Progress in Aqua Farming and Marine Biology
ISSN: 2640-6764

Academic Strive
Researcher's perception is our reality

Review article
Volume 4 Issue 1

Extending Meat Shelf Life by Using Natural Preservatives

Fahim AS*

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

***Corresponding author:** Fahim A Shaltout, Food Control, Faculty of Veterinary Medicine, Benha University, Egypt, Email: fahim.shaltout@fvtm.bu.edu.eg

Received Date: August 13, 2024; **Published Date:** October 11, 2024

Abstract

The Meat and the meat products are excellent sources of the nutrients for the humans. The Meat and the meat products also provide a favorable environment for the microbial growth. In order to prevent the microbiological contamination of the livestock foods, the synthetic preservatives, including the nitrites, the nitrates, and the sorbates, have been widely used in the food industry due to their low cost and the strong antibacterial activity. The Use of the synthetic chemical preservatives is recently being considered by the customers due to the concerns related to the negative health issues. The demand for the natural substances as the food preservatives has increased with the use of the plant-derived and the animal origin products, and the microbial metabolites. The natural preservatives inhibit the growth of the spoilage microorganisms or the food-borne pathogens by increasing the permeability of the microbial cell membranes, the interruption of the protein synthesis, and the cell metabolism. The Natural preservatives can extend the shelf-life and inhibit the growth of the microorganisms. The natural preservatives can influence the food sensory properties, including the flavor, the taste, the color, the texture, and the acceptability of the food. To increase the applicability of the natural preservatives, a number of the strategies, including the combinations of different preservatives or the food preservation methods, such as the active packaging systems and the encapsulation, have been explored. The applications of the natural preservatives for the meat and the meat products.

Keywords: Meat and Meat Products; Food Preservation; Packaging; Food-Borne Pathogens

Abbreviations

WHO: World Health Organization; HPP: High-Pressure Processing; FAO: Food and Agricultural Organization; IAEA: International Atomic Energy Agency; EUGCR: European Union Guidance to the Commission Regulation; ATP: Adenosine Triphosphate; NADH: Nicotinamide Adenine Dinucleotide; CFU: Colony-Forming Unit; GSE: Grapefruit Seed Extract; BLIS: Bacteriocin-Like Inhibitory Substance; ATCC: American Type Culture Collection.

Introduction

The Food-borne pathogens, including the *Listeria monocytogenes*, the *Staphylococcus aureus*, the pathogenic Escherichia coli, the Clostridium perfringens, the *Campylobacter spp.,* and the *Vibrio spp.,* cause a large number of the illnesses, with substantial damage to the human health and the economy. The World Health Organization (the WHO), the food contaminated with the food-borne pathogens, the chemicals, and the allergens results in 600 million cases of the food-borne illness and approximately four hundred thousand deaths worldwide/ year, Moreover, fifty-six million people die /year and approximately 7.7% of people worldwide suffer from the foodborne diseases. The Meat and the meat products are essential nutrient sources for the humans due to their excellent protein content, the essential amino acids, the vitamin B groups, and the minerals. The meat and the meat products also provide an appropriate environment for the spoilage microorganisms or the food-borne pathogens due to their high water activity and the nutrient factors [1-7]. The food industry has advanced worldwide, resulting in an enhanced threat of the food contamination by the pathogenic microorganisms, the chemical residues, the harmful food additives, and the toxins. The multiplication of the spoilage and the pathogenic microorganisms should be controlled to ensure the food safety. The food preservation techniques for protecting the food from the pathogenic microorganisms and extending the shelf-life include the chemical methods, such as the use of the preservatives; the physical methods, such as the heat treatment, the drying, the freezing, and the packaging; and the biological methods using the microorganisms that have an antagonistic effect on the pathogenic microorganisms and produce the bacteriocins. Among them, the addition of the food preservatives that inhibit the growth of the microorganisms is a widely used food protection technique. The countries in the world has different regulations for the food preservatives [8-14]. The Synthetic preservatives have the advantage for the meat processing due to low cost, guaranteed the antibacterial effect or the shelf-life extending activity, and the little effect on the taste, the flavor, the color, and the texture. However, the synthetic preservatives tend to be less preferred by the food consumers because of a number of health concerns regarding their side effects. The food consumers selected preservatives as the most concerned food additive owing to their negative impacts on the health. The Sorbic acid, the benzoic acid, and their salts have been reported to promote the mutagenic and the carcinogenic compounds. The Nitrites and the nitrate, used as preservative and coloring agents in the meat, have been associated with the leukemia, the colon cancer, the bladder cancer, and others. The Natural preservatives have emerged as alternatives to the synthetic preservatives. The Natural preservatives have shown potential to provide the effective antimicrobial activity while reducing the negative health effects. The Meat and the meat products containing the synthetic additives, are a major concern for the human health. Hence, the meat manufacturers and the researchers have begun to consider the use of the natural rather than the synthetic preservatives [15-21]. Representatively, the ‘clean label’ food trends, including the meat and the meat products, began and possessed an important source of the food marketing. It includes consumer-friendly characteristics, such as the synthetic additive-free, the least processing, a brief list of the food ingredients, and the procedure of the traditional methods. The clean label food material market, including the natural preservatives, is likely to value, mostly owing to growing consumer requests for all the natural products. The natural preservatives such as the nisin, the natamycin, the ε-polylysine, and the grapefruit seed extract are registered, but they are not approved for the meat products, or their concentration is not specified. The replacement of synthetic preservatives with the natural preservatives has major positive effects and is being accepted by the customers. The food producers also encounter challenges, including a decrease in price competitiveness due to the relatively high price of the natural preservatives and a decrease in the antibacterial effect due to the food ingredients, such as the carbohydrates, the proteins, and the lipids. In the case of the plant-derived substances, the standardization is problematic because of the influence of the country of origin, the soil, and the harvest seasons. The toxicity evaluation or identification of exact compounds for several plant-derived compounds contained in extracts and the essential oils have been performed. To solve these problems, various studies have been conducted to optimize the extraction process, combine other antimicrobial substances, apply active packaging, and encapsulate antibacterial substances to improve their utilization [22-28].

This review summarizes the current knowledge about the application of the natural preservatives for the meat and the meat products against the food-borne pathogens and the spoilage microorganisms.

The Application Technique of the Natural Preservatives to the Meat and the Meat Products

The Natural preservatives are manufactured in a variety of formulations including powder formed by drying methods and liquid forms such as essential oils. The Natural preservatives are directly added to the meat products and extend the shelf-life by inhibiting the bacterial growth. It is possible to increase the antibacterial effect of the natural preservatives through a combination of the other food processing methods [29-35]. In the case of the plant-derived natural preservatives, it is necessary to consider the form applied to the food. The Natural preservatives are commonly prepared in the form of extracts using organic solvents, water, and essential oils. The plant extracts obtained from rosemary, chestnut, sage, cranberry, oregano, grape seed, and others have been used as the meat preservatives. Many studies have been conducted to apply the plant-derived substances to the meat products in the form of the essential oil because the antibacterial effect of essential oil type is better than that of extract type. However, it is difficult to apply large amounts of the essential oil to the food because of its distinct organoleptic properties. Recent developments have attempted to solve this problem by applying essential oils with other antibacterial substances. The advantage of this application is that it reduces the amounts of essential oils with strong flavor and increases antioxidant and antibacterial effects through synergistic effects. In terms of industrial perspective, if synthetic preservatives cannot be completely replaced with the natural preservatives, due to the industrial problems, such as increasing the economic costs or the complexity of the product manufacturing process, they could be replaced gradually by composing a mixed formulation of the synthetic preservatives and the natural preservatives [36-42]. The gamma irradiation and the high-pressure processing (the HPP) treatment are the physical food-processing methods that can further increase the antibacterial efficacy of the natural preservatives. The Unlike thermal food processing, these two food processing techniques could be used for the pasteurization of the raw meat because it has a minor effect on the food composition. In 1997, the WHO, the Food and Agricultural Organization (FAO), and the International Atomic Energy Agency (the IAEA) concluded that foods processed in the proper doses of the irradiation are nutritionally sufficient and safe to consume. The irradiation is permitted for the food preservation in more than sixty countries. Recent approaches in the food irradiation have involved the use of combined treatments with the natural preservatives to reduce irradiation doses. The gamma irradiation of medium doses (2–6 kGy) with the natural compounds and active packaging has been applied to extend the shelf-life of the meat and the meat products. The HPP is also a non-thermal technique for the food preservation that inhibits the growth of the microorganisms and maintains the natural properties of the food. The HPP is performed under high pressures (100–800 MPa) at mild temperature or the weak heating. The Previous studies have reported the potential capability of combining the HPP and the natural preservatives including the essential oil and the antibacterial peptides in alleviating both the processing conditions of the HPP and the concentration of the natural preservatives while maintaining antibacterial effects [43-49]. The Encapsulation is one of the effective approaches for expanding the applicability of the natural preservatives to the food. The encapsulation was performed with GRAS (generally recognized as safe) materials such as the alginate, the chitosan, the starch, the dextrin, and the proteins using the various techniques including the spray-drying, the extrusion, the freeze-drying, the coacervation, and the emulsification. The application of the natural preservatives to the meat is limited due to their characteristics, such as low solubility and the bioavailability, the rapid release, and the easy degradation. Moreover, the environmental conditions, such as the pH, the storage temperature and the time, the oxygen and the light exposures could influence the efficacy of the natural preservatives. Through encapsulation, the natural preservatives, especially hydrophobic compounds (e.g., the essential oil), could improve its stability and expand the versatility of the food processing while maintaining the antibacterial effect [50-56]. The Active packaging is an innovative packaging technology that allows for an interaction with the product and its environment to extend the shelf-life and to ensure its microbial safety while keeping the original properties of the packaged food. In relation to the European Union Guidance to the Commission Regulation (the EUGCR), active packaging is a type of the food packaging with a further beneficial function, while providing a protective barrier against the external influence. In the meat industry, the antimicrobial active packaging could be applied in several methods which are the incorporation of the natural preservatives into a sachet inside the packaging, the packaging film composition with the natural preservatives, the packaging coated with the natural preservatives onto the surface of the food, and use of the antimicrobial polymers as the packaging materials [57-63]. The application of the microorganism-derived natural preservatives, known as the bio-preservation, in which the useful microorganisms or their antibacterial substances have antagonistic effects on pathogenic or spoilage microorganisms, are used is also a meat preservation method in the spotlight. This method is mainly involved in the lactic acid bacteria, the *Lactobacillus spp*., the *Leuconostoc spp*., the *Pediococcus spp*., and the *Lactococcus spp*., that have a GRAS status, widely participate in the fermentation processes, and produce the various antibacterial metabolites such as the organic acids, the hydrogen peroxide, and the bacteriocins. In terms of the application to the meat products, the bio-preservation methods included the direct inoculation with the lactic acid bacteria, which has an inhibitory effect on the spoilage or the pathogenic bacteria, the inclusion of bacterial strains producing antimicrobial substances in the fermentation starter, and treatment with the purified bacteriocins [64-70].

The Natural Preservatives from the Plants and Their Application for the Meat and the Meat Products

The antibacterial effect of the plant-derived natural preservatives is closely related to the polyphenols, the phenolics, and the flavonoids. The Plant-derived polyphenols have various classifications and structures, as the phenolic acids (the caffeic acid, the rosmarinic acid, the gallic acid, the ellagic acid, the cinnamic acid), the flavones (the luteolin, the apigenin, the chrysoeriol), the flavanols (the catechin, the epicatechin, the epigallocatechin, the gallocatechin, and their gallate derivatives), the flavanones (the hesperidin, the hesperetin, the heridictyol, the naringenin), the flavonols (the quercetin, the kaempferol, the myricetin), the isoflavones (the geinstein, the daidzin, the formononetin), the coumarins (the coumarin, the warfarin, the 7-hydroxycourmarin), the anthocyanins (the pelagonidin, the delphinidin, the cyanidin, the malvidin), the quinones (the naphthoquinones, the hypericin), the alkaloids (the caffeine, the berberine, the harmane), and the terpenoids (the menthol, the thymol, the lycopene, the capsaicin, the linalool) [71-77]. The Polyphenols have been recognized for their effective antimicrobial properties. Although the antimicrobial mechanism has not yet been clearly elucidated, the cell membrane-disturbing molecules, such as the hydroxy group (OH-), which induces the leakage of intracellular components, inactivation of metabolic enzymes, and extinction of the adenosine triphosphate (the ATP) structure; direct pH change in the environment by the improvement in proton concentration, reduction of the intracellular pH by separation of acid molecules, and modification of the bacterial membrane permeability; an organic acid in the plant extracts may influence the oxidation of the nicotinamide adenine dinucleotide (the NADH), the eliminating, the reducing agent used in the electron transport system [78-84].

The Rosemary

The Rosemary (the *Rosmarinus officinalis L.*) is a perennial herb with the woody, the aromatic, and the evergreen needle-like leaves. Originally from the Mediterranean region, it is broadly distributed throughout the globe. The Rosemary has been used as a spice and the flavoring agent in the food. The Rosemary essential oil is known to contain approximately fifteen kinds of the bioactive compounds. The principal compound was 1,8-cineole (35.32%). Other major compounds were the camphor, the α-pinene, the trans-caryophyllene, the α-thujone, and the borneol [85-90]. The antibacterial effect of the rosemary ethanol extracts against the *L. monocytogenes* in the beef. The application of 45% rosemary ethanol extract for the *L. monocytogenes* on the beef led to a 2 log colony-forming unit (CFU)/ gram reduction in the incubation at 4°C for 9 days. In the chicken meat, the effect of the rosemary essential oil on the inhibition of the *Salmonella Enteritidis* and the spoilage protective effects at 4 and 18°C was investigated. The 5 mg/mL of the rosemary essential oil induced the decrease in the coliform, the aerobic microorganisms, the lactic acid bacteria, and the anaerobic microorganisms at 18°C for 24 hours. In Comparing with the untreated chicken meat, the reductions of 1.75 log CFU/ gram (the coliform), 0.87 log CFU/ gram (the aerobic microorganisms), 1.05 log CFU/ gram (the lactic acid microorganisms) and 1.28 log CFU/ gram (the anaerobic microorganisms) were observed in the group treated with rosemary essential oil at 18°C. The Rosemary oil reduced the S. Enteritidis by more than 2 log CFU/ gram at 18°C, but less than 1 log CFU/ gram at 4°C [91-98]. The rosemary essential oil applied with modified atmosphere packaging for the inhibition of the food-borne pathogens (the *S. Typhimurium* and the *L. monocytogenes*) in the poultry filets under the refrigerated conditions for 7 d was investigated. The 0.2% rosemary essential oil did not affect the sensory profile and inhibited the growth of both pathogens in laboratory media within 24 hours Treatment with 0.2% rosemary essential oil did not affect the reduction in the S. Typhimurium, but showed weak antibacterial activity against the *L. monocytogenes* until the first day of the storage (approximately 0.1 log CFU/ gram reduction compared to control) [99-105].

The Sage

The Sage (*Salvia officinalis L.*), belonging to the Lamiaceae family, has been used since prehistoric eras because of its flavor, taste, therapeutic, and preservative properties. The Sage is known to contain considerable amounts of the rosemary acid, the p-coumaric acid, and the benzoic acid. The Sage essential oils, camphor, carvacrol, R(+) limonene, and linalool are the major components in terms of content [106-111].The antibacterial effects of various sage preparations were assessed for low-pressure mechanically separated meat (MSM) in vacuum packaging stored at −18°C for 9 months. The MSM from the chickens with the addition of the sage extracts inhibited the growth of all groups of the microorganisms (the mesophilic aerobic microorganisms, the psychrotrophic microorganisms, the *Enterobacteriaceae*, the coliforms, and the enterococci). The most effective antibacterial effect was exhibited by the 0.1% sage essential oil-treated groups [112-117].The antibacterial effect of the sage essential oil (0.625%) on the survival of the *L. monocytogenes* in the Sous-vide cook-chill beef stored in the refrigerated storage (2 or 8°C) for 28 days. The decrease of 1 log CFU/ gram of the L. monocytogenes was detected in the sage essential oil-treated groups compared to the control at 2°C. Although exponential growth was observed from day 14, lower L. monocytogenes counts of approximately 1 log CFU/ gram were detected in the sage essential oil-treated samples stored at 8°C [118-123].

The Thyme

The Thyme (*Thymus vulgaris*) is a representative herb used together with the meat and the meat products. The application of the thyme in the meat products can elevate the antioxidant, the antibacterial, the shelf-life extension, and the sensory properties. In the meat sausage, the thyme essential oil inhibited 2.69 log CFU/ gram of coagulase-positive *Staphylococcus* and 4.41 log CFU/ gram of aerobic mesophilic microorganisms, respectively, at a concentration of 0.95% by mixing with 1% (w/w) powdered beet juice. Moreover, the sensory properties, odor, flavor, and overall acceptability improved [124-129]. The 1% thyme oil led to the reduction in the S. enterica by 3 log CFU/ gram during the margination process with lemon juice and 0.5% Yucca schidigera extract in the raw chicken breast. The major composition of the thyme oil revealed 51.1% and 24.1% thymol and O-cymene, respectively. The antibacterial effects of thyme may be due to additive or synergistic effects with its major and/or minor components. The Thymol and its synergistic effect with other phenolic compounds, such as the carvacrol, the *p-cymene*, and the γ-terpinene, can change the permeability of the bacterial cell wall, leading to cell death [130-135]. The Thyme essential oil encapsulated with the casein and the maltodextrin was evaluated for its antibacterial potential in the vitro and in the situ (the hamburger-like meat products). The encapsulated thyme essential oil showed the same minimum inhibitory concentration (0.1 mg/mL) against the *E. coli,* the S. Typhimurium, the *S. aureus,* and the *L. monocytogenes* as that of the unencapsulated thyme essential. In the treated groups with 1% (v/v) of the encapsulated thyme essential oil for the meat, the E. coli counts were decreased from 23 most probable number (MPN)/ gram to 0 MPN/ gram, which was similar to the conventional preservative (the sodium nitrate) used as a control until 14 days of the refrigerated storage (4°C) [136-141].

The Oregano

The Oregano (the *Origanum vulgare*) is regularly used in the Mediterranean foods. The oregano essential oil has recognized antibacterial and antioxidant properties for the extension of shelf-life. The antibacterial effects of the oregano were due to two bioactive the polyphenols, the thymol and the carvacrol [142-147]. The component of the oregano essential oil and its impact on the shelf-life of black wildebeest *Biceps* femoris muscles was investigated at 2.6°C. The components of the oregano oil were the thymol, the carvacrol, the ρ-cymene, the β-caryophyllene, the γ-terpinene, the α-humulene, and the α-pinene; among them, the carvacrol (42.94%) and the thymol (17.40%) were the highest. The total viable counts and the lactic acid bacteria reached the spoilage limit (7 log CFU/ gram) after 3 days. The growth rates for the total viable counts and the lactic acid microorganisms in the treated group were 40% higher than those in the untreated groups [148-153]. The combinatorial effect of the oregano essential oil with the caprylic acid was studied in the vacuum-packed minced beef. The addition of 0.2% oregano essential oil with 0.5% caprylic acid and 0.1% citric acid in the minced beef reduced the counts of the lactic acid microorganisms by 1.5 log CFU/ gram in vacuum packaging. The cell counts of the psychrotrophic microorganisms and the *L. monocytogenes* were reduced by more than 2.5 log CFU/ gram at 3°C for 10 days. The Oregano essential oil inhibits the growth of the microorganisms by releasing volatile components during the drying process. It was reported that the addition of the oregano essential oil composed of the carvacrol (64.5%), the p-cymene (5.2%), and the thymol (2.9%) inhibited S. Enteritidis and E. coli in the beef drying process. For drying, a filter paper was soaked with oregano essential oil and placed in front of the fan of the drier. The beef samples were dried at 55°C for 6 hours. Consequently, both microorganisms (*S. Enteritidis* and *E. coli*) were not detected after treatment with 3 mL of oregano essential oil [154-159].

The Chestnut

The *Castanea crenata* was classified into the *Castanea* family and is a woody plant native to the East Asia, including the Korea and the Japan. The *Castanea sativa* is one of the most important Castanea families and the food resources of the European areas for long periods. Chestnut shells contain abundant phenols and hydrolyzable tannins. The chestnut inner shell extracts using ethanol exhibited antimicrobial effects against *C. jejuni* in the chicken meat at a concentration of 2 mg/mL. The polyphenol and flavonoid contents of chestnut inner shell ethanol extracts were 532.96 ± 3.75 mg gallic acid/100 g and 12.28 ± 0.03 mg quercetin/100 g, respectively [160-165]. The influence of the chestnut extracts (the *Castanea sativa*) on the leaf, the bur, and the hull of the beef patties under refrigerated conditions (2 ± 1°C) for 18 days to extend shelf-life. Among the chestnut extracts from the leaf, the bur, and the hull, only the leaf extract at a concentration of 1000 mg/kg had weak antimicrobial activity. The lactic acid microorganisms and the *Pseudomonas spp*. were reduced by 0.37 log CFU/ gram and 0.33 log CFU/ gram at 7 days, respectively [166-171].

The Grapefruit Seed Extract (the GSE)

The GSE is a by-product of the *Citrus paradise*. The GSE contains the various phenolic compounds and the flavonoids, such as the catechin, the citric acid, the naringenin, the procyanidin, and the epicatechin gallate. The GSE has been described to have a wide-ranging spectrum antimicrobial, the antiparasitic, and the antifungal activities. The Polyphenols in the GSE are unstable but can be chemically modified to become more stable using quaternary ammonium compounds, such as the benzethonium chloride, during the industrial procedure of the commercial GSE preparations [172-177]. The bacteriostatic effect of the commercial GSE (the Citricidal) on the sous-vide chicken products against the *C. perfringens.* The cell numbers of the *C. perfringens* were consistently approximately 2.5 log CFU/ gram regardless of the treatment or the control groups until 9.5 h of stored at 19°C; however, the storage of the control and 50 or 100 ppm GSE treated groups at 25°C for more than 6 h resulted in fast growth rates of *C. perfringens*, showing 2–3 log CFU/ gram. GSE concentrations at 200 ppm inhibited the growth of the *C. perfringens* stored at 19 and 25°C. The active packaging system for the inhibition of the food-borne pathogens used the mixed natural preservatives consisting of the GSE (80 mg/m^2) with the cinnamaldehyde (200 mg/m2) and the nisin (60 mg/m^2) was assessed for the beef storage. The Active packaging showed lower counts of the psychrotrophic and the anaerobic microorganisms compared to the control groups at 1–2 log CFU/ gram. The packaged beef samples with mixed natural preservatives showed a decrease in the L. monocytogenes, the S. aureus, and the *C. jejuni* for approximately 4.7 log CFU/ gram, 0.81 log CFU/ gram, and 3.1 log CFU/ gram compared to wrapped packaging at 28 days of the refrigerated storage, respectively. The C. jejuni was observed below the detection limit after 21 days of the storage [180-189].

The Cinnamon

The Cinnamon is a native plant in Asia that is acquired from the inner bark of the genus *Cinnamomum*. Cinnamon contains several active compounds, such as the cinnamaldehyde, the eugenol, the cinnamyl acetate, the L-borneol, the β-caryophyllene, the caryophyllene oxide, the camphor, the L-bornyl acetate, the α-terpineol, the α-cubebene, the α-thujene, and the terpinolene. The cinnamon (*Cinnamomum cassia*) essential oils could inhibit the *L. monocytogenes* in the ground beef at refrigerated (0 and 8°C) and frozen (-18°C) conditions. The concentration of 5.0% cinnamon essential oil to decrease by 3.5-4.0 log CFU/ gram of *L. monocytogenes* at 0 and 8°C for 7 days. Under frozen conditions, L. monocytogenes was reduced by 3.5–4.0 log CFU/ gram over 60 days. The antibacterial effect and shelf-life extending activity were evaluated using a chitosan edible coating containing 0.6% cinnamon essential oil on the roast duck slices under modified atmosphere packaging (30% carbon dioxide (CO2)/70% nitrogen (N2)) at the storage at 2 ± 2°C for 21 days. The edible coating with cinnamon essential oil showed total viable counts reduced by 1 log CFU/ gram compared to the control after 14 days of storage. This was similar to the results of *Enterobacteriaceae* counts. The number of the lactic acid microorganisms was lower than that of the control until the day 7 of the storage, but there was no significant difference from day 11 of the storage. The growth of the *Vibrio spp.* was delayed using edible coating with the cinnamon essential oil within the earlier period of the storage as a result of the microbial diversity sequencing [190-201].

The Turmeric

The Turmeric (*Curcuma longa L.*) has long been used as a flavor and the color agent in the food and traditional medicine to treat the various diseases, mainly in the South and East Asia. The main active compounds of the turmeric originate from its constituents, called the curcuminoids. The Curcuminoids (the curcumin, the demethoxycurcumin, and the bis-demethoxycurcumin) content of the turmeric varies between about 2–9% based on its growth environments, such as the cultivar, the soil, and the climatic conditions. The antibacterial effect of the turmeric on the chicken breast meat was assessed for the *E. coli* and the *S. aureus* stored at 4 °C for 48 hours. When 1% turmeric powder was added, no difference in the S. aureus counts was observed between the turmeric treated and the control groups. In the case of the *E. coli,* a reduction of 0.2 log CFU/ gram was observed, but this was not statistically significant [202-207]. The chicken meat was treated with the turmeric powder and the gamma irradiation to improve the meat quality and stability. The total aerobic microorganisms and the coliforms were completely decontaminated with 3% turmeric powder and 2 kGy of the gamma irradiation at 4°C for 14 days. The microbial characteristics of the edible coatings using the turmeric starch and the bovine gelatin were examined in the frankfurter sausages. The edible coating was developed with a 5% (w/w) aqueous solution of the turmeric starch and the gelatin. The microbial growth of the coated sausages stored at 5°C for 20 days decreased by 2.21, 1.01, and 1.65 log CFU/ gram for the mesophilic microorganisms, the lactic acid microorganisms, and the psychotropic microorganisms, respectively. At 10°C, the decreases were 1.57, 2.14, and 1.99 log CFU/ gram for the mesophilic microorganisms, the lactic acid microorganisms, and the psychotropic microorganisms, respectively [208-213].

The Plant-Derived Antimicrobial Peptides (the AMPs)

The Plant-derived AMPs have been studied for their potential to inhibit the different pathogens, including the food spoilage microorganisms, the food poisoning microorganisms, the mold, and the yeast species. The antibacterial peptide Leg1 from the chickpea legumin has been reported in the meat application of the plant-derived the AMPs. The Raw pork was pretreated with Leg1 and inoculated with the *E. coli* and the *B. subtilis*. The bactericidal activity was measured at 37°C for 16 hours. The minimum bactericidal concentrations of Leg1 on the pork meat were 125 μM and 15.6 μM for the *E. coli* and the *B. subtilis*, respectively. This was the same concentration as the MBC of the nisin, the bacteriocin from the Lactococcus lactis, for the tested strains. The AMPs from pea (the 11SGP) and the red kidney bean (the RBAH) were used to extend the shelf-life of the raw buffalo meat. In the laboratory media, the Gram-positive (the *L. monocytogenes*, the *B. cereus*, and the *Streptococcus pyogenes*) and the Gram-negative (the *E. coli*, the *Pseudomonas aeruginosa*, the *Acinetobacter baumannii*) microorganisms were inhibited by 11GSP (60 μg/mL) and the Gram-negative microorganisms by 60% and the Gram-positive microorganisms by 90%. RBAH (60 μg/mL) alleviated the growth of the Gram-negative microorganisms by 56% and the Gram-positive microorganisms by 85%. In the buffalo meat, the counts of the mesophilic microorganisms of 11SGP (400 μg/ gram) and the RBAG (400 μg/ gram) treated groups decreased by 1.60 log CFU/ gram and 1.94 log CFU/ gram compared to the control groups. The psychrophilic microorganisms, 11SGP and the RBAG reduced by 1.10 log CFU/ gram and 1.47 log CFU/ gram, respectively, after 15 d of the refrigerated storage (4°C) [172-176].

The Natural Preservatives from the Animals and Their Application for the Meat and the Meat Products

The Various antibacterial systems of the animal sources are associated with the defense mechanisms against external intruders. The preservatives derived from the animal sources include the lysozymes, the lactoferrin, the ovotransferrin, the lactoperoxidase, the AMPs from the livestock animals, and the polysaccharides. The Lysozyme can suppress several Gram-positive microorganisms because of the Lysozyme distinctive ability to injure bacterial membranes by hydrolyzing the 1,4-β-linkage between the N-acetyl-D-glucosamine and the N-acetyl-muramic acid of the peptidoglycan in the bacterial membrane. The Peptide-based antibacterial substances containing the AMPs from the animal sources, the ovotransferrin, and the lactoferrin could influence the cell membranes or the synthesize ATP, the peptides, and the enzymes. The antibacterial mechanism of the AMP has been reported to attach to the bacterial cell membrane and disturb its integrity, resulting in the cell lysis. The AMPs may also exert more complex activities that inhibit the metabolic and the translational systems. The ovotransferrin isolated from the eggs increased the cell membrane permeabilization of the Gram-positive and the Gram-negative microorganisms. The ovotransferrin destroyed the cell membrane integrity, increased the permeability of the pathogen membranes, and induced morphological changes. The Lactoferrin has antibacterial effects related to the large cationic patches present on the surface and the iron impoverishment. The Lactoferrin has an antibacterial effect only when in its iron-free state and the iron-saturated lactoferrin has a limited antimicrobial activity. The Lacroperoxidase oxidizes the sulfhydryl groups of the proteins present in the bacterial membrane, which could be injured by the efflux of the potassium ions, the amino acids, the peptides, and the enzymes [177-182].

The Lysozyme

The Lysozyme (the muramidase or the N-acetyl-muramichydrolase) is mainly extracted from the hen egg whites and is known as an antimicrobial enzyme. The Lysozyme is a glycoside hydrolase that hydrolyses the linkages in the peptidoglycan at the Gram-positive bacterial cell wall. The Lysozyme is composed of 129 amino acids, which contain the disulfide bonds and the tryptophan, the tyrosine, and the phenylalanine residues. The Lysozyme has been used commercially, named the Inovapure, against the spoilage microorganisms and the food-borne pathogens to prolong the shelf-life of the raw and the processed meat. The Modified lysozyme, the high hydrophobicity, and the low hydrolytic activity compared to the lysozyme monomer, at the concentrations of 5%, exhibited low microbial growth rates (the total viable count 4.59 log CFU/cm^2; the molds and the yeasts 2.17 log CFU/cm^2) in the pork meat surface with the modified atmosphere packaging with composites of 50% O_2, 40% CO_2, and 10% N_2. The mixed antimicrobials consisting of the lysozyme (250 ppm), the nisin (250 ppm), and the disodium ethylenediaminetetraacetic acid (the EDTA) (20 mM) had antibacterial effects against the *L. monocytogenes*, the total viable counts, the *Enterobacteriaceae*, the *Pseudomonas spp*., and the lactic acid microorganisms in the ostrich meat patties with the air and the vacuum packaging. The mixed lysozyme preparations reduced the *L. monocytogenes* below the official detection limit of the EU (<2 log CFU/ gram) in the ostrich meat patties. The treated samples showed a decrease in the total viable counts by 1 log CFU/ gram after 2 days of the storage and tended to increase thereafter. The *Enterobacteriaceae* and the *Pseudomonas spp.* were not affected by the mixed antimicrobials in either the packaging atmosphere, and the reduction in the lactic acid microorganisms was detected at 2 log CFU/ gram. The combination of the lysozyme with the chitooligosaccharide presented a more effective antibacterial effect against the Gram-negative microorganisms than the lysozyme alone. In the minced lamb meat, the mixture of the lysozyme and the chitooligosaccharide led to complete removal of 3–4 log CFU/ gram of the inoculated *E. coli, Pseudomonas fluorescens*, and *B. cereus* during 4 hours at the ambient temperature. The *S. aureus* was not completely eliminated, but was reduced up to 2 log CFU/gram [183-187].

The Ovotransferrin

The Egg white contains 13% ovotransferrin (the conalbumin), which is a monomeric 77.9 kDa glycoprotein comprised of 686 amino acid residues. The ovotransferrin contains N- and C- globular parts, each of which can reversibly Fe^{3+} and CO_3^{2-}. The ovotransferrin is the main constituent of the egg's defense system for the microorganisms, as it renders the iron unusable for the microbial growth within the albumen. The antimicrobial effects of the ovotransferrin against the *E. coli* in the fresh chicken breast involved in κ-carrageenan film. The growth of the *E. coli* in the fresh chicken breast wrapped with the active film was 2.7 log CFU/ gram by the addition of 25 mg of the ovotransferrin in combination with 5 mM EDTA. The ham models, 25 mg/mL of ovotransferrin with 100 mM sodium bicarbonate ($NaHCO_3$) did not show any antibacterial effects against the *E. coli* O157:H7 and the *L. monocytogenes* in commercial hams, whereas 25 mg/mL ovotransferrin with 0.5% citric acid had bacteriostatic effects against *L. monocytogenes* [188-193].

The Lactoferrin

The Lactoferrin, a glycoprotein that belongs to the transferrin protein family in milk and milk products as well as neutrophil granules and exocrine secretions in mammals, was able to bind iron within the cells. The ability of this 80 kDa protein to control free iron levels contributes to its bacteriostatic and health-beneficial characteristics, such as stimulating bone growth, protecting the intestinal epithelium, and promoting the immune system in animals. In the ground beef, application of the active lactoferrin, the immobilized lactoferrin with the glycosaminoglycans, and solubilized in citrate/bicarbonate buffer systems at concentrations of 3% and 5% resulted in 2 log CFU/ gram reductions of *E. coli* O157:H7 at 10°C for 9 days. The reduction of the *S. Enteritidis* growth was 0.8 log CFU/ gram when the active lactoferrin concentration was increased to 2.5%. A single application of 0.5% active lactoferrin reduced *L. monocytogenes* in the beef, resulting in 2 log CFU/ gram. The Bovine lactoferrin (0.5 mg) was tested against the *E. coli* O157:H7 and *P. fluorescens* inoculated on the chicken with HPP treatments between 200 and 500 MPa for 10 min at 10°C. As a result, the *P. fluorescens* was decreased when the lactoferrin was combined with the HPP treatment at 300 MPa for 2.3 log CFU/ gram additional reduction compared to only 300 MPa treatment on day 9. Additional reductions in the *E. coli* O157:H7 counts obtained by combined treatments remained below 0.5 log CFU/gram [194-198].

The Lactoperoxidase

The Lactoperoxidase is a member of the peroxidase family. It is a ubiquitous active enzyme in bovine milk, which has antimicrobial effects. Bovine lactoperoxidase is a glycoprotein that contains a peptide chain of 78.4 kDa and catalyzes the oxidation of thiocyanate ions (SCN-) in lactoperoxidase, producing oxidizing products, such as hypothiocyanite and hypothiocyanous acid. The lactoperoxidase coated with alginate at concentrations of 2, 4 and 6% on the shelf-life of the chicken breast filets. The chicken samples with active coating of alginate and 6% lactoperoxidase showed a reduction of *Enterobacteriaceae, P. aeruginosa*, and aerobic mesophilic microorganisms by approximately 5 log CFU/ gram, 4 log CFU/ gram, and 2.5 log CFU/ gram at 16 days of refrigerated storage, respectively. The antimicrobial effects of lactoperoxidase were also assessed against *L. monocytogenes* and *S. Enteritidis* in sliced dry-cured-ham for 60 d at 8°C treated with HPP at 450 MPa. The synergistic effect of lactoperoxidase and pressure was confirmed as S. Enteritidis decreased below the detection limit (1 log CFU/ gram). For *L. monocytogenes*, the synergistic effect reduced cell viability by 0.86 log CFU/ gram compared with untreated samples at the end of storage. In the beef, the effect of the lactoperoxidase on the growth of the inoculated pathogens (4 log CFU/ gram) composed of *S. aureus, L. monocytogenes, E. coli* O157:H7, *S. Typhimurium, P. aeruginosa, Yersinia enterocolitica,* and *indigenous microbiota* was investigated. All pathogens used in the experiment were reduced compared to the control at a chilling regime (−1 to 12°C) for 42 days. The total aerobe and *Pseudomonas spp*. increased less in the lactoperoxidase treated group than in the control group, but the antibacterial effect was not exhibited for anaerobes and lactic acid microorganisms . [199-203].

The Livestock Animal-Derived AMPs

The Livestock animal-derived products have been used as a source of AMPs. Among these by-products of livestock, blood, bones, collagen, gelatin, liver, lungs, placenta, skin, and visceral mass are important sources of AMPs, as well as muscle parts. The bovine cruor, a slaughterhouse byproduct containing mainly hemoglobin, broadly described as a rich source of fibrin proteins, was investigated for the extraction of AMPs. The faction named α137–141 (polypeptide with five components, Thr-Ser-Lys-Tyr-Arg), a small (0.65 kDa), and hydrophilic AMPs deviated from hemoglobin. The α137–141 preservative (0.5%, w/w) had bacteriostatic effects on the total microbial population, coliform microorganisms, yeasts, and molds at 4°C for 14 d on beef. The AMPs isolated from porcine leukocytes had antibacterial effects on the proliferation of *S. aureus* and *E. coli* inoculated in the ground meat (the boneless ham) and the sausage minces. The 20 µg/ gram AMPs decreased by 1.3 log CFU/ gram of S. aureus and 1.5 log CFU/ gram of E. coli in ground meat. It was also achieved that 160 µg/ gram of AMPs had the best inhibition and decreased in 3.9 log CFU/ gram of *S. aureus* and 3.3 log CFU/ gram of *E. coli* at 6 hours in the ground meats. In sausage mince, the AMPs at concentrations of 160 µg/ gram could decrease by 3 log CFU/g of *S. aureus* and 2.7 log CFU/ gram of *E. coli* at 12 hours. After 24 hours of storage, no visible colonies of *S. aureus* or *E. coli* were detected in the sausage mince [203-208].

The Natural Preservatives from the Microorganism and Their Application for the Meat and the Meat Products

The Lactic acid microorganisms (the LAB) strains secrete several bacterial growth inhibitory substances (the organic acids, the diacetyl, the phenyl-lactate, the hydroxyphenyl-lactate, the cyclic dipeptides, the hydroxy fatty acid, the propionate, and the hydrogen peroxide), the bacteriocins (the nisin, the acidophilin, the bulgaricin, the helveticin, the lactacin, the pediocin, the plantarim, the diplococcin, and the bifidocin), and the bacteriocin-like inhibitory substances (the BLIS), which exhibit antibacterial activity and can control the spoilage microorganisms and the food-borne pathogens. Among various bacteriocins, commercial bacteriocin preparations have been applied using nisin and pediocin. Bacteriocins are peptides or proteins with antibacterial and antifungal effects that produce microorganisms, mainly lactic acid microorganisms. These compounds are considered potential natural preservatives because of their inhibitory effects on the food spoilage microorganisms or pathogens. LAB bacteriocins vary in accordance with molecular size, the chemical structure, modifications during biosynthesis, presence of modified amino acid residues, and antimicrobial mechanisms. The LAB bacteriocins can be categorized into two major classes: class I (lanthionine-containing antibiotics) with three subclasses (Ia, Ib, and Ic) and the class II with four subclasses (IIa, IIb, IIc, and IId). The Class I bacteriocins generally include 19–50 amino acid residues (<5 kDa) and are largely post-translationally modified, ensuring the non-standard amino acids, such as the lanthionine, the β-methyllanthionine, and the labyrinthine. The class I bacteriocins are further subdivided into the class Ia (the lantibiotics), the class Ib (the labyrinthopeptins), and the class Ic (the sanctibiotics). The Class II bacteriocins comprise the small, heat-stable, the non-modified peptides (<10 kDa). It can be further subdivided into the class IIa (the pediocin-like bacteriocins), the class IIb (the non-modified bacteriocins with two or more peptides), the class IIc (the circular bacteriocins), and the class IId (the non-pediocin-like bacteriocins). The Pediocin-like bacteriocins (the class IIa) can be regarded as the main subgroup among all classified the LAB bacteriocins. The Class III bacteriocins are classified as the high molecular weight (>30 kDa) and the thermally unstable peptides. The Class IV bacteriocins are large peptides complexed with the lipids or the carbohydrates. The bacterial cell surface exhibits a negative charge because the anionic characteristics of the cell membrane consist of the phosphatidylethanolamine, the phosphatidylglycerol, the lipopolysaccharide, the lipoteichoic acid, and the cardiolipin, and is generally captured by the positively charged bacteriocins. The cationic charged groups of the bacteriocins electrostatically interact with the anionic bacterial cell surface, while the hydrophobic surfaces are attached to the membrane and traverse the lipid bilayer. The bacteriocins self-associate or polymerize to develop complexes after passing through the lipid bilayer. The bacteriocins induce the cell death by increasing the permeability of the bacterial membrane, forming pores that cause dissipation of the proton motive force, exhaustion of ATP, and leakage of intracellular substrates. Gram-positive microorganisms -derived bacteriocins only perform for Gram-positive microorganisms and are not effective against Gram-negative microorganisms because of their different membrane compositions and selective membrane permeability. These disadvantages could be compensated by mixing processing with other preservatives and the application of further preservation methods [209-213].

The Nisin

The Nisin is the most representative class I bacteriocin. The Nisin is produced by several strains of the *Lactococcus lactis*, a species that is widely used for the dairy production. The Nisin was first approved as a food preservative in the United Kingdom in the 1950s and is now widely used worldwide and is permitted in over 50 countries. The structure of the nisin consists of a polypeptide with 34 amino acids, a 3.5 kDa molecular mass, and contains the methyllanthionine and the lanthionine groups. The Nisin has antimicrobial activities against a wide range of the Gram-positive microorganisms, including the *Staphylococcus spp*., the *Bacillus spp*., the *Listeria spp*., and the *Enterococcus spp*. The Nisaplin is a typical commercial nisin formulation. The Nisin could provide long-lasting bacteriostatic effects on the pathogenic microorganisms in the beef jerky at room temperature. The shelf-life extensive effect of the nisin in the B. cereus inoculated with the beef jerky. In the beef jerky without the nisin, the counts of the mesophilic microorganisms and the *B. cereus* increasing is unlikely for the beef jerky treated with the nisin at 25°C for 60 days. The *B. cereus* grew after 3 days in the 100 IU nisin/ gram. The treated groups and after 21 days in the 500 IU/ gram nisin-treated groups. The nisin-containing fermentate from the L. lactis 537 strain was evaluated for the inhibition of the L. monocytogenes in ready-to-eat (RTE) sliced ham. The addition of the fermentate to the RTE sliced ham led to an immediate decrease in the L. monocytogenes counts from 3 log CFU/ gram to below the detection limit stored at 4°C (20 CFU/ gram). The Nisin with the cinnamaldehyde and the grapefruit seed extract presented synergistic antibacterial effects. It reduced the counts of the *L. monocytogenes* by 3 log CFU/ gram in the raw pork loin at 4°C for 12 hours. The minimum inhibitory concentration of the nisin against *L. monocytogenes* was 250 ppm in laboratory media, but it was possible to reduce the concentration of 5–6 ppm against the growth of L. monocytogenes by mixing with the natural antibacterial substances in the pork [214-219].

The Pediocin

The Pediococcus spp., *Pediococcus acidilactici,* and *Pediococcus pentosaceus* are the main pediocin-producing strains. Pediocin was classified into the bacteriocin group class IIa, characterized as small non-modified peptides (<5 kDa) comprising less than 50 amino acids.. Remarkably, pediocin showed antimicrobial activity even at nanomolar concentrations. The Food grade pediocin-containing formulations are commercially available and marketed as ALTA 2341 and MicroGARD. The Pediocin has been studied for the inhibition of the *Listeria spp.* for the meat preservation. The antibacterial activities of pediocin PA-1 in the frankfurters and the P. acidilactici MCH14, the pediocin PA-1 producing strain, in the Spanish dry-fermented sausages were assessed against the *L. monocytogenes* and the *C. perfringens* . In frankfurters treated with 5000 bacteriocin units (BU)/ mL of the pediocin PA-1 produced by the P. acidilactici the MCH14, the *L. monocytogenes* was reduced by 2 and 0.6 log CFU/ gram after the storage at 4°C for 60 days and at 15°C for 30 days, respectively. The *C. perfringens* decreased with 5000 BU/mL of the pediocin PA-1 by 2 and 0.8 log CFU/ gram after the storage at 10°C for 60 d and at 15°C for 30 days, respectively. The growth of the *L. monocytogenes* was inhibited by the pediocin-producing strain, the P. acidilactici MCH14, in the Spanish dry-fermented sausages at 2 log CFU/ gram compared to the control. The bacHA-6111-2, the pediocin from the *P. acidilactici* HA-6111-2, was applied to the Portuguese fermented meat sausage (the Alheira) with the HPP treatment (300 MPa, 5 min, 10°C) to inhibit the

Listeria innocua. The bacteriostatic effect was verified for high inoculation counts of the *L. innocua* at 4°C for 60 days. For lower the inoculated L. innocua, antibacterial effect was observed below 2 log CFU/ gram from day 3 of storage until the end of storage. The antibacterial activities of a mixed preparation containing pediocin from the P. pentosaceus and Murraya koenigii (curry tree) berries in a raw goat meat emulsion at 4°C for 9 days. The L. innocua was reduced for 4.1 log CFU/ gram in the treated samples concentrations at 8.3 mL pediocin/1000 grams of the meat emulsion with 10% (v/w) Murraya koenigii berries extract at the end of the storage. The total viable count and the psychrophilic count were also observed lower in the treated samples, 2.2 log CFU/gram and 1.6 log CFU/ gram, respectively [220-225].

The Sakacin

The Sakacins, a class II bacteriocin, are mainly produced by the Lactobacillus sakei or the Lactobacillus curvatus strains. The Commercial sakacin products are currently not presented. Compared to the nisin and the pediocin, the sakacins have a relatively narrow antimicrobial spectrum, especially with effective inhibition against the Listeria species. The antibacterial effect of the sakacin-producing strain, the *L. sakei* CWBI-B1365, and the L. curvatus CWBI-B28, on the fate of the L. monocytogenes in the raw beef and poultry. In the refrigerated (5°C) the raw beef, the *L. sakei* induced a decrease in the L. monocytogenes concentration by 1.5 log CFU/ gram after 7 days to 2 log CFU/ gram after 14 days, and below the detection limit at 21 days. The addition of the L. curvatus reduced the L. monocytogenes to below the detection limit after 7 days. However, in the poultry, the bacteriocin-producing strain did not affect the inhibition of the L. monocytogenes. It was assumed that the type of the meat may have influenced the bacteriocin production by the LAB. The antibacterial activity of different bacteriocin preparations using the sakacin Q produced by the L. curvatus ACU-1 on the meat surface was evaluated against L. innocua . The freeze-dried reconstituted cell-free supernatant (3200 AU/mL) was effective for the inhibition of L. innocua on the meat surface, decreasing its bacterial cell number to the detection limit (<2 log CFU/ gram) after 2 weeks of storage at 4–5 °C. The adsorption of the sakacin Q to the meat products, the main ingredients, the meat proteins, and the fat tissues did not affect its antibacterial activity [226-231].

The Bacteriocin-Like Inhibitory Substance (BLIS)

The BLIS are among the antimicrobial substances produced by microorganisms and are not completely categorized in terms of amino acid composition, molecular size, and nucleotide sequence. In RTE pork ham, the antibacterial effects of BLIS produced by *P. pentosaceus* American Type Culture Collection (ATCC) 43200 were assessed and compared with those of commercially available nisin preparations (the Nisaplin). BLIS showed effective antibacterial activity against the Listeria seeligeri by 0.74 log CFU/ gram in the RTE ham stored at 4°C after 2 days. However, a slight increase in the L. seeligeri counts was detected in the BLIS-treated samples from 6 days to the end of storage. Nisaplin did not present any antibacterial effect for up to 2 days. After 2 days, Nisaplin started to induce a decrease in the *L. seeligeri* counts throughout the refrigerated storage. This might have been due to the higher sensitivity of BLIS to residual proteases compared to the nisin, thus weakening its antibacterial effect. The BLIS-producing the LAB strains, the P. acidilactici KTU05-7, *P. pentosaceus* KTU05-9, and the *L. sakei* KTU05-6, were used to ferment the plant (the Jerusalem artichoke, the *Helianthus tuberosus* L.), and 5% of the fermented products were tested to inhibit the food-borne pathogen at 18°C for 12 hours in the ready-to-cook (the RTC) minced pork. The *P. acidilactici* fermented product presented the highest antimicrobial activity compared to the other strains. The counts of the E. coli, the Enterococcus faecalis, the S. aureus, and the Streptococcus spp. were reduced by 5.53, 4.37, 4.86, and 3.84 log CFU/ gram, respectively, compared to the control groups, suggesting that the fermented product of the BLIS-producing strains showed an enhanced antibacterial effect. The BLIS obtained from Enterococcus faecium DB1 inhibited the growth and formation of biofilms of *C. perfringens* in the chicken meat. The 2.5 mg/mL of DB1 BLIS suppressed the growth of the *C. perfringens* by approximately 30%. The *C. perfringens* growth was inhibited by 50% at 5 mg/mL The DB1 BLIS. Biofilm formation by the *C. perfringens* treated with 5 mg/mL DB1 BLIS was radically reduced by approximately 90% at 4 °C for 72 hours compared to the control groups. The 2.5 mg/mL of the DB1 BLIS also inhibited biofilm formation by the *C. perfringens* under the same conditions. The BLIS could inhibit the formation of the *C. perfringens* biofilms on the chicken surfaces due to its antibacterial effect [232-237].

Other Microorganism Sources

The mytichitin-CB peptide, which was isolated from the blood lymphocytes of the Mytilus coruscus, showed antibacterial effects against the Gram-positive microorganisms and fungi. The mytichitin-CB peptide expressed by *Pichia pastorisi* and applied it to the pork preservation. The total viable counts of the treated group with 6 mg/L of mytichitin-CB derived from the *P. pastorisi* was reduced by 33% (1–2 log CFU/ gram) compared to the control group after the storage at 4°C for 5 days. The Mytichitin-CB effectively inhibited the total bacterial growth during the storage compared to the groups treated with 50 mg/L of the nisin. The Mytichitin-CB at 6 and 12 mg/L suppressed Staphylococcus spp. and Escherichia spp., respectively, with a reduction of 1–2 log CFU/ gram, respectively. The Listeria spp. and the Pseudomonas spp. were not detected during the storage, unlike the control and nisin-treated groups. The Hispidalin is a unique AMP derived from the seeds of the Benincasa hispida and has been shown to exhibit the antimicrobial effects against the various microorganisms. The hispidalin expressed by the *P. pastorisi* was used as a preservative for the pork meat. The Pork meat treated with 100 μg/mL hispidalin showed bacteriostatic effects during the entire refrigerated storage period. The total viable count of the pork with 100 μg/mL hispidalin was 1 log CFU/gram lower than that of the control group at 4°C for 7 days [238-245].

Conclusions

The Meat and the meat products are excellent nutrient sources due to their abundant protein content, the essential amino acids, the vitamins, and the minerals. The meat and meat products are susceptible to the contamination by the food-borne pathogens and the various spoilage microorganisms because of their high water activity and the nutrient content. The application of the preservatives is an indispensable element in the livestock food industry to prevent the food poisoning, delay the spoilage, and extend their shelf life. The Industrial preservatives, commonly made up of the synthetic chemicals, are not demanded by the food customers because of their negative health concerns. The natural preservatives derived from the plants (the rosemary, the sage, the chestnut, the GSE, and the tumeric), the animals (the lysozyme, the lactoferrin, the lactoferoxidase, the ovotransferrin, and others), and the microorganisms (the organic acids, the bacteriocins, and the BLIS) have been explored as alternatives to the synthetic chemical preservatives. The versatility of the natural preservatives compared to the synthetic preservatives is limited due to the production cost, the standardization, the insufficient toxicity studies, and the negative sensory effects on the food. To compensate for these disadvantages, various applications have been studied for their synergistic effect with the other natural preservatives with reduced the application concentrations compared to single use, the application of the physical treatment (the gamma irradation, the high pressure processing, and the drying), the encapsulation, and the possibility of the packaging materials. The various natural preservatives and the application methods to inhibit the growth of the food-borne pathogens and the spoilage microorganisms in the livestock foods. The Natural preservatives are expected to be in high demand due to the consumer and the industrial requests. Therefore, it is necessary to explore various applications of the existing natural preservatives, while continuously searching for the novel ones.

ORCID

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

Conflicts of Interest

The author declare no conflicts of interest

References

1. Shaltout FA, Riad EM, Abou-Elhassan A (2017) Prevalence of Mycobacterium Tuberculosis in Imported cattle Offals And Its lymph Nodes. Veterinary Medical Journal -Giza (VMJG) 63(2): 115-122.

2. Papagianni M (2003) Ribosomally synthesized peptides with antimicrobial properties: Biosynthesis, structure, function, and applications. Biotechnol Adv 21(6): 465-499.

3. Shaltout FA, Riad EM, Abou-Elhassan A (2017) Prevalence of Mycobacterium Spp. In: Cattle Meat and Offal's Slaughtered in and out Abattoir (Edn). Egyptian Veterinary medical Association 77(2): 407-420.

4. Meng DM, Sun SN, Shi LY, Cheng L, Fan ZC (2021) Application of antimicrobial peptide mytichitin-CB in pork preservation during cold storage. Food Control 125: 108041.

5. Abd Elaziz O, Hassanin FS, Shaltout FA, Mohamed OA (2021) Prevalence of Some Foodborne Parasitic Affection in Slaughtered Animals in Loacal Egyptian Abottoir. Journal of Nutrition Food Science and Technology 41(1): 111-114.

6. Del Olmo A, Calzada J, Nuñez M (2012) Effect of lactoferrin and its derivatives, high hydrostatic pressure, and their combinations, on Escherichia coli O157:H7 and Pseudomonas fluorescens in chicken filets. Innov Food Sci Emerg Technol 13: 51-56.

7. Abd Elaziz O, Hassanin FS, Shaltout FA, Mohamed OA (2021) Prevalence of some zoonotic parasitic affections in sheep carcasses in a local abattoir in Cairo, Egypt. Advances in Nutrition & Food Science 6(2): 25-31.

8. Nieto-Lozano JC, Reguera-Useros JI, Peláez-Martínez MdC, Sacristán-Pérez-Minayo G, Gutiérrez-Fernández ÁJ, et al. (2010) The effect of the pediocin PA-1 produced by *Pediococcus acidilactici* against Listeria monocytogenes and Clostridium perfringens in Spanish dry-fermented sausages and frankfurters. Food Control 21(5): 679-685.

9. Al Shorman AAM, Shaltout FA, Hilat N (1999) Detection of certain hormone residues in meat marketed in Jordan. Jordan University of Science and Technology pp: 23-25.

10. Müller-Auffermann K, Grijalva F, Jacob F, Hutzler M (2015) Nisin and its usage in breweries: A review and

discussion. J Inst Brew 121(3): 309-319.

11. Saleh E, Shaltout FA, Abd Elaal E (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.
12. Cegielska RR, Szablewski T, Radziejewska KE, Tomczyk Ł, Biadała A, et al. (2021) The effect of modified lysozyme treatment on the microflora, physicochemical and sensory characteristics of pork packaged in preservative gas atmospheres. Coatings 11: 488.
13. Edris A, Hassanin FS, Shaltout FA, Elbaba AZ, Adel NM (2017) Microbiological Evaluation of Some Heat Treated Fish Products in Egyptian Markets. EC Nutrition 33(2): 305-316.
14. Elliot RM, McLay JC, Kennedy MJ, Simmonds RS (2021) Inhibition of foodborne bacteria by the lactoperoxidase system in a beef cube system. Int J Food Microbiol 91(1): 73-81.
15. Edris A, Hassan MA, Shaltout FA, Elhosseiny S (2013) Chemical evaluation of cattle and camel meat. Benha Veterinary Medical Journal 24(2): 191-197.
16. Rao MS, Chander R, Sharma A (2008) Synergistic effect of chitooligosaccharides and lysozyme for meat preservation. LWT 41: 1995-2001.
17. Edris AM, Hassan MA, Shaltout FA, Elhosseiny S (2012) Detection of *E. coli* and Salmonella organisms in cattle and camel meat. Benha Veterinary Medical Journal 24(2): 198-204.
18. Przybylski R, Firdaous L, Chataigne G, Dhulster P, Nedjar N (2016) Production of an antimicrobial peptide derived from slaughterhouse by-product and its potential application on meat as preservative. Food Chem 211: 306-313.
19. Edris AM, Hemmat MI, Shaltout FA, Elshater MA, Eman FMI (2012) Study On Incipient Spoilage Of Chilled Chicken Cuts-Up. Benha Veterinary Medical Journal 23(1): 81-86.
20. Lee JS, Park SW, Lee HB, Kang SS (2021) Bacteriocin-like inhibitory substance (BLIS) activity of *Enterococcus faecium* DB1 against biofilm formation by *Clostridium perfringens*. Probiotics Antimicrob Proteins 13(5): 1452-1457.
21. Edris AM, Hemmat MI, Shaltout FA, Elshater MA, Eman FMI (2012) Chemical Analysis of Chicken Meat With Relation to its Quality. Benha Veterinary Medical Journal 23(1): 87-92.
22. Rolfe V, Mackonochie M, Mills S, McLennan E (2020) Turmeric/curcumin and health outcomes: A meta-review of systematic reviews. Eur J Integr Med 101252.
23. Edris AM, Shaltout FA and Abd AAM (2005) Incidence of Bacillus cereus in some meat products and the effect of cooking on its survival. Zag Vet J 33 (2): 118-124.
24. Dong A, Malo A, Leong M, Ho VTT, Turner MS (2021) Control of Listeria monocytogenes on ready-to-eat ham and fresh cut iceberg lettuce using a nisin containing Lactococcus lactis fermentate. Food Control 119: 107420.
25. Edris AM, Shaltout FA, Arab WS (2005) Bacterial Evaluation of Quail Meat. Benha Vet Med J 16(1): 1-14.
26. Shwaiki LN, Lynch KM, Arendt EK (2021) Future of antimicrobial peptides derived from plants in food application-A focus on synthetic peptides. Trends Food Sci Technol 112: 312-324.
27. Edris AM, Shaltout FA, Salem GH, El Toukhy EI (2011) Incidence and isolation of Salmonellae from some meat products. Veterinary Medicine and Food Safety, pp: 172-179.
28. Jaspal MH, Ijaz M, Haq HA, Yar MK, Asghar B, et al. (2021) Effect of oregano essential oil or lactic acid treatments combined with air and modified atmosphere packaging on the quality and storage properties of chicken breast meat. LWT 146: 111459.
29. Edris MA, Hassanin FS, Shaltout FA, Elbaba AH, Adel NM (2017) Microbiological Evaluation of Some Heat Treated Fish Products in Egyptian Markets. EC Nutrition 33(2): 305-316.
30. Wang FS (2003) Effect of antimicrobial proteins from porcine leukocytes on Staphylococcus aureus and Escherichia coli in comminuted meats. Meat Sci 65(1): 615-621.
31. Edris AM, Shaltout FA, Salem GH, El Toukhy EI (2011) Plasmid profile analysis of Salmonellae isolated from some meat products. Veterinary Medicine and Food Safety, pp: 194-201.
32. Seol KH, Lim DG, Jang A, Jo C, Lee M (2009) Antimicrobial effect of kappa-carrageenan-based edible film containing ovotransferrin in fresh chicken breast stored at 5 degrees C. Meat Sci 83(3): 479-483.
33. Ragab A, Edris AM, Shaltout FAE, Salem AM (2022) Effect of titanium dioxide nanoparticles and thyme essential oil on the quality of the chicken fillet. Benha Veterinary Medical Journal 41(2): 38-40.

34. Anastasio A, Marrone R, Chirollo C, Smaldone G, Attouchi M, et al. (2014) Swordfish steaks vacuum-packed with Rosmarinus officinalis. Ital J Food Sci 26(4): 390-397.

35. Woraprayote W, Malila Y, Sorapukdee S, Swetwiwathana A, Benjakul S, et al. (2016) Bacteriocins from lactic acid bacteria and their applications in meat and meat products. Meat Sci 120: 118-132.

36. Hassan MA, Shaltout FA, Arfa MM, Mansour AH, Saudi KR (2013) Biochemical studies on rabbit meat related to some diseases. Benha Veterinary Medical Journal 25(1): 88-93.

37. Mastromatteo M, Lucera A, Sinigaglia M, Corbo MR (2010) Synergic antimicrobial activity of lysozyme, nisin, and EDTA against Listeria monocytogenes in ostrich meat patties. J Food Sci 75(7): M422-M429.

38. Hassan MA, Shaltout FA (1997) Occurrence of Some Food Poisoning Microorganisms in Rabbit Carcasses. Alex J Vet Science 13(1): 55-61.

39. Lee NK, Paik HD (2021) Prophylactic effects of probiotics on respiratory viruses including COVID-19: A review. Food Sci. Biotechnol 30(6): 773-781.

40. Hassan M, Shaltout FA, Saqur N (2020): Histamine in Some Fish Products. Archives of Animal Husbandry & Dairy Science 2(1): 1-3.

41. Wu T, Wu C, Fu S, Wang L, Yuan C, et al. (2017) Integration of lysozyme into chitosan nanoparticles for improving antibacterial activity. Carbohydr Polym 155: 192-200.

42. Hassan MA, Shaltout FA (2004) Comparative Study on Storage Stability of Beef, Chicken meat, and Fish at Chilling Temperature. Alex J Vet Science 20(21): 21-30.

43. Stimbirys A, Bartkiene E, Siugzdaite J, Augeniene D, Vidmantiene D, et al. (2015) Safety and quality parameters of ready-to-cook minced pork meat products supplemented with *helianthus tuberosus* L. tubers fermented by BLIS producing lactic acid bacteria. J Food Sci Technol 52(7): 4306-4314.

44. Hassan MA, Shaltout FA, Arafa MM, Mansour AH, Saudi KR (2013) Biochemical studies on rabbit meat related to some diseases. Benha Vet Med J 25(1): 88-93.

45. Lee D, Heinz V, Knorr D (2003) Effects of combination treatments of nisin and high-intensity ultrasound with high pressure on the microbial inactivation in liquid whole egg. Innov Food Sci Emerg Technol 4(4): 387-393.

46. Hassan MA, Shaltout FA, Maarouf AA, El-Shafey WS (2014) Psychrotrophic bacteria in frozen fish with special reference to pseudomonas species. Benha Vet Med J 27(1): 78-83.

47. Lee NK, Kim HW, Lee JY, Ahn DU, Kim CJ, et al. (2015) Antimicrobial effect of nisin against Bacillus cereus in beef jerky during storage. Korean J Food Sci Anim Resour 35(2): 272-276.

48. Hassan MA, Shaltout FA, Arafa MM, Mansour AH, Saudi KR (2013) Bacteriological studies on rabbit meat related to some diseases. Benha Vet Med J 25(1): 94-99.

49. Yousefi M, Farshidi M, Ehsani A (2018) Effects of lactoperoxidase system-alginate coating on chemical, microbial, and sensory properties of chicken breast fillets during cold storage. J Food Saf 38(3): e12449.

50. Hassanin FS, Hassan MA, Shaltout FA, Shawqy NA, Abd-Elhameed GA (2017) Chemical criteria of chicken meat. Benha veterinary medical journal 33(2): 457-464.

51. Delves-Broughton J (2012) Natural antimicrobials as additives and ingredients for the preservation of foods and beverages. In: Baines D, Seal R (Eds.), Natural Food Additives, Ingredients and Flavourings, 1st(Edn.), Wood head Publishing Series in Food Science, Technology and Nutrition; Cambridge, UK, pp: 127-161.

52. Hassanin FS, Hassan MA, Shaltout FA, Elrais-Amina M (2014) Clostridium perfringens in vacuum packaged meat products. Benha veterinary medical journal 26(1): 49-53.

53. Kumar Y, Kaur K, Shahi AK, Kairam N, Tyagi SK (2017) Antilisterial, antimicrobial and antioxidant effects of pediocin and Murraya koenigii berry extract in refrigerated goat meat emulsion. LWT 79: 135-144.

54. Hassanien FS, Shaltout FA, Fahmey MZ, Elsukkary HF (2020) Bacteriological quality guides in local and imported beef and their relation to public health. Benha Veterinary Medical Journal 39(1): 125-129.

55. Montville TJ, Bruno MEC (1994) Evidence that dissipation of proton motive force is a common mechanism of action for bacteriocins and other antimicrobial proteins. Int J Food Microbiol 24(1-2): 53-74.

56. Hassanin FS, Shaltout FA, Mostafa EM (2013) Parasitic affections in edible offal. Benha Vet Med J 25(2): 34-39.

57. Kotra VSR, Satyabanta L, Goswami TK (2019) A critical review of analytical methods for determination of curcuminoids in turmeric. J Food Sci Technol 56(12): 5153-5166.

58. Hassanin FS, Shaltout FA, Lamada HM, Allah EM (2011) The effect of preservative (nisin) on the survival of listeria monocytogenes. Benha veterinary medical

journal (S1): 141-145.

59. Ma B, Guo Y, Fu X, Jin Y (2020) Identification and antimicrobial mechanisms of a novel peptide derived from egg white ovotransferrin hydrolysates. LWT 131: 109720.

60. Khattab E, Shaltout F, Sabik I (2021) Hepatitis A virus related to foods. Benha veterinary medical journal 40(1): 174-179.

61. Sedighi R, Zhao Y, Yerke A, Sang S (2015) Preventive and protective properties of rosemary (*Rosmarinus officinalis* L.) in obesity and diabetes mellitus of metabolic disorders: A brief review Curr Opin Food Sci 2: 58-70.

62. Saad SM, Shaltout FA, Farag AAA, Mohammed HF (2022) Organophosphorus Residues in Fish in Rural Areas. Journal of Progress in Engineering and Physical Science 47(2): 27-31.

63. Dortu C, Huch M, Holzapfel WH, Franz CM, Thonart P (2008) Anti-listerial activity of bacteriocin-producing Lactobacillus curvatus CWBI-B28 and Lactobacillus sakei CWBI-B1365 on raw beef and poultry meat. Lett. Appl. Microbiol 47(6): 581-586.

64. Saif M, Saad SM, Hassanin FS, Shaltout FA, Zaghloul M (2019) Molecular detection of enterotoxigenic Staphylococcus aureus in ready-to-eat beef products. Benha Veterinary Medical Journal 37(1): 7-11.

65. Massantini R, Moscetti R, Frangipane MT (2021) Evaluating progress of chestnut quality: A review of recent developments. Trends Food Sci Technol 113: 245-254.

66. Saif M , Saad SM , Hassanin FS, Shaltout FA, Marionette Z (2019) Prevalence of methicillin-resistant *Staphylococcus aureus* in some ready-to-eat meat products. Benha Veterinary Medical Journal 37: 12-15.

67. Papagianni M, Anastasiadou SP (2009) The bacteriocins of Pediococci. Sources, production, properties and applications. Microb Cell Factories 8: 3.

68. Farag AA, Saad MS, Fahim AS, Hashim FM (2023a) Studies on Pesticides Residues in Fish in Menofia Governorate. Benha Journal of Applied Sciences 8(5): 323-330.

69. Castro S, Silva J, Casquete R, Queirós R, Saraiva J, et al. (2018) Combined effect of pediocin bacHA-6111-2 and high hydrostatic pressure to control *Listeria innocua* in fermented meat sausage. Int Food Res J 25: 553-560.

70. Farag AA, Saad MS, Fahim AS, Hashim FM (2023b) Organochlorine Residues in Fish in Rural Areas. Benha Journal of Applied Sciences 8(5): 331-336.

71. Kumariya R, Garsa AK, Rajput YS, Sood SK, Akhtar N, et al. (2019) Classification, synthesis, mechanism of action and resistance development in food spoilage causing bacteria. Microb Pathog 128: 171-177.

72. Shaltout FA, Mona NH, Nada KE (2023) Histological Detection of Unauthorized Herbal and Animal Contents in Some Meat Products. Journal of Advanced Veterinary Research 13(2): 157-160.

73. Marchese A, Orhan IE, Daglia M, Barbieri R, Di LA, et al. (2016) Antibacterial and antifungal activities of thymol: A brief review of the literature. Food Chem 210: 402-414.

74. Shaltout FA , Heikal GI , Ghanem AM (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.

75. De APODS, Converti A, Gierus M, De SORP (2019) Antimicrobial activity of bacteriocin-like inhibitory substance produced by Pediococcus pentosaceus: From shake flasks to bioreactor. Mol Biol Rep 46 (1): 461-469.

76. Shaltout FA, Ramadan MS, Eman ME, Fatma AD (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.

77. Shahnawaz M, Soto C (2012) Microcin amyloid fibrils A are reservoir of toxic oligomeric species. J Biol Chem 287: 11665-11676.

78. Shaltout FA, Abdelazez AB, Mohamed EA (2022) Pathogenic Microorganisms in Meat Products. Biomedical Journal of Scientific & Technical Research 41(4): 32836-32843.

79. Alba MD, Bravo D, Medina M (2015) Inactivation of Listeria monocytogenes and Salmonella Enteritidis in dry-cured ham by combined treatments of high pressure and the lactoperoxidase system or lactoferrin. Innov. Food Sci Emerg Technol 31: 54-59.

80. Shaltout FA, Thabet MG, Koura HA (2017) Impact of Some Essential Oils on the Quality Aspect and Shelf Life of Meat. J Nutr Food Sci 7: 647.

81. Moon SH, Paik HD, White S, Daraba A, Mendonca AF, et al. (2011) Influence of nisin and selected meat additives on the antimicrobial effect of ovotransferrin against Listeria monocytogenes. Poult Sci 90(1): 2584-2591.

82. Shaltout F, Islam Z, El SA, Afify (2020) Bacteriological

profile of some raw chicken meat cuts in Ismailia city, Egypt. Benha Veterinary Medical Journal 39: 11-15.

83. Ko KY, Mendonca AF, Ahn DU (2008) Influence of zinc, sodium bicarbonate, and citric acid on the antibacterial activity of ovotransferrin against Escherichia coli O157:H7 and Listeria monocytogenes in model systems and ham. Poult Sci 87: 2660-2670.

84. Shaltout FA, Islam ZM, El SA, 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: 101-104.

85. Meng DM, Sun XQ, Sun SN, Li WJ, Lv YJ, et al. (2020) The potential of antimicrobial peptide Hispidalin application in pork preservation during cold storage. J Food Process Preserv 44: e14443.

86. Shaltout FA, Em ED, Asmaa HMA (2020) Hygienic Quality of Ready To Eat Cooked Meat In Restaurants At Cairo. Journal of Global Biosciences 8(12): 6627-6641.

87. Giansanti F, Panella G, Leboffe L, Antonini G (2016) Lactoferrin from milk: Nutraceutical and pharmacological properties. Pharmaceuticals 9(4): 61.

88. Shaltout FA, Marrionet ZN, Lotfy LM, Bossi T, Gamil (2019) Microbiological status of chicken cuts and its products. Benha Veterinary Medical Journal 37: 57-63.

89. Vasconcelos N, Croda J, Simionatto S (2018) Antibacterial mechanisms of cinnamon and its constituents: A review. Microb Pathog 120: 198-203.

90. Shaltout FA (2019) Poultry Meat. Scholarly Journal of Food and Nutrition 22: 1-2.

91. Mei J, Ma X, Xie J (2019) Review on natural preservatives for extending fish shelf life. Foods 8(10): 490.

92. Shaltout FA (2019) Food Hygiene and Control. Food Science and Nutrition Technology 4(5): 1-2.

93. Yuan S, Yin J, Jiang W, Liang B, Pehkonen S, et al. (2013) Enhancing antibacterial activity of surface-grafted chitosan with immobilized lysozyme on bioinspired stainless steel substrates. Colloids Surf B 106: 11-21.

94. Hassanin FS, Shaltout FA, Seham N (2019) Natural preservatives in raw chicken meat. Benha Veterinary Medical Journal 37(1): 41-45.

95. Xu MM, Kaur M, Pillidge CJ, Torley PJ (2021) Microbial biopreservatives for controlling the spoilage of beef and lamb meat: Their application and effects on meat quality. Crit Rev Food Sci Nutr 62(17): 4571-4592.

96. Hazaa W, Shaltout FA, Mohamed ES (2019) Prevalence of some chemical hazards in some meat products. Benha Veterinary Medical Journal 37(1): 32-36.

97. Rivas FP, Castro MP, Vallejo M, Marguet E, Campos CA (2014) Sakacin Q produced by Lactobacillus curvatus ACU-1: Functionality characterization and antilisterial activity on cooked meat surface. Meat Sci 97(4): 475-479.

98. Hazaa W, Shaltout FA, Mohamed ES (2019) Identification of Some Biological Hazards in Some Meat Products. Benha Veterinary Medical Journal 37(2): 27-31.

99. De APOS, Mendonca CMN, Seibert L, Dominguez JM, Converti A, et al. (2020) Bacteriocin-like inhibitory substance of Pediococcus pentosaceus as a biopreservative for Listeria sp. control in ready-to-eat pork ham. Braz J Microbiol 51: 949-956.

100. Gaafar R , Hassanin FS, Shaltout FA, Marionette Z (2019) Molecular detection of enterotoxigenic Staphylococcus aureus in some ready to eat meat-based sandwiches. Benha Veterinary Medical Journal 37(1): 22-26.

101. Parada JL, Caron CR, Medeiros ABP, Soccol CR (2007) Bacteriocins from lactic acid bacteria: Purification, properties and use as biopreservatives. Braz Arch Biol Technol 50(3): 512-542.

102. Gaafar R , Hassanin FS, Shaltout FA, Marionette Z (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.

103. Galvez A, Abriouel H, Benomar N, Lucas R (2010) Microbial antagonists to food-borne pathogens and biocontrol. Curr Opin Biotechnol 21(2): 142-148.

104. Saad SM, Shaltout FA, Nahla AAE, Saber BE (2019) Antimicrobial Effect of Some Essential Oils on Some Pathogenic Bacteria in Minced Meat. J Food Sci Nutr Res 2(1): 012-020.

105. Yu HH, Song MW, Song YJ, Lee NK, Paik HD (2019) Antibacterial effect of a mixed natural preservative against Listeria monocytogenes on lettuce and raw pork loin. J Food Prot 82(11): 2001-2006.

106. Saad SM, Shaltout FA, Nahla AAE, Saber BE (2019) Incidence of Staphylococci and E. coli in Meat and Some Meat Products. EC Nutrition 14: 6.

107. Tosati JV, Messias VC, Carvalho PIN, Rodrigues PMA, Meireles MAA, et al. (2017) Antimicrobial effect of edible coating blend based on turmeric starch residue

and gelatin applied onto fresh frankfurter sausage. Food Bioproc Technol 10: 2165-2175.

108. Saad SM, Hassanin FS, Shaltout FA, Marionette ZN, Marwa ZS (2019) Prevalence of Methicillin-Resistant Staphylococcus Aureus in Some Ready-to-Eat Meat Products. American Journal of Biomedical Science & Research 4(6): 460-464.

109. Gogliettino M, Balestrieri M, Ambrosio RL, Anastasio A, Smaldone G, et al. (2020) Extending the shelf-life of meat and dairy products via PET-modified packaging activated with the antimicrobial peptide MTP1. Front Microbiol 10: 2963.

110. 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.

111. Chen X, Chen W, Lu X, Mao Y, Luo X, et al. (2021) Effect of chitosan coating incorporated with oregano or cinnamon essential oil on the bacterial diversity and shelf life of roast duck in modified atmosphere packaging. Food Res Int 147: 110491.

112. Shaltout FA, EL-diasty EM, Mohamed MSM (2018) Effects of chitosan on quality attributes fresh meat slices stored at 4 C. Benha veterinary medical journal 35(2): 157-168.

113. Lazzaro BP, Zasloff M, Rolff J (2020) Antimicrobial peptides: Application informed by evolution. Science 368(6490): 5480.

114. Shaltout FA, Abdel-Aziz A (2004) *Salmonella enterica* serovar Enteritidis in poultry meat and their epidemiology. Vet Med J Giza 52(3): 429-436.

115. Borrajo P, Pateiro M, Barba FJ, Mora L, Franco D, et al. (2019) Antioxidant and antimicrobial activity of peptides extracted from meat by-products: A review. Food Anal. Methods 12: 2401-2415.

116. Shaltout FA, El-Shorah HF, El-Zahaby DI, Lotfy ML (2018) Bacteriological Profile of Chicken Meat Products. Sci Fed Food & Dairy Technology Journal 1(3): 83-90.

117. Cegielka A, Hac-Szymanczuk E, Piwowarek K, Dasiewicz K, Slowinski M, et al. (2019) The use of bioactive properties of sage preparations to improve the storage stability of low-pressure mechanically separated meat from chickens. Poult Sci 98(10): 5045-5053.

118. Eslamloo K, Falahatkar B, Yokoyama S (2012) Effects of dietary bovine lactoferrin on growth, physiological performance, iron metabolism and non-specific immune responses of Siberian sturgeon Acipenser baeri. Fish Shellfish Immunol 32: 976-985.

119. Shaltout FA, El-Shater MAH, El-Aziz WM (2015) Bacteriological assessment of Street Vended Meat Products sandwiches in kalyobia Governorate. Benha veterinary medical journal 28(2): 58-66.

120. El-Saadony MT, El-Hack ME, Swelum AA, Al-Sultan SI, El-Ghareeb WR, et al. (2021) Enhancing quality and safety of raw buffalo meat using the bioactive peptides of pea and red kidney bean under refrigeration conditions. Ital J Anim Sci 20: 762-776.

121. Shaltout FA, El shatter MA, Fahim HM (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.

122. Heymich ML, Srirangan S, Pischetsrieder M (2021) Stability and activity of the antimicrobial peptide Leg1 in solution and on meat and its optimized generation from chickpea storage protein. Foods 10(6): 1192.

123. Shaltout FA, Zakaria IM, Nabil ME (2017) Incidence of Some Anaerobic Bacteria Isolated from Chicken Meat Products with Special Reference to *Clostridium perfringens*. Nutrition and Food Toxicology 33(2): 429-438.

124. Khaleque MA, Keya CA, Hasan KN, Hoque MM, Inatsu Y, et al. (2016) Use of cloves and cinnamon essential oil to inactivate Listeria monocytogenes in ground beef at freezing and refrigeration temperatures. LWT 74: 219-223.

125. Shaltout FA, Maarouf AAA, Elkhouly MES (2017) Bacteriological Evaluation of Frozen Sausage. Nutrition and Food Toxicology 1(5): 174-185.

126. Stojanovic-Radic Z, Pejcic M, Jokovic N, Jokanovic M, Ivic M, et al. (2018) Inhibition of Salmonella Enteritidis growth and storage stability in chicken meat treated with basil and rosemary essential oils alone or in combination. Food Control 90: 332-343.

127. Shaltout FA, El-Toukhy EI, 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.

128. Moura-Alves M, Gouveia AR, Almeida JMMM, Monteiro-Silva F, Silva JA, et al. (2020) Behavior of Listeria monocytogenes in beef Sous vide cooking with Salvia officinalis L. essential oil, during storage at different temperatures. LWT 132: 109896.

129. Shaltout FA, Ali AM, Rashad SM (2016) Bacterial

Contamination of Fast Foods. Benha Journal of Applied Sciences (BJAS) 1(2): 45-51.

130. Yu HH, Kim YJ, Park YJ, Shin DM, Choi YS, et al. (2020) Application of mixed natural preservatives to improve the quality of vacuum skin packaged beef during refrigerated storage. Meat Sci 169: 108219.

131. Shaltout FA, Zakaria IM, Eltanani J, Elmelegy A (2015) Microbiological status of meat and chicken received to University student hostel. Benha veterinary medical journal 29(2): 187-192.

132. Selmi S, Rtibi K, Grami D, Sebai H, Marzouki L (2017) Rosemary (*Rosmarinus officinalis*) essential oil components exhibit anti-hyperglycemic, anti-hyperlipidemic and antioxidant effects in experimental diabetes. Pathophysiology 24(4): 297-303.

133. Saad SM, Edris AM, Shaltout FA, Shimaa E (2012) Isolation and identification of salmonellae and E.coli from meat and poultry cuts by using a multiplex PCR. Benha Vet Med J 16.

134. Arshad MS, Amjad Z, Yasin M, Saeed F, Imran A, et al. (2019) Quality and stability evaluation of chicken meat treated with gamma irradiation and turmeric powder. Int J Food Prop 22(1): 154-172.

135. Saad SM, Shaltout FA (1998) Mycological Evaluation of camel carcasses at Kalyobia Abattoirs. Vet Med J Giza 46(3): 223-229.

136. Smaoui S, Hlima HB, Braiek OB, Ennouri K, Mellouli L, et al. (2021) Recent advancements in encapsulation of bioactive compounds as a promising technique for meat preservation. Meat Sci 181: 108585.

137. Saad SM, Shaltout FA, Elroos NAA, El-nahas SB (2019) Antimicrobial Effect of Some Essential Oils on Some Pathogenic Bacteria in Minced Meat. J Food Sci Nutr Res 2(1): 012-020.

138. Beya MM, Netzel ME, Sultanbawa Y, Smyth H, Hoffman LC (2021) Plant-based phenolic molecules as natural preservatives in comminuted meats: A review. Antioxidants 10(2): 263.

139. Saad SM, Hassanin FS, Shaltout, FA, Nassif MZ, Seif MZ (2019) Prevalence of Methicillin-Resistant *Staphylococcus aureus* in Some Ready-to-Eat Meat Products. American Journal of Biomedical Science & Research 4(6): 461-465.

140. Radunz M, Camargo TM, Nunes CFP, Magro JD, Filho PJS, et al. (2020) Antimicrobial potential of spray drying encapsulated thyme (*Thymus vulgaris*) essential oil on the conservation of hamburger-like meat products. Int. J. Food Microbiol 330: 108696.

141. Saad SM, Shaltout FA, Nahla AAE, Saber BE (2019) Incidence of Staphylococci and E. coli in Meat and Some Meat Products. EC Nutrition 14: 6.

142. Zamuz S, Lopez-Pedrouso M, Barba FJ, Lorenzo JM, Dominguez H, et al. (2018) Application of hull, bur and leaf chestnut extracts on the shelf-life of beef patties stored under MAP: Evaluation of their impact on physicochemical properties, lipid oxidation, antioxidant, and antimicrobial potential. Food Res Int 112: 263-273.

143. Shaltout FA, Riad EM, Ahmed TES, 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.

144. Kiprotich S, Mendonca A, Dickson J, Shaw A, Thomas-Popo E, et al. (2020) Thyme oil enhances the inactivation of Salmonella enterica on raw chicken breast meat during marination in lemon juice with added Yucca schidigera extract. Front Nutr 7: 619023.

145. Shaltout FA, Maarouf AAA, Elkhouly MES (2017) Bacteriological Evaluation of Frozen Sausage. Nutrition and Food Toxicology 1(5): 174-185.

146. Lourenço T, Mendonça E, Nalevaiko P, Melo R, Silva P, et al. (2013) Antimicrobial effect of turmeric (*Curcuma longa*) on chicken breast meat contamination. Braz J Poult Sci 15(2): 79-82.

147. Shaltout FA, Zakaria IM, 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): 429-438.

148. Lee NK, Jung BS, Na DS, Yu HH, Kim JS, et al. (2016) The impact of antimicrobial effect of chestnut inner shell extracts against Campylobacter jejuni in chicken meat. LWT 65: 746-750.

149. Shaltout FA, Hassan MA, Fatin SH (2004) Thermal Inactivation of Enterohaemorrhagic Escherichia Coli O157:H7 and Its Senstivity To Nisin and Lactic Acid Cultures. 1rst Ann Confr FVM Moshtohor 1: 336-344.

150. Hulankova R, Borilova G, Steinhauserova I (2013) Combined antimicrobial effect of oregano essential oil and caprylic acid in minced beef. Meat Sci 95(2): 190-194.

151. Shaltout FA, El-diasty EM, Elmesalamy M, Elshaer M

(2014) Study on fungal contamination of some chicken meat products with special reference to 2 the use of PCR for its identification. Veterinary Medical Journal-Giza 60: 1-10.

152. Hernandez H, Frankova A, Sykora T, Kloucek P, Kourimska L, et al. (2017) The effect of oregano essential oil on microbial load and sensory attributes of dried meat. J Sci Food Agric 97(1): 82-87.

153. Shaltout FA (2002) Microbiological Aspects of Semi-cooked chicken Meat Products. Benha Veterinary Medical Journal 13(2): 15-26.

154. Shange N, Makasi T, Gouws , Hoffman LC (2019) Preservation of previously frozen black wildebeest meat (Connochaetes gnou) using oregano (Oreganum vulgare) essential oil. Meat Sci 148: 88-95.

155. Shaltout FA, Thabet, MG, Hanan A Koura (2017) Impact of some essential oils on the quality aspect and shelf life of meat. Benha Veterinary Medical Journal 33(2): 351-364.

156. Lages LZ, Radünz M, Gonçalves BT, Silva DRR, Fouchy MV, et al. (2021) Microbiological and sensory evaluation of meat sausage using thyme (Thymus vulgaris, L.) essential oil and powdered beet juice (Beta vulgaris L., Early Wonder cultivar). LWT 148: 111794.

157. Shaltout FA, Farouk M, Ibrahim HAA, Afifi MEM (2017) Incidence of Coliform and Staphylococcus aureus in ready to eat fast foods. Benha Veterinary Medical Journal 32(1): 13-17.

158. De Oliveira TLC, De ASRD, Ramos EM, Gracas CMD, et al. (2011) Antimicrobial activity of Satureja montana L. essential oil against Clostridium perfringens type A inoculated in mortadella-type sausages formulated with different levels of sodium nitrite. International Journal of Food Microbiology 144(3): 546-555.

159. Shaltout FA, Zakaria IM, Nabil ME (2017) Detection and typing of Clostridium perfringens in some retail chicken meat products. Benha Veterinary Medical Journal 33(2): 283-291.

160. Zhu Y, Li C, Cui H, Lin L (2020) Encapsulation strategies to enhance the antibacterial properties of essential oils in food system. Food Control 123: 107856.

161. Shaltout FA (1992) Studies on Mycotoxins in Meat and Meat by Products. MVSc Thesis Faculty of Veterinary Medicine, Moshtohor, Zagazig University Benha.

162. Juneja VK, Fan X, Peña RA, Diaz CM, Pacheco AR (2006) The effect of grapefruit extract and temperature abuse on growth of Clostridium perfringens from spore inocula in marinated, sous-vide chicken products. Innov. Food Sci Emerg Technol 7(1-2): 100-106.

163. Shaltout FA (1996) Mycological And Mycotoxicological profile Of Some Meat products. Ph.D.Thesis, Faculty of Veterinary Medicine, Moshtohor, Zagazig University Benha branch.

164. Maes C, Bouquillon S, Fauconnier ML (2019) Encapsulation of essential oils for the development of biosourced pesticides with controlled release: A review. Molecules 24(14): 2539.

165. Shaltout FA (1998) Proteolytic Psychrotrophes in Some Meat products. Alex Vet Med J14(2): 97-107.

166. Ben FY, Cingolani MC, Li L, Chazot G, Salmieri S, et al. (2021) Effect of γ-irradiation and the use of combined treatments with edible bioactive coating on carrot preservation. Food Packaging and Shelf Life 28(100635): 1-9.

167. Shaltout FA (1999) Anaerobic Bacteria in Vacuum Packed Meat Products. Benha Vet Med J 10(1): 1-10.

168. Soyer F, Keman D, Eroglu E, Ture H (2020) Synergistic antimicrobial effects of activated lactoferrin and rosemary extract in vitro and potential application in meat storage. J Food Sci Technol 57(12): 4395-4403.

169. Shaltout FA (2000) Protozoal Foodborne Pathogens in some Meat Products. Assiut Veterinary Medical Journal 42(84): 54-59.

170. Kahraman T, Issa G, Bingol EB, Kahraman BB, Dumen E (2015) Effect of rosemary essential oil and modified-atmosphere packaging (MAP) on meat quality and survival of pathogens in poultry fillets. Braz J Microbiol 46(2): 591-599.

171. Shaltout FA (2001) Quality evaluation of sheep carcasses slaughtered at Kalyobia abattoirs. Assiut Veterinary Medical Journal 46(91): 150-159.

172. Motavaf F, Mirvaghefi A, Farahmand H, Hosseini SV (2021) Effect of Zataria multiflora essential oil and potassium sorbate on inoculated Listeria monocytogenes, microbial and chemical quality of raw trout fillet during refrigerator storage. Food Sci Nutr 9(6): 3015-3025.

173. Shaltout FA (2002) Microbiological Aspects of Semi-cooked Chicken Meat Products. Benha Vet Med J 13(2): 15-26.

174. Sojic B, Pavlic B, Ikonic P, Tomovic V, Ikonic B, et al. (2019) Coriander essential oil as natural food additive improves quality and safety of cooked pork sausages

with different nitrite levels. Meat Science 157: 107879.

175. Shaltout FA (2003) Yersinia Enterocolitica in some meat products and fish marketed at Benha city.The Third international conference Mansoura 29-30 April.

176. Asioli D, Aschemann-Witzel J, Caputo V, Vecchio R, Annunziata A, et al. (2017) Making sense of the clean label trends: A review of consumer food choice behavior and discussion of industry implications. Food Res Int 99(1): 58-71.

177. Shaltout FA (2020) Microbiological quality of chicken carcasses at modern Poultry plant. J Nutrition and Food Processing 3(1): 1-6.

178. Coutinho DOTL, Malfitano DCS, De ASR, Andrade MA, Cardoso MDG, et al. (2012) Antioxidant effects of Satureja montana L. essential oil on TBARS and color of mortadella-type sausages formulated with different levels of sodium nitrite. LWT 45(2): 204-212.

179. Shaltout FA, Abdel AAM (2004) Salmonella enterica Serovar Enteritidis in Poultry Meat and their Epidemiology. Veterinary Medical Journal Giza 52(3): 429-436.

180. (1999) High-Dose Irradiation: Wholesomeness of Food Irradiatied with Doses above 10 kGy. Report of a Joint FAO/IAEA/WHO Study Group. World Health Organization,Switzerland.

181. Shaltout FA, Abdel AAM (2004) Escherichia Coli Strains In Slaughtered Animals And Their Public Health Importence. J Egypt Vet Med Association 64(2): 7-21.

182. Abdeldaiem M (2014) Using of combined treatment between edible coatings containing ethanolic extract of papaya (*carica papaya L.)* leaves and gamma irradiation for extending shelf-life of minced chicken meat. Am J Food Technol 2(1): 6-16.

183. Shaltout FA, Amin R, Marionet Z, Nassif, Shimaa, et al. (2014) Detection of aflatoxins in some meat products. Benha veterinary medical journal 27(2): 368-374.

184. Akhter R, Masoodi F, Wani TA, Rather SA, Hussain PR (2021) Synergistic effect of low dose γ-irradiation, natural antimicrobial and antioxidant agents on quality of meat emulsions. Radiat Phys Chem 189: 109724.

185. Shaltout FA, Afify, Jehan R, EM, Abo E, et al. (2012) Improvement of microbiological status of oriental sausage. Journal of Egyptian Veterinary Medical Association 72(2): 157-167.

186. (2009) European Commission EU Guidance to the Commission Regulation (EC) No 450/2009 of 29 May 2009 on Active and Intelligent Materials and Articles Intended to Come into the Contact with Food.

187. Shaltout FA, Daoud JR (1996) Chemical analytical studies on rabbit meat and liver. Benha Vet Med J 8(2): 17-27.

188. Ming Y, Chen L, Khan A, Wang H, Wang C (2020) Effects of tea polyphenols on physicochemical and antioxidative properties of whey protein coating. Food Sci Biotechnol 29: 1655-1663.

189. Shaltout FA, Edris AM (1999) Contamination of shawerma with pathogenic yeasts. Assiut Veterinary Medical Journal 40(64): 34-39.

190. Balasubramaniam V, Martinez MSI, Gupta R (2015) Principles and application of high pressure–based technologies in the food industry. Annu Rev Food Sci 6: 435-462.

191. Shaltout FA, Eldiasty E, Mohamed MS (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, Egypt, pp: 79-89.

192. Chuang S, Sheen S (2021) High pressure processing of raw meat with essential oils-microbial survival, meat quality, and models: A review. Food Control 132: 108529.

193. Shaltout FA, Eldiasty E, Salem R, Hassan A (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.

194. Pedreschi F, Mariotti CMS (2020) Genetically Modified and Irradiated Food. Academic Press; Cambridge, MA, USA: 2020. Irradiation kills microbes: Can it do anything harmful to the food?, pp: 233-242.

195. Shaltout FA, Salem REE, Diab F (2016) Mycological evaluation of some ready to eat meat products with special reference to molecular chacterization. Veterinary Medical Journal-Giza 62(3): 9-14.

196. (2021) Global Newswire The Clean Label Ingredient Market–Growth, Trends, and Forecast (2018–2023). Eastern Standard Time, Business Wire.

197. Shaltout FA, Elshater M, Wafaa, Abdelaziz (2015) Bacteriological assessment of street vended meat products sandwiches in Kalyobia Governorate . Benha Vet Med J 28(2): 58-66.

198. Luong NDM, Coroller L, Zagorec M, Membré JM, Guillou S (2020) Spoilage of chilled fresh meat products

during storage: A quantitative analysis of literature data. Microorganisms 8(8): 1198.

199. Shaltout FA, Gerges MT, Shewail AA (2018) Impact of Organic Acids and Their Salts on Microbial Quality and Shelf Life of Beef. Assiut veterinary medical journal 64(159): 164-177.

200. Martillanes S, Rocha PJ, Llera OJ, Gil MV, Ayuso YMC, et al. (2021) Control of Listeria monocytogenes in sliced dry-cured Iberian ham by high pressure processing in combination with an eco-friendly packaging based on chitosan, nisin and phytochemicals from rice bran. Food Control 124: 107933.

201. Shaltout FA, Ghoneim AM, Essmail ME, Yousseif A (2001) Studies on aflatoxin B1 residues in rabbits and their pathological effects. J Egypt Vet Med Association 61(2): 85-103.

202. Lee JS, Choi YS, Lee HG (2020) Synergistic antimicrobial properties of nanoencapsulated clove oil and thymol against oral bacteria. Food Sci Biotechnol 29: 1597-1604.

203. Shaltout FA, Hanan MT, El L (2003) Heavy Metal Residues In Shawerma. Beni Suef Vet Med J 13(1): 213-224.

204. Park S, Mun S, Kim YR (2020) Influences of added surfactants on the water solubility and antibacterial activity of rosemary extract. Food Sci Biotechnol 29(10): 1373-1380.

205. Shaltout FA, Hashim MF (2002) Histamine in salted, Smoked and Canned Fish products. Benha Vet Med J 13(1): 1-11.

206. Fang Z, Zhao Y, Warner RD, Johnson SK (2017) Active and intelligent packaging in meat industry. Trends Food Sci Technol 61: 60-71.

207. Shaltout FA, Hashim MF, 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 .

208. Yong HI, Kim TK, Choi HD, Jang HW, Jung S, et al. (2021) Clean label meat technology: Pre-converted nitrite as a natural curing. Food Sci Anim Resour 41: 173-184.

209. Shaltout FA, Ibrahim HM (1997) Quality evaluation of luncheon and Alexandrian sausage. Benha Vet Med J 10(1): 1-10.

210. Barcenilla C, Ducic M, López M, Prieto M, Álvarez OA (2021) Application of lactic acid bacteria for the biopreservation of meat products: A systematic review. Meat Sci 183: 108661.

211. Shaltout FA, Nassif M, Shakran A (2014) Quality of battered and breaded chicken meat products. Global Journal of Agriculture and Food Safety Science 1(2): 2356-7775.

212. Crowe W, Elliott CT, Green BD (2019) A review of the in vivo evidence investigating the role of nitrite exposure from processed meat consumption in the development of colorectal cancer. Nutrients 11(11): 2673.

213. Shaltout FA, Amani MS, Mahmoud KAHA (2013) Bacterial aspect of cooked meat and offal at street vendors level. Benha veterinary medical journal 24(1): 320-328.

214. Choe E (2020) Roles and action mechanisms of herbs added to the emulsion on its lipid oxidation. Food Sci. Biotechnol 29(9): 1165-1179.

215. Shaltout FA, Salem RM (2000) Moulds, aflatoxin B1 and Ochratoxin A in Frozen Livers and meat products Vet Med J Giza 48(3): 341-346.

216. Marrone R, Smaldone G, Ambrosio RL, Festa R, Ceruso M, et al. (2021) Effect of beetroot (Beta vulgaris) extract on black angus burgers shelf life. Ital J Food Saf 10(1): 9031.

217. Yasser H, Al T, Al ZA, Shaltout FA, Abdel SH (2002) Microbiological status of raw cow milk marketed in northern Jordan. AVMJ 49(96): 180-194.

218. Lee NK, Paik HD (2016) Status, Antimicrobial mechanism, and regulation of natural preservatives in livestock food systems. Korean J Food Sci Anim Resour 36(4): 547-557.

219. Shaltout FA, Zakaria IM, 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.

220. Olszewska MA, Gędas A, Simões M (2020) Antimicrobial polyphenol-rich extracts: Applications and limitations in the food industry. Food Res Int 134: 109214.

221. Shaltout FA, El D, Mohamed MS (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, pp: 79-89.

222. Chaleshtori FS, Arian A, Chaleshtori RS (2018)

Assessment of sodium benzoate and potassium sorbate preservatives in some products in Kashan, Iran with estimation of human health risk. Food Chem Toxicol 120: 634-638.

223. Shaltout FA, El D, Salem RM, Asmaa MA, 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.

224. International Agency for Research on Cancer (IARC) (2010) monographs on the evaluation of carcinogenic risks to humans Ingested nitrate and nitrite, and cyanobacterial peptide toxins. IARC Monogr Eval Carcinog Risks Hum 94(5-7): 1-412.

225. Shaltout FA, Salem RM, El D, Hassan WIM (2019) Effect of Lemon Fruits and Turmeric Extracts on Fungal Pathogens in Refrigerated Chicken Fillet Meat. Global Veterinaria 21(3): 156-160.

226. Cao Q, Yan J, Sun Z, Gong L, Wu H, et al. (2021) Simultaneous optimization of ultrasound-assisted extraction for total flavonoid content and antioxidant activity of the tender stem of Triarrhena lutarioriparia using response surface methodology. Food Sci Biotechnol 30(1): 37-45.

227. Shaltout FA, El Dem, Elmesalamy M, Elshaer M (2014) Study on fungal contamination of some chicken meat products with special reference to 2 the use of PCR for its identification. Veterinary Medical Journal-Giza 60(2): 1-22.

228. Piper JD, Piper PW (2017) Benzoate and sorbate salts: A systematic review of the potential hazards of these invaluable preservatives and the expanding spectrum of clinical uses for sodium benzoate. Compr Rev Food Sci Food Saf 16(5): 868-880.

229. Shaltout FA, Salem RM, El D, Eman, Fatema AH D (2016) Mycological evaluation of some ready to eat meat products with special reference to molecular characterization. Veterinary Medical Journal- Giza 62(3): 9-14.

230. Shim SM, Seo SH, Lee Y, Moon GI, Kim MS, et al. (2011) Consumers' knowledge and safety perceptions of food additives: Evaluation on the effectiveness of transmitting information on preservatives. Food Control 22(7): 1054-1060.

231. Shaltout FA, Ahmed AAM, Eman MK A (2018) Heavy Metal Residues in chicken cuts up and processed chicken meat products. Benha Veterinary Medical Journal 34(1): 473-483.

232. Ministry of Food and Drug Safety (MFDS) (2021) Food Additives Code.

233. Shaltout FA, Hanan M, Lamada, Ehsan AME (2020) Bacteriological examination of some ready to eat meat and chicken meals. Biomed J Sci & Tech Res 27(1): 20461-20465.

234. Matthews KR, Kniel KE, Montville TJ (2017) Food Microbiology: An Introduction. 4th (Edn.), ASM Press, USA.

235. Sobhy, Asmaa, Shaltout F (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(2): 88-92.

236. Bohrer BM (2017) Nutrient density and nutritional value of meat products and non-meat foods high in protein. Trends Food Sci Technol 65: 103-112.

237. Sobhy, Asmaa, Shaltout F (2020) Detection of food poisoning bacteria in some semi-cooked chicken meat products marketed at Qaliubiya governorate. Benha Veterinary Medical Journal 38(2): 93-96.

238. Zhou G, Xu X, Liu Y (2010) Preservation technologies for fresh meat-A review. Meat Sci 86: 119-128.

239. Shaltout FA (2024) Abattoir And Bovine Tuberculosis as A Reemerging Foodborne Diseas. Clinical Medical Reviews and Report 6(1): 1-7.

240. World Health Organization (2015) WHO Estimates of the Global Burden of Foodborne Diseases: Foodborne Disease Burden Epidemiology Reference Group 2007-2015. World Health Organization (WHO), Switzerland, pp: 1-15.

241. Shaltout FA (2023) Viruses in Beef, Mutton, Chevon, Venison, Fish and Poultry Meat Products. Food Science & Nutrition Technology 8(4): 1-10.

242. Lee H, Yoon Y (2021) Etiological agents implicated in foodborne illness worldwide. Food Sci Anim Resour 41(1): 1-7.

243. Farnaud S, Evans RW, Lactoferrin (2003) A multifunctional protein with antimicrobial properties. Mol Immunol 40(7): 395-405.