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Using herbs and plant extracts to reduce the microbial load in meat and extend its shelf life

[1]Mustafa Asaad Majeed Alfatlawi , [2]Mohanad Abbood Alhamid

[3]Sharaf Ali Hadi Al-Shaikh , [4]Ameer Salem Al-Esawi

[1,2,3,4] Department of Food Science, Faculty of Agriculture, University of Kufa, Najaf, Iraq.

[1]*E-mail: mustafaa.alfatlawi@uokufa.edu.iq*
[2]*E-mail: mohanada.alhamid@uokufa.edu.iq*
[3]*E-mail: sharafa.alshaikh@uokufa.edu.iq*
[4]*E-mail: ameers.abukhurda@uokufa.edu.iq*

Abstract

Herbs and plant extracts are in important part of preserving meat for a longer period, as they contain active compounds that have antibacterial properties that cause meat spoilage. They play an important role in improving the safety and quality of meat and reducing the harmful effects of microbial agents. Some herbs such as propolis, green tea, thyme, rosemary, basil, turmeric, and green tea contain active compounds such as phenols and flavonoids that contribute to reducing meat spoilage and extending its shelf life by combining them with polymers such as gelatin and chitosan in addition to improving sensory properties.

Keywords. plant extracts , Antioxidant, meat spoilage, meat coating

I. Introduction

Herbs are considered natural sources that have antimicrobial properties, which makes them a promising option in reducing the microbial load in meat because they are a primary source of active ingredients, as humans have used them for thousands of years to treat many diseases [1]. Because it has antimicrobial properties, it can be applied in food preservation and reducing contamination [2] Microbial contamination of meat is one of the most important problems facing the food industry, as it leads to meat spoilage and causes food poisoning. Contamination occurs immediately after the slaughtering process due to the surrounding environment, the transportation and handling process, and the equipment used in the cutting process [3,4]. Another reason is that meat is a perishable food due to its moisture content and chemical composition [5]. In addition to defects that occur in color, smell, taste, and texture [6]. To reduce the microbial load, herbs are applied because they have antimicrobial properties, as they contain effective compounds such as phenols, tannins, alkaloids, flavonoids, and saponins [7]. These compounds act on the cytoplasmic membrane, disrupt the proton-motive force, and coagulate the cell contents, which leads to a reduction in the microbial content on the surfaces of meat [8]. It contributes to improving the safety and quality of meat and enhancing its shelf life, in addition to its role as an antioxidant [9]. Therefore, using herbs is a natural and safe solution that provides an effective alternative to industrial preservatives that contain chemicals that are harmful to human health. The use of herbs and spices not only improves food safety but also enhances sensory properties such as flavor, freshness, and taste

II. Properties of Meats

Meat is an animal tissue that is eaten as food and includes red meat such as beef and lamb, and white meat such as poultry, which is a rich source of proteins and minerals at 30% of the components of meat, while meat contains a small percentage of carbohydrates, and the proteins found in meat cannot be replaced by plant sources[10,11,12]. Meat is one of the most nutritious and palatable foods for humans

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because it is an important source of protein, fats, essential amino acids, minerals, vitamins, and other nutrients [13]. Red meat is a major source of protein and provides consumers with a large proportion of their daily protein needs. Fat is also an important component of meat because it provides energy, essential fatty acids, and fat-soluble vitamins [14]. Meat and its products are susceptible to spoilage due to their nutritional composition rich in nutrients [15]. The water content in meat is approximately 0.99%, and this level serves as a significant factor in the growth of microbes that lead to contamination and spoilage, posing a risk to consumer health [16,17,18]. The primary changes in quality result from oxidation and microbial spoilage of meat samples, causing meat products to become unacceptable from sensory, nutritional, or microbiological perspectives [19]. In addition, chemical and physical factors such as temperature, humidity, oxygen, time taken after slaughter, water used in slaughterhouses, air, and cutting equipment are important factors that affect the growth of microbes in mea, It should be noted that healthy animal tissues are sterile and free of microbes. Contamination occurs after slaughter, as the slaughtering process in slaughterhouses plays a significant role in the transmission of microbes. It has been shown that contamination primarily happens during the slaughtering, plucking, and evisceration processes[20,21,22,23,24,25]. The meat cooling process is one of the most important processing steps, therefore, improvement in hygiene practices throughout the food chain is essential to reduce the risk of contamination [26]. Therefore, meat recreates a vital role in the development of pathogens [27]. The microbiological condition and chemical properties of meat are important elements that determine the quality of meat, especially moisture, as moisture affects the quality of meat during storage and production[28]. Therefore, meat and meat products are susceptible to spoilage due to their nutritional composition, as this deterioration occurs as a result of many microbial and chemical changes, and the oxidation of fats in meat is one of the most prominent forms of chemical spoilage [29,30].

III. Bacterial meat-borne

Healthy animal tissues are often free of microorganisms, but they are contaminated during processing by workers, tools, or the surrounding environment in the meat [31,32]. The most important bacterial pathogens in meat and meat products responsible for foodborne infections include *E.coli*, *Salmonella* spp, *Staphylococcus aureus* , Aeromonas hydrophila , Clostridium perfringens and Listeria monocytogenes [33,34]. Foodborne bacteria are one of the most significant public health concerns worldwide and cause a wide range of diseases that attack humans and animals. More than 250 different foodborne illnesses have been described. They cause a wide range of symptoms including upset stomach, vomiting, diarrhea, and abdominal cramps [35,36].

3-1- Escherichia coli bacteria

Cattle are the most important reservoir of pathogenic E.coli, with contamination of carcasses occurring mainly during the process of skinning or evisceration and offal Meat contamination with E.coli bacteria is usually the result of contamination of the carcass with feces during the slaughtering process or when the meat comes into contact with dirty hides and cutting tools during the meat preparation and evisceration process The presence of E. coli bacteria on the surfaces of slaughtered animals is evidence of unsanitary slaughtering practices and indicates the possible presence of foodborne pathogenic bacteria , It may indicate the presence of E. coli bacteria that produce Shiga toxin, which causes mild watery or bloody diarrhea[37,38].

3-2- Salmonella spp bacteria

It is a Gram-negative, non-spore-forming, facultative anaerobic, rod-shaped bacterium belonging to the Enterobacteriaceae family. It has three antigens Flagellar antigen , Somatic antigen , Vi antigen . Causes infection to humans and animals [39,40,41]. The presence of Salmonella in animals after slaughter and cross-contamination poses a risk to meat safety [42]. Animals such as cattle may carry Salmonella at slaughter and can serve as sources of contamination and provide an opportunity for pathogens to enter meat products Which poses a risk to food safety [43]. The appropriate temperature for its growth is 37°C. It does not grow at a temperature lower than 5°C. This temperature is considered important to prevent its

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growth and reproduction in meat [44]. People who eat food contaminated with Salmonella bacteria may not show symptoms of poisoning, but they can transfer the bacteria to food and become a major source of contamination and infection [45].

3-3- Bacillus cereus bacteria

Some studies have indicated that B. cereus has been contaminating meat and meat products. One of these animal products is a beef burger made in Iran, which contains grain flour and some spices [46,47]. A study conducted in Japan stated that the reason for meat contamination with this type of bacteria is the addition of contaminated spices [48].

3-4- Staphylococcus aureus bacteria

It plays a role in meat contamination because it is often found on the skin surfaces and hands of workers. It grows at a temperature ranging from 15 to 45°C. The ideal conditions for its growth are room temperature, where it produces toxins in large quantities , the poison it secretes is of five types (A, B, C, D, E), and the type that causes the most food poisoning is the type A [49]. Staphylococcus aureus bacteria grow in food without showing any changes in flavor or taste, so spoilage cannot be detected by its external appearance and secretion of heat-resistant toxins [44]. It can survive in a low-temperature environment, so frozen food is also exposed to it [50]. Symptoms of poisoning appear quickly and may include vomiting, stomach pain, and diarrhea. The severity of symptoms depends on the type and amount of poison [51,52]. Some studies have indicated that its antigens cause diabetes by secreting a high-affinity protein that binds to insulin, causing type 2 diabetes. Its toxin also binds to the gp130 receptor and stimulates fat cells, producing cytokines that affect natural insulin signals [53].

The microbial safety of meat is important for increasing consumption and production during and after slaughter because these bacterial contaminants can grow or survive during food processing, causing many diseases [54]. Foodborne diseases occur all over the world and can have a significant impact on public health, and economic and industrial sectors [55].

The growth of large quantities of microbes in meat is a major cause of meat spoilage [56]. Spoilage is the process of meat deteriorating, causing it to become less good and unfit for consumption. Signs of spoilage are obvious, such as a bad odor, dull color, and stickiness [57]. Therefore, meat is considered a perishable product, representing 13% of food waste [58].

IV. Fat oxidation

Bacterial growth and lipid oxidation are the main culprits for the deterioration of the quality of meat products during storage, processing, and handling, which reduces their shelf life [59]. Oxidation is one of the most important mechanisms of non-microbial decomposition of meat[60]. Which affect sensory properties such as taste, color, texture, and nutritional value[61,62]. Oxidation reactions lead to a reduction in the nutritional value of meat due to the loss of essential fatty acids and a gradual decrease in sensory quality, which affects consumer acceptance [63,64,65]. Fat oxidation is a complex process and depends on the chemical composition of the meat, oxygen, light, and temperature [66]. Lipid oxidation in meat and meat products can be reduced or inhibited by antioxidants [67].

V. Antioxidants

Food spoilage can be prevented by using additives, such as antioxidant compounds, which prevent oxidative changes in food by protecting it from free radicals [68]. Antioxidants can be added to meat and meat products during processing to delay these reactions. Synthetic antioxidants are common in the meat industry due to their high effectiveness in combating oxidation reactions [69,70]. However, controversy has arisen over their use due to recent studies demonstrating the potentially toxic effects of these industrial additives [71]. In this regard, it is necessary to use alternatives, especially those that contain

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natural and biologically active ingredients with the ability to enhance health and are free of additives [72,73].

Therefore, many plant extracts and essential oils such as aromatic plants, fruits, leaves, seeds, and spices can be used as natural antioxidants in meat products, because they can delay or prevent oxidation by preventing oxidative chain reactions and can extend the shelf life of these products [74,75]. Therefore, there is an increasing use of plant extracts to replace chemical products in foods, especially in meat products[76]. Fruits, vegetables, spices, herbs, grains, and seeds are the main sources of plant-derived antioxidants [77]. The activity of extracts and essential oils obtained from these plant materials is mainly related to the presence of compounds in their composition that have antioxidant activity [78].

VI. Herbal plants and plant extracts

Plant products contain a wide range of volatile compounds, some of which are important factors in flavour quality [79]. Volatile substances in plants have been recognized as safe [80]. The development and application of natural products containing antioxidants and active compounds, especially in meat products, are useful for extending their storage period and preventing foodborne diseases [81]. Herbs and spices are generally considered safe and effective against some diseases. They are also widely used, especially in many Asian, African, and other countries. The use of spices and herbs has gradually increased in developed countries [82]. It is usually used as a rich source of phenols, flavonoids, alkaloids, and other compounds, in addition to its role in adding flavor and its potential application in the food industry to prevent the growth of bacteria and fungi and extend their shelf life by preventing rancidity through its antioxidant and antimicrobial activity [83,84,85,86].

The effectiveness of herbs depends on the type of herbs, microorganisms, and other storage factors (temperature, humidity, preservatives) [87].Plant extracts have antimicrobial activity and are used in many applications, including food preservation [88]. Several studies have shown that phenolic compounds found in spices and herbs contribute significantly to their antioxidant and antimicrobial properties, extending shelf life and improving their quality [89,90,91]. Compounds extracted from herbs and spices contain many phytochemicals, which are natural sources of antioxidants and antimicrobial growth factors such as phenols and flavonoids [92,93,94,95]. However, there is a lack of knowledge about the mechanisms and toxicological effects of naturally derived antimicrobials from plants [96].

VII. Studies on the application of gelatin fortified with plant extracts

A study was conducted on the application of gelatin with propolis extract, which led to extending the shelf life, preventing oxidation, and affecting the quality characteristics and general acceptability of pork [97]. In another study, green tea extract was effective against *Listeria monocytogenes* and *Staphylococcus aureus*. Sausages coated with 1.0% green tea extract and gelatin also showed a decrease in pH, an increase in acidity, and a lower peroxide index compared to uncoated sausages during storage [98]. The effect of gelatin supplemented with flavonoids at different concentrations on the appearance of beef was studied for 14 days at 4 °C. The results showed that gelatin supplemented with flavonoids preserved the appearance of beef better than normal films. Beef covered with this gelatin also maintained good color, pH, and texture during storage. In addition, it slowed down the oxidation of lipids and proteins.It also showed higher antimicrobial activity against spoilage microorganisms [99]. The effect of coating beef using gelatin with aqueous henna extract as a natural preservative was studied during refrigerated storage for 1, 3, 6, and 8 days. The coating showed an improvement in the shelf life of the meat by reducing the number of cold-loving bacteria and lipid oxidation compared to uncoated samples. The coating also preserved the color properties better and reduced the rate of protein degradation, which contributed to maintaining the quality of the meat [100]. A study was conducted on the effect of gelatin coating containing rosemary extract on the physical, chemical, and microbial properties of duck fillets. The results showed that the coating significantly reduced the pH compared to untreated samples. It also reduced the production of total volatile nitrogen (TVN), slowed down lipid oxidation, and reduced the growth of cold-loving bacteria during storage at 4°C [101]. The effect of chitosan and gelatin with the

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addition of papaya and thyme leaf extracts was studied. The results showed that the samples coated with gelatin-chitosan and papaya were the best in terms of tenderness, juiciness, and flavor, while gelatin-chitosan and thyme showed the highest antimicrobial and antioxidant effect [102]. The microbial, physical, and chemical properties of the turmeric-gelatin mixture on sausages were studied during the product shelf life and showed a positive effect on reducing microbial growth during storage at temperatures of 5 and 10 °C and maintaining the physical and chemical properties [103]. A study showed that adding walnuts and their shells to gelatin enhanced the barrier properties against water vapor reduced the tendency to crack, and also inhibited lipid oxidation by up to 30%. It helped extend the shelf life of beef patties for days [104]. Meat samples coated with 2.5% of the extract of Hypericum perforatum showed significant improvements in physical, chemical, and microbial properties during refrigerated storage (4°C for 9 days). A decrease in the growth of microorganisms was recorded [105]. A study showed that adding basil reduced fat oxidation without changing the pH of the meat. The meat coated with basil was darker, redder, and more yellow. Adding basil extract improved consumer acceptance of the meat [106]. A study reported that a chitosan-based coating with grape seed extract and thyme essential oils enhances the microbial, chemical, and sensory properties of turkey meat during refrigerated storage [107]. It was found that seasoning with thyme and coating with thyme extract and thyme essential oil was most effective in inhibiting microbes [108].

VIII. Conclusion

Meat contamination is one of the problems facing society and causes many diseases in addition to economic problems. Many plant extracts can stop or reduce the growth of many microbes because they contain many active compounds. [109] The effect of plant extracts is due to their content of phenols, flavonoids, and tannins, which have a biological activity towards the growth of bacteria. The active compounds form a complex with the bacterial cell wall [110]. As well as improving the chemical and sensory properties that the meat will acquire .

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