TRENDS IN AGRICULTURE SCIENCE

Popular Article

Vol.4 Issue 04 April 2025, Page: 3150-3155

Approaches in Food Processing to Improve the Preservation of Fruits and Vegetables

[1]Rajdeep Gandhi and [2]K. R. Jethva

[1] YP-I (ICAR DoCA Project), PFE Department, College of Agricultural Engineering and Technology, Anand Agricultural University, Godhra-389001, Gujarat, India

[2]Associate Professor, PFE Department, College of Agricultural Engineering and Technology, Anand Agricultural University, Godhra-389001, Gujarat, India

DOI:10.5281/TrendsinAgri.15249404

Abstract

Various approaches used in food processing to preserve the Fruits and vegetables. Among them, thermal and non-thermal treatments are among the most focused research areas in the food sector due to consumer demands for safe and nutritious food free from microbes. These non-thermal technologies may lead to some undesirable changes in food, such as oxidation of lipids and loss of color and flavor. But these technologies have many advantages compared to thermal processing. Additionally, the development of equipment to process food in bulk using non-thermal technology, understanding the proper mechanisms, development of processing standards using non-thermal treatments, and clarifying consumer myths and misunderstandings about these technologies will be helpful in the promotion of Thermal and non-thermal technologies in the food sector.

INTRODUCTION

Fresh fruits and vegetables are vital sources of essential vitamins, minerals, and antioxidants. In recent years, their consumption has increased significantly, driven by growing health awareness and the recognition of their potential in preventing non-communicable diseases. Alongside nutritional value, food safety including chemical, microbial, and toxicological aspects as well as traceability, are now key concerns across the supply chain from farm to table. Food quality is defined by attributes such as appearance, texture, flavor, and nutritional value, which directly affect consumer acceptance. Typically, the quality of fruits and vegetables is assessed by external factors like size, shape, color, gloss, firmness, texture, and taste, as well as internal chemical, physical, and microbial characteristics that relate to safety, nutrition, and sustainability.

While fresh consumption is ideal, the perishability of fruits and vegetables often makes processing a necessary alternative. Techniques such as canning, dehydration, and chemical preservation extend shelf life and offer year-round availability. Processed fruit and vegetable products including juices, purees, canned goods, jams, pickles, chutneys, and dehydrated snacks vary

Published: 19 April 2025
ISSN: 2583-7850

widely by region and are tailored to market demands. Due to the short shelf life of fresh produce, processed forms often dominate international trade. India, the world's second-largest producer of fruits and vegetables, accounts for about 15% of global production, yet faces a post-harvest loss rate of 30-35% due to spoilage during harvesting, storage, transport, and distribution. This highlights the critical need for effective preservation and processing methods to reduce losses and meet consumer demand.

Proper handling, preparation, and storage are necessary to retain the nutritional value of fruits and vegetables. Minimally processed products typically undergo operations such as washing, trimming, peeling, cutting, sanitizing, and packing. Despite the continued dominance of thermal processing for ensuring microbial safety and shelf stability, consumer preferences are shifting toward minimally processed foods with better nutrient and flavor retention. This demand has spurred the development of non-thermal techniques like ozone treatment, ultraviolet light, pulsed light, cold plasma, ultrasound, and advanced packaging, all of which show promise in producing safer and fresher products with fewer compromises on quality.

FOOD PROCESSING AND PRESERVATION

Food processing involves transforming raw agricultural products into forms that are more convenient, safe, and stable for consumption. This includes primary processes like milling and secondary processes such as the production of juices, dairy products, bakery items, and ready-to-eat foods. India, despite being a global leader in agricultural output, processes only a small fraction of its produce less than 10% for fruits and vegetables, and only about 1% of its meat is converted into value-added products. Most of India's processed food industry remains in the unorganized sector, emphasizing the need for innovation and infrastructure to enhance value addition and farmer income.

Food preservation aims to prevent spoilage caused by physical, chemical, or biological agents. Traditional methods like salting, curing, smoking, drying, freezing, and heat treatment remain widely used, while modern technologies such as high-pressure processing (HHP), irradiation, and pulsed electric fields (PEF) are gaining attention. Preservation techniques are also classified into biological methods like fermentation, which uses beneficial microbes, and chemical methods involving substances such as salt, sugar, vinegar, and approved food-grade preservatives like sorbates, benzoates, sulfites, and nitrates. These advances continue to improve the safety, shelf life, and quality of food products worldwide.

Thermal Processing for Food Preservation

Thermal processing involves heating food to specific temperatures for set durations to eliminate harmful microorganisms and deactivate spoilage enzymes, thereby extending shelf life.

Published: 19 April 2025
ISSN: 2583-7850

i. Pasteurization

Named after Louis Pasteur, pasteurization involves heating food to a temperature below 100°C for a specific time to destroy most pathogens and spoilage microbes. Commonly used for juices, this process typically occurs between 75–88°C for 30 seconds to 30 minutes. It can be performed via low-temperature long-time (LTLT) or high-temperature short-time (HTST) methods.

ii. Sterilization

Sterilization applies higher heat than pasteurization, destroying all viable microbes, including spores. It significantly extends shelf life and includes methods like retorting and aseptic processing.

iii. Hurdle Technology

Hurdle technology combines multiple preservation methods (e.g., temperature, pH, water activity) to inhibit microbial growth. More than 60 "hurdles" are known to improve food safety and quality.

iv. Retorting

Retorting involves sealing food in containers (metal cans, glass jars, flexible pouches, or trays) and sterilizing them at temperatures above 100°C, especially for foods with pH > 4.5. It ensures long shelf life and protection from external contamination.

v. Aseptic Processing

This method sterilizes both the product and its packaging separately before filling under sterile conditions. It uses high-temperature short-time (HTST) processing (90–110°C) and is common in products like fruit juices packaged in tetra packs.

vi. Freezing

Freezing lowers food temperature to -18°C or below, halting microbial activity and slowing chemical changes. Though not sterilizing, it maintains juice flavor, color, and aroma, especially when freezing is done rapidly.

vii. Refrigeration

Refrigeration stores food between 0–8°C to slow microbial growth. It maintains food freshness over short durations and is widely used in the cold chain for perishable items.

viii. Chilling

Chilling keeps foods at −1 to 8°C to delay microbial and biochemical changes. It's achieved through systems like air coolers, heat exchangers, and vacuum chillers and helps extend the shelf life of fresh and processed items.

Published: 19 April 2025
ISSN: 2583-7850

ix. Drying

Drying removes moisture to prevent microbial growth. Natural drying (sun, solar, shade) lacks environmental control, whereas artificial (mechanical) drying allows precise control of heat, air, and humidity. It can involve methods like heated air drying, drum drying, microwave drying, and use of commercial dehydrators (e.g., tray, tunnel, spray, or vacuum dryers).

x. Blanching

Blanching is a pre-treatment that inactivates enzymes before freezing or drying. It also improves appearance, cleans produce, and softens texture. Methods include boiling, steaming, and microwaving.

NON-THERMAL PROCESSING FOR FOOD PRESERVATION

Non-thermal processing preserves food without heat, maintaining better nutrient and sensory properties. Major methods include ultrasound, pulsed electric field, and high-pressure processing.

i. Ultrasound Technology

Ultrasound (>16 kHz) uses sound waves to generate compression and shear forces that disrupt cell membranes and reduce microbial loads. High-intensity ultrasound (10–1000 W/cm^2) creates cavitation, localized heating, and enzyme inactivation. It also aids in tenderizing meats and improving water retention but is rarely used alone for preservation.

ii. Pulsed Electric Field (PEF)

PEF applies short pulses of high-voltage electric fields (25–85 kV/cm) for milliseconds, disrupting microbial cells without heating the food. Effective mainly for liquid or semi-solid foods, PEF systems consist of a treatment chamber with electrodes. Microbial inactivation depends on field intensity, exposure time, and energy input, making it a promising method for pasteurization without quality loss.

iii. High Pressure Processing (HPP)

First explored in 1899, HPP subjects' food to pressures between 100–1000 MPa to inactivate microbes and enzymes while preserving nutrients and flavor. It can be performed at ambient or chilled temperatures. Effectiveness depends on pressure level, duration, and microbial type. HPP is widely used for juices, meats, and ready-to-eat foods.

iv. Cold Plasma Technology

Plasma, known as the fourth state of matter, was first termed by Langmuir in 1925. When gases are energized beyond a certain threshold, ionization occurs, forming plasma. Plasma treatments are classified into thermal and cold (non-thermal) types. Cold plasma, operating at 25–65°C, is particularly useful in food processing. In the food industry, cold plasma is applied to reduce microbial load on food surfaces, enhance the quality of food components like lipids and proteins, sterilize equipment, inactivate spoilage enzymes, treat packaging materials, and purify wastewater. Microbial inactivation results from reactive species generated by plasma, which damage DNA, proteins, and cell membranes, leading to microbial death. It is also effective in disinfecting food contact surfaces before processing.

v. Irradiation

Irradiation uses high-energy gamma rays, X-rays, or electron beams to preserve food without raising its temperature, thus preventing heat damage to sensitive nutrients. Common sources include gamma rays from radionuclides like Cobalt-60 and Cesium-137, X-rays (up to 5 MeV), and electron beams (up to 10 MeV). This technique damages microbial DNA and generates reactive oxidative species, effectively reducing harmful pathogens such as *E. coli*, *Staphylococcus*, and *Salmonella*. It also extends shelf life and enhances food safety with minimal impact on quality when used at low doses, often in combination with antimicrobial agents. Consumer education and better technology design are essential for wider acceptance of irradiated foods.

vi. Ultraviolet (UV) Light

UV radiation is classified by wavelength: UV-A (315–400 nm), UV-B (280–315 nm), and UV-C (100–280 nm). UV-C, especially at 254 nm, is commonly applied post-harvest to fresh fruits and vegetables due to its antimicrobial properties. It directly damages microbial DNA and can trigger resistance mechanisms in plants against pathogens. Low-dose UV-C treatment helps reduce spoilage and extend the freshness of various fruits and vegetables.

CONCLUSION

It can be concluded that there are many different technologies to reduce/eliminate the microorganisms present in fresh-cut fruits and vegetables. The proper use of these techniques will allow an increase safety of the minimally processed products. Thermal and non-thermal treatments are among the most focused research areas in the food sector due to consumer demands for safe and nutritious food free from microbes. These non-thermal technologies may lead to some undesirable changes in food, such as oxidation of lipids and loss of color and flavor. But these technologies have many advantages compared to thermal processing. Additionally, the development of equipment to process food in bulk using non-thermal technology, understanding the proper mechanisms, development of processing standards using non-thermal treatments, and clarifying consumer myths and misunderstandings about these technologies will be helpful in the promotion of Thermal and non-thermal technologies in the food sector.

REFERENCES

Mahajan, P.V.; Caleb, O.J.; Singh, Z.; Watkins, C.B.; Geyer, M. Postharvest Treatments of Fresh Produce. Philos. Trans. R. Soc. Math. Phys. Eng. Sci. 2014, 372, 20130309. [CrossRef] [PubMed]

Brasil, I.M.; Siddiqui, M.W. Postharvest Quality of Fruits and Vegetables: An Overview. In Preharvest Modulation of Postharvest Fruit and Vegetable Quality; Elsevier: Amsterdam, The Netherlands, 2018; pp. 1–40. ISBN 978-0-12-809807-3.

Chauhan, O.P.; Lakshmi, S.; Pandey, A.K.; Ravi, N.; Gopalan, N.; Sharma, R.K. Non-Destructive Quality Monitoring of Fresh Fruits and Vegetables. Def. Life Sci. J. 2017, 2, 103. [CrossRef]

NIIR Board of Consultants & Engineers. (2016). The complete technology book on processing, dehydration, canning, preservation of fruits & vegetables.

Torres, E. F., Rodrigo, D., & Martínez, A. (2016). Preservation of foods.

Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 19 April 2025
ISSN: 2583-7850