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MEAT SPOILAGE: THREATS, CAUSES AND THEIR PRESERVATION

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ABSTRACT

Preservation of meat started with mankind from day one of living and is still carried in every type of food such as vegetables, fruits, meat and their byproducts. The basic concept of meat preservation is to increase the shelf life of meat and its by product without deteriorating the quality and texture of products by delaying the growth of different types of microbial and fungal organism. Transformation of any food from edible to inedible with the denaturation of texture, quality and taste of product in presence of organisms (bacterial and fungal) that deteriorate the products. Every year economy of every country faces a huge loss in meat and its byproducts because of spoilage and low level of preservation skills carried out in handling and processing. Basic mechanisms of meat spoilage are microbial activity, lipid oxidation and enzymatic activity. Oldest preservation methods include drying, salting, pickling and smoking that's are helpful in preservation with freezing; however, with the passage of time new methods of preservation got invented including freezing, chilling and irradiation that increased the preservation duration and their ease in application. Now a day's preservation is done for every type of meat and its byproducts by using different modern techniques such as chilling and different types of freezing methods, ultimately increasing the shelf life, quality and texture of products by almost neutralizing the growth of microbial organisms.

Keywords: Meat, Preservation, Spoilage, Texture, Shelf Life, Microbial And Fungal.

I. INTRODUCTION

Meat is the rich source of protein that the world is utilizing and its utilization is increasing day by day. Animal protein (meat) is the first choice of peoples all over the world including protein sources such as chicken, turkey, beef, mutton, fish, pork, camel meat and their consumption is increasing day by day and for increasing consumption we have to think about the techniques through which more production can be achieved and also deals about its preservation (Heinz and Hautziner, 2007). Meat preservation process include preservation of meat for longer time by using different methods. Meat processing plants or slaughtering houses are always built far from the city, so there is desirable need of meat preservation for transporting it to far distances without deteriorating its quality. Animal transformation involves many steps like loading of animals from farm and transporting them to slaughter house where they are slaughtered (Gallo et al., 2018). Any poor technique used in facilitating animals will result in injuries and ultimately it will reduce meat quality and causes spoilage. Environment is surrounded by a numerous microbial pathogens and also excess water content in meat makes it

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more vulnerable for the pathogens attack ultimately cause spoilage. As animal meat consumption is increasing day by day and so do the spoilage losses are also increasing.

Stress during slaughtering of animal process will adversely affect meat quality, speedup spoilage activity and cause major portion of meat loss (Gallo et al., 2018). Heinz and Hautziner (2007) described that major meat constituents are fats, proteins, carbohydrates and water. In order to minimize the meat losses that are majorly caused by spoilage need to draw some new potential preservation methods in order to keep the freshness of products (Dave and Ghaly, 2011). As modern era is demanding well quality meat, that is dire need to establish some advance methods to prevent meat spoilage to make meat quality products to preserved for a longer time.

Dave and Ghaly (2011) studied that major cause of meat spoilage is rigor mortis of muscle, that term explains the hardness of muscle after the slaughtering of animal and more stress produced quicker rigor mortis. Also explained that meat contains many constituents like proteins, fats and carbohydrates that spoiled by different types of enzymatic activity.

In Middle Ages people used different traditional methods to secure the meat from being spoiled. In that era there was less microbial activity because there were less microbes present in air at that time. There was also less pollution at that time but now in advanced era air is already polluted, so therefore, is more spoilage of meat because of microbes. Meat losses due to spoilage are increasing every year greatly almost 302.4 million tons of meat is lost every year due to spoilage (Knowles et al., 2014). New techniques enable to establish a thought to urges about the economic losses and their reduction to maximize the economic gain from meat industry.

Causes for Meat Spoilage

There are many causes of meat spoilage, here will discuss pre-slaughtering meat quality deterioration and post-slaughtering meat quality deterioration effect. Both of these effects cause spoilage of meat due to poor handling and management practices. Animals face stress while pre-slaughter period as a result, this causes the reduction level of glycogen in muscle activity and ultimately changes the pH level of meat while glycogen content of animal muscle is broken down and lactic acid produced through anaerobic glycolytic pathway (Gallo et al., 2018; David and Ghaly, 2002; Rahman, 1999).

Meat changes to dark, firm and dry due to high level of pH. DFD caused due longer period of stress cause the reduction of shelf life of meat and meat gets paler, softer and exudative due to short time stress. When the meat is pale, soft and exudative its pH gets lower to 6.2 which is the point in which the protein breakdown takes place and this pH is suitable for bacterial growth. There are basically three mechanisms for spoilage of meat;

a) Microbial activity
b) Lipid oxidation
c) Autolytic Enzymatic activity

a) Microbial activity

A variety of microflora such as molds, yeasts and bacteria out of which some are pathogens grow excellently on meat and meat by products (Jay et al., 2005). Main sources of these microflora or pathogens is intestinal tract of animals and their skin. Pre-slaughter lookout practices, age of animals, handling during slaughtering, temperature control, preservation methods and handling by consumer are major factors on which composition of these pathogens depend (Cerveny et al., 2009). There are different species of bacteria, molds and yeasts that are present in the meat before the process of spoilage. Garcia-Lopez et al. (1998) defined that yeast species include Cryptococcus, Candida spp. while some mold species such as Cladosporium, Geotrichum and Penicillin. Many species of bacteria that are present in meat and meat products include Streptococcus, Micrococcus, Pseudomonas, Bacillus and Clostridium (Arnaut-Rollier et al., 1999; Lin et al., 2004; Nychas and Tassou, 1997).

Enterococcus species is the most dominant specie of bacteria that is found in 99% of meat sample from different animals in the state of Lowa (Hayes et al., 2013). Meat and meat products are effected with different types of microbes on different type of storage condition. Many types of microbes work more efficiently in colder environment than in hotter environment and enteric bacteria are present on those products which were refrigerated. Similarly, many species like Moraxella spp. and Acinetobacter spp. are most likely to grow in hotter environment (more than 20°Celsius). Many pathogens that likely to grow in hotter environment are mostly found in raw, salted cured products such as hams and uncooked beef, the reason for their growth is that

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they are salt resistant (curing salt). The growth of Pseudomonas and enteric bacteria is well favored in cold environment at 5° Celsius and is most prevalent in modified environment (Garcia-Lopez et al., 1998). Sentence (2010) describes that pseudomonas a bacterial specie can affect the shelf life of meat only at 2° Celsius and its growth rate is much slower at 0°Celsius. Russell et al. (1996) described that similarly many other species like salmonella above 7° Celsius can effect meat quality and shelf life but under 7° Celsius its growth is too slow and at pH of 5.5-7.0 is favorable for the growth of spoilage bacteria within above mentioned pH meat quality deteriorates because of microbial activity that will result in formation of slime, meat will be off odor and its appearance also changes. Dainty (1996) reported that many derivatives of ammonia like methylamine and others were detected in spoilage activity and there are many types of ketones, alcohols were produced by microbial activity having sweet odor.

b) Lipid Oxidation

Free radical production and oxidation of lipids present in meat will affect the fatty acids and the result will be presence of odor in meat, off-flavor and meat quality deterioration (Gray, 1978; Pearson et al., 1983; Samitzis and Deligeorgis, 2010). Metabolic process gets stopped when blood circulation gets stopped and the fatty acid present in meat start to get oxidize after the slaughtering of animal (Gray and Pearson, 1994; Linares et al., 2007). Hultin (1994) wrote that fatty acid always form double bond with oxygen present in air in lipid oxidation process and initiation, propagation and termination are three basic steps that involve in lipid oxidation (Frankel, 1984; Khayat and Schwall, 1983).

Initiation: During the process natural catalysts like heat and irradiation form free radicles, when these radicles react with the oxygen present in air the form peroxyl radicles.

Propagation: The peroxyl radicles that were formed during the initiation process will now react with other lipid molecules to form new free radicles and hydro-peroxides (Owen and Sam, 1998; Hultin, 1994).

Termination: It occurs when the free radicles that were produced in the first two steps interact with each other and form non-radicle products.

Different factors affect the oxidation of lipids like antioxidant vitamin E and composition of fatty acid. Breakage of hydro peroxide cause release of many products such as acids, ketones and aldehydes (Shahidi, 1994; Raharjo and Sofos, 1993). Simitzis and Deligeorgis (2010) wrote that these effect causes degradation in nutritive value and loss of colour because of their extreme effect on carbohydrate, lipids and vitamins and Lie et al. (1995) described that ultimately they are related to many extreme pathogenic process.

Toldrá (2006) explained that hydrolysis of lipid in meat can be done either enzymatically or non-enzymatically and while enzymatic hydrolysis is done with help of many enzymes such as phospholipase and lipase, main enzymes that are involved in hydrolysis of lipid in meat are Phospholipase A1 and A2. Proteins that are susceptible to oxidation and will produce hydro peroxides are hemoglobin, cytochrome and myoglobin and they are responsible for non-enzymatic hydrolysis (Love and Pearson, 1971; Kanner 1994).

c) Autolytic Enzymatic Activity

The main cause of meat deterioration is the enzymes that are present in body. They work normal only when an animal is living and when they die or get slaughtered they are the main cause of meat deterioration and reduced shelf life. Adam (2016) wrote that meat deterioration starts when enzymes react chemically with other compounds and act as catalyst for chemical reaction. Tissue protease is an enzyme that is responsible for flavor change and textural change and this enzyme is released by the breakdown of polypeptides (Toldrá and Flores, 2000). Post-mortem autolysis of meat through digestive process is done by some enzymes such as calpains and cathepsins (Gram and Huss, 1996; O'Halloran et al., 1997). Tenderization process (proteolytic tenderization) of meat is done by calpains. Rahman and Velez-Ruiz (2007) at low temperature growth of biogenic amine production and microbes increases which also increase proteolytic enzymes that's lead to deterioration of meat quality.

Preservation Methods

There are different methods that are being used for meat preservation. Since the man started to utilize the meat, he started to preserve it for later uses. Methods of preservation that are used for meat preservation are listed below

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- Drying
- Canning
- Smoking
- Freezing
- Chilling
- Curing/Salting
- Fermentation and Pickling
- Irradiation

Drying

Drying is the oldest preservation method that is still being used. Drying is also known as dehydrating. Bacteria and enzymes only multiply at a certain level of moisture content, in drying we reduce the moisture content to 10-20% by weight and hence the enzyme remain inactivated (Javeed and Ram, 2015). In the past meat was dried by sun drying method but now oven and dehydrators in practice. Lonergan et al. (2019) wrote that now it's easy to dry the meat at home with the help of stove and oven. By process, firstly, cut the meat into thin narrow strips then boil it at high temperature that's the bacteria could be killed, after boiling for 5-10 minutes' bake in the oven. Through this method we can preserve meat for 1-2 months in the air tight containers.

Canning

Another popular way of preserving meat is canning by the use any type of can or jar. Meat is filled in container then these containers are placed in hot water for 8-10 minutes with lids and immediately cooled to 38° Celsius (Nafissatou et al., 2020). For canning process, removal of oxygen is important and process of canning cause survival of many organisms because of additives. Many additives that were used in past and still now being used such as sodium benzoate, sodium sorbate, sodium ascorbate ascorbic acid and sulphur dioxide (Omorodion and Odu, 2014). Ellis et al. (2004) described that bacterial growth can be prevented by acetic acid and lactic acid and growth of yeast by sorbate and acetate. High temperature steam can sterilize the meat in canning process. For preservation of poultry meat, we use either hot pack or raw pack. During hot pack the meat is first roasted and then stewed in fat, while for the raw pack water or meat broth is placed on poultry (Downing, 2013).

Smoking

As the name suggests smoking, in this method meat is preserved by smoke of woods or plants. In this method moisture is removed from the meat surface from hot smoke but this method is only reliable when used with salting or additives. Meat remains tender if the smoke is not hot enough (Owen and Sam, 1998). By smoking the meat, the outer layer of meat becomes so dry that bacteria face very much difficulty while entering because at low moisture level bacteria don't grow. There are basically three methods of smoking that is hot smoking (involves the cooking of meat), smoke roasting (same as hot smoking) and cold smoking (meat is not cooked in this type). In cold smoking it is dried quickly so that it will stop/reduce the growth of bacteria. Also one thing to remember while smoking that don't directly smoke the meat from plants because it will cause growth of carcinogenic hydrocarbons (Phillips, 1999).

Freezing

It is very good method of preserving edible things, it includes all types of meat and vegetables by slowing the enzymatic activity of bacteria and microbes but the main problem of this type of preservation is that bacterial growth and enzymatic activity gets deactivated instead of permanent stop, whenever they animal gets suitable for growth they start replicated. Growing activity of bacteria can be reduced significantly by lower the temperature about to 0° Celsius or less than that. But when they face extreme low temperature they won't get killed but their activity is reduced and they will cause slow spoilage. -12° Celsius is good for longer shelf life without deteriorating the meat quality and its flavor. But for freezing you must require a good freezer and a good source of electric supply without interruption (Shoaib et al., 2016). The meat gets burned if you place meat directly in the freezer without any freezer bag and always make sure the bags are air tight in order to avoid contamination. Uncooked meat can be preserved for more than 3-4 months by this method. Different type of meat freezes at different temperature like meat freezer at -0.6° Celsius. One thing to look after is that try

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quick freeze but slow freeze will make larger ice crystals that may rupture the meat cells. It failed for vegetables but it worked best for meat, so this technology is only used for meat preservation (Rahman and Velez-Ruiz, 2007).

Chilling

Liang et al. (2022) wrote that to reduce the growth and proliferation of microflora on the carcass surface, lamb carcass should be chilled shortly after slaughtering, which is not only encourage in the quality of meat such as colour, weight loss, and tenderness but also increases the shelf life. Metabolic activity of pathogens, microbes and viruses can be reduced by the process of chilling. Many types of parasites such as Taenia cysts and many other when placed at 18° Celsius for consecutive 20-30 days they will destroyed completely. Pankina et al. (2019) wrote that temperature of chilling is in between 0° to 5° Celsius for preservation of many varieties of food products.

Salting or salt cured meat

Curing of meat is also an old method of preservation. Now modified methods are too much but still use curing in order to keep the taste and flavor in contact. In poor countries it is still used for preservation of different food products and meat its operation in production, transport, storage and access (National center of home Food Preservation). For salting sodium chloride is used because it absorbs the water content of meat, delays and retards the growth of microbes. Rubbing of salt on meat is termed as salting or placing the meat in salt solution. Moisture of the product can be drawn out by osmosis process with the help of curing technique. Injecting salt solution in meat is also getting popular these days (Parthasarathy and Bryan, 2012). Earliest form of curing was dehydration removal of water content from meat that will make difficult for microbes to grow (Chellaiah et al., 2020).

Fermentation and Pickling

Controlled microbial reaction in the absence of oxygen is termed as fermentation. In pickling higher amount of salt is used that act as barrier for bacteria. For pickling time and concentration of pickling agent is very much important that could be determined by the type of food (Mani, 2018; Barrett, 2003).

Irradiation

Ellis et al. (2004) described that another method of preservation is called irradiation (cold Sterilization). Different types of radiation effect the growth of bacteria. It has been seen that the shelf life of meat can be increased with the application of gamma rays. For sterilization of surface of meat UV rays are used because they are bactericidal.

II. CONCLUSION

From the reviewed literature it could concluded that meat spoilage produced very terrible effect in the past because of poor or no preservation methods but now it became extremely easy to prevent meat and its by products from spoilage by reducing or almost inhibiting the growth of microbial pathogenic organisms by using different types of preservation techniques including drying, canning, freezing and chilling without deteriorating the shelf life of products texture and quality. Most of these methods are still adopted on industrial level to achieve the maximum profit from these products. Industries and scientists are working to develop and establish easier and reliable techniques to ensure the safe transportation of meat and its byproducts.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data present in this review that support the findings of this study are openly available.

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