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Impact of Extending the Shelf Life of the Meat on Public Health

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Abstract

The shelf life of the meat and the meat products types is the storage time until the spoilage, which is a complex condition in which the combination of biological and physic chemical activities may interact and make the product unacceptable for the human consumption. A maximum acceptable microbial level and/or unacceptable off odor and off flavor identify the exact point of the spoilage, which is strictly dependent on the initial numbers and types of contaminating microorganisms, their growth, lipid oxidation, and autolytic enzymatic reactions. The Meat and the fish, due to their physic chemical characteristics, are excellent basic nutrients for microbial activity. The pH, the aw (activity water) and the high moisture values can support the growth of a wide variety of the microorganisms.

Keywords: The Shelf Life; Meat; Meat Products Types; Lipid Oxidation; Autolytic Enzymatic Reactions

Introduction

The initial microbial count of the meat and the cooked meat products types is about 23 log CFU/cm^2 or g, and for the fresh meat and the meat and the fish products about 45 log CFU/cm^2 or gram. The microbial species originate from the physiological status of the animal during the farming, the slaughtering, the harvesting, the fishing, the processing, the transportation, the preservation, and the storage conditions. The food contamination occurs after the heating process that is often used to prolong the shelf life either of the meat or the fish products. Only 10% of the bacteria initially present are psychrotolerant and may grow in the cold storage and that the fraction causing the spoilage is even lower [1-7]. During the storage, the temperature, the gaseous atmosphere, the pH, the NaCl, and the packaging are important factors affecting the selection, the growth rate, and the activity for certain bacteria. The initial mesophiiic bacterial count on the meat and the cooked meat products types is about lo' to 10' cfu,/cm' or gram, consisting of a large variety of species. Only 10% of the bacteria initially present are able to grow at refrigeration temperatures, and the fraction causing spoilage is even lower. The meat products types are heated to a temperature of 65 to 75”C, most vegetative cells are killed and post heat treatment recontamination determines the shelf life. The surface contamination of the cut meat and the meat products types will determine the potential shelf life. During the storage, the environmental factors such as the temperature, the gaseous atmosphere, the pH and the NaCl will select for certain bacteria, and affect their growth rate and activity. The shelf life of the refrigerated meat and the meat products types may vary from days up to several months. The bacteria able to grow and cause the spoilage during the storage of the meat, the cooked and the cured meat products types [8-14].

Causes of the Meat Spoilage

Caused by the physical, the chemical and the biological agents, including the microorganisms as the bacteria, the yeast and the mold, the action of the enzymes in the meat such as the lipases and the proteases, the chemical reactions in the foods such as the browning and the oxidation, the physical changes introduced by the freezing, the drying, and the application of the pressure. The Several agents are implicated in the meat spoilage; the microorganisms are the most common cause of the quality deterioration in the foods of animal origin. The spoilage organisms break down fat, carbohydrate, and protein in the meat resulting in the development of off flavors, slime formation, and discoloration, thereby rendering the meat disagreeable for consumption. The microbial spoilage is responsible for 25% of the postharvest food loss globally [15-21].

The Meat

The Environmental Influence on the Bacterial Growth and the Shelf Life

The Growth to high numbers is a prerequisite for the spoilage. The expected shelf life and growth ability of different bacteria under various environmental conditions. The Microbiome of the spoiled meat, The Microbial spoilage can be defined as the biochemical changes in the meat brought about by the dominant microorganisms that make up a significantly higher proportion of the microbial community associated with the meat. The overall composition of the spoilage microflora is diverse and primarily determined by the environment in which the animals are raised, and the postharvest and processing environment of meat. The spoilage organisms are conventionally grouped as the Gram negative rods, the Grampositive spore formers, the lactic acid bacteria (LAB), the other Gram positive bacteria, the yeast, and the molds. The meat products types are not commonly degraded by the yeast due to their inability to produce extracellular proteases. Some exceptions to this include the Yarrowia lipolytica, the Rhodoturola, the Cryptococcus, the Pichia, and the Saccharomyces in the fresh and the refrigerated meat and the poultry. Similarly, the mold found on the meat that could play a role in the spoilage includes the Alternaria, the Aspergillus, the Fusarium, the Rhizopus, and the Cladosporium [22-28].

The Micro Flora of the Fresh Meat

The muscle tissue in healthy living animals is essentially sterile. Thus the initial microbial load and composition of the fresh meat are primarily influenced by the physiological status of the animal at the time of slaughter, the spread of microbes during slaughter and the slaughterhouse environment. Following sacrifice, the main contamination of the meat occurs when the carcass is opened and the offals are removed. For instance, bacteria from the intestines, the lymph nodes, the skin, the hide, the handlers, the cutting knives, and the processing facility can potentially contaminate the meat. These microorganisms acquired by the meat can be termed as the slaughterhouse microbiome, which is a combination of the microbial population in the facility and the animal's gut. Toward this, Mills and coworkers demonstrated that Carnobacterium spp. identified on lamb carcasses were traced back to the meat processing environment. Spoilage bacteria and the meat quality. Further, investigations of microbial prevalence revealed that the core microbiota at the slaughterhouse consisted of Staphylococcus spp., Streptococcus spp., Brocothrix spp., Psychrobacter spp., Acinetobacter spp., and lactic acid bacteria. On the other hand, Proteobacteria especially Pseudomonas spp. and members of Enterobacteriaceae were found to dominate the carcass microflora [29-35].

The Packaging

Three different packaging types are in use: air, vacuum and modified atmospheres. Modified atmospheres contain different levels of oxygen and carbon dioxide, balanced with inert nitrogen. The Packages containing up to 80% oxygen and 20% carbon dioxide (High oxygen modified atmospheres) will reduce the color. The deterioration of the retail cuts of the meat, but will only slightly increase the shelf life, compared to the aerobic storage. The Pork is stored aerobically or in the modified atmospheres, and the beef in vacuum or modified atmospheres due to the need for tenderization during an extended storage. Transitions between the different packaging types may be performed for the retail cuts. The shelf life of the meat increases in the order: air, high oxygen modified atmospheres, vacuum, no oxygen modified atmospheres and 100% CO_2, the P.wudomonm spp. dominate on the aerobically stored meat, and due to a high growth rate the shelf life is a matter of days. The shelf life may be attained in the pure CO_2, The time needed to reach 10' bacteria/cm' and the off odour. Was 10 days in the air, and 40 days in 100% CO_2 for the pork stored at 4°C. The effect of CO_2 is enhanced by a low storage temperature, due to increased solubility of the gas. On the pork loins stored under CO_2, at ~ 1.5"C, a maximum bacterial number of 10(2) cfu/cm (2)" was reached after 63 days. The Shelf life extension by the CO_2, results from an immediate selection, as opposed to a gradual one in a vacuum pack, of the lactic acid bacteria growing at a reduced rate [36-42].

The Temperature

The lowest cold storage temperature for the meat is - 1.5"C, the minimum growth temperature of the psychrotrophic bacteria is - 3°C. Decreasing refrigeration temperatures decrease the bacterial growth, and affect the composition of the bacterial flora. In the vacuum packaged beef, a bacterial count of about 10(7) cfu/cm2 was reached after 14 weeks at - 1.5'C, but as early as after three weeks at 4°C. The growth of enterobacteria was drastically reduced at - 1.5C, but a transition on to 4°C initiated the growth [43-49].

The Product Composition

The meat pH and the availability of the nutrients affect the selection and the growth of the bacteria. Normally, the muscle pH decreases post mortem to values between 5.4 and 5.8. A high ultimate pH (> 6.0; the dark firm dry meat, the dark firm dry) may be the result of stress of the living animal. The Adipose tissues have a higher pH than normal meat. The meat contains about 0.2% glucose and 0.4% amino acids. In the adipose tissue and the high pH meat, the levels of the bacterial nutrients are lower. The High pH meat and the adipose tissue spoil more rapidly than the normal pH meat since the amino acids are rapidly attacked. The Vacuum packed pork has a shorter shelf life than the beef, even though the lactic acid bacteria dominate on both types of the meat. The Glycogen and the glucose decrease at a faster rate in the pork than in the beef, leading to an earlier initiation of the amino acid degradation in the pork. The Enterobacteriacae~ are developed better on the pork than on the beef. The pink colour of the cooked, the cured meat products types is the result of the addition of the nitrite and/or the nitrate prior to the heating, and the subsequent formation of the nitrosohaemochrome. The Nitrite has an inhibitory action on the growth of several microorganisms, such as the Enterobucferiuceue and the B. thermosphacta, but not on the lactic acid bacteria [50-56].

The Bacteria Associated with the Spoilage of the Meat Products types

The Lactic acid bacteria are the major bacterial group associated with the spoilage of the refrigerated vacuum or the MA-packaged cooked, the cured meat products types. The time of the spoilage some products contain a 'pure' culture of only one species, while in others a mixture of the lactobacillus spp. and the Leuconostoc spp. was found. The great diversity of the bacteria isolated from the spoiled meat products types. The genus/species of the lactic acid bacteria responsible for the spoilage depend on the product composition (product related flora) as well as the manufacturing site. The Lactic acid bacteria spoil the refrigerated meat products types by causing the defects such as the sour off flavors, the discoloration, the gas production, the slime production and the decrease in PH [57-63].

The Off Odors and the Off Flavors

The off devours in the vacuum or the MA-packaged cooked meat products types are typically described as sour and acid. The dominating bacteria, lactic acid bacteria, produce acids such as the lactic acid. The acetic acid and the formic acid: the levels depending on the genus species and the growth conditions. The Meat products types stored aerobically or vacuum packaged using a film with a relatively high permeability to the oxygen may in addition to the sour and the acid flavors. It Develop a slightly sweet, the cheesy obnoxious Odor, This is found in the meat products types that have initially been stored anaerobically and subsequent to opening the package in an aerobic atmosphere. The aerobic atmosphere induces the formation of the acetoin in the B. thermofecta lactobacillus spp. and the corynebacterium spp [64-70].

The Discoloration

The Bacteria producing H2O2 may cause a green discoloration through the oxidation of the nitrosohaemochrome to the choleomyoglobin, frequently seen as green spots. The Exposure to the air is necessary for the formation of H2O2. The bacterial greening in the Centre of the meat products types is caused by the bacteria surviving the cooking process which after exposure to air start to produce H2O2. The high heat resistance, the W.viridescens has been demonstrated to survive regular heat processing in the sausage processing, being able to survive for more than 40 minutes at 68°C. The surface greening is caused by the bacteria which contaminate the product after cooking. The Homofermentative Lactobacillus spp., the heterofermentative the Lactobacillus spp., the Leuconostoc spp. and the C. divergens are able to form H_2O_2. Other bacteria that have been associated with greening are the Elzterococcus spp. and the Pediococcus spp. [71-77].

The Gas Production

The Clostridium spp. has been associated with the production of large amounts of gas (H_2, and CO_2,) in the vacuum packaged beef, accompanied by the foul off odors. The Gas production (CO_2) by the lactic acid bacteria without the extensive off odours may be associated with the vacuum packaged beef and pork [78-84].

The Heat Processed Meat Products Types

The Environmental Influences on the Bacterial Growth and Shelf Life

The microbiological stability of the cooked, the cured meat products types depends on the extrinsic factors, mainly the packaging method and storage temperature, and on intrinsic factors, such as the product composition [85-90].

The Packaging

The Cooked meat products types are chill stored. The vaccum pack or in the MA-packs, but are distributed unpacked, i.e. stored in an aerobic atmosphere. In the retail shops slicing is performed after the opening of packages, with the subsequent storage in an aerobic atmosphere. During the aerobic storage of the cooked, the sliced meat products types a mixed florrt composed of the bacillus spp., the micrococcus spp and the lactobacillus spp. is recorded to dominate. The psuedomonus spp. may increase up to 105 Cfui\g. The cured, the raw meat products types, the B. thermophacta, the Moraxella spp\ psychrobacter spp. and the Pseudmonus spp. were retrieved. In addition good growth of yeast occurred. The Vacuum packaging is frequently used for the cooked meat products types. The combination of the microaerophilic conditions, the presence of the curing salt and the nitrite favors the growth of the psychotropic lactic acid bacteria [91-97].

The Temperature

On the vacuum or the MA-packaged meat products types the dominance of lactic acid bacteria is unaltered by the refrigeration temperature used, but the growth rate is affected. The lactic acid bacteria on the vacuum packaged Bologna type sausage with a decrease in temperature from 7°C to 2"C, the growth of lactic acid bacteria was retarded almost two fold; from 7°C to 0°C about four fold. The meat products types the storage temperature is an important factor affecting the shelf life [98-104].

The Analysis of the Spoilage

The Bacterial Indicators

The maximum level of bacteria reached during the refrigerated storage of the meat is 1O7 to 109 cfu\cm^2, and of the meat products types about 1O7 to 109 cfu /g. The correlation between bacterial numbers, in particular lactic acid bacteria, and sensorial spoilage is imprecise, which makes it difficult to use bacterial levels as an estimate of the spoilage. The probability that 107 lactobacillus lus spp\g meat product types would cause overt spoilage is about 10%. The times between reaching bacterial counts of 107 cfu\ig, and that of evident spoilage, were 19 days and one month storage at 4°C and 2°C respectively. A similar situation is valid for the vacuum packaged beef. The storage at 4°C off odours occurred one week after achieving a count of 107 cfu\cm'. However, at - 1.5°C off odors were pronounced as early as four weeks before a count of 107 cfu/cm^2 [105-111].

The Chemical Indicators

As an alternative to bacterial determinations, n-lactate, acetoin, tyrmine, pH value and headspace gas composition have been suggested as chemical indicators of the bacterial spoilage in the meat and the meat products types. The use of such spoilage indicators is, however, dependent on the product composition. The occurrence of the slime and the decrease in the pH in the meat products types will depend on the presence of the fermentable carbohydrates. The drop of the pH from 6.3 to 5.6 was observed in the Bologna type sausage, while in the liver Sausage, the pH dropped to five. The type and the amount of the bacterial end products formed were dependent on the type of the bacteria growing on the meat. The o-lactate and acetate indicated high numbers of the lactobacillus sp. While D-lactate and ethanol indicated high numbers of a Leuconostoc sp. [112-118].

The Microbiological Spoilage of the Meat

The Meat and the meat products types are ideal growth media for the animalborne as well as the environmental sources of the microbes. The skin and the intestinal contents are the primary sources of the animal borne microbes in the meat. The Muscle glycogen derived lactic acid from the anaerobic glycolysis along with the minor quantities of the glucose and the glucose-6-phosphate is some of the molecules available for the microbial utilization. The Glucose is the first source of energy, which is metabolized more rapidly by obligate aerobic pseudomonads than by facultative anaerobes such as the B. thermosphacta and the oxidative strains of the Shewanella putrefaciens. The Pseudomonads are predominantly seen during spoilage as a result of their faster growth rate along with a higher affinity for the oxygen. The glucose reserves are depleted; lactate is the next energy source utilized both under aerobic and anaerobic conditions, followed by the amino acids. The sensorial meat spoilage development is due to the metabolic activity of the meat surface micro biota on the nutrient substrates such as the sugars, the fatty acids, and the free amino acids favoring the release of the undesirable volatile organic compounds (VOCs), including the alcohol, the aldehydes, the ketones, the esters, and the volatile fatty acids. The Aerobic bacteria such as the pseudomonads oxidize the glucose and the glucose-6-phosphate to form the D-gluconate, the pyruvate and the 6-phosphogluconate. The Odoriferous metabolites derived from the amino acids such as the sulfides, the methyl esters, and the ammonia are usually the first signs of the spoilage of the chilled meat and the poultry. The microorganisms commonly involved in putrefaction include the *P. fragi*, the *S. putrefaciens*, the Proteus, the Citrobacter, the Hafnia, and the Serratia [119-124].

The Alcohols

The Alcohols are produced by the spoilage microbes during the chilling of the fresh meat when stored aerobically, and under the vacuum packaging and the MAP. The Microbial metabolism favors the breakdown of proteins and amino acids, reduction of the ketones, and the aldehydes derived from the lipid peroxidation to produce a variety of the alcohols. The Alcohols associated with the spoilage of the meat stored aerobically and in the vacuum packaging include methyl-1-butanol, 1-octen-3-ol, 2-ethyl-1-hexanol, 2, 3-butanediol, butanol, 1-heptanol, 1-hexanol, and 3-phenoxy-1- Propanol, whereas 1-octen-3-ol is associated with the MAP meats. The spoilage organisms, the Pseudomonas spp. and the Carnobacterium spp. are predominantly involved in the production of the alcohols, and some of the compounds generated are indicative of possible off odor in the meat [125-130].

The Aldehydes

The production of aldehydes by the spoilage organisms is known to impart sharp acidic to the fatty flavor in the meat. The Acidic flavors are commonly attributed to the short chain aldehydes, whereas an increase in the aldehyde chain length with the varying degrees of the unsaturation contributes to the fattiness. The Aldehydes are derived from the triglyceride hydrolysis, the oxidation of the unsaturated fatty acids, or the lipid auto oxidation. The aldehydes can be generated from the imide intermediates of the amino acid transamination reactions. The species mainly contributing to the off flavors by the aldehyde production include the Pseudomonas spp., the Carnobacterium spp., and the Enterobacteriaceae spp. The hexanal, the nonanal, the benzaldehyde, and the 3-methylbutanal are aldehydes seen in the naturally spoiled meat, which at the detectable threshold levels are known to generate the fresh green fatty aldehydic grass leafy, the fruity sweaty odor, the fatty and the green herbal odor, the volatile almond oil and the burning aromatic taste, and the cheese and the pungent apple like the odor, the respectively. The Increasing the higher concentrations than detectable odor threshold values are known to produce very unpleasant and the rancid aromas in the meat. The aldehydes are known to produce off flavors in fresh as well as the spoiled meat, correlating their presence with the spoilage bacteria is difficult due to their low concentration and oxidation to acids during the early storage phase, the Spoilage bacteria and the meat quality [131-135].

The Ketones

The Ketones are generated either via chemical or by microbial spoilage, and they are produced in the fresh meat stored under varying atmospheric conditions. Lipolysis and microbial alkaline degradation or dehydrogenation of secondary alcohols is some of the putative routes for ketone production in fresh meat. The aldehydes, the Pseudomonas spp., the Carnobacterium spp., and the Enterobacteriaceae are known to be primarily associated with volatile ketones from the spoiled meat. The Acetoin and the diacetyl are major ketones that contribute to the cheesy odor and the butter, the sweet, the creamy, and the pungent caramel flavor, respectively. Acetoin is known to be generated from the glucose catabolism by the B. thermosphacta, the Carnobacterium spp., and the Lactobacillus spp. and by the microbial breakdown of aspartate [136-139].

The Esters

The Esters are predominantly seen in fresh meat stored aerobically and their production is attributed to P. fragi, which is considered the major ester producer. Microbial esterase activity favors the esterification of alcohols and carboxylates found in meat resulting in a fruity off flavor. Some of the volatile esters produced from naturally spoiled meat or an inoculated model meat system include ethyl acetate, ethyl butanoate, ethyl-3- methylbutanoate, ethyloctanoate, ethyl hexanoate, and ethyl decanoate [5-11].

The Volatile Fatty Acids

The Volatile fatty acids are another group of compounds that originate from fresh meat following the hydrolysis of triglycerides and phospholipids. Amino acid degradation or the oxidation of ketones, esters, and aldehydes are other plausible reaction pathways for their production. B. thermosphacta and Carnobacterium spp. are associated with the production of volatile fatty acids in fresh meat. B. thermosphacta are known to produce 2- and 3-methylbutanoic acid from aerobically stored fresh meat, wherein isoleucine, leucine, and valine act as precursors for amino acid degradation. These acids provide a pungent, acid, and Roquefort cheese odor and a sour, stinky, feet, sweaty, and cheese odor, respectively, in aerobically stored fresh meat. Butanoic acid is produced by lactic acid bacteria via breakdown of amino acids through Stickland reaction, or by Clostridia through butyric fermentative metabolism in vacuum packaged meats. The Butanoic acid is known to produce a rancid, sharp, acid, cheesy, butter, and fruity odor in spoiled meat [31-36].

The Sulfur Compounds

The Volatile sulfur compounds are produced by spoilage microbes as a result of degradation of sulfur containing amino acids (methionine and cysteine) producing compounds such as dimethylsulfide, dimethyldisulfide, dimethyltrisulfide, and methyl thioacetate. The Pseudomonads are commonly associated with the production of volatile sulfur compounds which generate a wide variety of odors providing a sulfurous, cooked onion, vegetable, radish like, and savory meaty odors. The Biogenic amines are a consequence of meat spoilage by bacteria producing amino acid decarboxylases. The primary end product of bacterial amino acid metabolism in meat includes putrescine and cadaverine. Production of these amines leads to the development of putrefying odors associated with spoiled fresh meat [68-73].

The Factors Affecting Microbial Meat Spoilage

The Spoilage of the meat is principally caused by the growth and degradation of the nutrients in the product by a diverse group of microorganisms. The composition of this micro flora is dependent on the product itself and the processing and the storage conditions. In general, the factors that influence microbial proliferation on meat are grouped into three categories. The Intrinsic parameters, these include the physical and chemical composition of the substrate, water activity, pH, nutrient availability, initial microflora and presence of natural antimicrobial substances. The Extrinsic parameters, the storage and handling environment specifically temperature, humidity, and atmosphere condition (the aerobic, the anaerobic, and the MAP).The Implicit parameters, these constitute the synergistic and antagonistic effects of the factors mentioned above on the development and establishment of the spoilage microflora. The Intrinsic factors, The Meat composition and antimicrobial hurdles Like higher animals, microorganisms require energy for their growth and survival, essential nutrients and components for the constitution of cells. They acquire these molecules from their substrate or surrounding food environment. In this regard, meat and muscle foods, in general, are rich in proteins, lipids, minerals, and vitamins, but poor sources of carbohydrates. This nutrient composition and availability select for the growth and survival of certain groups of microbes (initial microflora) over the others. Further, the initial break down of these macromolecules to simpler molecules paves the way for microbial succession by organisms that in turn feed on these metabolites. Beyond nutrient availability, the presence of growth factors, natural and added inhibitors select for specific strains. These antimicrobial hurdles include the food additives, the preservatives, the natural antimicrobials, and the bioprotective cultures that are incorporated in the food to improve the shelf life and promote the food safety [134-139].

The meat pH Postmortem pH of meat is determined by the amount of the lactic acid produced from the glycogen during the anaerobic glycolysis, and is an essential determinant for the growth of the spoilage microbes. After slaughtering, the muscle pH reduces typically to 5.4 \5.8, which can inhibit the spoilage microbes to a certain extent. The Meat from the stressed animals produces a pH greater than or equal to 6.0 (dark, firm, and dry meat), and this makes it an ideal environment for microbes to multiply, eventually resulting in spoilage. The presence of the lipid (the adipose tissue) the high pH favor rapid bacterial proliferation, utilization of nutrients, and eventual spoilage of the meat. The Water activity High, The moisture content and low solute concentrations tend to provide a favorable environment for microbial growth on meat. The Water activity (aW) of a solution is defined as the ratio of its vapor pressure to that of pure water at the same temperature, and it is inversely proportional to the number of solute molecules present. The Spoilage molds and yeast are more tolerant to higher osmotic pressures than bacteria. The Bacteria tend to grow at a aW ranging from 0.75 to 1.0, whereas yeast and molds grow slowly at an aW of 0.62. Dried products (aW of less than 0.85), which are stored and distributed at ambient temperatures do not support growth and the toxin production bacteria such as the Staphylococcus aureus and the Clostridium botulinum. The microbe population in the curing salt solutions such as bacon brines has a shift in population toward osmotolerant and halotolerant organisms. For instance, certain Lactobacillus spp. can tolerate high sugar concentration generally used in the ham curing brine. They are capable of growing on the cured unprocessed hams and produce polysaccharides with associated deterioration in flavor and appearance. The Extrinsic factors, The Temperature is a major factor that controls bacterial growth. An understanding of time and temperature management to control spoilage microbes is essential to improve the shelf life of a product. The survivability of the microbes at different temperatures, they can be classified as the psychrotrophs, the mesophiles, and the thermophiles, whose tolerability includes the temperature ranges: 2°C 7°C, 10°C 40°C, and 43°C, 66°C, respectively. The Aerobic spoilage microflora at the chilling temperatures consists predominantly of the pseudomonads, but the lactic acid bacteria is the primary organisms of concern under anaerobic conditions or the MAP. The nutrient content at the certain storage temperatures in meat is another factor that affects the microbial growth. The inverse relation has been observed with temperature and amino acid utilization by Lactobacillus arabinosus, wherein the bacterium requires phenylalanine, tyrosine, and aspartate for growth at 39°C, phenylalanine and tyrosine at 37°C, and none of these amino acids at 26°C. The high microbial load before the freezing can contribute to the persistence of microbial enzymes such as the lipases even at freezing temperatures. The microbial growth process is arrested by freezing, microbial enzymes may continue to produce deleterious changes in meat quality even at temperatures as low as 30°C. The Packaging and the gaseous atmosphere, the gaseous atmosphere within a packed meat product types has a significant impact on the spoilage microbiome. The Pseudomonas spp., the Acinetobacter spp. and the Moraxella spp. are predominant bacterial genera involved in the aerobically stored meat products types within a temperature range of 1°C to 25°C. Specifically, the P. fluorescens, the P. fragi, the P. ludensis, and the P. putida are the significant species commonly isolated from aerobically packaged meat. In the vacuum packed and the MAP meat, there is a shift from aerobic bacteria to the overgrowth and prevalence of facultative and strict anaerobic spoilage microbes. Shewanella spp., Brochothrix spp. (*B. thermosphacta* and *B. campestris*), Serratia spp., and lactic acid bacteria are the major groups involved in spoilage of vacuum and/or MAP meat products types. *S. putrefaciens* is a predominant spoilage bacterium found in chilled and vacuum packaged meat. Reduced water activity along with microaerophilic conditions inhibits gramnegative spoilage microbes and favors the growth and establishment of the lactic acid bacteria.

The Implicit factors, The Implicit factors influencing spoilage develop as a result of microbial succession that occurs in meat through the production continuum. The factors previously described can either have a synergistic or antagonistic effect on strain selection and eventual composition of the spoilage microflora. Synergistic effects include the breakdown of macromolecules in meat by the initial microflora, thereby providing easily accessible nutrients for a subsequent group of microorganisms that would otherwise be unable to sustain themselves in the food environment. The changes in acidity or buffering capacity of meat and water activity help select for strains that are tolerant to the altered conditions thereby establishing the secondary spoilage microflora on meat. While these conditions may serve to support a certain group of organisms, they are antagonistic to other species that are sensitive to this food environment [12-19].

Conclusion

The microorganisms play in the spoilage of meat and meat products types, it is critical to develop effective and feasible approaches to prevent and curtail the growth of spoilage microorganisms. However, in order to develop practical antimicrobial hurdles, it is important to identify, characterize, and understand the predisposing factors in a food system that promotes bacterial growth and spoilage. Furthermore, the elucidation of the microbial signature associated with different foods, and the various handling and the storage conditions will help to develop intervention strategies that are product specific and can be applied along the food production continuum.

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