; lack of any effective breeding policy; worse still the existing policy is also not executed meticulously in the field, the problem being exacerbated by the fact that neither breed registry nor registration of farms are practised; under utilisation of male calves of buffaloes, and crossbred cattle.
ii. a callous attitude towards animal welfare both during transport of animals and during slaughter (Stunning is very rarely practised)
iii. ineffective ante –mortem inspection, and post – mortem examination due to the twin issues of lack of facilities and lack of personnel, including veterinarians in

slaughterhouses- owing to lack of the cadre of meat inspectors, who conduct post-mortem inspection across the world;

iv. glitches committed by personnel in slaughter and dressing, leading to stark deterioration in the microbial quality of meat which can be attributed to the woefully inadequate supply of qualified personnel, for even the meat workers who are involved in the meat production, processing and trade are not trained formally for their vocation and have just picked up the elements of butchery, by training on the job

v. inadequate facilities and personnel also contributing to non-utilisation/under utilisation of abattoir by-products, leading to loss of potential revenues but also lead to the added and increasing cost of disposal, which if not meticulously executed, leading to environmental pollution

vi. inadequate facilities for effluent treatment at slaughterhouses also leading to environmental pollution

vii. inadequate facilities for transport of carcasses, leading to avoidable deterioration in quality of meat, due to temperature abuse

viii. inadequate facilities and under qualified personnel also contributing to pathetically low levels of further processing and value addition of meat in India, which remain less than 2%,with the exception of poultry, where about 7.2% of meat undergoes processing and inadequate facilities for retail distribution of meat in terms of space requirements, equipment and infrastructure including refrigeration.

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.

To improve the status of meat production, processing and distribution, the stakeholders have to consider the following

1. **Processing, food quality and safety programmes**

   The post production losses of the livestock products could be achieved through strengthening of infrastructure facilities ensuring cold chain and processing. Any development programme should target for the improvement of the Marketable Surplus, which stands for net availability of the farm product for sale after farm family consumption, payments in kind and physical losses. Hence, in order to increase the marketable surplus, reduce the post production losses and to ensure food quality and safety, following programmes may be implemented;

   - Infrastructure development for food processing and storage
   - Capacity building programmes to reduce the post production losses
   - Empowerment on food processing and value addition
   - One health Concept
   - Development of standardization and grading for meat animals and livestock products
   - Development of programmes to ensure traceability of livestock products

2. Strengthening of livestock marketing

Live animal marketing system is totally unorganized and middlemen reap maximum share of buyer's rupee. In this context, following programmes are proposed to overcome those issues

- Implementation of Aggregated markets and e-Auction Programme for regulating live animal marketing, especially small ruminants
- Development of grades and pricing formulae for live animals
- Development of Price policy models for livestock products, especially on milk, mutton and chevon based on cost of production in order to ensure remunerative price for farmers and fair price to consumers.
- Strengthening of forward and backward linkage system in livestock enterprises through formation of farmer-based input suppliers and output dealers associations
- Strengthening Market Information and Forecasting system
- Improving infrastructure facilities on storage and transport of livestock products, and strengthening supply chain and cold chain management thereby increasing the marketable surplus.
- Development of Livestock Export Agency and Establishment of Export zones (EZ) for Milk and Milk product, Meat and Meat product, Poultry Product and Live animal with infrastructure for livestock processing and for livestock byproduct with export quality to trap the best destiny for livestock exports.
- Upgrade/ modernize/ strengthen livestock markets by building up infrastructural facilities on the pattern of Agriculture Produce Marketing Centres.

3. Improving meat production through meat animal development programmes

- Male buffalo calf rearing and development of practices for improving yield of meat per animal.
- Male cattle rearing and development of practices for improving yield of meat per animal
- Establish a two-tier system of farming of small ruminants – breeders involved exclusively in breeding small ruminants, who produce the meat animals meant for commercial meat production and market them as kids or lambs immediately post weaning to the second tier of farmers, who buy these animals and raise them to market weight and market them to processors
- Development of practices for improving yield of meat per animal in small ruminants
- Improvements in existing practices in desi chicken rearing to improve the yield of meat per bird.

4. Improving meat production through strengthening of abattoirs and distribution chains for marketing meat

- Establishment of slaughter houses for small ruminants and cattle exclusively, at each corporation.
- Establishment of poultry processing units at zonal level.
- Establishment of model retail meat outlets.
- Establishment of a fail proof system to deliver meat to the consumer at his/her doorstep.

Challenges to overcome to achieve the goal

With all the above-mentioned features, now we are in the state of increasing the yield of meat per animal and to satisfy the requirements of WTO regime pertaining to Sanitary and Phyto-Sanitary measures (SPS) and Technical Barriers on Trade (TBT) which stipulate quality assurance such as Hazard Analysis Critical Control Point (HACCP), Good Animal Feed Practices (GFPs), Good Hygiene Practices (GHPs), Good Manufacturing Practices (GMPs) and Cold Chain System.

To achieve these first we have to concentrate on the following

I. Production system:

1. **Development of meat animals** – At present in South India there is a steady increase in the cost of mutton/chevon and it is noticed that there is difficulty in the procurement of small ruminants for slaughter because of dwindling number of animals. So it is imperative to develop small ruminant breeds exclusively for meat production. It is must to develop the breeds suited to the native tract and preserving their germ plasm. Organised farming should be encouraged in the small ruminant sector for quality meat production.
2. **Grading of Animals/Carcasses** – Developing suitable grading system for Indian animals/carcass, considering the breed, sex and meat characteristics which in turn help the farmer as well as the processors in fixing the price of live animals/carcasses.
3. **Male animals rearing** – It is must to encourage the farmers to utilise the male animals for meat production.

II. Processing

A. <u>Establishment of Satellite Slaughterhouses/ mobile slaughter units/ rural slaughter houses</u> - Even though there are 3600 recognised slaughterhouses in our country; they are not suited for wholesome meat production because most of them were constructed by the then British rulers. To produce wholesome meat production, it is must to modernize the present slaughterhouses. But due to budgetary constraints, it is advisable to establish small to medium satellite slaughterhouses in the suburban areas to cater the needs of towns and cities.

An alternative proposal is establishment of slaughterhouses at the production area or mobile slaughter units. Mobile slaughter units suit well as our farmers are holding a few animals.

By adopting these, the movement of animals are restricted and so it facilities in wholesome meat production.

Layout and management of rural and modern abattoirs

Slaughter House or Abattoir is a place or premises approved by a local authority (Panchayat, Municipality or Corporation) or by any other regulatory agency where in slaughter of food animals are being carried out with the sole purpose of production of wholesome meat for human consumption.

Classification:

Slaughter houses are classified based on technology, capacity and management.

1. Technology: Traditional (Manual operation), Semi-modern (Semi mechanized operation) and Modern (Fully automated)

2. Capacity: Small abattoir (Up to 30,000 Units/ year), Medium abattoir (50,000 Units and above / year) and Large abattoir (Over 100,000 Units / year)

3. Management: Service abattoir (Municipal / Corporation) and Factory (Privately owned)

Points to be considered before constructing a slaughter house

1. Throughput- Number of animals' slaughtered/ day
2. Species to be slaughtered
3. Operation/ Activity: slaughter/ chilling/ portioning/further processing/ storage
4. Location and availability of space
5. Local issues- constraints such as socio-economic, political and religious
6. Marketing
7. Capital Investments

Important aspects to be considered while planning and designing a slaughter house:

The plan and design must fulfill the following

1. Hygiene: Animal, Operational, Personal and Environmental hygiene
2. Humane approach
3. Economic feasibility
4. Other important criteria include:
    a. Preventing contamination of carcass and edible offal
    b. Efficiency of operations
    c. Disposal of edible and inedible offal
    d. Proper means for disposal of effluent

For effective layout, design and construction it is imperative to appoint a competent architect, engineers and other experts with experience in abattoir construction. Use of efficient and durable equipments is important backed by competent maintenance staff to ensure smooth operation.

LOCATION

The essential considerations to be borne in mind while selecting a site for the construction of a slaughterhouse are

1. Water facility
2. Uninterrupted 3 phase electricity supply
3. Available of sufficient land for expansion
4. Accessibility by road and rail transport
5. Facility for sewage disposal
6. Proximity for supply of labour
7. Proximity to regular supply of resource animals
8. Social and religious background of the local habitants

SUBMISSION OF PLANS

Two sets of drawings and four sets of specifications submitted to responsible authority for approval.

The specifications must include

1. details of proposed throughput and capacity,
2. number of employees - category wise
3. building construction,
4. water supply,
5. refrigeration capacity,
6. lighting,
7. ventilation,
8. equipment and operations,
9. details for pest control - fly screening,
10. methods to be used for steam and vapour removal
11. proposed flow lines for product, equipment, personnel and packaging.

The site plan (scale 1:500)

The site plan show the complete premises and the location in relation to roads, railways, waterways and adjoining properties.

The floor plan (scale: 1:50 or 1:100)

It relates to layout of walls, doorways, windows, partitions, rail systems, equipment, benches, platforms, toilets, chutes, conveyors, staircases, hot and cold- water connections, ventilation fans, work positions of operatives, etc.

The plumbing plan

Details of the drainage system. Plan should compliance with hygiene, health and safety, EC regulations, good building standards and practices, precaution against fire.

Area requirement

• Generally for a small abattoir, the area required will be about 1-2 acres.
• For a medium plant, area required will be about 2-4 acres.
• A large abattoir, 100,000 units annually will require about 4-6 acres of land.
***One livestock unit is equivalent to ONE adult bovine or TWO pigs, THREE calves or FIVE sheep**.*

Organisation and Layout of Slaughter house (FSSAI Standards)

Food Safety Standards Authority of India has laid down standards for Specific Hygienic and Sanitary Practices to be followed by Food Business Operators engaged in manufacture, processing, storing and selling of Meat and Meat Products in PART IV of FOOD SAFETY AND STANDARDS (LICENSING AND REGISTRATION OF FOOD BUSINESSES), REGULATIONS 2011.

Location of Premises:

Slaughter Houses should be linked to a meat market located away from Vegetable, fish or other food markets and shall be free from undesirable odour, smoke, dust or other contaminants. The premises shall be located at elevated level in a sanitary place.

Premise requirements:

1. The slaughter house shall have a reception area/animal holding yard/resting yard, lairage, slaughter hall, side halls for hide collection, paunch collection, offals collection, and separation, holding room for suspected/ condemned carcass, by-product harvesting, refrigeration room/cold room etc.
2. Every such establishment / Slaughter House shall make separate provision in the slaughter hall for the slaughter of different species which are proposed to be slaughtered (like large animal viz; Cattle and Buffalo, Pigs and small animals like Sheep & Goat) and for different methods of slaughter (like Halal, Jewish and Jhatka).
3. The slaughter house shall have separation between clean and dirty sections.
4. The reception area/animal holding yard/ resting yard shall have facilities for watering and examining animals before they are sent to holding pens/lairage.
5. The lairage shall be adequate in size for the number of animals to be laired.
6. Separate space shall be provided for stunning (Wherever applicable), for collection of blood and for dressing of the carcasses.
7. The slaughtering of an animal shall not be done in the sight of other animals. The dressing of the carcass shall not be done on the floor.
8. Suitable hoists will be provided to hang the carcass before it is eviscerated.
9. All the floors in lairage, slaughter halls, work rooms, hanging rooms shall be of impervious and non-slippery material.
10. The internal walls will be paved with impervious glazed tiles up to 1 meter height in case of poultry and small ruminant animals and 5 meter height in case of large ruminant animals. Ceiling or roofs shall be so constructed and finished so as to minimise condensation, mould development, flaking and accumulation of dirt. Suitable and

sufficient accommodation shall be provided for segregation, storage and disposal of condemned meat.

11. The establishments / Slaughter Houses shall be so constructed and maintained as to permit hygienic production. Windows, doors and other openings suited to screening shall be fly proof. All doors shall have strong springs so that they may close automatically.
12. There shall be efficient drainage and plumbing systems and all drains and gutters shall
13. be properly and permanently installed. All drainages will have traps and screens so as to prevent entry of scavengers like rats, mice, vermin etc.
14. Suitable and separate space shall be provided for the storage of hides and skins.
15. A constant and sufficient supply of clean potable cold water with pressure hose pipes and supply of hot water should be made available in the slaughter hall during working hours.
16. Provision for latrines, toilets and change rooms will be made. Sufficient number of latrines, urinals, washbasins and bathrooms for each sex shall be provided.
17. Facilities for the workers to keep their clothing, valuable articles, etc., under safety in locker rooms, sufficient number of water closets, showers and wash-hand basins must be provided (one for every 15 employees). Separate lockers should be provided to each employee. Urinals should be installed in toilet rooms for male personnel.
18. Suitable and sufficient facilities shall be provided in convenient places within the slaughter house for the sterilisation of knives and sharpner (mushtala) and other equipment used in the slaughter house.
19. For large slaughter houses, a suitable provision of Effluent Treatment Plant will be made and the waste material should be rendered (cooked) in a rendering plant to produce meat, bone meal and inedible fats.
20. Suitable and sufficient facilities shall be provided for the isolation of meat requiring further examination by the authorised veterinary officer in a suitable laboratory (within the premises of the slaughter house).
21. A laboratory shall be provided, equipped and staffed with qualified (chemist/analyst
    a. and Veterinary Microbiologist) and trained personnel.
22. The lighting should not alter colours and the intensity should not be less than 540 Lux (50 foot candles) at all inspection points, 220 Lux (20 foot candles) in work rooms and 110 Lux (10 foot candles) in other areas.

Sanitary Practices:

1. Every part of the internal surface above the floor or pavement of such slaughter house shall be washed thoroughly with hot lime wash within the first 10 days of March, June, September and December.
2. All parts of the establishments / Slaughter Houses shall always be kept clean, adequately lighted and ventilated and shall be regularly cleaned, and disinfected.
3. Lime washing, colour washing or painting as the case may be, shall be done at least once in every twelve months.

4. All blood , manure, garbage, filth or other refuse from any animal slaughtered and the hide, fat, viscera and offal there from, shall be removed from the slaughter house within 8 hours after the completion of the slaughtering.
5. The premises shall be cleaned thoroughly with disinfectants, one day in advance of production of meat food products and the equipments shall be sterilized/ sanitized before use.
6. The rooms and compartments in which many meat food product is prepared or handled shall be free from dust and off odours.
7. Warm meat' meant for immediate sale need not be stored in cool conditions. It can be transported in a hygienic and sanitary condition in clean insulated containers with covers (lids)
8. to the meat shops/selling units.

Equipment & Machinery:

The equipment and fittings in slaughter hall except for chopping blocks, cutting boards and brooms, shall be of such material and of such construction as to enable them to be kept clean. The implements shall be of metal or other cleanable and durable material resistant to corrosion.

WATER

Mains water supply should provide an ample supply of potable water. Water should be distributed to all parts of the plant under adequate pressure, which in the mains pipeline should be at least 20 psi. The hot water supply should have a temperature of 82°C. Water storage tanks must hold at least one day's water requirement.

The recommended water requirement is 10 litres per kg of meat

If non-potable water is used for steam production, refrigeration or fire control, it must be carried in separate lines and identified as such.

DRAINAGE

• The floors in wet areas should slope uniformly to drains with a gradient of 1:50**.** One drain is for each 40 m^2 of floor area.

• Special provision must be made in the places where water and blood could collect with supply drainage valleys at a gradient of at least 1:25 and 60 cm wide.

• ***Catch Basins*** **-** Catch basins must be provided on drains for grease recovery.

• ***Traps*** **and** ***Vents*** **-** Traps and vents must also be provided on drains.

• The drains for bovine stomach and intestinal contents material must be at least 20 cm in diameter and for the smaller species 15 cm.

• All drains in the slaughter hall be trapped with 4 mm screens, to prevent the possibility of contamination of the effluent.

VENTILATION

Adequate ventilation should be provided to prevent excessive heat, steam and condensation.

DOORS

A width of 1.37 m (4.5 ft) is usually adequate. Doors must be constructed of rust resistant material.

PEST CONTROL

Plant location and design must be carefully done not to allow the birds, rats, mice and insects such as flies and cockroaches into the slaughtering, processing and storage areas.

FACILITIES FOR PERSONNEL

Separate welfare facilities may be provided for those employees working in inedible and other unwholesome areas.

A fully trained industrial nurse and a well appointed first aid room is essential.

A laundry and a car park are also necessary. A comprehensive system of communication comprising internal telephones, a staff location system of the VHF-radio type and loudspeaker equipment should be installed along with adequate security arrangements.

Mess room

This room is built for the convenience of the workers for their lunch etc. The access to this room should be restricted to employees.

VETERINARY OFFICE, OFFICE ACCOMMODATION, SUPERINTENDENT'S OFFICE AND VETERINARY LABORATORY

An adequately equipped lockable room for the exclusive use of the veterinary service is advocated. The rooms should be provided with hand-washing and shower facilities, and lockers for clothing (clean and dirty) and meat inspection equipment. A convenient means of cleaning footwear before entry into changing rooms is an advantage.

Office accommodation

Official work concerning the slaughterhouse is performed here.

Superintendent's office This building is so placed that it commands the best view of all slaughter operations and also as much of the abattoir as practicable.

INEDIBLE AREA, EQUIPMENT WASH AND DIGESTER ROOM

Inedible area

All materials unfit for human consumption, with the exception of hides and skins, are handled in this area.

Equipment wash

A properly designed equipment wash adjacent to work rooms is essential.

Fresh meat dispatch area

The fresh meat dispatch area must be sited away from the dirty area and access to it restricted to vehicles associated with meat and offal for human consumption.

Residential quarters Provision must be made for the Superintendent of the abattoir, a mechanic and watchman to reside within the area to be of ready assistance during emergencies.

ISOLATION BLOCK

This is also known as Emergency Slaughter Unit or Miniature Abattoir. In large abattoirs isolation block with a small lairage up to four cattle, slaughter hall, cooling hall, bacteriological laboratory, incinerator and sterilization rooms. This block must be located at a distance from the main buildings and workers should not move from here to the main buildings. It should be situated near to the suspect meat detention room and should be in direct communication with the by-products department.

DISPOSITION OF BUILDINGS

The following points have to be considered while constructing an abattoir

A most desirable arrangement in abattoir lay out is that in which the live animal enters at one end of the abattoir, and the finished produce leaves at the other end of it, with the whole process working in one direction only.

MANAGEMENT AND PRACTICES IN ABATTOIR

There are two main management systems are in practice in abattoir.

System 1

Permanent workers employed by one single authority operating the slaughterhouse carry out the slaughterhouse operations. This authority may be Governmental Municipal, Cooperative or Private Enterprise.

System 2

In this system the management only hires the place to private owners, who bear the responsibility for butchering operations with their own or hired labour.

HACCP CONCEPTS IN ABATTOIR MANAGEMENT

The Hazard Analysis Critical Control Point (HACCP) system is a scientific approach to **process control**. The key element of the HACCP system is its preventive nature i.e. potential **food safety hazards are controlled throughout the process**. It is designed to prevent the occurrence of problems by assuring that **controls are applied at any point in a food production system** where hazardous or critical situations could occur.

GMP – Good Manufacturing Practices

Describes the requirements for hygienic design and construction of slaughter premises and equipment.

GHP – Good Hygienic Practices- All practices regarding the conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain.

Sanitation Standard Operating Procedures - SSOP

SSOP are the **specific, written procedures** necessary **to ensure sanitary conditions** in the food plant. Both pre-operational (before daily processing begins) and operational (during processing) sanitation needs are included in SSOPs to prevent direct product contamination or adulteration.

Total quality management (TQM)

TQM is an integrated organizational effort designed to improve quality at every level. The meaning of quality is as defined by the customer. It means meeting and exceeding customer expectations by involving everyone in the organization through an integrated effort.

B. Establishment of meat processing plants/ meat stalls- It is imperative to establish state of art meat processing plants or meat stalls to fabricate the carcasses received from the satellite slaughter houses/ mobile slaughter units with sufficient packaging and cold storage facilities for proper distribution of meat to the consumers.

III. Packaging, Storage and Distribution

1. Establishment of cold storage and transport facilities- It is necessary to establish cold storage facilities to receive the packed retail meat and store it for further distribution. Successful running of the cold storage depends on properly designed refrigerated vehicles for transport of meat without temperature abuse. These cold storage facilities should be established both near the production site as well as the consumers end for easy maintenance.

IV. Extension

1. Awareness campaign- Training should be accorded to extension personnel so as to sensitize them about the significance of wholesome meat in control of zoonotic diseases, proper transport and storage of meat, proper packaging and labeling of meat, regulation of animal traffic in disease control, palatability and nutritive value of refrigerated meat to ensure they disseminate the knowledge gained to all the stakeholders.

Advertisement campaign must be launched through mass media to disseminate the issues mentioned above to stakeholders

Conclusion and summary (to keep in mind by all the stakeholders)

1. Development of meat animals - It is must to develop the animals suited to the native tract and preserving their germ plasm.
2. Grading of Animals/Carcasses – Developing suitable grading system for Indian animals/carcass.
3. Male animals rearing – It is must to encourage the farmers to utilise the male animals for meat production.
4. Determination of appropriate age for slaughter of animals

5. Traceability of meat
6. Establishment of Satellite Slaughterhouses/ mobile slaughter units/ rural slaughter houses. By adopting these, the movement of animals are restricted and so it facilities in wholesome meat production.
7. Establishment of meat processing plants/ meat stalls- It is imperative to establish state of art meat processing plants or meat stalls to fabricate the carcasses received from the satellite slaughter houses/ mobile slaughter units with sufficient packaging and cold storage facilities for proper distribution of meat to the consumers.
8. Establishment of cold storage and transport facilities
9. Facilitates in framing proper breeding and culling policies. Animals will be slaughtered at appropriate age, so the carcass size and weight will be uniform and easy for processor to market the meat.
10. Pricing of the live animals and meat can be regularized so the farmer, processor and the consumer will be benefitted.
11. Animals will not be slaughtered at early age before optimum maturity and unauthorized slaughter will be minimized and also facilitates in regularizing the market by regular supply of raw material.

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Chapter 7

CONSUMER BEHAVIOR AND CONSUMER LEVEL HANDLING OF MEAT

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Meat is one of the most appreciated foods in the world, with the variety of species and diversity of products appreciated by consumers, from children to elderly people. Meat has a fundamental socio-cultural role and is one of the most popular food products, valued not only for the pleasure of eating it but also because it is generally perceived as a healthy food (Font-i-Furnols and Guerrero, 2014). Meat production in India in 2022 was 9.29 million MT and has increased by 5.26 per cent when compared to previous year, with a per capita availability of 6.82 kg/person/annum (DAHD, 2022). Consumers' perceptions of meat quality depend on many extrinsic factors like region, religion, culture, social and economic status, age of the consumer, price, availability, cost effectiveness, ethical issues associated with animal welfare, environmental impact of animal rearingand intrinsic factors like sensory attributes, nutritive value, safety, health hazards etc. These factors make a consumer decide whether he should or should not consume meat or the type of meat or meat product to purchase, method of cooking to employ etc. Now a days consumer behaviour has become less predictable and has posed a significant challenge for producers and processors due to its fragmented and rapidly changing trends. The perception of meat quality is largely subjective, mainly depending on the consumers, how they perceive the meat quality and their needs and goals (Bernués *et al*., 2003).

Main attributes that affect meat consumption are sensory parameters. Colour / appearance is the main sensory parameter affecting the quality of meat, especially raw meat. Not only meat appearance and colour, but also the type and material used for packing and other packaging as well as labeling aspects influence the purchase of meat by consumers. Flavour of meat, its tenderness etc. are some other factors of importance.

Meat nutritive value influences its consumption all over the world, like the high content of proteins of good biological value, abundance of vitamins and minerals and lowered calorific value of poultry meat especially chicken. However, the concerns on hazards associated with meat and meat product consumption like abundance of saturated fat in red meats, absence of dietary fibre, risk of cardiovascular diseases and certain cancers associated mainly with processed meat etc. are also prevalent especially in developed countries and consumers in upper social and economic strata of developing nations. The use of healthy ingredients can improve the perception of the health image of processed meat products and many processors have turned to manufacture of meat products with functional characteristics like 'dietary fibre added', 'omega 3 enriched', 'meat products with vegetable fats with more unsaturated fatty acids' and many more. These health-oriented reformulations of meat products are promising ways to address the growing public health concerns and consumers' individual perceptions.

The strategy of reformulating meat products has also resulted in divergences in consumers' perception.

Not only these, but meat produced from animals subjected to proper animal welfare treatments, scientific and humane slaughter, hygienic dressing, ante and post mortem examinations by veterinarians in a hygienic abattoir is preferred by many consumers of the modern world. But in a developing nation like ours, the concerns of the above nature are limited only to a small section of the consumers, the majority being completely unaware or not at all bothered about the illegal slaughter operations in unlicensed and filthy slaughter premises, carried out by people not at all concerned with animal welfare or the dangers of harvesting meat from diseased animals slaughtered under unhygienic conditions.

The dangers of processed meat products like excess fat, salt, nitrites, smoke or high temperature cooking associated carcinogens etc. are of high concern in many developed nations of the Western world where the intake of processed meat products are more. There, products with natural ingredients and without synthetic additives or preservatives are gaining popularity. In our country processing of meat products into convenience products is less and the health risks associated with their consumption are meager. But with the gain in popularity of grilled, barbecued or broasted meat dishes in our place, especially in unhygienic eateries and with consumption of fat rich diets less in dietary fibre and with sedentary lifestyle, people have to become more cautious about their health. Apart from these, religious taboos, price and availability of meat, ethical concerns on animal welfare, unscientific slaughter and associated processes also affect meat consumption.

In India, purchase and consumption of meat by consumers are influenced mainly by religion, rituals and festivals associated with a particular religion/culture, socio-economic conditions, age, gender, price and availability of meat, fresh/frozen meat etc. In Indian context, culture, traditions, customs, and taboos influence meat consumption to a great extent especially in the rural societies and urbanization had resulted in rise in demand for meat products (Devi *et al.,* 2014). Only a few studies had been conducted to study the consumer pattern, attitude and perception regarding purchase and consumption of meat in our country. In a study conducted by Mohan *et al*. (2018) in Bengaluru district of Karnataka, it was observed that only 13.1 per cent of consumers bought frozen meat and 50 per cent of the consumers purchased meat directly from butchers and a majority (71.5 %) used colour as a quality indicator of fresh meat. Majority consumed meat on a weekly basis and gravy type meat dishes were most preferred followed by *biriyani* and dry meat preparations. Most preferred meat was chicken followed by mutton; pork and beef were the least preferred and might be due to the religious restrictions. A large percentage of the consumers (91.5 %) were unaware of animal welfare aspects of meat production though educated. A survey was conducted among meat consumers of North Indian cities of Ghaziabad, Noida, Gurugram, Delhi, Lucknow and Bareilly and it showed that chicken was the most preferred meat followed by chevon with53.46 per cent of the consumers rating “taste” as their first criteria of meat product purchase (Talukder *et al*., 2020). In another study conducted by Mohan *et al*. (2022) among women consumers in the

metropolitan city of Bengaluru, it was again confirmed that chicken was the most preferred meat and most of the women respondents rated tenderness (40.59 %) as the most important meat quality followed by juiciness (37.06 %) and flavour (12.94 %). Suresh (2016) surveyed the consumers in two metropolitan cities of Delhi and Hyderabad and observed that poultry was the most consumed meat, but the most preferred meat was mutton in both cities as the consumers believed it had higher nutritive value and meat had fewer chemicals due to the extensive rearing method on pastures. However, the high price of mutton limited the consumers from buying it. Around 68% consumers in Delhi and 59% in Hyderabad had never purchased any processed meat items. Majority of consumers rely on visual appraisal of meat as method of quality determination and less than 15 per cent never touch meat during purchase. In a consumer survey conducted in six European nations, it was noted that "colour" was the first intrinsic parameter for quality evaluation, followed by "flavour" in the next phase (Glitsch, 2000)

After the purchase of meat by consumers, the handling methods are also different and most of them unscientific in our country. Majority of our consumers prefer what they call "fresh meat" which is only muscles from the animal which have not undergone the post mortem chemical and enzymatic changes resulting in the formation of "meat". Stoppage of circulation following sticking results in cessation of supply of oxygen, vitamins, antioxidants etc. to tissues resulting in fall in oxidation-reduction potential. Moreover, neuronal and hormonal regulation in the body ceases. Aerobic glycoslysis happens for some time using the residual oxygen and then anaerobic glycolysis ensues producing ATP; also there is use of creatine phosphate for the production of small amount of ATP. Anaerobic glycolysis results in production of lactic acid and lowering of pH resulting in lowering of pH from neutral to 5.5 – 5.7 range, called as ultimate pH (pHu). Energy for contraction as well as relaxation of muscles is supplied by ATP. Due to lack of ATP the muscles contracted by interlinking of actin and myosin cannot relax and the actomyosin formed is permanent and this mechanism of muscle contraction and stiffening of joints is called as rigor mortis. Rigor mortis has three phases – delay phase, onset phase, resolution phase and the time for each depends on several factors like species of animal, type of muscle, variation between animals and by external factors like temperature of environment, nutritional status etc. Normally at 30 ºC, the delay and onset phases take 6-7 h and 7-20h and resolution happens in 36 h of death. During delay phase the body tries to maintain the equilibrium by the small amount of ATP produced from anaerobic glycolysis and creatine phosphate. When the resources of ATP are exhausted there is the onset of rigor and muscle contraction. The actomyosin formed after death is not separated and the flaccidity of muscles in resolution phase is due to proteolysis of Z line and weakening at A-I band junction. Resolution of rigor is by the natural enzymes in muscle, calpains, cathepsins and to a lesser extent by proteosome, caspases etc. The above mentioned changes in muscles happening after death results in proteolysis of muscle proteins causing tenderness and increased juiciness, release of flavour volatiles converting muscles to the food called 'meat'.

Most of the meat sold in our country is the muscles either in pre-rigor form or undergoing rigor. Immediately after buying, such meat is cooked immediately in households, restaurants or any food preparation units. Such muscles when cooked undergo intense rigor resulting in severe contraction of muscles and toughening of meat, resulting in a condition called as 'heat rigor'. This is because of the sudden release of ATP and intense actin-myosin contraction. This is one of the reasons for toughening of the meat that is already harvested from spent/aged animals, where the muscles have more collagen interlinkages. Usually the surplus meat purchased will be directly kept in freezers, either freezers of domestic refrigerators or cabinet freezers in restaurants. This meat undergoes freezing and when necessary the usual practice is to thaw the meat either by dipping the meat with or without packet in hot/tap water or thawing in air or by directly putting the meat into cooking utensils. When pre-rigor meat with large amounts of ATP is subjected to such thawing, there is rapid break down of ATP followed by severe contraction of muscles resulting in toughening of meat after cooking and loss of large volumes of drip resulting in a higher cooking loss. This is called thaw rigor and is a common defect when improper thawing of pre-rigor meat happens. To prevent this before freezing or cooking of meat, the rigor should be over so that the ATP is depleted. This is done by the process of electrical stimulation (ES) or by ageing which is often followed in modern abattoirs/processing units. Electrical stimulation results in hastening of rigor process by passing electric current through the carcass immediately after bleeding or dressing. Ageing is the process commonly followed in Western nations to make the meat tender and flavourful without spoilage by holding the meat at chiller temperature for days and sometimes weeks.

Another common mishandling of meat is the excessive washing of meat especially as small chunks/cuts. Many housewives wash meat several times in water, some even soaking in water to remove the 'blood'. The 'blood' they misinterpret is actually myoglobin, the water soluble sarcoplasmic protein which is removed from meat when it is soaked in water. There is loss of other water soluble compounds especially flavour principles. This results not only in protein loss but also results in lower flavour when meat is cooked. Large surface area due to small cuts of meat enhances this loss.

At home/restaurants where meat is purchased directly from the butcher/slaughter premises, the following steps are to be followed

1. Immediately after purchase, wash the meat as large cuts/portions with water 1-2 times to remove extraneous dirt, hairs, blood clots etc and drain. Never wash the meat excessively or as small pieces. Immediate chilling of meat is necessary.

2. The meat is to be packed and kept in the chiller compartments of refrigerator for the rigor process to pass. Minimum overnight chilling is desired for large muscle portions of beef, mutton or chevon and it is desirable for 24 h. For chicken, 6-8 h chilling is desired. However, the initial microbial quality of the carcass is crucial in this chiller aging for preventing spoilage. Application of salt or marinades for softening of meat

and to increase the juiciness and flavour can be done. Cooking of meat needs to be done only after this process.

3. If meat is not to be cooked immediately after its purchase and is to be frozen, the meat can be aged in chiller and then frozen. While freezing never freeze it in bulk, if we want to cook on different days. After aging, divide the meat into required portions, pack them in pouches, seal and keep them in freezer.

4. Thawing of the meat can be done by chiller thawing and other methods like immersing in water (hot/room temperature), with or without covers, thawing in air, thawingdirectly in cooking utensils etc. are not advised. Microwave thawing may be done in commercial establishments, but is not as preferred as chiller thawing. Chiller thawing reduces drip loss and helps meat to absorb its juices to some extent. According to Benli (2016) thawing in the microwave and refrigerator caused the lowest cooking loss values of 18.29 and 18.53 per cents, respectively.

5. Meat once thawed must not be frozen again since this results in re-crystallisation and increased damage to meat when it is thawed again causing textural changes and increased drip loss.It can also lower the microbial quality of meat by fast proliferation of microbes during thawing. Mohammed *et al*. (2021) observed in their experiments that in frozen beef and chicken thawed and then again refrozen, microbial counts increased and amino acid and mineral concentrations and water holding capacity decreased.

Buying of meat that has been subjected to aging and available as chilled or frozen meat solves this problem, but most of our consumers especially, rural or semi-urban areas are reluctant in purchasing refrigerated meat, especially frozen meat. In metropolitan cities, there is a gradual shift in the purchase of meat from buying of hot meat from butchers to buying of packed frozen meat or chilled meat from supermarkets/branded retail outlets. Wang *et al.* (2018) studied the consumer purchase of pork meat in four main Chinese cities and noted that Chinese consumers preferred hot meat from wet markets and also buying of chilled and plastic packaged meat from supermarkets has become an acceptable practice among young and old consumers. They concluded that the consumers did not know about the chilling and freezing preservation techniques and hence thought the refrigerated meats especially frozen meat as having lower quality than hot meats. In a study conducted in different districts of Kerala Sivaprasad *et al*. (2023) observed that majority of respondents (77.3 %) preferred fresh meat and the preference of chilled and frozen meat were very low, 4.9 and 6.1 percentages, respectively. Waghamare *et al*. (2021) in a study done in various regions of Maharashtra also reported that majority (90.21 %) of the consumers preferred to buy hot, freshly slaughtered chicken meat.

Handling of the meat after thawing, cutting, cooking etc. also need special care. Once thawed meat is taken out of the chiller, it must be cooked or processed as soon as possible. Delay in cooking/processing can reduce the microbial quality of meat and can cause incipient

spoilage. During handling of meat, personal hygiene like protective clothing, washing and sanitation of hands etc. must be followed. In large establishments, separate cutting boards and knives must be kept for raw and cooked meat and they must not be used for cutting fruits, vegetables or any other food item. This prevents cross contamination. Thorough cleaning and sterilization are requiredfor knives, especially those used for raw meat. Sterilization of knife sharpening steels, washing and drying of hand and kitchen towels are to be carried out regularly.

Cooking of meat must be done in such a way that internal temperature reaches atleast 75 ºC. Food poisoning cases are less reported in our country than in developed Western nations though proper scientific and hygienic practices are not generally followed during slaughter, processing and marketing processes. This could be attributed to the high temperature of cooking employed in Indian cooking where pressure cooking or prolonged traditional cooking on slow flame is followed mostly irrespective of the type of meat. It is desirable to employ lighter cooking methods like broiling, grilling etc. for tender meat cuts and more intense stewing, pressure cooking, roasting etc. for tough cuts. In any method of cooking employed for meat or meat products, the temperature and time should be sufficient as to eliminate pathogenic organisms, if any; at the same time for release of flavour volatiles and for optimum tenderness and juiciness. Overcooking or undercooking should be avoided since the appearance, flavour, tenderness, juiciness and overall acceptability of meat are lowered. Moreover, undercooked meat products can cause food poisoning outbreaks. Meat products after preparation should be consumed soon and if to be stored must be refrigerated after cooling to room temperature. Foods must be kept in the “temperature danger zone” of microbes (4 to 60 °C) for as short period as possible. While thorough cooking and often overcooking is done in most traditional Indian households, in fast food joints, wayside eateries etc. undercooking often happens mostly with exotic dishes where the core meat temperature reached and time of cooking are not sufficient enough for the destruction of organisms of concern. When visual means, pressing the meat pieces etc. are used for assessing the level of doneness of meat, the foolproof means is by using a meat thermometer for measuring the core internal temperature and must be employed in restaurants or catering units.

Reheating of refrigerated foods also needs to be taken care, and they should be thoroughly reheated. In many instances, the outer temperature or temperature of gravies rises, but the core temperature especially of thick cuts/products remain cold, making them resources of food poisoning outbreaks. Li *et al*. (2023) noted that open flame reheating of braised beef with potatoes resulted in better flavour and eating quality when compared to boiling, steaming and microwave heating.

Though most of the consumers have meat for its sensory attributes, the nutritive value of meat needs to be highlighted being as one of the most nutritious foods. It is considered as a keystone food in food based dietary interventions to improve the nutritional status of people relying largely on a cereal based diet. Meat is a concentrated source of high quality protein rich in all essential amino acids. It is rich in vitamins especially B complex vitamins including B12.

It supplies almost all minerals and is a good source of iron and zinc. Meat is a source of long chain omega three fatty acids, bioactive compounds etc. However, it lacks dietary fibre and it is always necessary that meat must be consumed along with fibre rich foods. Consumption of high levels of red meat and processed meat products has been linked to colorectal and stomach cancers and hence WHO has recommended to consume red meat in moderate amounts and to limit the intake of processed meat like cured, smoked and fermented products.

Consumer handling, cooking and storage of meat and meat products play an important part in the food safety, either at home or in larger establishments. Lack of proper knowledge of our consumers in fresh as well as cooked meat handling is of concern and scientific training must be given by competent people for relishing the meat dishes without affecting the health.

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Chapter 8

TRANSPORT OF LIVESTOCK FOR SLAUGHTER –SKILLS, KNOWLEDGE AND INTERVENTIONS

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Transporting livestock involves the movement of live animals for various purposes, including agricultural production, meat supply, and other commercial activities. This process is critical for the agricultural and meat industries, requiring careful planning and adherence to strict welfare regulations.

Key Aspects of Livestock Transport Modes of Transport Livestock can be transported by several means, including:

•Road: Most common for short to medium distances, using specialized vehicles like trucks and trailers designed for animal safety.

•Rail: Utilized for longer distances, particularly in regions with extensive rail networks.

•Sea: Necessary for international transport, particularly for large shipments of livestock. Species Involved The transport of livestock encompasses all species, including cattle, sheep, pigs, goats, horses, and poultry. Each species has specific requirements regarding space, handling, and care during transit to ensure their welfare and safety.

Importance of Animal Transport Education

Animal transport education plays a crucial role in ensuring the safe and humane movement of livestock. By equipping individuals involved in the transport process with the necessary knowledge and skills, education can significantly enhance animal welfare and improve outcomes for both the animals and the industries that rely on them.

Key benefits of animal transport education:

1. Minimizes Animal Stress During Transport Understanding animal behavior and needs allows transporters to implement practices that reduce stress. Techniques such as calm handling, proper loading procedures, and minimizing noise can create a more comfortable environment for the animals.
2. Prevents Injuries and Bruises to Animals Education on safe handling and loading practices helps prevent physical injuries. Knowledge of how to properly secure animals in transport vehicles and how to manage their movements can significantly reduce the risk of bruising and other injuries.

3. Ensures Adequate Rest and Hydration Transport education emphasizes the importance of planning for rest and hydration breaks. This knowledge ensures that animals receive adequate time to rest and access to water, which is essential for their health during long journeys.
4. Maintains Animal Health and Wellbeing Educated transporters are more aware of the signs of distress and health issues in animals. This awareness allows for timely interventions, ensuring that any health concerns are addressed promptly, thereby maintaining the overall wellbeing of the animals.
5. Reduces Mortality Rates during Transport Proper training in animal transport practices can lead to a significant reduction in mortality rates. By understanding the factors that contribute to stress and injury, transporters can implement strategies to minimize risks, ensuring safer journeys for the animals.
6. Improves Meat Quality Stress during transport can adversely affect meat quality, leading to issues such as dark cutting or poor texture. Education helps transporters understand how to manage animals effectively, resulting in better meat quality and higher market value.
7. Prevents Biochemical Stress Responses Stress during transport can trigger biochemical responses in animals, affecting their health and meat quality. Education on stress management techniques can help mitigate these responses, promoting healthier animals and better product outcomes.
8. Enhances Overall Meat Safety and Hygiene Transport education includes training on hygiene practices, which is vital for preventing contamination during transport. Knowledge of sanitation protocols helps maintain meat safety from the farm to the processing facility.
9. Complies with Animal Welfare Regulations Regulatory compliance is critical in the livestock transport industry. Education ensures that transporters are aware of and adhere to animal welfare regulations, reducing the risk of legal issues and promoting ethical practices.
10. Promotes Ethical Treatment Standards Finally, education fosters a culture of ethical treatment of animals. Understanding the importance of humane practices in transport not only benefits the animals but also enhances the reputation of the industry as a whole.

Animal transport, while necessary for the agricultural and meat industries, can have significant impacts on the stress levels and overall welfare of livestock. The stress experienced by animals during transport can lead to a range of negative consequences, affecting their health, productivity, and the quality of the final product. Understanding the impact of transport on animal stress and welfare is crucial for ensuring humane practices and maintaining the integrity of the industry.

Stress Factors During Transport Several factors contribute to the stress experienced by animals during transport, including:

Handling and loading: Improper handling techniques and poorly designed loading facilities can cause significant stress and anxiety. Confinement: Being confined in a vehicle for extended periods can lead to physical discomfort and psychological distress.

Noise and vibrations: The sounds and movements associated with transport can be unsettling for animals.

Temperature extremes: Exposure to extreme heat or cold can cause significant stress and discomfort. Lack of food and water: Insufficient access to food and water during long journeys can lead to dehydration and weight loss.

Consequences of Stress on Animal Welfare

The stress experienced by animals during transport can have farreaching consequences on their health and welfare, including: Increased susceptibility to diseases: Stress weakens the immune system, making animals more vulnerable to illnesses. Weight loss and dehydration: Lack of food and water, combined with the energy expended during transport, can lead to significant weight loss and dehydration.

Behavioral changes and anxiety: Animals may exhibit abnormal behaviors, such as excessive vocalizations, restlessness, or aggression, as a result of stress and anxiety.

Physical injuries and bruises: Stress can cause animals to become more reactive, leading to injuries from collisions or aggressive interactions with other animals.

Reduced meat quality and yield: Stress can negatively impact the quality and quantity of meat produced, leading to issues such as dark cutting or reduced tenderness.

Mortality: In extreme cases, prolonged stress or exposure to severe conditions during transport can lead to death.

Minimizing the Impact of Transport Stress: To mitigate the negative effects of transport stress on animal welfare, it is essential to implement proper handling techniques, provide adequate rest and hydration, and adhere to strict welfare standards.

Behavioral changes in livestock are critical indicators for monitoring stress levels and overall welfare. These changes can manifest in various ways depending on the species and the specific stressors they encounter. Here are some key insights based on the search results:

Behavioral Indicators of Stress

1. Response to Handling: Animals often exhibit physiological reactions to handling and restraint, such as increased heart rates. Cattle, for example, remember painful experiences and show elevated stress levels when returning to environments associated with past negative interactions.

2. Qualitative Behavior Assessment (QBA): This method involves observers describing animal behaviors in ordinary language. Studies have shown that animals acclimated to transport exhibit lower stress indicators compared to those experiencing it for the first time. For instance, acclimated sheep were described as comfortable, while those on their first trip appeared anxious.
3. Specific Behavioral Changes:
1. Cattle: They may stop or freeze when encountering dark areas or sharp shadows, indicating discomfort or fear.
2. Pigs: They tend to freeze when faced with distressing situations, a clear sign of stress.
3. Heat Stress in Dairy Cows: Behavioral changes in response to heat stress include seeking shade, reduced feed intake, and increased time spent standing to facilitate heat loss.
4. Negative Interactions and Welfare: Negative tactile interactions from handlers can lead to increased fearbased behaviors such as slips, falls, and vocalizations, which are associated with poor welfare. High frequencies of these behaviors indicate significant stress during handling and transport.
5. Acclimatization Effects: Animals generally show reduced stress responses after repeated exposure to handling or transport, suggesting that acclimatization can mitigate stress levels over time.

Monitoring and understanding behavioral indicators of stress in animals can significantly enhance their welfare during transportation. Here are practical applications that incorporate these indicators to improve the transport experience for livestock:

1. Exploratory Behavior

Encouraging Exploration: Recognize that exploratory behavior indicates an animal's need for comfort and space. Providing adequate space within compartments allows animals to explore and find suitable places to lie down, which can reduce stress during transport.

Environmental Enrichment: Incorporate elements that stimulate curiosity, such as novel objects or bedding materials, to encourage exploratory behavior. This can help alleviate anxiety during transport by providing mental stimulation.

2. Lying Down vs. Standing Calm Environment:

Ensure a calm environment during loading and transit, as sheep and cattle are more likely to lie down when they feel secure. This can be facilitated by minimizing noise and sudden movements.

Monitoring Behavior: Regularly observe animals for signs of stress, such as standing or pacing. If animals remain standing, it may indicate discomfort, prompting immediate adjustments to the transport conditions.

3. Impact of Vehicle Movements

Smooth Transport Practices: Train drivers to maintain smooth driving practices to minimize abrupt lateral movements, sudden braking, and acceleration. This helps prevent discomfort and allows animals the opportunity to lie down.

Vehicle Design: Use vehicles designed with shockabsorbing features to reduce the impact of road conditions on the animals during transport.

4. Fighting as a Welfare Indicator

Monitoring Aggression: Keep track of fighting behaviors among transported animals, particularly male adult cattle and calves. High levels of aggression can indicate stress and poor welfare; thus, reducing mixing of unfamiliar animals can help minimize this behavior.

Group Composition: Carefully plan group compositions based on social hierarchies and previous interactions to reduce fighting incidents during transport.

5. Avoidance Behavior

Understanding Past Experiences: Pay attention to avoidance behaviors that indicate an animal's reluctance to return to previously aversive environments. This knowledge can inform handling practices and help create a more positive transport experience.

Familiarization Protocols: Implement familiarization protocols for animals prior to transport, allowing them to acclimate to the vehicle or environment they will be in.

6. Environmental Considerations

Heat Stress Management: Monitor environmental conditions such as temperature and humidity during transport. Providing shade or ventilation can help mitigate heat stress, allowing animals to maintain comfort levels.

Feeding Adjustments: Adjust feeding times based on environmental conditions, ensuring that animals are not transported on a full stomach in hot weather, which can exacerbate stress.

By applying these practical measures based on behavioral indicators of stress, producers can significantly enhance the welfare of animals during transportation. These strategies not only improve animal comfort but also contribute to better health outcomes and overall productivity in livestock operations. Monitoring behaviors like exploratory activity, lying down versus standing, and aggression provides valuable insights into animal welfare that can lead to more humane handling practices throughout the transportation process.

Physiological Indicators of Stress

Understanding the physiological indicators of stress in animals is crucial for assessing animal welfare. These indicators can vary across species and contexts, but several common measures have been identified.

Key Physiological Indicators

1. Hormonal Changes:

Cortisol: Often referred to as the primary stress hormone, cortisol levels typically increase in response to acute stress. Chronic stress may lead to varying cortisol responses, sometimes resulting in hypocortisolism, where cortisol levels are lower than expected due to prolonged stress exposure.

Catecholamines: These hormones, including adrenaline and noradrenaline, also rise during stress and can be indicative of the animal's acute stress response.

2. Heart Rate and Respiratory Rate:

Tachycardia: An increased heart rate is a common physiological response to stress. For instance, dogs weighing less than 15 kg are considered to have tachycardia if their heart rate exceeds 160 beats per minute.

Tachypnoea: An elevated respiratory rate is another indicator of stress, often observed alongside tachycardia.

4. Immune Responses:

Stress can lead to immune system alterations, such as changes in leukocyte counts (e.g., neutrophilia and lymphopenia), which are often referred to as "stress leukograms". Increased levels of acute phase proteins may also indicate a stress response.

5. Body Temperature:

Elevated body temperature can be a sign of thermal stress, particularly in pigs where rectal temperature is frequently measured to assess stress levels related to environmental conditions.

6. Heat Shock Proteins (HSPs):

The synthesis of HSPs like HSP70 increases in response to various stressors and can serve as a marker for chronic stress exposure. Their levels may remain elevated for days following a stressful event.

Contextual Factors Influencing Stress Responses

Environmental Stressors: Factors such as overcrowding, extreme temperatures, and social dynamics significantly impact stress levels in animals. For example, pigs subjected to social stress or housed in barren environments show distinct physiological responses compared to those in enriched settings.

Chronic vs. Acute Stress: The physiological responses can differ markedly between acute and chronic stress situations. While acute stress typically results in heightened hormonal responses (like cortisol spikes), chronic stress may lead to blunted responses or adaptations that complicate assessment.

Practical Implications of Physiological Indicators of Stress in Animals

Physiological indicators of stress in animals play a crucial role in assessing animal welfare and informing management practices. Understanding these indicators allows for better decision-making in animal care, production, and research environments.

1. Welfare Assessment Comprehensive Evaluation: Physiological indicators, such as cortisol levels and heart rate, provide objective data that can be combined with behavioral observations to create a more comprehensive assessment of an animal's welfare. This multi-faceted approach helps in identifying both acute and chronic stressors affecting animals . Identification of Stressors: By monitoring physiological responses, caregivers can identify specific stressors—

be they environmental, social, or health-related—that negatively impact animal welfare. For instance, elevated body temperature and increased respiratory rates can indicate thermal stress in pigs during hot weather .

2. Management Practices Improved Housing Conditions: Understanding stress indicators can lead to modifications in housing and management practices. For example, if physiological indicators show high stress levels due to overcrowding, adjustments can be made to reduce animal density . Behavioral Interventions: Recognizing physiological signs of stress allows for timely interventions. For example, if certain animals exhibit increased heart rates or abnormal behaviors during handling, strategies such as gradual desensitization or environmental enrichment can be employed to mitigate stress .

3. Health Monitoring Early Detection of Health Issues: Physiological indicators can serve as early warning signs for health problems. Elevated cortisol levels may not only indicate stress but can also correlate with immune suppression, making animals more susceptible to diseases . Regular monitoring can help detect health issues before they escalate. Non-Invasive Techniques: The development of non-invasive methods for measuring physiological indicators (e.g., salivary cortisol instead of blood sampling) minimizes the stress associated with health assessments while still providing reliable data .

4. Research and Development Refinement of Animal Models: In research settings, understanding the physiological responses to stress can refine experimental designs involving animal models. This is particularly relevant when studying the effects of various treatments or conditions on animal welfare . Guiding Breeding Programs: Knowledge of stress indicators can inform breeding programs aimed at enhancing resilience to stress in livestock. Selecting for traits associated with lower stress responses could lead to healthier and more productive animals .

5. Ethical Considerations Informed Decision-Making: The use of physiological indicators promotes ethical decision-making by providing measurable evidence of animal welfare states. This is particularly important in industries where animal welfare is scrutinized by consumers and regulatory bodies . Compliance with Welfare Standards: Monitoring physiological indicators helps ensure compliance with animal welfare standards and regulations, which increasingly require evidence-based assessments of animal well-being .

The practical implications of physiological indicators of stress are significant across various domains, including welfare assessment, management practices, health monitoring, research development, and ethical considerations. By integrating these indicators into routine practices, stakeholders can enhance the overall welfare and productivity of animals under their care.

Importance of Rest Periods

1. Animal Welfare: Rest periods are crucial for the wellbeing of livestock during transport. Animals experience stress due to confinement, motion, and environmental factors. Providing

adequate rest allows them to recuperate, reducing fatigue and the risk of injury. For instance, cattle and other livestock need to lie down to rest, which is essential for their physical health and psychological comfort. Lack of rest can lead to abnormal behaviors and increased stress responses, which can compromise their welfare.

2. Physiological Needs: Animals have specific physiological needs that must be met during transport. For example, they require opportunities for drinking and feeding at regular intervals. This is not only important for their hydration and nutrition but also plays a role in reducing stress levels. Research indicates that proper rest can mitigate the adverse effects of transport, such as heat stress and motionrelated discomfort.

Legal Requirements

1. Transport of Animals Rules, 1978:
    - According to the Transport of Animals Rules in India, specific regulations govern the transport of livestock. Key provisions include:
    - Rest Intervals: Animals must be provided with rest periods during transport. Specifically, cattle should be allowed to drink every 2 hours and to feed every 4 hours. This is crucial for maintaining their hydration and nourishment, which directly impacts their health and wellbeing.
    - Maximum Distance and Duration: The rules limit the transport of cattle to a maximum distance of 30 kilometers in a single day when traveling on foot, with a stipulated maximum travel time of 8 hours. These regulations aim to prevent overexertion and ensure that animals do not endure prolonged confinement without adequate rest. Health
    - Certification: A valid health certificate from a qualified veterinary surgeon is mandatory for transporting animals, confirming they are fit for travel and free from infectious diseases. This applies to various animal species, including cattle, sheep, and goats.
    - Loading Limits: Specific loading limits are specified based on the gauge of the rail or road vehicle. For example, an ordinary goods wagon can carry no more than 10 adult cattle or 15 calves on broad gauge, 6 adult cattle or 10 calves on meter gauge, or 4 adult cattle or 6 calves on narrow gauge.
    - Separation of Species: Different types of animals must be kept separate during transport to avoid distress. Rams and male young stock shall not be mixed with female stock in the same compartment.
    - These regulations collectively aim to ensure the humane treatment of animals during transportation, addressing their physical needs and welfare throughout the journey.

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Chapter 9

PRE AND POST-HARVEST INTERVENTIONS FOR ENHANCING MARKET VALUE OF CHICKEN

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Meat foods play a very imperative role in human health by providing all essential nutrients needed for growth and maintenance. Around 70 per cent of Indians are now on non-vegetarian dietary habit and regular meat consumption is rigorously increasing over the years. Holding of 11.6% of world livestock population and 17.71% of the world human population, India has tremendous potential in meat production, processing and marketing. The revenue in Indian meat market is valued close to USD 33.70 billion in 2024 and is one of the fastest growing industries at an annual growth rate of 5.99 per cent (Statista, 2024). India produces about 9.8 million tonnes of meat annually from all species, out of which chicken alone contributes more than 51% (4.99 million tonnes). Technological interventions have resulted in transformation of unorganized and unscientific chicken farming practice in India to a highly successful commercial production system. Poultry Industry in India is a 28.8 billion USD sector with an annual growth rate of 8-10%. The total value of output at current basic price (2020-21) from livestock sector is Rs. 15,63,399 crores, out of which poultry egg and meat sector alone contributes Rs. 2,30,528 crores. Thus, poultry sector contributes 14.75% of total annual value of outputs from livestock (CSO, MoSPI, 2023).

Despite spectacular increase in broiler production with more 70% of poultry sector is organized, primary poultry processing as well as processed, value-added poultry product sector in India are in juvenile stage. In the present scenario, poultry trade is either in the form of sale of live birds or as skin-out carcasses in wet market. A minor proportion undergoes further processing as dressed whole carcass, cut-ups or value added products.

Changing face of retail meat sector in India

Eventhough, cultural patterns rather than income dominate meat consumption in India, the ready-to-eat meat sector is slowly growing with consumer affluence. Due to liberalization, urbanization, fast growing economy and government policies, the meat consumption habits are changing among Indian consumers especially in metros, cities and smaller towns. Establishment of about 50 modern, mechanized poultry processing plants, vertically integrated poultry companies with their own retail outlets/expansion in domestic food processing, proliferating fast food outlets and entry of multinational fast-food chains has provided impetus to the growth of this sector over the last two decades. Large meat and poultry processing companies like Venky's Xprs, Fresco Pollo, Suguna Daily Fresh, Australian Country Chicken, Al-Kabeer exports, Kentucky Fried Chicken (KFC), McDonald, Mary-Brown, Subway, Godrej-Tyson, Sumeru, Falcon Foods, Government Bacon Factories, Vista Food Processors, Alchemist, Meat Products of India Ltd., etc. have entered into meat processing and catering to the demands of certain percentage of population. The evolution of modern retail outlets and

recent entry of several startups into online marketing with better packaging, labeling, chilling and cold chain facilities will hopefully address the drawbacks of the existing situation. Few large players like METRO, SPAR Hypermarket, WalMart etc. have already entered into retail sector. Realizing the Indian quick service restaurant market, several food majors viz, Denny's Corp, Pollo Tropical Carrols Restaurant, Applebee's and Johnny Rockets, Wendy's have started their operations in India.

Enhancing demand and market through value addition

Value addition is an important avenue for efficient utilization of livestock resources with increased demand and higher returns. The purpose of further processing and value addition of chicken is to meet life style requirements of consumer, provide variety of meat products, provide increased convenience through decreasing preparation time and steps, minimizing preparation steps and taking risks out of kitchen. Further, the value addition enhances the value of raw meat, utilize different byproducts, incorporate non-meat ingredients for quality and economy, combine and compliment meats of different species with advantage, preserve, transport and distribute to larger populations, increase demand and marketability, and promote entrepreneur ventures and employment.

I. Pre-harvest interventions to enhance market value of chicken

Farming, feeding, animal welfare during transport, marketing and slaughtering have profound impact on carcass and meat quality. The farming systems and feeding programmes significantly contributes to nutritional as well as eating quality of meat. Feeding birds on certain additives, supplements, phytochemicals improve quality of meat in terms of its nutritional value, colour, lipid and protein oxidative stability. Poor handling and exposing animals/birds to various stress conditions during growing at farm and later during marketing and slaughtering has adverse effects on the animal health, carcass and meat quality.

Growing demand for meat from free range and naturally grown chicken and organic meat: A growing worldwide trend towards consumption of meat from animals/birds reared under free-range condition is evident. The demand for such produce is steadily on increase in response to the concerns of animal welfare and move away from the widespread use of antibiotics and feed additives. Organic animal and poultry production system, which follows natural process of animal production with utmost regards for food safety and food security is emerging as an effective alternative to address all these issues. All the products and services in the organic food value chain are likely to fetch premium price in the market as they are targeted for niche consumers who are quality conscious and would be willing to pay premium price for quality products.

Traceability: Traceability is the ability to, and the mechanism designed for, the tracing of an animal product along all steps in the production chain back to the holding of origin of the live animal/bird from which the product was derived. Traceability is an important aspect of quality assurance which aids tracing back the source of product in cases of discrepancy in quality of the product. It is a part of the strategy to reduce the risk or minimize the impact of food borne disease problems and to reduce the risk or minimize the impact. Globally, meat traceability is gaining increased emphasis in recent decades as it promises comprehensive quality assurance

in production of meat and meat products. of food borne illness. It is a risk reduction strategy. The integrated production will also suffice mandatory requirement of traceability of food products as per the Food Safety & Standards (Food Recall Procedure) Regulations, 2017. With largely scientific production system and fairly organized nature of production, the traceability system could be easily implemented in poultry sector, which not only expand consumer preference, but also boost meat exports to the next level.

Functional chicken meat: Functional foods used to refer to foods or isolated food ingredients that possess specific health-promoting properties over and above its usual nutritional value. As such meat is a source of food protein with high biological value and is an excellent source of minerals and vitamins. Due to increasing concerns for health a considerable efforts have been made by meat industries in many countries to develop new products with tertiary functions such as anti-carcinogenecity, antioxidative and antiageing activity. There are diverse possible strategies for developing healthier meat and meat products. This may be through manipulation of feeding materials viz., selenium & Omega 3 FA rich feed to produce designer chicken.

II. Post-harvest interventions to enhance value of chicken

Hygienic and safe meat: Consumers of today demand hygienically processed pathogen free safe meat with defined eating qualities and minimal impact on the environment. Hygienic and safe meat production can be achieved, provided where healthy animal/bird production, adequate infra structure facility for harvesting meat from birds, hygienic slaughter practice, trained man power and quality management system are followed.

Cut up parts: Chicken further processing involves converting whole carcass into cut-up parts, specialised cuts, deboning, and fabricating poultry meat into value-added products. Fabricating the carcass into consumer-ready products, offers more convenience as well as add value to the product that requires additional time or labor. High value cuts like breasts, thighs, legs, lollipops, wings could be made and sold. Thigh and breast cuts could be further made into boneless chicken, fillets, chicken slices, steaks, strips, cubes, minced meat, etc. to meet varying demands of consumers. Many processors also sell cleaned and ready to cook edible byproducts like liver, heart and gizzards.

Semi-convenient marinated products: The semi-convenience products (ready to cook), which involves seasoning, breading, sauces, and marinating, as well as special packaging to meet market demands for convenient products. This provides better consumer satisfaction, would be more ideal in the present situation with yet to develop consumer popularity of value added convenience products. The added values result in higher margins and profits while providing a large product choice for the consumer.

Variety of value added chicken products: Value added products could be broadly classified based on processing, variety/convenience and function. The processes such as portioning, size reduction and restructuring, emulsion preparation, battering and breading and variety of cooking methods are utilized to produce variety of value added meat products. Value added products also include processed products for convenience, portioned and institutional items for uniformity and nutritionally enhance meat for healthfulness. Appropriate quality of raw

materials, correct formulation, optimum processing and packaging, nutritional value, labeling requirements, product specifications and regulations etc. are important factors in the success of processed meat products. Some of the value addedchicken products are described in the following sections.

Table 1. Meat and meat products by processing type

Product Type	Examples
Sectioned and formed meat products	Rolls, Boneless chicken hams etc.
Emulsion meat products	Nuggets, Meat balls/kofta, Emulsion sausages
Restructured meat products	Restructured meat loaves/slices
Ground meat products	Ground meat patties
Enrobed meat products	Enrobed wings, drummettes, Enrobed patties
Cured and smoked meat products	Cured and smoked chicken breats, legs and wings
Dried meat products	Chicken jerky
Canned/retort pouched meat products	Chicken sausages, Corned chicken

i. Comminuted/emulsion meat products: Development of emulsion based meat products facilitate better utilization of meat, byproducts from spent animal and non meat ingredients. Chicken byproducts like heart, gizzard, mechanically recovered meat and skin could be incorporated to reduce cost of emulsion based meat products. Meat is minced in a mincer and emulsion is produced in a bowl chopper with salt, phosphates and other ingredients in correct proportion and sequence and batter is prepared to a desired consistency. A large variety of palatable products such as sausages, patties, nuggets could be prepared from such emulsion.

ii. Restructured meat products: The objective of restructuring whole tissue meat is to achieve a product that not only imitates but also possess the attributes of a whole tissue product. Restructuring refers to a group of procedures that partially or completely disassemble meat and then bind together the meat pieces to form a cohesive mass that resembles an intact muscle. The purpose is to effectively market less valuable carcass and cuts. The processes include chunking, flaking and forming through various processes like blade tenderization, tumbling and massaging.

iii. Enrobed meat products: Further enrobing/coating of meat products is a method of value addition which enhances the acceptability of meat products. Enrobing imparts a desirable crispiness and increases the pleasure of eating with attractive colour. The products will be juicier as natural juices are retained during frying of the products.

iv. Cured and smoked meat products: In curing also known as salting, smaller meat pieces or bigger cuts either deboned or with bone is dipped in/injected with curing brine/pickle solution. Curing and smoking contributes attractive colour, unique flavours along with extending shelf life of meat products, which makes them popular among consumers.

v. Shelf stable meat products: Production of thermally processed meat products either in cans or retort pouches with extended shelf life at ambient temperature promotes distribution and marketing. Recently metal cans have been replaced by retort pouches i.e. laminated multi-layer, flexible pouches which can withstand high temperature and pressure processing. These laminated pouches act as barrier to gases and moisture. Foil laminated retortable pouches costs less, lighter in weight enabling easy distribution and marketing with faster processing time.

vi. Snack meat products: Extruded snacks are made from meat and non meat ingredients. Extrusion helps to create different forms and shapes of products. They are very popular for convenience, crispiness and shelf stability. Incorporation of meat in snack type of products improves flavor, taste and nutritive value of the product.

vii. Traditional meat products: Traditional meat products have tremendous mass appeal with unique sensory attributes. Biryani, haleem, kebabs, koftas, tandoori items and meat curries are few to name. Even the multinational companies like Subway, KFC, and McDonald etc. have realized the importance of traditional meat products for Indian customers and started blending western products with traditional meat products or introducing new ethnic products with their brand. Most of traditional meat products are generally confined to the native geographical region mainly due to their shorter storage stability. There is huge demand for indigenous meat products from ethnic population residing various parts of the globe, especially to South-east and Middle-east countries. Further, the existing market is limited to a few identified snacks and meal accompaniments and specialty foods like haleem, kababs, biryani, tandoori items etc. However, many are still awaiting the larger recognition. Extending the shelf life through technological interventions will boost the commercial value of traditional meat products. Retort processing is a promising technology for increasing the shelf life, which will ensure their availability throughout the year. Hence shelf-stable traditional meat products could be produced in large scale and find export potential in different geographical areas.

viii. Functional chicken meat products: Functional / designer chicken products could be produced by reformulation of meat products by modification of the fatty acids, reduction of fat content, reduction of cholesterol, nitrites and incorporation of functional ingredients viz., vegetable protein, fibres, probiotics, phytochemicals, bioactive peptides etc.

Packaging for value addition: The packaging of muscle based foods is necessary to ensure that such products reach the consumers in a condition that satisfies his or her demands on a number of levels namely: nutrition, quality, safety and convenience which add to the value addition. The primary goal of packaging is to maintain the freshness of the product, and also to assure the safety of the product to the consumer at the point of ultimate consumption. modified atmosphere, vacuum skin, retort pouches, aseptic, microwavable etc are some of the new packaging technologies which could offer significant potential for the sale of meat products. Vacuum skin packaging is a new form of packaging that is rapidly becoming popular. The plastic material used takes the shape of the product with effectively no head space in the package. In active packaging, new packaging materials which interact with the surface of the food as well the head space atmosphere inside the packages could be used as an alternative or supplementary technique to vacuum and/or gas flushing.

Branding in Meat/Poultry Industry: Branding is a tool for improving marketability of meat/poultry produce. Many commodities like wheat flour, edible oil and milk are now transformed into the brands. The milk is a classical example of commodity which came over the challenge of perishability, sourcing, storage, supply chain and has produced various brands of dairy products. The branding made the milk business profitable. Chilled or frozen chicken has slowly started entering into consumer's refrigerator even though the availability is limited to some cities/location. Consumers in some cities are now witnessing few branded chicken shops and even the supermarkets have started to allocate a corner for the meat and fish.

Utilisation of byproducts: Over the years, the quantum of production of deboned carcass frames, offals, skin, head and feet from integrated poultry processing plants are increasing in many folds. Chicken carcass frames after deboning carries considerable quantity of lean meat.

1. Technologies are available for preparing highly acceptable, nutritionally superior low cost meat products by incorporating edible byproducts like fat, heart, gizzard and skin of chicken. Formulations were developed to incorporate chicken byproducts up to 30 % in the meat products. These carcass frames and edible byproducts can be profitably utilized for making several nutritious value added products viz., chicken samosa, pickle and soup.
2. Nutritious pet foods with good organoleptic (texture, flavour, and palatability) quality could be prepared from a combination of animal coproducts, cereals, cereal co-products. The carcass frame and other byproducts could be utilized to produce wet pet food by retorting processing technology.
3. Unutilized byproducts including intestine, skin, head, feet, carcass frame of chicken are made into meat cum bone meal rich protein and phosphorous and used as feeding materials for livestock, fish and pets.

Conclusion: Value addition is an important feature of organized meat sector with many benefits such as convenience, improved health, improved economics, increased demand, employment generation, utilization of low value meat and byproducts, shelf-life extension and entrepreneurship development. Value addition could be carried out at many points in the meat system of production, distribution, processing, packaging and sale of chicken. Though, the present level of meat processing is very low when compared to the developed countries, the Indian market is witnessing a revolutionary change and several multinational and national companies are establishing and expanding their business in the Indian markets. There has been an increase in the availability of value added meat products and this segment is currently growing at more than 20%. Emerging consumption of convenience and value added meat products will not only diversify the food production system, but also will provide huge employment opportunities to large number of micro, small and medium scale entrepreneurs. Effective interventions like creating better infrastructure for meat production, minimizing the post-harvest losses, increased value addition and further processing, e-marketing are necessary to supply the country with reliable, safe and high quality meat and meat productsand will play key roles in the shaping the meat sector development in the country.

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Chapter 10

SCIENTIFIC SLAUGHTER AND DRESSING OF ANIMALS: APPROACHES TO CAPACITY BUILDING AMONG BUTCHERS AND MEAT HANDLERS

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Introduction

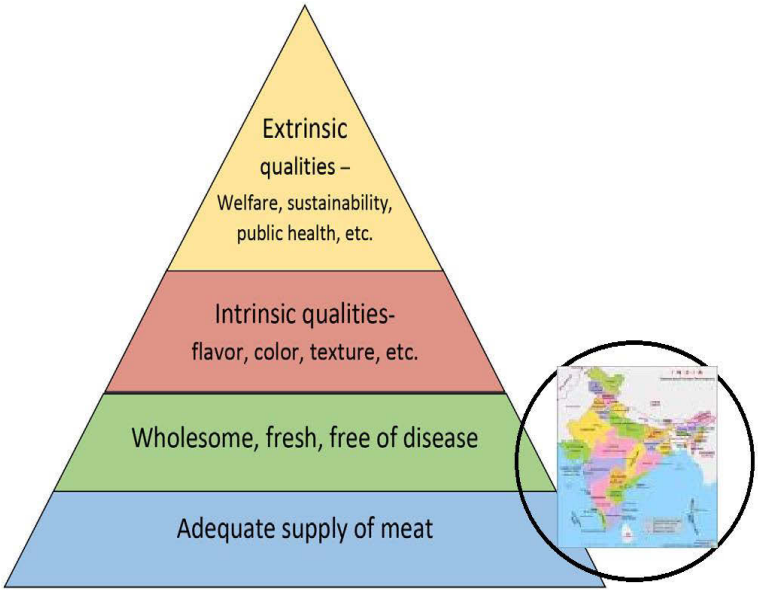
The process of slaughtering and dressing animals for meat production is a critical aspect of the meat industry. Proper techniques ensure food safety, animal welfare, and product quality. In many regions, especially in developing countries, traditional methods of slaughter and dressing often lead to poor hygiene, lower meat quality, and compromised safety standards. To address these issues, there is a growing need to promote scientific slaughter and dressing practices through comprehensive capacity-building programs for butchers and meat handlers. Scientific slaughter refers to the humane, hygienic and efficient handling of animals during slaughter, based on established standards and best practices. These practices not only enhance the quality of meat but also ensure animal welfare and environmental sustainability. By building the capacity of butchers and meat handlers through training, equipment and education, the industry can improve compliance with safety regulations and ethical standards.

Meat Production in India

India produces approximately 9.77 million tonnes of meat annually. While there are around 3,500 authorized slaughterhouses, more than 30,000 slaughter places exist, with 70% of the population consuming meat in varying quantities. There is a notable concern regarding the differences in meat quality due to varying production standards.

Consumer Perception of Meat Quality

Consumer perceptions of meat quality can be understood through a hierarchy similar to Maslow's triangle of needs, where basic requirements like safety and freshness form the foundation. Consumers first seek assurance that the meat is free from pathogens and has a fresh appearance and odour. Once these needs are met, they focus on sensory qualities such as flavour, tenderness and juiciness, which enhance their eating experience. At higher levels, consumers consider factors like ethical sourcing, animal welfare, and environmental impact, reflecting their values. At the top of the pyramid, they seek premium, gourmet meats for a fulfilling and elevated culinary experience.



Consumer's perceptions of meat quality revolve around sensory factors such as appearance, colour, flavour, texture, tenderness, juiciness and odour. The traditional definition of quality, particularly for whole meat, often focuses on these sensory attributes. Freshness or wholesomeness, the idea that meat is free from pathogens, parasites, and toxins, is also a key factor in the quality assessment. Although freedom from infectious agents is an unseen quality, we associate it with "freshness"; meat that looks old to us is untrusted.

Basic Requirements for Scientific Meat Production

Key elements necessary for scientific meat production include:

- **Lairage and Rest**: Animals should be given time to rest before slaughter to reduce stress.
- **Ante-mortem Examination**: A critical step to ensure animals are fit for consumption.
- **Stunning and Restraining**: Ensures humane treatment and easier handling.
- **Hoisting** of the slaughtered animal for bleeding and evisceration
- **Hygienic Practices**: Knife sterilization, blood collection in containers, personal hygiene practices and the segregation of clean and dirty areas during processing are vital.
- Collection of pluck
- Immediate removal of hide from the slaughter hall
- Water connection with hose pipes

- **Waste Management**: Proper disposal of solid and liquid wastes is essential for maintaining hygiene.
- Compound wall with gates

Concerns from Butchers and Meat Handlers

There are several concerns among butchers when adopting new facilities and techniques. Some key questions include:

- Will the new facilities ensure job security to the butchers?
- What is the incentive for the observing animal welfare measures?
- Do the design facilities suit the butchers' requirements?
- Are time and duration of slaughter meeting your requirements?
    - 3 hours
    - 60 large animals
    - No stunning
- Are these facilities and techniques user-friendly?
    - Hoist
    - Skinning cradle
    - Trolleys
    - Knife sterilizer
    - Hooks
- Do you have to substantially alter your slaughter practices?
- Do they make the slaughter process less strenuous?
- Are you able to complete your work irrespective of the skill and speed of other butchers working on other carcasses?
- Do the operational and maintenance practices of new slaughterhouses support the economics of the meat trade?
    - Holding in a covered lairage, overnight - **Legislation**
    - Stunning/Halal system- religious requirements, safety, space
    - Ante-mortem and PM inspection – UNFIT/CONDEMNED animals/carcasses? **Legislation**

- Butchers' health, zoonoses and protective measures

Butchers are often skeptical about new methods, especially if they require substantial alterations to traditional slaughter practices. Moreover, there are cultural and religious considerations, particularly regarding stunning versus ritual slaughter.

Simple techniques and interventions for enhancing meat quality and safety:

Meat colour is a critical quality attribute, especially for consumers, and varies significantly based on several factors, including the species of the animal, its age, diet, and post-slaughter handling. Meat colour is one of the first indicators of quality that consumers use when selecting meat. The visual appeal of meat greatly influences purchasing decisions. The colour of the meat reflects various properties such as freshness, pH levels, myoglobin content, and the animal's treatment before slaughter. Abnormal colour is often a sign of poor quality or spoilage. The colour of meat is primarily determined by the concentration of myoglobin, a protein responsible for storing oxygen in muscle tissue. Myoglobin content varies across species, which in turn affects the colour of meat:

- **Whale**: 0.91% myoglobin (very dark red meat)
- **Buffalo**: 0.6% (dark red meat)
- **Ox (Cattle)**: 0.5% (bright cherry red)
- **Sheep**: 0.25% (light red)
- **Pork**: 0.06% (pale pink)
- **Rabbit and Broiler Chicken**: 0.02% (pale white)

Colour is a more important attribute in beef and buffalo meat. Buffalo meat is inherently dark red due to its higher myoglobin content. The darker hue is characteristic and often preferred by certain consumer groups. Beef has a bright cherry red colour, especially in fresh meat. However, stress and improper handling can cause the colour to darken, resulting in what is known as **dark-cutting beef**.

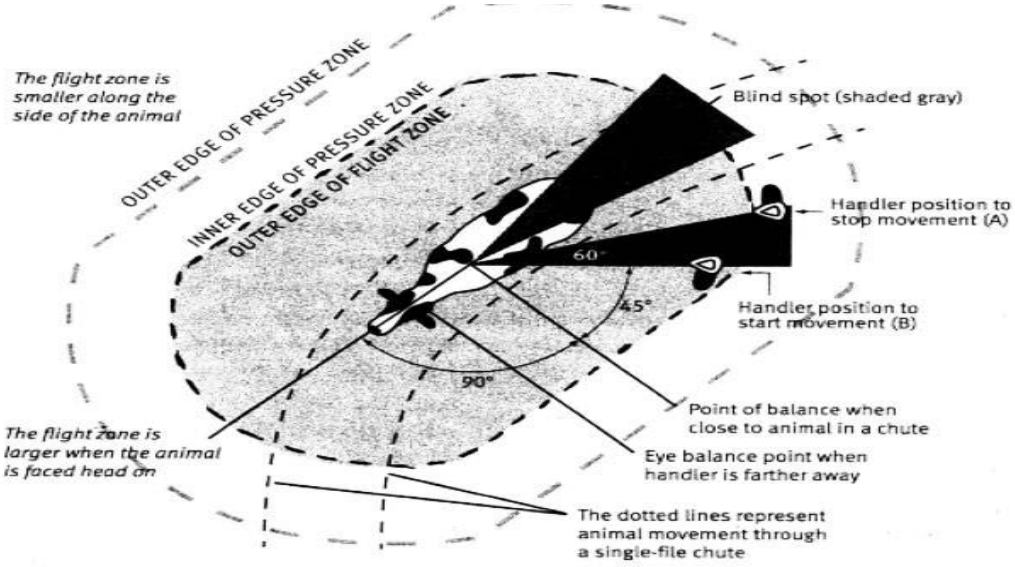
Handling Pre-slaughter Stress in Animals

Pre-slaughter stress is a critical issue, particularly in buffaloes and pigs. For example, buffaloes have a smaller flight zone, making them more difficult to handle, which often leads to physical abuse. The animals should be moved calmly using the principle of crossing the point of balance (the animal's shoulder). Handlers should avoid using narrow walkways and use calm vocal cues instead. The stunning and bleeding area should be brightly illuminated, as dark or shadowy areas increase fear. If animals become excited, it may take 20–30 minutes for them to calm down before they can be moved for slaughter. It is recommended to illuminate the stunning/bleeding area properly and minimize stress by avoiding high-pitched noises.

Different pig breeds have varying levels of stress sensitivity. Breeds like Pietrain and Belgian Landrace are highly stress-sensitive and prone to producing PSE meat. Stress-resistant breeds, such as Duroc and Large White, are better suited for environments with less stress management. In pigs, stress sensitivity varies across breeds, with some breeds more prone to stress-related conditions like Pale, Soft, and Exudative (PSE) meat.

Measures to minimize stress in pigs at small slaughter establishments

Proper pre-slaughter handling is crucial for minimizing stress and ensuring better meat quality. The key is to promote voluntary movement of animals. Pigs move more easily when they are allowed to walk alongside other pigs (double races). Solid boards or plastic panels can be used to direct their movement gently. Avoid differences in floor textures, puddles, or strange objects that could frighten pigs. Sharp, intense lighting should not fall directly into their line of sight.



Preslaughter stress in pigs

Pre-slaughter stress in pigs significantly affects the rate of onset of rigor mortis, which can have profound impacts on the quality of pork. Rigor mortis is the stiffening of muscles after death due to biochemical changes, and the rate at which it sets in can be influenced by the animal's stress levels before slaughter.

Changes in the rate of onset of rigor mortis

Stress in pigs, especially just before slaughter, leads to faster onset of rigor mortis. When pigs are subjected to stressful conditions, such as rough handling, loud noises, or improper transport, it triggers the rapid depletion of glycogen stores in the muscles. This leads to a quicker drop in muscle pH, resulting in the early onset of rigor mortis, which can cause issues like Pale, Soft, and Exudative (PSE) Pork.

Foreleg Angle (FLA) as a Measure of Rigor Mortis

A useful indicator to assess the rate of onset of rigor mortis in pigs is the **Foreleg Angle (FLA)**. The FLA is a physical parameter measured to gauge the rate at which rigor mortis sets in post-slaughter:

- **Smaller Foreleg Angle (FLA < 120°)**:
    - A smaller FLA (less than 120°) observed at 45 minutes post-slaughter indicates **faster rigor mortis development**. This rapid onset is often seen in pigs subjected to acute pre-slaughter stress, especially in stress-sensitive breeds like Piétrain and Belgian Landrace.
- **Larger Foreleg Angle (FLA > 120°)**:
    - A larger FLA (greater than 120°) at 45 minutes post-slaughter suggests **slower rigor mortis development**. This slower onset may occur in stress-resistant pigs or pigs that were handled in a low-stress environment before slaughter.

Pre-slaughter Washing

Washing animals before slaughter helps reduce microbial contamination and stress. Experiments at the Meat Technology Unit (MTU) showed that washing with water or hypochlorite solution before slaughter significantly reduces microbial counts. It is essential to allow time for the hide to dry to minimize bacterial transfer during dehiding. Hence sufficient time should elapse between animal washing and slaughter. If we need to wash immediately prior to slaughter, use an antimicrobial wash.

Stunning Techniques

Stunning, whether mechanical or electrical, is critical for humane slaughter and to comply with modern standards. Mechanical stunning (Penetrative percussive) causes permanent brain damage but does not result in immediate death, allowing for compliance with ritual slaughter requirements. Electrical stunning is more commonly used in pigs and is seen as a safer and less stressful option. Electrical stunning (ES) of pigs, particularly the use of low-voltage electrical stunning, is a common practice in small establishments. This method is designed to minimize the stress and squealing that pigs often experience during the slaughter process. One notable feature of low-voltage ES is that if the pig is not bled immediately after stunning, it can regain consciousness, making timely bleeding essential for humane slaughter. Many meat traders prefer using this method as it helps reduce the stress levels of pigs, which in turn contributes to better meat quality. Additionally, low-voltage electrical stunning is considered safe for the operator, allowing them to touch the animal while it is being stunned without risking harm.

Ritual slaughter box/ rotary restrainer

In India, the majority of cattle and buffaloes are slaughtered ritually, following traditional practices. One significant concern in this process is the stress caused by pre-

slaughter restraint, which can have negative effects on both the animal's well-being and meat quality. To address this issue, the use of a rotary restrainer is critical. This equipment is essential in all modernization projects as it allows for stress-free handling of the animals, minimizing the stress they experience before slaughter. The implementation of rotary restrainers helps ensure a more humane process and improves overall efficiency in the meat industry.

Bleeding after stunning

Bleeding after stunning, specifically through the technique of severing the brachiocephalic trunk by chest sticking, requires a high level of skill from the operator. This method ensures faster brain inactivity or death because it cuts off the collateral blood supply to the brain more quickly. One key advantage of this technique is the prevention of carotid ballooning, a condition where the carotid artery balloons due to partial cutting, leading to slower blood drainage and compromised meat quality. Chest sticking is also more hygienic compared to neck cutting, as it avoids severing the oesophagus, thereby preventing the spilling of ingesta, which could contaminate the carcass. This method offers a cleaner, more efficient approach to bleeding and ensures better hygiene in the slaughtering process.

In ritual slaughter without stunning, animals can experience prolonged periods before reaching insensibility after the incision is made. Studies show that around 10% of animals take approximately 60 seconds to lose posture, which is considered a sign of loss of consciousness, especially when the cut is performed while the animal is standing. This delay is primarily caused by a phenomenon known as carotid ballooning, where a false aneurysm forms at the cut end of the carotid artery. This false aneurysm obstructs blood flow, allowing continued blood supply to the brain through collateral vessels, thereby delaying the loss of consciousness. To avoid this complication, a neck cut parallel to the first cervical vertebra is recommended, as this helps eliminate the formation of a false aneurysm. However, in conventional practices, the neck cut is typically made at the level of the second to fourth cervical vertebrae (C2 to C4), which increases the likelihood of carotid ballooning and delays the onset of insensibility. By altering the position of the neck cut, the process can be made more efficient and humane.

Hygiene During Skinning/Flaying

Hygiene during the skinning or dehiding process is critically important to prevent carcass contamination. To maintain cleanliness, workers must avoid interchanging their "dirty" and "clean" hands. The hide should be cut from the inside to the outside with the blade positioned upwards, and the tail should be removed early in the process. It is advisable to start removing the hide from the clean area, specifically the back, rather than from the dirtier brisket area. For facilities processing more than 15 animals per hour, the use of hide pullers, particularly downward pullers, is recommended to streamline the operation. Care must be taken to avoid in-rolling the hide and incising the udder during the process. A recent approach includes washing and decontaminating the hide after bleeding and before flaying, which serves as a preventive measure. This is advantageous since the hide is considered inedible, so any

residual detergent left on the hide does not pose a problem. Overall, these practices are essential for ensuring the hygiene and safety of the carcass.

Hygiene of Evisceration

Ensuring hygiene during the evisceration process is crucial and should be completed no later than 45 minutes after slaughter. Key practices include rodding and bunging, which help maintain cleanliness throughout the procedure. A knife with a round tip is recommended to reduce the risk of accidental punctures, and it is essential to always cut with the sharp edge facing outwards. Additionally, the detection of adhesions during evisceration can aid in post-mortem inspection (PMI), providing valuable information about the health and condition of the animal prior to slaughter. By adhering to these hygiene protocols, the risk of contamination and spoilage can be minimized, ensuring the safety and quality of the meat.

Post-mortem Inspection and Meat Handling

After slaughter, inspection for adhesions during evisceration and ensuring a quick post-mortem process (not exceeding 45 minutes) are important. Proper handling of the carcass, particularly with tender and tough muscles, helps in maintaining meat quality. Guaranteed tender muscles in meat include the psoas major, longissimus dorsi, infraspinatus, and diaphragmatic pillars. These muscles are characterized by minimal physical stress during the animal's life, resulting in finer muscle fibers. The psoas major, located near the spine, is tender due to its limited use. The longissimus dorsi, which forms the ribeye steak, is tender because of its lower activity levels. The infraspinatus, situated in the shoulder, remains tender for similar reasons, while the diaphragmatic pillars, part of the diaphragm, are also less utilized in movement. Collectively, these muscles are highly valued for their tenderness and quality in culinary applications.

Retail Meat Sale and Cold Shortening

Surveys indicate that in authorized corporate slaughterhouses, animals are typically slaughtered between 3-4 AM, while unauthorized slaughter in rural areas often begins as early as 1 AM. Meat samples from both sources, collected between 6-8 AM, were found to be in a pre-rigor state, with unacceptably high microbial loads. This raises significant concerns regarding meat quality, including issues such as cold shortening, thaw rigor, and heat-induced shortening during cooking. To mitigate these problems, specific practices should be followed. For instance, if retail meat is frozen immediately in domestic freezers, thaw rigor is likely to occur. However, cold shortening can be prevented by chilling larger meat chunks, although standardizing chunk size can be challenging. Studies suggest that buffalo meat chunks larger than 12.5 x 10 x 10 cm stored at 4°C effectively eliminate cold shortening. Given the high

microbial load of retail meat, implementing standard carcass decontamination procedures at service abattoirs is essential to ensure meat safety and quality.

Hygiene in Poultry Shops

The hygiene conditions in retail meat facilities are concerning, with none of the cutting slabs being clean and only one-fifth of the shops having a clean knife. Clean floors were observed in just one-eighth of the facilities, most of which also lacked proper drainage and sewage systems. There was a significant shortage of potable water and adequate lighting, with only a few facilities providing disinfectants and other necessary hygienic practices. Insects and flies were prevalent in all shops, and while butchers selected apparently healthy birds, they did not prioritize the cleanliness of the poultry. None of the facilities had systems for poultry inspection and meat certification, and only a few followed proper washing protocols for carcasses before and after evisceration. Contamination of poultry meat with feathers and intestinal contents was common. Unhealthy habits among butchers, such as spitting, counting money, and using common cloths to wipe their hands, were widespread, with only 64% of butchers washing their hands during work hours. Handwashing was more frequent in licensed and medium shops, likely due to better water access. However, no butchers disinfected their hands, body or equipment. Awareness of risks associated with meat-borne diseases was limited, although butchers recognized the risks of meat-borne diarrhoea. There was minimal understanding of symptoms related to food poisoning or zoonotic diseases, indicating a lack of awareness about their health hazards. Overall, while butchers acknowledged the importance of bird health and cleanliness of equipment, there was little emphasis on personal hygiene and safe waste disposal practices.

Chicken processing units- design

- Three compartments

1. Rear 10 x 15 ft to carry out slaughter and dressing

- Separated in the middle by a civil platform of 6 x 2 ft to separate the clean and unclean operations
- Alternatively, a separating wall of civil construction can be recommended between the clean and unclean areas

2. Front compartment 10 x 5 ft as sales area

3. Facility for keeping live birds outside the slaughter area 10 x 5 ft

To ensure hygiene and safety in chicken processing units, it is crucial to keep live birds outside the processing area. This practice helps mitigate potential hazards such as airborne particulates, faecal matter, and pathogens of faecal origin. To assess and convince stakeholders of the importance of this separation, monitoring particulate content in the air can be effective.

Establishing separate clean and unclean areas is essential, with operations up to evisceration physically separated from subsequent processes. A window-type hatch can facilitate the transfer of carcasses to the clean area while preventing the movement of personnel and materials (like knives, utensils and trays) between the two zones, thereby minimizing risks of cross-contamination and exposure to enteric pathogens. Implementing electric stunners for individual birds, particularly wall-mounted options, significantly enhances bird welfare and improves meat hygiene and quality. This method allows for easy demonstration that the birds are not killed by stunning, while also reducing struggling and aerosol release during the bleeding process. Utilizing bleeding cones for restraining individual birds during bleeding further reduces particulate release and contamination, making blood collection and segregation more efficient. The availability of potable tap water is critical to ensuring that water does not become a source of contamination, as contamination can build up when water is stored in receptacles. Additionally, providing hot water at a minimum temperature of 82°C is vital for effective carcass washing, with a recommended use of at least 1.5 liters of water per carcass weighing up to 2.5 kg. These practices collectively enhance the overall hygiene and safety of the chicken processing operation.

Waste Segregation and Effluent Disposal

The management of poultry waste, including fat (skin) and feathers, poses significant environmental challenges. While sending these materials to biogas plants is an option, the initial hydrolysis process is slow and often limits effective waste breakdown. Skin can be composted; however, the presence of fat can create anaerobic conditions, leading to foul odours. Additionally, excess poultry waste at pig farms contributes to environmental contamination. To mitigate these issues, there is a critical need for affordable and environmentally-friendly small-scale rendering plants that can process waste from clusters of poultry slaughter units. Such facilities would enhance waste management, reduce environmental impact and promote sustainability in the poultry industry. For small-scale (petty) operations, the use of septic tanks and soak pits is a feasible method for wastewater disposal. Additionally, biomethanation and Phytorid technology, developed by NEERI (National Environmental Engineering Research Institute), offer alternative solutions for waste management. However, these methods are not suitable for implementation in shopping or residential areas due to space and environmental considerations. They are more feasible if suitable land is available, as they require minimal installation and operational costs. The treated water from these processes can be utilized for irrigation, providing an effective way to manage waste while promoting sustainable agricultural practices.

Some suggested innovations

Innovative solutions are emerging in the poultry industry, particularly in the areas of stunning and meat quality assessment. Wall-mounted and hand-held poultry stunners (Make in India), enhance the welfare of birds during slaughter. Advanced image analysis technologies are being utilized to assess key parameters such as tenderness, meat yield from live animals,

and carcass maturity. Additionally, a platform kit for evaluating microbial load helps ensure food safety. To improve the transportation of meat, feather-based insulating bags and boxes are designed for the safe transport of chilled and frozen poultry products, maintaining optimal temperatures during transit. Furthermore, Standard Operating Procedures (SOPs) for the transport of frozen meat using dry ice are essential to preserve quality and ensure compliance with safety regulations. These advancements contribute to a more efficient and hygienic poultry processing and distribution system.

Conclusion

Capacity building among butchers and meat handlers requires introducing techniques that not only improve the product value but also enhance customer confidence. Implementing modern slaughterhouse practices, educating handlers and ensuring better infrastructure can lead to safer and higher-quality meat production, particularly in India's unorganized meat sector.

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Chapter 11

FSSAI REGULATIONS AND REQUIREMENTS FOR MEAT PROCESSING ESTABLISHMENTS

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While setting up and operating slaughterhouses and meat processing establishments, the Food Safety and Standards Authority of India (FSSAI) has specific guidelines to ensure food safety and hygiene which are specified through various regulations.

Food Safety & Standards (Food Product Standards and Food Additives) Regulations, 2011

FSSAI has set the standards for meat and meat products as per 2.5 of Food Safety & Standards (Food Product Standards and Food Additives) Regulations, 2011. As per the said regulation

"**Meat**" means all edible parts (including edible offal) of any food animal slaughtered in an abattoir that are intended for or have been judged as safe and suitable for, human consumption.

"**Meat food products**" means any product prepared from meat and other ingredients through various processing methods in which meat should be the major ingredient of all the essential ingredients but shall not include the following products: (i) Meat extracts, soup, stock and meat sauces; (ii) Products containing fragments of meat, but which contain a quantity of meat or meat product not exceeding ten percent of the total weight of the final product;

"**Slaughter**" means killing of food animals for human consumption in an authorized slaughterhouse.

"**Slaughter house/ abattoir**" means a licensed place/ building/ premises where food animals are slaughtered humanely in hygienic manner with proper ante-mortem and post-mortem inspection by veterinarian for human consumption

The regulation specifies the standards for nearly 28 meat products which include the categories like Fresh or Chilled Meat, Canned or Retort Pouch Meat Products, Comminuted or Restructured Meat Products, Cured or Pickled and Cooked or Smoked Meat Products, Dried or Dehydrated Meat Products, Cooked or Semi-Cooked Meat Products, edible animal casing for sausage etc.

The list of additives permissible for the category of the meat products is specified under Appendix A of the FSS (Food Product Standards and Food Additives) Regulations, 2011 whereas the microbiological standards for meat and meat products comprising the process

hygiene criteria and food safety criteria have been specified under Appendix B of the FSS (Food Product Standards and Food Additives) Regulations, 2011.

Food Safety & Standards (Prohibition and Restrictions on Sales) Regulations, 2011

2.3.13 of Food Safety & Standards (Prohibition and Restrictions on Sales) Regulations, 2011, strictly prohibits the use of flesh of naturally dead animals or fowls in food. ie, No person shall sell or use as an ingredient in the preparation of any article of food intended for sale, the flesh of any animal or fowl which has died on account of natural causes.

Food Safety & Standards (Contaminants, Toxins and Residues) Regulations, 2011

This regulation specifies 'tolerance limits' of antibiotics and other veterinary drugs in meat/meat products and poultry along with the limits for heavy metals, biological toxins, pesticide residues etc.

Regulation No.	Parameter
2.1.1	Limit for Metal contaminants in various food products including Meat and Meat products described.
2.2.1(2)	Limit for Naturally occurring Toxic substances. Eg: Saffrole content in Meat preparations and meat products, including poultry and game which is 10 ppm.
2.2.1(3)	Polychlorinated biphenyls (PCBs) and Polycyclic Aromatic Hydrocarbon (PAH) compounds in Fish and Fishery Products.
2.3.1	MRL in mg/kg of various insecticides in food products including Meat and Meat products.
2.3.2(1)	Tolerance limit(mg/kg) of antibiotics in sea foods.
2.3.2(2	List of prohibited antibiotics and veterinary drugs in meat and meat products, poultry and eggs, sea foods
2.3.2(4)	Tolerance limit (mg/kg) of antibiotics and veterinary drugs in food articles including meat and meat products.
2.4	Limits of biotoxins in fish and fishery products
2.5.2	Histamine in Fish and Fishery Products

Table 1. Parameters specified under Food Safety & Standards (Contaminants, Toxins and Residues) Regulations, 2011

Food Safety & Standards (Licensing and Registration of Food Businesses) Regulations, 2011

FSSAI license is mandatory for commencing or carrying on any food business with the appropriate kind of business. As per Schedule 1 of this regulation, all slaughter houses

equipped to slaughter more than 50 large animals or 150 or more small animals including sheep and goats or 1000 or more poultry birds per day and Meat processing units equipped to handle or process more than 500 kg of meat per day or 150 MT per annum will fall under the purview of Central Licensing Authority.

The Food Safety and Standards Authority of India (FSSAI) provides General Hygienic and Sanitary practices to be followed by Food Business operators under Schedule 4 of the Food Safety and Standards (Licensing and Registration of Food Businesses) Regulation, 2011. The establishment in which food is being handled, processed, manufactured, stored, distributed by the food business operator and the persons handling them should conform to the sanitary and hygienic requirement, food safety measures and other standards These guidelines focus on maintaining hygiene and ensuring the safety of meat products. Here are the key requirements:

Statutory Requirements :

a. "No Objection Certificate" to be obtained from Municipality or Panchayat or applicable local bodies before grant of license.
b. "No Objection Certificate" from the pollution control board of the State has to be obtained.
c. License/Registration under FSS Act' 2006 as per the Food Safety and Standards (Licensing and Registration of Food Businesses) Regulations, 2011

1. **Location**:

The meat processing unit should be situated in areas not prone to regular flooding and free from objectionable odors, smoke, dust, and other contaminants. Roadways and areas within or near the unit should have hard paved surfaces suitable for wheeled traffic. There should be adequate drainage and provisions for cleaning in place. Controlled access to the facility is also essential.

2. **Building and Facilities**:

Adequate working space is necessary for all operations in the meat processing unit. Construction should ensure proper ventilation, good lighting (natural or artificial), and easy cleaning to prevent the entry and harboring of insects, birds, rodents, and other vermin. Separate areas to prevent cross-contamination. Ensure edible meat doesn't come into contact with floors or walls unless specifically designed for it. Chilling rooms, freezing rooms, and freezers must meet requirements. Floors in meat handling areas should be waterproof, non-absorbent, non-slippery, and easy to clean. Walls should be waterproof, washable, and light-colored. Ceilings should prevent dirt accumulation, condensation, and mold. Windows and openings should avoid dirt buildup. Doors should be smooth, non-absorbent, and self-closing. Structures like stairs and chutes should not cause meat contamination. Avoid materials that can't be adequately cleaned (e.g., wood) unless contamination risk is minimal. Office accommodation for meat inspection agency use should be provided.

3. Sanitary Facilities

Water Supply: Potable water under pressure should be available for use. Hot potable water (65°C for cleaning and 82°C for disinfection) must be accessible during working hours. Hot water for disinfection should be dispensed in a way that allows knives and utensils to be submerged for at least two minutes. Ice should be made from potable water. Steam used directly with meat should come from potable water without hazardous substances.

Effluent and Waste Disposal: Meat processing units need an efficient effluent and waste disposal system. Effluent lines (including sewer systems) should prevent contamination of potable water. Biological oxygen demand level should be less than 1500, and an effluent treatment plant may be necessary.

Storage of Waste and Inedible Material: Facilities for storing waste and inedible material should prevent pests' access and avoid contamination of food, water, and equipment.

Changing Facilities and Toilets: Conveniently located changing facilities and hygienic toilets are essential. Handwashing facilities with warm or hot and cold water should be near toilets. Proper signage should direct personnel to wash hands after using toilets.

Hand Washing Facilities in Processing Areas: Adequate handwashing and drying facilities should be available. Facilities for hand disinfection should also be provided.

Lighting: Adequate natural or artificial lighting is crucial throughout the meat processing unit. Light bulbs and fixtures suspended over meat must be of a safety type and protected to prevent contamination in case of breakage.

Area	Light intensity
Inspection points	At least 540 Lux (50 foot candles)
Work rooms	Minimum 220 Lux (20 foot candles)
Other areas	At least 110 Lux (10 foot candles)

Table 2. Light intensity levels specific for a meat processing unit

Ventilation: Proper ventilation inside the unit prevents excessive heat, steam condensation, and dust. Airflow should never move from a dirty area to a clean area. Ventilation openings should have insect screens and be easily removable for cleaning.

Equipment and Utensils: Materials used for equipment and utensils must have a smooth, impervious surface, resistant to corrosion, non-toxic and odor-free. It should be free from pits and crevices and withstand repeated cleaning and disinfection. Sanitary design and construction are essential for easy cleaning and inspection. Containers for inedible material and waste should be leak-proof and made of suitable materials. Refrigerated spaces should have temperature measurement or recording devices**.** Equipment and utensils used for inedible material or waste must be clearly identified and not used for edible products.

4. **Hygiene Requirements**

Maintenance: Buildings, rooms, equipment, and other physical facilities in the meat processing plant should be well-maintained and orderly. Areas not used for meat processing or cleaning should be free from steam, vapor, and excess water.

Cleaning and Disinfection: Amenities in the meat processing unit like changing facilities, toilets, inspection office space must be kept clean. Rooms primarily used for meat handling should be cleaned and disinfected before and after any other food preparation. Equipment (knives, cleavers, saws, containers) should be cleaned frequently during the day and disinfected when contaminated. If containers move between edible and inedible areas, they should be cleaned before re-entering the edible department. Floors, walls, and drains should be cleaned to remove contamination. Roadways and yards near the meat processing unit should be kept clean.

Hygiene Control Programme: Designate an individual responsible for cleanliness. Staff should be well-trained in cleaning tools and methods. Maintain a permanent cleaning and disinfection schedule for all areas and critical equipment.

Storage and Disposal of Waste: Handle waste to prevent food or water contamination. Remove waste from working areas daily and prevent pests' access to waste. Clean and disinfect receptacles and equipment after waste disposal.

Pest Control: Implement an effective and continuous program to control insects, birds, rodents, and vermin. Regularly examine the facility and surrounding areas for signs of infestation. Eradicate pests promptly if they gain entry. Use physical, chemical, or biological agents under supervision by knowledgeable personnel. Follow recommendations from the relevant authority and inspectors. Employ approved pesticides carefully to prevent contamination of equipment and utensils. Thoroughly wash equipment and utensils after pesticide application.

Handling and Storage of Hazardous Substances: Hazardous substances (e.g., pesticides) with toxicity warnings have to be labelled. Store such substances away from meat handling areas. Authorized and trained personnel should handle and dispense hazardous materials. Avoid contamination of meat during handling.

Personal Effects and Clothing: Do not deposit personal effects or clothing in meat handling areas.

Maintenance of Tools: Store cleaning and maintenance tools and products away from meat handling areas.

5. Personnel Hygiene and Health Requirements

Medical Examination: Individuals who handle meat should undergo a medical examination before employment. Routine examinations and assessments should occur at least once every 12 months.

Communicable Diseases: Anyone suspected of having or carrying a disease transmissible through meat (or with infected wounds, skin infections, sores, or diarrhea) should not work in areas where contamination of meat is likely.

Injuries: If a person is cut or injured, they should stop working with meat until properly bandaged. Exposed bandages must be covered to prevent accidental detachment.
Handwashing: Regular handwashing with suitable cleaning agents under running potable water is essential. Hands should be washed before work, after using toilets, handling contaminated material, and when necessary. Notices promoting handwashing should be displayed.
Personnel Cleanliness: Individuals handling meat should maintain high personal cleanliness standards. Protective clothing (including head coverings and footwear) should be washed (unless disposable) and kept clean. Aprons and similar items should not be washed on the floor or left on equipment in working areas. Prohibited behaviors include eating, tobacco use, chewing, and spitting in meat processing areas. Visitors to meat processing units should wear clean protective clothing and head covers.

Sanitary & Hygienic Requirements for Small Slaughter House & Retail

To ensure hygiene and safety of meat being sold, the following requirements should be followed:

- **Location**: Choose an area not prone to flooding, free from undesirable odors, smoke, and dust. Ensure adequate drainage and prevent storm water from entering the premises to avoid meat contamination. Maintain a minimum distance of 50 meters (or 100 meters if directly opposite) from any place of worship.
- **Facility Design**: Provide sufficient space for fixtures, fittings, and equipment. Prevent pest access and keep out contaminants (dust, dirt, fumes, smoke). Separate areas for holding, slaughter, and portioning & retail. Ensure edible meat doesn't contact floors or walls unless designed for it.
- **Premises Requirements and Construction**: Construct hygienic facilities for meat processing and sale. Display prominent signboards indicating the type of meat sold. Avoid cross-contamination when selling multiple types of meat. Use impervious materials for walls, partitions, and floors to facilitate cleaning. Ensure effective cleaning of doors, windows, and floors. Provide adequate drainage and protection against pests. Maintain an ample supply of portable water. Offer facilities for meat handlers to clean their hands.
- **Equipment and Accessories**: Use materials that allow easy cleaning, maintain hygiene, and prevent contamination. Ensure durability, resistance to corrosion, and suitability for repeated cleaning and disinfection. Cleanable implements, sanitizable weighing scales, and food-grade chopping blocks are essential. Deep freezers capable of maintaining -18°C or lower are necessary for retailing frozen meat.
- **Sanitary Practices**: Clean and sanitize equipment before and after use. Preferably use hot water or 50 ppm chlorinated water for cleaning. Strictly prohibit bird slaughtering inside the facility (unless it's a butchery cum retail shop). Chilled meat meant for

immediate sale over the counter doesn't require cool storage. Dressed meat not for immediate sale should be chilled below 4°C within 4 hours from slaughter.

- **Storage and Disposal of Waste**: Provide waste and garbage collection bins with lids. Line bins with garbage collection bags and keep lids closed to prevent pest breeding.
- **Pest Control**: Ensure no pest infestations that could compromise food safety. Use approved pesticides with precautions. Remove meat from the room before applying pesticides and thoroughly clean equipment and utensils afterward.
- **Personnel Hygiene and Cleanliness**: Meat handlers undergo annual medical examinations. Maintain trimmed fingernails and wash hands frequently with potable water. Provide clean clothing and headwear for meat handlers. Prohibit eating, chewing tobacco, smoking, and spitting in the facility.
- **Sourcing of Meat**: Meat shall only be procured from FSSAI-approved slaughterhouses.
- **Transportation of Meat**: Transport meat at safe temperatures (preferably at or below 4°C). Use clean insulated containers with lids to prevent contamination. Frozen meat should be transported under hygienic conditions at less than -18°C.

Food Safety & Standards (Packaging) Regulations, 2018

This regulation specifies the standards and type of packaging materials to come in contact with food products. The following packaging materials are suggested for the packaging of meat and meat products as per Food Safety & Standards (Packaging) Regulations, 2018.

Glass jars with plastic (polypropylene (PP) or High-density polyethylene (HDPE) caps, Metal Containers with metal lid (lacquered tin containers), Plastic based flexible pouches in paper & paper Board carton, Plastic based multilayered flexible laminates heat sealed pouches, Plastic tray with overwrap, Aluminium foil wrap, Polyethylene terephthalate (PET) punnets or containers with plastic caps.

Food Safety & Standards (Labelling and Display) Regulations, 2020

These regulations cover pre-packaged foods and essential information displayed in food premises. It prescribes details like the name of the food, list of ingredients, declaration of veg / non-veg logo, declaration of food additives, name and address of the manufacturer, manufacturing/ packing date, best before date/ expiry date, lot number, nutritional information, net quantity, instructions for use etc to be displayed on the food package.

Conclusion

FSSAI regulations and requirements are crucial for ensuring food safety and hygiene in meat processing establishments. From sourcing meat to maintaining cleanliness, pest control, and proper labeling, these guidelines play a vital role in safeguarding consumer health. By

following these standards diligently, meat processing units can contribute to safe and quality food production, benefiting both consumers and the industry.

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Chapter 12

WASTE MANAGEMENT IN SLAUGHTERHOUSES

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Introduction

In any production system, the utilization of resources inevitably leads to the generation of both valuable products and waste. While the focus is typically on maximizing the output, it is essential not to overlook the by-products that arise in the process. Waste, by definition, refers to materials that have low or no value and, if not properly managed and can pose significant risks. Abattoirs are places where animals are slaughtered and processed into meat and products. In the process, a variety of biological wastes are generated, including blood, offals (internal organs), dung, intestine, stomach or rumen contents, discarded meat, hair, tongue, ears, horns, hooves, bone and bone scraps. Some of these materials may be useful depending on the tradition and culture, but are predominantly considered waste products in the abattoir. What makes slaughterhouse waste particularly concerning is its biological nature. These wastes are rich in nutrients and provide an ideal medium for the growth of bacteria, pathogens, and other microorganisms. For example, blood which is a nutrient-rich fluid that could facilitate the rapid growth of harmful microbes, potentially leading to contamination of both the production environment and the meat itself. Similarly, offal and rumen contents are organic materials that, if not handled properly, can result in health hazards, attract pests, and cause environmental pollution. Odour generation due to their rapid degradation often causes nuisance. Furthermore, if not removed swiftly and properly disposed, slaughterhouse waste can become a public health concern. The waste can spread infectious diseases, contaminate water supplies, and lead to the growth of dangerous pathogens in the surrounding environment. The removal of such waste is therefore critical—not only to maintain the quality of the meat produced but also to safeguard the health of workers, consumers, and the public. The quantum of waste generated depends on the scale of operations. In larger units more sophisticated methods of management may be needed.

The success of any waste management program is based on the segregated collection and the minimisation of waste generation by following the 4 R's, i.e reduce, reuse, reclaim and recycle. The hierarchy of waste management is an inverted triangle with prevention at the base which is the most preferred and disposal which is the least preferred. Disposal of waste in landfills should be the last resort since it is just dumping of the resource because it could not be used elsewhere. In Waste Management, waste minimisation involves reducing the generation of waste,reusing any waste if possible, reclaiming any waste that cannot be reused, recycling as much unused reclaimed material as possible.

The Solid Waste Management Rules 2016, governs the management of waste in India. The Central Pollution control board is the apex body for waste management and environmental pollution in India. The state pollution control board operates at the state level. They ensure that the rules are followed, give advice to the government and help formulate rules related to waste management and pollution control. The following are the guidelines for waste management for different types of waste from slaughterhouses as given by the central pollution control board. The wastes are classified as Type I, which is vegetable matter and Type II, which is animal matter

B. Types of Solid waste and Recommended Methods for Disposal

Type of Waste	Constitute of waste	Category of Slaughter House	Disposal Method
Type I	Vegetables matter such as Rumen and stomach and intestine contents dung, agricultural residue etc.	Large	Biomethanation
		Medium	Biomethanation or composting
		Small	Biomethanation or composting
Type II	Animal matter, such as inedible offals, tissue, meat trimmings, waste and condemned meat, bones, etc.	large	Rendering
		Medium	Rendering or Composting with Type I waste
		Small	Composting with Type I waste or Burial

D. Percentage of solid waste generation

Category	Type of Waste	Percent %	Total %
Large Animals (Bovine)	Type I Waste	4.0	
	Type II Waste	23.5	27.5
Small Animals Sheep Goat	Type I Waste	7.0	
	Type II Waste	10.0	17.0
Pig	Type I Waste	1.0	4.0
	Type II Waste	3.0	

The importance of efficient waste management in slaughterhouses

One of the primary concerns in waste management within the slaughterhouses is the risk of contamination of meat. When waste accumulates or is improperly handled, it can come into direct contact with meat and its products, leading to contamination. Pathogens such as *Salmonella*, *E. coli*, and *Listeria* can spread rapidly, causing foodborne illnesses. Furthermore, if waste is not promptly removed, it can attract flies, rodents, and other pests that could also contribute to the spread of disease. The high organic content and moisture levels in slaughterhouse waste create optimal conditions for microbial proliferation. Blood, in particular, serves as an excellent growth medium for pathogenic organisms, necessitating rapid removal and appropriate treatment

Another significant concern is the odour generated by the rapid decomposition of organic waste. Decomposing blood, offals, and other organic materials release foul-smelling gases, including hydrogen sulphide, which can create a highly unpleasant work environment, effect the health of the workers and create a negative impact on adjoining populations. Putrefaction is the proliferation of bacteria from within the body, causing chemical changes with release of putrescine, cadaverine, ammonia, hydrogen sulphide etc. along with other volatile compounds. These odors can be especially challenging in areas when slaughterhouses are located near residential or commercial zones. In addition to the health and environmental impacts, there is a need to comply to the rules and regulations with regards to waste management. Many countries have very strict regulations governing the handling and disposal of slaughterhouse waste to prevent environmental pollution, safeguard public health, and ensure the safety of edible products. Central Pollution Control Board is the statutory body which has a key role in putting forth standards and regulations in India. Abattoir owners are to not only manage waste effectively but also have to comply with local, national, and international standards for waste handling, disposal and treatment.

Types of Waste Generated in Abattoirs

The Abattoir or slaughterhouses produce different types of waste, each with its own management challenges. These wastes can be broadly categorized into:

1. **Solid Waste:**
    - **Offal**: This includes internal organs such as the, rumen intestine and other parts which are not used for human consumption (this varies across the country) but can be rendered for animal feed or other industrial purposes.
    - **Bones and carcass parts**: These are the parts of the animal that are discarded or used for processing into by-products like gelatin, glue, pet food or bone meal.
    - **Hair, horn, hoof and hide**: Animal hides and hair may also be considered waste, although they are sometimes recovered for leather or wool production. Hoof and horn may be used sometimes for creating artisan products.
2. **Liquid Waste:**
    - **Blood**: Blood is one of the most nutrient-dense wastes produced in an abattoir. It must be carefully handled and managed to prevent contamination, as it can attract pests and harbor pathogens. Blood can be collected and processed into products such as blood meal, but if not properly handled, it can lead to significant hygiene and odour issues.
    - **Wastewater**: Slaughterhouses produce large volumes of wastewater used for washing carcasses as well as the floor. This can contain traces of blood, fat, detergents, and other residues from cleaning and processing. Proper treatment of this water is essential to prevent contamination of local water sources.
3. **Organic Waste:**
    - **Manure and bedding**: Manure and bedding may originate from the transport vehicles as well as the lairage facilities that house animals prior to slaughter. Although these materials are generally not part of the slaughtering process itself, they must be removed and disposed of in a sanitary manner.
    - **Stomach contents and rumen contents**: These can include partially digested food and liquids from the stomach and intestines of ruminants (e.g., cows, sheep). These materials are of organic nature and can degrade rapidly. They could form sources of contamination and attraction of vermin.

Waste Management Techniques

Effective slaughterhouse waste management involves a series of strategies to minimize health risks, ensure hygiene, and comply with regulatory standards. The goal is to reduce waste volume, recycle where possible, and dispose of hazardous materials safely. The scale of operations at the slaughterhouse determines the technique to be adopted. Some common techniques include:

Collection and Segregation: Waste should be carefully segregated at the source to ensure proper handling. Organic wastes should be separated from non-organic materials to facilitate recycling and proper disposal. Solid and liquid waste should be collected and handled separately for ease and successful management.

Different Waste Management Techniques

1. **Rendering**: Many slaughterhouse by-products, such as bones, blood, and offals, can be rendered to produce useful materials. Rendering is a process in which these by-products are cooked at high temperatures under pressure to separate useful fats, proteins, and other components. Connective tissues of individual fat and muscle cells are ruptured so that raw fat and other materials bound within are free. These materials can then be utilised for use in animal feed, fertilizers, or industrial products. Rendering is a costly process and one of the most efficient. It is not a practical option for a small slaughterhouse, but can be thought of as a centralised unit catering to the needs of several slaughter houses. The setting up of the plant needs a lot of investment and planning for operating successfully. Thickly populated neighbourhoods should never be selected for setting such plants. The hot air that is emitted from the operations need proper treatment before released to the environment. The meat and bone meal and fats produced from the rendering plants usually have good utility in different industries.The rendering process inactivates many viruses and bacteria.The rendering is carried out in a two ways i.e. dry rendering and wet rendering. In wet rendering the raw material (Type II waste) is processed with added water or condensate derived from steam. The cooking is carried out at high pressure from 3 kg/cm^2 to 4 kg/cm^2 .In dry rendering the Type II waste is cooked in specially designed cooker, where steam is applied to the outer jacket.

2. **Composting**:
   Organic wastes, such as manure and certain offals, can be composted. Composting is a natural process that turns organic waste into nutrient-rich soil. This is an environmentally friendly method of disposal that reduces the volume of waste and provides a valuable by-product. Composting is usually done under aerobic conditions and hence called aerobic composting. Here the organic matter along with a carbon source and a bacterial culture is mixed properly and aerated for the microbes to convert the waste into useful products. The composting process involves a thermal phase and a final maturation phase. During the thermal phase, heat is generated and thermophilic bacteria are more active. During the mesophilic and maturation phases the temperature is reduced and finally falls to that of the surroundings. The colour of the compost also often changes to a dark brown or grey.

   a. Composting when done in a large scale is done as windrow composting, where long rows of the mixed materials (waste, carbon source and microbes) are spread and heaped on the ground for a few feet height. The windrows are raked at regular intervals, the size of the heap gradually reduces and the composting may take three to four weeks to complete.
   b. In a small scale composting can be done as in vessel composting where waste along with the carbon source and microbes are filled in vessels and allowed to convert

without much mixing or no mixing at all. This takes more time but requires less labour. The final products are obtained after three to five months.

3. **Vermicomposting :** This is the process of converting organic wastes, utilising the earthworm into compost. It is better to compost the materials by aerobic composting before doing the vermicomposting. There should be a bedding at the bottom composed of coconut husks spread. Above this waste materials are added layer by layer, each layer which is about 5 cm. Slurry, which is dung mixed with water, is sprinkled on each layer. Earthworms are added at the top most layer, at the rate of 1kg per square meter. The whole bed is covered with branches and leaves to conserve the moisture. The earthworms move from the top to bottom, converting the waste to compost. Exotic earthworm species are preferred for vermicomposting.
4. **Maggot culture :** Fly larvae of flies like Black soldier fly (*Hermitia illucens*) are used to convert organic waste into high protein biomass. These larvae could be utilised for feeding fish and poultry. This method helps to reduce the loop of conversion, moreover we get a product that can be directly utilised as a feed. The leachate can be either used as a manure or in the biogas plant.
5. **Wastewater Treatment**: Abattoirs must have wastewater treatment systems in place to ensure that any wastewater produced meets environmental standards before being released into the local water system. This typically involves processes like screening, sedimentation, biological treatment and filtration to remove contaminants. Lagoons are an option in places where land is abundant, where waste water is converted in the large reservoirs by bacteria and action of the sun. Effluent treatment plants which have biological, mechanical and chemical parts are critical for any modern abattoir. Smaller units may properly segregate the solid and liquid waste and can handle a part of the liquid waste in biogas reactors, the slurry then dried or de-watered may be used as a fertiliser. Phytorid wastewater technology of NEERI, is a sustainable constructed wetland which is suitable to treat waste water from small establishments. The system is based on the specific plants, such as Elephant grass (Pennisetumpurpurem), Cattails (Typha sp.), Reeds (Phragmitessp.), Cannas pp. and Yellow flag iris (Iris pseudocorus), normally found in natural wetlands with filtration and treatment capability. There is considerable reduction in the total solids, BOD and coliform. Phytodepuration is another concept for those considering cheap wastewater treatment options. This involves the intentional use of a plant to remove toxins from soils, sludges, sediments, surface water, and groundwater.
6. **Biogas Production for Waste Management**: Some abattoirs are beginning to explore the use of organic waste, such as blood and fat, to produce biogas. This renewable energy source can be used to power the slaughterhouse, reducing reliance on external energy supplies. The principle of biogas is anaerobic digestion. Here bacteria act on waste materials which are loaded into the reactor and convert them into Methane and other gases including Carbon dioxide, Hydrogen sulphide and some Nitrogenous gases are produced. Methane is the only gas which is having utility, other gases may be removed by a process

called scrubbing. The input material is converted in the reactor by around 40 to 60 days which is called the HRT (hydraulic retention time). The reactor is designed based on the HRT and volume of input. The capacity of the plant is mentioned in cubic meters. Proper sunlight and controlling the pH of input materials are vital for the success of the plants. Hard objects like bones, shells, etc and slow degrading materials like the feather should be avoided in the plant. The input material should be well mixed with water in a 1:1 ratio for increased surface area and bacterial action. Each plant has a capacity and according to that the input volume should be controlled. If this is not practiced, excess input will result in excess outflow and loss of bacteria from the reactor.The final end product is slurry which can be used as a fertiliser.

7. **Incineration and Burial**: In cases where high-risk materials (e.g., diseased animals or contaminated products) are to be disposed of, incineration may be required. This ensures that any pathogens present in the waste are destroyed. Incineration helps to kill most of the microbes and the biggest advantage is that there is great mass reduction. The disadvantage of incineration is that it requires fuel to burn and results in production of odours and smoke. Similarly, burial in a sanitary landfill may be an option when no other disposal method is viable, but land for burial is not available in most areas.
8. **Products from ruminal contents**

   Bovine-blood-rumen-digesta-mixture' (BBRDM), an organic fertilizer prepared from recycled rural slaughterhouse wastes. Bovine blood and rumen digesta (3:1) are mixed and dried at 100−120 °C for 6−8 hours using a tray dryer to obtain BBRDM. It promoted healthy growth of plants and abundance of soil beneficial microbes

Conclusion

Slaughter waste management is a critical aspect of abattoir operations that cannot be overlooked. Properly managing waste not only ensures compliance with environmental and health regulations but also protects the quality of the meat produced and the safety of workers and consumers. By implementing effective waste management strategies, abattoir managers can mitigate the risks associated with biological waste, reduce the environmental impact of operations, and even find ways to repurpose by-products for commercial use.

As the industry continues to evolve, the integration of more sustainable waste management practices will be key to improving efficiency, reducing costs, and minimizing the ecological footprint of meat production.

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