Preserving Fruits and Vegetables: The Role of Canning in the Food Industry

Anerao K. K.* and Gangakhedkar Prasad S.

Ph.D. Research Scholar, Department of Food Microbiology and Safety, College of Food Technology, VNMKV, Parbhani

Corresponding Author: kishoranerao135101@gmail.com

Abstract

Canning is a vital food preservation technique involving hermetic sealing and heat sterilization to maintain quality and extend shelf life. Originating in the early 19th century, modern canning has evolved to address economic, environmental, and safety challenges. The process begins with the selection of fresh, blemish-free fruits or vegetables, followed by grading, washing, and peeling using methods tailored to specific fruits and vegetables. Blanching, a crucial step, enhances texture, inactivates enzymes, and improves color while minimizing microbial loads. The filling stage involves syruping or brining, which enhances flavor and aids in heat transfer during processing. Exhausting removes air to prevent spoilage and discoloration, while sealing ensures airtight containment. Processing at optimal temperatures ensures microbial safety without compromising nutritional and sensory qualities. Cooling and proper storage techniques prevent quality degradation, ensuring products retain their appeal for up to two years.

Tin containers dominate the industry due to their durability, lightweight nature, and cost efficiency, though glass containers are preferred for certain applications. Regulatory standards established by the Food Safety and Standards Authority of India (FSSAI) govern packaging, labelling, and quality to ensure consumer safety. Innovations in canning technology, such as multi-product strategies and emerging alternatives to traditional materials, enhance sustainability and efficiency. Despite challenges, canning remains a fundamental pillar of the food industry, preserving the nutritional and economic value of fruits and vegetables while meeting modern quality and environmental standards.

Introduction

Emerging technologies in canning technology can preserve food within a certain period, mainly traditional foods with the development process of transfer technology. Through SMEs, the prospect of traditional food canning can use as a way out in increasing sustainable economic value (Hendrix et al., 2021).

Understanding the influence of processing operations such as drying/dehydration, canning, extrusion, high hydrostatic pressure, pulsed electric field, and ohmic heating on the phytochemicals of fruits, vegetables, and grains is important in retaining the health benefiting properties of these antioxidative compounds in processed food products (Kaur, 2020).

The main crucial subsystems of the value chain are tuna fishing and the canning process, as it was expected considering other similar studies on seafood products. Moreover, this specific case study demonstrates that the multi-product strategy applied to the canning sector is environmentally viable. Thus, although the environmental impacts of the entire system are increased by including further valorisation operations, the environmental loads assigned to the main product (canned tuna) decrease compared to the one-product system by assigning environmental burdens to other value-added products (tuna pâté, fishmeal, and fish oil) (Cortés et al., 2021).

Canning, a method of preserving food through hermetic sealing and heat sterilization, originated in 1804 with Nicolas Appert, known as the 'Father of Canning.' His work laid the foundation for modern canning, sometimes referred to as appertizing. England also contributed to canning's development, with Saddington describing a method in 1807, and Peter Durand obtaining the first British patent for commercial fruit canning in the U.S. in 1810 (EIRI Board, 2007)

Fruits and vegetables are canned during peak seasons when raw materials are abundant. The preserved products are then sold in the off-season, providing better returns for growers. Canning has evolved into a vital method for preserving food quality, ensuring availability beyond natural harvest periods.

Principle and process of canning

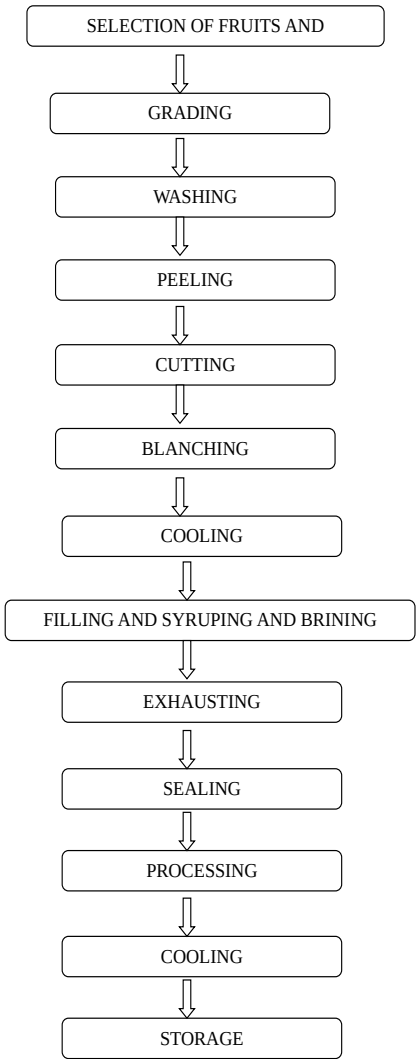
Principle: "Destruction of spoilage organisms within the hermitically sealed container by means of heat."

Canning process includes following crucial steps.

Selection of Fruits and Vegetables

- Fruits and vegetables should be absolutely fresh.
- Fruits should be ripe, but firm, and uniformly mature. Over-ripe fruits should be rejected because they are infected with microorganisms and give a poor-quality product. Unripe fruits should be rejected because they generally shrivel and roughen on canning.
- All vegetables except tomatoes should be tender.
- Tomatoes should be firm, fully ripe and of deep red colour.
- Fruits and vegetables should be free from dirt.
- They should be free from blemishes, insect damage or mechanical injury.

Flow-sheet for caning process



Grading

The canning process begins with the careful selection of fresh and ripe fruits and vegetables, followed by grading—a critical step in ensuring uniform quality. During grading, the size and color of the produce are assessed either manually by skilled workers or using advanced machines such as screw graders and roller graders. Smaller fruits like berries and cherries are graded in their whole form, while larger fruits, including peaches and pineapples, are graded after being cut into pieces or slices. This meticulous approach to grading plays a vital role in maintaining the consistent quality of canned products, enhancing their visual appeal, texture, and flavor.

Washing

The removal of pesticide residues and dust from fruits and vegetables is essential for ensuring food safety. Various methods are employed to achieve effective cleaning. Root crops, often heavily soiled, are soaked in water containing 25 to 50 ppm chlorine, which acts as a detergent to loosen dirt. Additional techniques, such as spray washing and steam washing, further enhance the cleaning process, effectively reducing contaminants and minimizing potential health risks.

Peeling

The objective of peeling is to eliminate the outer layer, and various techniques are employed to achieve this:

Hand Peeling: Applied to fruits with irregular shapes, such as mangoes and papayas, where mechanical peeling is impractical.

Steam Peeling: Free-stone and clingstone peaches undergo steam peeling; free-stone peaches are cut and steam washed. Steam or boiling water is also used for peeling potatoes and tomatoes.

Mechanical Peeling: Employed for apples, peaches, pineapples, cherries, and root vegetables like carrots, turnips, and potatoes.

Lye Peeling

Used for peaches, apricots, sweet oranges, mandarin oranges, carrots, and sweet potatoes. Involves dipping in a 1 to 2 percent boiling caustic soda solution (lye) for 30 seconds to 2 minutes, depending on the nature and maturity of the produce. The hot lye dissolves pectin, loosening the skin, making it easy to

remove. Any remaining alkali is eliminated by thorough washing in cold water or a brief dip in a 0.5 percent citric acid solution, reducing peeling costs and minimizing wastage.

Flame Peeling

Specifically used for garlic and onions with a papery outer covering, where the outer layer is burnt off. Other vegetables, like peas, are shelled, carrots are scraped, and beans are snipped or trimmed. These diverse peeling methods cater to the unique characteristics of different fruits and vegetables, ensuring efficiency and minimizing waste in the canning process.

Cutting

Pieces of the size required for canning are cut. Seed, stone and core are removed. Some fruits like plum from which the seeds cannot be taken out easily are canned whole.

Blanching

Blanching, also referred to as scalding, parboiling, or precooking, is an essential step in the canning process, primarily used for vegetables. In contrast, fruits typically bypass blanching to preserve their active oxidizing enzyme systems. For vegetables, the process involves brief exposure to boiling water or steam, usually for 2 to 5 minutes, followed by rapid cooling. Blanching softens the texture of vegetables, enabling a higher weight to be packed into containers without damaging individual pieces. The duration and intensity of blanching are carefully adjusted based on the type of vegetable, ensuring optimal texture and preservation in the final canned product.

This concise heat treatment serves multiple purposes in the canning process

1) Enzyme Inactivation: Inactivates plant enzymes responsible for toughness, discoloration (polyphenol oxidase), mustiness, off-flavour (peroxidase), softening, and loss of nutritive value in fruits and vegetables.

2) Shrinkage for Easy Packing: Reduces the size of leafy vegetables like spinach through shrinkage or wilting, facilitating easier packing.

3) Gas Removal: Eliminates tissue gases, particularly sulphides, enhancing the quality of the final product.

4) Microorganism Reduction: Decreases the microbial load by up to 99%, contributing to longer shelf life and increased safety.

5) Color Enhancement: Improves the green color of vegetables such as peas, broccoli, and spinach, enhancing visual appeal.

6) Saponin Removal: Eliminates saponin in peas, a compound that can impart undesirable flavors.

7) Acid and Astringent Taste Removal: Removes undesirable acids and astringent taste from peels, improving overall flavor.

8) Facilitates Peeling: Prepares vegetables like beetroot and tomatoes for easier peeling by removing the skin.

In short, blanching is a versatile heat treatment that not only addresses quality and safety concerns but also enhances the aesthetic and flavor attributes of the canned fruits and vegetables.

Disadvantages

1) Leaching of Water-Soluble Materials

Boiling water used in blanching can lead to the leaching of water-soluble components such as sugar and anthocyanin pigments.

2) Loss of Colour, Flavour, and Sugar in Fruits

Fruits subjected to blanching may experience a reduction in colour, flavour, and sugar content, impacting their overall quality.

Cooling

After blanching, vegetables are rapidly cooled in cold water to improve handling and preserve their optimal condition for subsequent processing.

Filling

Cans, pre-treated with hot water or steam, undergo the filling stage where advanced countries utilize automatic, large can-filling machines, while in developing countries like India, choice fruit grades are typically filled by hand to prevent bruising; this process, known as syruping or brining, involves covering the filled cans with syrup or brine.

Syruping

The quantities of sugar to be dissolved in one liter of water to make syrups of different concentrations are given in the table 1 below.

A sugar and water solution, known as syrup, is commonly used in canning, typically made from white, refined sucrose sourced from cane or beet; primarily employed for fruits, syrup enhances flavor and serves as

a heat transfer medium during processing. The process, called syruping, involves pouring a strained, hot syrup (with a concentration of 20-55º Brix) onto the fruit, with the syrup's concentration adjusted based on the acidity of the fruit. The filling is done at approximately 79-82º Brix, leaving a small headspace of 0.3 to 0.5 cm. In some cases, citric acid and ascorbic acid may be added to the syrup to improve flavor and nutritional value, respectively.

Sugar (kg)	Syrup Concentration (%)
0.250	20
0.333	25
0.428	30
0.538	35
0.666	40
0.818	45
1.000	50
1.222	55

Brining

Brining, involving a solution of salt in water known as brine, shares a purpose similar to syruping but is exclusively applied to vegetables. Using good-quality, iron-free common salt, a hot brine with a concentration of 1 to 3% is poured over vegetables at a temperature of 79 to 82°C, leaving a headspace of 0.3 to 0.5 cm. Prior to filling, the brine is filtered through a thick cloth to ensure clarity and cleanliness.

Brines of different strengths are prepared by dissolving different amounts of salt in one litre water, as shown in the table 2 below.

Salt (g)	Brine Concentration (%)
10.00	1
20.40	2
30.92	3
41.66	4
47.33	5
111.11	10
176.47	15

Modernized Canning Lid Process:

Following syruping or brining, cans are loosely covered with lids and exhausted; traditional lidding methods come with disadvantages like content spilling and lid topping. Modernization introduces the 'clinching' process, where lids are partially seamed. This technique allows lids to remain loose enough to facilitate the escape of dissolved and free air, along with vapor formed during the exhausting process, addressing drawbacks associated with traditional lidding methods.

Exhausting

The process of removal of air from cans is known as exhausting. After filling and lidding or clinching, exhausting is essential which has following advantages.

i) Corrosion Prevention: Avoids tinplate corrosion and pin-holing during storage.

ii) Discoloration Minimization: Prevents oxidation, minimizing contents' discoloration.

iii) Vitamin Retention: Aids in better retention of vitamins, especially vitamin C.

iv) Prevention of Can Buildup: Guards against can expansion in hot climates or high altitudes.

v) Reduced Chemical Reaction: Minimizes chemical reactions between the container and contents.

vi) Pressure Regulation: Prevents excessive pressure and strain during sterilization.

Exhausting Methods in Canning

Containers are exhausted either through heat treatment or mechanically, with the heat treatment method being more common. The cans undergo a hot water treatment at 82 to 87°C or move through a covered steam box. In the water exhaust box, cans are positioned with the water level 4-5 cm below their tops. The box is heated until the water reaches 82 to 100°C, ensuring the can's center reaches around 79°C. Exhausting time varies (6 to 10 minutes) based on the product. Glass jars or bottles often use vacuum closing machines, maintaining high vacuum levels in a closed chamber. Lower-temperature, longer-duration exhausting is preferred to avoid softening the contents into pulp. High-temperature exhausting is discouraged as it generates more water vapor, leading to a greater vacuum in the can.

Sealing: After exhausting, cans are immediately sealed airtight with a can sealer, while glass jars utilize a rubber ring between the mouth and lid for an airtight seal, ensuring the temperature during sealing remains above 74°C.

Processing: In canning, processing involves the heating or cooling of canned foods to deactivate bacteria, a vital preservation step. While extreme temperatures can eliminate bacterial spores, such treatments can

compromise food quality. Optimal processing conditions require adequate time and temperature to eliminate bacterial growth without over-cooking, preserving flavor and appearance. Most fruits and vegetables can be satisfactorily processed at 100°C, with acidity inhibiting bacterial growth. Non-acidic vegetables, prone to soil contamination, are processed at higher temperatures (115 to 121°C). The acidity of fruits and vegetables, measured by pH, influences microbial destruction, with lower pH levels facilitating easier processing and sterilization. Achieving effective sterilization while maintaining food quality is a delicate balance in canning technology.

Table 3. Fruits and vegetables can be classified into the following four groups according to their pH value

Class	pH	Product
Low acid, (called non-acid)	Above 5.0	Vegetables such as pea-s, lima bean, asparagus potato, cauliflower, spinach, beet, corn, French bean
Medium acid	4.5-5.0	Turnip, carrot, okra, cabbage, pumpkin, beet, green bean, etc., and products like soups and sauces
Acid	3.7-4.5	Tomato, pear, banana, mango, jackfruit, pineapple, sweet cherry, peach, apple and
High acid	Below 3.7	juice, rhubarb, prune, sauerkraut, pickle, chutney, etc.

In India, small vertical stationary retorts (frontispiece) are generally used for canned vegetable processing. The sealed cans are placed in the cookers, keeping the level of water 2.5 to 5.0 cm above the top of the cans. The cover of the cooker is then screwed down tightly and the cooker heated to the desired temperature. The period of sterilization (processing) should be counted from the time the water starts boiling. After heating for the required period, the cooker is removed from the fire and the petcock is opened. When the pressure comes down to zero the cover is removed and the cans are taken out.

Cooling

After processing. the cans are cooled rapidly to about 39°C to stop the cooking process and to prevent stack-burning. Cooling is done by the following methods:

(i) dipping or immersing the hot cans in tanks containing cold water;

(ii) letting cold water into the pressure cooker specially in case of vegetables;

(iii) Spraying cans with jets of cold water; and

(iv) exposing the cans to air.

Generally, the first method, i.e., dipping the cans in cold water, is used. If canned products are not cooled immediately after processing, peaches and pears become dark in colour, tomatoes turn brownish and bitter in taste, peas become pulpy with cooked taste and many vegetables develop flat sour (become sour).

Storage

After labelling the cans, they should be packed in strong wooden cases or corrugated cardboard cartons and stored in a cool and dry place. The outer surface of the cans should be dry as even small traces of moisture sometimes induce rusting. Storage of cans at high temperature should be avoided, as it shortens the shelf-life of the product and often leads to the formation of hydrogen swell. The marketable life of canned products varies according -to the type of raw materials used. Canned peach, grapefruit, pineapple, beans, spinach, pea etc., can be stored for about two years, while pear, apricot, carrot, beetroot, tomato, etc., can be stored for a comparatively short period only.

Valsikova & Vargova (2010), investigated selenium changes in garden peas, white cabbage, and tomatoes grown in treated and untreated soils, focusing on processing effects. For garden peas, 77% of selenium remained in grains after canning in salt pickle. In white cabbage, the majority of selenium stayed in the solid fraction, with 11–14% extracted to pickle, while tomatoes and their products, particularly purée, were identified as a relatively rich source of selenium, primarily concentrated in the seeds.

Containers for packing of canned products

Both tin and glass containers are used in the canning industry, but tin containers are preferred.

Tin containers

Tin cans, composed of thin, low-carbon steel coated with tin metal on both sides, may have

microscopic, uncoated spots during manufacturing. These spots, although imperceptible to the eye, can lead to product discoloration or tin plate corrosion due to reactions with the can's contents. To address this, the interior of the can is coated with a lacquer, a material that prevents discoloration without compromising the flavor or wholesomeness of the contents. This protective process is known as "lacquering."

Tin containers are favoured over glass containers due to several advantages:

i) Ease of Fabrication: Tin containers are easily fabricated, offering simplicity in the manufacturing process.

ii) Strength for Processing: They possess the strength to withstand various processing methods, ensuring durability during production.

iii) Lightweight: Tin containers are lightweight, making them easier to handle and transport.

v) Ease in Handling: Their design allows for easy handling, contributing to convenience in storage and transportation.

vi) Cost Efficiency: Tin containers are cost-effective, providing an economical packaging solution.

Compatibility with High-Speed Machines: They can be efficiently handled by high-speed machines, enhancing overall processing efficiency.

Glass Containers

Advantages of Glass Containers:

i) Visibility: Transparent nature allows easy display of contents.

ii) Reusable: Glass containers are reusable, promoting sustainability.

iii) Non-Contaminating: High-quality glass does not contaminate contents.

iv) Preferred for Baby Food: Often chosen for packaging baby food due to purity.

v) Challenges of Fragility: Fragile nature requires careful handling during processing and transportation.

vi) Emerging Alternatives: Research explores plastic containers and heat-sealable pouches as potential substitutes.

Fssai regulatory standards for canning of fruit and vegetables

The Food Safety and Standards Authority of India (FSSAI) has established comprehensive regulations for the canning of fruits and vegetables to ensure product safety and quality. Key aspects of these regulations include:

Packaging Requirements: Canned Fruits, Juices, and Vegetables: Must be packed in sanitary top cans made from suitable tin plates. Bottled Fruits, Juices, and Vegetables: Should be sealed in bottles or jars capable of providing a hermetic seal.

Labelling Standards: Products must comply with the Food Safety and Standards (Packaging and Labelling) Regulations, 2011.

Quality Standards: The FSSAI has set specific standards for various processed fruit and vegetable products, including thermally processed fruits and vegetables, fruit juices, and fruit-based beverages.

Hygiene and Safety

Manufacturers are required to adhere to guidelines specified in Schedule 4 of the Food Safety and Standards (Licensing and Registration of Food Businesses) Regulations, 2011, ensuring proper sanitation and safety during processing. The Food Safety and Standards Authority of India (FSSAI) has established specific regulations for the canning of fruits and vegetables, particularly concerning Total Soluble Solids (TSS) and the use of preservatives. Key aspects of these regulations include:

Total Soluble Solids (TSS)

Definition: TSS refers to the concentration of dissolved sugars, acids, and other soluble substances in a product, influencing its sweetness and preservation.

Standards for Canned Products: FSSAI specifies minimum TSS percentages for various canned fruit and vegetable products to ensure quality and safety. For instance, certain fruit products are required to have a minimum TSS content, which varies depending on the type of product.

Use of Preservatives

Permitted Preservatives: FSSAI allows specific preservatives in canned fruits and vegetables to inhibit microbial growth and extend shelf life. Commonly permitted preservatives include sulfur dioxide (SO_2) and benzoic acid, each with defined maximum permissible limits.

Concentration Limits: The allowable concentration of preservatives varies by product type. For example, certain chutneys may contain up to 100 ppm of SO_2 or 250 ppm of benzoic acid.

Regulatory References

Food Products Standards and Food Additives Regulations, 2011: This regulation outlines standards for processed fruits and vegetables, including permissible additives and their limits.

Compendium of Food Additives Regulations: This document provides detailed information on approved food additives and their permissible levels in various food products.

Manual of Methods of Analysis of Foods: This manual offers standardized methods for analyzing fruit and vegetable products to ensure compliance with FSSAI standards. (FSSAI, 2006).

Table 4 Specific requirement for canning of fruits

Fruits	Preparation	Syrup Strength(°B)	Exhaust	Processing time at 100°C A2½ can) minutes	Type of can
Banana	Peel, cut in to slices 12mm thick	30	-do-	25	plain
Guava	Peel, cut into pieces, remove seeds and keep in 2% brine to prevent browning and fill in can.	40	-do-	20	plain
Pineapple	Peel, core and slice fruit, punch circular rings (5.6-8.8 cm diameter)	40	-do-	25	plain
Pear	Peel by hand, cut longitudinally into two halves, core and keep in 2% brine to prevent browning until filled in cans.	40+0.1% citric acid	-do-	20-25	plain
Mango	Peel, cut into slice, dip in 2% salt solution until filled in can.	40+0.3% citric acid	-do-	25	plain

(Ref. Processing of Horticulture crops. Lecture 7-Canning and bottling of Fruits and Vegetables. e-Krishi Shiksha.www.Agrimoon.com)

Conclusion

Canning is a crucial method for preserving fruits and vegetables, extending their shelf life while maintaining quality and safety. By combining advanced techniques with adherence to stringent regulatory standards, it enhances nutritional value, ensures consumer safety, and supports sustainability. This integration of innovation and compliance solidifies canning's indispensable role in the modern food industry.

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