

Technology of Fruits and Vegetable Processing (FST-512)

Compiled By: Dr. Priti Jain and Dr. Pratibha Parihar

M.Sc.(Food Sci. & Tech): First Year, Second Semester

UNIT I: Indian and global scenario on production and processing of fruits and vegetable; Quality requirements of raw materials for processing; sourcing and receiving at processing plants; primary processing: grading, sorting, cleaning, washing, peeling, slicing and blanching; minimal processing.

UNIT II : Processing for pulp, puree and concentrates, especially from mango, tomato, guava, papaya, apple, pineapple, pomegranate, grapes etc. using aseptic packaging, canning, RTS fruit beverages, IQF and frozen fruits and vegetables; for peas, mango pulps etc.

UNIT III: Technology for processed products like pickles, chutneys, sauces particularly from raw mango, lime and other regional fruits and vegetables of importance.

UNIT IV: Processing of fruits for candies, bars, toffees, jams and jellies, squashes and syrups using locally available fruits like papaya, mango, aonla and other under-utilized fruits.

UNIT V: Dehydration of fruits and vegetables using various drying technologies like sun drying, solar drying (natural and forced convection), osmotic, tunnel drying, fluidized bed drying, freeze drying, convectional and adiabatic drying; applications to raisins, dried figs, vegetables, intermediate moisture fruits and vegetables. Fruit powders using spray drying.

UNIT I

Indian and global scenario on production and processing of fruits and vegetable

The Green Revolution and subsequent efforts through the application of science and technology or increasing food production in India have brought self-reliance in food. The impetus given by the Government, State Agricultural Universities, State Departments of Agriculture and other organizations through the evolution and introduction of numerous hybrid varieties of fruits and vegetables and improved management practices have resulted in increased food production. Fruits and vegetables are among the perishable commodities. They are important ingredients in the human dietaries. Due to their high nutritive value they make significant nutritional contribution to human well-being. They are the cheaper and better source, the protective foods. In developing countries agriculture is the mainstay of the economy. Fruit and vegetable processing are among the most important. Therefore, fruit and vegetable processing has been engaging the attention of planners and policy makers as it can contribute to the economic development of rural population. The utilization of resources both material and human is one of the ways of improving the economic status of family.

India is endowed with a remarkably heterogeneous area characterized by a great diversity of agro climatic zones. It allows for production of a variety of horticultural crops such as fruits, vegetables, flowers, spices, plantation crops, root and tuber crops, and medicinal and aromatic crops.

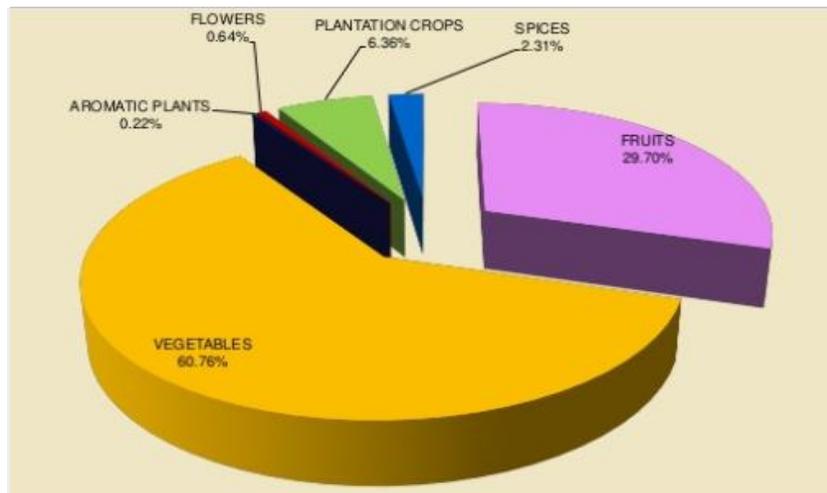


Fig. 1: Production share of horticultural crops in India

India's diverse climate ensures availability of all varieties of fresh fruits & vegetables. It ranks second in fruits and vegetables production in the world, after China. As per National Horticulture Database published by National Horticulture Board, during 2015-16, India produced 90.2 million

metric tonnes of fruits and 169.1 million metric tonnes of vegetables. The area under cultivation of fruits stood at 6.3 million hectares while vegetables were cultivated at 10.1 million hectares. India is the largest producer of ginger and okra amongst vegetables and ranks second in production of potatoes, onions, cauliflowers, brinjal, Cabbages, etc. Amongst fruits, the country ranks first in production of Bananas (25.7%), Papayas (43.6%) and Mangoes (including mangosteens and guavas) (40.4%). The vast production base offers India tremendous opportunities for export. During 2018-19, India exported fruits and vegetables worth Rs. 10236.93 crores/ 1,469.33 USD Millions which comprised of fruits worth Rs. 4817.35 crores/ 692.01 USD Millions and vegetables worth Rs. 5419.48 crores/ 777.25 USD Millions. Grapes, Pomegranates, Mangoes, Bananas, Oranges account for larger portion of fruits exported from the country while Onions, Mixed Vegetables, Potatoes, Tomatoes, and Green Chilly contribute largely to the vegetable export basket. The major destinations for Indian fruits and vegetables are Bangladesh, UAE, Netherland, Nepal, Malaysia, UK, Sri Lanka, Oman and Qatar. Though India's share in the global market is still nearly 1% only, there is increasing acceptance of horticulture produce from the country.

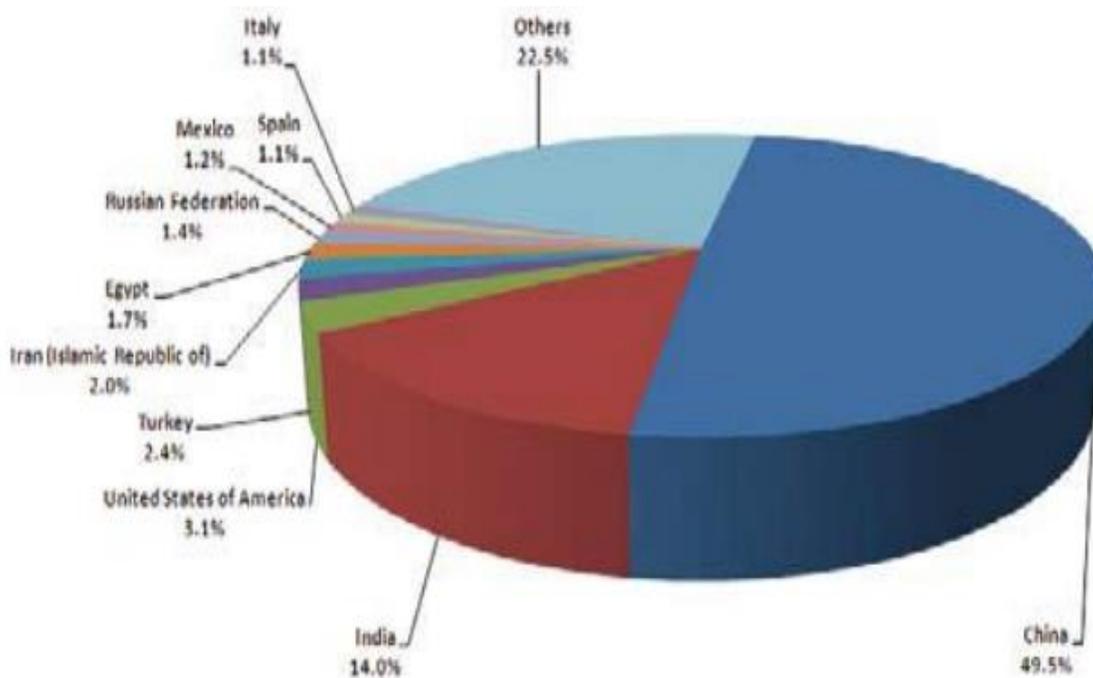


Fig. 2: Major vegetables producing countries

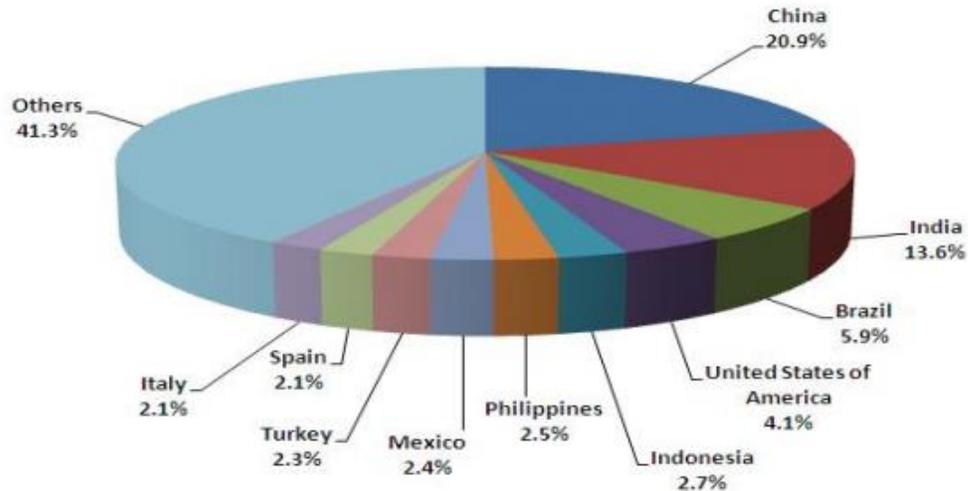


Fig.3: Major fruits producing countries

Objectives of fruit and vegetable processing:

- 1) To reduce wastage and losses: Fruit and vegetable industry is the backbone of horticulture industry as it takes care of all possible waste that occurs in spite of improvement in the distribution and marketing of fresh produce.
- 2) To handle glut: Produce during glut season utilized for making different processed products, thus fruit processing helps in reducing wastage and handling excess produce during glut season.
- 3) To stabilize farm prices and income: It stabilizes farm price by utilizing the excess produce in value addition to provide additional income to the farmers.
- 4) To utilize marketable surplus: Processing utilizes marketable surplus as well as cull and deformed produce, to ensure remunerative returns to the growers.
- 5) To generate employment: Processing of fruits and vegetables being a labour intensive helps to generate both direct and indirect employment for the masses.
- 6) To add variety to the diet: Value addition/processing make the food more attractive and palatable.
- 7) To ensure nutritional security.
- 8) To earn foreign exchange through export of processed fruit and vegetable products.

Principles of food preservation

- 1) Prevention or delay of microbial decomposition of food
 - By keeping out micro-organisms (asepsis)
 - By removal of micro-organisms (filtration)
 - By hindering the growth or activity of micro-organisms (use of low temperature, drying, creating anaerobic conditions or using chemicals).

- By killing the micro-organisms (using heat or irradiation).
- 2) Prevention or delay of self decomposition of food
 - By destruction or inactivation of food enzymes (blanching or boiling)
 - By prevention or delay of purely chemical reactions (use of antioxidants to prevent oxidation).
 - 3) Prevention of damage by insects, animals, mechanical causes etc (use of fumigants, cushioning, packaging etc).

Processing of fruit and vegetable

- a) **Primary processing:** Simple primary processing operations like sorting, trimming, grading, washing, surface drying and packaging can be used to prepare fruit and vegetables for immediate marketing. The available equipment and technologies for various unit operations of primary processing include farm level fruit and vegetable washing machine, basket centrifuge, shrink packaging of fruit and vegetable and hydro cooler-cum-washer for fruits and vegetables, vegetable dryer, tamarind dehuller and deseeder, pomegranate aril remover cumin cleaner-cumgrader, turmeric washing and polishing machine etc.
- b) **Secondary processing**
 - i) **Drying:** Drying is the oldest and cheapest method of preservation of horticultural produce. Significant information is available on the use of solar drier for drying of fruits, vegetables, plantation crops and spices. However, medicinal and aromatic plants can be dried in solar drier, poly tunnel solar drier or mechanical drier. Pre-treatments of fruits like peeling, slicing, blanching, sulphuring, etc, are used for preparing fruit and vegetables for drying.
 - ii) **Osmotic dehydration:** Osmotic dehydration consisting of partial removal of water by dipping in sugar syrup prior to washing in a mechanical dehydrator is now a standard accepted practice for preparation of intermediate moisture products with acceptable sensory qualities. Some fruits not otherwise fit for drying owing to inherent high acid and astringent taste can also be dried by using this technique. Fruits suitable for osmotic dehydration include pineapple slices, mango slices, banana slices, sapota, apricot, apple and grapes etc.
 - iii) **Processing of lesser utilized fruits:** Large quantities of lesser utilized horticultural crops like bael, aonla, jack fruit, aloe vera etc cannot be consumed in fresh form without processing. They are known for many therapeutic/medicinal and nutritive properties. Processing of such crops can play an important role in satisfying the demand for nutritious, delicately flavoured and attractive natural foods of high therapeutic value.
 - Bael fruit having hard shell and mucilaginous texture is popularly consumed as a dessert fruit in India.

- Kokum and hill lemon are not acceptable in the fresh form owing to their high acidity, while fresh aonla has a strong astringent taste.
 - The products prepared from such fruits include unripe mango drink,(mango pana) high fiber and anti-oxidant rich.
 - Cashew apple powder fortified with 2% cereal flour.
 - Bael products like ripe bael drink, squash, RTS, (ready to serve) drink jam and jelly, bael dry powder.
 - Aonla preserve, candy, shreds, chayawanprash, squash, dehydrated powder, aonla beverages, toffees etc.
 - Aloe vera gel and beverages.
- iv) **Value addition:** The fruit and vegetables which can not be sold in the fresh market can be utilized for preparation of different value added products. The value added products include juice, concentrate, fruit based carbonated juices, canning, pulp extraction, pickling, chutney and sauce making, preserves and candies, beverages like squashes, ready to serve (RTS) drinks and appetizer etc from different fruits and vegetables.
- v) **Fermented products:** Production of alcoholic drinks like cider, wine, vermouth, vinegar etc is now an accepted practice for utilization of different fruits.
- Manufacture of champagne (sparkling wine), still wine and brandy from grapes is commercially practiced in the country.
 - Other fermented beverages include cider, wine and vermouth from apple, plum, apricot, wild apricot, peach, strawberry, banana etc.
- vi) **By product waste utilization:** Fruit processing plants generate large volume of by-products in the form of pomace, seeds, stones/pits skin, peel which is thrown as a waste. Though such left over produce still contain good proportion of nutrients which can be utilized to prepare large number of value added products for industrial uses.
- Pomace can be used for extraction of pectin, dietary fibre and industrial alcohol.
 - Oil extracted from fruit stones/seed left after processing of stone fruits pulp can be used for cooking of foods, pharmaceutical and cosmetic purposes.
 - Vinegar extracted from mango peel.
 - High fiber containing biscuits from aonla and apple pomace.
 - Peel oil, pectin powder, peel candy and animal feed are some of the citrus peel products.
 - Oil and fiber from oil palm.

Steps involved in primary processing

Cleaning/ Washing: Harvested fruit is washed to remove soil, microorganisms and pesticide residues. Fruit washing is a mandatory processing step; it would be wise to eliminate spoiled

fruit before washing in order to avoid the pollution of washing tools and/or equipment and the contamination of fruit during washing. Washing efficiency can be gauged by the total number of microorganisms present on fruit surface before and after washing - best results are when there is a six fold reduction. The water from the final wash should be free from moulds and yeast; a small quantity of bacteria is acceptable. Fruit washing can be carried out by immersion, by spray/showers or by combination of these two processes which is generally the best solution: pre-washing and washing. Some usual practices in fruit washing are:

- Addition of detergents or 1.5% HCl solution in washing water to remove traces of insect-fungicides;
- Use of warm water (about 50°C) in the pre-washing phase;
- Higher water pressure in spray/shower washers. Washing must be done before the fruit is cut in order to avoid losing high nutritive value soluble substances (vitamins, minerals, sugars, etc.).

Cleaning can be performed by using:

- Wet procedures: Soaking, spraying, floatation, washing and ultrasonic cleaning.
- Dry procedures: Separation by air, magnetic attraction of metal contaminants or by physical methods depending upon the product and nature of the dirt.
- Fruit and vegetables are generally washed with water to remove dust, dirt and adhering surface micro-flora.
- Fruits like peach, apricot etc that are lye peeled are not washed before peeling.
- Washing after peeling removes vitamins and minerals and should be discouraged.
- Different methods of washing include soaking or agitating in water, washing with cold or hot water sprays etc.
- Mechanical washers involve agitating or tumbling the commodity on moving belts or revolving screens while they are immersed in water or subjected to water sprays.
- Washing by using high pressure sprays is most satisfactory.
- Detergents are frequently used in the wash or rinse water.
- Vegetables may be soaked in dilute solution of potassium permanganate or chlorine (25-50 ppm) for disinfection.

Sorting/Grading: Fruit sorting covers two main separate processing operations: a. Removal of damaged fruit and any foreign bodies (which might have been left behind after washing); b. Qualitative sorting based on organoleptic criteria and maturity stage. Mechanical sorting for size is usually not done at the preliminary stage. The most important initial sorting is for variety and maturity. However, for some fruit and in special processing technologies it is advisable to proceed to a manual dimensional sorting (grading).

Trimming and peeling (skin removal): This processing step aims at removing the parts of the fruit which are either not edible or difficult to digest especially the skin. Up to now the industrial peeling of fruit and vegetables was performed by three procedures:

- Mechanically
- By using water steam
- Chemically; this method consists in treating fruit and vegetables by dipping them in a caustic soda solution at a temperature of 90 to 100° C; the concentration of this solution as well as the dipping or immersion time varying according to each specific case.

Disintegration: It covers wide range of operations that are used to sub-divide large masses of foods into smaller. It covers wide range of operations that are used to sub-divide large masses of foods into smaller units or particles. It may involve cutting, slicing, chopping, grating, pressing to extract juice, pulping, homogenizing etc.

- **Slicing, chopping, cutting and dicing:** Fruit and vegetables are sliced to a desirable size either manually or by using semi or automatic slicing/chopping or dicing machines. These unit operations are collectively called as size reduction. These unit operations increase the rate of drying, heating, cooling and improve the efficiency and rate of extraction of liquid components like fruit juices.
- **Juice extraction:** For juice extraction, the fruits and vegetables like apple, pear, carrot, aonla etc are grated in fruit grater to reduce their particle size. The grated mass is then pressed through basket press/hydraulic press to extract juice.
- **Pulping:** For extraction of pulp, the fruits like apple, pear, apricot, guava, plums, tomato etc after preliminary treatment (crushing with or without heating), are passed through the pulper. With the action of blades/flights in the pulper, the fine pulp is forced through the openings of the screen/sieve which is collected at one end, while, seeds, skin and core is forced through other end of the pulper. Depending upon the type of fruit, various types of pulper like baby pulper, tomato pulper, mango pulper etc can be used.

Blanching: Treatment of fruit and vegetables by dipping in boiling water or steam for short periods followed by immediate cooling is called blanching. The basic objectives of blanching are:

- Inactivation of enzymes, to cleanse the product initially to decrease the microbial load.
- To preheat the product before processing.
- To soften the tissue for facilitating compact packing in the cans.
- To expel intercellular gases in the raw fruit.
- To prevent excessive pressure built up in the container.
- To allow improved heat transfer during heat processing.
- To ensure development of vacuum in the can
- To reduce internal can corrosion.

UNIT II

Processing for pulp, puree and concentrates

Pulp and juice processing are important agro-industrial activities for the food production sector as they add economic value to fruits, avoid fruit wasting and minimize losses during commercialization of unprocessed fresh fruits. Pulp and juice processing also constitute an alternative way by which fruit growers sell their products. One advantage of industrializing fruit pulp is the consumption of fruits native to particular regions throughout the country, some of which being highly coveted on the international market. Fruit pulps could also supply the food industry for producing juices, ice creams, candies and confectionery and dairy products such as yogurts. The markets of concentrated juice and pulp are notably relevant because they seek to attract consumers fundamentally by the idea of fruit nutritional value preservation. Preserving highly perishable fruits constitute a big challenge for agro-industries. Processing methods that conserve the physical structure, nutritional and sensory attributes and expanding the consumer market of fruit pulps. Fruit pulp production line normally embraces the following steps: reception, weighing, pre-selection, washing and sanitization, pulping, packaging and freezing. In general, fruits are frozen when there is insufficient amount of fruit to be pulp, whereas unripe fruits are cooled after the washing/sanitization step. The flowchart in Figure 1 illustrates the overall process that should be adopted in order to manufacture good quality fruit pulps. Pre-selection/selection of fruits, washing and sanitization, cooling or freezing are the most important steps and must be efficiently performed.

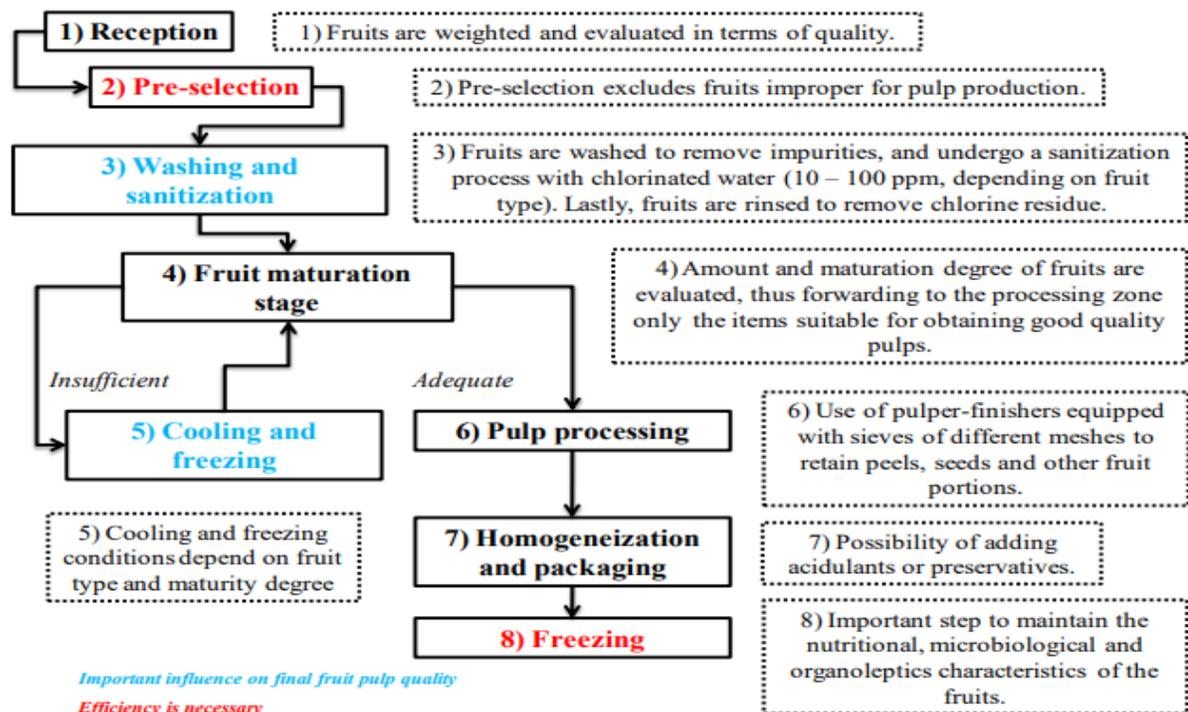


Figure 1: Fruit pulp processing flowchart

Puree and Concentrate

A purée (or mash) is cooked food, usually vegetables, fruits or legumes that has been ground, pressed, blended or sieved to the consistency of a creamy paste or liquid whereas, concentrate is juice only with some water removed.

A. Tomato Puree and Concentrate

The pulp-based concentrate product may be classified in puree (10 Brix°), simple (16 Brix°), double (29 Brix°) and triple (30-32 Brix°) concentrate. The double and triple concentrates are prepared by means of vacuum evaporators.

Raw materials

- Fresh ripe tomatoes
- Salt, optional

Materials and equipment

- Pot with lid
- Pulper or disc pulp remover
- Jars with screw-band lids (200 ml approximately) or bottles with crown corks (200 ml approximately)
- Manual capper
- Crown corks
- Kitchen utensils: wooden spoon, knife, spoons, funnel and wooden board, various plastic containers, kitchen cloths
- Heat production system.

Processing for puree

To prepare the puree, proceed as follows:

- Proceed as in the recipe for the preparation of tomato juice (without adding lemon juice) until the juice is extracted.
- Place the pot with the juice back on the fire and let it concentrate until it reaches 10 Brix°, stirring with a wooden spoon every now and then to prevent the mixture from sticking.
- Once 10 Brix° have been reached, add 1% salt, dissolve and remove the pot from the fire.
- Fill the bottles to the top with hot puree and cover.
- Sterilize the bottles as indicated in the procedure to make tomato sauce.

Processing for simple concentrate

To prepare the simple concentrate (16 Brix°), proceed as follows:

- Concentrate the product until 16 Brix° is reached.
- Add 2% salt, dissolve and remove from the fire.
- Fill the bottles or jars with the hot product and cover them.
- This product must be sterilized. Proceed as indicated in the recipe for the preparation of tomato sauce.

- Label the containers and seal the jar lids with adhesive tape.
- Once the container is opened, keep in the refrigerator.

Natural apple puree

Raw material

- Fresh apples of the green variety, if possible (Grand Smith): 20 kg.
- Cinnamon or clove: optional

Materials and equipment

- Aluminium pot with lid.
- Boards for cutting the fruit.
- Pulper.
- 250 or 500 g jars with screw-band lids.
- Kitchen utensils: wooden spoon, knives, funnel, skimmer, wooden chopping blocks, an assortment of plastic containers, kitchen cloths.
- Clothbag for the sterilization of jars (optional).
- Source of heat.

Processing

- Wash the fruits in drinking water.
- Blanch the fruits whole (the smallest) or in halves (the larger ones) for 10-15 minutes until they become softer.
- Cool the fruits partially and cut them in small pieces.
- Put the pieces through the pulper.
- Weigh the pulp.
- Heat the pulp, with or without cinnamon, in a pot until its volume is reduced by half. Use a wooden spoon to stir the mixture every now and then, to make sure that it does not stick to the pan.
- Pack the concentrated pulp in the jars, previously cleaned and sterilized with boiling water, making sure that they are filled to the brim with the pulp still hot. -
- Seal the jars.
- Sterilize the jars in boiling water for 15 minutes.
- Cool the jars with a jet of cold water, making sure that they do not break.
- Dry the jars and screw the lid on more tightly.
- Label and store.

Guava puree

Raw material

- Ripe guavas

Materials and equipment

- Aluminium pot with lid.

- Pulper.
- Sieve (0.05 cm mesh).
- Kitchen utensils: wooden spoon, knives, wooden chopping block, an assortment of plastic containers, kitchen cloths.
- Glass jars with screw-band lids.
- Source of heat.

Processing

- Wash the guavas and drain.
- Cut in quarters and blanch, if necessary.
- Extract the pulp.
- Sieve the pulp so that it acquires a uniform consistency (optional).
- Pasteurize at 90°C for 60 seconds and pack.
- Label and store.

Canning

The term canning refers to a process which involves heating food stuff in hermetically sealed containers for a specific time at specific temperature to eliminate microbial pathogens that endanger public health and micro-organisms as well as enzymes that deteriorate food during storage. Presently large quantity of fruits and vegetables are preserved by canning. There is a great scope for the development of canning industry as it is one of the processes which does not involve the use of any chemical in preservation. Fruit and vegetables are canned in the season when the raw material is available in plenty. Canned products are sold in off season and fetch better returns to the grower as well as processor.

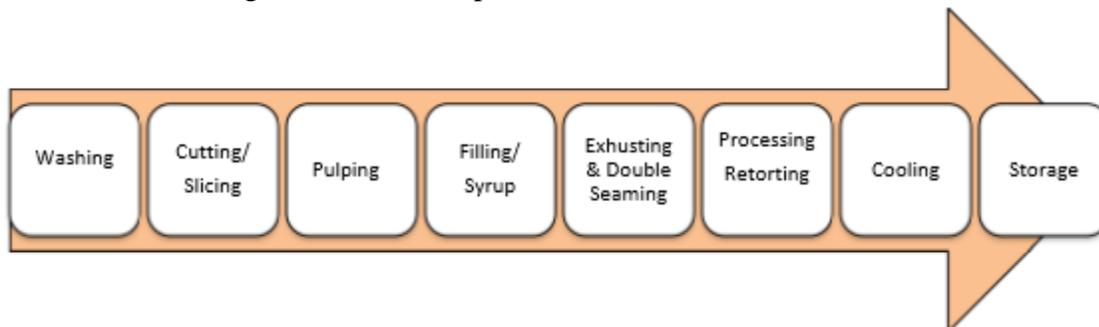


Figure2: Process flow for fruit canning

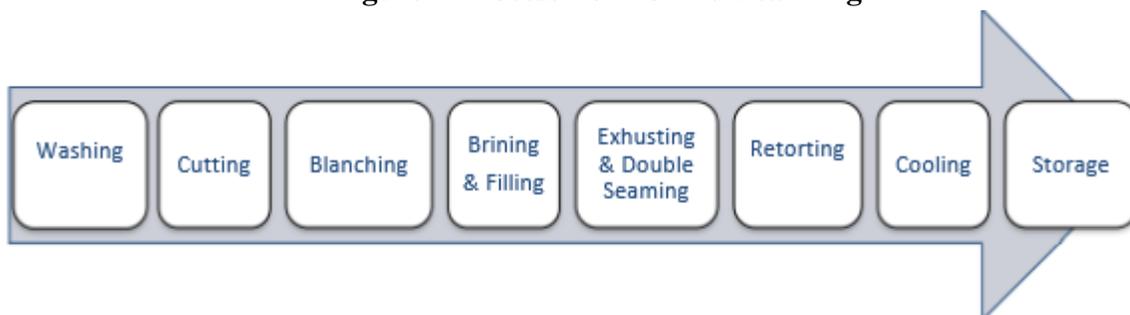


Figure3: Process flow for vegetable canning

The canning of fruit and vegetables broadly involves the following steps:

- 1) **Preparation of fruit and vegetables:** Preparation of food commodity for canning consists of washing, sorting, grading, peeling, halving, blanching etc.
- 2) **Raw material selection/receiving:** For canning, fruits should be ripe but firm, evenly matured, free from blemishes, insect damage and malformation. Thus, harvesting at proper maturity is an important step in selection of raw material for canning.
 - Most fruits are harvested at soft ripe stage. However, apple, pear, peach and banana harvested at mature stage are preferred for canning.
 - Over ripe fruits yield poor quality product, while under ripe/immature fruit generally shrivel or toughen on canning.
 - Vegetables except peas, beans etc are harvested at mature stage to enable them to withstand cooking during sterilization.
 - Vegetables like green beans, green peas, ladies finger should be tender and free from soil, dirt etc.
 - Tomatoes should however, be firm, fully ripe and uniformly deep red in colour.
- 3) **Washing:** Fruit and vegetables are generally washed with water to remove dust, dirt and adhering surface micro-flora. Fruits like peach, apricot etc are lye peeled so not washed before peeling. On the other hand, washing after peeling removes vitamins and minerals and should be discouraged. Different methods of washing include soaking or agitating in water, washing with cold or hot water sprays etc.
 - Mechanical washers involve agitating or tumbling the commodity on moving belts or revolving screens while they are immersed in water or subjected to water sprays.
 - Washing by using high pressure sprays is most satisfactory.
 - Detergents are frequently used in the wash or rinse water.
 - Vegetables may be soaked in dilute solution of potassium permanganate or chlorine (25-50 ppm) for disinfection.
 - The water temperature should be kept low to keep the fruit firm and to reduce leaching losses.
 - High pressure sprays should not injure the fruits.

Bacteria and other contaminants can accumulate in the wash water and hence appropriate cleaning and chlorination practices be followed.

- 4) **Sorting and grading:** Sorting and grading ensures the removal of inferior or damaged commodity. For sorting, inspection belt can be used, in addition to trained personnel who detect poor quality produce unsuitable for canning.

Automatic colour sorters can be used for sorting to reduce labour cost.

The fruit and vegetables are graded to obtain uniform quality with respect to size, colour etc. after preliminary sorting.

Grading can be done either manually or with the help of grading machines.

For mechanical grading, the fruit and vegetables are passed over screens with holes of different diameter.

Different types of mechanical graders include screen grader, roller grader, rope or cable grader etc. Screen graders fitted with vibrating screens of copper with circular openings are most commonly used. A set of six screens is generally provided to accommodate different sizes.

Soft and berry fruits are generally graded manually.

Plums, cherries and olives are graded whole while peaches, apricot, pears, mangoes etc are graded after cutting them into halves or slices for canning.

White button mushrooms are graded on cap size basis. Only healthy and light buttons with cap diameter up to 2.5cm and compact head are graded as A grade while, cap diameter beyond 2.5cm as B grade.

- 5) **Peeling, coring and pitting:** These are the primary unit operations for preparing fruit and vegetables for canning. Depending upon the type of commodity, peeling and coring methods are selected such as (1) by hand or knife (2) by machine (3) by heat treatment (4) by using lye solution. Cores and pits in fruits like apple, peach, apricot etc are removed by hand or by machine (de-corer).
- a) **Peeling by hand:** Many fruit and vegetables are peeled and cut by hand with the help of peeling knives. The peeling knife with a curved blade and a special guard to regulate the depth of peeling can be used for uniform peeling in case of irregular fruit shapes.
 - b) **Mechanical peeling:** Mechanical peeling, coring and cubing machines are used for peeling pears, apples, carrots, turnip, potatoes etc. Similarly, automatic peelers are used for peeling of peaches and cherries.
 - c) **Mechanical /Knife peeling:** Mechanical knife peelers are used for peeling of fruits like apples and pears. In mechanical knife peeler either stationary blades are pressed against surface of rotating food commodity or the rotating blades are pressed against the stationary food to remove the skin.
 - d) **Abrasive peeling:** It is used for peeling potatoes, ginger, carrots etc. The food commodity is fed on to the carborundum rollers or placed into a rotating bowl which is lined with carborundum crystal acting as abrasive surface. With the continuous supply of water, the rotating abrasive surface removes the skin from the surface of the food.
 - e) **Flame peeling:** Flame peeling is used in onions, garlic and brinjal. The peeler consists of a conveyor belt which carries and rotates food through a furnace heated to more than 1000°C. The outer layer and root hairs of onion are burnt off and charred skin is removed manually.
 - f) **Peeling by heat or hot water:** In this method peaches and potatoes are scalded in steam or boiling water to soften and loosen skin, which is subsequently removed manually. Infra-red heat peeling can also be used for peeling of apples and tomatoes.
 - g) **Flash steam peeling:** In flash-steam peeling, the fruit and vegetables are fed into a slow rotating (4-6 rpm) pressure vessel. High pressure steam (1500 kPa) is then introduced into the rotating vessel to expose all food surfaces to the steam for specified period depending upon the type of fruit. When the pressure is instantly released, the steam

formed under the skin causes the surface of the food to flash off. Most of the peeled material is discharged with the steam and finishing is done with additional water sprays to remove any skin traces.

h) **Lye peeling:** Lye is a boiling aqueous solution of caustic soda (Sodium hydroxide) or Potassium hydroxide (1-2%) used in conjunction with ample water supply and heat source for peeling. Fruit and vegetables like peaches, nectarines, apricot, sweet orange segments, carrots and sweet potatoes are peeled by dipping them in boiling caustic soda (1-2%) for 1-2 minutes (depending upon the strength of lye, temperature/maturity and nature of fruit or vegetable) followed by dipping in cold water. The hot lye loosens the skin from the flesh underneath which is removed by gentle rubbing of fruit by hand. The fruit can also be dipped in a dilute solution of hydrochloric acid or citric acid for few seconds to neutralize the alkali. The method is very quick and efficient to reduce wastage and peeling cost. The effectiveness of lye peeling depends upon lye concentration and temperature, product holding time and agitation.

- Lye peeling equipment varies from simple stainless steel (SS) pan for lye solution with SS baskets as cages for holding the food commodity to fully automatic system.
- In cottage and small scale canning units, the peeling system consists of three SS tanks attached in series, the one of which is having provision for steam, the second tank contains dilute solution of citric acid or hydrochloric acid while the third is filled with tap water.
- The fruit or vegetables placed in perforated SS crates/ basket or cage are dipped in the first tank which contains boiling hot lye solution. After 1-2 minute of dipping treatment, the crates are immediately dipped in second tank to neutralize the lye and final washing is carried out in third tank.

6) **Cutting/halving/ slicing:** After peeling, the fruits are halved or cored either manually or mechanically. However, peeled fruit should always be kept submerged in either water, containing 1-2 % salt solution or acid to avoid enzymatic browning. Peaches, apricot, pears, tomatoes etc are peeled before canning. However, the fruits which are canned retain better nutrients as compared to peeled fruits.

7) **Blanching:** Treatment of fruit and vegetables with boiling water or steam for short periods followed by immediate cooling prior to canning is called blanching. The basic objectives of blanching are as under:

- To inactivate enzymes
- To clean the product initially to decrease the microbial load and to preheat the product before processing
- To soften the tissue to facilitate compact packing in the can
- To expel intracellular gases in the raw fruit to prevent excessive pressure built up in the container.
- To allow improved heat transfer during heat processing

- To ensure development of vacuum in the can and to reduce internal can corrosion.

Blanching is carried out either by hot water or using live steam. Water blanching is generally of the immersion type or spray type as the product moves on a conveyor. Only soft water should be used for blanching as hard water toughens the tissue and destroys the natural texture.

8) **Prevention of browning:** Some fruits which cannot be blanched due to their delicate tissue structure are treated with some chemicals to prevent oxidative browning, occurring due to exposure to oxygen during peeling and slicing. Oxidative browning is caused by action of oxidase enzyme with catechol and tannins and is common in peach, apple, potato, mushroom cherry, apricot, grapes and persimmon. Pineapple, tomato and melons are however not prone to browning. Common methods used to prevent browning are as under:

- **Sulphite treatment:** Fruits are dipped in a solution containing 2000-4000 ppm SO₂ for 2-5 minutes. SO₂ fumigation can also be used commonly for grapes dehydration.
- **Acids:** Common acids used to increase acidity include citric, fumaric, tartaric, acetic, phosphoric etc. Low pH of solution is known to act as inhibitor for enzyme polyphenol oxidase thus inhibits the browning of fruits. The peeled fruits, slices or cut surfaces are dipped in a 1-2 % citric acid solution to prevent browning.
- **Antioxidants:** Ascorbic acid is commonly used as an antioxidant in most canned fruits. It acts as an inhibitor of peroxidase in some fruits like kiwi fruit. It also reduces quinones, which are generated by polyphenol oxidase upon oxidation of polyphenols to phenolic compounds thus preventing their conversion to brown pigments. Ascorbic acid can be used as such or mixed in dry sugar, citric acid or in syrups.
- **Sugars:** Sugar syrup is used to prevent browning in peeled and sliced fruits by inhibiting oxidation by partially excluding air in the tissues. Sugar is mixed with ascorbic acid and citric acid as an effective agent against loss of texture, colour and flavour. Addition of chitosan in filtered apple and pear juices also prevents enzymatic browning.
- **Salt:** Dipping of peeled and sliced fruit and vegetables in 1-2% salt solution also prevent enzymatic browning, as salt acts as inhibitor for polyphenol oxidase.

9) **Filling in cans:** Tin cans are washed in hot water or in steam jet to remove any adhering dust or foreign matter. The cans are then sterilized by dipping in hot water tank or the cans are passed through a steam sterilizing tunnel before use. Generally plain cans are used however, for coloured fruits like plums, black grapes; strawberries etc lacquered cans are employed. The fruit and vegetable either slices, halves or whole are filled into the cans keeping in view the declared drain weight.

10) **Syruping or brining:** The cans are filled with hot sugar syrup (35-55%) for fruits and with hot brine (2-10%) concentration for vegetables. The purpose of syruping or brining is to help in transfer of heat within the food pieces during processing. It also improves the taste of the canned product, fill up the inter-space between the fruit or vegetables in the can. The syrup or brine is added to the can at a temperature of 79-82⁰C, leaving 0.32-0.47cm head space either

manually or in automatic machines. In automatic machines, the prepared syrup or brine is drawn into the cans through a horizontal pipe having a row of small holes. The cans travel on a continuous belt in an inclined position below the syrup or brine pipe and get filled, the overflowing excess syrup is pumped back into the syrup tank by a centrifugal pump.

- 11) **Exhausting:** Exhausting is a unit operation in which practically all air from the contents in the can is removed before sealing. The purpose of exhausting and creation of vacuum is to create an anaerobic environment in the can that would inhibit microbial spoilage. The removal of air from the contents also reduces the risk of corrosion and pin holing of the tin plate and discoloration of can contents. Exhausting helps in better retention of vitamin C. Expansion and shriveling of contents during heating help to avoid over filling or under filling of the can. (Corn and peas expand on boiling in brine while strawberries shrivel upon heating in sugar syrup). The vacuum in can prevents bulging of the can during storage at higher altitudes or in hot climate. It also prevents excessive pressure and strain during sterilization.

Methods of exhausting: There are generally three methods of exhausting the cans to remove headspace gas and creation of vacuum.

- a) **Heat/thermal exhausting:** Heat exhausting is used in cans. The can covered with the lid or loosely sealed or clinched is passed through a tank of hot water at about 82-87°C or on a moving belt through a covered steam box. In water exhaust box, the cans are placed in such a manner that the level of water is 1.3-2.5 cm below their tops. The time of exhausting varies from 5 to 25 minutes depending upon the nature of the product. At the end of the exhausting, the temperature at the centre of the can should be about 79°C. During exhausting, the steam replaces the air inside the can and it is sealed while still hot.
 - b) **Steam flow or steam-vacuum closing:** In this system, high steam pressure is injected into the can headspace (at 100°C for 5-8 minutes) just prior to closing. Thus, all the air inside the can is quickly replaced with steam, which will condense and form vacuum following seaming. Steam vacuum closure coupled with hot fill, assures very high vacuum in the can.
 - c) **Mechanical vacuum sealing:** In high speed mechanical vacuum sealing, the cans filled with the product and covering syrup or brine, are passed through a clincher that clinches the cans (first operation roll seam) but does not form an airtight seal. The cans are subjected to a vacuum for a short period of time to remove the free headspace air but not all dissolved gases within the product. However, during this process some syrup may be drawn along with the dissolved air. To avoid syrup spillage, a pre-vacuumizing step before vacuum closing is recommended. High vacuum closing is also used in case of glass jars where the jar is placed in a closed chamber in which high vacuum is maintained
- 12) **Seaming/closing:** Immediately after exhausting, the cans are sealed by using a double seamer. Double seaming is a two step operation. In the first operation, the can lid is inserted on the can body hook by holding and rotating the lid-in-position can between two rollers. This operation is called as clinching; during which first operation roller gently guides the lid in the body hook. The next step is to press the seam using the second operation roller, which

results in an appropriate overlap of the body hook and cover hook which results in an appropriate countersink. Between the cover hook and body hook lies a layer of sealing compound which ensures the sealing process. The critical parameters for an ideal hermetic seam are body hook, cover hook, seam thickness, seam width and overlap which need to be carefully controlled to prevent leakage in the can. Immediate closing of the cans is required to prevent excessive cooking of the surface of the product. Double seamers are of different designs and capacities like hand operated, semiautomatic and fully automatic. Modern double seamers operate at high speeds (300 cans per minute) while liquid products are sealed in cans at speed of up to 1600 per minute.

13) **Coding/Embossing:** Coding of lid of the can is essential to identify the can, once it is closed. The code provides the necessary information about the product like name of canning unit, product packed in the can, date of packing; lot number etc. Coding is done on the second lid (end cover) of the can just before sealing.

14) **Heat processing:** The cans after sealing are immediately transferred to the heating retorts to achieve sterilization of contents. Heat processing consists of heating cans to a predetermined time and temperature of heating to eliminate all possibilities of microbial spoilage. Over cooking should be avoided as it spoils the texture, flavour and appearance of the product. Generally all fruits and acid vegetables can be processed satisfactorily in boiling water (100°C) as the presence of acid retards the growth of bacteria and their spores. While non acidic vegetables (except tomato and rhubarb) are processed at higher temperatures of about 115-121°C under pressure. It needs to be ensured that required temperature reach the centre of the can. The temperature at the centre of the can should be maintained for sufficiently long period to destroy spores of more heat resistant bacteria.

Processing methods: Processing methods differ with the kind of fruit and vegetables to be processed. The cans containing most fruit and acid vegetables (pH < 4.5) are heated in open cookers, continuous non-agitating cookers and continuous agitating cookers.

- Open cooker consists of stainless steel (SS) or galvanized iron tanks to which perforated water pipes are placed underneath the false bottom to supply the steam for heating of water. The sealed cans are placed in SS or GI crates and immersed in the tank containing boiling water.
- In continuous non-agitating cookers, the cans travel in boiling water in crates carried by over-head conveyors on a continuous moving belt.
- While in continuous agitating cookers, the sealed cans while moving on the belt are rotated by a special mechanical device to agitate the contents of the cans. This helps in reducing the processing time.
- For low acid foods like vegetables (pH > 4.5), with hard texture, the processing is carried out in a pressurized vessel (retorts) at elevated temperatures (= 110°C) under higher steam pressure (2-3 atmospheres). The retorts vary in shape and size (horizontal or vertical), type of operation (batch to continuous, non-agitating to agitating) and with different types of heating media such as water, steam, steam/air or flame.

- In small scale canning units, vertical stationary retorts are generally used. They are made of cast iron cylinders and are fitted with a lid which can be bottled steam tight. They are provided with steam and water feeds, drain cock, safety valve, pressure gauge and thermometers.

Fruit juice and Beverages

Fruit juice and beverages generally comprise of naturally extracted juices, drinks, ready to serve (RTS) beverages, nectars, squashes, cordials and appetizers etc. These products are highly refreshing, thirst quenching, appetizing and nutritionally superior to many synthetic and aerated drinks. Fruit juice is the natural liquid expressed by pressure or other mechanical means from the edible portion of the fruit. Fruit juices are generally extracted from fruits in a number of ways, depending on their structure and composition. The composition of juice is unaltered during preparation and preservation while for fruit beverages like drinks, squashes, cordial etc the fruit juice or pulp, sugar, acid, colour, flavour etc are mixed in appropriate proportions to a desirable taste. Apple juice, orange juice, mango squash, guava drink, pineapple juice and squash, mixed fruit drink, mango nectar etc are the commercial products available in the market.

Types of fruit juice and beverages

- a) ***Unfermented beverages*** Fruit juices which do not undergo alcoholic fermentation are termed as unfermented beverages. They include natural fruit juices, sweetened, ready to serve drinks, nectar, cordial, squash, crush, syrup, fruit juice concentrate and fruit juice powder. They are discussed as under:
- ***Fruit juice:*** It is a natural juice pressed out of the fruit and remains practically unaltered in its composition during processing and preservation. It is also called as unfermented fruit juice or pure fruit juice, for example apple juice.
 - ***Fruit juice beverage:*** It is fruit juice which is considerably altered in composition during preparation. It may or may not be diluted before consumption. Ready to serve (RTS) drinks, nectar, squash, cordial, appetizer are all fruit juice beverages.
 - ***Synthetic drinks:*** Synthetic drinks are prepared by using sugar, water, flavourants, acidulents, colour etc. These drinks do not contain any fruit juice or pulp.
 - ***Ready to serve (RTS) drink:*** This is a type of fruit beverage which contains atleast 10% fruit juice (for lime drink 5% juice) and not less than 10% total soluble solids. The acidity in these drinks shall not exceed 3.5% as citric acid. RTS beverages are preserved by using class II preservatives not exceeding 70 ppm SO₂ or 120 ppm benzoic acid. It is not diluted before serving hence it is known as ready to serve drink for example mango drink, guava drink, pineapple drink etc.
 - ***Fruit nectar:*** This type of fruit beverage contains atleast 20% fruit juice or pulp and 15% total soluble solids and is preserved by heat processing. The acidity in fruit nectars shall not exceed 1.5% as citric acid. No class II preservative like SO₂ or benzoic acid is permitted in fruit nectar as per Indian Food Laws. It is not diluted before serving.

- **Squash:** Fruit squash consists of fruit juice or pulp to which cane sugar is added for sweetening. According to Indian Food Laws, the fruit squash shall contain atleast 25% fruit juice or pulp and not less than 40% TSS. It shall not contain class II preservative in excess of 350 ppm SO₂ or 600 ppm benzoic acid. Acid content in squashes generally remain between 1-1.5% but shall not exceed 3.5% as citric acid. Squash is generally diluted with water in 1:3 ratio before serving. Lime, lemon, mango, orange, guava and pineapple squashes are commercially manufactured.
 - **Fruit juice cordial:** It is a sparkling, clear, sweetened fruit juice from which pulp and other suspended substances have been completely removed. It contains atleast 25% juice, 30% total soluble solids and not exceeding 350 ppm SO₂ or 600 ppm benzoic acid as preservative. It is also used for mixing with alcoholic drinks for example lime juice cordial.
 - **Fruit Appetizer:** Fruit appetizer is similar to fruit squash but also contains spices, condiments and herb extract. Spices like black pepper, cumin, large cardamom, ginger along with mentha extract and salt are used for manufacture of appetizer. They are also called as spiced fruit squash. Plum and apricot appetizers are quite common.
 - **Fruit crush:** Fruit crush contains minimum of 25% fruit juice or pulp, 55% total soluble solids (TSS) and not exceeding 350 ppm of SO₂ or 600 ppm of benzoic acid. It is diluted before serving.
 - **Fruit syrup:** It is prepared by using minimum of 25% fruit juice or pulp and sweetened by using cane sugar. It shall contain not less than 65% total soluble solids and not exceeding 350 ppm SO₂ or 600 ppm benzoic acid as class II preservative.
 - **Synthetic syrup:** Heavy sugar syrup of 70-75 percent strength is used as the base of all synthetic syrups, which are flavoured and coloured with artificial flavour and colours. They may or may not contain fruit pulp or juice. Rose, sandal, almond, khuskhus, kewra sherbets/syrups are quite common.
 - **Carbonated fruit beverages:** It is a ready to serve fruit juice beverage which contains variable amount of fruit juice, sugar, acid etc and impregnated with carbon dioxide gas. Apple juice, lime, lemon and grape juice can be used for the preparation of carbonated fruit juice beverages. They are prepared either by pre mix or post mix method.
 - **Fruit juice concentrate:** It is a fruit juice, which has been concentrated by removal of water either by evaporation, freezing or reverse osmosis. Several products can be made from fruit juice concentrate. Apple juice concentrate, orange juice concentrate etc are commercially prepared in the industry.
 - **Fruit juice powder:** This is a fruit juice which has been converted into a free flowing powder. They can be prepared either by freeze drying, foam mat drying or spray drying processes. They are readily reconstituted to yield full strength fruit juice drinks.
- b) **Fermented beverages:** Fermented fruit beverage is a fruit juice which has undergone alcoholic fermentation by yeast like *Saccharomyces cerevisiae*. The product contains varying

amount of ethyl alcohol. Apple cider, plum wine, grape wine, vermouth etc are common fermented beverages.

Method for preparation of fruit juice beverages

- 1) **Selection of Fruits:** All fruits are not suitable because of difficulties in extracting the juices or due to poor quality juice. The variety and maturity of the fruit and locality of cultivation influence the flavour and keeping quality of its juice. Only fully ripe fruits are selected. Over ripe and unripe fruits adversely affects the quality of the juice.
- 2) **Sorting and Washing:** Diseased, damaged or decayed fruits are rejected or trimmed off. Dirt and spray residues of arsenic, lead etc are removed by washing with water or by using dilute hydrochloric (HCl) acid solution (0.5%) followed by washing in water.
- 3) **Juice Extraction:** Generally juice is extracted by crushing or grating the fruit and pressing the crushed mass in a basket or hydraulic press. Juice can also be extracted by using a screw type juice extractor. Common equipment used for juice extraction are fruit grater or mill, basket or hydraulic press, screw type juice extractor, rosing or burring machine, fruit pulper etc. There are two types of extraction methods i.e., single and double operation system.
 - i. **Single operation:** In single operation, screw type, plunger type or roller type press is generally used to crush and press the prepared fruit to extract the juice. Citrus fruit segments are fed through a hopper, passed through conical screws and the juice flows out through the perforations while the pomace comes out at the end of the conical jacket. The screw type extractor is operated either manually or by using electricity depending upon the requirement. The juice extracted is generally thick and cloudy and contains a considerable amount of macerated pulp. Care should be taken to remove the rind of citrus fruits completely otherwise it makes the juice bitter. Citrus fruits like lemon, kinnow etc can also be extracted by using a rosing or burring machine. Finally, the juice is strained through a thick cloth or a sieve to remove seeds.
 - ii. **Double operation:** In this system, the fruits are crushed and then pressed separately. Fruit like apple, aonla, berries, grapes, jamun, phalsa etc are crushed in fruit grater or crusher and the crushed mass is pressed by means of basket press and hydraulic press.

Process variables for juice extraction for some fruits are:

- Soft fruits such as berries or tomatoes can be pressed through a fruit press or pulped by using a juicer attachment to a food processor.
- Citrus fruits are usually reamed to extract the clear juice.
- Harder fruits like pineapple are peeled, pulped and pressed to extract the juice.
- Apple and pear fruits are crushed in a fruit grater and pressed in a hydraulic/basket press to extract a clear juice.
- Passion fruit juice is prepared by using a pulper-finisher that separates skin and seeds from the pulp.

The fruits like mango, guava, apricot, peach etc from which the clear juice extraction is difficult are passed through the pulper to make pulp and then the pulp is utilized for preparation of juice, fruit drinks and ready to serve beverages.

- 4) **Deaeration:** Freshly extracted juice contains appreciable quantity of oxygen which may affect the quality of juice if not removed before packing. Air in juice is due to the presence of intra-cellular spaces present in the fruits. Most of the air as well as other gases are removed by subjecting the fresh juice to a high vacuum. This process is called as deaeration and the equipment used for the purpose is known as the deaerator. Heating of juice during heat processing also helps in removal of the air.

Clarification of Juice

Fruit and vegetable juices are clarified by using different methods like straining or screening, settling or sedimentation and filtration.

- a) **Straining or screening:** Un-clarified fruit juices contain varying amounts of suspended matter consisting of broken fruit tissue, seed, skin, pectic substances and protein in colloidal suspension. Seeds and skin which adversely affect the quality of juice are removed by straining through a muslin cloth or sieve. The fruit juices are strained or screened by muslin cloth or stainless steel mesh sieves manually to remove coarse particles in a small-scale industry. But in large industries power operated screening system or filter press is used.
- b) **Finishing:** Citrus juices need finishing for separating cloudy but otherwise clean juice from pulp, rag and seeds. The finisher separates the pulpy matter from the juice by the action of a rotating auger inside a cylinder screen. Screen hole size range from approximately 0.020 to 0.030 inch in diameter, depending on the condition and softness of the fruit. Finishing is judged by the pulp content in the orange fruit juice.
- c) **Decantation:** Decantation is the simplest method of clarification, in which the juice containing solids is allowed to settle down and then clear juice is decanted or siphoned out. Keep juice at low temperature for long periods also helps in setting of solid to allow clarification.
- d) **Centrifugation:** The clouding particles can be separated by centrifugal action. The juice containing solids is fed into a basket or disc type centrifuge, where the centrifugal force separates the light and dense components in each layer. The clear juice is collected and unwanted solids are separated.
- e) **Enzymes:** The plant carbohydrates, pectin, starch and proteins make the colloidal suspension in the freshly extracted fruit juice. The pectinase enzyme is widely used for better juice recovery as well as clarification of fruit juices as it breaks pectin into soluble form thereby freeing the suspended particles which settle down and leaves the juice clear. Similarly, proteolytic and starch liquefying enzymes i.e. amylases are used to remove protein and starch from fruit juices. Pectinase is more effective in the case of acidic juices. Fruit juices can be clarified in about 1-2 hours at 40-50°C but requires 20 hrs at 20°C.

- f) **Physical finings:** Certain fining agents, which have physical or mechanical action are kaolin, diatomaceous earth, Spanish clay, bentonite or china clay and are known as filter aids. Generally 0.5 to 0.1 percent earths is mixed with fruit juice and then passed through the filter press. Ultra filtration is a process that separates particles based on molecular weight and has better retention of the nutrients in the juice. It is necessary to degrade the pectin enzymatically before ultrafiltration, to reduce viscosity and allow a satisfactory juice.
- g) **Chemical finings:** Gelatin and casein are used to clarify the fruit juices and act partly to neutralize the electrical charged particles and partly by forming insoluble precipitate with the constituents of the juice. The gelatin combines with tannins and casein with acid of the juice. The gelatin may cause juice cloudy if used in excess. Depending on the tannin content of the fruit juice, gelatin solution is mixed and allowed to stand for 18 to 24 hrs to ensure that the precipitated matter clots together and settles down. The clarified juice is then siphoned off. Albumin (egg white) can also be used in clarification of juices.
- h) **Clarification by freezing:** Grape juice contains cream of tartar or potassium hydrogen tartarate along with pulp and skin which is removed by freezing and thawing the juice or by refrigeration for a long storage. Apple juice can also be clarified using this method after freezing is precipitated on thawing.
- i) **Clarification by heating:** During heating, the colloidal material in fruit juices coagulates and settles down on cooling which can be separated by using a filter press. For clarification of apple and pomegranate juice, the juice is heated to 80-85⁰C for few minutes and cooled immediately followed by filtration by passing the juice through a filter press.
- j) **Addition of sugars:** All juices are sweetened by adding sugar, except those of grapes and apple. Sugar can be added directly to the juice or as syrup made by dissolving it in water. Fruit squash, cordial, syrups are made by adding appropriate quantity of sugar into the pulp or juice using cane sugar. Similarly ready to serve drinks and fruit nectar are sweetened by using cane sugar.

Preservation of Juices

Fruit juices, RTS and nectars are preserved by pasteurization or by using chemical preservatives. Squashes, crushes, syrups and cordials are preserved by adding chemical preservative like potassium metabisulphite or sodium benzoate.

A. Pasteurization: Preservation of fruit juices by application of heat is the most common method. Pasteurization is a process in which juice is heated to 100⁰C or slightly below for a sufficient time to inactivate/kill the micro-organisms, which cause spoilage. Usually the fruit juices are pasteurized between 75 and 88⁰C with times ranging from 30 sec to 30 min depending on the type of heating system, the nature of the juice and the size of the container. Pasteurization can be performed either by heating at low temperature for a long time (LTLT) or heating at high temperature for short time (HTST). Commonly followed methods are:

- a) ***Holding pasteurization:*** In this method, the prepared juice is filled into glass bottles with a proper head space and the bottles are sealed airtight. After sealing the bottles are pasteurized. However, this method is not followed for commercial scale products.
 - b) ***Pasteurization by overflow method:*** In this method, the juice is heated to a temperature about 2.5°C higher than the pasteurization temperature and filled into the hot sterilized bottles up to the brim. Care should be taken to maintain the temperature during filling and sealing operation. The sealed bottles are processed in boiling water for specified period. After processing the bottles are cooled. On cooling, the juice contracts to leave a small headspace in the bottle which does not contain any air. The method is commercially followed in preservation of all types of juices in the food industry.
 - c) ***Flash Pasteurization:*** In this process, the juice is heated only for short time at a temperature about 5.5°C than the pasteurization temperature, filled into the containers and sealed air tight under cover of a steam to sterilize the seal and then cooled. This process is also known as HTST (High temperature and short time) method and the juice is heated vary rapidly. Flash pasteurization helps to minimize the loss of flavour, better retention of vitamins, keep juice uniformly cloudy and minimize the cooked taste of the juice.
- B. Aseptic processing and packaging of fruit juices:** Aseptic processing and packaging is defined as the process in which a commercially sterile product is packed into pre-sterilized container in a sterile environment. The system make use of high temperature short time (HTST) sterilization in the temperature range of 90-110°C for acid products (pH4.6). The commercial aseptic sterilization process takes place in a continuous, closed system. Aseptic processing may produce products with better retention of nutrients and excellent sensory quality. Apple, mango, litchi, pineapple drinks etc. in tetra pack are processed commercially using aseptic processing and packaging system.
- C. Preservation with chemical:** Fruit juices, pulps, squash, cordial, syrup, RTS drinks etc, are preserved with chemical preservatives. Fruit juice and pulps in bulk are preserved with chemical preservatives. Two chemical preservatives most commonly used in preservation of fruit and vegetable products are (i) Benzoic acid (benzoates) (ii) Sulphur dioxide (Sulphites).
- i. ***Benzoic acid:*** Benzoic acid is the effective agent but sparingly soluble in water, thus its sodium salt, which is water soluble, is generally used. Benzoic acid is more effective against yeast as compared to moulds. However, it does not stop lactic acid and acetic acid fermentation. The quantity of sodium benzoate required depends on the nature of the juice, its acidity and type of microbial infection.
 - ii. **Sulphur dioxide:** Potassium meta-bi-sulphite ($K_2O_2SO_2$ or $K_2S_2O_2$) is commonly used as a source of sulphur dioxide. On addition to fruit juice or beverage it reacts with acid of the juice and form potassium salt and sulphur dioxide, which is liberated and form sulphurous acid with the water of the juice. Sulphur dioxide is more effective against mould spores and bacteria than yeast and also inhibits enzymes etc. It acts as antioxidant and bleaching agent thus help in the retention of ascorbic acid, carotene and other

oxidisable compounds. It also retards nonenzymatic browning or discoloration of the product. Its effectiveness depends on the acidity, pH, temperature and other substances present in the fruit juice.

- The SO₂ should not be used in naturally colored juices like phalsa, Jamun, pomegranate and strawberry juices, on account of its bleaching action.
- It should also not be used in those juices, which are to be packed into tin containers, because it may act on the tin of the containers causing pinholes, forms hydrogen sulphide and black compounds.
- The potassium meta-bi-sulphite should be first dissolved in a small quantity of water and then added to the juice to be preserved.

D. *Preservation by sugar:* Fruit juice containing 66% sugar generally does not ferment. Fruit syrup or sharbats with high total solids (65% and above) have a very low water activity hence micro-organisms do not grow. The sugar acts as a preservative by osmosis and does not support the growth of micro-organisms. However, the growth of mould and yeast can occur on the surface of jams or jellies which need to be protected by using airtight packing or covering the product with molten paraffin wax.

E. *Preservation by freezing:* The properly frozen juice retains its freshness, colour, taste and aroma for a long time. De-aerated juice is transferred into containers, which are hermetically sealed and frozen. Freezing does not sterilize fruit juices, it merely reduces the temperature to the point where micro-organisms do not multiply and chemical changes take place very slowly. The more rapidly a juice is frozen, the smaller the ice crystal formed and the less the amount of colloidal matter coagulates. When the juice is frozen to -18°C, practically all of the juice will be solid except for a little thick syrup in the centre of the containers. This method is particularly useful in the case of juices whose flavour is adversely affected by heating.

F. *Preservation by drying:* Micro-organisms need water for their growth and multiplication and as the water is removed, they are unable to grow. Fruit juices can be preserved in the form of powder by different methods viz., spray drying, drum drying, freeze-drying, foam-mat drying etc. Fruit juice powders are highly hygroscopic and require special care in packing. It should be packed in free flowing powder form in hermetically sealed containers with in package desiccant to prolong the shelf-life of the product. Lemon juice powder can also be prepared by using foam mat drying process.

G. *Preservation by carbonation:* Carbonation is a process of mixing carbon dioxide under pressure with water, juice or beverages so that the product when served; gives off gas in fine bubbles and has the characteristic taste. Carbonated beverages are generally bottled with carbon dioxide content ranging from 1 to 8 g/litre. Though this concentration is much lower than that required (14.6 g/litre) for complete inhibition of microbial growth, yet it is significant in supplementing the lethal effect of acidity on pathogenic bacteria. Carbonation also helps in removal of air which creates anaerobic condition and reduces

the oxidation of ascorbic acid. Since moulds and yeasts require oxygen for their growth and as such become inactive in the presence of carbon dioxide. Thus the absence of air and presence of carbon dioxide in fruit beverages help to prevent the growth of moulds and yeast. The keeping quality of carbonated beverages is enhanced by adding about 50ppm sodium benzoate. Carbon dioxide in beverages is measured in terms of gas volume. The gas volume is defined as the amount of gas in millilitres that a given volume of water will absorb at atmospheric pressure i.e. 760 mm of Hg at 15.5⁰C temperature. Generally 1.3-4.0 gas volume CO₂ is used for carbonation of fruit juice. Lime, lemon, grape, apple juice can be carbonated by using carbonation process.

H. Preservation by filtration: In this method, the clarified fruit juices (particularly apple and grapes) are passed through special filters, which are capable of retaining yeasts and bacteria. Various types of germ proof filters are used for this purpose and the method is used for soft drinks, fruit juices and wines.

5) Filling and Processing: Bottles are thoroughly washed with hot water and filled leaving 1.5-2.5 cm headspace. The bottles meant for heat processing are sealed by using crown corks while those preserved by using chemical preservative can be sealed by using PP (pilfer proof) caps.

Individual Quick Freezing

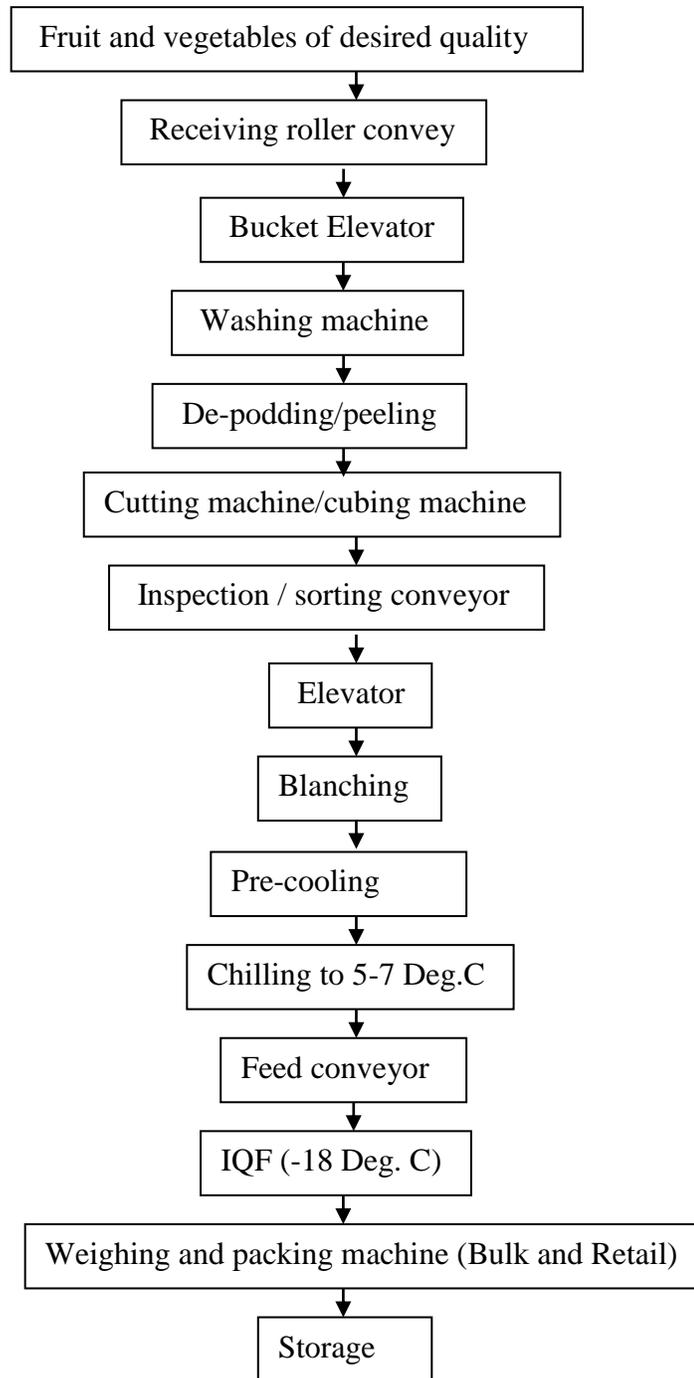
Quick freezing is at present the only process whereby virtually all the properties of most foodstuffs can be preserved. The important feature of this process is ultra-rapid freezing to very low temperatures (-30°C to -40°C) designed to halt the activities of the microorganisms that cause decay and deteriorate foodstuffs.

Individual Quick Freezing (I.Q.F.) is the latest technology available in freezing and with the advent of the same, it is now possible to preserve and store raw fruit and vegetables in the same farm-fresh condition for more than a year, with the color, flavor and texture of produce remaining as good as fresh from the farm. In IQF, each piece is frozen individually using technique of fluidization resulting in freezing of fruit and vegetables only in 10 to 12 minutes which otherwise takes at least 3 to 4 hours or even more in the blast freezer. This results into better texture and there is no lump/ block formation and the product is free flowing. One does not have to thaw or defrost the whole packet to take out only a portion, and the rest will remain frozen till required again.

Table 1: Process description for frozen vegetables/fruits

Procedure (in sequential order)	Description
Grower Storage	Raw materials –Peas/other produce arrive at the plant for processing.
Acceptance sampling	Samples of the unprocessed produce are taken to be graded and for grower payment.
Grading	In some fruits and vegetables size and maturity grading is required
Washing	All fruits and vegetables are washed to remove field contamination.
Preparation/Peeling	This operation is conducted in some of the vegetables and fruits
Depodding/Cutting	Peas are depoded in automatic depoder machine. Other products are cut according to market specifications or buyer specifications. Special cutting equipment are proposed for all types of raw materials proposed in the product mix.
Blanching	All vegetables Product require blanching at 90 to 95 Deg C for 2 to 5 minutes to inactivate per oxidase enzyme and tested in Lab. to confirm.
Pre-cooling/Chilling	Blanched produce is pre-cooled to room temperature and chilled to 5 to 7°C and moisture is removed by blower before feeding to the IQF.
Freeze Tunnel	Produce is quickly frozen in the IQF machine to (-) 18°C.
Packaging	The IQF frozen products are packaged into bulk bags or retail packs.
Deep Freeze Cold store	Packages are stored in a cold storage warehouse until shipment to grocery stores, restaurants and other customers.

Process flow diagram for frozen peas, mango cubes, litchi, sweet corn, baby corn and other vegetables



UNIT III

Technology for processed products like pickles, chutneys, sauces

The preservation by using common salt, spices and vinegar is a common method for preparation of pickles, sauce and chutneys. Salt is mostly used as preservative in pickles in combination with acid. Minimum concentration of salt to act as preservative is about 12%. It inhibits enzymatic browning/discoloration by acting as an anti-oxidant. It exerts its preservative action by:

- Causing high osmotic pressure and thus suppress the microbial cells.
- Dehydrating food by tying up the moisture thus making it unavailable for the growth of microorganisms.
- Salt in the food affects the solubility of oxygen and thus growth of aerobic microorganisms is inhibited
- Chlorine in sodium chloride being good oxidizing agent is toxic to microorganisms
- Salt increases the permeability of the cell wall and thus cause changes in the permeability. Only the haloduric microorganisms can tolerate these effects while others are unable to survive.
- Similarly addition of acid to the food lowers the pH of the food which inhibits the growth of spoilage causing microorganisms.
- Addition of spices and edible oil in these products besides improving flavour and taste also help in preservation.

Thus preservation by using salt, spices and acid is one of the most ancient and effective methods of food preservation. Vegetable sauce, continental sauce, tomato sauce, mixed fruit chutney, mango pickle, lime/lemon pickle, mixed vegetable pickle etc are common products made in this category.

PICKLES

The preservation of fruit and vegetables in salt and vinegar is called pickling. Pickles may prepare without fermentation or with partial or complete fermentation. Spices, edible oil, sugar/jaggery etc are added to improve taste and palatability of the product. Thus, pickles are good appetizer and help in digestion by stimulating the flow of gastric juices. The nutritive value of pickle varies with the kind of raw material used and method of preparation such as with or without fermentation. Manufacturing of pickle has developed as an industry in the country. Mango pickle, cauliflower, turnip, carrot (mixed vegetable), anola, lime/lemon pickle etc. are the commercial products available in the market.

Pickling process: Pickling is the process of fermentation by lactic acid forming bacteria, present on the surface of commodities. Lactic acid bacteria (active at 30°C) convert fermentable sugar in the food to lactic acid and volatile acids. The acid and brine acts upon vegetable tissues to produce characteristic taste and aroma of pickle. The salt and lactic acid formed preserve the pickle by preventing the growth of putrefactive bacteria provided oxygen is excluded. Fermented cucumber and olive pickles are quite common. Pickle is prepared by using either of following processes followed by finishing and packing:

- Curing or fermentation with dry salting

- Fermentation in brine
- Salting without fermentation



Figure 1: Process flow for pickle making

A) **Dry salting:** The dry salt added to the prepared vegetables, extracts the juice from the vegetables and forms the brine. The brine is then fermented by lactic acid forming bacteria which serves the purpose of pickling. The method is known as dry salting.

Procedure for dry salting

1. Vegetables are washed, sliced and placed in barrel in layers to which salt is sprinkled followed by placing another vegetable layer and sprinkled with salt. Generally, 3 kg dry salt is used for each 100 kg of prepared vegetable. The salt is added in layers till the barrel is $\frac{3}{4}$ full. The vegetables are covered with a cloth and wooden board along with a weight to press the vegetable. Brine is formed in 24 hours.
2. The barrel is placed in warm and dry place to allow the fermentation to proceed within short period. Once brine is formed, fermentation and bubbles of CO_2 begin to rise from the liquid. The fermentation temperature is $27\text{-}32^\circ\text{C}$ and completes in 8-10 days.
3. When the gas bubbles cease to form, the fermentation is considered as complete. This may be confirmed by taping the barrel gently. The pickle is then pressured and packed by excluding the air.
4. If air is not removed from the pickle, pickle scum (a type of mould yeast) appears on the surface, which destroys the lactic acid formed by fermentation and spoils the pickle.

Methods to remove air /expel air from the pickle:

1. By making air seal on the surface of brine by pouring 0.6 cm thick layer of edible oil (rapeseed oil/mustard oil or cotton seed oil) on the top of it. The oil being lighter than brine floats on the surface and prevents the access of air in to the pickle.
2. After dry salting and fermentation, the barrel is filled with the prepared vegetables to its maximum capacity and covered with a lid. A 1.25 cm hole is bored in the lid (cover). The barrel is filled up to the brim with the brine so that very little air is left inside. It is allowed to stand for 48 hours till all gas bubbles ceases to rise. When the bubbling stops the vent hole is closed tightly and barrel kept in a cool dry place.

3. The barrel is kept undisturbed. The molten paraffin wax is poured over the surface of the brine. It imparts air tight-seal. The paraffin wax can be easily separated from the brine and the wax can be remelted and reused.

B) **Fermentation in Brine (Brining):** Immersing vegetable or unripe fruits like mangoes in salt-solution of known concentration for a certain length of time is called brining. Brining is generally used for pickling of cucumber, olives, raw mangoes and similar other vegetables, which do not contain sufficient juice to form brine with dry salt.

Brine preparation: Brine is prepared by dissolving common salt in water and filtered through a muslin cloth. The amount of brine required to cover the vegetable is approximately equal to about half the volume of the material to be fermented (for each barrel of 100 litres, about 50 litres of brine is required). Brine with 8 -10 % strength is considered optimum for the growth of salt tolerant lactic acid bacteria. Thus vegetables are placed in 10 % brine to allow lactic acid fermentation to take place and then the proportion of salt is increased gradually, so that when pickle is ready, salt concentration would have reached 15 % level. The brine strength can also be maintained by adding dry salt. Brining takes about 4-5 weeks.

C) **Salting without fermentation:** In this method, vegetables raw mango slices are packed with a large quantity of salt to inhibit fermentation. Generally, 25 kg salt is mixed with 100 kg of prepared vegetable. The cured vegetables are drained and excess salt is removed by soaking in cold or warm water. After removal of salt, the vegetables are stored in plain vinegar 10% (100 grain) strength. This treatment reduces the tendency of the vegetable to shrivel when packed in sweetened and spiced vinegar and also helps in absorption of vinegar by the vegetable tissues.

Packing: After curing, the vegetables become semi translucent in appearance with their colour changing from green to dark olive green or yellowish green. During this process the raw flavour of the vegetables is lost and the texture becomes firm and crisp. For good keeping quality they are packed by using salt, vinegar and lactic acid in sufficient quantities which act as preservative either singly or in combination.

- I. **Salt:** The concentration of 15-20% salt is used for pickling. Mould and lactic acid forming bacteria do not grow at this concentration. The fermentation of vegetables is inhibited when they are covered with strong brine or packed with fairly large quantity of salt. This method of preserving is applicable to those fruit and vegetables which contain very little sugar because sufficient lactic acid cannot be formed by fermentation to act as preservative.
- II. **Vinegar:** Vinegar acts as preservative in vinegar pickles by lowering down the pH of final product. The final concentration of acid as acetic acid in the finished pickle shall not be less than 2%. However, vegetables are placed in strong vinegar of 10 % acidity to avoid dilution of the vinegar by the water liberated from the tissues. This treatment helps to expel the gases present in the intracellular spaces of vegetative tissues and prevents subsequent dilution of the vinegar in the pickle. Spiced vinegar can be prepared by soaking the ground spices in vinegar, boiling the spices in the vinegar or by adding essential oil of spices and added to the prepared pickle.
- III. **Lactic Acid:** Though bacteria do not grow in acidic media, yet lactic acid bacteria are capable of growing in acidic media and can also produce acid through their action on the substrate. They can also grow in high salt concentration of 8-10%. This principle is used

in pickling as growth of undesirable organism is inhibited by adding salt and allowing the lactic fermentation to proceed. The pickled vegetables (onion, garlic, green chilies, olives etc) are then packed in to the glass jars without damaging the shape and appearance of the pieces and covered with fresh vinegar to fill up the spaces between the pieces. The closed jars are then stored in a cool dry place for some time to allow thorough absorption of vinegar before sending them to the market. Brined vegetables and raw mango slices are also used for preparing different types of pickles by using combinations of spices, salt and vinegar.

Types of Pickles

Types of Pickles: Pickles are generally categorized into fermented pickle and partial or non-fermented pickles. Cucumber and olive pickles are examples of fermented pickles. While nonfermented pickles are of four general types depending upon the covering medium used.

1. Pickles preserved with salt: lime and mango pickle.
2. Pickles in oil: Mango, lime, lemon, cauliflower, aonla, karonda.
3. Pickle in vinegar (acetic acid): Garlic, green chilli etc.
4. Pickle in mixture of salt, oil, spices and vinegar: Cauliflower, carrot, jackfruit, mixed vegetable pickle etc.

A. **Fermented pickles:** Cucumber pickle, dill pickle and olive pickle.

- **Fermented cucumber pickle:** For preparation of fermented cucumber pickle, the immature cucumber are washed, placed in barrels or tanks and filled with brine (salt solution). Salt is added either by using low salt method or high salt method. In low salt method 8% brine (30 °salometer) is added to the cucumber along with 9 kg salt per 100kg cucumber. In high salt method, the brine of 10.5% salt (40 °salometer) and 9 kg salt per 100 kg cucumber is used. The cucumbers are kept submerged in brine and brine strength is increased weekly by about 3 °salometer up to 60 °salometer (15.9% salt). In low salt method, increase in brine strength is about 20 per week up to 50 salometer and 10 per week up to 60 °salometer. It takes about 6-9 weeks for completion depending upon the method of salting and temperature of fermentation. During fermentation, most of the lactic acid is produced by the action of *Lactobacillus planetarium*. However, *Lactobacillus brevis*, *Streptococcus faecalis*, *Pediococcus cerevisiae*, *Leuconostoc mesenteroides* and *Coliform* bacteria. Total titratable acid on completion of fermentation range between 0.6-0.8 percent. Initial colour of the cucumber from chalky white and opaque in cross section changes to olive or yellow green with translucent flesh after completion of fermentation. The prepared pickle is too salty to taste which is freshened by soaking and made into sour, sweet sour or mixed pickles.
- **Dill pickle:** Dill pickle is also a cucumber pickle prepared by using dill herbs as flavourant along with spices, garlic and onion. Overnight dill pickle and genuine dill pickle are the common types of dill pickle.
- **Olive pickle:** In preparation of olive pickle, fully developed but still green or straw yellow olives are treated by dipping in 1-2% lye solution to remove the bitterness of olives due to glucoside oleuropein. During this treatment, the lye penetrate up to $\frac{1}{2}$ to $\frac{3}{4}$ towards the pit; which is detected by placing a drop of phenolphthalein to give faint pink colour. This treatment removes most of the bitterness of olives. The fruit after washing

are placed in barrels containing 10-15% brines which results in a salt concentration in olives of about 6-9% after stabilization. During fermentation the salt concentration is maintained 7-8% throughout by adding more salt. Lactic acid fermentation takes about 6-9 months depending upon the atmospheric temperature. Generally 29°C is the optimum temperature for rapid fermentation. During the initial stage of fermentation lasting for 7-14 days the brine stabilizes, food for micro-organism leach out from the olives and potential spoilage organism like Pseudomonas, Enterobacter, Clostridium, Bacillus and yeasts may grow in Leuconostoc mesenteroides starts. In the next intermediate state lasting for 2-3 weeks Leuconostoc become permanent in growth and acid production and Lactobacillus brevis began to grow and produce acid. In the final stage, Lactobacillus plantarum become predominant and produce acid. The final acidity is about 0.7-1.0 percent with a pH of 4.0 -3.8 or lower. After fermentation, the olives are sorted and graded, washed and packed into glass jar or other containers and covered with fresh brine (7% salt) containing edible lactic acid. They may be pasteurized in container at 60°C or brined at 79-82°C for good keeping quality.

- Spiced olive pickle: The fermented olives can also be used for preparation of spiced pickles. For preparation of spiced pickles, the olives after draining from brine are kept in shade for removal of surface moisture. Chopped onion, garlic and ginger are fried in oil to which olives are mixed. Ground spices like cumin, cardamom, black pepper along with salt and turmeric are mixed thoroughly. Acetic acid and sodium benzoate are mixed during the packing of pickle in glass jars. Jars after filling with mustard oil are sealed and stored in cool and dry place.

B. Pickles preserved with salt: Lime and mango pickle.

- **Mango pickle**

Recipe: Mango slices 1.0 kg, Salt 200g, red chilli powder 10g, turmeric powder 10g, asfoetida (heeng) 5g, black pepper, cardamom (large), fenugreek, cinnamon (ground) and cumin 10g each. Procedure: Wash the mature green mango fruits, cut into 4 equal pieces (depending upon fruit size) and remove the kernel. Mix the fruit slices with salt and turmeric powder. Fill mango slices in glass jars and keep the covered jars in sunlight for 7-10 days. Shake the jar at least 2-3 times during drying (Fig 11.1). Mix the ground spices in well dried mango slices. Store the pickle in cool and dry place.

- **Lime pickle**

Recipe: Lime 1.0 kg, Salt 200g, red chilli powder 15g, black pepper, cardamom (large), cumin 10g each. Procedure: Wash the lime fruits, cut into 4 equal pieces. Squeeze the juice from ¼ of fruits and mix the salt and ground spices with juice. Mix the lime pieces with the mixture and fill into glass jars. Cover the jars with lid and keep in sunlight for 4-6 days. Shake the jars atleast 2-3 times during drying. Store the pickle in cool and dry place at ambient temperature. Similarly the sweet pickles from mango and lime is made by adding 500-700g jaggery or sugar to the above recipe.

C. Pickles in oil: Mango, lime, lemon, cauliflower, aonla, karonda etc.

- **Mango pickle**

Recipe: Mango slices 1.0 kg, salt 150g, powdered fenugreek 25g, red chilli powder 10g, turmeric powder 15g, black pepper, cardamom (large), cinnamon (powdered), cumin,

powdered aniseed 15g each, asafoetida 2g and mustard oil 350ml. **Procedure:** Wash the mature green mango fruits, cut into 4 equal pieces length wise (depending upon fruit size) and remove the kernel. Dip the mango slices in 2% salt solution to prevent browning. Drain off the water and dry the slices in shade for 4-5 hours (Mango slices preserved in salt can also be used for pickle preparation). Heat the oil, cool and mix spices in a little oil and mix the fruit slices thoroughly. Fill mango slices in glass jars and keep the covered jars in sunlight for a week. Shake the jars atleast 2-3 times during drying. Press the mango slices to remove the air, add remaining oil to cover the mango slices. Store the pickle in cool and dry place at ambient temperature (Fig. 11.1).

- **Aonla pickle Recipe:** Aonla 1.0 kg, salt 150g, powdered fenugreek 30g, red chilli powder 10g, turmeric powder 10g, cumin 10g and mustard oil 350 ml.

Procedure: Wash the mature healthy aonla fruits. Boil for 15 minutes to soften segments, cut and remove the seed. Heat the oil and fry all spices. Mix the segments with spices. Mix salt with aonla segments and fill in the jar. Keep the jar in sunlight for a week. Press the aonla pieces to remove the air, add remaining oil. Store the pickle in cool and dry place.

- **Karonda pickle Recipe:** Karonda 1.0 kg, salt 200g, red chilli powder 15g, turmeric powder 10g, cumin 10g, powdered fenugreek 10g, aniseed 10g and mustard oil 300 ml.

Procedure: Select mature, pink colour karondas and wash in clean water. Cut into two pieces and remove the seed. Mix salt with karonda and fill in the jar. Keep the jar in sunlight for 4 days. Heat the oil, fry all spices and mix the segments with spices thoroughly. Add remaining oil and store the pickle in cool and dry place.

- **Green chili pickle Recipe:** Green chilies 1.0 kg, salt 150g, mustard 100g, lime juice 200ml, powdered fenugreek, aniseed, turmeric, cardamom large, cumin, 15g each and mustard oil 400 ml.

Procedure: Select healthy green chilies and wash in clean water. Make incision and mix all spices in a little lime juice. Mix all spices in chilies and fill in clean jars. Add lime juice and keep the glass jars in sunlight for a week. Store the pickle in cool and dry place.

D. Pickle in vinegar (acetic acid): Garlic, green chili, papaya etc.

- Papaya pickle

Recipe: Green papaya slices 1kg, salt 150g, red chilli powder 10g, black pepper, cardamom (large), cinnamon (powdered), cumin 10g each and vinegar 750ml.

Procedure: Select green but mature papayas. Wash the fruits, peel, cut into equal sized slices and remove the seeds. Dip the cut pieces in boiling water to soften, remove papaya slices from boiling water. Mix with salt and dry in shade for few minutes. Mix the slices with spices thoroughly. Fill in glass jars and add vinegar to cover all the slices. Keep the covered jars in sun for a week and store the pickle in cool and dry place.

- Cucumber pickle

Recipe: Cucumber 1.0 kg, salt 200g, red chilli powder 15g, black pepper, cardamom (large), black pepper powder, cinnamon (ground) and cumin 10g each, clove 6 numbers and vinegar 750ml.

Procedure: Select green immature cucumbers. Wash, peel, cut into equal 5 cm thick slices. Mix slices with salt and fill in glass jars. Keep for about for about 6 hours and drain off water. Add all the spices and vinegar to the drained slices. Keep the covered jars

in sun for a week and store the pickle in cool and dry place. Similarly pickle from other fruits can be made by following the same method.

E. **Pickle in mixture of salt, oil, spices and vinegar:** Cauliflower, carrot, jackfruit, mixed vegetable pickle, etc.

- Cauliflower pickle

Recipe: Cauliflower florets/slices 1.0 kg, salt 150g, ginger (chopped) 25g, garlic 10g, red chilli powder, turmeric, black pepper, cardamom (large), cinnamon (powdered), cumin, aniseed powder 15g each, tamarind pulp 50g, mustard seeds 50g, vinegar 150ml and mustard oil 400ml.

Procedure: Select healthy and fresh cauliflowers. Wash and cut into equal pieces 2-2.5 cm. Blanch in boiling water for 2-4 minutes, drain and keep in sunlight for 2 hours. Fry all the spices in a little oil and mix them with cauliflower slices. Heat for 5 minutes and cool. Make paste of tamarind pulp in vinegar and add with cauliflower slices. Fill in the jar, keep in sunlight for a week. Add oil after heating and cooling to keep the pickle for long time. Store the pickle in cool and dry place. Sodium benzoate @ 250 ppm can be added as a preservative.

- Turnip pickle (sweet)

Recipe: Turnip 1.0 kg, salt 100g, ginger (chopped) 20g, garlic 10g, red chilli powder, turmeric, black pepper, cardamom (large), cinnamon (powdered), cumin, aniseed powder 10g each, tamarind pulp 100g, mustard 20g, vinegar 100ml, jaggery 200g and mustard oil 200ml.

Procedure: Select healthy, sound and tender turnip. Washing, trimming and peeling is done to remove rough and thick skin. Cut into equal pieces of 1-1.5cm thickness. Blanch for 5 minutes, drain the water and dry in shade to remove moisture. Fry the spices in a little oil except tamarind. Mix the turnip slices with spices thoroughly. Make paste of tamarind pulp in vinegar along with jaggery and mix paste with turnip slices. Fill in the jar and keep in sun for a week. Add oil after heating and cooling to keep the pickle for longer time. Store the pickle in cool and dry place. Sodium benzoate @ 250 ppm can be added as a preservative.

- Mixed vegetable pickle

Recipe: Cauliflower + carrot + turnip 1.0 kg, salt 100g, red chilli powder 15g, ginger (chopped) 20g, onion chopped 50g, red chilli, turmeric, black pepper, cardamom (large), cinnamon (powdered), cumin, aniseed powder 10g each, mustard 50g, vinegar 200ml and mustard oil 350ml.

Procedure: Mixed vegetable pickle is prepared similarly to that of sweet turnip pickle. If sweetness is required then jaggery may be added by making a paste with vinegar. Sodium benzoate @ 250 ppm can be added as a preservative.

- Jackfruit pickle (sweet) (Fig. 11.2)

Recipe: Jackfruit slices 1.0 kg, salt 100g, red chilli powder 15g, ginger (chopped) 20g, turmeric, black pepper, cardamom (large), cinnamon (ground), cumin, aniseed powder 10g each, mustard 20g, vinegar 150ml, jaggery 250g and mustard oil 350ml.

Procedure: Select small mature jackfruits, wash, peel and cut into equal suitable sized slices. Steeping in 10% salt solution is done for a week. Drain off the brine and wash the slices with plain water. Fry all the spices in oil except vinegar, jaggery or sugar. Mix spices with jackfruit slices and fry for 5 minutes, allow to cool and fill in the glass jars.

Keep the jar in sunlight for a week. Make paste of sugar/jaggery with vinegar and mix the paste to the prepared slices. Store the pickle in cool and dry place.

Table 1: Common defects noticed in different pickles during storage.

S.No.	Common Defects	Cause
1	Blackening	It is mainly due to the presence of iron which enters through the brine or from the equipments. Blackening may also be caused by the action of microorganisms.
2	Dull and faded pickle	It is due to either insufficient curing or use of water of inferior quality.
3	Shriveling	It occurs when vegetables like cucumber are placed directly in a very strong solution of salt or vinegar. To avoid this, use weak solution at the start and increase gradually.
4	Softness and slipperiness	It is the most common type of spoilage caused by the action of bacteria. Use of weak brine or improper covering with brine results in these defects. Thus this defect can be checked by using brine of proper strength and keeping the pickle well below the surface of the brine.
5	Bitter Taste	It is due to the use of very strong vinegar or cooking the spices for a long time or by using spices in excess.
6	Scum formation	It is due to growth of film yeast on the brine kept for curing of vegetables. The scum may be thin or thick varying from imperceptible film to a thick wrinkled layer. It retards the formation of a lactic acid and helps in the growth of putrefactive bacteria which makes the vegetable soft or slippery. The scum may be removed as soon as it is formed. Use of 1% acetic acid to the brine prevents the growth of wild yeast on the brine, without hindering the formation of lactic acid.
7	Cloudiness	In many fermented solid vegetables like onion, cucumber, olives etc the vinegar becomes cloudy and turbid, thus spoiling the appearance of the product. It is due to non-penetration of acetic acid from vinegar deep in to the tissues to check the activity of bacteria or other micro organisms. This results in fermentation which make the vinegar cloudy. Use of brine and vinegar of proper strength prevents cloudiness.
8	Blemishes in pickles	In onion pickle in brine, white blotch is seen under the first layer of the skin which is termed as blemish. Blemishes are generally caused by improper fermentation or non removal of all brine prior to the final pickling of cured onion in vinegar.

FPO specifications for pickles: According to FPO specifications the minimum percentage of salt (w/v) in pickle in brine shall be 12% while for pickle in citrus juice the acidity as citric acid

shall not be less than 1.2% and only citrus fruit juices should be used . For oil pickles any edible vegetable oil like rapeseed, mustard, olive etc can be used. Other general characteristics for these pickles include use of wholesome fruit and vegetables which are free of fungal or insect attack or any rotting. All ingredients shall be thoroughly clean and free from of extraneous matter. Only substances that may be added are spices, salt, sugar, jaggery, onions, garlic, benzoic acid, soluble calcium salts. Pickles shall be free from added copper, alum, mineral acids or other preservatives.

Chutney and Sauces

Chutney and sauces are the important products prepared from fruits and vegetables. Salt, spices, sugar, acid in these products is added to improve taste and to act as a preservative. These products are well known for their palatability and appetizing nature. Mango, apple, plum, apricot, tomato, carrot etc are the raw materials for these products. Mango chutney, plum chutney and mixed fruit chutney are quite popular. Fruit chutney is a product-made in the same way as that of jam except that spices, salt and vinegar are also added. Vinegar extract of the spices is added most preferably in place of whole spices. The chutney shall contain minimum of (40% fruit)(w/w) in the final product with total soluble solids not less than 50% and acidity not exceeding 2.1%. Sauces are also prepared from more or less similar ingredients and in same manner as chutney. Except the fruit pulp is sieved after cooking to remove the skin, seeds and stalks of vegetables; to give a smooth consistency to the final product. The consistency of sauce is comparatively thin than of fruit chutney. According to FPO specifications, the quantity of total soluble solids and acidity as acetic acid in the sauce shall not be less than 15% and 1.2% respectably. Sauces may be of two kinds. Thin sauces of low viscosity mainly consist of vinegar extracts of flavouring spices, herbs etc and thick sauces which are highly viscous.

Fruit Sauce: A fruit sauce of better quality should be cooked to such a consistency that it can be poured freely without fruit tissues separating out in the bottle. The colour should be bright. The neck of jar/bottle should be covered with paraffin wax layer for airtight sealing.

CHUTNEY

Fruit chutney: The recipe for preparation of fruit chutney from different fruits is given in following table as a general guideline and method is discussed as under:

<i>Recipe</i>	<i>Mango</i>	<i>Apple</i>	<i>Plum</i>	<i>Apricot</i>	<i>Papaya</i>
Fruit slices/pulp,kg	1	1	1	1	1
Sugar, g	750	750	750	1000	750
Cumin, Black pepper, cinnamon, aniseed, g (each)	10	10	10	10	10
Cardamom(large), red chillies powder g (each)	10	10	10	10	10
Salt, g	45	45	45	45	45
Onion chopped, g	50	250	50	50	100
Garlic chopped, g	15	15	15	10	15
Vinegar, ml	170	200	175	150	200
Clove (headless), no.	5	5	5	5	5
Sodium benzoate (ppm)	250	250	250	250	250

Procedure for preparing chutney

The fruit/vegetable is cut into slices of suitable size and softened by dipping in boiling water. Slow cooking is preferred to yield better product than that of bristle heating at high temperature. Onion and garlic are added at the start to mellow their strong flavour. Spices are coarsely powdered and added. Spices can also be added by placing all ingredients in a cloth bags, loosely tied and placed in the mixture during cooking. Vinegar extract of spices can also be added. The vinegar is added just little before final stage of boiling. In place of vinegar, acetic acid can also be used as source of acidity. The product is cooked to a consistency of jam and filled hot into sterilized jars. The product can be pasteurized and processed at 82⁰C for 30 minute. The storage of chutney is done at ambient temperature in cool and dry place.

SAUCE

Recipe used for preparation of fruit sauce as a general guideline is given in following table and explained as under:

<i>Recipe</i>	<i>Tomato</i>	<i>Apple</i>	<i>Plum</i>	<i>Mashroom</i>	<i>Papaya</i>
Fruit pulp,kg	1	1	1	1	1
Sugar, g	75	250	100	75	50
Salt, g	10	10	20	25	14
Cardamom, red chillies powder g (each)	5	10	10	5	5
Ginger chopped, g	10	100	25	10	10
Onion chopped, g	50	200	50	100	50
Garlic chopped, g	5	50	10	10	5
Acetic acid, ml	5	50	40	40	40
Aniseed powder, cumin g (each)	10	15	10	10	10
Sodium benzoate (g/kg sauce)	0.25	0.7	0.7	0.25	0.7

Procedure for preparing sauces

Sauces are of thinner consistency as compared to ketchups and contain not less than 15⁰B total soluble solid. Plum apple, papaya and mushroom etc are used successfully for preparation of sauces. High quality sauces are prepared by maceration of spices, herbs, fruits and vegetables in cold vinegar or by boiling. Thickening agents can also be added to sauces to prevent sedimentation of solid particles.

The fruits are washed and cut in to pieces (plum and apricot are used as whole). Cook for 10 minutes by adding little quantity of water in stainless steel (SS) pan or in pressure cooker. Pass heated fruits through pulper to separate skin and seeds. Fruit pulp can also used in preparation of sauce. Add half the quantity of sugar and place the spices in a muslin cloth bag and immerse in the pulp during cooking. Cook till the pulp is reduced to half the original volume. Remove the muslin bag and squeeze into pulp. Add acetic acid salt and remaining sugar. Heat the mass for few minutes. To judge the end point, place a spoon of sauce in plate, if no water oozes out, it indicates the end point or else more cooking is needed. Fill the finished product in sterilized

glass bottle, crown corked and process in boiling water for 25-30 minutes. Keep the bottles in cool and dry place.

Problem during preparation of sauce or chutney

Black neck: It is a formation of black ring in the neck of the bottles. It is caused by the iron which gets into the product from equipment metal or cap/crown cork. This iron when come in contact with tannins in spice forms ferrous tannate which on oxidation change to black colour.

Prevention of black neck

- Fill hot sauce at temperature not less than 85°C.
- Leave less head space in bottles (more air in bottles will result in more blackening).
- Reduce the chances of iron contamination.
- Partial replacement of sugar by corn syrup or glucose may prevent blackening.
- Store bottles in horizontal or inverted position to diffuse the entrapped air/oxygen.