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Preserving Food in the Modern Age: Blending Tradition with Innovation

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Abstract

Food preservation is a fundamental practice essential for ensuring the availability and safety of food over extended periods. Drawing from centuries-old practices passed down through generations, along with the latest technological innovations offers a comprehensive solution to the challenges of food preservation in the 21st century. By leveraging traditional methods such as fermentation, drying and pickling with advancements like vacuum sealing, high-pressure processing and controlled atmosphere storage, food preservation becomes not only a means of extending shelf life but also a way of enhancing nutritional value and flavour retention. Through this integration, a comprehensive approach that honours traditional wisdom while embracing future opportunities guarantees the effectiveness and sustainability of food preservation. This article demonstrates how this integration not only prolongs the shelf life of perishable goods but also improves food safety, quality and sustainability.

Keywords: Food safety, Modern technology, Preservation, Traditional methods

Introduction

Food stands as a fundamental necessity for human survival and advancement, serving as a vital source of energy and sustenance whether consumed raw or processed. Regrettably, the issue of food wastage has evolved into a global concern (NIFA, 2024). According to the 2021 Food Waste Index by the United Nations Environment Programme, the world generates an astounding 931 million tonnes of food waste annually, with households contributing 569 million tonnes, trailed by the food service (244 million tonnes) and retail sectors (118 million tonnes) (Figure 1a). On average, each individual globally produces 74 kg of food waste yearly, emphasizing the pressing need for widespread improvements in addressing this challenge (McCarthy, 2021).

Food waste is a significant global issue, with China discarding 91.6 million tonnes annually, India wasting 68.8 million tonnes and the United States contributing 19.4 million tonnes. In Europe, France and Germany together produce between five and six million tonnes of waste yearly. The average Indian household discards 50 kg of food annually, while in the United States, it's 59 kg. Despite Australia's lower total food waste of 2.6 million tonnes per year, the per capita waste is high at 102 kg household^{-1} yearly. In contrast, Russia's total household waste amounts to 4.9 million tonnes annually, with a per capita waste of 33 kg (McCarthy, 2021).

A recent publication by the United Nations Environment Programme reveals that globally, 931 million tonnes of food are discarded annually, with an average per capita food waste of 74 kg household^{-1}. Of this, 569 million tonnes are attributed to household waste. Additionally, the food service industry wastes about 244 million tonnes yearly, while the retail sector discards around 118 million tonnes. A report from the UN Food and Agriculture Organization indicates that approximately 14% of the world's food is lost before reaching the retail stage, with the most significant losses seen in roots, tubers and oil-bearing crops, followed by fruits and vegetables (McCarthy, 2021).

Addressing food wastage calls for sustainable solutions, with food preservation emerging as a pivotal strategy. Throughout history, food preservation has ensured the

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availability of nourishing sustenance over extended periods. Techniques such as sun drying, salting and pasteurization were introduced in ancient times to maintain food freshness and edibility, adapted to varying climatic and seasonal conditions. With industrialization, methods like thermal treatment, canning and freezing gained prominence, offering prolonged shelf life by controlling pathogens (Buchholz, 2019). However, traditional methods such as heat treatment and freezing entail drawbacks like food shrinkage, texture and nutrient loss and alterations in organic properties, resulting in substantial overall food loss. Recent years have witnessed advancements in chemical and microbiological treatments, incorporating additives, coatings and various polyphenolic plant extracts, presenting effective solutions to food preservation challenges. Despite these advancements, a research gap remains in bridging the connection between food wastage and preservation techniques (Sridhar *et al.*, 2021). Consequently, this article explores emerging food preservation technologies poised to transform the industry.

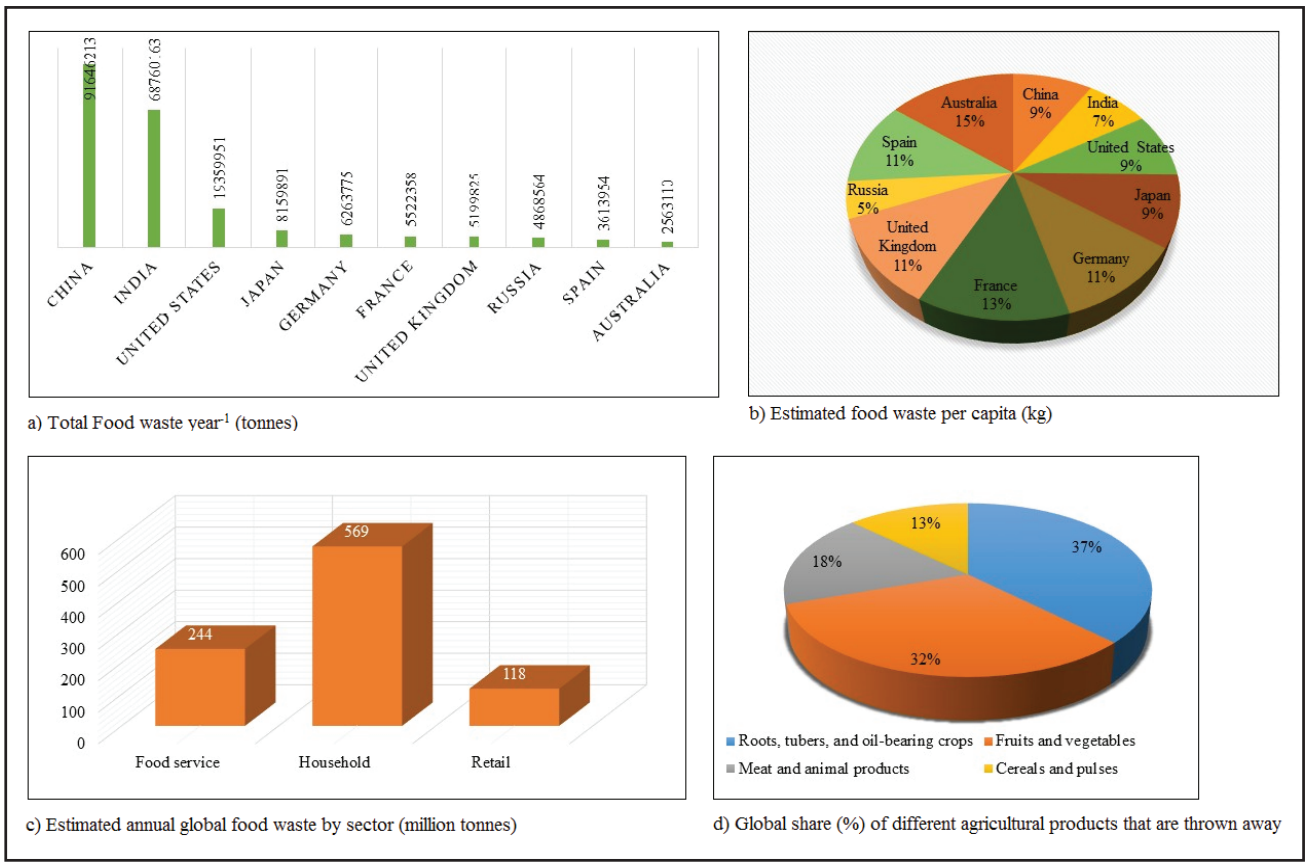

Figure 1: The Enormous Scale of Global Food Waste (Buchholz, 2019; McCarthy, 2021)

Traditional Food Preservation Methods

Canning

Originating in the early 19th century, canning emerged as a ground-breaking technique involving the sealing of food in airtight containers to thwart microbial proliferation. Initially reliant on heat and vacuum sealing, this method significantly prolonged the lifespan of perishable items. However, despite its efficacy, canning posed certain constraints, such as the risk of nutrient depletion and alterations in food texture and flavour (Sridhar *et al.*, 2021).

Drying and Dehydrating

One of the oldest methods of preserving food is by drying and dehydrating. Removing moisture inhibits the growth of bacteria and mould, allowing food to last for several months. Drying food using the sun, air, or low-heat mechanical dehydrators are simple, low-cost techniques suitable for herbs, fruits, vegetables and meats. Dried foods require proper storage in an airtight container (Sridhar *et al.*, 2021).

Fermenting and Pickling

Fermenting and pickling uses acidity and anaerobic environments to preserve food. Fermentation produces lactic acid, which inhibits pathogens, through the action of Lactobacillus bacteria. Common fermented foods include sauerkraut, kimchi, yoghourt and sourdough bread. Pickling also uses acid, usually vinegar, to create an inhospitable environment. Pickled cucumbers, cabbage, eggs and pig's feet can last for several months when properly refrigerated (Sridhar *et al.*, 2021).

Salting

Salting food draws moisture out through osmosis and inhibits microbial growth. Ancient cultures preserved meats, fish and vegetables through salting. Curing meats like bacon, ham and beef jerky, as well as pickled vegetables, rely on the preservative power of salt. Excess salt must be rinsed before eating and the food may require further cooking. With proper storage, salted meats can last for years (Sridhar *et al.*, 2021).

Sugaring

Like salting, sugaring food inhibits microbial growth through osmosis. Jams, marmalades, chutneys and fruit preserves rely on the natural preservative power of sugar. By heating fruit and sugar, the sugar penetrates the fruit's cells, preventing spoilage for several months when properly refrigerated. Sugared foods also often depend on acid from the fruit and additional preservatives like citric acid (Sridhar *et al.*, 2021).

Low-Temperature Packing

By quickly heating food and then sealing it in an oxygen-free environment, anaerobic bacteria and enzymes are deactivated, preventing spoilage for up to 12 months. This allows foods like soups, stews and ready-to-eat meals to be shelf-stable without preservatives. Studies show low-temperature packing may preserve up to 90% of nutrients in food (Sridhar *et al.*, 2021).

High-Pressure Processing

Applying extreme pressure, up to 100,000 pounds inch^{-2}, destroys bacteria, viruses and moulds in foods. High-pressure processing allows foods like guacamole, oysters and fruit juices to be preserved for 2 to 3 weeks without heat or preservatives. It causes minimal changes in taste, colour and nutrition. Although equipment costs are high, this method is gaining popularity (Sridhar *et al.*, 2021).

Pulsed Electric Field

Short pulses of electricity are used to punch holes in cell membranes of microorganisms, killing them instantly. Pulsed electric field processing allows foods like fruit juices, milk and eggs to be preserved for up to 2 weeks. It is a non-thermal process, so it causes almost no loss of nutrients or changes in flavour. It requires significant equipment investment and is still limited to liquid and semi-liquid foods (Sridhar *et al.*, 2021).

Cutting-Edge Preservation Technology

Modified Atmosphere Packaging (MAP)

MAP involves altering the atmospheric conditions within food packaging to create an optimal environment for food preservation. The oxygen level is reduced and carbon dioxide increased, which inhibits the growth of aerobic microorganisms and slows down oxidation reactions. MAP is commonly used to produce, meat, poultry and prepared meals. It can extend the shelf life of foods for weeks or even months (Tumuluru, 2023).

Pulse Electric Field Processing (PEF)

PEF processing exposes foods to short bursts of high voltage electricity to destroy microorganisms. By creating pores in cell membranes, PEF causes cell death while preserving the food's sensory attributes. It is used commercially to pasteurise fruit juices, milk and liquid egg products. PEF provides an alternative to traditional thermal pasteurisation for temperature-sensitive foods (Tumuluru, 2023).

High Pressure Processing (HPP)

High pressure processing subjects foods to extreme hydrostatic pressures, up to 87,000 pounds inch^{-2}, to destroy pathogens and spoilage microorganisms. At room temperature, HPP can achieve up to a 5-log reduction in bacteria without damaging the food. It is used for preservative-free guacamole, deli meats, oysters and juices. HPP helps in retaining nutrition, flavours and textures better than thermal processing methods (Tumuluru, 2023).

Ultrasonic Processing

Powerful ultrasonic waves can be used to preserve foods through cavitation, microstreaming and shockwaves. Ultrasonic processing disrupts cell membranes, accelerates chemical reactions and generates heat through cavitation. At lower frequencies, it can inactivate bacteria, moulds and yeasts to extend shelf life. Ultrasonic processing may be useful for egg whites, milk and fruit juices. More research is needed to fully exploit its potential for commercial food preservation (Tumuluru, 2023).

Combining Traditional and Modern Techniques

Maximising Shelf Life through Hybrid Approaches

Certain foods are best suited to particular techniques. For example, canning works well for acidic foods like tomatoes, while drying is ideal for vegetables and fruits. Vacuum sealing and freeze-drying, though more technologically advanced, can be used for a wide array of goods. By utilising the optimal method for each food type and then combining multiple approaches, shelf life can be extended significantly (Tumuluru, 2023).

Monitoring and Rotation for Best Quality

No matter the preservation methods used, monitoring food storage conditions and rotating stock are essential. As shelf lives are reached, older foods should be consumed first. By integrating diligent oversight and rotation into preservation plan, researchers can achieve optimal food storage that keeps your supplies fresh and avoids waste (Tumuluru, 2023).

Best Practices for Preserving Different Food

Fruits, Vegetables and Meats

Cleanly butcher the meat and pack it in sterilised jars or containers. For raw pack canning, tightly pack the meat in jars and cover with broth, sauce, or water. Pressure can change according to the recommended times for that particular meat. For dried meats like jerky, slice the meat thinly and expose it to circulating air. Use a dehydrator or oven on a low setting, checking often and turning the meat, until it has dried completely. For fruits and vegetables, the preservation methods used will depend on the acidity and moisture content of the produce. High-acid fruits with low moisture like berries are ideal for sweet spreads and dehydrating. Vegetables and low-acid fruits are best preserved through pickling, pressure canning or blanching followed by freezing. For vegetables, blanching in boiling water, then quickly cooling in ice water helps retain colour and texture before freezing (Tumuluru, 2023).

Dairy and Herbs

Refrigerate or freeze dairy products promptly after purchase. When making cheese or cultured products like yoghourt or kefir at home, carefully monitor temperatures and acidity

levels. Use sterilised equipment and containers and properly age and cure products. For long term preservation of cheese, waxing or drying completely protects from exposure to air and spoilage. Herbs are best preserved through air drying or freezing. To air dry, gather stems, tie together and hang upside down in a cool, dry, well-ventilated area away from direct sunlight, or place leaves in a single layer on a drying screen or rack. Gently crush dried herbs to release essential oils before storing in an airtight container (Tumuluru, 2023).

Benefits of Food Processing and Preservation

Food processing plays a crucial role in maintaining the quality and stability of products. For instance, it prevents phase separation and enzyme degradation in fresh juice by pasteurization, thus slowing spoilage. This applies to fatty products too, as active enzymes and oxygen can cause rancidity. Additionally, processing enhances digestibility by softening or breaking down tissues. It also aids affordability and addresses food shortages, especially in developing regions, through proper storage and preservation techniques. Benefits of food processing include reduced bacterial growth via dehydration and altered pH, enhancing shelf life. However, drawbacks include the presence of artificial ingredients, excessive processing leading to overconsumption and high sugar content in many processed foods, posing health risks (Tumuluru, 2023).

Food Packaging

Food packaging plays a pivotal role in extending the storage and shelf life of food products by regulating the storage environment. Commonly utilized food packaging materials encompass flexible paper, plastic film and semi-rigid materials like aluminum foil and paperboard. Among these, plastic stands out as the most prevalent material due to its cost-effectiveness, lightweight nature and versatility in shaping. Furthermore, low gas permeability films prove effective in reducing oxidation reactions in foods rich in fatty acids. Conversely, packaging materials with high gas permeability, such as polyethylene, find suitability for preserving fresh fruits and vegetables that respire. Innovative smart packaging systems, integrating oxygen-absorbing materials, cater to specific food requirements. Nevertheless, concerns arise regarding the health and environmental impacts associated with petroleum-based packaging materials like plastics and styrofoam. These materials have the potential to release toxins when subjected to heat and contribute to environmental pollution. To address these concerns, biodegradable packaging materials such as polyhydroxyalkanoates (PHAs), synthesized by microorganisms, emerge as a sustainable alternative (Tumuluru, 2023).

Conclusion

Progressing from the traditional practice of canning to the innovative high-pressure processing technology, the food industry persists in its evolution towards efficient preservation techniques. These advancements not only combat food spoilage but also meet the increasing consumer preference for fresh, minimally processed and nutrient-rich food items. As technology advances, the horizon of food preservation presents thrilling opportunities, guaranteeing a sustainable and robust global food provision system.

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