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Review Article

Exploring the Efficacy of Naturally Occurring Ingredients in Advanced Meat Processing and Preservation Techniques

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Abstract

Meat and animal products have long been recognized as essential sources of vital nutrients for human consumption. However, the inherent nutrient-rich environment of these products also creates a conducive breeding ground for microbial growth, leading to concerns about food safety and spoilage. To combat the issue of microbial contamination, synthetic preservatives, such as nitrites, nitrates, and sorbates, have been extensively employed in the food industry due to their cost-effectiveness and potent antibacterial properties. Nevertheless, recent consumer awareness and apprehensions about potential adverse health effects associated with the use of synthetic chemical preservatives have driven a shift in perspectives. As a result, there has been a growing interest in exploring alternative approaches, leading to an increased demand for natural ingredients as food preservatives. This scientific article delves into the utilization of naturally occurring ingredients as a promising solution to address microbial challenges in livestock meals. Through a comprehensive exploration of plant-based, animal-derived, and microorganism-based ingredients, researchers have sought to develop innovative and sustainable methods for food processing and preservation. In-depth analyses of various natural ingredients have revealed their potential as viable alternatives to synthetic preservatives. Phenolic compounds found in herbs and spices, for instance, exhibit remarkable antioxidant and antimicrobial effects. Furthermore, enzymes and bacteriocins derived from microorganisms have demonstrated efficacy in inhibiting pathogenic bacteria, enhancing food safety. Moreover, this article investigates the feasibility and scalability of integrating natural preservatives into industrial food processing practices. Challenges related to stability, dosage, and regulatory approvals are discussed, along with ongoing research efforts to overcome these hurdles. As food manufacturers and regulatory bodies increasingly recognize the importance of sustainable and health-conscious food preservation methods, the demand for natural ingredients continues to surge. This article aims to foster awareness and understanding of the potential of natural preservatives, encouraging further exploration, and supporting evidence-based decision-making in the food industry. The utilization of naturally occurring ingredients for processing and preservation of meat represents a significant stride towards promoting food safety, health, and consumer confidence. By embracing nature's potential, we can revolutionize the food preservation landscape, paving the way for a sustainable and health-oriented future.

Keywords: Naturally; Ingredients; Meat Processing; Preservation

Introduction

Meat encompasses the edible portions of animal tissues, as well as any processed or manufactured products derived from these tissues. It is commonly categorized based on the type of animal it comes from. Red meat refers to mammalian meat, white meat pertains to fowl meat, seafood includes fish and shellfish, while game encompasses meat from non-domesticated animals. Additionally, specific terms are used to identify meats according to the live animal source, such as beef from cattle, veal from calves, pork from hogs, lamb from young sheep, and mutton from older sheep.

Various meats like chicken, pork, lamb, and beef are all excellent sources of protein. Red meat provides essential nutrients such as iron, zinc, and B vitamins, with vitamin B12 being especially abundant in meat-based diets. Proper food hygiene practices are crucial when handling, storing, preparing, and cooking meat to ensure safety and prevent foodborne illnesses. The meat processing industry consists of four main segments: animal slaughtering, processing meat from carcasses, rendering and meat byproduct processing, and poultry processing. Meat can undergo various processing methods like salting, curing, fermentation, smoking, and the addition of chemical preservatives. These techniques not only enhance taste and flavour but also extend the shelf life of meat products. The addition of different ingredients further improves the sensory attributes of processed meats, making them more appealing to consumers. The processing of meat contributes to its overall nutritive value, rendering it a vital aspect of the meat industry often referred to as "meatpacking." The convenience and ease of handling associated with processed meat products have made them popular choices among consumers. Moreover, these processing methods play a significant role in optimizing the nutritional content of meats and ensuring their long-term preservation.

The principles of meat preservation are mainly associated with preventing or delaying microbial spoilage and chemical action and avoiding as far as possible weight loss and many change in taste or texture. A vast number of infections are brought on by food-borne pathogens, such as Listeria monocytogenes, Staphylococcus aureus, pathogenic Escherichia coli, Clostridium perfringens, Campylobacter spp., and Vibrio spp., which also inflict significant harm to human health and the economy. The World Health Organisation (WHO) estimates that each year, food-borne pathogens, chemicals, and allergens cause 600 million cases of illness and 400 000 deaths worldwide. Additionally, 56 million people die and 7.7% of the world's population is thought to be affected by food-borne diseases.

Figure a

An increased risk of food contamination due to pathogenic microbes, chemical residues, toxic food additives, and toxins has resulted from the global advancement of the food business. To preserve food safety, it is important to limit the growth of harmful microbes and rotting organisms. Accordingly, chemical methods, such as the use of preservatives, physical methods, like heat treatment, drying, freezing, and packaging, and biological methods using microorganisms that have an antagonistic effect on the pathogenic bacteria and produce bacteriocins are all used to preserve food and increase shelf life. One popular method of food protection is the inclusion of food preservatives that prevent the growth of germs.

Synthetic preservatives are advantageous for processing meat since they are inexpensive, guaranteed to have an antibacterial action or to extend shelf life, and have little impact on taste, flavour, colour, or texture. Consumers often don't prefer synthetic preservatives as much as natural ones due to a variety of health issues with their potential negative effects. Sorbic acid, benzoic acid, and their salts have been shown to encourage the production of mutagenic and carcinogenic substances. Nitrites and nitrates, which are used to preserve and colour meat, have been linked to many cancers, including bladder cancer, colon cancer, and leukaemia. As substitutes for synthetic preservatives, natural preservatives have begun to take hold.

Customers support the use of natural preservatives in place of synthetic ones because it has several advantages. Nevertheless, food manufacturers also face difficulties, such as a decline in price competitiveness brought on by the relatively high cost of natural preservatives and a reduction in the antibacterial action of food components including carbohydrates, proteins, and lipids. The influence of the country of origin, the soil, and the harvest seasons makes standardisation difficult in the case of compounds derived from plants. Several plant-derived chemicals found in extracts and essential oils have also undergone toxicity investigation or exact compound identification. In order to address these issues, numerous studies have been carried out to enhance the extraction process, mix additional antimicrobial compounds, use active packaging, and encapsulate antibacterial substances to enhance their effectiveness.

Processing of meat

Processed meat products are those in which the qualities of fresh meat have been altered by one or more techniques such as grinding, seasoning addition, colour change, or heat treatment. It includes smoking curing and any treatment or technique that results in a significant change in the natural state of the meat, but excludes boning, cutting, cleaning, and trimming. There is an unavoidable link between meat processing and preservation. This is because some processing methods produce products with a long shelf life, such as salted and smoked meat, which is prepared for flavour and also preserved by the presence of sale, smoke, and heat treatment. On the other hand, raw, spiced beef sausage goes through processing without being preserved.

Principles of meat processing

Protein, salt, water, smoke, heat, and other substances interact during processing. A salt solution with a concentration of 2 to 10% ensures protein extraction, prevents bacterial development, and has a pleasant flavour at lower concentrations. Water retention is ensured by the final product's inclusion of 0.5% polyphosphate.

Heating a gel to remove the protein from the meat. To create a consistent product, this gel encapsulates fat and other non-meat additions or fillers. All lean meat products have a potential for developing a dry, leathery feel that is modified by fat in processed goods. Fat in processed products must be released by causing cell damage by grinding or blending. In addition to adding acids such "aldehydes and phenols as preservatives, hot smoke provides heat for dehydrating meat. Additionally, it gives the goods a tint and flavour of smoke. If nitrite is applied, it contributes to the formation of the colour pink. Ascorbates are used to accelerate the nitrite reaction and stabilise the hue.

Methods of preservation of meat

Curing

Curing is the process of adding salt, flavours, and colour-fixing agents to meat in order to give the finished products certain qualities. How ever, a high salt concentration causes myoglobin to oxidise, giving the meat an unappealing greyish or greyish-brown colour. The traditional goal of curing was to preserve the meat with a very high concentration of salt. In order to get a vivid reddish-pink hue, colour-fixing agents like sodium nitrite and potassium or sodium nitrate were used.

Heat treatment or cooking

High temperatures cause the structural and chemical changes in lipids and carbohydrates, which make the meat more flavourful and tender. They also cause the coagulation and denaturation of meat proteins. After the animal is killed, the flesh is chopped, and the first processing steps are taken, the number of microorganisms steadily rises. Heat treatment is crucial for microbial control since it can minimise or completely get rid of contaminating bacteria. There are two types of heat treatment, which are: Pasteurization (or cooking): Heat treatment at temperatures below 100^{o}C, mostly between 60-85^{o}C. Sterilization: Heat treatment at temperatures above 100^{o}C.

Drying

Lowering the water activity in meat and meat products is known as drying. The amount of unbound, free water that is available for microbial growth is measured as water activity. When the amount of free water available is less than what is needed for a particular species to grow, the growth of microorganisms is prevented. Meat drying may be carried out to preserve or lengthen the storage life (shelf life), or it may simply be one of the processes involved in the creation of particular meat products. One process where drying plays a significant role is the production of fermented meat products. These materials are typically dried in climate-controlled rooms with adjustable humidity and temperature. Ovens could be used for drying at temperatures between 70 ^{o}C and 80 ^{o}C.

Smoking

Smoking, also known as pyrolysis, is the process of allowing smoke produced from natural woods to contact the surface of meat or meat products. More than 1000 chemicals are produced from smoke by additional processes such condensation, polymerization, and oxidation in addition to breakdown. Phenols, aldehydes, organic acids, carbonyls, hydrocarbons, and alcohols are the most significant of these substances.

Fermentation

Fermentation is a simple, low-tech, and low-cost method of food preservation that can be done at room temperature. Fermentation is a chemical transformation that occurs in an organic substrate due to the activity of enzymes released by microbes. microbes produce lactic acid, volatile acids (such as acetic acid), antibiotics, and bacteriocins during fermentation, which prevent the growth of unwanted microbes and provide a preservation effect in foods. Lactic acid bacteria (LAB), moulds, and yeasts are the microorganisms responsible for fermentation. LAB are one of the key types of bacteria responsible for the fermentation of meat and meat products, as well as the production of silage from fish, poultry, and animals' offal. The generation of lactic acid during fermentation distinguishes Lactic acid bacteria.

Natural preservatives used in meat

Natural preservatives are produced in a range of formulas, including powder and liquid forms such as essential oils. Natural preservatives are added directly to meat products to increase shelf life by suppressing bacterial growth. Furthermore, natural preservatives' antibacterial impact can be enhanced by combining them with other food processing procedures.

Salt is a natural preservative that has been used to preserve food for ages. It works by absorbing moisture, preventing the growth of bacteria and mould. However, excessive salt might make your meal taste overly salty, which is unhealthy for your body. Salt curing is an old way of preserving meats like bacon, ham, and salami. Meat is rubbed with a mixture of salt, sugar, and other spices before being left to cure for several days or weeks in a controlled atmosphere. Pickling with salt, also known as fermentation pickling, is a way of preserving vegetables like cucumbers, onions, and radishes in a brine of salt and water for several days or weeks.

Sugar is also a natural preservative since it inhibits the growth of bacteria and mould. It can be combined with salt to preserve food. But, once again, moderation is key; too much sugar can make your food excessively sweet, which is unhealthy for your body.

Vinegar's acidity makes it an excellent natural preservative. To add diverse flavours to your dish, experiment with different vinegars such as apple cider vinegar, red wine vinegar, and balsamic vinegar.

Lemon juice can be marinated with meats including chicken, fish, and shellfish. The acidity of the lemon juice helps to tenderise and eliminate moisture from the meats, allowing them to be stored for several days.

Garlic has inherent antibacterial qualities that can suppress the growth of germs and mould, making it an excellent food preservation component. Garlic can be added to meat and fish marinades to help preserve and flavour them. It can be added to dry rubs for meat to help preserve it while also adding flavour.

Plant extracts such as rosemary, chestnut, sage, cranberry, oregano, grape seed, and others have been used to preserve meat. Many studies have been undertaken to apply plant-derived chemicals to meat products in the form of essential oil since essential oil has a better antibacterial impact than extract. However, because to its specific organoleptic features, it is difficult to apply large volumes of essential oil to food. Recent research has attempted to address this issue by combining essential oils with other antimicrobial compounds. This use has the advantage of reducing the amount of essential oils with strong flavours while increasing antioxidant and antibacterial effects through synergistic actions. If synthetic preservatives cannot be completely replaced with natural preservatives due to industrial issues such as rising economic costs or the complexity of the product manufacturing process, they could be gradually replaced by composing a mixed formulation of synthetic and natural preservatives.

Natural preservatives from plants

Polyphenols, phenolics, and flavonoids are all involved in the antibacterial activity of plant-derived natural preservatives. Plant-derived polyphenols are classified and structured in the following ways: phenolic acids (caffeic acid, rosmarinic acid, gallic acid, ellagic acid, cinnamic acid), flavones (luteolin, apigenin, chrysoeriol), flavanols (catechin, epicatechin, epigallocatechin, gallocatechin, and their gallate derivatives), flavanones (hesperidin, hesperetin, heridictyol, naringenin), flavonols (quercetin, kaempferol, myricetin), isoflavones (geinstein, daidzin, formononetin), coumarins (coumarin, warfarin, 7-hydroxycourmarin), anthocyanins (pelagonidin, delphinidin, cyanidin, malvidin), quinones (naphthoquinones, hypericin), alkaloids (caffeine, berberine, harmane), and terpenoids (menthol, thymol, lycopene, capsaicin, linalool).

Rosemary

Rosemary (*Rosmarinus officinalis* L.), a perennial herb, has woody, fragrant, and needle-like leaves that are always green. In food, rosemary has been used as a spice and flavouring. 1,8-Cineole made up the majority of the mixture (35.32%). Camphor, -pinene, trans-caryophyllene, -thujone, and borneol were other important substances. Previous studies show that [1] rosemary ethanol extracts have an antibacterial impact *on L. monocytogenes* in beef. A 2log colony-forming unit (CFU)/g reduction in *L. monocytogenes* was seen in the incubation at 4 °C for 9 days after the application of 45% rosemary ethanol extract to beef. The influence of rosemary essential oil on Salmonella Enteritidis inhibition and spoiling preventive effects on chicken flesh at 4 and 18 °C was examined. At 18 °C for 24 hours, rosemary essential oil at a concentration of 5 mg/mL caused a decrease in coliform, aerobic bacteria, lactic acid bacteria, and anaerobic bacteria.

SAGE

Since ancient times, sage (*Salvia officinalis* L.), a member of the Lamiaceae family, has been utilised for its flavour, taste, medicinal, and preservation characteristics. It is well known that sage contains significant levels of benzoic acid, p-coumaric acid, and rosemary acid. Camphor, carvacrol, R (+) limonene, and linalool, which are all of its essential oils, make up the majority of its content [2]. For low-pressure mechanically separated meat (MSM) in vacuum packing kept at 18 °C for 9 months, the bactericidal effects of several sage preparations were evaluated. All types of microbes (Enterobacteriaceae, coliforms, mesophilic aerobic bacteria, psychotropic bacteria, and enterococci) were unable to develop when MSM from hens was combined with sage extracts. The 0.1% sage essential oil-treated groups demonstrated the strongest antibacterial activity.

Thyme

One typical herb used with meat and meat products is thyme (*Thymus vulgaris*). The addition of thyme to meat products can improve its sensory, antimicrobial, antioxidant, and shelf-life extending qualities. Thymol and O-cymene were found to make up 51.1% and 24.1%, respectively, of the thyme oil's primary components. Thyme's antibacterial properties may result from the additive or synergistic interactions of its primary and/or minor constituents. Thymol can alter the permeability of the bacterial cell wall, resulting in cell death, and it works synergistically with other phenolic chemicals including carvacrol, p-cymene, and -terpinene.

When combined with 1% (w/w) powdered beet juice, thyme essential oil inhibited 2.69 log CFU/g of coagulase-positive Staphylococcus and 4.41 log CFU/g of aerobic mesophilic bacteria in pork sausage, respectively. Additionally, the sensory attributes, including odour, flavour, and general acceptability, improved [3].

Chestnut

The woody plant Castanea crenata, which is native to East Asia and includes Korea and Japan, was placed in the Castanea family. One of the most significant Castanea families and a long-standing source of food in European regions is Castanea sativa. Chestnut shells are rich in phenols and tannins that can be hydrolysed. In order to increase the shelf-life of beef patties,[4] looked into the effects of chestnut extracts (*Castanea sativa*) on the leaf, bur, and hull. Only the leaf extract from the chestnut, at a dose of 1000 mg/kg, exhibited any antibacterial activity among the extracts from the bur, hull, and leaf. At 7 days, the levels of Pseudomonas spp. and lactic acid bacteria had decreased by 0.37 log CFU/g and 0.33 log CFU/g, respectively. At a dosage of 2 mg/mL, chestnut inner shell extracts using ethanol demonstrated antibacterial activity against *C.jejuni* in chicken flesh, according to Lee and Jung, Chestnut inner shell ethanol extracts contained 532.96 3.75 mg gallic acid/100g and 12.28 0.03 mg quercetin/100g of polyphenols and flavonoids, respectively.

Turmeric

Traditionally, mostly in South and East Asia, turmeric (*Curcuma longa* L.) has been used to flavour and colour food as well as to heal a variety of illnesses. Turmeric's components, known as curcuminoids, are where the majority of its active ingredients are found. The content of turmeric's curcuminoids (curcumin, demethoxycurcumin, and bis-demethoxycurcumin) varies by roughly 2-9% depending on the environment in which it grows, including the cultivar, soil, and climatic factors. For 48 hours at 4 °C, the antibacterial impact of turmeric on chicken breast flesh was evaluated for *E. coli* and *S. aureus*. No change in S. aureus counts was seen when 1% turmeric powder was applied. Although a 0.2 log CFU/g reduction in E. coli was noted, this was not statistically significant. In a different investigation [5], gamma radiation and turmeric powder were used to enhance the quality and stability of chicken flesh. With 3% turmeric powder, all coliforms and aerobic bacteria were entirely eliminated.

Oregano

Mediterranean cuisine frequently uses the herb oregano (*Origanum vulgare*). The antibacterial and antioxidant properties of oregano essential oil are well known for extending shelf life. Two bioactive polyphenols found in oregano, thymol and carvacrol, are responsible for its antibacterial properties. Thymol, carvacrol, -cymene, -caryophyllene, -terpinene, -humulene, and -pinene were among the components of oregano oil; carvacrol (42.94%) and thymol (17.40%) were the greatest among them. After 3 days, the lactic acid bacteria and total viable counts both exceeded the spoiling limit (7 log CFU/g). Total viable counts and lactic acid bacteria grew 40% faster in the treatment group than they did in the control groups [6]. By releasing volatile components as it dries, oregano essential oil prevents the growth of bacteria. *S. Enteritidis* and *E. coli* were reportedly suppressed by the addition of oregano essential oil, which contains carvacrol (64.5%), p-cymene (5.2%), and thymol (2.9%). A filter sheet was moistened with oregano essential oil and set in front of the dryer's fan to dry. For six hours, the beef samples were dried at 55 °C. As a result, after treatment with 3 mL of oregano essential oil, neither S. Enteritidis nor E. coli were found [7].

Grape seed extract (GSE)

Citrus paradise produces GSE as a byproduct. GSE contains a number of phenolic substances and flavonoids, including procyanidin, naringenin, citric acid, and epicatechin gallate. According to reports, GSE has a broad spectrum of antibacterial, antiparasitic, and antifungal properties. Using commercial GSE (Citricidal®) to protect sous-vide chicken products from *C. perfringens*, Juneja., *et al.* [8], reported bacteriostatic results. Until 9.5 h of storage at 19 °C, C. perfringens cell counts were consistently around 2.5 log CFU/g regardless of treatment or control groups; however, storage of the control and 50 or 100 ppm GSE treated groups at 25 °C for more than 6 h led to fast growth rates of *C. perfringens,* showing 2-3 log CFU/g. Growth of C. perfringens kept at 19 and 25 °C was suppressed by GSE doses of 200 ppm.

Cinnamon

The inner bark of plants in the genus Cinnamomum is used to produce cinnamon, a native plant of Asia. L-borneol, -caryophyllene, caryophyllene oxide, camphor, L-bornyl acetate, -terpineol, -cubebene, -thujene, and terpinolene are only a few of the active ingredients found in cinnamon. Using a chitosan edible coating containing 0.6% cinnamon essential oil over slices of roasted duck stored at 2 2 °C for 21 days, under changed atmospheric packing (30% carbon dioxide (CO_2)/70% nitrogen (N_2), the antibacterial impact and shelf-life extending activity were assessed. After 14 days of storage, the edible coating containing cinnamon essential oil displayed total viable counts that were 1 log CFU/g lower than the control. The outcomes of the Enterobacteriaceae counts were comparable to this. Up until day 7 of storage, there was a decrease in the amount of lactic acid bacteria compared to the control, but there was no discernible difference by day 11. Notably, as a result of microbial diversity sequencing, the growth of Vibrio spp. was inhibited utilising edible coating with cinnamon essential oil during the early time of storage [9].

Natural preservatives derived from animals.

Different animal antibacterial systems are linked to defence responses against outside invaders. Lysozymes, lactoferrin, ovotransferrin, lactoperoxidase, AMPs from farm animals, and polysaccharides are a few of the preservatives obtained from animal sources. Due to its unique capacity to damage bacterial membranes by hydrolyzing the 1,4--linkage between N-acetyl-D-glucosamine and N-acetyl-muramic acid of peptidoglycan in the bacterial membrane, lysozyme can suppress a number of Gram-positive bacteria. Antibacterial peptides with AMPs from animal sources, ovotransferrin, and lactoferrin may alter cell membranes or stimulate the production of ATP, peptides, and enzymes. According to reports, AMP's antibacterial mechanism attaches to the bacterial cell membrane, disrupts its integrity, and causes cell lysis. Both Gram-positive and Gram-negative bacteria's cell membranes were more permeable as a result of the ovotransferrin extracted from eggs. Ovotransferrin also caused morphological alterations and damaged cell membrane integrity in addition to making pathogen membranes more permeable.

Lysozymes

Lysozyme, also known as muramidase or N-acetyl-muramichydrolase, is a well-known antimicrobial enzyme primarily derived from hen egg whites. This 129-amino acid glycoside hydrolase is instrumental in breaking down peptidoglycan connections within the cell walls of Gram-positive bacteria. It contains essential amino acids, including tryptophan, tyrosine, and phenylalanine residues, as well as disulfide linkages. Commercially, lysozyme is employed under the name Inovapure® to safeguard raw and processed beef from food-borne pathogens and bacteria that cause spoilage [10].

Ovotransferin

Ovotransferrin, also referred to as conalbumin, is a monomeric glycoprotein weighing 77.9 kDa and consisting of 686 amino acid residues, constituting approximately 13% of egg white. This protein exhibits globular N- and C-termini, each with the ability to reversibly bind Fe3+ and CO32 ions. Ovotransferrin serves as a pivotal component of the egg's defense system against microbial threats by sequestering iron, hindering its utilization for microbial growth in the albumen, as evidenced by several studies [11].

Lactoferrin

Lactoferrin, a glycoprotein found in milk, milk products, neutrophil granules, and exocrine secretions of mammals, exhibits the remarkable capability to bind iron within cells. With a molecular weight of 80 kDa, this protein plays a crucial role in regulating free iron levels, leading to its bacteriostatic properties and health-enhancing benefits, including support for bone formation, protection of intestinal epithelium, and reinforcement of animals' immune systems [12].

Lactoperoxidase

Lactoperoxidase belongs to the peroxidase family and is an abundant biologically active enzyme with antibacterial properties found in cow's milk. This glycoprotein, with a peptide chain weighing 78.4 kDa, facilitates the oxidation of thiocyanate ions (SCN-) within lactoperoxidase, leading to the production of oxidizing agents such as hypothiocyanite and hypothiocyanous acid [13].

Conclusion

Meat and meat products are highly valuable food sources, providing essential protein, amino acids, vitamins, and minerals. However, their elevated water activity and nutrient content create an ideal environment for pathogenic microorganisms and spoilage microbes to thrive, leading to foodborne infections and deterioration. To combat these challenges, the use of preservatives becomes indispensable in the livestock food industry, aiming to prevent food poisoning, delay spoilage, and extend shelf life. Traditional industrial preservatives, predominantly composed of synthetic chemicals, raise concerns among consumers due to potential health risks. As a result, there is a growing interest in natural preservatives derived from various sources, such as plants (e.g., rosemary, sage, chestnut, GSE, and turmeric), animals (e.g., lysozyme, lactoferrin, lactoperoxidase, ovotransferrin, and others), and other natural origins. Researchers have explored different approaches, including physical treatments like gamma irradiation, high pressure processing, and drying, as well as encapsulation techniques and innovative packaging materials to address the limitations of natural preservatives. These methods offer potential synergistic effects with lower application concentrations, presenting an opportunity for enhanced preservation outcomes compared to single-use applications. This article presents an overview of various natural preservatives and their application techniques to prevent the growth of harmful microorganisms in food and combat foodborne diseases. As consumers and the industry increasingly demand safer and healthier alternatives, the demand for natural preservatives is expected to rise. Consequently, while exploring new natural preservatives, it is equally crucial to investigate and fully utilize the potential of the existing ones. Natural preservatives offer a promising solution to enhance the safety and longevity of meat and meat products while catering to the preferences of health-conscious consumers. Continuous research efforts into new natural preservatives, along with the exploration of multiple application methods, will be instrumental in meeting the rising demand for safer and more sustainable food preservation options.

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