Acta Scientific MICROBIOLOGY (ISSN: 2581-3226)

Volume 5 Issue 9 September 2022

Review Article

# Modern Innovative Tools of Biotechnology for Improving Quality of Meat and Meat Products

**Meena Goswami*, Vikas Pathak, Sanjay Kumar Bharti, Barkha Sharma, Parul, Sanjay Singh, Abhishek Mishra and Rishi Kumar**

*College of Veterinary Sciences and Animal Husbandry, DUVASU, Mathura, India*

***Corresponding Author:** Meena Goswami, Assistant Professor, Department of Livestock Products Technology, College of Veterinary Sciences and Animal Husbandry, DUVASU, Mathura, India.

**DOI:** 10.31080/ASMI.2022.05.1141

**Received:** June 27, 2022

**Published:** August 23, 2022

© All rights reserved by **Meena Goswami*., et al.***

## Abstract

Biotechnology is one of the leading areas in scientific development of the world today. Biotechnological advancement has spread nearly to all spheres of science *viz.* agriculture, animal sciences, environmental science, food-science, medicine etc. so as to improve the living standards of the globe. The meat processing is bridging the gap and is been proven as a promising pace in the developing world. This industry has been constantly upgraded by new technologies but the application of latest biotechnological methods is still hindered. The share of food processing market is largest in biotechnology despite the fact that the health care market is leading due to high valued end products. The link between biotechnology and food processing has been proved on different platforms and still explored by various researchers and organizations. During last few decades, the tools of biotechnology have proved a boon to improve the livestock products (milk, meat products etc.). The various fields of application of biotechnological tools are: increasing production of high yielding animals, quality control and improvement of products, production of hormones, designer food, functional food, enzymes, bio preservation and end-product utilization.

**Keywords:** Biotechnology; Meat Processing; Bio Preservation; Genetically Modified Organisms; Proteomics; Shelf Life; Quality Characteristics

## Introduction

Meat is a major fraction of food for many people and is nutritionally very rich. All the important nutrients are present in meat like: proteins, fat, vitamins and minerals; which promotes good health, growth and normal functioning of body. Developing countries have high demand for meat because of increasing population, income and urbanization. In urban areas, there is demand for safe meat, with good quality and food safety; this increased demand can be confirmed by increasing number of super value stores. Consumers are the final buyers in this production flow, so their behavior is very important to be noted regarding satisfaction and purchase [1]. The producers must understand and respond; that which section of the society wants which type of product regarding safety attributes and quality and whether they are ready to pay for these attributes or not. This will lead to better understanding and fulfillment of consumers demand, expectations and needs. The complex structure of protein is now simplified and gene expression is now well understood only by the help of proteomics and genomics. This modern branch of science is a proven key to enhance livestock production by improving their health, nutrition, digestion, reproduction, breeding and genetics. The advantages are sure shot if we counter the cost of its adoption and acceptance. Its objective is clear i.e., to improve or multiply a product by manipulating the living organisms [2]. In meat processing industry, biotechnology is applied by targeting a particular organism which is used for meat preservation and production of various attributes like enzymes, flavors etc. which enhance the quality and safety of these processed meat products. Not only this, but breed improvement has also been done of meat producing animals. Other revolutionary step was DNA based identification of meat products which has ensured authenticity.

## Stock raising of high-grade meat animals

Earlier the meat parameters were improved by the application of selective breeding strategies and use of hormones but currently biotechnology gears up with safer tools to improve the quality, yield and safety of meat products; by direct gene manipulation. The further development of this field is possible due to gene mapping and genome sequencing. The major areas of biotechnology are gene transfer, rDNA technology, vaccine development (DNA vaccines) etc. One of the earliest DNA markers used for construction of first true genomic maps was Restriction Fragment Length Polymorphism (RFLP). Then a major achievement came i.e., identification of microsatellite sequences. These microsatellites are generally genotyped by PCR and now; the application of recent, automated DNA analyzers has allowed us to analyze 5-10 microsatellite loci simultaneously. Knowing the physiological effect of a gene helps us to identify the genes controlling a particular trait. Major genes for meat quality offer excellent opportunities for increasing level of meat quality and decreasing variability. It is stated that tenderness is 30% and Pale soft and exudative (PSE) is 50% genetically governed characters [3]. Genes affecting tenderness of meat before slaughter are myostatin in beef, CLPG in sheep and RN gene in pork.

## Authenticity of meat

In present scenario we are very much concerned to identify the meat origin of processed meat products due to many economic, religious and health reasons. Food analysis has been made easier by the immense development of nucleic acid based technologies. DNA analyzing methods are best for species differentiation even in pre-heated food samples because of their higher thermostability than proteins. The DNA-based species-differentiation techniques mainly rely on the sensitivity of PCR (polymerase chain reaction). The authentication of meat origin can be achieved either by amplifying the specific DNA fragments with species-species primers or by PCR, using universal primers followed by restriction fragment length polymorphism (RFLP) of resulting amplicons. There are two types of specific PCR used for species identification, Specific PCR targeting nuclear DNA and Specific PCR targeting mitochondrial DNA [4]. Not only PCR but dot-blots hybridization is also a potent technique to detect species-specific DNA fragments in cooked meats of chicken, pig, goat, sheep, beef etc. However, this technique is heat sensitive and requires species specific probe.

## Bio preservation

This is an important tool to control microbiological activity and ensure the safety of meat/meat products. This technology is employed with an objective to extend the shelf-life of food by the use of protective microbes e.g., use of lactic acid bacteria (LAB) with bacteriocin production (antibacterial property). Fermented meat products that do not undergo heat treatment are excellent carriers for probiotics. An essential agent used while meat fermentation is LAB, as it improves the sensory quality and hygiene of the meat product. The fermentation due to LAB prevents spoilage and curbs pathogenic microbiota by the resulting decrease in pH; additionally, it stabilizes color and improves the texture. The generation of new peptides after fermentation acts as sensorial and hygiene marker [5]. The bacteriocins are bioactive proteins synthesized in ribosomes of Gram-negative bacteria [6]. They are biotechnologically very potent as they have the ability to destroy pathogenic and deteriorating bacteria. Bacteriocins reduce the harm due to pathogenic microflora and increase the shelf-life of the product thereby decreasing the use of synthetic preservatives [7].

## Proteomics

Proteomics is the advanced step of genomics in the study of biological systems. The term proteome represents a set of expressed proteins in a cell at a particular time and specific conditions. Proteome is defined as quantitative totality of proteins in cell, tissue or organism. Proteome studies aims to encrypt the genome information into useful biological spheres allowing the scientist to explore more and counteract the food crisis. Protein expression significantly implies the development of muscle-tissue, as the raw gene product undergoes about 400 chemical changes to become fully functional [8]. Proteome analysis methods include protein extraction, separation, purification and its identification. Major tools of proteomics include two-dimensional gel electrophoresis (2-DE), mass spectrometry (MS) and bioinformatics. Proteome analysis tells the identity, relative quantity and state of protein in a cell, under specific conditions [9].

## Fermentation

It's one of the pioneer techniques in preservation of perishable foods (like meat). It imparts a distinct flavor, color and aroma which is pleasant and appealing to consumers. The fermentation of meat is done by specific microbial cultures which lowers its pH and imparts the exclusive meat properties and microbial-safety. Lowered pH ensures meat safety as it decreases the water activity of the meat and hence creates a hurdle to the pathogens. The fermentation process is a major biotechnological application in meat Industry. Meat starter cultures available in market constitutes of LAB and GCC. Fermentation results in cascade of actions including pH decrease, nitrate reduction and aroma production [10]. The bacteria used in meat cultures produce catalase (anti-oxidant enzyme) that decomposes hydrogen peroxide to oxygen and water and prevents spoilage of fermented meat. The catalase producing gene, *Kat*A, of *Staphylococcus xylosus* has been studied in detail. Nitrate is commercially added in meat and sausages to achieve the typical colour of cured meat. In addition to it, other species like *Bifidobacterium*, *Lactococcus, Enterococcus, Saccharomyces* and *Propionibacterium* are regarded as probiotics as they enhance digestibility in the host. For temporary colonization in intestine, the estimated viable probiotic bacteria to be ingested is approximately $10^9$ to $10^{10}$ CFU/g of product, in accordance with the counts of $10^6$ to $10^8$ viable cells found in 1 g of faeces [11]. Hence, in a fermented meat-product having $10^8$ CFU/g; the minimum daily consumption might be 10-100 g of product [12].

## Starter culture microorganism for fermented meat products [13]

| Micro-organisms | Strains |
|---|---|
| Bacteria | Lactic acid bacteria<br>*Micrococci*<br>*Pediococci*<br>*Staphylococci*<br>*Enterobacteria* |
| Yeast | *Debaryomyces hansenii*<br>*Yarrowia lipolytica*<br>*Candida spp.* |
| Molds | *Penicillium spp.* |

**Table a**

## *Invitro*/cultured meat

This technique aims at meat production with the help of tissue-engineering technologies and cell culture; without actual rearing and slaughter of animals. This controlled, scientific laboratory meat production promotes health, animal welfare, global environment and economics. The farm animals (ruminants) reared under traditional meat production system, accounts for 37% of methane release. Artificial meat is manufactured from three basic types of natural substitutes from non-animal sources, plants, or fungus [10]. Soya meat is engineered with plant-based proteins (Joshi., *et al*. 2015), laboratory-cultured meat, or in vitro meat from the cell lines and others from the genetically modified organisms such as transgenic pigs and cows for the production of cheese and milk [14] and even Enviropig [15] for the production of omega 3 fatty acids. Modernization in science has now made it possible to culture meat from seed muscle tissue, live animal biopsies, animal embryos and grown in enriched media under specified conditions [16].

## Bioactive peptides

Bioactive compounds are the health-benefitting components of food and typically present in small quantity in food. Omega-3 fatty acid present in fish and poultry meat manifests cardio-protective effects and prevents immune mediated disorders (e.g., rheumatoid arthritis, diabetes, and inflammatory bowel disease) and mental disorders. Linoleic acid (conjugated) has anti-carcinogenic, anti-oxidative and immuno-regulatory properties. However, many problems are observed when these bioactive compounds are added in food, as they react with other food-components during processing, storage and transport. Bioactive compounds are poorly soluble in aqueous solution [17]. It is also sensitive to light, oxygen and temperature leading to change in colour, flavour and odour. Sometimes these bioactive compounds are bound to the food matrix in order to show sustained release in GI tract. These bioactive compounds can also be nano-encapsulated (particle diameter below 100 nm) enabling stability to entrapped compounds potentiate their absorption and bioavailability [18].

## Innovative (advanced) methods for meat safety

Food safety is the burning global topic in accordance with increasing awareness and globalization. The consumption pattern of foods of animal origin has changed a lot with more purchasing power and availability of value-added convenient products. Classical microbiological techniques for identification of pathogens and their toxins are often time consuming and unreliable [19]. Therefore, biotechnology is deployed to develop sensitive, reliable and rapid detection methods to ensure efficient trade. So, now DNA-probes are used to detect *Salmonella, Listeria monocytogenes* and other microorganism in cooked, ready-to-eat meat and poultry products. These methods are more advantageous than traditional methods as they save time and are more specific in detecting organisms. DNA probes have been created by the DNA-fragment of pathogens that codes for toxins or virulence factors, which detects the specific organism in meat products by hybridization-analysis e.g., Rapid quantitative detection of *Listeria monocytogenes* in the meat products by Real time PCR has been done. Monoclonal antibodies are also an important asset in biological-monitoring of meat-products by antigen identification. Biosensors are the most recent developed techniques of biotechnology [20]. The running principle behind the working of these biosensors is attaching an antibody, enzyme or nucleic acid with electrode, then these sensors can detect food borne pathogen or antibiotic. They can detect the shelf life of meat by detecting the amount of surface glucose on meat (substrate for bacterial spoilage). Monoclonal antibodies can detect pathogenic-microbes as well as non-microbial components also. Another method to ensure safety by controlling microbial population is use of rDNA technology and incorporating bacteriocin against specific pathogens [21].

## Conclusion

In modern time biotechnology has proven a boon to meat processing industry as it has greatly enriched our knowledge of factors controlling muscle growth, function and development: as well as meat safety and new product development. To quench the world hunger and fulfill the high-quality nutrient demand: application of various biotechnological tools has paced the meat industry in this race. Production of high-quality animals, encapsulation of bio active peptides, fermentation, bio preservation, proteomics and invitro meat production offer a promising approach for quality meat production along with ensuring animal welfare. Food safety issues and export standards can be well coped-up with rapid methods for meat-products quality evaluation (microbial load estimation). Even after having enormous advantages, the application of modern biotechnological tools in meat industry is hindered due to high-cost demanding methodologies, instruments and skilled technicians. Therefore biotechnological and meat processing interface is required for strong symbiotic bonds between meat scientists, researchers and academicians to overcome such problems and to rule out maximum benefits from this area in meat sector.

## Bibliography

1. Ellies-Oury MP., *et al.* "Influence of selection for muscle growth capacity on meat quality traits and properties of the rectus abdominis muscle of Charolais steers". *Livestock Science* 150 (2012): 220-228.
2. Arihara K and M Ohata. "Bioactive compounds in meat". In Meat biotechnology. Springer New York. (2008): 231-249
3. Oliveira C., *et al.* "Bacteriocinas como alternativa na conservação de alimentos". *Revista verde de Agroecologia E Desenvolvimento Sustentável* 7. 1 (2012): 09-15.
4. Anklam E., *et al*. "Analytical methods for detection and determination of genetically modified organisms in agricultural crops and plant-derived food products". *European Food Research and Technology* 214 (2002): 3-26.
5. Naveen K., *et al.* "Technological and Health Impacts of Meat Based Functional Foods - A Review". *International Journal of Science and Research* 5 (2014): 6-11.
6. Simons A., *et al.* "Bacteriocins, Antimicrobial Peptides from Bacterial Origin: Overview of Their Biology and Their Impact against Multidrug-Resistant Bacteria". *Microorganisms* 8.5 (2020): 639-643.
7. Gálvez H., *et al.* "Bacteriocin-based strategies for food bio preservation". *International Journal of Food Microbiology* 120.1-2 (2007): 51-70.
8. Pennington SR and Dunn MJ. "Proteomics from Protein Sequence to Function". Oxford: BIOS Publishers Ltd, 3 (2001): 313-321.
9. Weckwerth W and R Steuer. "Metabolic networks from a systems perspective: from experiment to biological interpretation". (Vaidyanathan, S., Harrigan, G. G., and Goodacre, R., eds) Springer, NY (2005): 265-289,
10. Kumar P., *et al.* "Meat analogues: Health promising sustainable meat substitutes". *Critical Review of Food Science and Nutrition* 57 (2017): 923-932.
11. Terpou A., *et al.* "Probiotics in Food Systems: Significance and Emerging Strategies Towards Improved Viability and Delivery of Enhanced Beneficial Value". *Nutrients* 11.7 (2019): 1591.

12. Renata EFDM., *et al.* "Probiotic Meat Products". Open access peer-reviewed chapter (2012).

13. Muthukumarasamy P and RA Holley. "Microbiological and sensory quality of dry fermented sausages containing alginate-microencapsulated Lactobacillus reuteri". *International Journal of Food Microbiology* 111 (2006): 164-169.

14. Gaydhane MK., et al. "Cultured meat: State of the art and future". Biomanufacturing Reviews 3 (2018): 1-10.

15. Zhang X., et al. "Novel transgenic pigs with enhanced growth and reduced environmental impact". *eLife* 7 (2018): e34286.

16. Bhat ZF and H Bhat. "Prospectus of cultured meat-advancing meat alternatives". *Journal of Food Science and Technology* 48 (2011): 125-140.

17. McClements DJ., *et al.* "Structural design principles for delivery of bioactive components in nutraceuticals and functional foods". *Critical Review of Food Science and Nutrition* 49 (2009): 577-606.

18. Onwulata CI. "Encapsulation of new active ingredients". *Annual Reviews of Food Science and Technology* 3 (2012): 183-202.

19. Chriki S and JF Hocquette. "The myth of cultured meat: A review". *Frontier Nutrition* 7 (2020): 7-9.

20. Gupta S and CV Savaliya. "Application of biotechnology to improve livestock products". *Veterinary World* 5.10 (2012): 634-638.

21. Joshi VK and S Kumar. "Meat analogues: Plant based alternatives to meat products—A review". *International Journal of Food Fermentation and Technology* 5 (2015): 107-119.