

Non-Thermal Processing Methods for Food Safety and Shelf-Life Enhancement

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The manufacturing sector which includes the production of food and beverages is one of the largest in the world. Food processors face ongoing challenges in creating consumer-driven products that meet their needs while maintaining food safety in an economical and consumer-driven market. Foods that taste better, are fresher-tasting, and contain few or no preservatives are preferred by consumers who lead health and wellness-conscious lifestyles. To maintain the health and welfare of society at large, food safety management has gained prominence on a global scale. Novel techniques have enhanced the shelf life of food products without impacting their functional properties, freshness, or quality. Traditional thermal processing methods that are believed to utilize the most energy in the food industry include pasteurization, evaporation, drying, sterilization, chilling, and freezing process. To reduce the growth of microbes, which will improve food goods' safety and shelf life. (Putnik *et al.*, 2017) reported that conventional methods are used to prevent the formation of enzymes that cause spoiling, including lipo-oxygenase, peroxidase, polyphenol oxidase, and pectin methyl esterase. Bhattacharjee *et al.*, (2019) reported that novel thermal techniques have been widely used to increase food safety with less of an impact on the nutritional quality of food products. Having applications in the field of nutraceuticals, it is used to reduce the microbial load that contaminates fresh produce before and after harvest, dehydrate it and enhance its physico-chemical properties. Delorme *et al.*, (2020) reported that milk retains its nutrients, which include lipids, carbohydrates, proteins, enzymes, essential amino acids, minerals, and vitamins.

Due to increased consumer awareness of food safety, customers nowadays have higher expectations for wholesome, premium foods with excellent nutritional qualities and mouthfeel. Foods that are natural and fresh are in great demand after because

they are free from any chemicals. Therefore, scientists are working hard to develop appropriate technologies that will reduce the need for chemical additives without impacting the natural flavors and quality of the final product. These techniques are used to produce high-quality food with a reduced microbial load. In terms of destroying microbes and harmful bacteria in the food as well as denaturing, inhibiting, and gelatinizing protein, enzymes, and starch. It was reported that compared to heat treatment technique and non-thermal processing technologies cause less damage to food quality (Liu *et al.*, 2020). This is because non-thermal processing techniques typically have an impact on the food molecules' non-covalent bindings, including ionic, hydrophobic, and electrovalent bonds.

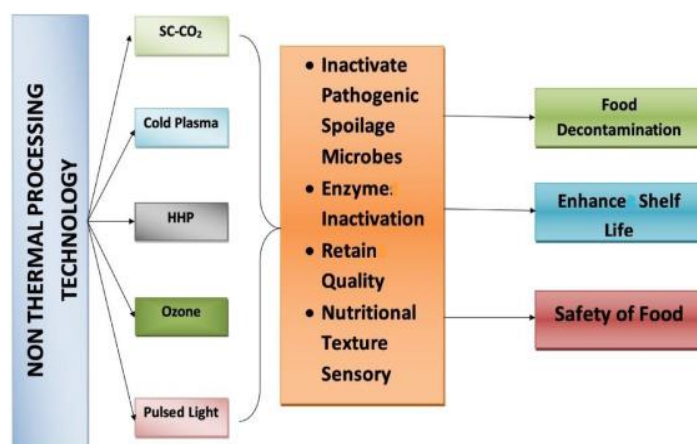


Fig. 1. Novel technologies for reducing contamination and enhancing food safety

Non-Thermal Processing Methods

High-Pressure Processing (HPP)

High-Pressure Processing is a non-thermal technique that involves subjecting packaged foods to elevated pressures, usually between 100 to 1000 MPa. This process effectively inactivates microorganisms, enzymes, and pathogens without the use of high temperatures. HPP is particularly beneficial for beverages, deli meats, and ready-to-eat meals, as it preserves the nutritional content and sensory qualities of the food.

Pulsed Electric Field (PEF)

PEF is a non-thermal method that applies short bursts of electrical energy to food products. These pulses create pores in microbial cell membranes, leading to microbial inactivation. PEF is effective in preserving the color, flavor, and nutritional quality of fruits, juices, and liquid foods. Its ability to target specific microorganisms makes it a valuable tool in the food industry.

Ultrasound Technology

Ultrasound technology involves the use of high-frequency sound waves for microbial inactivation and food preservation. This non-thermal method is particularly useful for liquids and semi-liquids. Ultrasound helps to disrupt cell structures of microorganisms, thereby extending the shelf life of products such as fruit juices, sauces, and purees.

Ionizing Radiation

Ionizing radiation, including gamma radiation and electron beam irradiation, is employed to control microbial growth and enhance the shelf life of various food products. It is a highly effective method for eliminating pathogens and parasites in spices, dried fruits, and some types of seafood. Despite initial concerns, extensive research has demonstrated the safety of irradiated foods within established dosage limits.

Ozone Treatment

Ozone, a powerful oxidizing agent, is gaining popularity for its ability to eliminate microorganisms and enhance food safety. Ozone treatment is applied in gaseous or aqueous forms to fruits, vegetables, and even water. It helps in controlling spoilage organisms, extending shelf life, and reducing the need for chemical preservatives.

Cold Plasma Technology

Cold plasma involves the use of ionized gases to inactivate microorganisms on the surface of food products. This non-thermal method has shown promise in enhancing the safety of fruits, vegetables, and even packaging materials. Cold plasma technology also has the advantage of being environmentally friendly, as it does not leave chemical residues.

Advantages of Non-Thermal Processing Methods**Preservation of Nutritional Quality:**

Non-thermal methods such as high-pressure processing (HPP) and pulsed electric fields (PEF) are known for their ability to preserve the nutritional content of food products. Unlike thermal methods that can lead to nutrient degradation, non-thermal techniques maintain the integrity of vitamins, enzymes, and other essential nutrients.

Improved Retention of Flavor and Texture

Non-thermal processing helps retain the natural flavors and textures of food products. Minimal heat exposure prevents undesirable changes in taste and texture, ensuring that the final products closely resemble their fresh counterparts.

Reduced Risk of Pathogen Contamination

Non-thermal methods effectively reduce the risk of pathogen contamination in food. Techniques such as ultraviolet (UV) light treatment and high-pressure processing can eliminate harmful microorganisms, contributing to enhanced food safety without the need for excessive heat.

Extended Shelf Life

Non-thermal processing methods contribute to the extension of shelf life by minimizing the impact on the quality of food products. This allows for longer storage periods, reducing food waste and providing consumers with products that maintain their sensory attributes over an extended period.

Energy Efficiency and Sustainability

Unlike traditional thermal processing methods that often require significant energy input, many non-thermal techniques are more energy-efficient. This increased efficiency aligns with the growing emphasis on sustainability in the food industry, reducing both energy consumption and greenhouse gas emissions.

Minimal Impact on Colour and Appearance

Non-thermal methods help preserve the natural colour and appearance of food products. Traditional heat-based processing can lead to colour changes and visual alterations, while non-thermal methods maintain the appealing visual characteristics of the original products.

Flexibility in Packaging

Non-thermal processing allows for greater flexibility in packaging options. The reduced impact on food quality enables the use of various packaging materials, including those that may not withstand traditional thermal treatments, expanding the possibilities for eco-friendly packaging solutions.

Compliance with Consumer Preferences

With an increasing focus on minimally processed and fresh-like foods, non-thermal methods align well with consumer preferences. These techniques allow manufacturers to meet the demand for products with natural flavors, textures, and nutritional profiles while ensuring safety and extended shelf life.

Conclusion

- ❖ Emerging non-thermal technologies for enhancing food safety and shelf life have completely changed the food processing industry.
- ❖ By lowering spoilage and waste, the use of various non-thermal techniques such as cold plasma and high hydrostatic pressure technologies can extend the shelf life of food and improve its quality.
- ❖ Examine shows that these innovative techniques and novel approaches preserve the nutritional value of heat-sensitive components in food while also assuring its freshness.

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