ClinicSearch

Clinical Trials and Case Studies

Fahim A Shaltout*

Open Access

Review Article

How we can prolong the shelf life of the meat and meat products

Fahim A. Shaltout

Food Control, Faculty of Veterinary Medicine, Benha University, Egypt.

***Corresponding Author:** Fahim A. Food Control, Faculty of Veterinary Medicine, Benha University, Egypt.

Received Date: July 12, 2024; Accepted Date: July 15, 2024; Published Date: July 23, 2024

Citation: Fahim A. Shaltout,. (2024), How we can prolong the shelf life of the meat and meat productsClinical Trials and Case Studies; 3(4):

DOI: 10.31579/2835-835X/076

Abstract

The shelf life of the meat and the meat products is the storage time until spoilage, which is a complex condition in which the combination of biological and physico-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 spoilage, which is strictly dependent on the initial numbers and types of contaminating microorganisms, their growth, lipid oxidation, and autolytic enzymatic reactions. Meat and fish, due to their physico-chemical characteristics, are excellent basic nutrients for microbial activity. Indeed the pH, aw (activity water) and high moisture values can support the growth of a wide variety of microorganisms.

Keywords: The shelf life; meat; meat products; lipid oxidation; autolytic enzymatic reactions

Introduction

Usually, the initial microbial count of the meat and the cooked meat products is about 23 log CFU/cm2 or g, and for fresh meat and meat and fish products about 45 log CFU/cm2 or g. The large variety of 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 contamination also occurs after the heating process that is often used to prolong the shelf life either of meat or fish products. It is estimated that only 10% of the microorganisms initially present are psychrotolerant and may grow in 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 is about lo'-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 Iower. Since the meat products are heated to a temperature of 65-75"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 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 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 [8-14].

Causes of the meat spoilage

can be caused by physical, chemical and biological agents, including the microorganisms-bacteria, yeast and mold, the action of enzymes in meat such as lipases and 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. Although 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. It is estimated that 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 meat brought about by dominant microorganisms that make up a significantly higher proportion of the microbial community associated with 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. These 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 are not commonly degraded by the yeast due to their inability to produce extracellular proteases. Some exceptions to this include Yarrowia lipolytica, Rhodoturola, Cryptococcus, Pichia, and 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 Alternaria, Aspergillus, Fusarium, Rhizopus, and 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, lymph nodes, skin, hide, handlers, 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 LAB. 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 (MA). MA contains different levels of oxygen and carbon dioxide, balanced with inert nitrogen. The Packages containing up to 80% oxygen and 20% carbon dioxide (High oxygen-MA) will reduce the color. the deterioration of the retail cuts of the meat, but will only slightly increase the shelf-life, compared to aerobic storage. The Pork is generally stored aerobically or in MA, and beef in a vacuum or MA due to the need for tenderization during an extended storage. Transitions between the different packaging-types may be performed for retail cuts. The shelf-life of meat increases in the order: air, high oxygen-MA, vacuum, no oxygen-MA and 100% CO2, P.wudomonm spp. dominate on aerobically stored meat, and due to a high growth rate the shelf-life is a matter of days. A long the shelf-life may be attained in pure CO2, The time needed to reach 10' bacteria/cm' and off-odour. was 10 days in air, and 40 days in 100% CO2 for pork stored at 4°C. The effect of CO2, is enhanced by a low storage temperature, due to increased solubility of the gas. On pork loins stored under CO2, at ~ 1.5"C, a maximum bacterial number of 10(2) cfu/cm (2)" was reached after 63 days. Shelf-life extension by CO2, results from an immediate selection, as opposed to a gradual one in a vacuum-pack, of lactic acid bacteria growing at a reduced rate [36-42].d meat products. The combination of the microaerophilic conditions, the presence of the curing salt and tThe temperature

The lowest cold-storage temperature for the meat is - 1.5"C, while the minimum growth temperature of psychrotrophic bacteria is - 3°C. Decreasing refrigeration temperatures decrease the bacterial growth, and affect the composition of the bacterial flora. For 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; DFD-meat, dark firm dry) may be the result of stress of the living animal. The Adipose tissues also 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 adipose tissue spoil more rapidly than the normal pH meat since the amino acids are rapidly attacked. The Vacuum-packed pork have 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. In addition, the Enterobacteriacae~ are developed better on the pork than on the beef. The pink colour of the cooked, the cured meat products is the result of the addition of the nitrite and/or nitrate prior to the heating, and the subsequent formation of the nitrosohaemochrome. The Nitrite has an inhibitory action on the the growth of several micro-organisms, 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.

The Lactic acid bacteria are the major bacterial group associated with the spoilage of the refrigerated vacuum- or MA-packaged cooked, cured meat products. At 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. The genus/species of the lactic acid bacteria responsible for the spoilage depend on the the product composition (product-related flora) as well as the manufacturing site. The Lactic acid bacteria spoil the refrigerated meat products 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 are typically described as sour and acid. The dominating bacteria, lactic acid bacteria, produce acids such as lactic acid. acetic acid and formic acid: the levels depending on genus species and growth conditions. The Meat products stored aerobically or vacuum packaged using a film with a relatively high permeability to oxygen may in addition to sour and acid flavors. Develop a slightly sweet, cheesy obnoxious Odor,This is also found in the meat products that have initially been stored anaerobically and subsequent to opening the package in an aerobic atmosphere. An aerobic atmosphere induces the formation of acetoin in B. thermofecta lactobacillus spp. and corynebacterium spp. [64-70].

The Discoloration

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

The Gas production

The Clostridium spp. have been associated with the production of large amounts of gas (H2, and CO2,) in the vacuum-packaged beef, accompanied by foul off-odors. The Gas production (CO2) by lactic acid bacteria without extensive off-odours may be associated with the vacuum-packaged beef and pork [78-84].

The Heat processed meat products

The Environmental influences on the bacterial growth and shelf-life

The microbiological stability of the cooked, the cured meat products 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 are chill-stored. Usually in vaccum-pack or in MA-packs, but are also distributed unpacked, i.e. stored in an aerobic atmosphere. Furthermore, in retail shops slicing is performed after the opening of packages, with subsequent storage in an aerobic atmosphere. During the aerobic storage of the cooked, the sliced meat products a mixed florrt composed of bacillus spp., micrococcus spp and lactobacillus spp. is reported to dominate. In addition, psuedomonus spp. may increase up to 105 Cfui\g. In the cured, the raw meat products, B. thermophacta, 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 cookehe nitrite favors the growth of the psychotropic lactic acid bacteria [91-97].

The Temperature

On the vacuum or the MA-packaged meat products the dominance of lactic acid bacteria is unaltered by the refrigeration temperature used, but the growth rate is affected. Inoculation studies with lactic acid bacteria on vacuum-packaged Bologna-type sausage demonstrated that 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. Thus, for meat products the storage temperature is an important factor influencing the shelf-life [98-104].

The Analysis of the spoilage

The Bacterial indicators

The maximum level of bacteria reached during refrigerated storage of meat is 1O7- 109 cfu\cm2, and of meat products about 1O7- 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 spoilage. The probability that107 lactobacillus lus spp\g meat product would cause overt spoilage is about 10%. The times between reaching bacterial counts of107 cfu\ig, and that of evident spoilage, were 19 and 30 days at 4°C and 2°C respectively. A similar situation is also valid for vacuum-packaged beef. 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/cm2 [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 bacterial spoilage in meat and meat products. The use of such spoilage indicators is, however, dependent on product composition. The occurrence of slime and the decrease in pH in meat products will depend on the presence of fermentable carbohydrates. For example, a drop in pH from 6.3 to 5.6 was observed in Bologna-type sausage, while in liver Sausage, the pH dropped to 5.0. The type and amount of bacterial end-products formed were dependent on the type of bacteria growing on the meat. o-lactate and acetate indicated high numbers of 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 are ideal growth media for animalborne as well as environmental sources of microbes. In general, the skin and intestinal contents are the primary sources of animal borne microbes in meat. Muscle glycogen-derived lactic acid from anaerobic glycolysis along with minor quantities of glucose and glucose-6-phosphate are some of the molecules available for microbial utilization. Glucose is the first source of energy, which is metabolized more rapidly by obligate aerobic pseudomonads than by facultative anaerobes such as B. thermosphacta and oxidative strains of 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. Once glucose reserves are depleted, lactate is the next energy source utilized both under aerobic and anaerobic conditions, followed by the amino acids. In general, 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 pseudomonads oxidize glucose and glucose-6-phosphate to form D-gluconate, pyruvate and 6-phosphogluconate. The Odoriferous metabolites derived from the amino acids such as the sulfides, the methyl esters, and the ammonia are usually the first manifestation of the spoilage of the chilled meat and the poultry. Some of the microorganisms commonly involved in putrefaction include P. fragi, S. putrefaciens, Proteus, Citrobacter, Hafnia, and 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 MAP. 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. 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 MAP meats. Among the different spoilage organisms, Pseudomonas spp. and Carnobacterium spp. are predominantly involved in the production of the alcohols, and some of the compounds generated are indicative of possible off-odor in 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. These compounds are derived from the triglyceride hydrolysis, the oxidation of the unsaturated fatty acids, or the lipid auto oxidation. Moreover, the aldehydes can also 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..For example, the hexanal, the nonanal, the benzaldehyde, and the 3-methylbutanal are aldehydes seen in the naturally spoiled meat, which at detectable threshold levels are known to generate fresh green fatty aldehydic grass leafy, fruity sweaty odor, fatty and green herbal odor, volatile almond oil and burning aromatic taste, and cheese and pungent apple-like odor, respectively. Exceedingly higher concentrations than detectable odor threshold values are known to produce very unpleasant and rancid aromas in the meat. Although aldehydes are known to produce off-flavors in fresh as well as the spoiled meat, correlating their presence with spoilage bacteria is difficult due to their low concentration and oxidation to acids during the early storage phase.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. As with aldehydes, Pseudomonas spp., Carnobacterium spp., and Enterobacteriaceae are also known to be primarily associated with volatile ketones from the spoiled meat. Acetoin and diacetyl are major ketones that contribute to cheesy odor and butter, sweet, creamy, and 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 also 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 LAB 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 also 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 [39,68-73].

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 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 (aerobic, anaerobic, and 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 also 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 food additives, preservatives, natural antimicrobials, and bioprotective cultures that are incorporated in food to improve shelf life and promote food safety [134-139]. The meat pH Postmortem pH of meat is determined by the amount of lactic acid produced from glycogen during anaerobic glycolysis, and is an essential determinant for the growth of spoilage microbes. After slaughter, muscle pH reduces typically to 5.4 \5.8, which can inhibit spoilage microbes to a certain extent. The Meat from 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 lipid (adipose tissue) 320 Chapter 17 and 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 toxin production bacteria such as Staphylococcus aureus and Clostridium botulinum. The microbe population in 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 ham-curing brine. They are capable of growing on 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. Based on the survivability of microbes at different temperatures, they can be classified as psychrotrophs, mesophiles, and thermophiles, whose tolerability includes the following temperature ranges: 2C 7C, 10C 40C, and 43C, v66C, respectively. The Aerobic spoilage microflora at chilling temperatures consists predominantly of the pseudomonads, while the LAB are the primary organisms of concern under anaerobic conditions or MAP. The nutrient content at certain storage temperatures in meat is another factor that influences microbial growth. An 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 39C, phenylalanine and tyrosine at 37C, and none of these amino acids at 26C. Also, a high microbial load before freezing can contribute to the persistence of microbial enzymes such as lipases even at freezing temperatures. Although 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 30C. The Packaging and the gaseous atmosphere, The gaseous atmosphere within a packed meat product has a significant impact on the spoilage microbiome. The Pseudomonas spp., Acinetobacter spp. and Moraxella spp. are predominant bacterial genera involved in aerobically stored meat products within a temperature range of 1C to 25C. Specifically, P. fluorescens, P. fragi, P. ludensis, and P. putida are the significant species commonly isolated from aerobically packaged meat. In the vacuum-packed and 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 LAB are the major groups involved in spoilage of vacuum and/or MAP meat products. 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 LAB. 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. Similarly, 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, 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 promote bacterial growth and spoilage. Furthermore, the elucidation of the microbial signature associated with different foods, and various handling and storage conditions will help to develop intervention strategies that are product specific and can be applied along the food production continuum.

ORCID

https://orcid.org/0000-0002-8969-2677

Conflicts of Interest

The author declare no conflicts of interest

References:

1. Shaltout, F. , Riad,E.M ., and AbouElhassan, Asmaa , A(2017): prevalence Of Mycobacterium Tuberculosis In Imported cattle Offals And Its lymph Nodes. Veterinary Medical Journal -Giza (VMJG), 63(2): 115 – 122.
2. Blickstad. E. and Molin, G. (1984) Growth and end-product formation in fermenter cultures of gaseous atmospheres. J. Appl. Bacterial. 57. 213-220.
3. Shaltout, F., Riad,E.M ., and Asmaa Abou-Elhassan (2017): Prevalence Of Mycobacterium Spp . In Cattle Meat And Offal's Slaughtered In And Out Abattoir. Egyptian Veterinary medical Association, 77(2): 407 – 420.
4. Blickstzad, E. and Mofin, G. (1983b) The microbial flora of smoked pork loin and frankfurter sausage stared in different atmospheres at 4*C. J. Appl. Bacterial. 54. 45-56.
5. Abd Elaziz, O., Fatin S. Hassanin, Fahim A. Shaltout and Othman A. Mohamed (2021): Prevalence of Some Foodborne Parasitic Affection in Slaughtered Animals in Loacal Egyptian Abottoir. Journal of Nutrition Food Science and Technology 2(3): 1-5.
6. Abd Elaziz, O., Fatin, S Hassanin, Fahim, A Shaltout, Othman, A Mohamed (2021): Prevalence of some zoonotic parasitic affections in sheep carcasses in a local abattoir in Cairo, Egypt. Advances in Nutrition & Food Science 6(2): 6(2): 25-31.
7. Al Shorman,A.A.M. ;Shaltout, F. and hilat,N (1999):Detection of certain hormone residues in meat marketed in Jordan.Jordan University of Science and Technology, 1st International Conference on Sheep and goat Diseases and Productivity, 23-25 October, 1999.
8. Ebeed Saleh, Fahim Shaltout, Essam Abd Elaal (2021): Effect of some organic acids on microbial quality of dressed cattle carcasses in Damietta abattoirs, Egypt. Damanhour Journal of Veterinary Sciences 5(2): 17-20.
9. Edris A, Hassanin, F. S; Shaltout, F., Azza H Elbaba and Nairoz M Adel (2017): Microbiological Evaluation of Some Heat Treated Fish Products in Egyptian Markets.EC Nutrition 12.3 (2017): 124-132.
10. Edris ,A., Hassan,M.A., Shaltout, F. and Elhosseiny , S. (2013): Chemical evaluation of cattle and camel meat.Benha Veterinary Medical Journal, 24(2): 191-197 .
11. Edris ,A.M., Hassan,M.A., Shaltout, F. and Elhosseiny , S(2012): Detection of E.coli and Salmonella organisms in cattle and camel meat. Benha veterinary medical journal, 24(2): 198-204.
12. Edris A.M.; Hemmat M. I., Shaltout, F.; Elshater M.A., Eman F.M.I. (2012): study on incipient spoilage of chilled chicken cuts-up. Benha veterinary medical journal, vol. 23, no. 1, june 2012: 81-86
13. Edris A.M.; Hemmat M.I.; Shaltout, F.; Elshater M.A., Eman, F.M.I.(2012):chemical analysis of chicken meat with relation to its quality. Benha veterinary medical journal, 23(1): 87-92 .
14. Edris, A.M.; Shaltout, F. and Abd Allah, A.M. (2005): Incidence of Bacillus cereus in some meat products and the effect of cooking on its survival. Zag. Vet. J.33 (2):118-124.
15. Edris, A.M.; Shaltout, F. and Arab, W.S. (2005): Bacterial Evaluation of Quail Meat. Benha Vet. Med.J.16 (1):1-14.
16. Asensio, M.A., Ordon ˜ez, J.A., Sanz, B., 1988. Effect of carbon dioxide and oxygen enriched atmospheres on the shelf-life of refrigerated pork packed in plastic bags. J. Food Prot. 51 (5), 356 360.
17. Edris, A.M.; Shaltout, F. ;Salem, G.H. and El-Toukhy,E.I. (2011): Incidence and isolation of Salmonellae from some meat products.Benha University ,Faculty of Veterinary Medicine , Fourth Scientific Conference 25-27th May 2011Veterinary Medicine and Food Safety) 172-179 benha , Egypt.
18. Edris AA, Hassanin, F. S; Shaltout, F., Azza H Elbaba and Nairoz M Adel.(2017): Microbiological Evaluation of Some Heat Treated Fish Products in Egyptian Markets. EC Nutrition 12.3 (2017): 134-142.
19. Edris, A.M.; Shaltout, F. ;Salem, G.H. and El-Toukhy,E.I. (2011): Plasmid profile analysis of Salmonellae isolated from some meat products. Benha University ,Faculty of Veterinary Medicine , Fourth Scientific Conference 25-27th May 2011Veterinary Medicine and Food Safety 194-201 benha , Egypt.
20. Ragab A , Abobakr M. Edris, Fahim A.E. Shaltout, Amani M. Salem(2022): Effect of titanium dioxide nanoparticles and thyme essential oil on the quality of the chicken fillet. Benha Veterinary Medical Journal41(2): 38-40.
21. Hassan, M.A, Shaltout, F. , Arfa M.M , Mansour A.H and Saudi, K. R(2013): biochemical studies on rabbit meat related to some diseases. Benha veterinary medical journal 25(1):88-93.
22. Hassan, M.A and Shaltout, F. (1997): Occurrence of Some Food Poisoning Microorganisms In Rabbit Carcasses Alex.J.Vet.Science, 13(1):55-61.
23. Hassan M, Shaltout FA* and Saqur N (2020): Histamine in Some Fish Products. Archives of Animal Husbandry & Dairy Science 2(1): 1-3.
24. Hassan, M.A and Shaltout, F. (2004): Comparative Study on Storage Stability of Beef, Chicken meat, and Fish at Chilling Temperature. Alex.J.Vet.Science, 20(21):21-30.
25. Hassan, M.A ; Shaltout, F. ; Arafa ,M.M. ; Mansour , A.H. and Saudi , K.R.(2013): Biochemical studies on rabbit meat related to some diseases . Benha Vet. Med.J.25 (1):88-93.
26. Hassan, M.A ; Shaltout, F. ; Maarouf , A.A. and El-Shafey, W.S.(2014): Psychrotrophic bacteria in frozen fish with special reference to pseudomonas species. Benha Vet. Med.J.27 (1):78-83.
27. Hassan, M.A ; Shaltout, F. ; Arafa ,M.M. ; Mansour , A.H. and Saudi , K.R.(2013): Bacteriological studies on rabbit meat related to some diseases. Benha Vet. Med.J.25 (1):94-99.

28. Bell, R.G., 1997. Distribution and sources of microbial contamination on beef carcasses. J. Appl. Microbiol. 82 (3), 292 300.
29. Hassanin, F. S; Hassan,M.A., Shaltout, F. , Nahla A. Shawqy and 2Ghada A. Abd-Elhameed (2017): Chemical criteria of chicken meat. Benha veterinary medical journal, 33(2):457-464.
30. Hassanin, F. S; Hassan,M.A.; Shaltout, F. and Elrais-Amina, M(2014): clostridium perfringens in vacuum packaged meat products. Benha veterinary medical journal, 26(1):49-53.
31. Blickstad. E., Enfors, S.-O. and Molin, G. (1981) Effect of hyberbaric carbon dioxide pressure on the microbial flora of pork stored at 4 or 14°C. J. Appl. Bacterial. 50, 493-504.
32. Hassanien, F.S.; Shaltout, F.; Fahmey, M.Z. and Elsukkary, H.F. (2020): Bacteriological quality guides in local and imported beef and their relation to public health. Benha Veterinary Medical Journal 39: 125-129.
33. Hassanin, F. S; Shaltout,F. and , Mostafa E.M(2013): Parasitic affections in edible offal. Benha Vet. Med.J.25 (2):34-39.
34. Ahvenainen, R., Skytta, E. and Kivikataja, R.-L. (1989) Factors affecting the shelf-life of gas- and vacuum-packed cooked meat products. Part I: sliced ham. Lebensm. Wiss. u. Technol. 22, 391-398.
35. Hassanin, F. S; Shaltout, F., Lamada, H.M., Abd Allah, E.M.(2011): the effect of preservative (nisin) on the survival of listeria monocytogenes. benha veterinary medical journal (2011)-special issue [i]: 141-145.
36. Khattab, E., Fahim Shaltout and Islam Sabik (2021): Hepatitis A virus related to foods. Benha Veterinary Medical Journal 40(1): 174-179.
37. Saad M. Saad , Fahim A. Shaltout , Amal A. A. Farag & Hashim F. Mohammed (2022): Organophosphorus Residues in Fish in Rural Areas. Journal of Progress in Engineering and Physical Science 1(1): 27-31.
38. Saif,M. , Saad S.M. , Hassanin, F. S; Shaltout, F. , Marionette Zaghloul (2019): Molecular detection of enterotoxigenic Staphylococcus aureus in ready-to-eat beef products. Benha Veterinary Medical Journal 37 (2019) 7-11.
39. Boerema. J.A., Penny, N, Cummings. T.L. and Bell, R.G. (1993) Carbon dioxide controlled atmosphere packaging of sliced ham. Int. J. Food Sci. Technoi. 28, 435-442.
40. Saif,M. , Saad S.M. , Hassanin, F. S; Shaltout, F. , Marionette Zaghlou (2019); Prevalence of methicillin-resistant Staphylococcus aureus in some ready-to-eat meat products. Benha Veterinary Medical Journal 37 (2019) 12-15.
41. Farag, A. A., Saad M. Saad¹, Fahim A. Shaltout1, Hashim F. Mohammed (2023 a): Studies on Pesticides Residues in Fish in Menofia Governorate. Benha Journal of Applied Sciences ,. 8(5): 323-330.
42. Farag, A. A., Saad M. Saad¹, Fahim A. Shaltout1, Hashim F. Mohammed (2023 b): Organochlorine Residues in Fish in Rural Areas. Benha Journal of Applied Sciences , 8 (5): 331-336.
43. Shaltout, F. , Mona N. Hussein, Nada Kh. Elsayed (2023): Histological Detection of Unauthorized Herbal and Animal Contents in Some Meat Products. Journal of Advanced Veterinary Research 13(2): 157-160.
44. Shaltout, F. , Heikal, G. I. , Ghanem, A. M.(2022): Mycological quality of some chicken meat cuts in Gharbiya governorate with special reference to Aspergillus flavus virulent factors. benha veteriv medical journal veterinary 42(1): 12-16.
45. Aim. I". Erichsen. I. and Molin, N. (1961) The effect of vacuum packaging on some sliced processed meat products as judged by organoleptic and bacteriological analysis. Food Technol. 4, 1999203.
46. Shaltout, F. , Ramadan M. Salem, Eman M. Eldiasty, Fatma A. Diab (2022): Seasonal Impact on the Prevalence of Yeast Contamination of Chicken Meat Products and Edible Giblets. Journal of Advanced Veterinary Research 12(5): 641-644.
47. Shaltout, F. , Abdelazez Ahmed Helmy Barr and Mohamed Elsayed Abdelaziz (2022): Pathogenic Microorganisms in Meat Products. Biomedical Journal of Scientific & Technical Research 41(4): 32836-32843.
48. Shaltout, F. , Thabet, M.G. and Koura, H.A. (2017). Impact of Some Essential Oils on the Quality Aspect and Shelf Life of Meat. J Nutr Food Sci., 7: 647.
49. Shaltout, F. , Islam Z. Mohammed², El -Sayed A. Afify(2020): Bacteriological profile of some raw chicken meat cuts in Ismailia city, Egypt. Benha Veterinary Medical Journal 39 (2020) 11-15.
50. Shaltout, F. ,Islam, Z. Mohammed²., El -Sayed A. Afify(2020): Detection of E. coli O157 and Salmonella species in some raw chicken meat cuts in Ismailia province, Egypt. Benha Veterinary Medical Journal 39 (2020) 101-104.
51. Shaltout, F. , E.M. El-diasty and M. A. Asmaa- Hassan (2020): HYGIENIC QUALITY OF READY TO EAT COOKED MEAT IN RESTAURANTS AT Cairo. Journal of Global Biosciences 8(12): 6627-6641.
52. Shaltout, F. , Marrionet Z. Nasief , L. M. Lotfy , Bossi T. Gamil(2019): Microbiological status of chicken cuts and its products. Benha Veterinary Medical Journal 37 (2019) 57-63.
53. Shaltout, F. (2019): Poultry Meat. Scholarly Journal of Food and Nutrition 22 1-2.
54. Shaltout, F. (2019): Food Hygiene and Control. Food Science and Nutrition Technology 4(5): 1-2.
55. Hassanin, F. S; Shaltout, F. , Seham N. Homouda and Safaa M. Arakeeb(2019): Natural preservatives in raw chicken meat. Benha Veterinary Medical Journal 37 (2019) 41-45.
56. Allman, R., Hann, A.C., Manchee, R., Lloyd, D., 1992. Characterization of bacteria by multiparameter flow cytometry. J. Appl. Bacteriol. 73 (5), 438 444.
57. Hazaa,W. , Shaltout, F. , Mohamed El-Shate(2019): Prevalence of some chemical hazards in some meat products. Benha Veterinary Medical Journal 37 (2) 32-36.
58. Hazaa,W, Shaltout, F. , Mohamed El-Shater(2019): Identification of Some Biological Hazards in Some Meat Products. Benha Veterinary Medical Journal 37 (2) 27-31.
59. Gaafar,R. , Hassanin, F. S; Shaltout, F. , Marionette Zaghloul (2019): Molecular detection of enterotoxigenic Staphylococcus aureus in some ready to eat meat-based sandwiches. Benha Veterinary Medical Journal 37 (2) 22-26.
60. Blickstad. E. (1983) Growth and end product formation of two psychrotrophic spp. and at different pH values and tern~r~~t~~res. Appl. Environ. Microbial. 46, 1345- 1350.
61. Gaafar,R. , Hassanin, F. S; Shaltout, F. , Marionette Zaghloul (2019): Hygienic profile of some ready to eat meat product sandwiches sold in Benha city, Qalubiya Governorate, Egypt. Benha Veterinary Medical Journal 37 (2) 16-21.
62. Saad S.M. , Shaltout, F. , Nahla A Abou Elroos, Saber B El-nahas(2019) : Antimicrobial Effect of Some Essential Oils on Some Pathogenic Bacteria in Minced Meat. J Food Sci Nutr Res. 2019; 2 (1): 012-020.
63. Saad S.M. , Shaltout, F. , Nahla A Abou Elroos2 and Saber B El-nahas(2019): Incidence of Staphylococci and E. coli in Meat and Some Meat Products. EC Nutrition 14.6 (2019).
64. Saad S.M. , Hassanin, F. S. ; Shaltout, F. , Marionette Z Nassif, Marwa Z Seif.(2019: Prevalence of Methicillin-Resistant Staphylococcus Aureus in Some Ready-to-Eat Meat Products. American Journal of Biomedical Science & Research 4(6):460-464.

65. Shaltout, F. (2019): Pollution of Chicken Meat and Its Products by Heavy Metals. *Research and Reviews on Healthcare: Open Access Journal*, 4, 3(381-3382).
66. Shaltout, F. A.; E.M EL-diasty; M. S. M Mohamed (2018): Effects of chitosan on quality attributes fresh meat slices stored at 4 C. *Benha veterinary medical journal, vol. 35, no. 2: 157-168.*
67. Shaltout, F. and Adel-Aziz, 2004: *Salmonella enterica* **serovar Enteritidis in poultry meat and their epidemiology.** *Vet. Med. J. Giza*, 52 (2004), pp. 429-436.
68. Shaltout, F. , Hala F El-Shorah, Dina I El Zahaby, Lamiaa M Lotfy(2018):Bacteriological Profile of Chicken Meat Products. *SciFed Food & Dairy Technology Journal, 2:3.*
69. *Shaltout, F.* , Mohamed, A.H. El-Shater ., Wafaa Mohamed Abd El-Aziz(2015): Bacteriological assessment of Street Vended Meat Products sandwiches in kalyobia Governorate. *Benha Veterinary Medical Journal*, 28(2:)58-66,
70. *Shaltout, F.* , Mohamed A El shatter and Heba M Fahim (2019): Studies on Antibiotic Residues in Beef and Effect of Cooking and Freezing on Antibiotic Residues Beef Samples. Scholarly Journal Of Food And Nutritionm 2(1) 1-4.
71. Blickstad, E. and Molin, G. (1983a) Carbon dioxide as a controller of the spoilage flora of pork, with special reference to temperature and sodium chloride. *J. Food Protec. 46, 756-763.*
72. Shaltout, F., Zakaria IM and Nabil ME. (2018): Incidence of Some Anaerobic Bacteria Isolated from Chicken Meat Products with Special Reference to *Clostridium perfringens*. *Nutrition and Food Toxicology* 2.5 (2018): 429-438.
73. Shaltout, F. , Ahmed A A Maarouf and Mahmoud ES Elkhouly. (2017): Bacteriological Evaluation of Frozen Sausage. *Nutrition and Food Toxicology* 1.5 ; 174-185.
74. Shaltout, F. , El-Toukhy EI and Abd El-Hai MM.(2019): Molecular Diagnosis of *Salmonellae* in Frozen Meat and Some Meat Products. *Nutrition and Food Technology Open Access 5(1): 1-6.*
75. *Shaltout, F. , A.M.Ali and S.M.Rashad (2016):* Bacterial Contamination of Fast Foods. Benha *Journal of Applied Sciences* (BJAS) 1 (2)45-51.
76. *Shaltout, F.* , Zakaria. I. M. , Jehan Eltanani , Asmaa . Elmelegy(2015): Microbiological status of meat and chicken received to University student hostel. *Benha Veterinary Medical Journal*, 29(2):187-192, December, 2015.
77. Saad,S.M.;Edris, A.M.; Shaltout, F. and Edris, Shimaa(2012): Isolation and identification of salmonellae and E.coli from meat and poultry cuts by using A.multiplex PCR. *Benha Vet. Med.J.special issue* 16-26.
78. Saad, S.M. and Shaltout, F. (1998): Mycological Evaluation of camel carcasses at Kalyobia Abattoirs. *Vet.Med.J. Giza*,46(3):223-229.
79. Bailey, J.S., Reagan, J.O., Carpenter, J.A., Schuler, G.A., Thomson, J.E., 1979a. Types of bacteria and shelf-life of evacuated carbon dioxide-injected and ice-packed broilers. *J. Food Prot.* 42 (3), 218 221.
80. Saad S.M. , *Shaltout, F.* , Nahla A Abou Elroos, Saber B El-nahas. 2019: Antimicrobial Effect of Some Essential Oils on Some Pathogenic Bacteria in Minced Meat. *J Food Sci Nutr Res*. 2019; 2 (1): 012-020.
81. Saad S.M. , Hassanin, F. S; *Shaltout, F.* , Marionette Z Nassif, Marwa Z Seif.(2019): Prevalence of Methicillin-Resistant *Staphylococcus Aureus* in Some Ready-to-Eat Meat Products. ***American Journal of Biomedical Science & Research** 4(6)*:460-464.
82. Saad S.M. , *Shaltout, F.* , Nahla A Abou Elroos and Saber B El-nahas. (2019): Incidence of *Staphylococci* and *E. coli* in Meat and Some Meat Products. *EC Nutrition* 14.6 (2019).
83. Shaltout, F. , Riad EM,TES Ahmed and AbouElhassan A.(2017): Studying the Effect of Gamma Irradiation on Bovine Offal's Infected with *Mycobacterium tuberculosis* Bovine Type. *Journal of Food Biotechnology Research* 1 (6): 1-5.
84. Shaltout, F., Ahmed A A Maarouf and Mahmoud ES Elkhouly.(2017): Bacteriological Evaluation of Frozen Sausage. *Nutrition and Food Toxicology* 1.5 (2017): 174-185.
85. Shaltout, F. , Zakaria IM and Nabil ME.(2018): Incidence of Some Anaerobic Bacteria Isolated from Chicken Meat Products with Special Reference to *Clostridium perfringens. Nutrition and Food Toxicology* 2.5 (2018): 429-438.
86. Shaltout, F., Mohamed, A.Hassan and Hassanin, F. S(2004): Thermal Inactivation Of Enterohaemorrhagic Escherichia Coli O157:H7 And Its Senstivity To Nisin And Lactic Acid Cultures. *1rst Ann. Confr. , FVM., Moshtohor, Sept, 2004.*
87. Shaltout, F., El-diasty, E,M. ;Elmesalamy, M. and Elshaer, M.(2014): Study on fungal contamination of some chicken meat products with special reference to 2 the use of PCR for its identification . Conference, *Veterinary Medical Journal* – Giza vol. December 2014/12/17 vol.60: 1-10.
88. Barlow, J., Kitchell, A.G., 1966. A note on the spoilage of prepacked lamb chops by Microbacterium thermosphactum. *J. Appl. Bacteriol*. 29 (1), 185-188.
89. shaltout, F. (2002): Microbiological Aspects of Semi-cooked chicken Meat Products. *Benha Veterinary Medical Journal* 13,2,: 15-26.
90. Shaltout, F., Thabet, M.G2 and Hanan, A. Koura3. (2017): Impact of some essential oils on the quality aspect and shelf life of meat. *Benha veterinary medical journal, 33, (2): 351-364.*
91. Shaltout F. , Mohammed Farouk; Hosam A.A. Ibrahim and Mostafa E.M. Afifi4.2017: Incidence of Coliform and Staphylococcus aureus in ready to eat fast foods. *Benha veterinary medical journal*, 32(1): 13 - 17, march, 2017.
92. Shaltout, F. , Zakaria, I.M., Nabil, M.E.(2017): Detection and typing of *Clostridium perfringens* in some retail chicken meat products. *Benha Veterinary Medical Journal*, 33(2):283-291.
93. Bailey, J.S., Reagan, J.O., Carpenter, J.A., Schuler, G.A., 1979b. Microbiological condition of broilers as influenced by vacuum and carbon dioxide in bulk shipping packs. *J. Food Sci*. 44 (1), 134 137.
94. Shaltout, F. (1992): Studies on Mycotoxins in Meat and Meat by Products. M.V.Sc Thesis Faculty *of Veterinary Medicine,Moshtohor,Zagazig University Benha branch.*
95. Shaltout, F. (1996): Mycological And Mycotoxicological profile Of Some Meat products. Ph.D.Thesis, *Faculty of Veterinary Medicine, Moshtohor, Zagazig University Benha branch.*
96. Shaltout, F. (1998): Proteolytic Psychrotrophes in Some Meat products. Alex. *Vet. Med. J.14 (2):97-107.*
97. Shaltout, F. (1999): Anaerobic Bacteria in Vacuum Packed Meat Products. *Benha Vet. Med.J.10 (1):1-10.*
98. Shaltout, F. (2000):Protozoal Foodborne Pathogens in some Meat Products. *Assiut Vet. Med. J.* 42 (84):54-59.
99. Boers, R.H. (1992) The keepability of vacuum packaged pork. PhD thesis. University of Utrecht, Netherlands.
100. Shaltout, F. (2001): Quality evaluation of sheep carcasses slaughtered at Kalyobia abattoirs. Assiut Veterinary Medical Journal, 46(91):150-159.
101. Shaltout, F. (2002): Microbiological Aspects of Semi-cooked Chicken Meat Products. Benha Vet.Med.J. 13(2):15-26.
102. Shaltout, F. (2003): Yersinia Enterocolitica in some meat products and fish marketed at Benha city. The Third international conference Mansoura 29-30 April.

103. Shaltout, F. (2009):Microbiological quality of chicken carcasses at modern Poultry plant. The 3rd Scientific Conference, Faculty of Vet. Med., Benha University, 1-3 january.
104. Shaltout, F. and Abdel Aziz ,A.M.(2004): Salmonella enterica Serovar Enteritidis in Poultry Meat and their Epidemiology .Vet.Med.J.,Giza,52(3):429-436.
105. Shaltout, F. and Abdel Aziz ,A.M.(2004): Escherichia Coli Strains In Slaughtered Animals And Their Public Health Importence. J.Egypt. Vet. Med. Association 64(2):7-21.
106. Andreani, N.A., Carraro, L., Martino, M.E., Fondi, M., et al., 2015. A genomic and transcriptomic approach to investigate the blue pigment phenotype in Pseudomonas fluorescens. Int. J. Food Microbiol. 213, 88-98.
107. Shaltout, F. , Amin, R., Marionet , Z., Nassif and Shimaa, Abdel-wahab(2014): Detection of aflatoxins in some meat products. Benha veterinary medical journal , 27(2) :368-374.
108. Shaltout, F. and Afify , Jehan Riad,EM and Abo Elhasan , Asmaa,A.(2012): Improvement of microbiological status of oriental sausage. Journal of Egyptian Veterinary Medical Association 72(2):157-167.
109. Ammor, M.S., Argyri, A., Nychas, G.J.E., 2009. Rapid monitoring of the spoilage of minced beef stored under conventionally and active packaging conditions using Fourier transform infrared spectroscopy in tandem with chemometrics. Meat Sci. 81 (3), 507 514.
110. Shaltout, F. and Daoud, J. R.(1996): Chemical analytical studies on rabbit meat and liver. Benha Vet. Med.J.8 (2):17-27.
111. Shaltout, F. and Edris, A.M.(1999): Contamination of shawerma with pathogenic yeasts. Assiut Veterinary Medical Journal,40(64):34-39.
112. Shaltout, F. ;Eldiasty , E. and Mohamed , M.S.(2014): Incidence of lipolytic and proteolytic fungi in some chicken meat products and their public health significance. Animal Health Research Institute : First International Conference on Food Safety and Technology 19-23 June 2014 Cairo Egypt pages 79-89.
113. Shaltout, F. ;Eldiasty, E. ; Salem, R. and Hassan, Asmaa (2016): Mycological quality of chicken carcasses and extending shelf – life by using preservatives at refrigerated storage. Veterinary Medical Journal -Giza (VMJG)62(3)1-7.
114. Shaltout, F. ; Salem, R. Eldiasty, E. ; and Diab, Fatema. (2016): Mycological evaluation of some ready to eat meat products with special reference to molecular chacterization. Veterinary Medical Journal -Giza 62(3)9-14.
115. Shaltout, F. ;Elshater , M. and Wafaa , Abdelaziz (2015): Bacteriological assessment of street vended meat products sandwiches in Kalyobia Governorate . Benha Vet. Med.J.28 (2):58-66.
116. Shaltout, F. ; Gerges, M.T. and Shewail, A.A.(2018):Impact of Organic Acids and Their Salts on Microbial Quality and Shelf Life of Beef. Assiut veterinary medical journal 64(159): 164-177
117. Shaltout, F. ;Ghoneim, A.M.; Essmail, M.E. and Yousseif ,A.(2001): Studies on aflatoxin B1 residues in rabbits and their pathological effects. J.Egypt. Vet. Med. Association 61(2):85-103.
118. Shaltout, F. and Hanan ,M.T. El-Lawendy (2003): Heavy Metal Residues In Shawerma. Beni-Suef Vet.Med.J. 13(1):213-224.
119. Shaltout, F. and Hashim, M.F. (2002): Histamine in salted, Smoked and Canned Fish products. Benha Vet. Med.J.13 (1):1-11.
120. Shaltout, F.; Hashim,M.F. and Elnahas,s.(2015): Levels of some heavy metals in fish (tilapia nilotica and Claris lazera) at Menufia Governorate. Benha Vet. Med.J.29 (1):56-64.
121. Shaltout, F. and Ibrahim, H.M.(1997): Quality evaluation of luncheon and Alexandrian sausage. Benha Vet. Med.J.10 (1):1-10.
122. Shaltout, F.; Nassif, M and Shakran, A(2014): Quality of battered and breaded chicken meat products. Global Journal of Agriculture and Food Safety Science – 1(2) ISSN 2356-7775.
123. Shaltout, F., Amani M. Salem, A. H. Mahmoud, K. A (2013): Bacterial aspect of cooked meat and offal at street vendors level. Benha veterinary medical journal, 24(1): 320-328.
124. Shaltout, F., and Salem, R.M. (2000): Moulds, aflatoxin B1 and Ochratoxin A in Frozen Livers and meat products.Vet . Med. J.Giza 48(3):341-346.
125. Ali, J., Najeeb, J., Ali, M.A., Aslam, M.F., Raza, A., 2017. Biosensors: their fundamentals, designs, types and most recent impactful applications: a review. J. Biosens. Bioelectron. 8 (235).
126. Yasser H. Al-Tarazi, A. Al-Zamil, Shaltout, F. and H. Abdel-Samei (2002). Microbiological status of raw cow milk marketed in northern Jordan. AVMJ Volume 49 Issue 96 Pages 180-194
127. Shaltout, F., Zakaria IM and Nabil ME.(2018): Incidence of Some Anaerobic Bacteria Isolated from Chicken Meat Products with Special Reference to Clostridium perfringens. Nutrition and Food Toxicology2(5):429-438.
128. Shaltout, F.; El-diasty, E.M. and Mohamed, M. S.(2014): Incidence of lipolytic and proteolytic fungi in some chicken meat products and their public health significance. 1st Scientific conference of food safety and Technology .2014, pp. 79-89.
129. Shaltout, F.; El-diasty, E.M.; Salem, R. M. and Asmaa, M. A. Hassan. 2016: Mycological quality of chicken carcasses and extending shelf -life by using preservatives at refrigerated storage. Veterinary Medical Journal – Giza ,62(3) :1-10.
130. Shaltout, F., R.M. Salem, E.M. El-Diasty and W.I.M. Hassan. 2019: Effect of Lemon Fruits and Turmeric Extracts on Fungal Pathogens in Refrigerated Chicken Fillet Meat. Global Veterinaria 21 (3): 156-160,
131. Shaltout, F. , El-diasty, E,M. ;Elmesalamy, M. and Elshaer, M.(2014): Study on fungal contamination of some chicken meat products with special reference to 2 the use of PCR for its identification. Conference, Veterinary Medical Journal – Giza vol. December 2014/12/17 vol.60 1-10.
132. Shaltout, F. ; Salem, R. M; El-diasty, Eman and Fatema, A.H. Diab. (2016): Mycological evaluation of some ready to eat meat products with special reference to molecular characterization. Veterinary Medical Journal – Giza. 62(3): 9-14.
133. Shaltout, F. , Ahmed, A.A. Maarouf , Eman, M.K. Ahmed(2018): Heavy Metal Residues in chicken cuts up and processed chicken meat products. Benha Veterinary Medical Journal, 34(1): 473-483.
134. Shaltout ,F. ; Hanan M. Lamada , Ehsan A.M. Edris.(2020): Bacteriological examination of some ready to eat meat and chicken meals. Biomed J Sci & Tech Res., 27(1): 20461-20465.
135. Sobhy, Asmaa and Shaltout, Fahim (2020): Prevalence of some food poisoning bacteria in semi cooked chicken meat products at Qaliubiya governorate by recent Vitek 2 compact and PCR techniques. Benha Veterinary Medical Journal 38 (2020) 88-92.
136. Borch. E. and Molin, G. (1988) Numerical taxonomy of psychrotrophic lactic acid bacteria from prepacked meat and meat products. Antonie van Leeuwenhoek 54, 301-323.
137. Sobhy, Asmaa and Shaltout, Fahim (2020): Detection of food poisoning bacteria in some semi-cooked chicken meat

products marketed at Qaliubiya governorate. Benha Veterinary Medical Journal 38 (2020) 93-96.
138. Shaltout, F.A. (2024): Abattoir And Bovine Tuberculosis as A Reemerging Foodborne Diseas. Clinical Medical Reviews and Report 6(1):1-7.
139. Shaltout, F.A. (2023): Viruses in Beef, Mutton, Chevon, Venison, Fish and Poultry Meat Products. Food Science & Nutrition Technology 8(4):1-10.