Literature Study on Food Preservation Methods and Their Effects on Product Quality and Shelf Life

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Abstract: Food preservation is an essential technology in the food industry aimed at maintaining product quality, ensuring food safety, and extending shelf life. Various preservation methods have been developed, ranging from conventional techniques such as refrigeration, freezing, drying, and fermentation to modern technologies including vacuum packaging, Modified Atmosphere Packaging (MAP), edible coatings, and non-thermal processing. This article aims to review different food preservation methods and analyze their effects on food quality and shelf life based on published scientific studies. The research employed a literature review method by collecting and analyzing relevant national and international journal articles on food preservation technologies. The findings indicate that each preservation method operates through different mechanisms to inhibit microbial growth, enzymatic activity, and chemical reactions responsible for food deterioration. Refrigeration and freezing effectively slow biological spoilage, while drying reduces moisture content and limits microbial growth. Fermentation enhances product stability and may improve functional properties. Furthermore, modern preservation technologies, such as MAP, edible coatings, and non-thermal methods, have demonstrated greater effectiveness in maintaining nutritional value, color, texture, and sensory characteristics of food products. Combining multiple preservation techniques often provides superior results in extending shelf life without significantly compromising product quality. Therefore, selecting appropriate preservation methods is crucial for maintaining food quality, ensuring safety, and minimizing postharvest losses during storage and distribution.

Keywords: food preservation, food quality, shelf life, food technology, food safety.

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Introduction

Food is a basic human necessity that plays a crucial role in maintaining health and supporting life. However, most food products are highly perishable due to microbial activity, enzymatic reactions, oxidation processes, and environmental factors during storage and distribution (Fellows, 2017; Rahman, 2020). Food deterioration not only reduces the physical, chemical, nutritional, and sensory quality of products but also contributes to significant economic losses and increased food waste worldwide.

Food preservation technologies have been widely applied to delay spoilage and extend the shelf life of food products. Conventional preservation methods such as refrigeration, freezing, drying, fermentation, smoking, and canning have long been utilized to maintain food quality and safety. These methods primarily function by controlling microbial growth, enzymatic activity, and chemical reactions that lead to food deterioration (Rahman, 2020).Recent advances in food science and technology have led to the development of innovative preservation techniques that aim not only to prolong shelf life but also to maintain nutritional value and sensory characteristics. Technologies such as Modified Atmosphere Packaging (MAP), edible coatings, antimicrobial packaging, High Pressure Processing (HPP), Pulsed Electric Field (PEF), and cold plasma have gained increasing attention due to their effectiveness in preserving food quality while minimizing quality degradation (Tiwari et al., 2019; Misra et al., 2016). Several studies have demonstrated the effectiveness of modern preservation technologies. Tiwari et al. (2019) reported that non-thermal processing technologies effectively reduce microbial contamination while preserving nutritional compounds and sensory attributes. Similarly, Misra et al. (2016) found that cold plasma technology can significantly inhibit spoilage microorganisms without causing major changes in food quality. Despite these findings, studies comparing the effectiveness of conventional and modern preservation methods in maintaining food quality and extending shelf life remain limited. Furthermore, the advantages and limitations of each preservation technique have not been comprehensively discussed in a single review.

Therefore, a comprehensive literature review is needed to analyze various food preservation methods and evaluate their effects on food quality and shelf life. This study aims to examine the principles, advantages, limitations, and effectiveness of conventional and modern food preservation technologies based on findings from recent scientific

literature. The results of this review are expected to provide useful information for researchers, students, and food industries in selecting appropriate preservation methods according to product characteristics and quality requirements.

Methods

This study employed a literature review method using a descriptive qualitative approach. The literature review was conducted to collect, examine, and analyze various scientific publications related to food preservation methods and their effects on food quality and shelf life. The data used in this study were secondary data obtained from national and international journal articles, scientific books, conference proceedings, and other academic publications relevant to the research topic. Literature searches were carried out through several scientific databases, including Google Scholar, ScienceDirect, SpringerLink, MDPI, and Garuda. The keywords used in the search process included:

> "*food preservation*, *food preservation methods*, *shelf life*, *food quality*, *Modified Atmosphere Packaging (MAP)*, *edible coating*, *non-thermal technology*, and *food preservation*."

The selected literature mainly consisted of publications from 2020 to 2026 to ensure the inclusion of recent developments in food preservation technology.

The literature selection process was conducted based on the relevance of the title, abstract, research objectives, methodology, and findings to the focus of this study. Articles discussing conventional and modern food preservation methods, their effects on the physical, chemical, microbiological, nutritional, and sensory quality of food products, as well as their effectiveness in extending shelf life, were included in the review.

The collected data were analyzed using a descriptive approach through the processes of identification, classification, comparison, and synthesis of previous research findings. The results were then systematically organized to provide a comprehensive overview of various food preservation methods, their working principles, advantages, limitations, and impacts on food quality and shelf life. This approach was expected to provide a deeper understanding of recent advances in food preservation technologies and their potential applications in supporting food quality, safety, and sustainability.

Results

Commonly Used Food Preservation Methods

The literature review revealed that food preservation methods can be broadly categorized into conventional and modern techniques. Conventional preservation methods include refrigeration, freezing, drying, fermentation, smoking, and canning. These methods remain widely used because they are relatively simple, cost-effective, and capable of inhibiting food spoilage caused by microbial activity, enzymatic reactions, and chemical changes. Refrigeration and freezing are commonly applied to fresh products such as fruits, vegetables, meat, fish, and dairy products because they effectively maintain freshness and delay deterioration during storage.

Refrigeration works by lowering the temperature to slow down microbial growth and enzymatic activity without completely stopping biological processes. This makes it suitable for short-term preservation of perishable foods. Freezing, on the other hand, significantly reduces the temperature below the freezing point of water, thereby halting microbial growth and drastically slowing chemical reactions. However, both methods may still allow slow quality deterioration over long storage periods, particularly due to oxidation and moisture migration (Zega et al., 2026a).

Drying is another widely used preservation method, particularly for agricultural commodities, spices, grains, fruits, and fishery products. By reducing moisture content, drying lowers water activity (aw), which is essential for microbial growth. Traditional sun drying is still widely practiced in developing regions due to its low cost, while industrial drying methods such as spray drying, freeze drying, and hot air drying provide better control over product quality. Nevertheless, drying may also lead to nutrient losses, especially heat-sensitive vitamins, and may alter texture and sensory properties.

Fermentation is also frequently utilized as a preservation technique because it not only prolongs shelf life but also enhances flavor, aroma, texture, and nutritional value. This process relies on beneficial microorganisms such as lactic acid bacteria, yeasts, and molds that convert carbohydrates into organic acids, alcohols, and other metabolites. These compounds inhibit pathogenic and spoilage microorganisms while improving functional properties such as digestibility and probiotic activity (Zega et al., 2026b).

Smoking is another traditional preservation method that combines drying, heating, and chemical preservation through smoke compounds such as phenols and organic acids. These compounds contribute antimicrobial and

antioxidant effects, although excessive smoking may introduce harmful substances if not properly controlled. Canning involves sealing food in airtight containers followed by heat treatment to destroy microorganisms and inactivate enzymes. This method ensures long-term shelf stability but may affect sensory and nutritional quality due to high thermal exposure.

Recent developments in food science and technology have led to the emergence of modern preservation methods, including Modified Atmosphere Packaging (MAP), vacuum packaging, edible coatings, High Pressure Processing (HPP), Pulsed Electric Field (PEF), irradiation, and cold plasma technology. These technologies have gained increasing attention because they are capable of extending shelf life while maintaining product quality more effectively than some conventional methods. Unlike traditional methods, many of these technologies operate under minimal heat conditions, thereby preserving heat-sensitive nutrients and natural sensory attributes.The reviewed studies indicate that the focus of food preservation has shifted from merely extending shelf life to maintaining overall product quality, safety, nutritional value, and sensory characteristics that meet consumer expectations. This shift reflects the growing demand for minimally processed, fresh-like, and nutritious food products in modern markets.

Effects of Preservation Methods on Food Quality

The findings showed that preservation methods have varying impacts on food quality. Refrigeration and freezing generally preserve color, aroma, taste, and nutritional value better than thermal processing methods. Low temperatures slow down metabolic activity, microbial growth, and oxidative reactions that contribute to food deterioration. However, prolonged freezing may cause structural damage in certain products due to ice crystal formation, which can negatively affect texture.

The formation of ice crystals during freezing can rupture cell walls, leading to drip loss upon thawing. This affects juiciness and firmness, particularly in meat, fish, and certain fruits. Despite this limitation, freezing remains one of the most effective methods for long-term preservation of high-quality food products. Drying has been proven effective in reducing moisture content and water activity, which are critical factors influencing microbial growth. Numerous studies have reported that drying significantly enhances product stability and storage life. Nevertheless, high-temperature drying may result in color changes due to Maillard reactions, texture hardening, vitamin degradation, and reductions in certain bioactive compounds such as phenolics and antioxidants.

Fermentation produces distinct effects compared to other preservation techniques. In addition to extending shelf life, fermentation promotes the formation of metabolites that contribute to desirable flavor, aroma, and functional properties. The enzymatic activity of microorganisms during fermentation can also increase bioavailability of nutrients and improve gut health through probiotic effects. Canning provides long-term preservation and ensures microbiological safety through thermal sterilization. However, exposure to high temperatures during processing may reduce the concentration of heat-sensitive nutrients, particularly certain vitamins such as vitamin C and some B vitamins. Despite these changes, canned products generally maintain acceptable quality and safety over extended storage periods, making them highly suitable for large-scale food distribution.

The review further indicated that sensory attributes such as color, texture, taste, and aroma are among the most commonly evaluated parameters in determining the effectiveness of preservation methods. Preservation techniques that minimize undesirable changes in these characteristics are generally considered more successful in maintaining product quality and consumer acceptance.

Effectiveness of Modern Preservation Technologies

The reviewed literature demonstrated that modern preservation technologies offer significant advantages in maintaining food quality during storage. Modified Atmosphere Packaging (MAP) regulates the composition of gases inside packaging, thereby reducing respiration rates, oxidation processes, and microbial growth. By adjusting oxygen, carbon dioxide, and nitrogen levels, MAP slows down spoilage mechanisms in fresh produce.

Vacuum packaging has shown high effectiveness in reducing oxygen availability within the package. This condition inhibits the growth of aerobic microorganisms and slows lipid oxidation, which is a major cause of rancidity in food products. In addition, vacuum conditions help maintain moisture and reduce contamination risks during storage and transportation. Edible coating technology has emerged as one of the most promising innovations in food preservation. These edible protective layers act as barriers against moisture loss, gas exchange, and external contaminants. They can also be enriched with antimicrobial and antioxidant agents to further enhance preservation performance. Research findings indicate that edible coatings can significantly reduce weight loss, maintain firmness, delay enzymatic browning, and preserve overall quality of fruits and vegetables during storage (Halawa et al., 2025).

Non-thermal technologies such as High Pressure Processing (HPP), Pulsed Electric Field (PEF), and cold plasma have demonstrated remarkable potential in controlling microbial contamination without causing heat-related

damage. HPP, for example, applies extremely high hydrostatic pressure to inactivate microorganisms while preserving sensory and nutritional properties. PEF disrupts microbial cell membranes using short electrical pulses, while cold plasma generates reactive species that eliminate pathogens on food surfaces. Consequently, these technologies are increasingly considered sustainable alternatives for future food preservation applications. Furthermore, the literature indicates that modern preservation technologies are generally more effective in maintaining nutritional quality and sensory properties than many conventional methods. Foods preserved using these technologies often experience fewer changes in color, texture, flavor, and nutritional composition throughout storage.

Effects of Preservation Methods on Product Shelf Life

The literature review showed that all preservation methods contribute to extending the shelf life of food products, although their effectiveness varies depending on product characteristics, storage conditions, and processing techniques. Refrigeration can extend the shelf life of fresh foods from several days to several weeks, depending on the type of product and hygiene conditions during storage. Freezing may preserve product quality for several months or even longer when maintained under stable low temperatures. In meat and fish products, freezing significantly inhibits spoilage microorganisms and enzymatic reactions, thereby maintaining safety and quality during long-term storage.

Drying is among the most effective preservation methods for extending shelf life because it substantially reduces moisture content to levels that do not support microbial growth. Dried products such as grains, spices, dried fruits, and fish products can often be stored for several months or even years under appropriate packaging and controlled environmental conditions. However, improper drying or storage may lead to moisture reabsorption, which can accelerate spoilage. Fermentation extends shelf life through the production of organic acids, alcohols, hydrogen peroxide, and antimicrobial compounds that suppress spoilage microorganisms. As a result, fermented products generally exhibit greater stability than their fresh counterparts, while also developing unique sensory characteristics that enhance consumer acceptance.

Modern preservation technologies improve shelf life through a combination of microbial inhibition, oxidation control, and protection against physical and chemical deterioration. Several studies have reported that MAP, vacuum packaging, and edible coatings can extend the shelf life of fresh products by up to two times compared with conventional storage methods. In some cases, when combined with refrigeration, shelf life extension can be even more significant. The findings also revealed that shelf life is influenced not only by preservation methods but also by factors such as storage temperature, humidity, packaging type, moisture content, water activity, pH, and distribution conditions. Therefore, successful food preservation requires an integrated approach involving appropriate preservation technologies and effective storage management.

Trends in Food Preservation Technology Development

The literature review indicates that food preservation technology has undergone rapid development in recent years. Current innovations are no longer focused solely on extending shelf life but also on improving product quality, food safety, nutritional value, and sustainability. Increasing consumer awareness of healthy lifestyles has encouraged the food industry to reduce the use of synthetic preservatives and adopt more environmentally friendly preservation technologies. This trend is reflected in the growing number of studies on edible coatings, active packaging, antimicrobial packaging, and non-thermal technologies that can maintain food quality without compromising consumer health. Another major trend identified in the literature is the application of hurdle technology, which combines multiple preservation methods to achieve greater effectiveness. This approach utilizes several preservation factors simultaneously to inhibit microbial growth and quality deterioration. Examples include combining refrigeration with MAP, edible coatings with cold storage, and non-thermal processing technologies with active packaging systems. The synergy between these methods allows for lower intensity treatments while maintaining high preservation efficiency.

Overall, the findings suggest that future food preservation technologies will continue to prioritize the production of safe, high-quality, nutritious foods with extended shelf life while meeting consumer demands and supporting sustainable food systems. These developments highlight the important role of preservation technology in enhancing food security, reducing postharvest losses, and supporting global food sustainability goals.

Conclusion

Based on the results of this literature review, it can be concluded that various food preservation methods play an important role in maintaining food quality and extending the shelf life of food products. Conventional preservation methods, such as refrigeration, freezing, drying, and fermentation, have been proven effective in inhibiting microbial

growth and slowing down food deterioration processes, although each method has its own advantages and limitations regarding product quality.

The development of modern food preservation technologies, including *Modified Atmosphere Packaging* (MAP), vacuum packaging, edible coatings, and non-thermal technologies such as *High Pressure Processing* (HPP), *Pulsed Electric Field* (PEF), and *cold plasma*, has demonstrated greater effectiveness in preserving the physical, chemical, nutritional, and sensory qualities of food products during storage. These technologies can significantly extend shelf life while minimizing undesirable changes in food quality.The review also revealed that no single preservation method is universally effective for all types of food products. The effectiveness of a preservation technique depends on the characteristics of the food material, storage conditions, and processing objectives. Therefore, the application of combined preservation methods, known as *hurdle technology*, represents one of the most promising approaches for enhancing food safety, maintaining product quality, and maximizing shelf-life extension.

Overall, advances in food preservation technology make a significant contribution to food security by reducing food losses, improving storage and distribution efficiency, and ensuring the availability of safe and high-quality food products. Continuous innovation and development in food preservation technologies are therefore essential to meet increasing consumer demands for safe, nutritious, and sustainable food products.

AI Declaration

The authors declare that artificial intelligence (AI)-assisted tools, specifically ChatGPT (OpenAI), were used solely to support language improvement, grammar correction, translation, and manuscript organization during the preparation of this article. The authors independently reviewed, verified, and revised all generated content and take full responsibility for the accuracy, originality, and integrity of the manuscript.

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