Preserving Nutrients: How Minimal Processing Can Retain the Goodness in Food

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Preserving the inherent nutritional value of food is achievable through minimal processing, which involves novel (non-thermal) techniques. These methods aid in maintaining essential vitamins, minerals, and antioxidants found in fruits and vegetables. Furthermore, minimal processing contributes to enhanced nutritional profiles by minimizing the inclusion of unhealthy chemical additives and preservatives. By upholding the natural integrity of ingredients, minimal processing leads to elevated nutritional content, ultimately offering improved health benefits for consumers. Minimal processing involves employing techniques like High pressure processing (HPP), pulsed electric field (PEF), ultrasound, non-thermal plasma, light pulses, and enzyme-assisted extraction (EAE) to preserve natural food attributes, nutrients and extend shelf life.

Conventional thermal processing (high temperature) affects the functional and nutrients qualities of food product. Nonthermal or Minimal processing techniques effectively preserve foods by deactivating microorganisms and, in certain instances, enzymes, without substantial heat application. These methods have minimal impact on pigments, structural polymers, flavor compounds, and vitamins, allowing foods to maintain their nutritional integrity and sensory attributes to a significant extent. Consumer preferences align with a growing inclination toward "natural" products devoid of additives. The essence of minimal processing lies in the objective of reducing the processing of foods without compromising on quality. Products that undergo minimal processing are gaining traction in the market, driven by the widespread belief that they can fulfill the current need for essential nutrients. The increasing consumer demand for minimally processed foods presents a substantial market opportunity, fostering innovation in extraction, preservation, and packaging technologies

Despite the overall benefits, minimal processing may alter some sensory attributes or result in nutrient loss if not carefully controlled. The future

holds potential for continued innovation in technologies to further enhance the nutritional content and quality of minimally processed foods, aligning with the increasing demand for natural and clean-label products. Therefore, it is crucial to reassess concepts before selecting processing techniques for fruits and vegetables. Modern and innovative processing modules offer alternatives to thermal processing, helping mitigate nutrient losses and enhance nutritive quality, thereby gaining greater consumer acceptability.

Need of minimally processed vegetables and fruits

A minimally processed product involves the washing, peeling, trimming, and slicing of fruits and vegetables, treated appropriately, and then packaged in sterilized glass containers. The primary goal of adopting fresh-cut, minimally processed technology is to extend the availability of these products in the market in their fresh form for an extended period. In the contemporary context, heightened awareness and concerns about nutrition and food safety are evident among consumers. The 21st-century consumer, empowered by modern technology and widespread internet access, is more informed and discerning than ever. This demographic seeks food options that are not only safe, reliable, and of high quality but also possess the necessary nutrients, all while avoiding the use of preservatives. Products subjected to minimal processing exhibit high-quality attributes, including color, flavor, aroma, and overall acceptance.

the perishable nature of fruits and vegetables, careful handling is crucial before and during storage.

Inadequate handling of fruits and vegetables can significantly diminish its shelf life and market share, with nearly half of the harvested product going to waste. The use of proper postharvest technologies can mitigate decay issues, particularly those caused by pathogenic attacks. Consumers typically opt for minimally processed products due to factors such as convenience, freshness, nutritional value, food safety, and dietary preferences. The demand for quality parameters from consumers has positively influenced the minimally processed industry, offering consumers a convenient way to access a variety of foods in a single packet or box. But the minimal processing necessitates investments in technology, equipment, and management systems. Adhering to strict food safety principles and practices is crucial to ensure the quality of these products.

Health Advantages of Minimally Processed Vegetables and Fruits

The nutritional advantages of minimally processed vegetables and fruits are valuable. Vegetables and fruits, known for their rich mineral and vitamin content, are recommended by the World Health Organization with a guideline of consuming at least 3 servings of vegetables and 2 servings of fruits daily. The recommended choices include fresh, frozen, dried, or canned vegetables, with a particular emphasis on incorporating dark-green leafy vegetables. These vegetables and fruits also contain phytochemicals that serve as antioxidants, acting as detoxifying agents, preventing tumour growth, and contributing to the modification of metabolic processes. Antioxidants play a vital role in providing oxidative stability to larger amounts of lipids and DNA at minute concentrations, safeguarding cells from oxidation and reacting with radicals.

Nutritional changes in minimally processed vegetables

Vegetables contain varying amounts of essential nutrients, including carbohydrates, vitamins, and minerals. In addition to major nutrients, there are minor components such as organic acids that play a crucial role in enhancing the appearance, taste, flavor, color, and aroma of fruits by interacting with sugar content. The aroma of fruits and vegetables is produced by esters of aliphatic alcohols and short-chain fatty acids.

The nutritional composition of fruits and vegetables is influenced by vitamins, particularly vitamin A, B, C, thiamine, and niacin. Minerals and dietary fibers also contribute to their nutritional profile. Various compounds, including carotenoid pigments, polyphenols, flavonoids, and other phytonutrients, are found in plant tissues. These compounds have been linked to reducing the risk of cancer and cardiovascular diseases in humans, minimally processed fruits and vegetables may exhibit visual blemishes without experiencing nutrient loss. Looking ahead, there is an anticipation that plant-breeding techniques could be instrumental in developing cultivars with enhanced nutritional characteristics that can withstand the effects of processing.

Emerging technologies in minimal processing

High-pressure processing (HPP)

High-pressure processing (HPP) stands out as a non-thermal technique increasingly employed to eliminate microbial cells by disrupting noncovalent bonds. This method effectively maintains the organoleptic properties and nutritional value of food without the use of high temperatures. HPP involves subjecting food to elevated hydrostatic pressure, effectively eliminating pathogens and extending shelf life without the need for heat or preservatives. In this process, products undergo high pressure in the range of 3000–8000 bars to deactivate microorganisms and enzymes without degrading flavors and nutrients. HHP has found extensive applications in the food processing industries, improving the nutritional quality of diverse food products, including dairy items, vegetables, fruits, fish, meat, and meat products.

Pulsed electric field (PEF) processing

PEF, or pulsed electric field, is a preservation technology This technique utilizes short electrical pulses with high voltages between two electrodes, keeping thermal effects low, contributing to the retention of nutritional content and the extension of flavor. PEF, recognized as a promising preservation method, effectively safeguards volatile flavor

compounds and thermolabile nutrients in comparison to traditional heat pasteurization. PEF is primarily employed to reduce microbial activity, extract value-added compounds, enhance the extraction of plant materials, facilitate mass transfer through cell disruption, and minimize stress induction in cells.

Ultrasound processing

Ultrasound technology enhances nutrient extraction, improves texture, and refines the flavor of certain products. Ultrasound treatments are recognized for their ability to deliver reproducible outcomes, cost-effectiveness, simplicity, and the achievement of high-purity products. Ultrasound refers to a longitudinal wave with a frequency beyond the upper limit of human hearing (20,000Hz). It is a nonthermal, nondestructive, nonintrusive, and noninvasive technology suitable for Minimal Processing of Fresh Produce, effectively preventing biochemical and microbial spoilage. This high-energy application can effectively inhibit enzymes responsible for quality loss, such as browning.

Non-thermal plasma treatment

This emerging technology utilizes ionized gas for sterilizing and decontaminating food surfaces, extending shelf life while maintaining nutritional quality. This nonthermal technology operates at atmospheric pressure and does not involve the use of chemicals or water. It is generated by applying energy to a gas mixture, leading to ionization and the accumulation of active compounds like radicals, charged particles, and UV radiation. Among these, free radicals prove to be the most effective against microorganisms. While this technique is actively being researched and utilized as an antimicrobial treatment, certain drawbacks have been noted, including the variability in the formed plasmas, which is contingent on numerous parameters. Consequently, comparing the effectiveness of specific conditions with other studies poses a challenge.

High-intensity light pulses

Light-based processing methods sterilize and preserve food without heat, thereby safeguarding natural nutrients and flavors. Pulse light (PL) treatment involves the application of a series of high-intensity, short bursts of light pulses to eliminate microorganisms. PL technology is effective for sterilizing packaging materials and equipment surfaces. However, its application in food processing is limited due to challenges posed by the opacity of certain food products, their non-uniform surfaces, and the potential temperature rise, which could adversely affect organoleptic qualities. Nevertheless, concerning the nutritional quality of foods, PL has been shown to maintain the levels of phytochemicals during post-harvest storage, with demonstrated enhancements in phenolic compounds, carotenoids, and antioxidant activity.

Enzyme-assisted extraction

Enzymes play a crucial role in breaking down cell walls in plant-based foods, enhancing the efficiency of nutrient extraction and preserving the nutritional content. The advantages of employing enzymes in this context include higher recovery yields, minimal contamination, and a high selectivity rate. However, there are certain disadvantages, such as the high cost of enzymes, extended processing times, and lower efficiency rates. The use of enzymes in food processing contributes to increased shelf life by reducing oxidative spoilage and microbial activity, while also improving the textural properties of the final product.

Edible film and coatings

An edible film is described as a thin layer or solid sheets of edible material applied onto or in between food components. The utilization of edible coatings aims to extend the shelf life of fresh and minimally processed produce, shielding them from adverse environmental effects. This need is underscored by the growing demand for high-quality minimally processed foods and advanced storage technologies. Edible coatings, by regulating the transfer of moisture, oxygen, carbon dioxide, and taste compounds in a food system, have proven effective in enhancing food quality and prolonging the shelf life of fresh produce. Furthermore, edible coatings can incorporate functional ingredients such as antioxidants, antimicrobials, nutrients, and flavor.

Hurdle technology

Hurdle technology represents an innovative approach to producing foods that are not only safe and

stable but also nutritious, flavorful, and cost-effective. This method involves the strategic combination of diverse preservation techniques to decontaminate fruits and vegetables. Hurdle technology is also referred to as combined processes, combined methods, combination preservation, combination techniques, or barrier technology. The key hurdles employed in food preservation within this approach include temperature variations (high or low), water activity, acidity, redox potential, preservatives, and the presence of competitive microorganisms. These efforts are driven by consumer concerns for healthier and improved food products that retain their natural nutritional characteristics.

Conclusion

In conclusion, minimal processing techniques play a pivotal role in preserving the nutritional integrity of fruits and vegetables. Technologies such as High-Pressure Processing (HPP), Pulsed Electric Field (PEF), ultrasound, non-thermal plasma, light pulses, enzyme-assisted extraction, and edible films contribute to maintaining essential nutrients, flavors, and textures while extending shelf life. These methods offer alternatives to traditional thermal processing, aligning with the contemporary consumer preference for natural, additive-free products. Despite potential drawbacks such as sensory alterations or nutrient loss, ongoing research and innovation continue to enhance the nutritional content and quality of minimally processed foods. The rising demand for minimally processed products reflects a consumer-driven shift towards convenient, fresh, and nutritionally rich food options. As the food industry embraces these technologies, the future holds promise for further advancements in preserving nutrients and meeting consumer expectations for healthier and high-quality food choices.

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