Emerging Technologies for Shelf-Life Enhancement of Food

Aditya Prasad Sahu, Suman Mohanta, P. Sameer, Minati Mohapatra* and Sanjaya K. Dash
Department of APFE, College of Agricultural Engineering and Technology, Odisha University of Agriculture and Technology, Bhubaneswar-3
Corresponding Authors: minati.agfe@gmail.com

Food preservation has been practiced for ages, with salting, smoking, pickling etc. usually regarded as the first and primitive methods of preservation. Conventional food preservation methods such as drying, freezing, chilling, pasteurization, Modified and control atmospheric packaging and other chemical preservation techniques are widely used and also becoming increasingly popular worldwide.Advances in food processing and engineering have led to a considerable evolution in preservation techniques through the use of creative strategies that involves reducing the microbial growth and metabolism to prevent undesirable chemical changes in food. Therefore, it articulates some of the most current advancements in food preservation techniques emerging now-a-days with a focus on safety, nutritional values and freshness of the products.

High-Pressure Processing

High-pressure processing, or HPP, is a "nonthermal" food preservation method that uses pressure instead of heat to pasteurize food, inactivate dangerous pathogens and vegetative spoilage bacteria. With the use of high pressure (Fig.1) (about 400–600 MPa or 58,000–87,000 psi) and cold or moderate process temperatures (less than 45°C), HPP preserves most foods with no affects on their nutritional content, taste, texture or appearance. Recent tests have demonstrated that HPP retains the scent of fresh fruit juices, making them quite appealing to customers. As a result, beverage manufacturers are actively looking to add HPP into fruit juice manufacturing. High-pressure processing has a lower effect on low molecular-weight chemicals such as vitamins, color pigments, and highly volatile flavoring compounds than ultra-heat treatment. It can be applied to raw materials such as milk, meat, and sea foods but also to products that have already been processed, such as sliced cooked meat products and RTE meals.

Cold Plasma Technology

Cold plasma technology is a new and novel approach that uses energetic, reactive gases for inactivating pathogenic microbes on meats, poultry, fruits, and vegetables. Cold plasma gets generated when a gas is partially ionized at atmospheric pressure or in a low-level vacuum. This resulting cold plasma comprises of free electrons, ions, UV light, and reactive chemical species such as O_3, NO, and NO_2. Cold plasma has been proven effective for inactivating food-borne germs from fresh produce, improving printability on packing materials, increasing antibacterial activity, wastewater treatment, changing structural features, degrading agrochemical residue, and disinfecting food processing equipment. Recent studies have shown that using high energy and low temperature plasma completely eliminated or significantly reduced low levels of bacteria in both skinless chicken breasts and chicken skin (fig. 2). Hence, this type of technology can be used in the fresh produce business after proper validation and process modifications to meet commercial market demands.

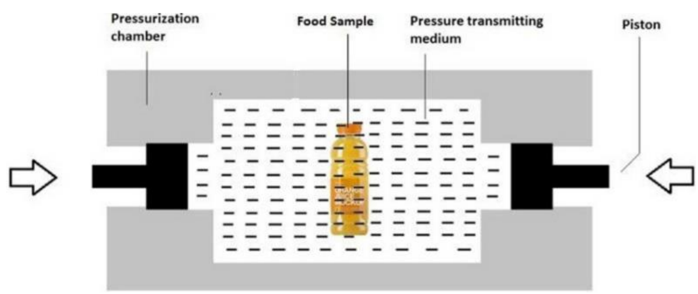

Fig. 1 Microbial inactivation by isostatic pressurization of foods (Source: Rachna Sehrawat *et al.*, 2020).

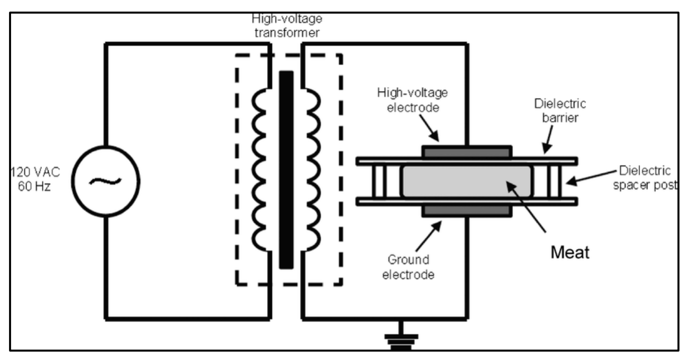

Fig. 2. In-package cold plasma treatment for chicken breast meat (Source: Hong Zhuang *et al.*, 2019).

Pulsed Electric Field Technology (PEF)

PEF processing uses a succession of short, high-voltage pulses. These pulses disrupt vegetative bacterial cell membranes by forming or widening existing pores (electroporation). The ruptures cause the leakage of intracellular contents, resulting in the concurrent loss of cellular metabolic activities such as growth and division, thereby inducing microbial inactivation A report revealed that pre-treatment of fresh tea leaves with PEF can enhance extraction yield, reduce extraction time, and manage temperature while maintaining phenolic profiles. PEF technology has recently been used in a variety of applications, including pasteurization, enzyme activity modification, food preservation, sugar extractions and pretreatment to improve metabolite extraction. Because of its energy efficiency, PEF processing holds great potential for the healthcare, food processing and biomedical engineering sectors in the future.

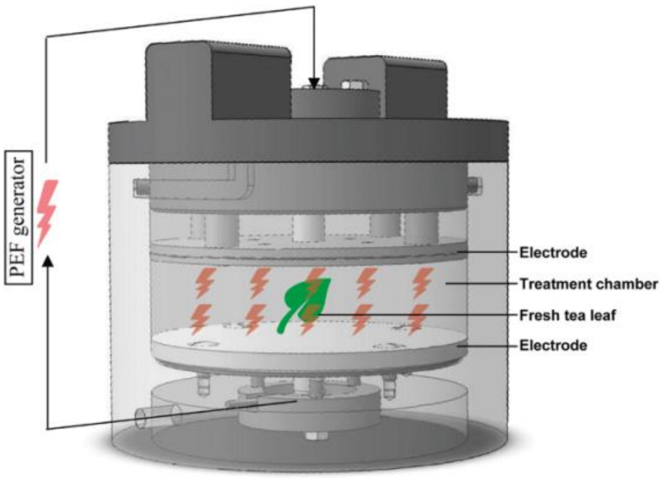

Fig. 3 PEF treatment on tea leaves (Source: Zhibin Liu *et al.*, 2019).

Infrared Drying

Infrared (IR) radiations are valuable source of energy in the food sector for a variety of applications including drying, roasting, pasteurization, blanching, peeling and removing antinutrients from legumes. Infrared rays penetrate raw materials, acting on them at the molecular level, allowing for high-quality product processing and extended shelf life without the use of preservatives. Infrared radiation allows evaporating water without harming the product's tissue, thus preserving the taste, vitamins, and biologically active compounds in the finished product. Figure 4 shows a simple setup for infrared drying. Infrared drying is a popular method for drying fruits and vegetables with high water content, such as kiwi, chives, and mushrooms, due to its low energy consumption, sensory quality, rehydration ability, and high nutrient retention. IR drying can be coupled with other drying technologies like as hot air, vacuum, microwave and freeze drying to increase the pace of the process and get superior outcomes.

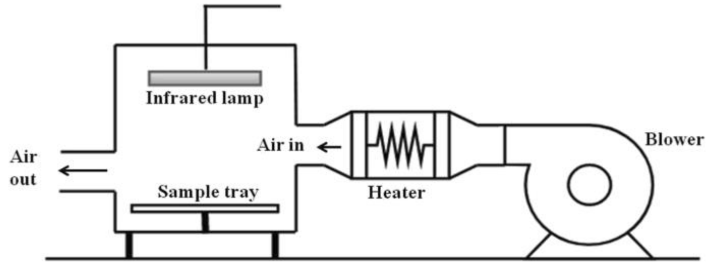

Fig. 4 Infrared drying setup for food (Source: Priyanka Sakare *et al.*, 2020)

Fortification with Extrusion Technique

Fortification is the process of increasing the nutritional content of fundamental foods such as rice, milk, and salt by adding minerals such as iron, iodine, zinc and vital vitamins such as A and D. There are various fortification technologies available, such as coating and dusting, however in India, 'extrusion' is widely considered as the most reliable technology. Extrusion-based fortification is successful because of micronutrient retention, increased bioavailability, reduced post processing losses, long-term storage stability and few sensory modifications. It has been found that after hot extrusion, rice protein no longer forms networks but rather appears as protein assemblies distributed throughout the kernel in which starch is now in the continuous phase, acting as a structural agent (fig. 5) and adjusting the degree of gelatinization allows for product swelling when cooked in water while avoiding excessive starch solubilization. All in all, fortification is a potential set of strategies that can increase global nutritional wellness and get us closer to eradicating hunger and malnutrition.

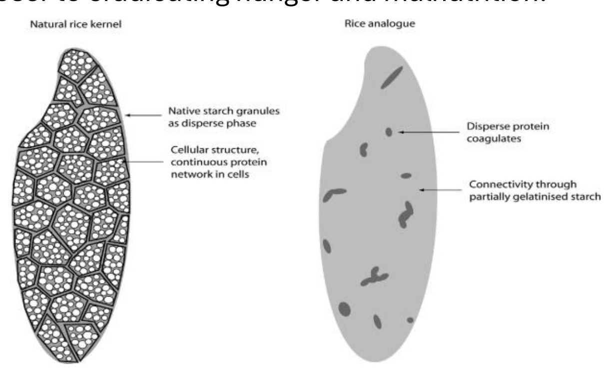

Fig. 5 Kernel microstructure of native and recomposed extruded rice (Source: Georg Steiger *et al.,* 2014).

Hurdle Technology

In order to achieve a safe product with an acceptable shelf life, taste, and consistency, hurdle technology applies a combination of hurdles such as heat, refrigeration, preservatives, irradiation etc. to inhibit or eliminate the growth of microbes. For example, minimal processing can be done to further prolong the shelf life of fish products through the combined application of preservative hurdles such as low storage temperature, addition of antimicrobials and/or antioxidants, water activity, pH, and high pressure processing with alternative packaging, such as modified atmospheres. Similarly hurdles Heat, high solids content, low water activity and high acidity all play a role in jams and fruit preserves. Hurdle technique preserves food commodities with little sensory and nutritional changes, making them more valuable and acceptable than traditional ways.

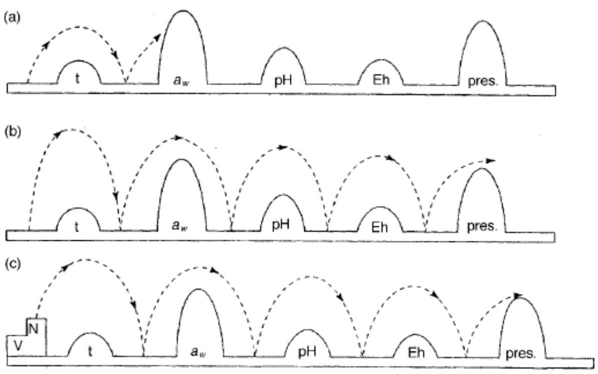

Fig. 6 Hurdles in food processing (t = chilling, *a*w = low water activity, pH = acidification, Eh = low redox potential, pres. = preservatives, V = vitamins, N = nutrients) (Source: P. Fellows, 2000)

Conclusions

There is a continuous evolution in the food sector which can be seen through its adoption of various advanced technologies which have a purpose of making sure products take long before them expire out. Innovations such as High-pressure processing, pulsed electric fields (PEF), Cold plasma technology, Fortification, Hurdle technology and Irradiation have shown significant strides in this field. In comparison to traditional heat treatments, these technologies have enhanced food availability and quality while being faster, more energy efficient and environmentally friendly. Various strategies such as advanced wrapping materials have been employed alongside new methods for treatment and all these strategies assist in maintaining the nutrition, quality and safety of our foods while still reducing wastage thus ensuring sustainable practices by industries. Innovative processing procedures are becoming increasingly popular due to their positive influence on health, leading to fewer complaints from consumers. Innovative food processing techniques are fast gaining traction in the global market, and will soon replace traditional thermal processing. However, there is a need to enhance the level of adoption of novel technologies so that the food business can fully capitalize on their potential benefits. As the researchers progresses with their work we are likely to witness more discovery of knowledge about preserving techniques of edibles as well as new modes through which they can be prepared.

References

Ahmad, J., Ali, M. Q., Arif, M. R., & Iftikhar, S. (2021). Review Article on; Traditional and Modern Techniques for Food Preservation. *International Journal of Modern Agriculture*, *10*(3), 219-234.

Fellows, P. J. (2022). *Food processing technology: principles and practice*. Woodhead publishing. Laroque, D. A., Seó, S. T., Valencia, G. A., Laurindo, J. B., & Carciofi, B. A. M. (2022).

Cold plasma in food processing: Design, mechanisms, and application. *Journal of Food Engineering*, *312*, 110748.

Liu, Z., Esveld, E., Vincken, J. P., & Bruins, M. E. (2019). Pulsed electric field as an alternative pre-treatment for drying to enhance polyphenol extraction from fresh tea leaves. *Food and Bioprocess Technology*, *12*, 183-192.

Riadh, M. H., Ahmad, S. A. B., Marhaban, M. H., & Soh, A. C. (2015). Infrared heating in food drying: An overview. *Drying technology*, *33*(3), 322-335.

Rostami, Z., Ahmad, M. A., Khan, M. U., Mishra, A. P., Rashidzadeh, S., & Shariati, M. A. (2016). Food preservation by hurdle technology: A review of different hurdle and interaction with focus on foodstuffs. *Journal of pure and applied microbiology*, *10*(4), 2633-2639.

Steiger, G., Müller-Fischer, N., Cori, H., & Conde-Petit, B. (2014). Fortification of rice: technologies and nutrients. *Annals of the New York Academy of Sciences*, *1324*(1), 29-39.

Tao, Y., Sun, D. W., Hogan, E., & Kelly, A. L. (2014). High-pressure processing of foods: An overview. *Emerging technologies for food processing*, 3-24.

* * * * * * * * *