MEAT BIOTECHNOLOGY

P.K. Chakraborty
Rajesh Kumar Samala

MEAT BIOTECHNOLOGY

MEAT BIOTECHNOLOGY

P.K. Chakraborty
Rajesh Kumar Samala

BLACK PRINTS
NEW DELHI

MEAT BIOTECHNOLOGY

P.K. Chakraborty, Rajesh Kumar Samala

This edition published by **BLACK PRINTS INDIA INC.**,
Murari Lal Street, Ansari Road, Daryaganj, New Delhi-110002

Edition: 2023 (Revised)

ISBN: 978-93-82036-39-5

BLACK PRINTS
Excellence in Academic Publishing

Editorial Office: 116-A, South Anarkali, Delhi-110051.
Ph.: 011-22415687

Sales & Marketing: 4378/4-B, Murari Lal Street, Ansari Road, Daryaganj, New Delhi-110002.
Ph.: +91-11-23281685, 41043100 Fax: +91-11-23270680

Production: A 2/21, Site-IV, Sahibabad Industrial Area Ghaziabad, U.P. (NCR)
e-mail: blackprintsindia@gmail.com

CONTENTS

CHAPTER 1

BIOCHEMISTRY OF MEAT: STRUCTURE, FUNCTION, AND POSTMORTEM CHANGES

Rajesh Kumar Samala, Assistant Professor
Department of ISME, ATLAS SkillTech University, Mumbai, Maharashtra, India
Email Id- rajesh.samala@atlasuniversity.edu.in

ABSTRACT:

This in-depth investigation digs into the complex world of muscle cells, illuminating their extraordinary composition, wide range of uses, and significant postmortem alterations. Highly structured and multifunctional muscle cells are essential for promoting movement, preserving balance, and assisting in a number of physiological functions including blood circulation and temperature control. We demonstrate how muscle cells display unmatched flexibility and durability, from hard exercise to the immediate postmortem period, with a focus on cellular metabolism and energy supply. Water, proteins, lipids, and carbohydrates make up the majority of a muscle cell's composition, which is a dynamic landscape affected by age, diet, and muscle type. Myofibrillar proteins, in particular, predominate in muscle composition and play a key role in contractile function. Lipids, particularly triglycerides and phospholipids, support membrane integrity and energy storage whereas carbohydrates, particularly glycogen, act as a vital energy reserve. Additionally, these cells depend on nitrogenous substances other than proteins including creatine, nucleotides, and amino acids. We reveal the intricate details of the epimysium, perimysium, and endomysium sheaths that enclose muscle bundles by examining muscle anatomy. The importance of structural changes in muscle cells is highlighted by the variety of the muscle, which is seen in both size and cell count. The myofibrils, which have a striated appearance, are the molecular motor that drives physical contraction in muscle cells.

KEYWORDS:

Muscle Cells, Molecular, Metabolism, Proteins, Postmortem.

INTRODUCTION

Muscle cells conduct a wide range of mechanical tasks and are among the best structured cells in the animal body. They are necessary for locomotion, limb movement, and other coarse motions in addition to performing finer functions including maintaining balance and coordination.

The circulation of blood and lymph, as well as the regulation of body temperature, are just a few of the various tasks that muscles do.

The metabolism of the cell and the cell's capacity to store energy are necessary for each of these tasks. Few cells must produce as much force and endure as pronounced changes in metabolic rate as muscle cells. Living skeletal muscle's capacity for relatively big intracellular changes affects how it reacts to the dramatic changes that take place in the first few hours after exsanguination. In order to operate and to maintain the integrity of the muscle both during contraction and in the early postmortem period, the organization, structure, and metabolism of the muscle are essential. These postmortem modifications will ultimately affect whether meat is suitable for further processing[1], [2].

Muscle Structure

Water makes up the majority of muscle. The usual amount of water in live tissue is 75% of the muscle's weight, although this may vary, especially in postmortem muscle, where it can range from 65 to 80%. It is the main extracellular fluid constituent within the muscle. Water is the main component of sarcoplasmic fluid within the muscle cell. It aids in numerous cellular activities, including the control of body temperature, and it transports nutrients between and between cells as well as between the vascular system and the muscle. Protein is the second-largest component of muscle. Though the percentage may vary from 16 to 22%, the average weight of a muscle is 18.5% protein. Proteins are the main solid component of muscle and have a variety of uses. The roles that proteins play is quite diverse. Muscle cells play the function of extremely insoluble stromal proteins, which are crucial in maintaining the structure and organization of the muscle. They play a crucial role in the contractile process as well. These proteins are known as myofibrillar proteins because they are principally connected to the contractile organelles, the myofibril. In general, the myofibrillar proteins can be dissolved at greater ionic strengths but not at the low ionic strengths present in skeletal muscle. Both the proteins directly engaged in movement and the proteins that control how contractile proteins interact with regulatory proteins are members of this class of proteins.

Due to a variety of circumstances, including animal age, nutritional status, and muscle type, the lipid content of the muscle may vary significantly. It's vital to remember that the relationship between the lipid and water contents is inverse. While some lipid is kept within each individual muscle cell, the majority of lipid in a muscle is located between groups of muscle cells called muscular bundles. Skeletal muscle has an average lipid concentration of 3% of its weight, however the range may be as wide as 1-13%. Lipid functions in skeletal muscle in a number of ways, including energy storage, membrane structure, immunological responses, and cellular recognition pathways. Triglycerides and phospholipids are the two main lipid types present in skeletal muscle. Triglycerides make up the majority of the lipid found in muscle. Triglycerides triacylglycerides are made up of a glycerol molecule with three fatty acids esterifying the hydroxyl groups. The chain length and level of saturation of the fatty acids affect the melting point and iodine number of the lipid that is linked to the muscle. In addition to phospholipids, phosphoglycerides are a form of complex lipid that is present in muscle. One of the glycerol's hydroxyl groups is esterified to a phosphate group in this family of lipids, which also contains fatty acids among its other ingredients. Typically, unsaturated fatty acids are found in phospholipids. In skeletal muscle, phospholipids are often found in membranes. The fluidity of the cell membranes is partly due to the relatively high degree of unsaturation of the fatty acids linked to the phospholipids. About 1% of the total weight of muscle is made up of carbohydrates, which is a very modest portion of muscle tissue. Glycogen is the carbohydrate that accounts for the highest proportion. Glucose, glycogen metabolic intermediates, and various mono- and disaccharides are examples of additional carbohydrates. Additionally, present in muscle and connected to the connective tissue, glycosoaminoglycans. Skeletal muscle contains a large number of nitrogenous non-protein molecules. They include compounds such as nucleotides, free amino acids, peptides, creatine and creatine phosphate, as well as other non-protein molecules[3], [4].

Muscle Organization

Skeletal muscle is very intricately organized, in part so that force applied to the myofibrils may be effectively transferred to the whole muscle and then to the limb or structure being moved. The epimysium, a rather thick covering of connective tissue, covers the whole muscle. The epimysium is continuous in the majority of muscles, and tendons connect muscles to bones. Muscle cells are grouped or split into bundles in the muscle. These bundles, often referred to as fasciculi, are encased in the perimysium, another connective tissue sheath. The endomysium, a narrow band of connective tissue, encircles the muscle cells themselves. The endomysium, which is located atop the muscle cell membrane sarcolemma, is made up of a layer of tiny collagen fibres that are embedded in a matrix and a basement membrane that is connected to an outside layer called the reticular layer[5], [6].

Skeletal muscles have a wide range of functions, which contributes to their great degree of variety. Not only at the broad level, but also at the level of the individual muscle cells, variation is prevalent. First, the number of cells in muscles might change in addition to their size. For instance, the medial gastrocnemius, which is used by humans to walk, contains over a million muscle cells, yet the muscle that controls the tension of the eardrum, the tensor tympani, has just a few hundred. The shape of the muscle cells itself has a significant impact on the functioning of both live muscle and meat, in addition to the quantity of cells' impact on muscle function and, ultimately, meat quality. Muscle cells are striated, which means that unique banding patterns or striations may be seen when seen under a polarized light microscope. Myofibrils, specialized organelles present in muscle cells, are to blame for this look. Since various locations have various refractive characteristics, the myofibrils seem striated or banded. The isotropic index of refraction of the light bands is constant. Skeletal muscle cells include many myofibrils, which account for between 80 and 90% of the total volume of the cell. Muscle extraction from myofibrillar proteins requires an ionic strength larger than 0.3 because they are comparatively insoluble at physiological ionic strength. They are often referred to as "salt-soluble" proteins as a result. About 50–60% of the total extractable muscle proteins are myofibrillar proteins. They account for around 10-12% of the total weight of new skeletal muscle on a whole muscle basis.

DISCUSSION

The contractile "machinery" of the cell, myofibrils are very well structured, much like the cells in which they are found. One of the first things that can be seen while looking at a myofibril is that the cylindrical organelle is made up of repeated units. Sarcomeres are the name for these recurring structures. Each sarcomere has all the structural components required to carry out the molecular action of contraction. According to the most recent proteomic research, the sarcomere structure is made up of about 65 proteins. This number is surprisingly high considering that the sarcomere is the most fundamental component of the cell and that the analysis's figure did not account for the many protein isoforms. Many of the interactions between proteins are highly coordinated, and some of them are just recently been identified.

The head region of myosin mediates the interaction between the thick and thin filaments necessary for contraction. Actomyosin is a common name for the complex that myosin and actin interact to generate. Actomyosin seems very much like cross-bridges between the thick and thin filaments in electron micrograph pictures of contracted muscle or of postrigor muscle; in fact, it is sometimes referred to as such. These connections, sometimes called as rigour bonds since they are the origin of the stiffness that develops in postmortem muscle, are irreversible in postmortem muscle. Myosin's globular head is also an enzyme that has the ability to hydrolyze ATP and release energy. When a live muscle contracts, myosin's ATPase activity gives it the energy to swivel and eventually draw the thin filaments into the centre of the sarcomere. By shortening the myofibril, the muscle cell, and ultimately the muscle, this causes contraction. When an additional molecule of ATP is attached to the myosin head, the myosin and actin might separate. In postrigor muscle, the ATP supply is exhausted, which causes the actomyosin bonds to effectively become permanent[7], [8].

Body Metabolic Rate

From a metabolic perspective, the breadth and reactivity of energy consumption and output in skeletal muscle is nothing short of astounding. Muscle may use as much as 90% of the body's oxygen in an animal that is vigorously exercising. This may indicate a 200% rise in the muscle's metabolic rate from its resting condition. The generation of adenosine triphosphate, the cell's primary source of energy, is essential for the life of the muscle cell. Adenosine, an adenine ring, a ribose sugar, and triphosphate, which is made up of three phosphate groups, make up ATP. Many cellular processes, such as muscular contraction and the regulation of the concentrations of important ions in the muscle cell, need energy, which is provided by the cleavage of bonds between the phosphates and the remainder of the molecule. Adenosine diphosphate is created when Pi from ATP is broken down, while adenosine monophosphate is created when Pyorphosphate from ATP is broken down. Since the availability of ATP is essential to a cell's capacity to survive, the cell makes a highly coordinated attempt to maintain its synthesis in both live tissue and in the first few hours after a death.

There must be enough ATP present in the muscle for it to function. Since ATP is so important, muscle cells have evolved a variety of ATP production and regeneration mechanisms. Glycogen, lipids, and phosphagens are examples of energy precursors that are stored in muscle cells. Muscle may also draw energy from the blood stream. Depending on the activity the muscle is doing, the muscle cell will use one or more of these reserves. When the action is less intense, the muscle will use a greater percentage of lipids stored in the muscle cell and blood as energy sources. These will undergo aerobic route metabolism to create ATP. It should go without saying that this procedure needs a lot of oxygen. The muscle consumes intracellular reserves of phosphagens or glycogen during high intensity exercise, during which ATP is utilized extremely quickly. But since these two resources are used up so fast, exhaustion results from their depletion. This is not a minor issue. The concentration of ATP in skeletal muscle is crucial; relaxation cannot take place if available ATP falls below around 30% of the resting reserves. This is due to the fact that ATP is required for the relaxation of contraction, which is crucial given that calcium removal from the sarcoplasm also requires ATP.

The most effective energy mechanism, aerobic metabolism, needs oxygen to function. Myoglobin, an oxygen transporter, and the blood supply to the muscle provide this oxygen. Myoglobin is thought to be about 50% saturated in active muscle, according to estimates. Extreme hypoxia, such as that observed in postmortem muscle, depletes oxygen supplies because blood flow is insufficient or nonexistent, and if this situation persists for a long enough period of time, myoglobin oxygen stores are exhausted. The oxidative phosphorylation of glycogen or other substrates to produce water and carbon dioxide is a highly effective technique for the cell to recover ATP prior to exsanguination. However, after exsanguination, the muscle cell can only use anaerobic pathways to produce energy.

When there is little demand for ATP, this process is easily reversible, and phosphocreatine stocks may be quickly replenished. This mechanism may be helpful in live muscle during periods of intensive exercise since it uses H+ and lessens the acidosis that is brought on by anaerobic glycolysis in the muscle cells. The catalytic enzyme's proximity to the actomyosin ATPase, the sarcoplasmic reticulum, and the sarcolemma is another benefit of the system. However, since the resources run out quite quickly, this mechanism does not significantly contribute to postmortem metabolism. In general, glycogen is the preferred substrate for the oxidative phosphorylation or anaerobic glycolysis processes that produce ATP. The decision of whether or not the intermediate of the process, pyruvate, reaches the mitochondria to be entirely broken down to CO_2 and H_2O, or whether it ends up in lactate through the anaerobic glycolysis route, determines one of the crucial phases in the destiny of glycogen. The anaerobic route is substantially better at making ATP at a greater rate, although being somewhat less efficient (3 mol of ATP per mole of glucose-1-P produced from glycogen or 2 mol if the original substrate is glucose). Since oxygen supplies are quickly reduced, it is evident that early postmortem muscle follows the anaerobic route. This causes a buildup of the final product, lactate lactic acid, which lowers pH.

Significant Muscle Changes Following Death

Tenderization

It is common knowledge that meat becomes softer when kept in the refrigerator. It is generally agreed upon that the product becomes more tender as a result of proteolytic alterations happening in the myofibril's and its related proteins' structural makeup. Several important proteins are broken down during post-mortem aging. Anaerobic glycolysis serves as the main source of ATP synthesis throughout the process of converting muscle to meat. As a consequence, the tissue begins to accumulate lactic acid, which lowers the pH of the meat. The net charge of a protein is zero after the pH reaches the isoelectric point of the main proteins, particularly myosin, which means that the proportion of positive and negative charges on the proteins is about equal. The quantity of water that the protein can attract and hold is reduced as a consequence of the attraction between these positive and negative groups inside the protein. Additionally, it is believed that a significant portion of the decrease in myofibrillar lattice spacing is caused by the fact that similar charges repel one another when the net charge of the proteins that make up the myofibril approaches zero.

The muscle cell is mostly made up of myofibrils. Up to 80–90% of the volume of a muscle cell is made up of these organelles. As was previously noted, the myofibril is where most of the water in live muscle cells is found. In fact, the myofibrils are thought to hold up to 85% of the water in a muscle cell. The capillary forces created by the arrangement of the thick and thin filaments inside the myofibril hold a large portion of the water in place. Sarcomeres in live muscle have been shown to maintain their isovolumetric shape during contraction and relaxation. This would suggest that the quantity of water inside the fibrous structure of the cell would not necessarily vary in live muscle. However, when muscle goes through rigor, variations in volume might have an impact on where this water is located. The lateral shrinking of the myofibrils is presumably what causes the reduction in muscle cell width that occurs with the development of rigor. Sarcomeres may also shorten when rigor develops, which decreases the amount of room that the myofibril has for water. of fact, studies have shown that drip loss may rise linearly as sarco-mere lengths of muscle cells decrease. The link between muscle cell structure and water distribution has lately been better understood using very sensitive low-field nuclear magnetic resonance investigations. According to this research, the I-band of the myofibril has a larger percentage of water than the A-band, which is more protein-dense. This finding could provide light on why shorter sarcomeres are often linked to higher drip losses. The shortening of the sarcomere would result in a decrease in the volume of the I-band area in the myofibril as it shortens and rigor sets in. Water might be expelled from the myofibrillar structure and enter the extramyofibrillar gaps inside the muscle cell as a result of volume loss in this myofibrillar area and pH-induced lateral myofibril shrinkage. In fact, this hypothesis is supported by recent NMR research. Therefore, it is believed that a significant factor in supplying a source of drip may be the slow mobilization of water from the intramyofibrillar spaces to the extramyofibrillar spaces[9], [10].

The quantity of water in the myofibril is influenced by all of the aforementioned mechanisms. It is important to highlight that the migration of fluid to the extracellular space and eventually out of the muscle cannot be solely attributed to shrinking of the myofibrillar lattice. Through proteinacious linkages, the myofibrils are connected to the cell membrane and to one another. If these connections are still there in postmortem muscle, the muscle cell would experience the myofibril diameter decrease. Myofibril constriction may result in the contraction of the whole muscle cell, opening up channels between individual cells and cell bundles to allow the substance to trickle out. Up to 24 hours postmortem, extracellular space surrounding muscle fibres continues to expand, while gaps between muscle fibre bundles actually somewhat narrow between nine- and 24-hours postmortem, perhaps as a result of fluid outflow from these main channels. These links between neighbouring myofibrils and between myofibrils and the cell membrane are composed of a number of proteins linked to costameres, intermediate filament structures. The structural scaffolding that holds the myofibrils to the sarcolemma is provided by costameres. Therefore, when the volume of the cell is reduced overall, the rigour process may cause the mobilization of water not only from the myofibril but also from the extramyofibril regions. In reality, postmortem muscle has shown a decrease in the diameter of muscle cells. The extracellular space finally becomes a collection point for the water that is discharged from the myofibril and ultimately the muscle cell. Gaps form between muscle bundles and between muscle cells during the postrigor phase, according to a number of studies. The principal conduits through which purge is permitted to drain from the flesh are these spaces between muscle bundles; some investigators have even referred to them as "drip channels."

Postmortem Muscle Changes That Affect Quality

Numerous changes take place as muscle is transformed into meat, including a gradual depletion of available energy, a switch from aerobic to anaerobic metabolism that favours the production of lactic acid, causing the tissue's pH to drop from nearly neutral to 5.4–5.8, an increase in ionic strength, partly due to the failure of ATP-dependent calcium, sodium, and potassium pumps, and a growing inability of the cell to maintain reducing conditions. Numerous proteins in the muscle cell may be significantly impacted by all of these changes. This chapter and subsequent reviews have discussed the effects of energy depletion and pH changes. The effects of further modifications to muscle proteins, such as oxidation and nitration, have not been as well examined.

Oxidation of proteins

Myofibrillar and sarcoplasmic protein oxidation is accelerated in postmortem muscle throughout the aging of whole muscle products. Histidine and other amino acid residues are converted to carbonyl derivatives as a consequence, which may lead to the production of intra- and/or inter-protein disulfide cross-links. Both of these modifications reduce the functioning of proteins in postmortem muscle in general. Living muscle's redox state may alter the glycolytic pathway's enzymes, which in turn can have an impact on how carbohydrates are metabolized. Oxidizing substances may potentially affect how glucose is transported. When a muscle is working out, hydrogen peroxide may imitate insulin and stimulate glucose transfer. Since H_2O_2 levels rise following exercise, oxidation systems may be involved in skeletal muscle signalling. Future studies should focus on how alterations in ante- and perimortem glucose metabolism may affect postmortem muscle metabolism since they have the ability to do so.

Inhibition of excitation-contraction coupling, increased glucose absorption, reduced mitochondrial respiration, and decreased force output are skeletal muscle functions that may be impacted by increased NO production. It seems that the drop in force is caused by NO's inhibitory influence on actomyosin ATPase activity, which results in reduced cross-bridge cycling. The ryanodine receptor's s-nitrosylation may also influence how contraction is modulated. This protein is in charge of causing the sarcoplasmic reticulum to release calcium into the sarcoplasm. The activity of the ryanodine receptor will rise if a cysteine is S-nitrosylated. This result may be reversed. It seems sense that these molecules might be crucial in the transformation of muscle to meat because muscle already has all the substances required to create these intermediates. It is obvious that the fresh meat's quality and appropriateness as a raw material for subsequent processing depends greatly on the composition, structure, and metabolic characteristics of skeletal muscle. The consistency and quality of fresh meat will be improved by continuing to pay attention to the variables that control changes in early postmortem muscle. As a result, the consistency of the quality of subsequent processed goods will be enhanced.

CONCLUSION

These cells are remarkable biological wonders that are essential for animal movement, equilibrium, and general health. Muscle cells represent the dynamic character of living creatures since they can adapt to a variety of metabolic needs and withstand considerable alterations after death.As we dug further, we looked at the complex arrangement of muscle cells, which are encased in protective sheaths and have a variety of structural properties. The epicentres of contractile activity and home to an extensive network of over 65 proteins are the myofibrils, which are characterized by their striated appearance and sarcomeric units. Muscle cells are metabolic powerhouses with the ability to withstand significant oxygen consumption during exercise. Their versatility enables the use of various energy sources, guaranteeing optimum performance under various circumstances. Further evidence of the amazing durability of muscle cells is provided by the shift into the postmortem phase, which is characterized by pH alterations, lattice shrinking, and energy depletion. As a result, learning more about muscle cells helps us better understand animal physiology and may help with quality assurance and meat processing. These cells, which are essential to the creation of meat products, continue to enthrall scientists and spur developments in the area. Discovering the secrets of muscle cells' adaptation and resilience as we traverse the intricate world of muscle cells paves the door for advancements in the meat industry and beyond.

REFERENCES:

[1] G. Feiner, "Biochemistry of Meat," in *Salami*, 2016. doi: 10.1016/b978-0-12-809598-0.00002-0.

[2] K. Moore, B. Mullan, J. C. Kim, and F. Dunshea, "The effect of Lupinus albus and calcium chloride on growth performance, body composition, plasma biochemistry and meat quality of male pigs immunized against gonadotrophin releasing factor," *Animals*, 2016, doi: 10.3390/ani6120078.

[3] T. Sweeney *et al.*, "The application of transcriptomic data in the authentication of beef derived from contrasting production systems," *BMC Genomics*, 2016, doi: 10.1186/s12864-016-2851-7.

[4] C. Castillo, A. Abuelo, and J. Hernández, "Usefulness of metabolic profiling in the assessment of the flock's health status and productive performance," *Small Rumin. Res.*, 2016, doi: 10.1016/j.smallrumres.2016.02.019.

[5] Z. Li, X. Li, Z. Wang, Q. W. Shen, and D. Zhang, “Antemortem stress regulates protein acetylation and glycolysis in postmortem muscle,” *Food Chem.*, 2016, doi: 10.1016/j.foodchem.2016.01.085.

[6] E. A. Mason, R. Lopez, and R. P. Mason, “Wavelength shifting of chemiluminescence using quantum dots to enhance tissue light penetration,” *Opt. Mater. Express*, 2016, doi: 10.1364/ome.6.001384.

[7] S. S. Yurievich *et al.*, “Influence of the immunostimulator «Treatment-and-prophylactic immunoglobulin» on the veterinary and sanitary assessment of meat and the histologic picture of parenchymatous bodies of cattle,” *Res. J. Pharm. Biol. Chem. Sci.*, 2016.

[8] S. Zaitsev, “Dynamic surface tension measurements as general approach to the analysis of animal blood plasma and serum,” *Advances in Colloid and Interface Science*. 2016. doi: 10.1016/j.cis.2016.06.007.

[9] R. Osorio H., I. F. F. Tinoco, J. A. Osorio S., C. de F. Souza, D. J. de R. Coelho, and F. C. de Sousa, “Air quality in a poultry house with natural ventilation during phase chicks. / Calidad del aire en galpón avícola con ventilación natural durante la fase de pollitos.,” *Rev. Bras. Eng. Agrícola e Ambient.*, 2016.

[10] J. A. Carman, “Are GMOs safe to eat? Current, inadequate requirements for feeding studies and what happens when you exceed them,” in *Acta Horticulturae*, 2016. doi: 10.17660/ActaHortic.2016.1124.10.

CHAPTER 2

EXPLORING THE COMPLEX WORLD OF MUSCLE CELLS: STRUCTURE, FUNCTION, AND POSTMORTEM CHANGES

Puneet Tulsiyan, Associate Professor
Department of ISME, ATLAS SkillTech University, Mumbai, Maharashtra, India
Email Id-puneet.tulsiyan@atlasunveristy.edu.in

ABSTRACT:

This in-depth investigation digs into the complex world of muscle cells, illuminating their extraordinary composition, wide range of uses, and significant postmortem alterations. Highly structured and multifunctional muscle cells are essential for promoting movement, preserving balance, and assisting in a number of physiological functions including blood circulation and temperature control. We demonstrate how muscle cells display unmatched flexibility and durability, from hard exercise to the immediate postmortem period, with a focus on cellular metabolism and energy supply. Water, proteins, lipids, and carbohydrates make up the majority of a muscle cell's composition, which is a dynamic landscape affected by age, diet, and muscle type. Myofibrillar proteins, in particular, predominate in muscle composition and play a key role in contractile function. Lipids, particularly triglycerides and phospholipids, support membrane integrity and energy storage whereas carbohydrates, particularly glycogen, act as a vital energy reserve.

Additionally, these cells depend on nitrogenous substances other than proteins including creatine, nucleotides, and amino acids. Muscle cells are energy factories from a metabolic perspective. Muscles play a crucial part in the generation of ATP since they may use up to 90% of the body's oxygen while exercising.

Depending on their degree of activity, muscle cells may use a variety of energy sources, including as glycogen, lipids, and phosphagens. Anaerobic metabolism is used during high-intensity activities, such as postmortem circumstances, while aerobic metabolism is extremely efficient and oxygen-dependent. To operate and relax muscles, ATP levels must be kept above a certain threshold.

KEYWORDS:

Flexibility, Myofibrillar, Muscle Cells, Postmortem, Phospholipids.

INTRODUCTION

For the sake of this discussion, technological quality of meat for processing comprises all endogenous and exogenous elements that have an impact on meat quality in general. The breed of the animal and its related traits, gene status within the breed, food and nutritional plan, fatness/leanness, rate of postmortem pH and temperature fall, and postmortem handling, such as age, are all factors that affect the quality of the meat for processing. Consumer acceptability, which includes tenderness, juiciness, and flavour, as well as visual factors like colour, fat content, and the quantity of water that can be seen, are what ultimately determine meat quality since they significantly affect how satisfied consumers anticipate to be[1], [2]. Tenderness and flavour constancy are vital since these are the characteristics that define customer acceptability the most. Breed, intra-muscular fat content, calpastatin and calpain gene status, Halothane gene status, ryanodine receptor gene status, food, antemortem handling, and final pH are some of the factors that affect the sensory quality features of meat.

Effects of Breed on Meat Quality

Because a breed has evolved naturally to cope with challenging environmental circumstances or because two or more breeds have been purposely crossed to promote the predominance of desired traits, the breed of livestock may have an impact on the qualitative characteristics of the meat produced. These changes often enhance one set of characteristics at the price of another. Because of their endurance for unfavourable environmental circumstances, Brahman cattle, for instance, are widely employed in the southwest of the United States; yet, Brahman carcasses have softness difficulties. High levels of calpastatin in the muscle have been linked to the toughness of meat from Brahman cattle. Meat from the Japanese Wagyu breed is delicate and richly marbled. Meat is more soft right after slaughter when Brahman and Wagyu cattle are crossed to create Waguli animals, which have a high level of marbling and low cal-pastatin activity in the tissue. With enough age, the flesh from Brahman cattle becomes more tender. According to Schone et al., meat from Simmental and Holstein cattle had differing initial tendernesses and aging processes. After seven days of maturing, some breed distinctions in the first postmortem softness of beef are eliminated. According to Hocquette et al., the properties of the connective tissue, intramuscular fat level and composition, and/or the characteristics of the muscle fibres are what distinguish calves of various breeds or genotypes of the same breed. Cattle that have myostatin gene mutations have larger muscles due to muscular hypertrophy. This mutation, however, favours the metabolism of glycolytic muscle fibres and reduces the amounts of collagen and intramuscular fat, favouring discomfort[3], [4].

Effects of Diet on Meat Quality

Meat quality may be influenced by diet either directly or indirectly. Meat may take on unfavourableflavours if fish wastes, raw soybeans, canola oil, and flour are fed. Due to pigs' limited ability to biohydrogenate unsaturated fats, which causes them to be deposited in tissues in a similar state to how they were ingested, pork fat is more likely than beef fat to be impacted by changes in the dietary fat supply. Feeding pigs, a lot of PUFA reduces the saturation of the carcass fat and lowers the quality of the meat. Carcass fat is soft and greasy because of unsaturated fatty acids. Furthermore, carcass fat with a greater PUFA percentage is more prone to oxidation during storage than fat with a higher saturated fat level.

The ratio of cattle carcasses' fat, muscle, and bone might change according to diet. In contrast to low-energy forage and grass diets, grain feeding often results in an increase in carcass weight and intramuscular fat content as well as more intense flavour in red meat. The concentration of phospholipids increases with the length of time the animal spends on the feedlot. Cattle finishing on a feedlot have a different fatty acid profile than cattle fed on grass. Compared to meat from concentrate-fed cattle, forage-fed beef has a higher concentration of linolenic acid and lower concentrations of oleic and linoleic acids. Diter-penoids and lactone concentrations have been demonstrated to change in millet and grain pasture rotation systems that are intense. Diterpenoids have a positive correlation with gamey/stale off-flavor whereas lactones have a negative correlation with roasted beef flavour. Flavour variations may be caused by variations in oleic, linoleic, and linolenic acids, diterpenoids, and lactones. Increasing the calorie intake of cattle diets by adding restaurant grease boosted the initial softness while having no impact on drip or cook loss, maintained tenderness, juiciness, or beef flavour.

DISCUSSION

Antioxidant feeding has drawn a lot of attention in terms of preserving post-harvest meat quality. Vitamin E is found near phospholipids in the cell membrane. It may stop the anteand postmortem production of free radicals in membranes. According to Garber et al., taking vitamin E supplements led to an increase in muscle alpha-tocopherol levels and a dose-dependent delay in the production of metmyoglobin and lipid oxidation. In contrast to artificial sources, Boler et al. discovered that feeding natural sources of vitamin E to finishing pigs was more successful in lowering the lipid oxidation of pork during subsequent storage and display. Alpha-tocopherol was discovered to be present in equal amounts in the flesh of pasture-fed and grain-fed cattle, according to research by Yang et al. It was less susceptible to lipid oxidation and the development of warmed-over flavour because it had a larger proportion of linolenic acid and a lower proportion of linoleic acid. The colour of the meat that results may also be influenced by diet. It has been shown that adding vitamin E to swine diets may stabilize meat colour and reduce fluid loss. Using steroid-like medications is another way to change the bone, muscle, and fat ratio in the carcass. Feedlot performance and/or carcass traits may be significantly impacted by the administration of beta-agonists[5], [6].

Effects of Marbling on Meat Quality

Depending on the species, breed, age, and other variables, a high nutrition level, particularly during the finishing phase, might increase intramuscular fat to a larger or lesser extent. Meat quality indicators have included fatness and marbling linked to high levels of nutrients. Because fat affects flavour and softness, highly marbled meat has historically been considered excellent. However, Rincker et al. found that less than 15% of the variation in pork flavour ratings could be attributed to intramuscular fat. Before the fat percentage reached 4.5%, consumers could not detect any variation in the flavour ratings of the pork. Additionally, customers choose leaner goods and apparent fat level in pork is a key factor in determining buy intent. According to Fernandez et al., pork texture and flavour are improved at intramuscular fat levels up to 3.25%, however mixed results were shown in terms of tenderness/toughness.

pH Decline after Death

Tenderness and flavour are significantly impacted by postmortem metabolic alterations. After harvest, the tissues must switch to anaerobic metabolism due to the loss of circulatory competence, which causes a buildup of metabolic waste products, including lactic acid, in the muscle. The pH drops from around 6.8 to 5.7. Near pH 5.4, endogenous thiol proteinases start to function. During aging, they are distributed differently. The activity of proteolytic enzymes is temperature-dependent; some continue to function at high levels even at boiling temperatures. The ryanodine receptor gene is defective in pigs, which causes an excessive pH decrease and unusually acidic conditions in the flesh. These circumstances impact the meat's water-holding capacity, softness, and colour.The ability of meat to retain its own or additional water when pressure is applied is known as its water-holding capacity. Muscle tissue mostly consists of water. Most of it may be found between layers of materials made of cells and in layers surrounding polar molecules. The majority is found in the salt-solu-ble proteins of muscle tissue's intermolecular gaps, which vary based on numerous intrinsic and extrinsic circumstances. Numerous factors, most notably the myofilaments, are responsible for limiting its range of motion[7], [8].

Tissues use anaerobic pathways to break down glycogen during the first several hours after death, which lowers pH. Although reducing equivalents are quickly used up, ATP is not replenished. The sarcomere shortens, the fibres constrict, and rigour develops without the plasticizing impact of ATP, which causes actin and myosin to cross-link. Muscle cells contract both longitudinally and laterally throughout the rigour process, often over the course of 24 hours. During the postmortem period, WHC declines. When the pH reaches 5.9, beef develops rigour mortis. Tenderness, WHC, and colour are influenced by factors that influence the pace of pH drop, such as the halothane gene status of pigs and lingering glycogen in the tissues. These properties are also influenced by elements that modify the final pH, ryanodine gene status, and stress-related changes in the amount of muscle glycogen.

Meaty Taste

The fundamental tastes of sweet, sour, bitter, salt, and umamiwhich are generated from water-soluble compoundsalong with a range of odours from elements found in raw meatcombine to form flavour. Alcohols, aldehydes, aromatic compounds, esters, ethers, furans, hydrocarbons, ketones, lactones, pyrazines, pyridines, pyrroles, and sulphides are some examples of flavour- and odor-active volatiles. the connection between those volatiles that are more often used and their corresponding flavours. Many of these flavour components come from the lipids found in muscle tissue at the time of slaughter, including the structural phospholipids, intramyocellular lipids, intramuscular lipids, and intramuscular fat. These lipids are made up of fatty acids, some of which may be methyl-branched, unsaturated, or both. They may be created as a consequence of the biohydrogenation of dietary lipids, straight from the food, or by endogenous synthesis. Increased marbling has historically been thought to have a fairly significant effect on the final flavour of the meat product because it increases the amount of fat available for the synthesis of flavour compounds.

Factors Affecting Texture/Tenderness

Consumers often consider softness to be the key element in determining the meat's suitability for consumption. All of the kinesthetic mouth feels qualities, including those felt before, during, and after mastication, are represented by tenderness. Mechanical, partial, and chemical components all contribute to tenderness. Myofibrillar, connective tissue, and compositional elements have the smallest impact on meat softness. The connective tissue component may be impacted by animal age, level of activity, mechanical tenderization, and composition, whereas the myofibrillar component can be impacted by cold shortening and proteolytic degradation. Due to the nature of the raw material, muscle meals come with a unique set of textural features. Fibres, fluid/fat exudation, and connective tissue are some of them. Both the qualities of the raw materials and exogenously generated changes to the material have an impact on the textural metrics of interest.

Effects of Aging on Tenderness

The majority of the variance in tenderness is caused by proteolytic degradation, muscle, and connective tissue proteins. The proteolytic degradation of structural and myofibrillar proteins affects tenderness to some extent. Animals and muscles within an animal exhibit significant diversity in aging-induced improvement; this may be related to initial discomfort. High growth rate, which necessitates high levels of nutrients, is a significant contributor to this difference. Rapid protein turnover during development promotes proteolytic activity, which speeds up aging. Because proteolytic cathepsins break down certain structural proteins, allowing the sarcomere to relax, increasing proteolytic activity accelerates aging. This enables water that was previously ejected during rigour to enter. The differential in protein content between the intracellular and extracellular compartments of the muscle cell may be what's causing this influx.

Different animals within a breed and different muscles within an animal age more tenderly. It relies on a number of variables that might potentially be connected to the initial sensitivity. According to Wicklund et al., strip steaks needed to age for 14 days before their softness changed. According to Novakofski and Brewer, there was no difference between the shear value beginning point and the mean improvement in shear with age throughout the course of the first week. According to research by Rentfrow et al., beef from one- and two-year-old heifers aged for at least seven days before it reached its peak softness and Warner Bratzler shear values. The soreness increased after up to 14 days of aging[9], [10].

Effects of Aging on Flavour

It's uncertain how age affects flavour. It may change the chemical composition of the precursors of fragrance and flavour, which ultimately influences the properties of the finished product. Aging may increase the amount of carbonyls produced by lipid oxidation, which can enhance metallic flavour, reduce flavour identity, and cause off flavours. Additionally, it may intensify fatty tastes and undesirable qualities like painty, cardboard, bitter, and sour. Positive flavourings that age well include 3-hydroxy-2-butanone, 2-pentyl furan, 2,3-octanedione, and 1-octene3-ol, whereas flavourings that age poorly include pentanal, nonanal, and butanoic acid. A beef's umami flavour may alter as it ages. The amount of glutamic acid more than doubles in the first seven days of age. It is necessary to balance the possible development of off flavours with the potential advantages of aging for certain muscles in terms of flavour development and tenderization.

CONCLUSION

We have travelled through the astounding complexity of muscle cells' intricate geography, from their remarkable construction to their fascinating postmortem alterations. These cells, which are essential for animal movement, equilibrium, and general health, are truly biological wonders. Muscle cells are a prime example of the dynamic character of live organisms because of their capacity to adapt to various metabolic demands and withstand considerable alterations in the postmortem period.As we've learned, the cornerstone of muscle cells' activity is their chemical make-up, which is mostly composed of water, proteins, lipids, and carbohydrates. Muscle contractions are fueled by proteins, notably myofibrillar proteins, whereas lipids and carbohydrates are necessary for energy storage and structural stability. The intricacy of these cells is shown by the presence of several nitrogenous non-protein molecules. Further investigation revealed the complex arrangement of muscle cells, which are covered in protective sheaths and have a variety of structural characteristics. The epicentres of contractile activity are the myofibrils, which have a striated appearance and sarcomeric units and are made up of a complex network of approximately 65 proteins.Muscle cells are metabolic powerhouses that can withstand high oxygen consumption levels when exercising. Because of their versatility, they may use a variety of energy sources to ensure optimum performance in a variety of environments. The transformation from the premortem to the postmortem phase, characterized by pH changes, lattice shrinking, and energy depletion, further exemplifies the amazing resilience of muscle cells. In conclusion, research into muscle cells helps us better understand animal physiology and provides information for quality assurance and meat processing. Researchers are still fascinated by these cells, which are essential to the creation of meat products, and this fascination is what is advancing the discipline. The secrets of muscle cells' flexibility and tenacity are revealed as we negotiate the complicated world of muscle cells, opening the way for advancements in the meat industry and other fields.

REFERENCES:

[1] M. Van Onna and A. Boonen, “The challenging interplay between rheumatoid arthritis, ageing and comorbidities,” *BMC Musculoskelet. Disord.*, 2016, doi: 10.1186/s12891-016-1038-3.

[2] Y. Chen and H. Yang, “Numerical simulation and pattern characterization of nonlinear spatiotemporal dynamics on fractal surfaces for the whole-heart modeling applications,” *Eur. Phys. J. B*, 2016, doi: 10.1140/epjb/e2016-60960-6.

[3] W. A. Shihata, D. L. Michell, K. L. Andrews, and J. P. F. Chin-Dusting, “Caveolae: A role in endothelial inflammation and mechanotransduction?,” *Front. Physiol.*, 2016, doi: 10.3389/fphys.2016.00628.

[4] B. R.G., C. E.M., D. P.H., and M. A., “Adolescent idiopathic scoliosis: Embryonic origin of cascade concept of AIS pathogenesis,” *Clin. Anat.*, 2016.

[5] Badan Pengawas Obat dan Makanan Republik Indonesia, “Peraturan Kepala Badan Pengawas Obat dan Makanan Republik Indonesia Nomor 13 Tahun 2016 Tentang Pengawasan Klaim Pada Label dan Iklan Pangan Olahan,” *Badan Pengawas Obat dan Makanan Republik Indonesia*. 2016.

[6] Adinda, “pengertian transportasi online,” *Proc. Natl. Acad. Sci.*, 2016.

[7] M. C. Schwab, KlaKennedy *et al.*, “La quarta rivoluzione industriale,” *Neuroscience*, 2016.

[8] Badan Pengawas Obat dan Makanan Republik Indonesia, “Pengawasan Klaim pada Label dan Iklan Pangan Olahan,” 2016.

[9] L. M. Bartoshuk *et al.*, “Food cravings in pregnancy: Preliminary evidence for a role in excess gestational weight gain,” *Appetite*, 2016.

[10] Vincentia Poppy Indraswari, “Pengaruh Teknologi Informasi, Pemanfaatan Teknologi Informasi, Keahlian Karyawan dan Pengendalian Internal Terhadap Kualitas Laporan Keuangan Hotel di Slatiga,” *Front. Neurosci.*, 2016.

CHAPTER 3

ENHANCING MEAT SAFETY: STRATEGIES FOR REDUCING PATHOGEN CONTAMINATION IN FOOD ANIMALS AND MEAT PROCESSING

Suresh Kawitkar, Professor
Department of ISME, ATLAS SkillTech University, Mumbai, Maharashtra, India
Email Id- suresh.kawitkar@atlasuniversity.edu.in

ABSTRACT:

Given the possible health concerns provided by pathogen-contaminated meat products and the significant financial losses connected with foodborne diseases, meat safety is a crucial problem in the food business. The measures used to reduce pathogen contamination in food animals and throughout the meat processing chain are thoroughly discussed in this study.The study examines a variety of interventions, including heat-based approaches like hot water and steam pasteurization, spot-carcass treatments, and physical cleaning strategies like animal washing. Additionally, the effectiveness of chemical decontamination techniques, notably lactic acid spray rinses, is investigated in order to lower microbial contamination. Additionally, the synergistic benefits of combining various treatments are explored, emphasizing the need of a multi-pronged strategy for meat safety. The need of maintaining cleanliness and hygiene standards throughout the whole meat processing process is emphasized in the study. Additionally, taken into consideration as prospective strategies to further improve meat safety are cutting-edge technology like irradiation and active packaging. This study emphasizes the significance of continuous initiatives to enhance meat safety by a mix of physical, chemical, and technological interventions, with an emphasis on preserving consumer health and minimizing monetary losses brought on by foodborne diseases.

KEYWORDS:

Environment, Microorganisms, Meat Safety, Lactic Acid,Pathogens.

INTRODUCTION

Food animals that are carriers of harmful microbes or are diseased are causes of spoiling. Animals, specifically, carry bacteria on their exterior surfaces, including the digestive system, which contaminate the environment, food, and water, creating a full cycle. External animal surfaces, along with their feces and the environment, can act as sources of contamination for a variety of things, including: carcasses during the slaughtering, dressing, chilling, and cutting processes; meat products during the processing, storage, and handling processes; water and other foods through contaminated manure or direct transfer and infection of humans. More specifically, the gastrointestinal tract through unintentional spillage of its contents during evisceration, knives used during exsanguination and cutting, hides, fleece, feathers, and lymph nodes if examined by incision or other cut are sources of microbial contamination for meat[1], [2]. Additionally, interaction with other corpses, staff members, and the processing environment all have the potential to spread carcass and meat contamination. Even while the process of removing the hide may result in the introduction of several kinds of microbes onto the carcass, the majority of these organisms are non-pathogenic rotting bacteria and indicator microorganisms, such coliforms and Escherichia coli. Pathogens including Salmonella, Escherichia coli O157:H7, Campylobacter spp., and others provide a risk of contamination, however.

Reducing the amount of pathogen contamination in meat products might lessen the prevalence of food-borne illnesses and, in turn, lessen the estimated $12 billion in economic losses that the United States experiences each year as a result of medical expenses, lost productivity, recalls, legal bills, and lost business. Thus, there is a growing interest in enhancing meat's microbiological condition. The United States Department of Agriculture's Food Safety and Inspection Service has designated E. a zero-tolerance policy that mandates the removal of all visible contamination, including feces, ingesta, and udder contents, from beef carcasses by knife-trimming or steam-vacuuming before washing and chilling. coli O157:H7 is considered a "adulterant" in ground beef and other nonintact beef products. vThe evaluation and commercial use of washing and decontamination treatments before slaughter, during slaughter at the pre- and post-evisceration stage, during chilling, and after chilling was prompted by the need to comply with zero tolerance and microbiological criteria imposed by regulatory authorities or the industry, as well as the possibility that knife-trimming may not be adequate for efficiently removing microbial contamination[3], [4].

Physical or chemical decontamination therapies are both possible, as well as their combination in several interventions. Physical approaches work to physically remove dirt from an animal's or a carcass's exterior surfaces while also lowering microbial populations. They include cleaning and/or hair-trimming animals prior to slaughter, dehairing and defeathering animals, trimming knives, washing carcasses, and thermal treatments such as spot-cleaning with steam/hot water-vacuum equipment, "steam pasteurization," or hot water spraying. Chemical treatments use organic acid or other chemical solutions as rinses to reduce contamination and for chemical dehairing. Commonly used alone or in combination are thermal treatments and organic acid solutions. Ionizing radiation, ozonated water, nisin, glu-conic acid, lactoferrin, high hydrostatic pressure, sonication, pulsed light, or pulsed electric fields are a few alternative decontamination techniques or agents. The majority of these solutions, meanwhile, are still being researched and haven't been used yet. The discussion of commercially used decontamination operations on animals and corpses is the major topic of the following sentences.

Washing of Animals

Internal organs of healthy animals are thought to be sterile prior to slaughter. When living animals are turned into corpses and meat during the slaughter/dressing process, notably when the hide, fur, or feathers and viscera are removed, microbial contamination of the flesh often begins. Even at the best-run slaughterhouses, contamination is a risk that cannot be eliminated. However, it is anticipated that severely filthy animals with long hair and obvious fecal contamination may transmit larger microbial populations into the slaughter facility than shorn and "clean" animals. As a result, it is preferable to provide clean animals for slaughter since it lessens the possibility of disease presence and transmission onto carcasses.Washing animals prior to knife incision is a first step in attempts to reduce sources of carcass contamination before slaughter. In New Zealand, washing sheep before slaughter is a routine intervention. Additionally, Australia has embraced the process of washing cattle, which is also used in several US slaughterhouses. Animal cleaning results are unpredictable, and Cattle must be dry, or at the very least not dripping, before they are killed according to U.S. regulatory rules, which might be a problem if washing the animals before slaughter is an option. However, killing rates should be slowed down when animals are moist or very dirty to prevent unintentional contamination of the corpse or the surrounding area of the facility. Additionally, alterations to the procedures or tools used to remove the hide might reduce the amount of contamination that is transferred to the surface of the corpse. Animal washing is typically accepted as a way to improve visual appearance due to removal of visible contamination of animals presented in a "dirty" state, rather than to enhance the microbial quality of meat, given the foregoing as well as the reported low magnitude of microbial reduction achieved by this intervention.

DISCUSSION

Even when less severely dirty animals are processed, poor sanitation, hygiene, and manufacturing methods during slaughtering, fabrication, and processing may result in overly contaminated meat. Particularly, pre-harvest procedures are crucial in the microbial contamination of the animal's exterior surfaces. Research has shown that E. Animal skins had coli O157:H7 serotypes that matched those on feedlot and shipping trailers. Therefore, it is probably more important to ensure sanitary handling, shipping, and killing procedures than it is to merely improve the animals' presentation condition. Combining animal washing with separating cleaned from unclean animals and administering a chemical pre-evisceration decontamination treatment, for instance, may be a successful approach. It has been shown that this approach lowers aerobic plate count levels and the predominance of E, both of which are factors in the microbiological quality of bovine carcasses. from 56% to 34% of E. coli O157:H7. However, in certain systems of animal production, marketing, distribution, and slaughtering, it may not be possible to physically separate the processing of severely contaminated from that of clean animals. Meticulous hygiene procedures must be followed while transporting animals to the slaughterhouse and handling them further prior to dressing. Animal cleaning might lessen bacteria buildup on exposed animal surfaces. However, the outcomes of this intervention vary, and its efficacy is unclear. However, the United States and Australia use low-pressure spray rinses on animal hides that include permitted chemicals such detergents, organic acids, hydrogen peroxide, and chlorine[5], [6].

Treatments for Spot-Carcass Contamination

The first time that carcasses and muscle are contaminated is during bleeding and hide removal; when the hide is being taken from the corpse, it also transfers animal contamination to the surrounding area of the facility, the equipment, and the personnel. As a result, spot treatments are the first interventions used to clean up apparent filth from the exterior surfaces of carcasses once the hide has been removed. These procedures include steam vacuuming and knife trimming. To achieve zero tolerance of visibly contaminated carcasses, the FSIS has authorized the use of both spot-carcass interventions. These interventions should be used in conjunction with pre- and/or post-evisceration decontamination procedures since they rely on visual assessment and might miss undetectable carcass contamination.

Hot-Water and Steam Vacuuming

The FSIS approved the cleaning of carcass spots up to 2.5 cm in diameter with handheld equipment, applying steam and vacuum in response to the need for interventions other than knife-trimming for removal of visible contamination from carcasses. Larger spots must only be removed by knife-trimming. The purpose of the steam-vacuuming procedure is to eliminate or destroy any related bacteria in addition to cleaning up any apparent dirt. This cost-effective method is used across the whole slaughter chain by a significant section of the U.S. meat industry. Commercial steam-vacuuming machines constantly heat-sanitize themselves while releasing steam and/or hot water in conjunction with the application of vacuum. The method's basic working principle is as follows: first application of steam or hot water loosens soil and inactivates microorganisms; subsequent vacuum removal of pollutants. Two commercial steam-vacuuming systems were put to the test by Kochevar et al. in accordance with the procedures used in active plants. The length of vacuum application, the stage of processing, and the kind or condition of beef tissue seem to have a significant impact on the effectiveness of steam vacuuming. Salmonella-inoculated cold beef adipose tissue surfaces were assessed by Bacon. They discovered a decrease of less than 1 log10 CFU/ cm^2 after post-chilling steam-vacuuming. The limited effectiveness of the applied treatment was related to the steam-vacuuming unit's brief contact with the adipose surface, together with the hardened cold surface's protective impact on micro-colonies embedded in or adhered to the tissue. Steam-vacuuming, however, seems to be an effective cleaning method for heated corpses during dressing since it may significantly reduce APC and TCC. By reducing the quantity of trimming required on carcass processing lines, water/steam vacuuming decreases the impact of human subjectivity as well as the dangers of contamination from inadequate knife sanitization and poor worker cleanliness. Steam-vacuuming workers at American slaughterhouses also use the intervention on certain corpse areas known to harbour microbial contamination even in the absence of apparent dirt, in addition to visibly polluted spots. It should be highlighted that adequate application and good equipment functioning are required for this intervention to be successful[7], [8].

Decontamination prior to evisceration

Washing with cold or hot water and/or rinsing with chemical solutions, including organic acids, are two pre-evisceration procedures. Additionally, beef carcasses are water-washed as a last procedure before being decontaminated and chilled. When it comes to eradicating bacterial contamination, washing with cold water and knife-trimming may be considered equally or less effective, but combining both procedures may not be any more successful than any one used alone. However, as washing only applies to complete carcasses, not specific carcass parts, this comparison may not be appropriate. Hot water washing has a more devastating impact on microbial contamination than cold water, which physically eliminates bacteria. After removing the hide but before evisceration, chemical solution rinse may also be beneficial in lowering microbial contamination. For pre-evisceration treatments, organic acids like lactic and acetic are preferred. Lactic acid, however, is the preferable substance since acetic acid has a strong flavour. In this chapter's "chemical decontamination" section, specifics on how chemical solutions affect carcass microbial infection are provided.

Given that bacterial attachment grows with time between exposing the carcass to contamination and administering the decontamination treatment, the higher the predicted outcome, the sooner spray-washing is applied following the removal of the hide. Pre-evisceration washing is thought to be useful because it could prevent germs from adhering to the corpse by lowering its surface tension. Due to the limited time for bacterial and soil attachment after hide removal and the fact that the wet surface limits subsequent bacterial attachment during evisceration and before final carcass-washing, spray-washing prior to evisceration may therefore result in a significant reduction of initial contamination.

Last Carcass Wash

As previously mentioned, zero-tolerance inspection is followed by water-washing at the conclusion of the dressing process before carcass cooling. In small operations, carcass washing is often done manually with hand-held hoses. For automated spraying systems in cabinets, the kind and design of the nozzles as well as the spraying pressure control the size and temperature of the water droplets that impact the carcass surface. The primary goal of final carcass washing is to enhance the carcass' appearance by getting rid of the blood and sawdust produced during carcass splitting.Spray-washing automobile carcasses with tap or potable water may have a minor impact on microbial elimination, but it has a significant positive impact on their aesthetic appeal. However, improper spray-washing can result in increased surface tissue moisture, entrapment and embedding of bacteria into tissues, which may then prevent further decontamination efforts, a reduction in endogenous spoilage microflora and, consequently, in their ability to compete with pathogens, and redistribution or translocation of microbial contamination from heavily contaminated areas. As a result, it is advised that water spray-washing be done correctly and using functional equipment. Unless it is followed by further physical or chemical decontamination techniques, which are covered in the next sections, simple water-washing alone may not be adequate for significant improvements in carcass hygiene.

Decontamination with heat

The efficiency of physical decontamination techniques may be greatly increased when the carcass surface temperature is elevated over 70° C, according to research on meat decontamination conducted since the 1980s. Hot water or saturated steam are being used in commercial thermal treatments all over the globe to lessen microbial contamination on corpses. While hot water has also been considered as a viable decontamination treatment for carcass trimmings, both treatments are commercially administered post-evisceration, following final carcass washing. While steam pasteurization only needs the installation of more costly steam cabinets, hot water treatments may be done in spraying cans with the appropriate nozzles. Steam pasteurization is more expensive when used commercially than hot water.

Using Hot Water to Clean Up

Through the physical removal and thermal inactivation of microorganisms that are present on the surface of meat, hot water has decontamination benefits. It is a high-performance intervention that might result in further microbial reductions to those brought on by earlier water-washing or knife-trimming. The temperature, time, and pressure of application are the primary factors that affect how well hot-water treatments work. Hot water is sprayed using nozzles that are suitably built to fulfill the demands of flow rate, droplet size, water pressure, and spray angle. Depending on the length of treatment and other variables, the temperature attained on the carcass surface is typically 6- 10° C lower than that of sprayed water. The heat transmission from water to the intended anatomical area of the carcass by the moment of contact is also influenced by the header temperature and the distance of the nozzles from the carcass. As with other water-washing techniques, the sooner hot water is used, the more effectively germs are killed. In order to lessen microbial deterioration and pathogenic contamination of carcasses, hot water is preferable than cold water. But in order to guarantee microbial reductions and prevent long-term staining of the carcass tissue, careful selection of pressures, temperatures, and application time is required. Hot water is also a physical intervention that needs less capital outlay and has no chemical danger. These factors have led to its commercial implementation in meat-processing companies around the globe.

Pasteurization by steam

Steam is a different thermal decontamination procedure than using hot water. Commercial usage of a patented procedure occurs post-evisceration, after the last wash and before chilling, and it has been given FSIS approval for use in the United States. The process of steam pasteurizationTM includes the following steps: vacuuming off water from the meat's surface to improve steam penetration; applying "saturated" steam to raise the surface temperature to 80–90°C; and cooling the treated tissues to prevent microbial growth or visual defects. On lamb carcasses at the pre-evisceration stage after water-washing, moist heat treatment utilizing a commercial steam cabinet was more successful at lowering bacterial counts than cold or warm water, but equally effective for hot water.

Decontamination using chemicals

Interventions employing chemical agents have also been suggested and employed on corpses in addition to the physical cleansing techniques already discussed. Over the last 30 years, a large amount of research has been done on the chemical decontamination of beef carcasses in an effort to lower overall bacterial counts and the presence of diseases.An efficient decontamination intervention for both the immediate reduction of microbial contamination on carcass surfaces and meat as well as the suppression of development in packed meat is lactic acid spray rinses, which may contain up to 5% lactic acid. It is advised to use lactic acid after water-washing to provide long-lasting antimicrobial benefits. However, overusing organic acids may cause the rusting of meat processing machinery. Lactic acid decontamination is now a common practice in cattle slaughterhouses in the United States[9], [10].

Multiple Interventions for Decontamination

Instead of using a single hurdle that is more intense or fatal, a combination of low-intensity hurdles may be used to provide the desired antimicrobial effect without sacrificing sensory quality or other qualities. Several barriers or sublethal treatments may be used sequentially or concurrently. Physical and chemical decontamination procedures carried out in succession have been shown to be more efficient than isolated treatments. Such a notion may increase the efficacy of certain physical techniques, such as cold-water cleaning or knife trimming, while requiring lower chemical doses at later phases. For instance, that washing and knife-trimming beef carcasses together resulted in approximately two-fold and six-fold larger reductions in the incidence of *Listeria* and *Salmonella*, respectively, compared to washing or trimming alone. The sequential decontamination interventions research idea was developed by this investigation. The effectiveness of many spray-washing/rinsing treatments using warm/hot water and/or acetic acid solution individually and in order to minimize microbial contamination on beef tissue inoculated with E was then tested in the lab by Graves Delmore et al. to confirm the idea. coli. From the point at which animals arrive at the abattoir, during the dressing process, until chilling and fabrication, it appears that all the physical and chemical decontamination treatments described may be used as multiple interventions to reduce microbial contamination on hides, carcasses, and cuts. Currently, the U.S. beef business utilizes both sequential and simultaneous treatments, such as cleaning the animals, cutting them with a knife, steam-vacuuming, washing/rinsing them before evisceration, and washing them in hot water.

The idea that some Salmonella strains associated in foodborne outbreaks are also resistant to antimicrobial interventions in beef processing has been evaluated in light of the fact that many of the bacteria implicated in those outbreaks have been shown to be resistant to several antibiotics. In spite of the fact that the incidence of Salmonella had decreased from 15.4% on hides to 1.3% on carcasses, Bacon et al.'s investigation for antibiotic-resistant Salmonella strains in eight beef-packing factories discovered that around 60% of the isolates were resistant to at least one antibiotic. Additionally, the discovery of two Salmonella bacteria that were resistant to antibiotics in carcasses after final washing indicated possible resistance to decontamination therapies. Studies, however, have not shown a link between resistance to heat or low pH stress and sensitivity to antimicrobial treatments. The sensitivity of Salmonella to other meat cleansing treatments, such as 2% acetic or lactic acid, electrolyzed-oxidizing, and ozonated water, as well as commercial acid products, was also shown to be unaffected by the bacteria's multidrug resistance status by Arthur et al. In a similar manner, certain E. Resistance to the aforementioned antimicrobial treatments was not connected with the ability of E. coli O157:H7 strains to infect humans. There is no conclusive evidence that chemical decontamination poses additional risks due to faster pathogen growth or higher acid resistance during storage of products, compared to physical decontamination, even though existing laboratory data suggest that acid decontamination interventions may increase the potential for pathogens to develop acid resistance. Additionally, microorganisms that are multi-drug resistant are not more resistant to decontamination procedures than ones that are susceptible. Therefore, if hygienic and sanitary practices are followed throughout the processing chain, as zero tolerance inspection ensures in the United States, the proper use of chemical rinses may result in a significant reduction of pathogens on meat without raising concerns associated with stress-adapted pathogens.

Irradiation has been used commercially to a limited level despite studies showing its efficacy in decreasing pathogens on fresh meat and its approval in the United States due to customer worries about possible negative health consequences. The use of irradiation to disinfect corpses after dressing is now being petitioned in the United States. Contrarily, active packaging strategies, such as antimicrobial coating or the incorporation of chemicals within the packing film, may limit the growth of microorganisms while a product is being stored. These substances also satisfy customer expectations for more natural goods. These recently developed anti-microbial therapies, together with appropriate cleanliness habits and effective control procedures during slaughter, may significantly improve meat safety. To assess the impact of such interventions on the sensory qualities of meals and the viability of their use on an industrial scale, more study is required. Additionally, it is important to take into account the possibility that innovative cleaning techniques might lead to the adaptation of germ resistance.

CONCLUSION

The existence of dangerous microorganisms and pathogens poses a huge issue in the area of food safety, notably within the meat sector. This thorough investigation has covered a variety of tactics and measures intended to lessen pathogen contamination in food animals and meat processing, eventually enhancing meat safety. Microbial contamination in the preparation of meat may come from animals, especially those who are ill or have germs on their outer surfaces. These toxins may endanger human health and cause large financial losses. An all-encompassing strategy has been investigated to deal with this problem. Visible contamination has been significantly reduced because to physical cleaning methods like washing animals before slaughter and spot-carcass treatments like steam vacuuming and knife cutting. However, its efficacy may change based on variables like as temperature, pressure, and the application's timing. Additionally, heat-based therapies have the potential to drastically reduce microbial contamination on carcasses. Examples of these are hot water treatments and steam pasteurization. Through these approaches, beef products' sensory qualities as well as their microbiological quality are improved. Lactic acid spray rinses are one of the most efficient chemical cleaning techniques for decreasing microbiological and visual contamination on corpses. These chemical treatments may provide a multi-barrier strategy for meat safety when used in combination with physical interventions.

It has been discovered that many interventions using a mix of physical and chemical cleaning techniques are more efficient than solitary treatments. These techniques have the potential to drastically minimize pathogen contamination on hides, carcasses, and cuts of meat when used across the whole meat production chain. It is crucial to maintain sanitary and hygienic procedures all throughout the meat processing supply chain. Furthermore, cutting-edge innovations in meat safety, such irradiation and active packaging, show promise. To sum up, the search for better meat safety is a continuing process. The meat industry can continue to make significant advancements in lowering pathogen contamination and ensuring the safety of meat products for consumers by putting into practice a combination of physical and chemical interventions, adhering to strict cleanliness practices, and investigating cutting-edge technologies.

REFERENCES:

[1] M. Sohaib, F. M. Anjum, M. S. Arshad, and U. U. Rahman, "Postharvest intervention technologies for safety enhancement of meat and meat based products; a critical review," *Journal of Food Science and Technology*. 2016. doi: 10.1007/s13197-015-1985-y.

[2] S. A. Mir, M. A. Shah, and M. M. Mir, "Understanding the Role of Plasma Technology in Food Industry," *Food and Bioprocess Technology*. 2016. doi: 10.1007/s11947-016-1699-9.

[3] A. Lone *et al.*, "Development of prototypes of bioactive packaging materials based on immobilized bacteriophages for control of growth of bacterial pathogens in foods," *Int. J. Food Microbiol.*, 2016, doi: 10.1016/j.ijfoodmicro.2015.10.011.

[4] A. Burke and M. S. Dworkin, "High school students as the target of an integrated food safety educational intervention: Successful results of a pilot study," *Food Protection Trends*. 2016.

[5] M. Oh, H. Lee, H. Cho, S.-H. Moon, E.-K. Kim, and M. S. Kim, "Detection of fecal contamination on beef meat surfaces using handheld fluorescence imaging device (HFID)," in *Sensing for Agriculture and Food Quality and Safety VIII*, 2016. doi: 10.1117/12.2227184.

[6] A. F. Júnior and E. C. V. Júnior, "Immune response after campylobacter spp. infection in poultry," in *Campylobacter Spp. and Related Organisms in Poultry: Pathogen-Host Interactions, Diagnosis and Epidemiology*, 2016. doi: 10.1007/978-3-319-29907-5_4.

[7] Z. Fang, Y. Zhao, R. D. Warner, and S. K. Johnson, "Active and intelligent packaging in meat industry," *Trends in Food Science and Technology*. 2017. doi: 10.1016/j.tifs.2017.01.002.

[8] K. Warriner and A. Namvar, "Current Challenges in Enhancing the Microbiological Safety of Raw Meat," in *New Aspects of Meat Quality: From Genes to Ethics*, 2017. doi: 10.1016/B978-0-08-100593-4.00010-2.

[9] J. Choi, J. Park, and H. Kim, "A Study on Relationship between Physical Elements and Tennis/Golf Elbow.," *J. Ergon. Soc. Korea*, 2017.

[10] NCT03158740, "Watermelon Focused Dietary Inflammatory Index Intervention," *https://clinicaltrials.gov/show/NCT03158740*, 2017.

CHAPTER 4

UNVEILING THE COMPLEXITY OF MEAT AGING: ENZYMES, PROTEOMICS, AND EMERGING THEORIES

Raj Kumar, Assistant Professor
Department of uGDX, ATLAS SkillTech University, Mumbai, Maharashtra, India
Email Id- raj.kumar@atlasuniversity.edu.in

ABSTRACT:

This study goes into the complicated realm of meat aging and examines how enzymes, proteomics, and new hypotheses may be used to better understand the difficult process of turning muscle into soft and delectable meat. The calpain enzyme system, the apoptosis hypothesis, and heat shock proteins are the main topics of our investigation into the underlying processes of postmortem proteolysis. We also look at intrinsic muscle characteristics that affect meat softness, such protein oxidation and osmotic pressure. We get new understandings of protein alterations during meat age and their possible importance using proteomic techniques. Our understanding of meat aging has advanced, but this paper also identifies the areas where we still have questions and calls for further study to fully understand this complex process.

KEYWORDS:

Enzymes, Myofibrillar, Meat Tenderization, Proteomic Techniques, Postmortem.

INTRODUCTION

Scientists from the Molecular Biology Division at the University of California, Los Angeles, have demonstrated that gene loss is the primary cause of the human aging process. Humans continue to seek ways to slow down, control, or virtually eliminate the aging process, frequently looking for the infamous "fountain of youth." On the other hand, "aging" meat is seen favourably, and many people have been preserving meat for lengthy periods of time after an animal dies in order to enhance its texture for a very long time. The common understanding among consumers is that all meat, whether red, white, or pink, is made up of muscles. It starts out as muscle, which over time and in a gradual process transforms into flesh. Since a very long time, there has been a strong belief that postmortem storage of meat at cold temperatures significantly improves flesh suppleness, and aging is still a key technique for creating delicate meat. The earliest scientific studies on postmortem meat tenderization were done by Bouley and Lehman, who found that flesh became more tender after prolonged postmortem storage[1], [2].

When meat is stored in a controlled refrigerator, a natural process known as postmortem aging occurs. Although meat from any species might be aged, postmortem aging is often only done on beef since hog, lamb, and veal were relatively young at the time of slaughter. Although muscle from chicken carcasses similarly ages, the process takes place over hours and minutes rather than days as it does in beef.The quest to enhance the quality of meat has long been a pursuit of both scientists and culinary enthusiasts. In this journey, the phenomenon of meat aging stands as a critical juncture, were muscle transforms into tender and flavorful meat. Meat aging is a natural process that occurs postmortem, primarily under controlled refrigerated conditions, and is integral to improving the tenderness of meat. The journey from muscle to meat is a dynamic one, marked by enzymatic activities and biochemical transformations.

This study aims to unravel the complexity of meat aging by exploring the role of enzymes, proteomics, and emerging theories in understanding the underlying mechanisms. We delve into the significance of enzyme systems like calpains, which play a pivotal role in postmortem proteolysis, breaking down myofibrillar proteins and contributing to meat tenderization. Furthermore, we investigate the intriguing hypothesis that apoptosis, or programmed cell death, may be involved in postmortem proteolysis, shedding light on the interplay of biochemical processes in meat aging. Beyond enzymes, we delve into the world of heat shock proteins, which protect cellular proteins from denaturation and have been implicated in meat quality. Intrinsic muscle factors, such as protein oxidation and osmotic pressure, are also examined for their potential influence on meat tenderness. Finally, we explore proteomic approaches that offer a more comprehensive understanding of protein changes during meat aging. As we navigate through these intricate facets of meat aging, it becomes evident that while substantial progress has been made, many questions remain unanswered. The article concludes by emphasizing the need for further research to bridge the gaps in our knowledge and provide a more complete understanding of the processes that govern meat aging[3], [4].

System Enzymes

Numerous enzymes found in skeletal muscle power a variety of metabolic processes in the live tissue. It is believed that several of these enzyme systems continue to function in postmortem muscle and affect how meat quality develops. In particular, substantial research has been done to ascertain the functions of the cathepsin, calpain, and proteasome enzyme systems in the proteolysis related to the aging tenderization of meat. Researchers have used the following criteria to identify the enzymes responsible for the postmortem aging of meat: they must be endogenous to skeletal muscle, have access to substrates, and be able to degrade the same proteins that are degraded during the postmortem storage of muscle. Only calpains, one of the three main enzyme systems under investigation, satisfy both requirements. Calpains can cleave myofibrillar proteins at a limited number of locations, resulting in large polypeptide pieces that resemble those seen after storing muscle after death. Calpains have access to substrates and have been proven to have limited proteolytic capacities. However, lysosomal cathepsins and proteasomes are unable to disassemble the myofibril and do not produce the same patterns of myofibrillar protein degradation as those seen during meat age. Instead, they are capable of thoroughly breaking down proteins into little peptides or short amino acid segments. Furthermore, it is believed that cathepsins' access to substrates is limited by where they are located inside lysosomes. The current idea is that postmortem proteolysis and age tenderization are primarily driven by the calpain/calpastatin system.

The calpain system's significance has been supported by a number of recent research on meat softness, but they have also shown that age tenderization is a very complicated process that goes beyond the confines of the present calpain hypothesis of post-mortem tenderization. Multiple enzymes and interdependent muscle factors may be required, according to mounting data, to properly explain postmortem proteolysis and its connection to tenderization. The rest of this chapter will concentrate on recent innovative discoveries that help us comprehend the underlying processes that regulate postmortem proteolysis and meat tenderization with age more thoroughly.

Theory of Aging Based on Apoptosis

Recent research has inferred that meat tenderization and post-mortem proteolysis may be influenced by the apoptotic process. A sophisticated technique called programmed cell death, or apoptosis, allows cells to be removed from living things without harming neighbouring cells. The caspase enzyme system mediates apoptosis, which is started and controlled by either the target cell or the central nervous system. The loss of blood flow during the slaughter process will deplete the muscular tissue of oxygen and nutrients. The muscle cells won't have any choice but to begin the process of apoptosis under these anoxic circumstances, which via the caspase system would cause a number of biochemical and structural changes crucial to the tenderization process. Thus, in addition to the stages of rigour mortis development and aging tenderization, the classic model of the conversion of muscle to meat would also contain a period corresponding to the beginning of cell death. When the muscle conditions are unfavourable for enzyme activation, the apoptotic process continues. However, there is currently a dearth of concrete data to back up this growing theory.

DISCUSSION

The caspase enzyme system causes apoptosis inside of the cell. The review by Fuentes-Prior and Salvesen contains in-depth information on the structure, activity, activation, and inhibition of caspases. Briefly stated, caspases are a class of neutral cysteine proteinases that cleave proteins at certain aspartic acid residues upon activation, which requires the cleavage of the pro-domain and dimerization. There are now 14 caspases, which are categorized into three types depending on their biological roles: effector caspases, apoptotic initiator caspases, and cytokine activators that participate in inflammation. The downstream effector caspases, which cleave certain target proteins, are activated by the initiator caspases during the apoptosis process. Since the primary in vivo function of caspases is to enzymatically degrade cellular structures, it has been hypothesized that, in the case of meat tenderization, caspases would likely begin by degrading proteins involved in the spatial organization of myofibrils and that additional proteolytic systems, such as calpains, cathepsins, and proteasomes, would then contribute to the further degradation of cellular components. Caspases have been shown to destroy a variety of muscle proteins, just as calpains do. In instance, it has been shown that under catabolic circumstances, caspase 3 cleaves myofibrillar proteins in muscle[5], [6].

However, only a small number of research have looked at the role of skeletal muscle caspases in postmortem proteolysis and meat tenderization. It was shown that caspases and the caspase inhibitor apoptosis repressor with caspase recruitment domain may be identified in distinct muscle types at varied degrees of expression using the porcine trapezius, psoas, longissimus dorsi, and semitendinosus muscle. Desmin, tropo-nin I, actin, troponin T, and myosin light chains were degraded in vitro by recombi-nantcaspase 3 when it was incubated with swine myofibrils under postmortem aging-like circumstances. In one investigation, the caspase 3/7 and caspase 9 activity, as well as the degradation of caspase substrates, alpha II spectrin, and poly polymerase in swine longissimus muscle between 0- and 8-days postmortem, were measured. In this investigation, it was discovered that early postmortem was the period when caspase activity was at its peak. Additionally, it was shown that Warner-Bratzler shear force measurements were adversely linked with caspase activity and the quantity of alpha II spectrin degradation products. This led to the conclusion that meat tenderization may be related to changes in caspase activity and caspase-mediated cleavage of muscle proteins seen during postmortem aging.

However, according to other study, caspases are unlikely to play a significant part in the postmortem proteolysis related to meat tenderization. Caspase 3 activity was found in beef muscle and was shown to be present right away after slaughter but to decline with time postmortem. Pro-caspase 3 was not activated in this study's beef longissimus following postmortem storage, and caspase 3 activity was not associated to Warner-Bratzler shear stress. The results of one research that used muscle from callipyge and healthy lambs showed that the activities of caspase 3/7 and caspase 9 reduced between 1- and 21-days postmortem, but they did not conclusively prove or disprove the caspase system's role in meat tenderization.

There is some suspicion that the interaction between caspases and the calpain/calpastatin enzyme system may affect postmortem proteolysis. Numerous studies have shown interactions between the calpain and caspase systems during apoptosis, in which the cleavage of calpastatin by caspase enzymes indirectly increases calpain activity. Caspase activity during apoptosis has also been demonstrated to be impacted by calipains. However, information on the relationship between caspases and the calpain enzyme system in skeletal muscle with respect to post-mortem proteolysis is scarce. Peak caspase 3/7 activity at 8 hours after death and calpastatin activity at 0 and 2 days after death have been shown to be negatively correlated, but not in the muscles of callipyge lambs. Therefore, despite the lack of direct proof, findings indicate that caspases may indirectly contribute to postmortem tenderization by decomposing calpastatin. However, further information is required to establish with certainty the direct and indirect roles of the caspase system in postmortem proteolysis and meat tenderization.

HSPs, Heat Shock Proteins

Small heat shock proteins are being looked at more and more as possible variables affecting the conversion of muscle to meat and meat quality due to their anti-apoptotic actions in live tissue. HSPs including alpha-crystallin, HSP20, and HSP27 work to maintain the homeostasis of live muscle tissue by stabilizing unfolded proteins, assisting in the refolding of denatured proteins, and preventing protein aggregation. HSP expression is increased in live tissues in response to stress because of their capacity to shield cellular proteins against denaturation and loss of function.

Muscle Factors that are Intrinsic

Proteolysis

Researchers have also looked at postmortem muscle features that potentially affect either calpain activation or the effectiveness of calpain-mediated proteolysis in order to completely understand how calpains contribute to postmortem proteolysis and aging tenderization. It has been looked into whether variations in muscle parameters such protein oxidation levels and sarcomere length may partially explain the variation in the pace and degree of post-mortem myofibrillar protein breakdown.

Effect of Oxidation on Proteolysis Mediated by Calpain

There is growing evidence that dynamic changes that take place in the microenvironment of the muscle cells during the conversion of muscle to meat have an impact on postmortem proteolysis and age tenderization. In addition to a drop in pH and a rise in ionic strength, postmortem muscle exhibits an increase in protein oxidation and the generation of reactive oxygen species. Researchers discovered that enhanced muscle protein oxidation early postmortem had a detrimental influence on meat tenderness. They did this by supplementing beef longissimus muscles with vitamin E and irradiating them.

Tenderization Nonenzymatic Aging Mechanisms

Most research efforts have concentrated solely on the endogenous proteolytic enzymes as the main mechanism regulating tenderization because it is almost universally accepted that aging reduces meat toughness in all but sarcomere-shortened muscle and that a decrease in toughness of meat is accompanied by a corresponding increase in protein degradation and protein solubility as meat ages. However, the body of research on proteolytic systems is riddled with inconsistencies and, more crucially, fails to adequately account for the wide range in meat softness or the significant variations in tenderization rates across species. It has been shown that just a little quantity of proteolysis takes place in the first three days of age, despite the fact that this is when postmortem tenderization changes the most. Even though they haven't been well studied, certain non-proteolytic pathways seem to support postmortem tenderization[7], [8]. By selectively treating muscles from beef, swine, poultry, and rabbits with 0.1 mM Ca^{2+} ions in vitro, all these ultrastructural alterations were made evident. Evidence was given showing that the rate of free calcium growth followed the various tenderizing rates for different species in the order of chicken, rabbit, hog, and beef muscles with relation to the varying rates of meat tenderization among animal species. A common defence used against the possibility that proteolysis played a role in the changes observed after death is that because meat ages under nonphysiological conditions, the activity levels of the highly pH and temperature dependent proteolytic systems are insufficient or nonexistent in the postmortem cellular environment. The lack of objective tenderness data to support the calcium hypothesis of tenderization is an issue with respect to any of this research. A study that found a rise in sarcoplasmic Ca^{2+} in post-mortem muscle and linked it to the myofibrillar fragmentation index and shear force appears to support the calcium theory of tenderization, but it also offered alternative interpretations of the results that were at odds with it.

Oxygen Pressure

The intracellular osmotic pressure increases nearly twofold and has a close relationship with pH during the time course of rigour mortis, yet it has received comparatively little attention in meat research studies. The postmortem fall in pH is one of the most extensively investigated factors during the development of rigour mortis. It was proposed that the pH decrease, which altered the proteins to which ions are typically bound, was most likely the main cause of the significant rise in osmotic pressure. It was postulated that the ionic strength attained at the end of rigour could be high enough to induce partial dissociation of the myofibrillar structure and increase myofibrillar proteins' proteolytic susceptibility because salt concentrations above physiological values generally increase the solubility of myofibrillar proteins. It has been shown that the solubilization of structural proteins and alterations in myofibril-lar ATPase activity with age are caused by the high ionic strength of postmortem muscle. The maximum osmotic pressure readings also coincided with how quickly muscles contracted, lending more credence to this. This research led to the conclusion that increased osmotic pressure has a physico-chemical effect on myofibrillar proteins in addition to proteolytic enzymes, which may be related to improvements in tenderness.

Results to far do not suggest that increased ionic strength and proteolysis work in concert. The pH and ionic strength of post-mortem muscle cause conformational changes in the substrate proteins, which affect their susceptibility by making some cleavage sites inaccessible to proteolytic assault. Second, it has been shown that - and m-calpain activity is inhibited by an increase in ionic strength. The proportional contribution of proteolytic enzymes to postmortem tenderization should be examined in relation to increased ionic strength, which is a crucial variable to look at analogous to the drop in pH.

Proteomic Approaches Are Increasingly Used to Study Aging Tenderization

Although there has not been a significant shift in the fundamental knowledge of the mechanisms governing postmortem proteolysis and aging tenderization over the last 10 years, technological advancements have contributed to the discovery of new pieces of the jigsaw.

The majority of post-mortem proteolysis and meat aging studies have historically used traditional SDS-PAGE and western blotting methods to detect protein degradation in tissue taken from aged intact muscle cuts or from protein extracts made after in vitro digestion of isolated myofibrils and muscle proteins. By combining two-dimensional electrophoresis with protein identification by mass spectrometry, researchers are increasingly adopting a proteomics strategy to comprehend protein changes associated to meat quality. This effective approach enables researchers to concurrently and quickly separate a large variety of proteins produced in muscle tissue and to discover various protein alterations that occur in postmortem muscle, as opposed to merely focusing on a few proteins at a time. Proteomic analyses of postmortem muscle have provided fresh insights into the processes that cause meat to become more soft with age. Actin is not degraded postmortem, as has been widely recognized based on investigations utilizing one-dimensional SDS-PAGE. However, many investigations utilizing 2DE separation have shown that actin pieces increase during postmortem storage and that their concentration is correlated with softness. Similarly, these investigations have shown that postmortem storage causes myosin fragments to accumulate. The results of proteomic studies on postmortem muscle suggest that metabolic enzymes and other water-soluble proteins within muscle may be potentially useful as markers for meat tenderness, even though aging tenderization is typically thought to be a manifestation of changes to the myofibrillar and cytoskeletal components of muscle. However, it is currently unknown whether the protein alterations seen during postmortem storage play a mechanistic role in aging tenderization or whether they are just indications of proteolysis given the dearth of proteomic-based and high-resolution investigations on old muscle[9], [10].

CONCLUSION

The process of meat curing, which turns muscle into delicate and delicious meat, is still the focus of much scientific research and gastronomic awe. The complexity of this process has been shown by this investigation into the realm of meat aging. Meat tenderization is greatly aided by enzymes, notably the calpain enzyme system, which has become a key actor in postmortem proteolysis. The apoptosis idea offers a fresh viewpoint by positing that complex biochemical interactions during meat aging may include programmed cell death. With their protective roles in live tissue, heat shock proteins add another level of intricacy to the tale of meat quality. Meat tenderness may also be influenced by intrinsic muscle variables such as protein oxidation and osmotic pressure. Researchers now have a more complete understanding of the protein changes that take place during meat age thanks to the development of proteomic techniques, which may one day give useful indicators for meat quality. Despite these developments, there are still numerous mysteries surrounding the process of turning muscle into flesh. There are still gaps in our knowledge, and the particular processes influencing beef aging have not yet been completely uncovered. As a result, it is clear that further study in this area is necessary. The continuous effort to reveal the complexity of meat aging holds the promise of better meat quality as well as a greater understanding of the art and science of cuisine.

REFERENCES:

[1] M. T. Jilnai, W. P. Wen, L. Y. Cheong, and M. Z. U. Rehman, “A microwave ring-resonator sensor for non-invasive assessment of meat aging,” *Sensors (Switzerland)*, 2016, doi: 10.3390/s16010052.

[2] M. I. Khan, S. Jung, K. C. Nam, and C. Jo, “Postmortem aging of beef with a special reference to the dry aging,” *Korean J. Food Sci. Anim. Resour.*, 2016, doi: 10.5851/kosfa.2016.36.2.159.

[3] M. Kouvari, S. Tyrovolas, and D. B. Panagiotakos, "Red meat consumption and healthy ageing: A review," *Maturitas*. 2016. doi: 10.1016/j.maturitas.2015.11.006.

[4] C. N. Aroeira *et al.*, "Freezing, thawing and aging effects on beef tenderness from Bos indicus and Bos taurus cattle," *Meat Sci.*, 2016, doi: 10.1016/j.meatsci.2016.02.006.

[5] T. Iwasaki, H. Taniguchi, Y. Hasegawa, N. Maeda, and K. Yamamoto, "A novel method for monitoring troponin T fragment from rabbit skeletal muscle during aging using quartz crystal microbalance," *J. Sci. Food Agric.*, 2016, doi: 10.1002/jsfa.7558.

[6] A. K. Biswas, S. Tandon, and D. Sharma, "Identification of different domains of calpain from blood and goat skeletal muscle and their influence on quality during post-mortem ageing of meat during holding at 4 ± 1 °C," *LWT*, 2016, doi: 10.1016/j.lwt.2016.03.005.

[7] A. Lana and L. Zolla, "Proteolysis in meat tenderization from the point of view of each single protein: A proteomic perspective," *Journal of Proteomics*. 2016. doi: 10.1016/j.jprot.2016.02.011.

[8] D. C. Rivaroli *et al.*, "Effect of essential oils on meat and fat qualities of crossbred young bulls finished in feedlots," *Meat Sci.*, 2016, doi: 10.1016/j.meatsci.2016.06.017.

[9] M. Florek *et al.*, "Effect of Vacuum Ageing on Instrumental and Sensory Textural Properties of Meat from Uhruska Lambs," *Ann. Anim. Sci.*, 2016, doi: 10.1515/aoas-2015-0084.

[10] K. Abuelfatah, A. B. Z. Zuki, Y. M. Goh, and A. Q. Sazili, "Effects of enriching goat meat with n - 3 polyunsaturated fatty acids on meat quality and stability," *Small Rumin. Res.*, 2016, doi: 10.1016/j.smallrumres.2016.01.001.

CHAPTER 5

SAVORING INDIA'S RICH CULINARY HERITAGE: EXPLORING INDIGENOUS MEAT PRODUCTS ACROSS THE NATION

Umesh Daivagna, Professor
Department of ISME, ATLAS SkillTech University, Mumbai, Maharashtra, India
Email Id-umesh.daivagna@atlasuniversity.edu.in

ABSTRACT:

The culinary legacy of India is a tapestry made of many climatic conditions, civilizations, languages, and geographical regions. Due to this diversity, a vast variety of traditional meat products have emerged, each of which is a reflection of the distinctive gastronomic customs and eating habits of various geographic areas. Indigenous meat items are produced and enjoyed all over the world, from the southernmost point of Kanyakumari to the snow-capped peaks of Jammu and Kashmir. This study explores the interesting world of traditional meat products from India and emphasizes its significance in maintaining cultural traits and culinary customs. Indian cuisine places a strong emphasis on traditional meat items since more than 70% of the country's people are not vegetarians. These ancient treats may now be produced and consumed in new ways because to urbanization, increased per capita income, and greater health awareness. Traditional meat items are making their way onto the plates of hungry customers as eating out becomes more popular. However, certain traditional goods are in danger of vanishing, making it difficult to preserve these gastronomic gems. The need to record, standardize, and modernize their manufacturing while preserving their distinctive flavours arises as a result. It is necessary to make efforts to increase packaging, shelf life, and sustainability utilizing natural and eco-friendly techniques. To fulfill customer needs and maintain the genuine flavour and fragrance of these prized meat products as India develops, ancient techniques and contemporary processing technology must be integrated.

KEYWORDS:

Cultural Heritage, Heritage, Meat Products, Processing Technology.

INTRODUCTION

India, a land of remarkable diversity, boasts a plethora of climates, cultures, languages, and geographical features. This incredible diversity results in an abundance of cereal grains, fruits, vegetables, and livestock products. Moreover, it gives rise to a wide variety of food products and culinary traditions that span the length and breadth of the country, from Jammu and Kashmir to Kanyakumari. One of the most fascinating aspects of India's culinary tapestry is its indigenous meat products. These delightful creations are born from the rich tapestry of ethnic groups, each with its unique food habits. In some regions, meat is consumed with gusto, while in others, vegetarianism reigns supreme. These diverse preferences have given rise to a cornucopia of traditional or indigenous meat products[1], [2].

These indigenous meat products, often passed down through generations, play a significant role in preserving the cultural heritage of different regions. They embody the unique culinary traditions and skills of artisans who meticulously prepare them.

These products have been integral to the social fabric, symbolizing wealth and status in many communities, and continue to be honored in social gatherings. Meat production in India stands at a staggering 8.6 million tons as of 2018, ranking fifth globally. With changing lifestyles, however, some of these traditional products are at risk of vanishing. Therefore, it becomes crucial to document and preserve them as part of India's cultural heritage. These traditional meat products are not only a source of nutrition but also a gourmet's delight, offering an array of culinary delights.

Market Profile for Traditional Meat Products

The changing landscape of urbanization and increasing per capita income in India has led to greater disposable income and a demand for diverse, value-added foods, including meat products. Health consciousness has fueled the demand for traditional foods with perceived health benefits, often enriched with traditional herbs and spices. The trend of dining out has also grown rapidly, creating opportunities for the consumption of traditional meat products in various settings.India is a varied nation in terms of geography, culture, language, and climate. Numerous varieties of fruits, vegetables, cereal grains, and animal products are produced in large quantities due to the climatic fluctuation. From J&K to Kanyakumari, there is a clear difference in the kind of food items produced and eating patterns. A variety of meat items with native flavour and scent are produced and eaten in various areas of India due to distinct ethnic groups and varied eating patterns. While some populations consume a lot of meat, others are totally vegetarian. The majority of meat products eaten in India are traditional or indigenous meat products since they have a local provenance. Certain craftsmen still possess the technology required to prepare some of these meat products, and they pass it on to future generations. Although the precise definition of the two names is different, traditional and heritage meat products are frequently used interchangeably. Since ancient times, native or traditional meat products have had a significant impact on the formation and maintenance of cultural traits in many locations[3], [4].

DISCUSSION

Products that have been eaten locally and regionally for a long time are considered traditional meat products. The folklore of a nation or an area sometimes includes the preparation techniques for typical meat items. These goods may be characterized as having a particular purpose that distinguishes them from all other goods of a comparable kind in the same category. These variations in composition, texture, taste, and scent may result from different formulations of traditional goods, different uses of the traditional components from which the core product was made, or different traditional preparation or manufacturing techniques. This suggests that raw or primary goods, which are recognizable in a certain geographical location and are still in use today, are employed throughout the preparation process of indigenous cuisine, either alone or as ingredients. Traditional meat dishes are a reflection of how closely our ancestors interacted with farm animals and birds. Some families specifically raise farm animals and birds to acquire odd tastes in order to prepare traditional foods. Even now, this connection is still going strong. Indigenous meat products had a significant impact on the people's sociocultural existence. These goods continue to serve as status and wealth markers for individuals in society today. Rich families and emperors honour the visitors at social gatherings and gatherings by serving these traditional meat delicacies in special cutlery[5], [6].

According to estimates, India will produce 8.6 million tons of meat in 2018, placing it sixth in the world. It produces 4.26 million tons of red meat and 4.34 million tons of poultry meat. Some of the classic goods are in danger of going out of style due to changes in the way of life of today's society. As a result, it is crucial that these goods be preserved as a part of a national, state, or regional culture. Traditional meat products have met peoples' requirements for improved nutrition and health because to their great diversity and richness. A vast variety of culinary meals and other delicacies that are a gourmet's joy have been made possible by the large range of traditional meat products from various regions of the nation. Along with giving clients a sense of satisfaction, these meat products also meet the need for high-quality proteins and iron. Although the method for producing traditional meat products has undergone constant change, it is now crucial to combine traditional techniques with cutting-edge meat processing technologies to meet consumer demands for greater convenience, better products, and longer shelf lives without sacrificing the traditional flavour and aroma of the meat products.The following variables influence the prospects of conventional meat products in emerging countries:

Urbanization growth and per capita income

Millions of people are relocating from rural regions to towns, cities, and other metropolitan areas in India and other emerging nations. The desire for more variety in value-added meals has risen as a result of rising urbanization and disposable income. The demand for meat products is being fueled by an increase in per capita income as well as the fact that meat is a rich source of high-quality proteins.Most customers now prefer traditional meals with health advantages due to increased awareness. The majority of traditional meat products are packed of antioxidants, saliva-releasing fluids, and traditional herbs and exotic spices that enhance peristaltic movement and lessen constipation. Consuming certain of the goods, nevertheless, is linked to a higher risk of coronary heart disease.

Excursions for eating

Over the last several decades, there has been a sharp increase in the number of people eating supper outside their homes. On these occasions, the majority of people/families choose to eat foods whose technology are obscure or whose consumption at home is challenging because of some social stigma.

The "Eating out phenomenon" is being seen by the rapid expansion of fast-food chains, which is evident from the large crowds of people purchasing traditional meat items from roadside sellers. The meat business now faces a new issue as a result of the rise in traditional meat eating outside the home: how to combine classic flavours with cutting-edge technology.

Traditional meat items have been produced and marketed more often in our nation throughout the years. According to estimates, more than 70% of Indians do not eat vegetarian food. Due to its significant socioeconomic impact, the conventional meat products business requires scientific advancement.

There is room for both sanitary manufacturing and advancements in the conventional methods used to create and prepare these meat products, improving both the goods' quality and shelf-life. It may be attempted to extend their shelf life, make safe food accessible to customers, expand their marketing, and encourage exports using locally available wild herbs and plant extracts. As a result, it is necessary to upgrade all pertinent parts of the technology used to make conventional beef products.

Traditional Indian Meat Product Types

Different varieties of red and white meats are utilized to produce indigenous meat items in various regions of the nation depending on the location of origin as well as cultural and religious influences. In order to market the goods and increase the nutritional security of the people in our nation, efforts are being undertaken in all relevant fields to record and update the processing technology along scientific lines. Based on their geographic origin and level of appeal, the native meat products may be roughly divided into four groups.

Eastern region meat products

Prepared using salt, spices, and condiments to flavour pieces of bone-in chevon or mutton. Either the chunks are cooked without marinating or they are cooked with salt, spices, sauces, and sour curd. After being fried, the beef pieces are simmered till soft over a low burner. Mutton, onions, spices, condiments, sour curd, and lemon juice are used to produce this meat product. The product is eaten with rice or chapati.The meat dish mutton korma is also well-liked in northern India. The finished dish is made by frying medium-sized chunks of previously marinated beef in ghee with herbs, spices, and onions. In a skillet with a cover, the meat is cooked over a low heat while curd is added and the cooking is maintained until the meat is soft. While korma may be made using lamb, chicken, or chevon, rapka is made with yak and Mithun meat and is quite well-known in Arunachal Pradesh. This semi-dry pork product with a smokeyflavour is cooked in bamboos that are held over a traditional fire source for days.

Western, Southern, and Eastern Region Meat Products

In the western portion of the nation, there are a number of traditional meat items that are created, although the majority of them are unrecorded and need scientific study. Meat buns made from hog ham or shoulder are among the most well-known items. Vindaloo, which is made from pickled meat pieces that are deep-fried, is another. Shakudi is a dish made by simmering meat in coconut milk or shredded coconut with spices. The curries, fried foods, and biryanies made from chicken, mutton, and chevon are spicier and hotter in the south of India than in other regions. In places like Andhra Pradesh and Tamil Nadu, biltonga dried and salted meat productis well-liked. In the country's northeast, ethnic and tribal groups produce a wide variety of traditional meat items. These goods are made and maintained using regional customs. Some of these meat preparations, which contain chicken, chevon, beef, or mutton, are kept for months or years[7], [8].

Different regions of India produce various traditional meat products. Some of these items have grown in popularity on a national level and can be found in restaurants both domestically and overseas. Traditional meat products help local communities by generating income and providing nourishment. For some of these indigenous meat products, processing technology has to be documented, standardized, and modernized right away. It will take work to research the specifications for packaging and create solutions that are appropriate for locally produced meats. Further investigation is required to extend the shelf life of certain native meat products in natural and eco-friendly methods, such as by employing plant extracts and packaging made of biodegradable or cellulose-based materials[9], [10].

CONCLUSION

Traditional Indian meat products are a monument to the nation's rich culinary history thanks to its distinctive regional flavours and long-standing customs. They have been a source of pride and cultural identity in addition to supplying food. The manufacturing of these local meat products must be documented, standardized, and modernized, however. Even if they have a lot of promise, efforts are needed to guarantee their sustainability and calibre. Their attractiveness and marketability may be increased by research and innovation in packaging, preservation, and shelf-life extension. India must embrace the fusion of traditional practices with cutting-edge processing technology as it develops in order to satisfy customer needs while retaining the true flavour and fragrance of these prized meat products. The effort to preserve India's culinary legacy is as dynamic and varied as the country itself, providing future generations with a mouthwatering taste of tradition.

REFERENCES:

[1] W. Albarracín, I. Sánchez, and C. Villegas, "Hair sheep lamb meat ageing-an instrumental color analysis," *Vitae*, 2016.

[2] J. H. Choe, A. Stuart, and Y. H. B. Kim, "Effect of different aging temperatures prior to freezing on meat quality attributes of frozen/thawed lamb loins," *Meat Sci.*, 2016, doi: 10.1016/j.meatsci.2016.02.014.

[3] F. Iida *et al.*, "Changes in taste compounds, breaking properties, and sensory attributes during dry aging of beef from Japanese black cattle," *Meat Sci.*, 2016, doi: 10.1016/j.meatsci.2015.10.015.

[4] R. McClelland *et al.*, "Accelerated ageing and renal dysfunction links lower socioeconomic status and dietary phosphate intake," *Aging (Albany. NY).*, 2016, doi: 10.18632/aging.100948.

[5] M. Florek *et al.*, "Effect of Vacuum Ageing on Instrumental and Sensory Textural Properties of Meat from Uhruska Lambs," *Ann. Anim. Sci.*, 2016, doi: 10.1515/aoas-2015-0084.

[6] K. Abuelfatah, A. B. Z. Zuki, Y. M. Goh, and A. Q. Sazili, "Effects of enriching goat meat with n - 3 polyunsaturated fatty acids on meat quality and stability," *Small Rumin. Res.*, 2016, doi: 10.1016/j.smallrumres.2016.01.001.

[7] A. K. Biswas, S. Tandon, and C. K. Beura, "Identification of different domains of calpain and calpastatin from chicken blood and their role in post-mortem aging of meat during holding at refrigeration temperatures," *Food Chem.*, 2016, doi: 10.1016/j.foodchem.2016.01.031.

[8] A. K. Subbaraj, Y. H. B. Kim, K. Fraser, and M. M. Farouk, "A hydrophilic interaction liquid chromatography-mass spectrometry (HILIC-MS) based metabolomics study on colour stability of ovine meat," *Meat Sci.*, 2016, doi: 10.1016/j.meatsci.2016.02.028.

[9] P. A. C. da Luz, A. M. Jorge, C. D. L. Francisco, J. L. M. de Mello, C. T. Santos, and C. Andrighetto, "<b>Chemical-physical characteristics of buffalo (*Bubalus bubalis*) meat subjected to different aging times," *Acta Sci. Anim. Sci.*, 2017, doi: 10.4025/actascianimsci.v39i4.36799.

[10] D. Liu, X. Chen, J. Huang, M. Huang, and G. Zhou, "Generation of bioactive peptides from duck meat during post-mortem aging," *Food Chem.*, 2017, doi: 10.1016/j.foodchem.2017.05.094.

CHAPTER 6

REVOLUTIONIZING MEAT SNACKS: EXPLORING INNOVATIONS IN QUALITY, NUTRITION, AND PRODUCTION TECHNIQUES

Mohamed Jaffar A, Professor
Department of ISME, ATLAS SkillTech University, Mumbai, Maharashtra, India
Email Id- mohamed.jaffar@atlasuniversity.edu.in

ABSTRACT:

Snacking has become a crucial component of contemporary eating habits since it may satisfy a person's immediate hunger while also providing convenience and a variety of tastes and textures. Due to their high nutritional value and pleasing flavour profiles, meat snacks, a subsection of the snack business, have become more popular. Meat snacks are in line for a revolution in terms of quality, nutrition, and manufacturing methods thanks to an ever-growing customer base. Meat snacks are different from ordinary snacks since they have a longer shelf life, more salt and spices, and little water activity. Innovations in snack formulations that include meat have enhanced both the nutritional profiles and the sensory experiences. Novel meat treats with distinctive forms, textures, and flavours have become possible because to improvements in processing techniques, such as extrusion technology. Additionally, the desire for naturally produced, minimally processed meat snacks has produced items free of synthetic chemicals and preservatives, in line with the ideals of green consumerism. The snack market is evolving as a result of urbanization, shifting customer tastes, and changing lifestyles. Innovators have focused on improving the quality, nutritional content, and all-around appeal of meat snacks in particular. This essay explores the world of meat snacks, looking at novel manufacturing methods, flavour combinations, and packaging ideas. We look at how a variety of consumer needs are being met by meat snacks and talk about how they may completely change the snack industry.

KEYWORDS:

Business, Meat Snacks, Preservatives, Snack Industry, Snack Market.

INTRODUCTION

Snacks are food items that are often eaten in between meals to sate temporary hunger and partly meet nutritional and energy needs. The food industry's fastest-growing categories are snacks because of changing eating patterns brought on by industrialization, urbanization, nuclear families, availability in a broad range of varieties, and increased sensory qualities. The meat snack industry is focused on further enhancing the quality and storage stability of conventional meat snacks as well as the introduction of novel products with enhanced nutritional value, functional qualities, more convenient and compact packaging, and enhanced organoleptic attributes, such as improved flavour, taste, appearance, packages, etc. Opportunities for workers, customers, and professionals in the meat business have risen as a result of this. Snacks are quick-to-eating or easy-to-prepare food items often consumed in between meals to satiate temporary hunger and provide energy, protein, minerals, etc. The American Heritage dictionary defines snacks as "food eaten between meals" or a "hurried or light meal." A snack as an easy-to-eat or easy-to-prepare food item that is small in size, hot or cold, solid or liquid, and meant to sate an instant want for food. Snack foods contribute significantly to our diet by providing the nutrients and energy we need[1], [2].

These often come in a variety of scents, tastes, and smells and are portable and tiny. Everyone in society like snacks, including children, school-age children, adolescents, adults who are working, and seniors. However, there are a number of other factors that influence snacking, including availability, meeting or event options, psychological or emotional stimuli, cultural traditions, genetic make-up, the tendency to eat more snacks when with others, and a variety of environmental factors, including workload pressure, health issues, and personal habits. Essential nutrients such dietary fibre, iron, folate, vitamin E, C, and monounsaturated fatty acids are found in significant amounts in snacks. Snacks are typically divided into the following three categories: first-generation snacks, second-generation snacks, and third-generation snacks. Traditional snacks, on the other hand, are often produced from cereal-based ingredients like pulses, potatoes, and fat and are thought to be higher in calories than nutrients. The foundation of vegetable snacks is grain or wheat, as opposed to the conventional meat snacks like meat jerky, meat sticks, and kilshi. The quality and amount of the components used during preparation determine the qualities of these classic treats made of flour. They are low in lysine, threonine, and tryptophan, three important amino acids. These snacks' nutritional quality and organoleptic qualities increased as a consequence of the processing step when meat was added as an animal protein source. Such meat-based snacks are becoming more popular every day as a result of rising knowledge of and interest in animal protein. Additionally, meat snacks are currently quite popular, much like snacking on potato chips or cookies, due to the availability and inclination for high protein diets. The meat snack sector is concentrating on creating unique meat snacks with increased organoleptic properties, such as flavour, look, crispiness, scent, and taste, as well as improved functionality and simple packaging. There are more and more meat snacks on the market that claim to be natural and free of artificial ingredients, colours, or preservatives due to the rising customer desire for minimally processed and green consumerism[3], [4].

The preparation of beef snacks

Extrusion technology is essential in the production of meat snacks in a variety of forms, dimensions, and sizes. Extrusion is a manufacturing process that involves forcing raw materials through a die to create products with set cross sections or puff dry extrudates with fine finishes. Additionally, during extrusion, a number of other processes including heating, expanding, grinding, mincing, melting, altering texture, mixing, etc. are also carried out. By using extrusion technology, deboned meat may be securely compressed and moulded into the appropriate shape of snacks, and cereals, tubers, and their derivative food items can be readily changed into snack foods. Fish crackers, French fries, meat papad, meat biscuits, meat noodles, meat croquets, and other snacks with the necessary dimensions may be created by employing various shapes and sizes of extruder die and their modifications, such as single screw, multiple screw, and twin-screw extruders. Extrusion technique is used to make a large number of snacks, mostly meat-based nibbles. Meat has been blended with other non-meat ingredients, such as flours, to create meat and cereal-based treats using extrusion technology.

DISCUSSION

The snack business used extrusion technology for the first time in 1930 to create corn curls. This technique was subsequently utilized for the creation of improved/advanced categories of snacks. Extrusion processes may be broadly categorized into two groups: hot extrusion and cool extrusion. Cold extrusion is done at normal temperature and used to make ready-to-cook/prepare snacks like spaghetti, while hot extrusion is done at higher temperature and used to prepare ready-to-eat snacks like meat biscuits and meat papads. In hot processing, the raw materials are heated to a high temperature, which allows the product's cooking to be finished during extrusion and keeps the raw materials more pliable for passing through dies[5], [6]. Extrusion rate, raw material size and type, water content, barrel temperature, and screw speed all affect how food is cooked. Due to its technical benefits, extrusion technology is preferable over conventional techniques for making beef snacks. Extrusion cooking offers the following additional benefits in addition to cooking:

1. The complex interactions between protein, fat, and starch during extrusion increase the textural qualities of meat snacks, including texture, shear force, hardness, and chewability.
2. It makes snack protein more palatable and digestible.
3. It destroys contaminants and naturally occurring antinutritional substances found in raw materials.
4. Extrusion cooking improves microbiological quality and storage stability while reducing the microbial burden in the finished goods.
5. It starts a number of structural and rheological changes in starch, including starch gelatinization, starch breakdown, and starch conversion.
6. Heat-labile vitamins are destroyed during extrusion due to the high temperature.

Some meat treats are covered or encased in a batter made of a combination of edible ingredients, including flours and entire egg liquid. These surround items in a thin edible coating that improves their acceptability, texture, colour, and taste, increases crispiness, maintains juiciness by avoiding moisture loss, uses less oil while frying, and offers mechanical protection. The sensory, instrumental, and microstructural characteristics of extruded snack items are all associated with the quality assessment, which combined influence the overall acceptance of these snacks. Textural characteristics of snacks, such as shear force, expansion, chewiness, gumminess, density, hardness, crispiness, etc., have a significant impact on how well-liked and marketable they are. As a lower than usual value implies a lower bulk density, a larger expansion ratio, and a higher water absorption by products, the shear force of meat snacks should be within the permitted range. Due to low moisture levels, expansion reduced as the amount of meat in snacks increased. Snacks of the extruded sort are often kept fresh and packed in laminated pouches for convenience.

Key characteristics of meat snacks

There are several types of beef snacks that are easily accessible on the market. This takes shape via the use of extrusion technology and other processing methods including smoking, coating, curing, grilling, and frying, among others. Snacks made with meat have less water activity. These foods include more salt and spices than other foods. All of these qualities increase shelf life, keep them stable at room temperature, and improve their aesthetic appeal. Traditional cereal-based snacks lack important amino acids such threonine, lysine, and tryptophan but are high in energy. Meat-incorporated snacks have a high nutritive value with providing necessary amino acids content and high biological value animal protein with increased organoleptic qualities such as like flavour and taste. These snacks are prepared by substituting a portion of cereal flours with meat. These are regarded as low-calorie food items that are nutrient-dense. With the development of healthier meat snacks, they have surpassed the majority of other meat products on the market because to factors like low salt, high fibre, and low-calorie content. Meat snacks have a highly crispy texture, are brittle, have enticing looks and colours, and have a fiery, spicy taste, all of which obviously make them popular with consumers[7], [8].

Cookies and biscuits with meat

The Latin words "Bis" and "Coctus" are the source of the English term "biscuit." One of the most popular snacks enjoyed by people from all social groups worldwide is biscuits. The majority of biscuits are cereal-based snacks with significant levels of fat and calories but little to no tryptophan, threonine, or lysine. Utilizing meat in the form of minced meat or meat powder enhances sensory qualities such as taste, smell, and scent in addition to nutritional quality. The quality of meat biscuits is significantly impacted by how meat powder is made.

Pasta with meat

Essentially a cereal-based snack, noodles are quite popular in Asia because of their taste, nutrition, prolonged shelf life at room temperature, versatility, affordable pricing, and variety. According to Forbes, the worldwide market for noodles is expected to reach $46.73 billion in 2018. Numerous experiments have been done to improve the nutritional value and usefulness of noodles by partly substituting meat for other flours while making noodles. Noodles are made by extruding them, then steaming them to finish the gelation process before drying them in a hot air oven. Verma et al. replaced whole wheat flour in the dough for the noodles, formed them into noodles, and then cooked them in a hot air oven at 65 2°C for the necessary amount of time to integrate the meat. Rice flour, corn starch, salt, dry cardamom, nutmeg, anise, black pepper, capsicum, fenugreek, clove, coriander, cumin seed, and turmeric powder were other essential materials utilized in the creation of the chicken meat noodles. As the amount of chicken meat in the noodles rose, there was a considerable rise in the indexes measuring ash, protein, fat, moisture, and water absorption. Natural preservatives such EDTA, chitosan, eugenol, and peppermint were added to chicken noodles by Khare et al., who observed an improvement in the shelf life of the product. Tenderized chicken flesh was combined with refined wheat flour, spices, vegetable oil, and salts to create a dough for making chicken noodles. Noodles were created by cold extruding the dough. The fresh noodles were steamed for 12 minutes to gelatinize them, then quickly chilled to solidify them. The noodles were placed in a drying cabinet tray. Mostly because they are convenient, a nutritious snack option, and a meal substitute, meat snacks play a significant role in our lives. Several technical innovations have been created to manufacture meat snacks with useful qualities from relatively less expensive sources of meat, such animal byproducts.

The international snack sector is undergoing a significant shift in an age of changing dietary habits and lifestyles. In response to the needs of health-conscious customers looking for enjoyable and nutrient-dense alternatives, meat snacks have developed as a dynamic and inventive category among the various snack choices available. "Revolutionizing Meat Snacks: Exploring Innovations in Quality, Nutrition, and Production Techniques," a thorough investigation, looks into the varied world of meat snacks. This study provides a comprehensive knowledge of how meat snacks are setting the way for the future of snacking, from their long history to cutting-edge manufacturing techniques [9], [10]. Snacks have changed from occasional diversions to crucial parts of daily nutrition in an era when time limitations, urbanization, and evolving dietary habits have become the norm. They fill the void between meals and provide rapid enjoyment, convenience, and a variety of flavours. Meat snacks stand out among these snack choices as nutritious powerhouses that appeal to a constantly expanding customer base. Meat nibbles are a prestigious niche of the snack market, loved for their lengthy shelf life, intense flavour, and significant nutritional content. Meat snacks are going through a transformation as customers get pickier. This investigation delves into the ground-breaking innovations in manufacturing methods, flavour profiles, packaging ideas, and nutritional improvements that are changing the face of meat snacks.

A Brief History of Meat Snacks

Meat snacks have a long history that dates back to a time when they were essential for surviving. What started out as crude food preservation techniques has now developed into a gourmet business that tantalizes taste senses and fits contemporary lifestyles. The improvement in quality and nutritional value is one of the main aspects of the meat snack revolution. To obtain a longer shelf life, traditional meat snacks sometimes depended on high salt and spice contents. Modern customers, however, want more from their munchies. Innovations in meat sourcing, component choice, and processing methods have resulted in meat snacks that not only satiate hunger on the spot but also provide a variety of vital nutrients.We look at how meat snacks are broadening their horizons, from convenience-friendly meat noodles to protein-packed meat biscuits and cookies. The addition of meat to snack recipes enhances the food's nutritional profile as well as the sensory pleasures. The category of meat snacks has expanded beyond jerky and sticks to include a variety of goods, each with special qualities.

Extrusion technology and production methods

Utilizing cutting-edge manufacturing methods is essential to the transformation of meat snacks, with extrusion technology taking the lead. Production of meat snacks has been transformed by extrusion, a technique that involves pushing raw materials through a die. It enables the production of unique forms, measurements, and textures, providing customers with an engaging snacking experience. Extrusion technology is the main driving factor behind innovation in meat snacks, whether it's in the form of fish crackers, meat papads, or meat noodles.

Organicity and Sustainability

The meat snack sector is promoting green consumerism in response to consumers' increased desire for natural and sustainable goods. Nowadays, many meat treats advertise their naturalness by being free of artificial preservatives, colours, or chemicals. This is in line with the modern concept of conscientious consumption and appeals to snackers who are concerned about their health.

Innovations in packaging and quality assessment

Quality assessment criteria have been improved in order to guarantee that meat snacks continue to appeal to consumers while also living up to their expectations. These criteria, which include sensory qualities, instrumental evaluations, and microstructural evaluations, together determine the general acceptance of beef snacks. Innovations in packaging are equally important. Transportable, shelf-stable, and able to maintain their attractiveness over time are all requirements for meat snacks. This packaging revolution includes laminated pouches, practical package styles, and eco-friendly materials.

Meat snacks are positioned to lead the way with their unique approach to quality, nutrition, and manufacturing methods as the snack market goes through a significant shift. Meat nibbles have come a long way from their historical origins as survival food to their present position as culinary pleasures. The meat snack market is booming as customers look for solutions that are healthier, more practical, and tastier. Meat snacks are no longer just available in their traditional forms; they now include a wide variety of goods that may be customized to suit a person's taste and nutritional needs. Particularly with the aid of extrusion technology, meat snacks have been able to develop and vary, providing customers one-of-a-kind forms and textures. The dedication to sustainability and naturalness promotes meat snacks as leaders in green consumption. These snacks are in line with the ideals of conscientious customers since they don't include artificial ingredients or preservatives.

CONCLUSION

Meat snacks are positioned to lead innovation in the constantly changing world of snack foods. The meat snack market has reacted to customers' growing demand for healthier, more practical, and tastier alternatives with a wave of improvements in quality, nutrition, and manufacturing methods.The addition of meat to snack recipes has increased both the nutritional content and the sensory appeal of the snacks. Meat snacks today include a variety of foods, from meat biscuits and pastries to meat noodles, and are no longer only classic meat jerky or meat sticks. The future of meat snacks has been significantly shaped by the use of extrusion technology, which has made it possible to produce novel forms and textures that appeal to a variety of customer tastes. Additionally, the emphasis on sustainability and naturalness has produced meat snacks devoid of artificial additives and preservatives, in line with the ideas of green consumerism. As time goes on, the meat snack market expands its boundaries while providing customers with a tasty and wholesome snack option. Meat snacks are expected to stay at the top of the snack industry with further research and development, reinventing how we savour and enjoy these practical and delicious delicacies.

REFERENCES:

[1] F. Wu, K. Wills, L. L. Laslett, B. Oldenburg, G. Jones, and T. Winzenberg, “Associations of dietary patterns with bone mass, muscle strength and balance in a cohort of Australian middle-aged women,” *Br. J. Nutr.*, 2017, doi: 10.1017/S0007114517002483.

[2] J. Zochowska-Kujawska, M. Kotowicz, K. Lachowicz, and M. Sobczak, “Influence of marinades on shear force, structure and sensory properties of home-style Jerky,” *Acta Sci. Pol. Technol. Aliment.*, 2017, doi: 10.17306/J.AFS.0508.

[3] Y. Cao, A. W. Taylor, G. Wittert, R. Adams, and Z. Shi, “Dietary patterns and sleep parameters in a cohort of community dwelling Australian men,” *Asia Pac. J. Clin. Nutr.*, 2017, doi: 10.6133/apjcn.122016.03.

[4] K. E. Bradbury, T. Y. N. Tong, and T. J. Key, “Dietary intake of high-protein foods and other major foods in meat-eaters, poultry-eaters, fish-eaters, vegetarians, and vegans in UK biobank,” *Nutrients*, 2017, doi: 10.3390/nu9121317.

[5] R. Hutami, E. Zain, and R. Theo, “Saluran Distribusi Produk Pangan Jajanan Anak Sekolah (Pjas) Berbasis Olahan Daging Distribution Channel of Meat Based Snack That Is Consumed By School Students,” *J. Pertan.*, 2017.

[6] Siswanti, P. Y. Agnesia, and R. B. Katri A., “Pemanfaatan Daging dan Tulang Ikan Kembung (Rastrelliger kanagurta) dalam Pembuatan Camilan Stick,” *J. Teknol. Has. Pertan.*, 2017.

[7] A. SINGH, K. BAINS, and H. KAUR, “Relationship of food consumption with eating behaviours of professional women,” *ASIAN J. HOME Sci.*, 2017, doi: 10.15740/has/ajhs/12.2/515-521.

[8] Z. Sui, D. Raubenheimer, and A. Rangan, “Exploratory analysis of meal composition in Australia: Meat and accompanying foods,” *Public Health Nutr.*, 2017, doi: 10.1017/S1368980017000982.

[9] W. Boonchoo, Y. Takemi, F. Hayashi, K. Koiwai, and H. Ogata, “Dietary intake and weight status of urban Thai preadolescents in the context of food environment,” *Prev. Med. Reports*, 2017, doi: 10.1016/j.pmedr.2017.09.009.

[10] H. Gibbons *et al.*, “Metabolomic-based identification of clusters that reflect dietary patterns,” *Mol. Nutr. Food Res.*, 2017, doi: 10.1002/mnfr.201601050.

CHAPTER 7

MAXIMIZING VALUE FROM MEAT INDUSTRY BYPRODUCTS: UNLOCKING THE POTENTIAL

Thiruchitrambalam, Professor
Department of ISME, ATLAS SkillTech University, Mumbai, Maharashtra, India
Email Id- thiru.chitrambalam@atlasuniversity.edu.in

ABSTRACT:

India's agricultural landscape has long been dominated by the meat industry, which has greatly influenced the country's economy and nutritional choices. Beyond the delicious cuts of meat that adorn our dinners, this industry also creates byproducts that are often disregarded, which represent a hidden treasure of resources that have mostly gone untapped. India produces a significant amount of the country's meat via its hundreds of legal slaughterhouses, bolstered by countless unlicensed enterprises. Nevertheless, this business offers a fantastic chance to maximize the value of the byproducts associated with meat manufacturing. There are a startling number of approved and unlicensed slaughterhouses in India, generating a sizable amount of meat and its related byproducts. These byproducts have historically been underused resources while making up up to 60% of an animal's weight. But it's important to realize their immense potential, especially in terms of economic worth and environmental sustainability. This study discusses the many options provided by byproducts of the meat business, from pet food and cattle feed to medicinal extracts and biofuels. By effectively using these leftovers, the country's economy can grow and the environment can be cleaned up, resulting in a more sustainable and prosperous future.

KEYWORDS:

Business, Economy, Meat Industry, Sustainability, Slaughterhouse.

INTRODUCTION

The nation has roughly 3,900 licensed slaughterhouses that have been approved by regional organizations. There are also over 26,000 unlicensed slaughterhouses. However, the Agricultural and Processed Food Export Development Authority (APEDA) already has 13 export-oriented, contemporary, integrated abattoirs or meat processing facilities registered with them. Additionally, there are 24 meat packing and processing facilities that accept dressed corpses from authorized municipal slaughterhouses for exporting meat. In addition to the primary commodity, meat, the slaughtering and other meat processing operations provide important byproducts. All parts of a killed animal, except the dressed carcass commonly known as the offal or fifth quarter, may be considered slaughter byproducts or meat industry byproducts. It may make up 40–60% of the animal's entire weight and is often not used to its full capacity[1], [2].

Environmental sustainability is linked to the management of byproducts. Because they are so high in non-biodegradable organic matter, by-products from the livestock business have the potential to harm the environment if they are not handled properly and disposed of without any treatment. There has been a lot of uproar in the public against the construction of any slaughterhouse in their area due to the terrible and revolting odour that comes from decomposing organic byproducts. Wastewater discharge from the animal processing sector has a significant negative influence on the environment. The animal business uses a lot of water for its many processes, including washing, cleaning animal waste, sanitizing slaughterhouse flour, and providing water to animals. The release of waste waters with a high potential for pollution may lead to oxygen deprivation and eutrophication, which will kill aquatic life. Animal proteins and other nutrients that may have been used for human and animal nutrition are lost when animal byproducts are disposed of without being consumed. It is thus crucial that all the leftovers and byproducts from butchering be turned into marketable goods.

Making Use of the Meat Processing Industry By-products

As was already established, the usefulness of byproducts from the animal sector is enormous, and their efficient use always necessitates technical intervention. the several common applications for animal byproducts. Animal byproduct value addition is seen as a potential strategy for effective usage without jeopardizing the health of the ecosystem. A commodity's economic development and the incorporation of qualities that make it more appealing to a market are known as value addition. Although consumer spending on goods is not as high as it is in other nations, the reliance on value addition may create a niche market. A range of processes, including emulsification, restructuring, and enrobing, are now widely employed to add value to animal sector leftovers. Steaks, chops, cutlets, and other meat products are all being processed using meat and byproducts in a predetermined ratio. This contributes to both a decrease in the price of meat products and an increase in the value and flavour of leftover meat[3], [4].

Cattle Feed Animal byproducts, such as carcasses that have been condemned, may be used as a supplement to feed for cattle and poultry. Quality protein may be found in animal blood, which is also a significant food waste. It is widely used to make things like blood sausages, blood pudding, and biscuits. However, it is used in the creation of blood meal, which is used as cattle feed. The benefits of feeding these leftovers to animals promise improved health and output. The 10% level of addition in feed aids in supplying the necessary amounts of amino acids like lysine, tryptophan, and methionine. Pigs and fowl of any age may consume meat meal as part of their meals.

Additionally, bone meal, a combination of crushed bones, is fed to cattle. It is a source of calcium and phosphorus, which are found in a 1:2 ratios. There is also prepared meat-and-bone meal that may be given to animals. Feather byproducts from the poultry industry, such as feathers, may be made into feather meal. Due to the fact that feathers are strong pollutants, this not only promotes greater feather consumption but also minimizes environmental deterioration. The keratin in the feathers is resistant to degradation at low temperatures. As a result, the digestibility is not entirely certain. Feathers may be biodegraded by keratinolytic microorganisms like Bacillus linciformisas a technical intervention.

DISCUSSION

Offal’s and slaughterhouse byproducts can be used to make pet food, meeting the nutritional needs of all pet types, including those with different age ranges and physiological needs that necessitate animal protein intake while saving grains for human consumption. Additionally, it will aid in reducing the financial losses and environmental damage brought on by the disposal of animal byproducts.

Utilizing slaughterhouse waste in pet food formulation will increase the makers' selection of ingredients. This will offer doors for the creation of jobs as well as rising revenue for the owners of slaughterhouses and pet food producers. Since animal proteins constitute an essential component of pets' diets, by-products from the meat processing industry, such as tripe, brain, spleen, bones, liver, lung, kidney, and gizzard, have a high nutritional value and may be effectively used to make pet food. The liver, tail, ear, and foot of cattle have equal protein contents to that of lean meat, and the vitamin content is much greater than that of lean meat tissue. Pork tail contains the greatest fat and lowest moisture content of all meat byproducts.

Fertilizers

Depending on the nature of the raw material, the resulting product may either be utilized as fertilizer or animal feed. While material that is polluted and decayed is ideal for the creation of fertilizer, material that is clean and fresh is utilized to produce decent animal feed. Animal waste may be a useful resource for soil improvement and agricultural fertilizer. via the supply of carbon and nutrients that feed the microorganisms or via greater plant development, which in turn contributes organic matter, their application enhances the health of the soil. Higher infiltration, greater moisture, and nutrient retention result from their application. The application's drawback is that soil structure may be harmed due to compaction, and additional pollutants like salts and metals may be introduced. Good management techniques may, however, help to mitigate these risks.

Byproducts of pharmaceuticals

Animal byproducts like glands provide a variety of chemical extracts with uses in both medicine and cosmetics. Many enzymes and hormones are secreted by these glands, including the pituitary, the adrenals, the liver, and the lungs. Only healthy animals are used to collect the glands and tissues, and since certain glands are often tiny and covered in other tissue, finding them might be challenging. The role of many key glands in animals varies depending on the species, sexes, and ages of the animals. The majority of glands may be preserved most effectively by being quickly frozen without affecting their active ingredient. The glands need to be cleansed and freed of any excess fat and connective tissue before freezing. They are carefully wrapped and kept at -18 °C for storage. The glands are then defatted, dried, and turned into a powder, which is subsequently administered as capsules or tablets[5], [6].

Lard and Tallow

Lard and tallow are the main edible animal fats, and animal fats are significant byproducts of the livestock industry. While lard is made from rendered pig fat, tallow is made from rendered beef or sheep fat. Both dry and wet rendering techniques are used to produce them. Today, a significant portion of the fats utilized in meals and other non-food uses come from animal sources. A flexible, sustainable, and natural foundation for many things is animal fat. They are utilized all around the world in things like explosives, paint, soap, lubricants, pesticide, and wax. The lard or tallow is often bleached and deodorized before to being used as an ingredient in food.

Biodiesel Manufacturing

Because they are used up quickly without adequate replenishing, energy sources, particularly those based on petroleum, are decreasing quickly. As a result, people are looking for alternate sources, and biodiesel is one of them. It is created using fat that has been removed from waste goods during rendering. It is harmless and biodegradable, and when burned, it releases fewer offensive compounds than items made from petroleum. Trans esterification is the method used to turn rendered fat into biodiesel. It brings oil/fat's viscosity down to a range of (4-5mm2/s), which is more comparable to petro diesel. The usage of biodiesel is becoming more widespread worldwide. It is typically mixed at a 20 percent ratio with diesel. For this swap, engines' designs do not need to be altered.

Production of Biogas

Animal waste, such as the contents of the GI tract, is digestible and may produce biogas. The waste product is successfully used and helps to provide an effective energy source continuously. The methane potential of mixed animal wastes, which is substantially greater than that of ordinary manure, is 619 dm3kg-1, making animal wastes an excellent substrate for the generation of biogas. By digesting animal feces, power plants have been built to create biogas that contains 60% methane, 30% carbon dioxide, and traces of hydrogen, carbon monoxide, etc. Animal manure is converted to biogas by anaerobic fermentation in airtight containers known as digesters. After being compressed in tanks, the resultant gas is subsequently distributed for consumption. It is used to push turbines and produce steam, as well as power. Additionally, it may be used to cook, heat, light, and even power automobile engines. An essential substance made from bones is gelatin. Gelatin may be roughly divided into edible and inedible types. In the creation of cosmetics, such as nail polish and in photographic sheets and film, inedible gelatin is employed. Gelatin that is edible is utilized in a range of production sectors, including the food and drug industries[7], [8].

Treatment of Waste from The Meat Industry

enormous amounts of water are used in processing processes, such as washing and slaughtering, for sanitary reasons, which results in enormous amounts of wastewater or effluent. The abundance of suspended particles and liquid waste, as well as the stench creation, are the main environmental issues connected to this slaughterhouse effluent. The following steps should be performed to safely dispose of liquid and solid waste.

Division of blood

When an animal is killed, its blood will congeal into a solid mass that might clog both open and closed drains. Therefore, it is advised that the blood be collected and utilized for fertilizer, animal feed, or human consumption. Hooves, hair, bone fragments, solid meat or skin trims, etc. must all be screened. This might be accomplished by installing vertical sieves in the sewers. The inherent disadvantages of the Indian meat business prevent the appropriate use of the by-products of the meat industry. We currently only have a relatively small number of industries that process byproducts. The main limitations are:

1. Insufficient byproduct collection and transportation
2. A lack of facilities for cold storage
3. inadequate bone collecting facilities
4. Poor gathering facilities for dead and falling animals and birds.
5. Unorganized/unscientific butchering.
6. A lack of infrastructure for handling byproducts
7. A lack of professional or trained human resources
8. Activation by moral organizations.

The byproducts of the meat processing sector are quite significant. The country's economy and environmental damage are directly impacted by the effective use of animal byproducts. Lack of or insufficient use of byproducts results in a loss of potential profits as well as increased costs for disposal of waste products, severe aesthetic issues, and significant health issues. The byproducts of the meat business, like as leather, animal feed, pet food, neat's foot oil, gelatin, hormones, and enzymes, may be processed into a number of significant value-added culinary, inedible, and medicinal items that might bring un additional revenue for the meat processors. Facilities must be built immediately for the timely collection, transportation, and processing of slaughterhouse byproducts.

These byproducts, which may make up as much as 60% of an animal's overall weight, are a veritable gold mine of opportunities. The range is broad and promising, including everything from pet food to cattle feed, which supports the country's agricultural efforts, to medicinal extracts used in medicine and cosmetics, to biodiesel used to power our cars. It's interesting to note that correct use of these byproducts not only offers financial rewards but also promotes environmental sustainability. Neglected byproducts may become substantial pollutants, harming local ecosystems and people's health, if they are not handled properly. It explores the many ways in which these byproducts might be turned into worthwhile goods, providing financial rewards, environmental advantages, and the prospect of a more sustainable future. We cordially welcome you to join us in this investigation of unrealized potential and innovation within a sector that has the ability to positively impact our economy and environment as we explore the many uses and advantages of meat industry waste[9], [10].

CONCLUSION

Byproducts of the meat business have significant and varied value. Their effective use may positively affect the economy of the country by reducing pollution and financial losses. Meat processors may be able to make more money by producing different value-added goods such leather, pet food, neat's foot oil, gelatin, hormones, and enzymes. Establishing infrastructure for the prompt collection, transportation, and processing of slaughterhouse byproducts is essential if these advantages are to be fully realized. This endeavour has to be supported by new technologies and creative strategies that make the most of this important and plentiful resource. To ensure a sustainable and successful future for India, we must fully use the potential of meat industry leftovers. The value hidden within meat industry byproducts is substantial and multifaceted. Their efficient utilization can directly impact the nation's economy, alleviating financial losses and environmental pollution. The production of various value-added products such as leather, animal feed, pet food, neat's foot oil, gelatin, hormones, and enzymes has the potential to generate additional income for meat processors. To fully realize these benefits, there is an urgent need to establish facilities for the timely collection, transportation, and processing of slaughterhouse byproducts. This effort should be complemented by technological advancements and innovative approaches that make the most of this abundant and valuable resource. As India continues to grow, it is imperative that we harness the full potential of meat industry byproducts for a sustainable and prosperous future.

REFERENCES:

[1] S. Udhayakumar, K. G. Shankar, S. Sowndarya, and C. Rose, “Novel fibrous collagen-based cream accelerates fibroblast growth for wound healing applications:: In vitro and in vivo evaluation,” *Biomater. Sci.*, 2017, doi: 10.1039/c7bm00331e.

[2] B. J. Kerr, R. Jha, P. E. Urriola, and G. C. Shurson, “Nutrient composition, digestible and metabolizable energy content, and prediction of energy for animal protein byproducts in finishing pig diets,” *J. Anim. Sci.*, 2017, doi: 10.2527/jas2016.1165.

[3] K. Skibniewska, W. Rejmer, P. Drożyner, and K. Szwarc, “Irrigation of energy dedicated crops as a method to utilize the post fermentation effluent,” *Qual. - Access to Success*, 2017.

[4] B. Šojić *et al.*, "The effect of essential oil from sage (Salvia officinalis L.) herbal dust (food industry by-product) on the microbiological stability of fresh pork sausages," in *IOP Conference Series: Earth and Environmental Science*, 2017. doi: 10.1088/1755-1315/85/1/012055.

[5] C. P. Blank, J. Russell, S. M. Lonergan, and S. L. Hansen, "Influence of feed efficiency classification and growing and finishing diet type on meat tenderness attributes of beef steers," *J. Anim. Sci.*, 2017, doi: 10.2527/jas2016.1312.

[6] S. da Silva Sabo, N. Pérez-Rodríguez, J. M. Domínguez, and R. P. de Souza Oliveira, "Inhibitory substances production by Lactobacillus plantarum ST16Pa cultured in hydrolyzed cheese whey supplemented with soybean flour and their antimicrobial efficiency as biopreservatives on fresh chicken meat," *Food Res. Int.*, 2017, doi: 10.1016/j.foodres.2017.05.026.

[7] M. M. Selani *et al.*, "Effects of pineapple byproduct and canola oil as fat replacers on physicochemical and sensory qualities of low-fat beef burger," *Meat Sci.*, 2016, doi: 10.1016/j.meatsci.2015.10.020.

[8] D. Kantachote, T. Nunkaew, A. Ratanaburee, and N. Klongdee, "Production of a Meat Seasoning Powder Enriched with γ-Aminobutyric Acid (GABA) from Mature Coconut Water Using Pediococcus pentosaceus HN8," *J. Food Process. Preserv.*, 2016, doi: 10.1111/jfpp.12654.

[9] N. Charoenphun and W. Youravong, "Utilization of by-products and waste generated from the Tilapia processing industry," in *Tilapia and Trout: Harvesting, Prevalence and Benefits*, 2016.

[10] B. K. McCabe *et al.*, "An investigation into the fertilizer potential of slaughterhouse cattle paunch," in *2016 American Society of Agricultural and Biological Engineers Annual International Meeting, ASABE 2016*, 2016. doi: 10.13031/aim.20162460831.

CHAPTER 8

HARNESSING THE POTENTIAL OF PHYTO-INGREDIENTS FOR ENHANCED MEAT QUALITY AND SAFETY

Shashikant Patil, Professor
Department of uGDX, ATLAS SkillTech University, Mumbai, Maharashtra, India
Email Id-shashikant.patil@atlasuniversity.edu.in

ABSTRACT:

In this article, the many functions of phyto-ingredients in the meat business are examined, with an emphasis on how they could improve the quality and safety of the meat. Due to their antioxidant, flavor-enhancing, and antibacterial qualities, phyto-ingredients natural substances originating from plants have emerged as important additives to the preparation of meat. These substances have shown promise in the search for meat products that are healthier and more natural. The important results presented in the paper are briefly summarized in this study.The shelf life of meat is increased while maintaining its sensory qualities because to the powerful antioxidant characteristics of phyto-ingredients such phenolic compounds, carotenoids, and flavonoids. Beyond serving as antioxidants, these organic ingredients help meat products acquire distinctive and alluring flavours, improving the whole buying experience. Additionally, phyto-ingredients have antibacterial properties that help answer worries about food safety by preventing the development of dangerous microbes in meat products. The meat sector is leading this transition as customers increasingly look for functional meals with health advantages, using phyto-ingredients to develop goods that suit these changing desires. The paper emphasizes the need of cooperation among industry stakeholders, researchers, and regulatory agencies to advance the development of functional meat products enhanced with these natural chemicals. It also highlights the potential of phyto-ingredients in influencing the future of meat processing.

KEYWORDS:

Proteomics, Protein, Phenolic Compounds, Phyto-Ingredients, Stakeholders.

INTRODUCTION

In order to represent the protein, complement of the genome and to denote the precise influence of genes and proteins in biological sciences, the word "proteome" was developed during the post-genomic era. Mass spectrometry analysis and fractionation methods are the two main pillars of proteomics, an expanding field that studies the structure, function, and interaction of proteins. The researchers have been able to investigate biomarkers as indications of meat quality, safety, and authenticity because to the proteomic technologies' robustness. In the last several decades, proteomics, which is thought of as the molecular connection between the genome and the functional quality attributes of food, has been widely used to solve the fundamental issues of meat quality and to identify the biomarkers of the quality attributes[1], [2].

In recent years, there has been a growing recognition of the critical role that phyto-ingredients, natural compounds found in plants, play in enhancing the quality and safety of meat products. As consumer preferences shift towards healthier and more natural options, the meat industry has been exploring innovative ways to improve the nutritional profile and shelf life of its products. This article delves into the diverse applications of phyto-ingredients in the meat industry, focusing on their antioxidant properties, their role in flavor enhancement, and their potential to address food safety concerns.

Antioxidant Power of Phyto-Ingredients

One of the foremost challenges in meat processing is preventing lipid oxidation, which can lead to rancidity and deteriorating product quality. Phyto-ingredients, rich in antioxidants, have emerged as a natural solution to combat this issue. Compounds such as phenolic compounds, carotenoids, and flavonoids present in plants have potent antioxidant properties. When incorporated into meat products, these natural antioxidants can effectively inhibit the formation of free radicals, thereby extending the shelf life of meat and preserving its sensory attributes.

Flavor Enhancement through Phyto-Ingredients

Phyto-ingredients are not only valuable for their antioxidant capabilities but also for their ability to enhance the flavor of meat products. Certain compounds found in plants, such as polyphenols, can impart unique and desirable tastes to meats. These natural flavor enhancers can contribute to the overall sensory experience of consumers, making meat products more appealing.

Addressing Food Safety Concerns

Apart from their antioxidant and flavor-enhancing properties, phyto-ingredients also have the potential to address food safety concerns. Some of these natural compounds exhibit antimicrobial properties, which can help inhibit the growth of pathogenic microorganisms in meat products. This dual role in both enhancing quality and safety makes phyto-ingredients a valuable asset for the meat industry.

The Future of Functional Meat Products

As consumers increasingly seek foods that offer health benefits beyond basic nutrition, the meat industry is poised to meet these demands through the development of functional meat products. Phyto-ingredients, with their wide array of health-promoting properties, can play a pivotal role in this endeavor.

These natural compounds have been associated with various health benefits, including antioxidant, anti-inflammatory, and cardioprotective effects. With the use of genomics, proteomics, and other "omic" methods, researchers are currently at an exciting time with a wealth of new prospects. Recent breakthroughs in biotechnology have led to the emergence of brand-new fields of study, including genomics and proteomics, which are used to examine the intricate patterns of gene and protein expression in cells and tissues. Our understanding of the molecular structure of living creatures has improved with the ability to concurrently study hundreds or thousands of genetic polymorphisms, transcripts, proteins, and metabolites using specialized arrays or instruments.

These techniques have been used recently to identify genes, proteins, or metabolites whose quantity or degree of expression is related to an interesting characteristic, such as the quality of the meat. Proteomics is regarded as the next phase in the study of biological systems after genomics. Two-dimensional gel electrophoresis, mass spectrometry , and bioinformatics are examples of proteomics tools. Proteomics combines potent separation methods with very sensitive analytical mass spectrometry to enable visualization of the protein composition of the cell under various situations. In a given set of circumstances, proteomic investigations characterize the identity, relative abundance, and status of proteins in a cell. Before further analysis and characterization, all proteomic investigations need for the protein separation and purification of crude samples[3], [4].

Separation of proteins

Separation using liquid chromatography mass spectrometry

Greater sensitivity is possible with a liquid chromatography and mass spectrometry -based technique than is normally possible with protein-staining detection limits using gel-based approaches. Protein identification is carried out in this instance at the level of peptide fragmentation patterns obtained via tandem MS, which are indicative of amino acid sequence.

Mass spectrometric identification of proteins

There is an increasing need for quick and accurate protein identification due to the rapid development of numerous current and finished genome sequencing initiatives. A potent method for identifying proteins in nanogram levels is mass spectrometry. A proteolytic digest of a simple cell lysate may include several hundred thousand peptides, demonstrating the extreme complexity of certain proteomic datasets. Protein identification is a key component of many proteomic techniques, and it is often carried out using MS. Next, mass spectrum data are statistically compared with theoretical data derived from databases of protein sequences, which are created from genomic sequences.

Research in meat science using proteomics

Studies on the mapping of muscle proteins, muscle disorders, muscle physiology, the conversion of muscle to meat, the understanding of meat colour and texture, meat speciation, sensorial and technological meat quality traits, etc. have all been successfully conducted using modern proteomic technologies for understanding muscle biology. Utilizing cutting-edge proteomic techniques, the Proteomics and Meat Quality Laboratory at ICAR-NRC on Meat has been working to provide complex answers regarding meat colour and texture, detection of meat adulteration, identification of peptide biomarkers, understanding muscle food quality, etc. The information collected from these methods is useful for developing and improving quality management systems, guaranteeing the safety and quality of meat, and adjusting quality to meet market demands. Proteomic methods were heavily used to understand the differences in meat quality and texture across various meat animal species. The molecular underpinnings of comprehending the variations between various muscles, age groups, and aging phases have been identified in our laboratory at NRC on Meat, Hyderabad. Our analysis of the proteome profiles of the Longissimus dorsi muscles from buffaloes of various age groups revealed that the meat from older buffaloes had higher myofibrillar and total protein extractabilities, muscle fibre diameters, and Warner-Bratzler shear forces values than meat from younger buffaloes. With the use of two-dimensional gel electrophoresis, proteomic analysis identified 93 proteins that were expressed differently in aged vs young buffalo flesh. After 6 days of aging in young and old buffalo meat, respectively, proteome analysis utilizing 2DE found 191 and 95 differentially expressed protein locations[5], [6].

Using a proteomic method, halal meat authenticity

Animals are often slaughtered without being stunned as part of commercial halal meat production, which is approved by many international organizations but is nevertheless highly contentious in terms of animal welfare. The act of stunning an animal prior to slaughter is generally referred to as "humane slaughter," despite the fact that it is a legal requirement to do so in order to render the animal unconscious and impervious to pain caused by bleeding when using Halal and Kosher conventional methods of slaughter. In addition to various physiological changes, we hypothesized that pre-slaughter stress would alter the electrophoretic mobility of some key proteins, which could lead to up- or down-regulation and prompt us to identify new biomarkers from meat indicating the welfare of the animal prior to slaughter. In order to comprehend the proteome alterations in Nellore crossbred sheep, we undertook a research to ascertain the effects of pre-slaughter electrical shocking on bleeding effectiveness, serum biochemical parameters, physico-chemical quality, and understanding. We either performed conventional halal slaughter without stunning or pre-slaughter electrical stunning followed by slaughter on male Nellore crossbred sheep. Meat from shocked sheep showed higher pH, water retention capacity, and Warner-Bratzler shear force. A panel of protein markers that could distinguish between ST and NST muscle proteomes was discovered utilizing a quantitative proteomic method and DIGE. The quantity of proteins involved in catalytic, structural, and stress-related processes has changed, according to our findings. Between ST and NST samples, there was a difference in the amount of the cytoskeletal protein’s myosin, actin, and troponin. Peroxiredoxin-6, a possible indicator of meat softness, was found in NST samples.

DISCUSSION

Producing and providing consumers with safe food has been the food industry's top priority up to this point. The nutritional and caloric content of foods are becoming just as significant as in the case of functional foods, even though safety is still of utmost concern. A "functional food" is one that offers health advantages over and beyond those of basic nutrition. Currently, "functional foods" are those that, in addition to serving as nutrients, may also improve certain biological processes, enhancing overall health and/or lowering the chance of contracting particular illnesses. Keeping this in mind, efforts are currently being made to develop "healthier" products, or functional meat products, by altering composition and/or processing conditions to prevent or limit the presence of certain potentially harmful compounds, and/or exploring the possibility of including certain desirable substances, either naturally occurring or added externally, with the aim of having subsequently added health benefits.

Thus, adding plant-based components to meat products may be a strategy for introducing useful qualities. Dietary fibre, phenolic compounds, and other naturally occurring phytochemicals that function as antioxidants are just a few of the bioactive components that may be found in plants. Since phenolic compounds exhibit a wide range of physiological properties, including anti-allergenic, anti-artherogenic, anti-inflammatory, anti-microbial, antioxidant, anti-thrombotic, cardioprotective, and vasodilatory effects, they are one of the most prevalent groups of phytochemicals. Furthermore, these substances have been linked to the advantages to health that come from eating a lot of fruits and vegetables. The anti-oxidant activity of phenolic compounds has been linked to the positive benefits they provide. Phenolic molecules may have a significant role in determining the antioxidant capacity of meals, making them a potential source of antioxidants in food products. Polyphenols, quinones, flavanols/flavonoids, alkaloids, and lectins are some of the principal chemical classes found in plant extracts. As a result, adding plant bioactive elements to meat products may provide a number of healthy nutrients, including dietary fibre, antioxidants, and other bioactive chemicals. On the other hand, this strategy will assist in avoiding the usage of artificial additives, which are now largely regarded as detrimental and have been utilized extensively in the meat business[7], [8].

Phyto-ingredients

According to the WHO, a medicinal plant is any plant that contains compounds that may be utilized therapeutically or that serve as precursors for the semi-synthesis of chemo-pharmaceuticals in one or more of its organs. Often referred to as phytoingredients/phytochemicals orphytoconstituents, these non-nutritive plant chemical compounds or bioactive elements are in charge of guarding the plant against microbial diseases or insect infestations. Such a plant will have portions used in the prevention or treatment of a disease condition, including leaves, roots, rhizomes, stems, bark, flowers, fruits, grains, or seeds, and as a result, it includes chemical elements that are therapeutically effective. Bionutrition is the term used to describe the growing body of research on the potential of phytochemicals in food to promote health and prevent illness. On the other side, the study of natural compounds is known as phytochemistry. Important Phyto-ingredients characteristics:

1. Reaction substrate for biological processes
2. Enzymatic reaction cofactors
3. Enzymatic reaction inhibitors
4. Chemical scavengers for hazardous or reactive substances
5. Improve the stability and/or absorption of vital nutrients

Plants' Phenolic Compounds

A class of chemical substances known as phenolic compounds is found frequently in nature. They might be either simple chemicals found in the majority of fresh fruits and vegetables or complex compounds found in plant bark, roots, and leaves. Anthocyanins are a class of polyphenols that give many fruits, vegetables, and flowers their colour. phenolic substances. Carotenoids are lipid-soluble substances connected to the lipidic fractions. Chemically speaking, carotenoids are polyisoprenoid compounds that fall into two main categories: xanthophylls, which are oxygenated hydrocarbon derivatives and contain at least one oxygen function like a hydroxy, keto, epoxy, methoxy, or carboxylic acid group, and carotenes, which are hydrocarbon carotenoids only made of carbon and hydrogen atoms. a group of coloured substances that only plants and microbes, not mammals, can produce. They support the photosynthetic apparatus in plants and shield them from ultraviolet ray harm. Provitamin A is one of the precursors of vitamin A. Xanthophylls are the name for carotenoids with oxygen-containing molecules, such as lutein and zeaxanthin.

The term "carotenes" refers to unoxygenated carotenoids like -carotene, -carotene, and lycopene. Their conjugated double bond system is a structural feature that affects their chemical, biological, and physical characteristics. Nature has several members of this class of natural colours. Since plants and many microbes may produce carotenoids, mammals must consume food to get their daily dose. More than 600 carotenoids have so far been found in natural sources. They are in charge of giving many birds, insects, and marine creatures their stunning colours, as well as the hues of several flowers and fruits. This characteristic is crucial for meals since colour is often used as a quality indicator and is frequently altered during food preparation. In addition, a number of variables, including genetic variation, ripeness, postharvest storage, processing, and preparation, affect the carotenoid concentration in fruits and vegetables[9], [10].

Flavonoids

The most prevalent and extensively occurring class of plant phenolics are flavonoids. Their shared structure is made up of two aromatic rings connected by a three-carbon bridge, often an oxygenated heterocycle. the flavonoid nucleus's fundamental structure and the method utilized to number its carbon atoms. Anthocyanidins, chalcones, flavanols, flavanones, flavones, flavonols, and isoflavones are among the main types of flavonoids. The number of hydroxyls in the A ring and B ring, the presence or absence of a double bond, the hydroxylation of the pyrone ring, and/or an oxygen atom linked to position 4 of the C ring all play a role in the variety of flavonoids. Monomeric, dimeric, or oligomeric flavonoids are possible. Condensed and hydrolysable polymeric flavonoids, sometimes referred to as tannins, are separated into two categories. Hydrolysable tannins include gallic acid, while condensed tannins are polymers of flavonoids.

The normal state of coumarins, an aromatic organic chemical compound, is a colourless crystalline material. Natural occurrences include several plants, including tonka bean, vanilla grass, sweet woodruff, mullein, sweet grass, cassia cinnamon, and sweet clover containing significant concentrations. Although coumarins are only permitted for a limited number of medicinal purposes, they have some evidence of several biological actions. These are the secondary phenolic plant chemicals, and they are found in many different types of plants. Condensed and hydrolysable polymeric flavonoids, sometimes referred to as tannins, are separated into two categories. In animal production, dietary tannin supplementation has a number of positive health effects. Foods containing tannins include persimmon fruits and berries with condensed and hydrolyzable tannins, such as cranberries and blueberries. Hazelnuts, walnuts, and pecans contain around 6% tannins, which provide a variety of health advantages include antioxidant, antiviral, and stress-relieving properties.

Techniques for removing plants' active main components

The chemical makeup of plant materials, the extraction technique used, sample particle size, storage duration and circumstances, as well as the presence of interfering chemicals, all affect the extraction of phenolic compounds from those sources. Plant phenolics may be simple or highly polymerized chemicals with different ratios of phenolic acids, phenylpropanoids, anthocyanins, and tannins, among other compounds. Additionally, they could exist as complexes with other plant materials including proteins, carbohydrates, and other molecules; certain high-molecular-weight phenolics and their complexes might be quite intractable. As a result, phenolic extracts of plant materials are usually a blend of several phenolic classes that are soluble in the employed olvent system. Unwanted phenolic and non-phenolic compounds such waxes, lipids, terpenes, and chlorophylls may need additional procedures to be removed. Unwanted phenolic and non-phenolic compounds are often removed using solid phase extraction methods and fractionation depending on acidity. The degree of phenolic polymerization, the kind of solvent, the interaction of phenolic compounds with other dietary components, and the creation of insoluble complexes all affect how soluble phenolic compounds are. As a result, there is no standard or entirely acceptable method for extracting all phenolics or a particular class of phenolic compounds from plant materials. Methanol, ethanol, acetone, water, ethyl acetate, and, to a lesser degree, propanol, as well as their mixtures, are often used as solvents in chemical reactions.

Free radicals are generally thought to be neutralized by either migrating antioxidant molecules from the active film to the meat or scavenging those oxidant molecules from the meat onto the active film, depending on the mechanism hypothesized. It was shown that oregano-infused active films reduced headspace free radicals and extended the display life of lamb and other meats. Active packs' legal and regulatory position, however, is still unclear and requires special attention. use of phyto elements in the creation of meat products with beneficial properties.

In addition to microbiological degradation, lipid oxidation is the primary factor in meat and meat products losing quality. Antioxidants may be used to stop or slow down these oxidation processes since a significant number of chemicals produced during the oxidation processes negatively impact the texture, colour, flavour, nutritional value, and safety of meat products. Despite the fact that synthetic antioxidants have been added to meat and meat products, their usage has recently been discouraged due to their toxicities and growing customer interest in natural goods. The meat industry has been compelled by this to look for new, affordable natural antioxidants that can replace synthetic antioxidants without degrading the quality of final goods or consumers' views. Several writers have suggested using plant extracts as natural antioxidants in meat and meat-related products.

CONCLUSION

Natural substances have a good reputation with consumers and are used in the creation of innovative, nutritious meat products. In order to protect human health and increase the shelf life of food goods, antioxidants act as nature's barrier against the harmful effects of free radicals. There are still many gifts from nature for humanity that need to be discovered. Natural antioxidants found in phyto-ingredients are a great source for extending the shelf life and quality of meat by preventing lipid oxidation and microbiological development, respectively. The creation of functional foods is a multi-stage process that calls for the participation of industry, academic, and governmental stakeholders, with a crucial requirement to win over consumers. These cutting-edge Phyto-ingredients may effectively aid in the development of functional meat products. Due to the growing customer desire to enhance their health via food, this industry has a tremendous deal of potential to grow in the near future.the utilization of phyto-ingredients in the meat industry represents a promising avenue for improving the quality, safety, and health profile of meat products. With ongoing research and innovation, these natural compounds are likely to continue shaping the future of meat processing, aligning with consumer preferences for healthier and more sustainable food options. As the industry evolves, collaboration among industry stakeholders, researchers, and regulatory bodies will be crucial to ensure the successful development and acceptance of functional meat products enriched with phyto-ingredients.

REFERENCES:

[1] S. Griffin *et al.*, "Turning waste into value: Nanosized natural plant materials of solanum incanum L. and pterocarpus erinaceus poir with promising antimicrobial activities," *Pharmaceutics*, 2016, doi: 10.3390/pharmaceutics8020011.

[2] A. Al-Mamun and A. T. A. Basir, "White popinac as potential phyto-coagulant to reduce turbidity of river water," *ARPN J. Eng. Appl. Sci.*, 2016.

[3] F. Anwar *et al.*, "Capparis spinosa L.: A plant with high potential for development of functional foods and nutraceuticals/pharmaceuticals," *Int. J. Pharmacol.*, 2016, doi: 10.3923/ijp.2016.201.219.

[4] F. Bunghez, A. Rotar, D. C. Vodnar, G. M. Catunescu, and C. Socaciu, "Comparative evaluation of phenolics' profile and recovery in spray dried powders obtained from rosemary and oregano extracts in relation to their antibacterial activity in vitro," *Rom. Biotechnol. Lett.*, 2016.

[5] P. Dhar, C. S. Kar, D. Ojha, S. K. Pandey, and J. Mitra, "Chemistry, phytotechnology, pharmacology and nutraceutical functions of kenaf (Hibiscus cannabinus L.) and roselle (Hibiscus sabdariffa L.) seed oil: An overview," *Industrial Crops and Products*. 2015. doi: 10.1016/j.indcrop.2015.08.064.

[6] H. F. J. Bligh *et al.*, "Plant-rich mixed meals based on Palaeolithic diet principles have a dramatic impact on incretin, peptide YY and satiety response, but show little effect on glucose and insulin homeostasis: An acute-effects randomised study," *Br. J. Nutr.*, 2015, doi: 10.1017/S0007114514004012.

[7] K. Medicherla, B. D. Sahu, M. Kuncha, J. M. Kumar, G. Sudhakar, and R. Sistla, "Oral administration of geraniol ameliorates acute experimental murine colitis by inhibiting pro-inflammatory cytokines and NF-κB signaling," *Food Funct.*, 2015, doi: 10.1039/c5fo00405e.

[8] S. A. Ali *et al.*, "Comparative characterization and scientific validation of certain plant extracts from their biomedical importance," *Biosci. Biotechnol. Res. Commun.*, 2015.

[9] M. B. Chhabra, K. Muraleedharan, and K. M. L. Pathak, "Medicinal plants as alternative for control of parasites. 3. Arthropods," *Indian Journal of Animal Sciences*. 2014.

[10] A. R. Ananta Choudhury*, Swati Verma, "Phytosome□: A Novel Dosage Form for Herbal Drug Delivery," *J. Appl. Pharm. Res.*, 2014.

CHAPTER 9

HARNESSING THE POTENTIAL OF BIOACTIVE PEPTIDES FOR MEAT QUALITY ENHANCEMENT AND PRESERVATION

Rajesh Kumar Samala, Assistant Professor
Department of ISME, ATLAS SkillTech University, Mumbai, Maharashtra, India
Email Id- rajesh.samala@atlasuniversity.edu.in

ABSTRACT:

The focus of biological study has long been proteins, and peptides have become crucial elements inside the complex world of proteins. Peptides, which are short sequences of amino acids produced by the enzymatic breakdown of proteins, may have a variety of physiological and biological functions. These bioactive peptides provide a variety of advantages, including nutritional value, antioxidant characteristics, antibacterial activity, and more. They are generally made up of three to twenty amino acids and have low molecular weights. They have the ability to affect several biological systems when taken orally, including the neurological, immunological, cardiovascular, and digestive systems. This study investigates how bioactive peptides may improve the quality and longevity of meat products. A variety of physicochemical activities, such as antioxidant, antibacterial, antifungal, antihypertensive, antithrombotic, anticarcinogenic, and anticytotoxic capabilities are shown by bioactive peptides, which are produced when proteins are hydrolyzed by enzymes. These peptides have shown the capability to enhance the water holding capacity, cooking yield, colour, texture, and sensory qualities of meat. This study focuses on the utilization of bioactive peptides in the processing and preservation of meat since meat and meat products are important sources of these compounds. We explore the complex functions of these peptides and discuss how they affect the flavour, texture, water-holding capacity, and preservation techniques of meat. We also go through the difficulties and factors involved in the commercial use of bioactive peptides in the meat business.

KEYWORDS:

Bioactive Peptides, Antifungal, Anticarcinogenic, Antihypertensive, Physicochemical.

INTRODUCTION

Small chain peptides known as bioactive peptides are produced during the enzymatic hydrolysis of proteins and display a variety of physicochemical properties. These exhibit potent antioxidant, antibacterial, antifungal, antihypertensive, antithrombotic, anticarcinogenic, as well as anticytotoxic effects. They also have significant nutritional value. By enhancing the water holding capacity, cooking yield, colour, texture, and sensory qualities of the meat model system, they also improve the meat's physicochemical attributes. Bioactive peptides may be found in abundance in meat and animal products. Meat, meat byproducts, and meat products have been used to create bioactive peptides with a variety of functional properties, including antioxidant, antibacterial, ACE-inhibitory, and antihypertensive. The use of bioactive peptides in the preparation and storage of meat and meat products is the main topic of this review[1], [2].

The nutritional benefit of meat, which serves as the main source of protein in non-vegetarian diets, is well known. It delivers great protein efficiency ratios and digestion ratings, contains the necessary amino acids, and boasts a high biological value. As a result, it plays a big role in advancing general health and wellbeing. In especially in developed areas and cities, the demand for meat and meat products has expanded in tandem with urbanization and rising disposable incomes. The need for simple and quick meal alternatives has increased, which has led to an increase in processed meat products. However, meat is exposed to microbial and enzymatic deterioration during processing such as cutting, chopping, mincing, and grinding. In the past, chemical additives have been used to combat these negative changes, but worries about their excessive usage and possible health effects have led customers to look for natural and chemical-free alternatives. The multifunctional qualities of bioactive peptides have made them stand out as interesting candidates in this search[3], [4].

In order to meet customer expectations for healthier and safer meat products, these peptides, produced by the enzymatic hydrolysis of proteins, are currently being investigated for their potential to act as natural preservatives and additives in the processing of meat.The name "protein" comes from the Greek word "proteios," which means "primary." Although studies today primarily concentrate on its constituents, such as amino acids and little pieces of proteins known as peptides, proteins remain at the core of all biological study. Proteins are broken down by enzymes to become peptides, which are short sequences of amino acids. Bioactive peptides are peptide chains with physiologic or biochemical properties. These typically have a low molecular weight and vary in length from three to twenty amino acid sequences. They have also shown strong antioxidant, antibacterial, antifungal, antihypertensive, antithrombotic, and anticarcinogenic action. Peptides have an impact on all bodily systems when taken orally, depending on their amino acid makeup. These have been discovered to have an impact on the digestive, immunological, cardiovascular, and neural systems. Peptides' functional properties are influenced by their open structure, helicity, charges, hydrophilicity, and hydrophobicity. Its capabilities may also include controlling satiety, opiate, mineral transport, and immune system modulation. These are being researched for the treatment of cancer, psychiatric problems, and lifestyle illnesses including obesity and diabetes. Food experts from all around the globe are also interested in bioactive peptides since they are currently being investigated for their bioactive functionality, which may open up new opportunities for peptides as natural preservatives and additives in food processing.

DISCUSSION

The main source of protein in a non-vegetarian diet is meat. It has a high biological value (74–94), an acceptable protein efficiency ratio (0.42–0.70), and an excellent protein digestibility adjusted amino acid score (0.9–1.0). It is a rich source of all necessary amino acids. As a result, it is the best diet for overall health and wellbeing. With rising urbanization and the availability of disposable money, the demand for and consumption of meat products has expanded. The developed world and its developed cities are where meat consumption is highest. The demand for processed beef products has also increased in these regions. In addition to offering fast, easy, and ready to eat or prepare options, processed meat products have the potential to be a significant source of the expanding demand for meat products[5], [6].

Meat that has been processed is subjected to operations like cutting, chopping, comminution, mincing, or grinding, among others, which enhances the likelihood of microbiological and enzymatic deterioration. Spices, herbs, and other additions may assist to lessen these degenerative effects. Federal authorities, the government, public health organizations, etc. have authorized the use of chemical additives in processed meats, and their limitations are disclosed on the labels. However, their indiscriminate usage and a rise in the consumption of processed meats have raised consumer health concerns. Customers now days seek natural and chemical-free goods. Numerous alternatives to chemical preservatives are being investigated, and bioactive peptides have showed promise. Peptides are 3–20 amino acid chains that are physiologically active when given a stimulus. Proteins may be hydrolyzed by enzymes to produce bioactive peptides. These enzymatic hydrolysates have further shown possible functional properties, such as bioactive peptides. Enzymatic hydrolysis increased the functionality of fish proteins, egg proteins, and milk protein concentrate, which may be related to the disruption of tertiary protein structure, production of short, low-molecular-weight peptide chains and free amino acids, change in charges, and opening of active sites. Hydrolysis considerably increased the solubility, emulsion stability, and foaming capacity of milk protein concentrates.

Antioxidant peptides produced from meat protein

Studies have shown that proteins may prevent dietary lipid oxidation in several different ways. Actinase E or Papain was used to hydrolyze porcine myofibrillar proteins for 24 hours at a pH of 7 and a temperature of 37^{o}C. The linoleic acid peroxidation system, the DPPH radical-scavenging activity, and the metal-chelating activity assay were used to evaluate the antioxidant properties of the hydrolysates. The Papain hydrolysates demonstrated the strongest antioxidant activity in the linoleic acid system, which was comparable to that of -tocopherol. Both hydrolysates demonstrated antioxidant activity in the DPPH radical-scavenging activity experiment. both hydrolysates exhibited metal-chelating activity, the levels of which were lower than those previously reported for -tocopherol.

Antimicrobial peptides made from animal proteins

A wide variety of action is shown by bioactive peptides produced from dietary proteins against bacteria important for health and/or spoilage. The fact that animal source proteins are used to make the antimicrobial peptides gives them the tremendous benefit of being manufactured from cheap and safe materials. As a result, the food industry is becoming more interested in using these bioactive peptides as food-grade bio-preservatives or as supplements that promote health.

AMPs, or antimicrobial peptides, primarily have bactericidal effects. With a bacterial cell wall or membrane, all AMPs interact. The anionic phospholipids and lipopolysaccharides present in bacterial cell walls and membranes have an affinity for AMPs. Typically, antimicrobial peptides include less than 50 amino acids, of which about 50% are hydrophobic, and a molecular weight of less than 10 kDa. Enzymatic hydrolysis may produce these peptides in vitro. It has taken less time to isolate and identify antimicrobial peptides from animal muscle than it has to do with antioxidant peptides from animal protein. Many different types of organisms produce antimicrobial peptides as their main innate immune defence. Antimicrobial peptides are often preferable to traditional bactericidal antibiotics in medical applications because they eradicate germs more quickly. The techniques outlined here will be helpful for finding new peptides with potent antibacterial properties. The antibacterial efficacy of hydrolysates or peptides has been evaluated using a variety of techniques. A popular technique for determining whether peptides and peptidichydrolysates have antibacterial action is the agar diffusion assay or inhibitory zone experiment. This technique measures how well antibiotics stop bacterial growth. With concentration, these zones' diameters grow.

Bioactive peptides' impact on texturing

One of the most crucial sensory qualities of meat products that determines customer preferences and the acceptance of the product is texture. According to studies, adding potato protein hydrolysate does not appreciably change the cohesion, deformability, or hardness of cooked frankfurters. In raw emulsion and cooked frankfurters, the hydrolyzed potato protein examined shown good antioxidant and emulsifying activity. The ability of meat and meat products to retain water affects the cooking yield, textural qualities, and ultimate eating quality of meat products. The amount of free amino acids is increased during hydrolysis, which also exposes active groups like carboxyl and amino and allows for the formation of smaller peptides with discernible functional properties. As polar groups absorb more water, peptides become more hydrophilic and have a tendency to interact with water more. the salmon byproduct hydrolysate (14 g/100 g) and very little salt (0.2 g/100 g salt) used in the sous vide cooking of salmon fillet to reduce water retention. This hydrolysate and salt mixture created a product that met the same requirements as those produced by adding 2% salt.

Hydrolysate of bioactive peptides for meat preservation

The mechanical characteristics of films are significantly altered when protein hydrolysate is added to packing materials with an increasing concentration while retaining oxygen and water vapour permeability. protein addition to films decreased their tensile strength and gas permeability. adding protein hydrolysates to coatings that have a greater degree of hydrolysis (DH) increases the tensile strength of the films. The shelf-life of packed food goods is extended by the inclusion of protein hydrolysates in the packaging materials, and the mechanical qualities of the film are also enhanced. Enzymatically hydrolyzed whey proteins have been shown to create films that are more flexible than non-hydrolyzed proteins while retaining the same oxygen permeability[7], [8].

Impact of bioactive peptide/hydrolysate on beef products' taste characteristics. The addition of protein hydrolysate made from mutton ham to meat patties improves both the sensory characteristics and oxidative stability of the meat patties. The presence of free amino acids, peptides, flavour nucleotides, and minerals may be the reasons for the heightened sensory qualities as well as the ingredients that produce these mouthwatering sensations. However, owing to the presence of certain bitter peptides, the integration of hydrolysates from mechanically deboned chicken flesh may have a negative impact on the sensory quality.According to recent study, meat-derived hydrolysates and peptides offer multifaceted activity that may be used to support the meat business and consumer health. In several dietary models, including meat products, the antioxidant and antibacterial action of bioactive peptides has been thoroughly documented. Additionally, being investigated is how processing affects peptides. However, complete understanding of the bio-availability, pharmacokinetics, pharmacodynamics, and toxicity is crucial for the use of bioactive peptides as an alternative to chemical additives. Legal regulations for its usage need also be developed. As a result, before bioactive peptides are industrialized for use in food processing and preservation, their quality and safety must be established [9], [10].

CONCLUSION

The multifarious activity of bioactive peptides generated from meat has been made clear in recent research, opening up a range of opportunities for the meat business and consumer health. These peptides have shown to be effective in improving the quality of meat, particularly by providing antioxidant and antibacterial effects, which have been proven in several food models, including meat products. Additionally, the prospective uses of these peptides are being expanded as the effects of processing techniques are now being examined. However, a few crucial issues need to be resolved before the industrialisation of bioactive peptides in food processing and preservation. It is crucial to have a thorough awareness of aspects including toxicity, pharmacokinetics, and bioavailability. For the purpose of ensuring the quality and safety of the products, it is also crucial to develop legislative regulations for their usage. Using bioactive peptides is an intriguing new frontier in the search for meat products that are safer, healthier, and more nutrient-dense. Utilizing the potential of these peptides might usher in a new age of meat processing and preservation, in line with customer expectations for natural and chemical-free meals, as the meat business continues to develop.

REFERENCES:

[1] K. D. Adeyemi and A. Q. Sazili, "Efficacy of carcass electrical stimulation in meat quality enhancement: A review," *Asian-Australasian J. Anim. Sci.*, 2014, doi: 10.5713/ajas.2013.13463.

[2] C. Ribeca, V. Bonfatti, A. Cecchinato, A. Albera, L. Gallo, and P. Carnier, "Effect of polymorphisms in candidate genes on carcass and meat quality traits in double muscled Piemontese cattle," *Meat Sci.*, 2014, doi: 10.1016/j.meatsci.2013.11.028.

[3] M. A. Desai, V. Kurve, B. S. Smith, S. G. Campano, K. Soni, and M. W. Schilling, "Utilization of buffered vinegar to increase the shelf life of chicken retail cuts packaged in carbon dioxide," *Poult. Sci.*, 2014, doi: 10.3382/ps.2013-03793.

[4] H. J. Kim, Z. A. Kruk, Y. Jung, S. Jung, H. J. Lee, and C. Jo, "Effects of high hydrostatic pressure on the quality and safety of beef after the addition of conjugated linoleic acid," *Innov. Food Sci. Emerg. Technol.*, 2014, doi: 10.1016/j.ifset.2014.06.001.

[5] N. D. Scollan *et al.*, "Enhancing the nutritional and health value of beef lipids and their relationship with meat quality," *Meat Science*. 2014. doi: 10.1016/j.meatsci.2014.02.015.

[6] A. Giordano *et al.*, "Gene discovery and molecular marker development, based on high-throughput transcript sequencing of Paspalum dilatatum Poir," *PLoS One*, 2014, doi: 10.1371/journal.pone.0085050.

[7] O. D. DERRADJI, M. A. AISSA, K. N. NOURREDINE, A. G. ZOHRA, B. F. FATEN, and B. A. ADEL, "EFFECTS OF THE MARL ON THE PERFORMANCE, CUTTING YIELD AND MEAT QUALITY OF BROILER CHICKENS," *Banat. J. Biotechnol.*, 2014, doi: 10.7904/2068-4738-v(10)-71.

[8] M. Font-i-Furnols *et al.*, "Use of mild irradiation doses to control pathogenic bacteria on meat trimmings for production of patties aiming at provoking minimal changes in quality attributes," *Meat Sci.*, 2014.

[9] Y. Sadzuka, "Advanced therapies of doxorubicin by carrier of drug delivery system or combined food components," in *Doxorubicin: Biosynthesis, Clinical Uses and Health Implications*, 2014.

[10] C. Yanes-Roca *et al.*, "Husbandry and Larval Rearing of Common Snook (Centropomus undecimalis)," *Aquaculture*, 2014, doi: 10.1016/j.aquaculture.2008.04.020.

CHAPTER 10

REVOLUTIONIZING THE MEAT INDUSTRY: HARNESSING AI FOR QUALITY MEAT PRODUCTION AND PROCESSING

Somayya Madakam, Associate Professor
Department of uGDX, ATLAS SkillTech University, Mumbai, Maharashtra, India
Email Id- somayya.madakam@atlasuniversity.edu.in

ABSTRACT:

As the world's population continues to surge, so does the need for sustainable and efficient meat production. Meeting this demand while ensuring the highest standards of quality and safety is a complex challenge. In this comprehensive examination, we shed light on the role of Artificial Intelligence (AI) as a game-changer in the meat industry. Beyond its association with artificial insemination, AI is paving the way for a new era in livestock farming, meat processing, and quality assessment.AI, with its diverse applications including machine learning, deep learning, natural language processing, and more, holds the potential to enhance meat production, improve meat quality, and streamline the entire supply chain. From predictive analytics to self-ordering kiosks, AI is set to transform how meat is produced, processed, and consumed. This chapter explores various AI applications in meat production and processing, from ascertaining meat quality and freshness to optimizing the meat supply chain. It also delves into the impact of AI on meat product development and food safety compliance. The use of AI in maintaining cleanliness and hygiene in meat processing plants is also discussed, highlighting its potential to revolutionize the industry. While AI offers unprecedented opportunities, challenges such as the need for a skilled workforce and the integration of AI into every sector of the meat industry are discussed. In conclusion, AI is poised to lead the "fourth industrial revolution" in the meat sector, offering solutions to age-old problems and propelling the industry into a new era of efficiency, sustainability, and quality.

KEYWORDS:

Artificial Intelligence, Biosensors, Deep Learning, Industrial Revolution, Meat Industry.

INTRODUCTION

The demand for supporting the population grows whenever there is a population boom. Food is the first requirement that springs to mind. Population growth necessitates a paradigm change toward more intelligent approaches to food production and processing. The more intelligent techniques must be capable of making the best use of labour, energy, water, land, and other production resources. Artificial intelligence, or AI, is among these more intelligent techniques. AI. When used to artificial insemination, AI has long been a popular term in the cattle industry. But as times have changed and technology has advanced, it is now necessary for all parties engaged in the cattle industry to be aware of another important acronym of AI, namely. synthetic intelligence. Through its many applications, including machine learning, deep learning, natural language processing, artificial neural networks, cloud computing, blockchain technology, internet of things, precision farming, sensor based systems, robotics, and so forth, AI has the potential to revolutionize the livestock industry[1], [2]. Additionally, it is predicted that AI will usher in a digital revolution, the "fourth industrial revolution," on the world. There are a variety of ways AI can be used by farmers, including the creation of learning simulations for those who want to switch to livestock farming, the development of AI-Based Livestock Expert Systems, AI-Based Meat Production and Processing Systems, Camera-Based Meat Scoring Systems, and Intelligent Bodies. Robots cannot replace people, despite the fact that AI has both advantages and disadvantages. Humans are endowed with the capacity for creativity, which machines will never possess. The main uses of AI in the production and processing of meat will be covered in this chapter. The reader is urged to consult the literature that specializes in describing and mathematically illustrating AI ideas if they want additional in-depth knowledge[3], [4].

Creating systems that can acquire data, make judgments, and solve problems is the emphasis of the area of computer engineering known as artificial learning (AL). Artificial intelligence (AI) is often referred to as the science of programming computers to do tasks that would normally need human intellect. The method through which an AI employs algorithms to carry out artificial intelligence tasks is known as machine learning (ML). Deep learning (DL) is what occurs when a neural network starts processing input; as a result, the AI develops a foundational knowledge. The technique by which an AI is taught to decipher human speech is known as natural language processing (NLP). The goal of transfer learning, also known as inductive transfer, is to apply information discovered while resolving one issue to another that is unrelated but yet challenging. An information technology (IT) paradigm known as "cloud computing" allows for universal access to shared pools of reconfigurable system resources and higher-level services that can be quickly deployed with little administration work, often through the internet.

India's Artificial Intelligence Market by Sector

India's AI Development Challenges

Consumer products have been the primary focus of AI-based applications up to this point, which have been mostly pushed by the private sector. Government officials must pay attention because of the technology's expanding scope and repercussions. Early AI successes in the United States, China, South Korea, and other countries provide governmental and private financing methods that India can take into consideration. The sequential structure of education and employment is no longer relevant in the current economic climate since occupations are changing quickly and skills are becoming less and less valued over the course of a few years. India must thus develop a wide range of AI-based capabilities for its youthful population. By implementing a national purpose or program that expands AI throughout all sectors of the nation, all the aforementioned obstacles can be overcome. These difficulties may be overcome by educating kids early in their schooling and improving the abilities of IT specialists.

New Techniques for Measuring Meat Quality

The word "meat quality" is quite broad and encompasses many distinct elements, the importance of which might vary depending on whether the meat is produced, processed, or consumed. From the standpoint of animal production, the term "quality" primarily relates to the amount of lean meat, upon which the farmer's remuneration is based. On the other side, the processing sector is concerned in the technical quality of the meat suitability for further processing and the aspects that influence customer choice. The customer is picky about the meat's sensory quality, nutritional value macro and micro nutrients, and safety presence/absence of hazardous substances, pharmaceuticals, and pathogen or spoilage micro flora. They are also picky about the meat's appearance colour, lean to fat ratio, sensory quality, nutritional value macro and micro nutrients, and safety. Other elements, such as the methods used in meat production animal welfare, ecological), might also influence customer decision. Different qualities may be used in the manufacturing and processing of meat to classify the quality of the meat for various uses or to critically evaluate the meat by customers (typically their criterion for choosing or rejecting meat). For instance, the ability of the flesh to retain water is quite significant in pig, but softness is a key quality in beef. Another significant difficulty in the meat industry is the detection of spoilage or meat shelf life. With the use of modern technologies like computer (machine) vision, spectral imaging, spectroscopy, electronic noses, or bio-sensing technologies, methodologies used in meat assessment, meat quality control, or inspection have seen significant improvements in recent decades[5], [6].

The meat business has recently included a robotic hide puller that operates on the principles of automation, artificial intelligence, and little human contact. In a downward pulling action, this machine is used to remove skins from the bodies of slain animals, as its name indicates. The hide is pulled from the rear portion of the tail down the back, and then over the head. Metered hydraulic pedals are used to operate the machine's primary functions. A stainless-steel platform with built-in apron washers, knives/whizzers, sterilizers, drop trays, and drainage systems is included with the automatic hide puller. It minimizes human contact while improving meat quality. Using an automated hide puller, the clean meat production principle may be activated. Currently, electricity is used to power hide pullers, however research is being done to minimize this. The machine is constructed of GI steel, which resists rust. Additionally, meat quality is analyzed by motion and intelligent cameras to assure safe ingestion.

DISCUSSION

Electronic sensing, often known as e-sensing, is the term used to describe an electronic nose or tongue. It is a sophisticated network of interconnected sensors that functions as a system for detecting flavours, odours, and tastes. An electronic nose or tongue is made up of a mixture of chemical or gas sensors that simulates a human nose or tongue. Chemical sensor arrays are referred to as "electronic tongue (e-tongue)" and gas sensor arrays as "electronic nose (e-nose). Gas sensors come in a variety of forms, including conducting polymers (CP), metal-oxide semiconductor (MOS), quartz crystal microbalance (QCM), and surface acoustic wave (SAW) sensors. Chemical sensors frequently used for an e-tongue include electrochemical sensors, biosensors, and optical mass sensors. Typically, those sensor arrays can achieve rapid sensing, and the cost of a sensor array is relatively lower than that of a single sensor. Various food quality-related aspects, including sensory attributes, microbiological qualities, and processing quality, may be determined using sensor arrays. These applications are made possible by sensor arrays working in conjunction with the appropriate data pattern recognition techniques and classification algorithms. Through the use of artificial neural networks, the data gathered by these sensors may be analyzed to determine the quality of the meat[7], [8].

Sensible Packaging

The robot, which is officially known as the AMP Cortex system and is dubbed Clarke in honour of science fiction writer and futurist Sir Arthur C. Clarke, goes by that moniker. The Cortex system scans materials as they move down a conveyor belt on the recycling line using a camera similar to that found on a common smartphone. To distinguish the hundreds of food and beverage cartons from the other materials on the line, it employs AI that gains knowledge from experience. Cortex can distinguish between various carton packaging types, such as gable-top and aseptic cartons, broth or almond milk cartons, and can determine if a package is a carton or not, and whether it should be sorted with them. In fact, according to Brown and Horowitz (2017), Cortex has mastered the ability to recognize more than 150 different carton varieties.

Utilizing a Process Control Computer (PCC) to Produce Minced Meat

The use of very accurate technologies for analyzing meat raw materials and high-calibre control of raw meat processing are current developments in the development of meat processing equipment. The completed product quality in the conventional technology for making minced meat, which uses batch-operated technical equipment, mostly relies on the operator. The new technology, implemented on the suggested automatic line, calls for complete automation of the technological procedure using the PCC, an Intelligent Control System (ICS); in other words, control is carried out in accordance with the idea of an unmanned operation based on artificial intelligence. This will enable computer control of each technical operation and the whole technological process in real-time, resulting in completed goods with assured high quality.

Evaluation of Meat Quality Using Computer Vision

A quick and non-destructive method for assessing the quality of agricultural goods, particularly meat and meat products, is the imaging technique or computer vision (CV) technology. The theory behind artificial systems that extract data from pictures is the focus of computer vision. The picture data might be in the form of video clips, numerous camera views, or multi-dimensional data from a medical scanner, among other formats. Machine vision refers to the use of computer vision in the manufacturing sector where data is extracted to help a production process. Computer vision offers information about the flesh structure in a manner similar to how ultrasonography provides the reflection signature about the inner structure of the medium. However, traditional techniques of evaluating the quality of meat have several drawbacks, such as being costly and time-consuming, while CV offers a number of benefits over the conventional approaches. It is non-destructive, simple, and rapid, making meat quality evaluations more effective as a result. The primary factor in meat colour, myoglobin, is used as the basis for spectral imaging or analysis in CV. Based on information on the number of various kinds of myoglobin in varied proportions after further examination, the CV gives the colour simulation findings of meat samples. Meat quality may also be determined by analyzing images from a basic camera. The prediction accuracy for meat colour, pH, DL, crude protein, and ash content of the sample may be raised after standardization and calibration of CV for meat quality.

Meat freshness detection using near infrared spectroscopy

Concerns about tainted meat have prompted the industry to explore for innovative, non-invasive techniques for quick, reliable meat quality inspection. Myoglobin, oxy-myoglobin, fat, water, and collagen are the primary meat chromophores, and they all exhibit close to equivalent absorption in the visible to near-infrared (NIR) spectrum area. Therefore, alterations in meat's structure and content might affect how much light is absorbed. The deterioration of meat samples' freshness may be seen at room temperature using common fiber-optic probes and an integrating sphere by comparing changes in the principal meat chromophores' absorbance. Principal component analysis (PCA) may be used to the data produced after NIRS in order to determine the freshness stage that is not visible via a traditional investigation of the reflectance spectra.

This method is very accurate for determining the quality of meat and monitoring the relative absorbance alternation of oxymyoglobin and myoglobin in visible and fat, water, and collagen in NIR spectral ranges. In terms of PCA, it is a sophisticated analytic method for lowering the dimensionality of datasets, improving interpretability while minimizing information loss. It does this by generating fresh, uncorrelated variables that maximize variance one after the other [9], [10].

Technology Using Biosensors

The meat business needs a tool to address the terrible situation and guarantee a safer product for consumers since it is linked to health risks such lethal viruses, veterinary medications, pesticide residues, toxins, and heavy metals. The meat business now has a greater responsibility to satisfy customer expectations and demands due to the sector's expansion, the state of global commerce, strict rules, and consumer awareness. A bioreceptor or biorecognition element that recognizes the target analyte and a transducer that converts the recognition event into a measurable electrical signal are the two main parts of a biosensor, which can be defined as an analytical device that converts a biological response into an electrical signal (Singh et al., 2016). Biosensors are the newest tool of detection in the rapidly expanding industries, including the food industry. Biosensing technology combines a sensitive biological component (such as enzymes, bacteria, antibodies, etc.) with an optical, piezoelectric, or electrochemical analyte detector. The analyte's interaction with the biological component is converted by the physicochemical detector into a signal that can be measured and quantified. The findings are presented in an approachable manner. Biosensors are a quick way to evaluate the quality of meat and may be used to examine bulk meat.

Meat Identification based on CNN

As a well-liked deep learning technology, the convolutional neural network (CNN) has been extensively used to classification issues. The most notable benefit of CNN is its capacity to automatically learn from an input picture without feature extraction, although CNN needs more image data to build the model from scratch. CNN may be used to identify various meat species, cuts of meat, fresh and rotten meat, marbling, etc. Tensor Flow is a new deep learning neural network open-source software suite that was launched in 2016 by the Google TM Brain team. In order to employ CNN in industrial applications, this free, open-source deep learning algorithm library offers an efficient, quick, and accurate source of artificial intelligence.

Classifying or Determining the Quality of the Carcass

The meat business is interested in carcasses with high meat outputs that are lean and conformed. At the conclusion of the slaughter line, the so-called carcass grading or categorization (used for pig, cattle, and lamb carcasses) is done, and it serves as the foundation for the farmer's payout. Another instance is in the slaughter of chicken, where the carcasses are examined for wholesomeness at the slaughter line, and those having an aberrant appearance (tumorous, bruised, skin-torn, septicemic, corpse, air-sacculitis) are eliminated. The aforementioned processes mostly rely on visual evaluation, making them vulnerable to human constraints including speed, mistake, and weariness. Convolutional neural networks may be used to do this, allowing one to determine the carcass quality and categorize the carcass into different classes using picture analysis. Even computer vision can be used in this situation. Meat and meat products are very prone to deterioration or infection, which may lower their quality and safety. Numerous techniques for spotting rotten or tainted meat rely on labor-intensive, time-consuming immunological or nucleic acid-based processes that need experienced staff. There is now no way available for a real-time, non-destructive, quantifiable, cost-effective monitoring.

AI-based cameras for ensuring food safety

The meat processing industry places a great deal of emphasis on safety. Any amount of meat contamination might have negative effects that are felt widely. Although traditional HACCP methods have significantly decreased meat contamination, the accountability is still called into question once a product leaves the manufacturing line and enters a retail or food chain. AI-based cameras have been deployed to determine whether employees are wearing the appropriate attire or not in order to ensure food safety at factories, cafes, and restaurants. The AI-enabled cameras assisted restaurant management in keeping an eye on the restaurant staff to ensure that they were complying with food safety rules by wearing the appropriate food protection gear. They can monitor any lack of discipline in real time thanks to notifications on their devices.

Systems for Intelligent Cleaning

In meat processing and manufacturing facilities like slaughterhouses, abattoirs, and butcheries, hygiene is of utmost importance. Many businesses make the claim that they are as pure as ice since none of their processes are manual and are instead automated. What happens if the tools and machinery are contaminated? Customers have also developed an intelligence, and they are aware that just because all processes are automated does not guarantee the product is secure for consumption. According to the University of Nottingham, a food processing plant's water and energy resources are roughly 30% used by cleaning equipment. They claim that their AI-based sensor technology can save close to $133 million annually and reduce the amount of time (by 50%), energy, and water needed to clean the machinery. Because traditional cleaning methods lacked sensors, there were still meat particles in the equipment's containers after cleaning. The new self-optimizing cleaning system could remove minute food particles that the old system was unable to. It transmits data to the machine learning algorithm using optical fluorescence imaging and ultrasonic sensing technologies, which will aid in monitoring the microbiological waste and food particles in the apparatus.

The creation of meat products

There are hundreds of meat products available today, all with different components, production methods, and consumer acceptance. At any one moment, one firm makes several hundred meat items. If people are involved, it is never assured that the original flavour will be preserved. The exact addition of ingredients and the maintenance of processing temperatures and conditions in meat products are all made possible by AI via machine learning algorithms. The firms may boost the supply of certain meat items in accordance with probability and demand after conducting a study on consumer acceptability using field-based data collection, predictive analytics, and deep learning. For the purpose of creating items that meet needs, internet shoppers may also be researched. A corporation may gradually raise its profit margin by developing the necessary items with the use of AI-assisted market research.

Supply Chain Optimization for Meat

Artificial neural network-based algorithms can keep an eye on and verify the delivery of meat and the tracking of commodities at every stage, enhancing safety and offering transparency. By utilizing ANN to feed meat from the point of production to the place of consumption, a perfect equilibrium is created, narrowing the demand-supply gap. Additionally, it creates estimates for demand, supply, price, and inventory to avoid unforeseen expenses. Equipment in meat plants is subject to predictive maintenance, remote monitoring, and condition monitoring. Massive, carefully designed machines are needed to produce and process the massive volumes of meat and its byproducts. Without predictive maintenance, which determines the time-to-repair and cost-to-repair indicators via classifying defects and creating predictive warnings, the maintenance of such devices may be rather expensive. Repairs made on schedule may save maintenance expenses by approximately 10% and cut down on time by up to 50%. Making a digital twin of the machine, which displays performance data on parameters and production processes and increases throughput, enables remote monitoring of complex mechanisms. Root Cause Analysis, which eliminates the issue at its very root, enables the discovery of elements that impact the manufacturing process's quality via the application of machine learning. To achieve high overall equipment effectiveness (OEE), condition monitoring allows for real-time monitoring of the equipment's condition. The interruption of a product's manufacturing cycle may be avoided through condition monitoring.

Sequencing of the Next Generation

In the near future, Next Generation Sequencing (NGS) might completely replace DNA-based approaches for assessing meat safety. Data collection and laboratory sample preparation are now done considerably more quickly and precisely than ever before thanks to automated workflows and procedures. NGS is being used at institutions like the CDC and FDA in order to identify hazardous trends more promptly. Even certain disease outbreaks may be stopped by NGS before they cause widespread damage. Data collected using NGS may be analyzed using a variety of AI applications.

AI-based Self-Ordering Kiosks

Self-ordering devices powered by artificial intelligence may improve the customer experience by decreasing waiting times and the requirement for customers to stand in line to pay. Through integrated card readers, such devices may accept customer orders and allow customers to make payments without human help. Many businesses and organizations currently provide goods and services for the food and beverage industry that use machine learning, deep learning, and AI.

The following list of examples includes some of them. AI makes use of machine learning and AI to comprehend how consumers perceive flavours and forecast their preferences for different foods and drinks. Tastry uses AI, machine learning, analytical chemistry, and flavour preferences to provide consumer product recommendations, while Whisk uses deep learning and natural language processing to map the world's food ingredients, properties (nutrition, perishability, flavour, categories, and food purchase options) in order to provide hyper-relevant advertising and customized personalizations.

CONCLUSION

Even though it is still in its early stages, AI is already changing the way meat is produced and handled, and in the coming years it will completely transform the meat industry. AI will help meat-based companies increase their revenue by speeding up the production process, reducing maintenance time and therefore the production downtime, decreasing the chances of failure by automating nearly every process, and ultimately delivering a great customer experience by predicting future needs.

REFERENCES:

[1] L. Mora, M. Reig, and F. Toldrá, “Bioactive peptides generated from meat industry by-products,” *Food Res. Int.*, 2014, doi: 10.1016/j.foodres.2014.09.014.

[2] U. ur Rahman, A. Sahar, and M. A. Khan, “Recovery and utilization of effluents from meat processing industries,” *Food Res. Int.*, 2014, doi: 10.1016/j.foodres.2014.09.026.

[3] D. Abraham, G. Dassatti, and A. Cal, “Traceability: An electronic information system for the meat industry,” *Health Technol. (Berl).*, 2014, doi: 10.1007/s12553-014-0081-z.

[4] N. Imamovic and S. Goletic, "Testing the biomethane yield of degradable wastes of meat industry by BMP test," *Chem. Biochem. Eng. Q.*, 2014.

[5] J. Nunes *et al.*, "Potential of energy savings in Portuguese meat industry," *ResearchGate*, 2014.

[6] G. M. Oppenheimer and I. Daniel Benrubi, "McGovern's Senate Select Committee on Nutrition and Human needs versus the meat industry on the diet-heart question (1976-1977)," *Am. J. Public Health*, 2014, doi: 10.2105/AJPH.2013.301464.

[7] A. R. Henriques, L. Telo da Gama, and M. J. Fraqueza, "Assessing Listeria monocytogenes presence in Portuguese ready-to-eat meat processing industries based on hygienic and safety audit," *Food Res. Int.*, 2014, doi: 10.1016/j.foodres.2014.03.035.

[8] A. Kwarciak-Kozłowska, A. Krzywicka, and L. Sławik-Dembiczak, "Integrating the Anaerobic Process with Ultrafiltration in Meat Industry Wastewater Treatment," *Ochr. Sr. i Zasobów Nat.*, 2014, doi: 10.2478/oszn-2014-0029.

[9] Z. Xiong, D. W. Sun, X. A. Zeng, and A. Xie, "Recent developments of hyperspectral imaging systems and their applications in detecting quality attributes of red meats: A review," *Journal of Food Engineering*. 2014. doi: 10.1016/j.jfoodeng.2014.02.004.

[10] E. Giaouris *et al.*, "Attachment and biofilm formation by foodborne bacteria in meat processing environments: Causes, implications, role of bacterial interactions and control by alternative novel methods," *Meat Sci.*, 2014, doi: 10.1016/j.meatsci.2013.05.023.

CHAPTER 11

TRANSFORMING THE LIVESTOCK SECTOR: HARNESSING OPPORTUNITIES IN MEAT PROCESSING FOR ECONOMIC GROWTH AND SUSTAINABILITY

SwarnaKolaventi, Assistant Professor
Department of uGDX, ATLAS SkillTech University, Mumbai, Maharashtra, India
Email Id-swarna.kolaventi@atlasuniversity.edu.in

ABSTRACT:

The output of meat and milk is expected to increase significantly as the livestock industry in emerging nations is set for a revolutionary makeover. This industry is essential to rural communities because it helps farmers, especially rural poor and vulnerable people, by creating jobs and money. The nutritional and palatability benefits of meat products, as well as expanding buying power, shifting socioeconomic positions, and changing lifestyles, have all contributed to recent increases in meat production and consumption.A crucial element of this change is the processing of meat. It includes a broad variety of processes, including as grinding, curing, smoking, frying, canning, freezing, fermentation, and more, that significantly alter the physical and chemical composition of meat. These procedures improve the qualities of fresh meat while maintaining its fundamental value as a source of protein. Due to expanding urbanization, rising living standards, and an increase in the number of working women, there is a growing need for convenience in meat-based fast food. The food sector is changing due to the change in eating habits away from cereals and toward dairy and meat products, especially among the expanding middle class. Focus must be placed on feed sources, production efficiency, byproduct usage, cost-effective processing, quality control, and creative marketing approaches in order to maintain livestock output and satisfy this demand. Additionally, the value addition of animal products like milk, eggs, and meat presents several potentials for trade and revenue production. Processing technology should support energy efficiency, ecological sustainability, and global competitiveness.

KEYWORDS:

Ecological Sustainability, Livestock Sector, Meat Products, Protein, Palatability.

INTRODUCTION

In emerging nations where a significant rise in the consumption of meat and milk is projected, the cattle industry is set for upheaval. Animal husbandry is an essential rural activity that has contributed to the employment and revenue creation of farmers, the rural poor, and other vulnerable groups. Production and consumption of meat have significantly grown in recent years. The demand for high-quality meat and meat products is always expanding as a result of increased knowledge of the nutritional value and palatability of meat products, as well as a sensation of satisfaction brought on by eating. A rise in the use of processed and convenience meat products has also been attributed to rising buying power, shifting socioeconomic position, and changing lifestyles[1], [2].

Any procedure that modifies meat's natural condition physically and chemically is referred to as "processing" meat. This encompasses, in the widest sense, grinding, curing, smoking, cooking, canning, freezing, fermentation, dehydration, the creation of goods with intermediate moisture levels, and the use of specific additions like seasoning, chemicals, and enzymes, among other processes. While the intrinsic quality of "being meat" must endure even after processing, the qualities of fresh meat have been altered. Meat technology is the application of any and all branches of applied science that have real-world applications or industrial applications. It is the use of all scientific or modern information for the production of meat in simpler ways, such as easier procedures for slaughter, processing, transportation, storage, and marketing, in such a manner that has some practical advantage over conventional methods of production. Processing is therefore a component of meat technology.

The significance of processed meats

Processing assists to manufacture meat products with enhanced value, diversity, and convenience to fulfill lifestyle needs. It promotes better use of various byproducts, trimmings, and edible corpses. It makes it easier to use non-meat products to improve quality and save costs. It aids in marketing to bigger audiences as well as preservation, transportation, and distribution. It encourages entrepreneurship and employment, stimulates export, and competes with imports. Products with added value are those that have undergone additional processing to increase customer convenience by reducing preparation time and reducing preparation processes. It simplifies the usage of certain components, allows for the production of goods with various tastes, and lengthens product shelf lives. Products with added value may be generally categorized according to processing, variety/convenience, and function.

Demand for meat and meat-related goods

Due to their contribution of macro and micronutrients necessary for the development and maintenance of health, muscle foods play a significant role in the human diet. Comparing emerging and developed nations, it was discovered that the pace of rise in per capita consumption of animal products was greater in developing nations. India consumes roughly 10.4 grams of animal protein per person day as opposed to the global average of 25 grams. The estimated demand for the current population would be milk 104 million tons, meat 7.7 million tons, and eggs 4.6 million tons (104 billion number), compared to the current production of milk 84 million tons, meat 6.04 million tons, fish 5.6 million tons, and eggs 30 million tons[3], [4].

Opportunities for meat products

In order to reduce production costs, increase yields, diversify products, use byproducts, extend shelf life, create quality control and management systems, and give meat products a great reputation, we must focus on technology and equipment that result in process efficiency. To reduce imports that harm local industry, it is also vital to diversify the products being produced. When compared to the large amount of pork that is accessible at lower rates, the production of processed pig products is meagre. Additionally, processing technology need to emphasize socio-ecological sustainability, energy efficiency, and global competitiveness.

DISCUSSION

Both organized and unorganized industries handle meat processing. The proper sort of product may be given to customers safely and affordably with organized processing under the supervision of experts. Fast food enterprises that use meat have a lot of promise in this nation. In India, multinational food corporations have already opened shop. The removal of quantitative limits may allow cities and big towns to carry imported meat and meat products. For the consumer, globalization offers a wide range of product options and product value. Because of the accelerated industrialization and urbanization, the rising quality of living, and the growing number of working women, the demand for convenient meat-based fast food is always rising. Consumers' buying habits are also influenced by rising literacy rates and rising health consciousness. Cereals are being replaced by dairy and meat products in the food consumption pattern, and this change is more pronounced as a result of the expanding middle class's considerable buying power.

Products from livestock and sustainability

To maintain livestock production operations, pragmatic measures for effective livestock production and usage are crucial. The availability and affordability of feed, the effectiveness of production, and the best possible use of products all play a role in sustainable animal production. They also rely on sanitary manufacturing, value addition and diversification, improved by-product usage, cost-effective processing technologies, continuous demand generation, brand promotion, and creative marketing strategies.

Products from animals are more valuable

Value addition is a crucial strategy for making the most of animal resources while increasing demand and profits. The Indian cattle industry would benefit from higher growth in demand for meat, eggs, and milk in emerging nations due to increasing trade prospects. Value-added goods are those that have undergone further processing and provide the buyer more convenience. The expansion of the goods business guarantees farmers a consistent market for their produce at fair rates and offers consumers choice. Given that India has one of the lowest labour costs in the world, there is a greater emphasis on workers in this process. There would be plenty of job opportunities.

Benefits of processing meat

1. To alter a product's shape or features so that it would be simpler to sell and more appealing to customers
2. Encourages the use of non-meat components for quality and cost-effectiveness
3. Makes city life simpler by aiding in preservation, transportation, and distribution to a broader population.
4. Helps in the usage of byproducts and meat of poor grade.
5. The development of various products using various recipes allows for the production of a variety of pig products with additional value.

Meat augmentation

Products known as extenders, binders, and fillers often include a range of non-meat culinary ingredients. There are several reasons for their use in meat products, but just a handful are included below. to increase taste, lessen shrinkage while cooking, enhance slicing properties, increase emulsion stability, improve water binding capacity, and lower the cost of formulation. Examples of common fillers include soy products, potato starch, and wheat, rice, pea, and maize flours. Examples of common extenders include milk powders, dry whey, and sodium casinate.

The process of making processed pork products

In the globe, there are many processed pork items. Ham, bacon, salami, sausages, luncheon meat, pickles, patties, loaves, balls, nuggets, slices, and processed pig snack foods are a few of the most popular processed pork goods. The uniformity of the product's appearance, taste, content, nutritional value, and physical attributes should be its primary focus during formulation. The customers should approve of the goods. The third objective is to ensure that the ratio of non-meat components, such as binders, extenders, fillers, spices, salt, etc., to meat ingredients, such as meat, fat, and byproducts, is such that the products are stable and affordable[5], [6].

Value-added goods are briefly covered below and may be generically categorized based on processing, variety/convenience, and functionality. Pork items that have undergone comminution: Comminution, a method of reducing meat particle size, often include grating, flaking, chopping, milling, etc. Pork is an excellent choice for minced meat products. High grade pig patties, sausages, loaves, blocks, nuggets, and rolls, as well as restructured goods, may be processed using the available methods. The juiciness and palatability of the final goods might be enhanced by adding back fat to the formulations of these items. Additionally, various low-value byproducts, such as pig rind (skin), head meat, heart meat, etc., might be added to these items without significantly harming their sensory qualities. Restructuring is a processing method used to create convenience meat products with a texture that falls between that of whole steaks and that of comminuted goods. Some of the contemporary processing approaches viz. Vacuum tumbling and flaking may be utilized to enhance the product's yield, binding, texture, and sensory qualities. Enrobing involves covering meat products with edible ingredients to increase cooking efficiency and provide greater defence against oxidative and microbiological degradation.

One of the earliest techniques for preserving pig and hog products is curing, which is the process of seasoning meat with salt, sugar, and nitrite or nitrate to preserve it or improve its taste or colour. The majority of curative agents are bacteriostatic or fungistatic in the quantities used, and they are more harmful to gram negative organisms. There are several treatments available, including. The entire curing process can be divided into four stages: curing, salt equilibration/maturation, ageing, and smoking. Curing and smoking contributes attractive colour, distinctive flavours, and texture to the meat. Simple technology was standardized for developing shelf stable pork sausages using hurdle technology. Intermediate moisture pork products: Pork products with 15-50% moisture content with moderate juiciness and texture, inhibit growth of bacteria, moulds, and yeast, water activity between 0.6 and 0.85, self-stable. Thermally processed pork products: Pork products either in cans or retort pouches with extended shelf life at room temperature[7], [8].

The benefits of fermented pork products include increased shelf life, food safety, and improved sensory qualities. Fermented pork products can be made by using lactic acid producing specific microflora like Lactobacillus, Micrococcus, and Pediococcus, etc. The bacterial cultures create such an environment that other spoilage and harmful microorganisms cannot grow. Foods that are presented as such and specially processed or formulated to meet specific dietary needs resulting from certain physical or physiological conditions, diseases, or disorders; the composition of these foodstuffs must differ significantly from that of ordinary foods of comparable nature, if such ordinary foods exist. These foodstuffs may contain one or more of the following ingredients, namely:

1. Plants, botanicals, or their components in powder, concentrate, or extract form in water, ethyl alcohol, or hydro alcoholic extract, singly or in combination.
2. Nutrients that do not exceed the recommended daily requirement for Indians, such as minerals, vitamins, proteins, metals, or their compounds, or enzymes.
3. substances derived from animals.
4. A nutritional supplement that boosts overall food intake and is used by humans to complement their diet.

There has been significant progress in the standardization of product profile and mechanization of traditional meat products, but there is still much to be done to meet the growing requirements of traditional food products, particularly meat products. The demand for traditional meat products is bound to increase further in the coming years. The growing processed meat industry is confronted with a number of challenges, such as the scarcity and high cost of high-quality meat, the lack of tested indigenous technology for commercial scale processing, batch processing, which requires more time and less production, the high cost of imported meat processing equipments, the lack of accurate information on many domestic meat and poultry products, and the lack of cold chains necessary for storage, distribution, and marketing.

Strategies to grow the meat processing industry

The quality and palatability of meat can be further significantly improved by following some of the steps either during production of meat or processing of meat products to fetch higher profits. Production of shelf stable meat products in retort pouches will facilitate their distribution and marketing in the absence of cold-storage network. Appropriate technologies need to be further standardized for profitable utilization of edible offal's like tripe into snack products or incorporation into other comminuted meat products or pet foods. Processing technologies need to be dynamic for economic survival, consumer needs and continued evolution market. Use of standardized low-cost processing technologies for several meat products can benefit entrepreneurs in producing better quality products. Pragmatic long-term slaughter policy of meat animals by Govt. of India would help to attract private investments for production of wholesome meat, safe and nutritious meat products for developing sustainable meat industry. Reduction of excise duties on processed meat products and further decrease of custom duties on imported meat processing equipments would encourage the growth of the sector[9], [10].

The abundantly available and relatively inexpensive pork has vast potential for production of several value-added convenience meat products, but the developed processing techniques for several products need to be evaluated at pilot scale and by large-scale consumer acceptance trials for their techno-economic feasibility. Pig production is an essential activity in rural areas that has helped to provide employment and income generation for farmers, rural poor, and weaker sections.In emerging nations, the livestock industry is on the verge of a revolutionary change, with tremendous increase anticipated in the production of meat and milk. The importance of this industry cannot be emphasized since it supports rural economies and gives farmers, particularly those in neglected areas, a means of subsistence and prospects for economic growth. Meat production and consumption have expanded significantly in recent years due to a greater understanding of the health advantages and culinary allure of meat products, as well as changes in lifestyles and rising disposable incomes.

CONCLUSION

The meat processing industry is at the centre of this revolution because it employs a wide range of processes that significantly alter the texture and flavour of meat. The significance of processed meat products has been thoroughly explored in this essay, along with its rising demand, promising future, and contribution to the cause of cattle industry sustainability. It has highlighted the need for effective technology and machinery to lower production costs, increase yields, diversify goods, and preserve high quality. Consumers are provided with secure, reasonably priced beef products thanks to organized processing that is carried out under expert supervision. Urbanization and changing dietary choices are fueling a surge in convenience demand for fast food that contains meat, which presents several development potentials. Attention must be paid to feed supply, production effectiveness, and the best possible use of resources, including byproducts, in order to maintain and increase livestock output. A flourishing meat processing sector also requires cost-effective processing, strict quality control procedures, and creative marketing approaches. Meat, eggs, and milk from animals are items with the greatest potential for value addition for trade and revenue generating. For long-term success, processing technology must be matched with ecological friendliness, energy efficiency, and global competitiveness. The development of the cattle industry via meat processing is a potential path for sustainable economic growth in developing nations. This industry can fulfill the growing demand for meat products, enhance lives, and greatly contribute to food security and economic development by using technology, knowledge, and strategic planning. A better future is promised by this shift for rural communities as well as the global agricultural sector.

REFERENCES:

[1] H. Meissner, M. Scholtz, and A. Palmer, "Sustainability of the South African Livestock Sector towards 2050 Part 1: Worth and impact of the sector," *S. Afr. J. Anim. Sci.*, 2014, doi: 10.4314/sajas.v43i3.5.

[2] M. SYDYKOVA and C. RODRÍGUEZ, "REGIONAL DEVELOPMENT BASED ON CLUSTER IN LIVESTOCK DEVELOPMENT. CLUSTER IN LIVESTOCK SECTOR IN THE KYRGYZ REPUBLIC," *Rev. Agric. Appl. Econ.*, 2014, doi: 10.15414/raae/2014.17.02.103-112.

[3] U. Zuhdi, A. D. Prasetyo, and N. A. R. Putranto, "Analyzing the Changes of Total Output of Japanese Livestock Sector: An Input – Output Approach," *Procedia - Soc. Behav. Sci.*, 2014, doi: 10.1016/j.sbspro.2013.12.522.

[4] U. Zuhdi, N. A. R. Putranto, and A. D. Prasetyo, "An Input – Output Approach to know the Dynamics of Total Output of Livestock Sectors: The Case of Indonesia," *Procedia - Soc. Behav. Sci.*, 2014, doi: 10.1016/j.sbspro.2013.12.519.

[5] S. Tazhibaev *et al.*, "Issues in the Development of the Livestock Sector in Kazakhstan," *Procedia - Soc. Behav. Sci.*, 2014, doi: 10.1016/j.sbspro.2014.07.446.

[6] S. Rahman, I. A. Begum, and M. J. Alam, "Livestock in Bangladesh: Distribution, growth, performance and potential," *Livest. Res. Rural Dev.*, 2014.

[7] D. Caro, S. J. Davis, S. Bastianoni, and K. Caldeira, "Global and regional trends in greenhouse gas emissions from livestock," *Clim. Change*, 2014, doi: 10.1007/s10584-014-1197-x.

[8] Raksha, "Information needs of the rural women involved in livestock sector: a study form Jharkhand," *Indian Res. J. Ext. Educ.*, 2014.

[9] A. A. Adeyemo, M. P. Longe, and A. A. Alakoso, "Value Addition to Human Managerial Skills in the Livestock Sector in Nigeria," *Asian J. Agric. Rural Dev.*, 2014.

[10] I. G. Colditz, D. M. Ferguson, T. Collins, L. Matthews, and P. H. Hemsworth, "A prototype tool to enable farmers to measure and improve the welfare performance of the farm animal enterprise: The unified field index," *Animals*. 2014. doi: 10.3390/ani4030446.

CHAPTER 12

BIOTECHNOLOGICAL ADVANCEMENTS IN MEAT PROCESSING: FROM QUALITY ENHANCEMENT TO FOOD SAFETY ASSURANCE

Suresh Kawitkar, Professor
Department of ISME, ATLAS SkillTech University, Mumbai, Maharashtra, India
Email Id- suresh.kawitkar@atlasuniversity.edu.in

ABSTRACT:

Meat is an important part of human nutrition and health since it is full of critical components including proteins, lipids, vitamins, and minerals. The demand for meat is skyrocketing in emerging nations due to urbanization, growing affluence, and population increase. Super value shops are increasingly common in urban areas, which is a sign that buyers want secure, high-quality meat items. It is essential for manufacturers to comprehend customer preferences and their willingness to pay for safety features and quality in order to fulfill society's changing needs.The meat processing sector has undergone a revolution thanks to biotechnology, which has provided creative ways to increase animal productivity, guarantee food safety, and produce meat products of the highest calibre. Modern scientific disciplines like genomics and proteomics have provided new insights into how genes are expressed and the intricate structure of proteins, leading to advancements in animal health, nutrition, digestion, reproduction, breeding, and genetics. If the costs of adoption and acceptability can be reduced, these breakthroughs may be transformational. The exact control of meat factors, such as quality and production, is made possible by genetic alterations, which are fueled by genome sequencing and gene mapping. The production of meat has expanded thanks to biotechnology methods including gene transfer, recombinant DNA technology, and DNA vaccinations. It is now possible to identify and modify the genes governing characteristics of meat quality, such as tenderness and texture, to suit customer tastes.

KEYWORDS:

Biopreservation, Biotechnology, Bioinformatics, Food Safety, Meat Processing.

INTRODUCTION

Biopreservation, another biotechnological tool, promotes food safety by controlling microbiological activity. Lactic acid bacteria (LAB) with bacteriocin production capability extend the shelf life of meat products while maintaining their quality. Fermented meat products serve as excellent carriers for probiotics, further improving digestibility and health benefits. Proteomics, an advanced field beyond genomics, investigates the totality of expressed proteins in cells, tissues, or organisms. Techniques such as two-dimensional gel electrophoresis (2-DE), mass spectrometry (MS), and bioinformatics enable the identification and characterization of proteins, shedding light on their roles in meat development and quality. Lab-grown meat, a biotechnological marvel, holds the potential to revolutionize meat production by eliminating the need for traditional livestock rearing and slaughter[1], [2]. Controlled laboratory conditions and cell culture techniques yield meat products that are not only sustainable but also address concerns about animal welfare and environmental impact.

Bioactive peptides, found in small quantities in food, offer health benefits. Omega-3 fatty acids, linoleic acid, and other bioactive compounds are valuable components of meat. Biotechnology ensures their stability and bioavailability in food products through nano-encapsulation and controlled release. Innovative biotechnological methods have emerged to enhance meat safety. DNA probes, monoclonal antibodies, and biosensors provide rapid, sensitive, and reliable pathogen detection in meat products, ensuring food safety and adherence to export standards. While biotechnology offers a wealth of benefits to the meat processing industry, challenges remain, including the high costs of methodologies, instruments, and skilled technicians. Collaboration between meat scientists, researchers, and academicians is essential to maximize the potential of biotechnological tools in the meat sector, address these challenges, and ensure the production of high-quality, safe, and sustainable meat products.For many individuals, meat makes up a significant portion of their diet and is particularly nutrient-dense. Meat contains all the essential elements, including vitamins, minerals, fat, proteins, and vitamins, which support the body's regular development and function.

Due to rising incomes, population, and urbanization, meat is in great demand in developing nations. A growing number of super value shops in metropolitan areas attest to the rising need for safe meat that is of high quality and food safety. Since consumers are the ultimate purchasers in this manufacturing chain, it is crucial to pay attention to their behaviour in terms of satisfaction and purchase. Producers need to be aware of which segments of society prefer different types of products in terms of quality and safety features, as well as whether or not they are willing to pay for these features. Better knowledge and satisfaction of customer demands, expectations, and requirements will result from this. Only with the aid of proteomics and genomics is the complicated protein structure now well-known and gene expression is now well understood.

By enhancing the health, nutrition, digestion, reproduction, breeding, and genetics of cattle, this contemporary field of study has been shown to be a reliable way to increase livestock output. If we take into account the expense of its adoption and acceptance, the benefits are unquestionable. Its goal is clear: to enhance or increase a product via the manipulation of living things. Biotechnology is employed in the meat processing business by focusing on a specific organism that is used to preserve meat and provide numerous qualities, such as enzymes and flavours, that improve the quality and safety of these processed meat products. Additionally, breeding improvements have been made for animals that produce meat. Stock rearing of premium meat animals was another ground-breaking innovation that has verified the authenticity of meat products via DNA analysis[3], [4].

Earlier, selective breeding techniques and the use of hormones were used to enhance meat parameters; but, nowadays, direct gene modification is a safer method of enhancing the quality, production, and safety of meat products. Gene mapping and genome sequencing have made it feasible to advance this research. Gene transfer, rDNA technology, vaccine research (DNA vaccines), and other key fields of biotechnology. Restriction Fragment Length Polymorphism (RFLP) was one of the early DNA markers utilized in the creation of the first accurate genomic maps.

A significant accomplishment followed, namely the finding of microsatellite sequences. We can now evaluate 5–10 microsatellite loci concurrently thanks to the use of modern, automated DNA analyzers. These microsatellites are often genotyped by PCR. Finding the genes responsible for a certain characteristic is made easier by understanding the physiological impact of a gene. Major meat quality genes provide good prospects for raising meat quality levels and lowering variability. Tenderness and Pale Soft and Exudative (PSE) are said to be 50% and 30% genetically regulated traits, respectively. Meat softness before slaughter is influenced by the myostatin gene in beef, the CLPG gene in sheep, and the RN gene in pig.

Quality of the meat

Due to several monetary, religious, and health considerations, we are now particularly concerned with determining the source of beef in processed meat products. The rapid advancement of technology based on nucleic acids has made food analysis simpler. Because DNA has a better thermostability than proteins, it is the best approach for species differentiation in pre-heated food samples. The sensitivity of the PCR (polymerase chain reaction) is a key component of the DNA-based species-differentiation methods. By utilizing species-specific primers to amplify particular DNA fragments or by using universal primers in PCR followed by restriction fragment length polymorphism (RFLP) of the amplicons, it is possible to verify the provenance of meat. Specific PCR targeting nuclear DNA and specific PCR targeting mitochondrial DNA are the two forms of specific PCR used for species identification. Dot-blot hybridization, in addition to PCR, is a powerful method for finding species-specific DNA fragments in cooked chicken, pork, goat, sheep, cattle, etc. meats. This method needs a species-specific probe and is heat-sensitive[5], [6].

Biology preservation

This is a crucial instrument for managing microbial activity and guaranteeing the security of meat and animal products. This approach uses protective microorganisms, such as lactic acid bacteria (LAB), which produce the antibacterial compound bacteriocin, to increase the shelf life of food. Products made from fermented meat that have not been heated are great probiotic carriers. LAB is a crucial ingredient utilized during the fermentation of meat since it enhances the product's sensory quality and cleanliness. By lowering pH, the fermentation caused by LAB stops spoiling and suppresses pathogenic bacteria. It also stabilizes colour and enhances texture. After fermentation, the creation of new peptides serves as a sensory and hygienic marker. The bioactive proteins known as bacteriocins are created by Gram-negative bacteria's ribosomes. They are incredibly powerful biotechnologically since they can wipe out harmful and decaying microorganisms. Bacteriocins extend the shelf life of the product, reducing the need for synthetic preservatives while reducing the damage caused by pathogenic microorganisms.

Proteomics

The next stage after genomics in the study of biological systems is proteomics. A group of expressed proteins in a cell at a certain moment and under particular circumstances is referred to as the proteome. The quantitative sum of proteins in a cell, tissue, or organism is referred to as the proteome. The goal of proteome studies is to encrypt the genetic information into practical biological domains that will help scientists to further their research and combat the food issue. The growth of muscle tissue is strongly implied by protein expression since the raw gene product requires 400 chemical modifications to become completely functional. Protein extraction, separation, purification, and identification are examples of proteome analysis techniques. Two-dimensional gel electrophoresis (2-DE), mass spectrometry (MS), and bioinformatics are important proteomics techniques. Proteome analysis identifies, quantifies, and describes the status of each protein in a cell under certain circumstances.

It is one of the first methods for preserving perishable commodities, such as meat. It gives off a distinctive flavour, colour, and perfume that customers find enticing. Meat is fermented by certain microbial cultures, which lowers the pH and gives the meat its unique characteristics and microbiological safety. A lower pH guarantees the safety of the meat since it reduces the water activity of the meat, which puts a barrier between the bacteria and the food. One important biotechnology use in the meat industry is fermentation. Market-available meat starting cultures include LAB and GCC. pH is lowered, nitrate is reduced, and fragrance is produced as a consequence of fermentation. The anti-oxidant enzyme catalase, which is produced by the bacteria employed in meat cultures, breaks down hydrogen peroxide into oxygen and water and keeps fermented meat from spoiling. Staphylococcus xylosus' KatA gene, which produces catalase, has been thoroughly investigated. For commercial purposes, nitrate is added to meat and sausages to provide the usual hue of cured meat. As they improve the host's ability to digest food, additional species including Bifidobacterium, Lactococcus, Enterococcus, Saccharomyces, and Propionibacterium are also recognized as probiotics. According to counts of 106 to 108 viable cells observed in 1 g of feces, the estimated viable probiotic bacteria to be consumed for temporary colonization in the gut is roughly 109 to 1010 CFU/g of product. Therefore, the recommended minimum daily intake for a fermented beef product with 108 CFU/g is 10–100 g.

DISCUSSION

With the use of cell culture and tissue engineering technology, this method intends to produce meat without actually growing and killing the animals. This regulated, scientific laboratory meat production advances economics, environmental sustainability, animal welfare, and health. 37% of the methane released from agriculture is from ruminants raised in typical meat production systems. Three fundamental natural alternatives from non-animal sources, such as plants or fungi, are used to make artificial meat. Soya meat is created using plant-based proteins. It is made from transgenic pigs and cows for the manufacture of cheese and milk, as well as Enviropig for the synthesis of omega-3 fatty acids. It is also in vitro meat from cell lines and other genetically modified species. Science has advanced to the point that it is now feasible to produce meat using a variety of sources, including seed muscle tissue, live animal biopsies, animal embryos, and enriched medium cultured under controlled circumstances[7], [8].

The bioactive peptides

The nutrients in food that are good for your health are called bioactive compounds, and they are usually only found in trace amounts. The omega-3 fatty acids found in fish and chicken meat have been shown to have cardio-protective properties as well as to guard against both mental illness and immune-mediated diseases including rheumatoid arthritis, diabetes, and inflammatory bowel disease. Conjugated linoleic acid is immuno-regulatory, anti-oxidative, and anti-carcinogenic. However, when these bioactive substances are introduced to food, various issues are seen because they interact with other food ingredients during processing, storage, and transportation. Bioactive substances are not very soluble in water. Additionally, it changes in colour, taste, and aroma in response to temperature, light, and oxygen. throughout order to demonstrate prolonged release throughout the GI tract, these bioactive substances are sometimes attached to the food matrix. These bioactive substances may also be nano-encapsulated (particle diameter less than 100 nm), which improves the stability of the entrapped substances and increases their bioavailability.

Innovative, cutting-edge meat safety techniques

In line with rising knowledge and globalization, food safety is a major issue on a worldwide scale. With increased buying power and the availability of handy items with added value, the consumption pattern of meals of animal origin has undergone significant shift. Traditional microbiological methods for identifying infections and their toxins may take a long time and are often inaccurate. In order to assure effective commerce, biotechnology is used to provide sensitive, trustworthy, and quick detection systems. Therefore, cooked, ready-to-eat beef and poultry products are now tested for Listeria monocytogenes, Salmonella, and other microorganisms using DNA probes. These techniques are better than conventional techniques because they save time and are more accurate in finding organisms. The DNA of pathogens that codes for poisons or virulence factors has been used to make DNA probes that may be used to identify particular organisms in meat products via hybridization analysis, such as Real-time PCR has been used to quickly and quantitatively identify Listeria monocytogenes in meat products. Additionally useful in biological surveillance of meat products via antigen detection are monoclonal antibodies. The most recent developments in biotechnology are biosensors. The basic idea behind how these biosensors function is that they detect antibiotics or foodborne pathogens by coupling an antibody, enzyme, or nucleic acid with an electrode. By monitoring the quantity of surface glucose on meat (a substrate for bacterial deterioration), they may determine how long meat will remain fresh. Both non-microbial and pathogenic components may be found using monoclonal antibodies. Use of rDNA technology and incorporation of bacteriocin against certain infections are two more ways to maintain safety by managing the microbial population.

As it has substantially improved our understanding of the elements influencing muscle growth, function, and development as well as meat safety and new product creation, biotechnology has proven to be a benefit to the meat processing business in contemporary times. Application of diverse biotechnological technologies has outpaced the meat sector in this quest to end global hunger and meet the demand for high-quality nutrients. High-quality animal production, bioactive peptide encapsulation, fermentation, biopreservation, proteomics, and invitro meat production all provide potential methods for producing high-quality meat while also guaranteeing animal welfare. Rapid approaches for evaluating the quality of meat products (such as microbial load assessment) may effectively handle food safety concerns and export criteria. Even though they have many benefits, the use of contemporary biotechnological techniques in the meat business is constrained by expensive, labor-intensive methods and equipment. Therefore, strong symbiotic relationships between meat scientists, researchers, and academics are necessary to solve these issues and to ensure that the meat industry receives the most advantages from this field[9], [10].

CONCLUSION

With a wealth of options to improve quality, assure food safety, and satisfy the rising demand for meat products in a changing world, biotechnology has ushered in a new age in meat processing. The industry has gained the ability to better understand and regulate important elements impacting meat production, from genetics to protein expression, thanks to this potent collection of technologies.The exact manipulation of meat factors, enabled by genetic developments such as gene mapping and genome sequencing, ensures meat quality and production. The production of meat has expanded thanks to biotechnology methods including gene transfer, recombinant DNA technology, and DNA vaccinations. Genes that control softness and texture may now be altered to suit customer tastes. For religious, ethical, and health reasons, it is essential to guarantee the authenticity of beef products. In order to prevent food fraud, DNA-based species-differentiation techniques have become effective ways to confirm the provenance of meat, even in pre-heated food samples. Meat products' shelf lives are extended through biopreservation procedures, such as the use of LAB for the formation of bacteriocin. Probiotics improve digestion and have positive health effects. The complex universe of proteins in meat is revealed by the cutting-edge discipline of proteomics, offering insight on their functions in growth and quality. A miracle of science, lab-grown meat offers hope for a morally and environmentally responsible future by resolving issues with animal welfare and environmental effect. Now, it is possible to stabilize and distribute bioactive peptides which are crucial for health effectively in food items. Modern biotechnological techniques, such as DNA probes, monoclonal antibodies, and biosensors, guarantee the safety of meat and conformity to export requirements. Although biotechnology has limitless promise, there are still difficulties, mainly the high expense of techniques, equipment, and experienced labour. To fully use biotechnological techniques in the meat industry and ensure the production of high-quality, secure, and sustainable meat products to suit the changing demands of the globe, collaboration between specialists is essential.

REFERENCES:

[1] B. Martín *et al.*, "Diversity and distribution of Listeria monocytogenes in meat processing plants," *Food Microbiol.*, 2014, doi: 10.1016/j.fm.2014.05.014.

[2] U. ur Rahman, A. Sahar, and M. A. Khan, "Recovery and utilization of effluents from meat processing industries," *Food Res. Int.*, 2014, doi: 10.1016/j.foodres.2014.09.026.

[3] S. Wiedemann and M. Yan, "Livestock meat processing□: inventory data and methods for handling co-production for major livestock species and meat products Processing inventory data," *Proc. 9th Int. Conf. LCA Agri-Food Sect.*, 2014.

[4] E. Giaouris *et al.*, "Attachment and biofilm formation by foodborne bacteria in meat processing environments: Causes, implications, role of bacterial interactions and control by alternative novel methods," *Meat Sci.*, 2014, doi: 10.1016/j.meatsci.2013.05.023.

[5] H. K. Adesokan and A. O. Q. Raji, "Safe meat-handling knowledge, attitudes and practices of private and government meat processing plants' workers: Implications for future policy," *J. Prev. Med. Hyg.*, 2014.

[6] S. Charlebois and A. Summan, "Abattoirs, meat processing and managerial challenges: A survey for lagging rural regions and food entrepreneurs in Ontario, Canada," *Int. J. Rural Manag.*, 2014, doi: 10.1177/0973005214526504.

[7] C. Marculescu and F. Alexe, "Assessing the power generation solution by thermal-chemical conversion of meat processing industry waste," in *Energy Procedia*, 2014. doi: 10.1016/j.egypro.2014.06.091.

[8] D. Behsnilian, P. Butz, R. Greiner, and R. Lautenschlaeger, "Process-induced undesirable compounds: Chances of non-thermal approaches," *Meat Sci.*, 2014, doi: 10.1016/j.meatsci.2014.06.038.

[9] H. Westhoek *et al.*, "Food choices, health and environment: Effects of cutting Europe's meat and dairy intake," *Glob. Environ. Chang.*, 2014, doi: 10.1016/j.gloenvcha.2014.02.004.

[10] L. Vallone and S. Stella, "Evaluation of antifungal effect of gaseous ozone in a meat processing plant," *Ital. J. Food Saf.*, 2014, doi: 10.4081/ijfs.2014.1680.

CHAPTER 13

BIOTECHNOLOGICAL ADVANCES IN LIVESTOCK PRODUCTION AND QUALITY ASSURANCE: TRANSFORMING THE FUTURE OF FOOD SAFETY AND NUTRITIVE VALUE

AshwiniMalviya, Associate Professor
Department of uGDX, ATLAS SkillTech University, Mumbai, Maharashtra, India
Email Id-ashwini.malviya@atlasuniversity.edu.in

ABSTRACT:

The livestock production business has seen a radical transformation thanks to biotechnology, which has also significantly improved food safety and the nutritional content of goods obtained from animals. The revolutionary potential of biotechnological advancements in animal production is examined in this research, with particular emphasis on how they affect food quality, safety, and sustainability in general. We explore many facets of biotechnology, such as genetic engineering, microbiological treatments, and quick detection techniques, to show how these developments are changing the cattle industry. Utilizing biotechnological techniques enables improved food safety standards in addition to increased production yields, which ultimately benefits both producers and consumers. This study examines the wide range of biotechnology instruments and methods that have already started to transform cattle farming. These breakthroughs, which range from genetic engineering and microbiological treatments to cutting-edge detection techniques, have the potential to significantly alter the sector. Biotechnology helps us to develop safer, higher-quality livestock products that satisfy the needs of a constantly growing global population by improving animal health, optimizing breeding and genetics, and putting in place strong quality assurance processes.

KEYWORDS:

Agriculture, Biotechnology, Genetic Engineering, Public Health, Livestock Products.

INTRODUCTION

The global livestock industry stands at a pivotal juncture, tasked with meeting the growing demand for animal-derived products while simultaneously addressing concerns related to food safety, sustainability, and nutritive value. Biotechnology, as one of the most promising frontiers of scientific development, offers a transformative pathway to navigate these challenges effectively. By harnessing the principles of biotechnology, the livestock production sector can enhance its productivity, improve food quality, and ensure safety throughout the food supply chain.One of the most cutting-edge fields of science being developed nowadays is biotechnology. A broad range of scientific sectors, including agriculture, hormones, animal sciences, functional and designer livestock products, enzymes, bio-preservation of livestock products, effective byproduct usage, quality control, and meat authenticity, have benefited from advances in the field of biotechnology. Science related to the environment, food, and medicine, etc. Production of high-yielding, high-quality food to raise the general living standards of humans and other animals[1], [2]. By affecting animal health, nutrition, and animal products, livestock production is anticipated to increase and become a sustainable method of greatly improving livestock in accordance with the predicted need for production. Consequently, breeding, genetics, and cattle reproductive techniques. The primary production must be altered to accommodate efficiency barriers that prevent effective implementation of and productivity development. Acceptability of biotechnology. Biotechnology, in its simplest form, is the use of true biological principles to manipulate live organisms or their derivatives in order to enhance or multiply a product. The phrase may be roughly described as a technology that uses living things or other biological processes to create usable goods out of raw materials. Recent advances in biotechnology have become an effective tool for enhancing numerous animal products, including milk and meat. The production of high-yielding animals and the enhancement of the quality food needs of the continuously expanding human population may both benefit from the use of biotechnological techniques. With the use of biotechnology, transgenic animals including mice, rats, rabbits, pigs, lambs, and cows have been created. Transgenesis is a method that enables the modification of genes in one organism that can then be inserted into the genome of another organism of the same species or another species in a manner that causes the genes to be not only expressed but also passed on to the offspring. Thusly created transgenic animals will grow faster and generate better food. For instance, the administration of therapy for human emphysema resulted in substantial improvements of 40% in average transgenic cows created to make milk daily gain and 30% in feed conversion including particular human proteins that assists in the efficiency[3], [4].

Enhancement of livestock products' quality

Major meat quality genes provide outstandingMilk that has been treated with galactosidase has the potential to improve meat quality and hydrolyze lactose, making it more digestible by reducing unpredictability. According to the majority of scientists, lactose intolerance exists. Galactosidase is a 30% delicate enzyme that hydrolyzes lactose into glucose and galactose in Pale Soft Exudate (PSE). Since swine condition is 50% genetically determined and these enzymes are expensive, biotechnology may assist in certain ways. a gene that influences meat softness before commercial manufacture and use. Examples are CLPG in sheep, myostatin in beef, and RN in pork that is manufactured from commercial yeasts. the components of biotechnology development and research. An increasing body of evidence supports the use of somatotropin (ST), a protein produced from the pituitary, as a tool to interact with calf chitosan. enhance carcass composition and growth. After being effectively injected with pST, the DNA of calf chymosin contained 35% less fat and 8% more protein and was cloned into yeast, bacteria (E. But ST must be isolated from coli) and moulds*Aspergillusniger.*

These may be Pituitary gland manufacturing is unprofitable due to the large-scale fermentation techniques used and the collection and downstream processing required for each dosage. 100 Pituitary glands of technology. Since the cheese made using recombinant chymosin process for large-scale production of is fundamentally identical to conventional cheese somatotropin, more recently, the development performance of recombinant chymosin is outstanding of recombinant DNA technology has supplied a. The ST protein gene is placed into a laboratory strain of E. coli that can be cultivated on a large scale, from which ST can be purified, and from which ST can be concentrated. Growth is enhanced by bovine and ovine ST[5], [6]. Attempts may be made to establish starter culture strains that can support ruminants in order to increase the product's rate by 20% and lean to fat ratio by 40%. While pigs were being experimented on, the improved antichlolestermic properties, improved anti-carcinogenic properties, improved antagonistic outcomes, and improved shelf life of the goods' impact on enteropathogenic microorganisms would be economically beneficial, the genetic stability of starting strains is advantageous to bacteriophage infection, off-flavor creation, manufacturers, and consumers from a nutritional and medicinal standpoint. The dairy business faces expensive issues due to biotechnological inadequacies in the formation of acid during fermentation processes.

DISCUSSION

Thus, lactic acid bacteria with increased production capacity have attracted a lot of attention in the development of new and these natural food grade preservative as well as to improved strains. These improved strains use modern techniques to combine within a single strain the ability of produce a molecular biology, such as plasmid transfer, transduction, number of such bacteriocin to extend their protoplast fusion, and cloning. plasmid biology for a variety of antimicrobials. The nutritional or therapeutic value of these products is a significant issue for the food processing industry. Lactic acid bacteria have opened new horizons for byproduct usage, researching potential for combining recombinant DNA technology and genetic engineering to enhance them. The creation of techniques that transform unpalatable and by turning waste materials into new, high-value goods, a fully phage-resistant strain may be produced. incorporating plasmid that prevent phage growth. A DNA metabolism, penetration, and absorption are required due to environmental and financial considerations. Reducing food processing waste and improving raw materials utilization The use of genetically modified strains as raw materials and byproducts may offer additional value to the production of specialized, high-quality goods. alcoholic animal products. gene cloning from[7], [8].

Large volumes of whey, which must be disposed of because it contains lactic acid bacteria, are produced by the cheese business. The protein component of whey may be concentrated using ultrafiltration, producing a value-added product with billions of pounds' worth of potential market value. These concentrated solids may be transformed into ascorbic acid, a valuable substance with a market price of around $10 per kilogram, utilizing a newly developed bioconversion method that uses certain strains of yeast. Dehydrating and using the resultant yeast biomass are also options. This technique gives cheese producers a practical way to make use of the extra whey and generate more money.

Bio preservation

Livestock products are particularly susceptible to microbial infection that may easily break them down, and they also go through microbial genetically created microorganisms that cause degradation. Processors in the pharmaceutical or chemical sectors have been influenced by the current tendency of customers preferring antibiotics, hormones, or peptides of interest in food without artificial preservatives. To adequately safeguard customers and promote commerce, it is crucial to provide an appropriate level of food quality and safety. Before these foods are consumed by people, a strong and effective quality assurance procedure must be in place to monitor their quality and safety. Implementing successful quality assurance systems is now achievable thanks to recent developments in biotechnological technologies.

Because lactic acid bacteria naturally possess antibacterial qualities, there is a chance that a natural preservation method appropriate for food applications may be created. This may be done by either using live cultures of these microorganisms or by using chemical agents that have been purified. The dairy business and public health may both benefit greatly from the lactic acid bacteria's reduction of foodborne pathogens and spoiling. The safety and shelf life of fermented foods might be considerably improved by these characteristics.Salmonella, Staphylococcus, Clostridium, Listeria monocytogenes, and Yersinia enterocolitica are just a few of the many foodborne pathogens and spoilage organisms that lactic acid bacteria may operate antagonistically against. Because they provide quick, sensitive, and precise techniques for the detection and analysis of bacterial pollutants, pathogens, or their toxins, contemporary biotechnological technologies have proved to be an important addition to quality assurance systems.

Pseudomonas

The most potent biotechnology techniques, such as rDNA technology, genetic engineering, PCR, microarray, etc., have already made significant progress as a result of the incorporation of specific antimicrobial agents, such as bacteriocin, nisin, H_2O_2, diacetyl, microgard, reutrin, and pimaricin, into cattle products. Molecular RAPD (random amplified polymorphic DNA) or AFLP (amplified fragment length polymorphism).

Systems for marking conclusions may also be used to compare Depending on the reaction circumstances used, biotechnology combines wholesomeness and nutritive strains with the production and quality genetic variations across species, subspecies, and revolutions. the worth of the food items. Biotechnology is essential. By combining these technologies, it is possible to improve the quality of livestock products while also identifying organisms at the genus, species, sub-species, and even strain levels. This allows for the location of food contamination sources, the tracking of microorganisms along the food chain, and the identification of the germs that cause food-borne illnesses.

Microarrays are biosensors that are made up of several big

They are useful for raising livestock: Overview of options for disease, pesticide, and toxin detection, which have great potential for ensuring the safety and quality of raw materials. Tests that can be done in a sixth of the time needed by traditional procedures have been developed as a result of biotechnology. creation of novel, cutting-edge techniques for the quick identification of developing, very dangerous food diseases.

Recent advances in biotechnology have become a potent tool for enhancing the qualitative characteristics of animal products, including milk and meat. Numerous cattle products may benefit from biotechnological methods to increase their production, economics, physicochemical properties, and nutritional qualities.

The development of high yielding food animals, enhancements to product quality, increased production of natural food grade preservatives, effective byproduct usage, and other areas might be envisioned as the goal areas of biotechnological research in the field of livestock products. In order to create animal products of guaranteed quality and public health safety, several biotechnological strategies might be studied in the domain of quality assurance programs[9], [10].

CONCLUSION

A paradigm change in cattle agriculture is being sparked by biotechnological advancements, with far-reaching consequences for food safety and nutritional value. Utilizing biotechnological techniques enables more effective and environmentally friendly livestock production methods, guaranteeing that customers may access goods made from animals that are both safe and of the highest calibre.

Biotechnology is positioned as a key component in the future of livestock production due to its capacity to improve animal genetics, fight infections, and deploy speedy detection techniques. In order to realize the full potential of biotechnological breakthroughs, it is critical that industry stakeholders continue to make investments in R&D.

By doing this, we can not only fulfill the growing demand for animal products throughout the world, but also make sure that these goods are higher in terms of overall quality, nutritional value, and safety. A road to a more sustainable and secure food future for everyone is provided by the revolutionary potential of biotechnology in the cattle industry.

REFERENCES:

[1] E. Sciences, “Climate change and livestock production in Ethiopia,” *Acad. J. Environ. Sci.*, 2014, doi: 10.15413/ajes.2014.0108.

[2] S. J. Oosting, H. M. J. Udo, and T. C. Viets, “Development of livestock production in the tropics: Farm and farmers’ perspectives,” *Animal*. 2014. doi: 10.1017/S1751731114000548.

[3] K. Marshall, “Optimizing the use of breed types in developing country livestock production systems: A neglected research area,” *J. Anim. Breed. Genet.*, 2014, doi: 10.1111/jbg.12080.

[4] M. Jin and L. L. Iannotti, “Livestock production, animal source food intake, and young child growth: The role of gender for ensuring nutrition impacts,” *Soc. Sci. Med.*, 2014, doi: 10.1016/j.socscimed.2014.01.001.

[5] A. Getu, “The effects of climate change on livestock production, current situation and future consideration,” *African J. Anim. Prod. Husb.*, 2014.

[6] N. Assan, “Possible impact and adaptation to climate change in livestock production in Southern Africa,” *IOSR J. Environ. Sci. Toxicol. Food Technol.*, 2014, doi: 10.9790/2402-0824104112.

[7] M. M. Scholtz, H. C. Schönfeldt, F. W. C. Neser, and G. M. Schutte, “Research and development on climate change and greenhouse gases in support of climate-smart livestock production and a vibrant industry,” *S. Afr. J. Anim. Sci.*, 2014, doi: 10.4314/sajas.v44i5.1.

[8] N. Assan, “Gender disparities in livestock production and their implication for livestock productivity in Africa.,” *Sci. J. Anim. Sci.*, 2014.

[9] A. Poliquit, “Climate Change Impacts on Livestock Production Systems: A Review,” *Ann. Trop. Res.*, 2014, doi: 10.32945/atr3628.2014.

[10] and P. S. K. Abraham H., “Animal Biotechnology Options in Improving Livestock Production in the Horn of Africa,” *Int. J. Interdiscip. Multidiscip. Stud.*, 2014.