Processing of Fruits and Vegetables

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India is the second largest producer of fruits and vegetables in the world after China with quantum post-harvest losses of around 25-30 %. Nearly 3% of the total fruit & vegetable production is processed into value added products in India whereas the processing level about 80% in Malaysia, 30% in Thailand, and 60-70% in the UK and USA. The scope of fruit and vegetable processing sector has increased manifold and has been given a new lease of life owing to rapid urbanization and more women joining the workforce. Processing fruit and vegetable into semi-finished products like pulps and juices is an important part to handle glut during the fruit harvesting season. During the off season, these semi-finished products (raw pulp and juices) can be converted to finished products such as squashes, ready-to-serve drinks (RTS), nectar, cordial etc. In this regard, processing and preservation forms major pillars of food industry. World trade of fruit and vegetable juices averaged nearly US$4,000 million during last decade (FAOSTAT, 2005). Whereas during the year 2012-13, India exported processed food products worth Rs. 41,309.04 crores, which included major products like mango pulp (Rs.607.96 Crores), alcoholic and non-alcoholic beverages (Rs. 1932.73 Crores) and other processed products (MoFPI, 2013). The important importing countries were: USSR, Yemen, UK, UAE, Saudi Arabia, Kuwait, Germany, USA, Holland and Switzerland. Thus, there is a good scope for processing of fruit and vegetables into different products to reduce wastage and earn foreign exchange.

Fruit juice and pulp

Fruit juices and beverages generally comprise of naturally extracted juices, RTS drinks, 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 a natural liquid extracted by pressure or other mechanical means from the edible portion of a fruit. Certain vegetable juices are also consumed in fresh form. For example, tomato juice is the most commonly consumed vegetable juice in processed form either canned or bottled. Pulp is defined as the inner edible part of a fruit or vegetable. The composition of juice and pulp 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.

I. 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, RTS drinks, nectar, cordial, squash, crush, syrup, fruit juice concentrate and fruit juice powder. They are prepared by following minimum standards as prescribed under Food Safety and Standards Regulation(FSSA), 2011 (Table 1) and discussed as under:

Table 1: Food Safety and Standards Regulation (FSSA) specifications for fruit beverages

Product	Minimum % of total soluble solids in final product (w/w)	Minimum % of fruit juice in final product (w/w)	Maximum acidity expressed as citric acid (%)
Unsweetened juice	Natural	100	3.5
Fruit syrup	65	25	3.5
Crush	55	25	3.5
Squash	40	25	1.5
Fruit nectar (excluding orange and pineapple)	15	20	1.5
Orange and pineapple nectars	15	40	1.5
Cordial	30	25	3.5
Sweetened juice	10	85	-
Lime/lemon Ready to serve beverage	10	5	-
Ready-to-serve beverage/drink	10	10	-
Fruit juice concentrate	32	100	-
Synthetic syrup/sherbet	65	-	-

*Preservative SO_2/BA ppm specified by Food Safety and Standards Regulation, 2011,SO_2- sulphur dioxide; BA-benzoic acid

B. Fermented beverages

Fermented fruit beverage is a fruit juice, which has undergone alcoholic fermentation by yeast (*Saccharomyces cerevisae).* 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 (non-fermented beverages)

1. **Selection of fruits:** All fruits are not suitable because of difficulties in extracting the juice. The variety, maturity and locality of cultivation of the fruit influence the flavour and keeping quality of the juice. Only fully ripe fruits are selected as 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 acid (0.5%) solution followed by washing in water.
3. **Juice extraction:** Common equipment used for juice extraction of juice 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.

a) **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 electricity. Removal of rind is required to avoid bitterness. Finally, the juice is strained through a thick cloth or a sieve to remove seeds.

b) **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

1. 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.
2. Citrus fruits are usually reamed to extract the clear juice.
3. Harder fruits like pineapple are peeled, pulped and pressed to extract the juice.
4. Apple and pear fruits are crushed in a fruit grater and pressed in a hydraulic/basket press to extract a clear juice.
5. Passion fruit juice is prepared by using a pulper-finisher that separates peel 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. Most of the air is removed by subjecting the fresh juice to high vacuum. This process is called as deaeration and the equipment is known as the deaerator. Heating of juice during heat processing also helps in removal of the air.
5. **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 (broken fruit tissue, seed, skin, pectic substances, protein). Seeds and skin which adversely affect the quality of juice are removed by straining through a muslin cloth or power operated screening system or filter press.

b) **Finishing:** Citrus juices need finishing for separating cloudy but otherwise clear 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 off. Keep juice at low temperature for long periods to facilitate 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 pectinol enzyme is widely used for better juice recovery and clarification of fruit juices as it breaks pectin into soluble form thereby freeing the suspended particles which settle down and leaves the juice clear. Pectinol is more effective in the case of acidic juices. Fruit juices can be clarified in about

1-2 hours at 40-50^{o}C but requires 20 hours at 20^{o}C. Similarly, proteolytic and starch liquefying enzymes such as amylases are used to remove protein and starch from fruit juices.

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 earth is mixed with fruit juice and then passed through the filter press.

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 and casein combines with tannins and acid of the juice. Depending on the tannin content of the fruit juice, gelatin solution is mixed and allowed to stand for 18 to 24 hours to ensure settling of precipitated matter. 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 tartrate along with pulp and skin which is removed by freezing and thawing the juice or by refrigeration for a long period.

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 80-85^{0}C for few minutes and cooled immediately followed by filtration by passing the juice through a filter press.

6. **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.

7. **Preservation of juices**

Fruit juices, RTS and nectars are preserved by heat processing or by using class II preservatives like potassium meta-bisulphite (KMS) or sodium benzoate as described hereunder:

a) **Pasteurization**: It is a process in which juice is heated to 100^{o}C or slightly below for a sufficient time to inactivate/kill the micro-organisms causing spoilage. Usually juices are

pasteurized between 75 and 88^{0}C for 30 sec to 30 min depending on the type of heating system, nature of the juice and size of the container. Pasteurization can be performed at low temperature for a long time (LTLT) or high temperature for short time (HTST). Commonly followed pasteurization methods are:

i. **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.

ii. **Pasteurization by overflow method**: In this method, the juice is heated to a temperature about 2.5^{o}C higher than the pasteurization temperature and filled into the hot sterilized bottles up to the brim. The sealed bottles are processed in boiling water for specified period and cooled.

iii. **Flash Pasteurization/HTST**: In this process, the juice is heated only for short time at a temperature about 5.5^{o}C higher than the pasteurization temperature, filled into the containers and sealed air tight under cover of a steam to sterilize the seal and then cooled. It can be used for processing of orange juice, apple and grape 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 makes use of HTST sterilization in the temperature range of 90-110^{o}C for acid products (pH<4.6) and ultra-high temperature (UHT) sterilization 121^{o}C and above for low acid foods (pH>4.6). Products with better nutritional value and excellent sensory quality are produced. Juices in tetra pack are processed commercially using aseptic processing, e.g., apple, litchi.

c. Preservation with chemical: Benzoic acid (benzoates) and sulphur dioxide (Sulphites) are commonly used class II preservatives in juices. The limit of preservatives to be added in various products as per FSSA is given in Table 2.

i. **Benzoic acid**: Sodium salt of benzoic acid is generally used being soluble in water. Benzoic acid is more effective against yeast as compared to moulds. The quantity of sodium benzoate required depends on the nature of the juice, its acidity and type of microbial infection.

ii. **Sulphur dioxide**: Potassium metabisulphite is commonly used as a source of sulphur dioxide. On reaction with the juice it forms sulphurous acid. SO_2 is more effective

against moulds and bacteria than yeast and also inhibits enzymes. Its effectiveness depends on the acidity, pH, temperature and other substances present in the juice. This chemical should not be used in naturally colored juices due to its bleaching effect, it should not be used in juices to be packed in tin containers causing pinholes.

Table 2: Limits for permitted preservatives in fruit juice and beverages as per Fruit Products Order

Fruit juice/beverages	Preservative	Part per million (ppm)
1.Fruit pulp or juice for conversions into jams and other products		
a. Cherries	SO_2	3,000
b. Strawberries & Raspberries	SO_2	2,000
c. Other fruits	SO_2	1,000
2. Fruit juice concentrate	SO_2	1,500
3.Squashes, crushes, fruit syrup, sharbats, cordials, fruit juice and barley water.	SO_2 Or Benzoic acid	350 600
4. Sweetened ready to serve Beverages	SO_2 or Benzoic acid	70 120

d) Freezing Preservation: 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. 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^{o}C, practically all of the juice will be solid except for a little thick syrup in the center of the containers. This method is good for heat sensitive juices.

e) 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 packed in hermetic sealed containers with in-package desiccant to prolong the shelf-life of the product.

f) 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 with a characteristics taste. In carbonated beverages, carbon dioxide content

ranging from 1 to 8 g/L. Though this concentration is much lower than that required (14.6 g/L) for complete inhibition of microbial growth, yet it is significant in supplementing the lethal effect of acidity on pathogenic bacteria. Carbonation also helps in creating anaerobic conditions unsuitable for yeasts and moulds and also reduces the oxidation of ascorbic acid. The keeping quality is enhanced by adding 50ppm sodium benzoate.

g) 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.

8. **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 class II preservatives can be sealed by using PP (pilfer proof) caps.

II. Method of preparation of Pulp

The fruit is washed thoroughly to remove any adhering dust and dirt. The fruit is then subjected to preliminary treatments which vary with the type of fruit (strawberries are crushed between rollers; raspberries are steamed, crushed and passed through sieves, plums, peach and apricots are heated with a small quantity of water until they become soft) Fruit after softening can be passed through the pulper to extract the pulp.

Method for preparation of Tomato juice/pulp

Plant ripened fully red tomatoes are selected for juice making and green, blemished and over-ripe fruits are sorted out. Tomatoes are washed thoroughly with water, crushed (fluted wooden roller-crushers or fruit grater) and passed through pulper using either hot or cold pulping method.

Pulping Method

a) Cold pulping: It is commonly referred to as cold break process in which the tomatoes after washing are sliced or crushed in a fruit grater and immediately passed through a pulper to extract the pulp

b) Hot pulping: It is also known as hot break process. The tomatoes after slicing or crushing in a fruit grater are boiled in pressure cooker/ steam jacketed stainless steel kettle or aluminum pans till softening to facilitate pulp extraction in pulper.

Equipment for juice/pulp extraction: Tomato juice/pulp is extracted either by passing the crushed tomatoes through a continuous spiral press or pulper.

a) **Continuous spiral press**: It consists of a long spiral screw which presses the tomatoes against a tapered screen of fine mesh. The juice passes through the screen while seeds and peel are removed from the lower end of the sieve.

b) **Pulper**: The pulper consists of a horizontal cylinder made of fine stainless steel. The heavy paddles inside the cylinder rotates rapidly, forcing the fine pulp to pass through the screen/sieves which is collected separately while the pieces of skin, seeds, fibreetc pass out through another end of the machine. For extraction of custard apple pulp the scooping device has been developed (fig), similarly *bael* pulper and *jamun* pulpers (fig) can be used for extraction of *bael* or *jamun* pulp.

Finishing and homogenization: After extraction, edible common salt (0.4-0.6 %) and sugar (1%) are added to the extracted pulp/juice to improve the taste and flavour of the finished product. For homogenization, the juice is heated to 66^{o}C and forced under high pressure (70 kg/cm^{2}).

Filling: The finished juice is heated to 82-88^{o}C and filled hot in pre-sterilized glass bottles or cans (plain or lacquered). The bottles are then hermetically sealed using crown corks and sterilized in boiling water (100^{o}C) for about 25-30 minutes. The cans are double seamed and processed in boiling water depending upon the can size.

Labeling and storage: After sterilization, the cans are cooled and stored in a cool dry place. Glass bottles are allowed to air cool. Both bottles and cans are labeled before sending them to market/sale.

Different value added products from fruits

Fruit beverages: Fruit juices are rich sources of vitamins, particularly vitamin-C and minerals. These are easily digestible, highly refreshing and invigorating, thirst quenchers and far superior to most aerated drinks, which have practically no food value. They are beneficial against a number of ailments and tonics for heart and brain and serve as cold drinks in hot summer. Fruit juices are preserved in different forms such as pure juices, squashes, cordials, and fermented juices etc. These are broadly classified

Fruit juices

as under:

Pure fruit juice: This is the natural, unfermented juice processed out of the fruit and remains practically unaltered in its composition during preparation and preservation. Fruit juices can be prepared from almost types of fruits.

Fruit Squashes

Ready-to-serve (RTS) : This prepared from fruit juice. It contains minimum of 10% fruit and 10% sugars. It not diluted before serving.

Fruit juice beverage: This is a fruit juice, which is considerably altered in composition before consumption. It may be diluted before it is served as a drink.

Fermented fruit beverage: This is a fruit juice, which has undergone alcoholic fermentation by yeast. The product contains varying amounts of alcohol. Grape wine, apple ciders, berry wines etc., are typical examples for this kind of beverages.

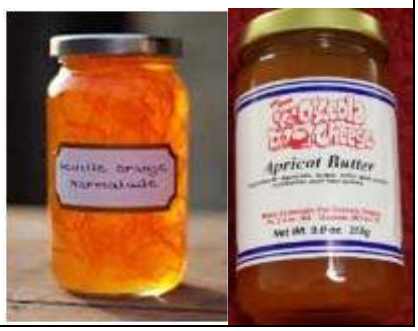
Fruit juice squash: This consists essentially of strained juice containing moderate quantity of fruit pulp to which sugar is added for sweetening. Fruit squash can be prepared from mango, lemon, orange etc.

Fruit juice cordial: Sparkling, clear, sweetened fruit juice from which all the pulp and other suspended materials have been completely eliminated (e.g. lime juice cordial, guava).

Sherbet or Syrup: Clear sugar syrup, which has been artificially flavoured.

Fruit juice concentrate: Fruit juice, which has been concentrated by the removal of water either by heat or freezing. Carbonated beverages and other products can be made from this.

Fruit juice powder: Fruit juice which has been converted into a free-flowing, highly hygroscopic powder to which natural fruit flavour in powder form is incorporated to compensate for any loss of flavour in concentration, dehydration etc. Freeze dried fruit juice powders makes the best quality products. The powders are reconstituted to yield readily full strength, full fruit, fruit juice drinks..



Preparation: Fruit juices have their best taste, aroma and colour when they are freshly extracted and used for product making. The important steps in beverage making are selection and preparation of fruits, extraction of juice,

de-aeration, straining, filtration, clarification and preservation.

Jams, jellies and marmalades

Jam: Jam is a concentrated fruit pulp, possessing a fairly heavy body and rich in natural fruit flavour. Pectin in the fruit gives it a good set and high amount of sugars (more than 68.5 %) facilities its preservation. It is prepared by boiling t

Marmalade *Apricot butter*

sufficient quantity of sugar to get thick consistency. A good jam must have bright colour, rich typical fruit flavour, stiff but should not be sticky or crystallization of sugar.

Jelly*:* It is a semi-solid product prepared by concentrating essentially a clear fruit extract with sugar. In jelly making, pectin is the most essential constituent. Good jelly should be transparent, attractive in colour, give strong flavour of the fruit and firm enough to retain a sharp edge when cut. Pectin from cell wall of fruits sugar, acid and water combine together when corked to form jelly. Guava jelly is very popular in all parts of the world.

Marmalade: It is usually made from citrus fruits and consists of jellies or jam of the concerned fruit containing shreds of peels suspended in them. Usually citrus peel is used for making shreds in marmalade.

Fruit butter, cheese and toffees

Fruit butter*:* It is a thick product but soft enough to spread easily. The butters can be prepared from any fruit but, most commonly used fruits are apple, pear, plum, peaches, apricot and grapes.

Fruit cheese

Fruit cheese: This product is commonly prepared from fruits like guava, apple and pear.

Fruit toffee: It is prepared by using fruit pulp, sugar, glucose, skimmed milk powder, butter and essence.

Preserves (murrabbas) and candies

Murabbah of Aonla

Preserves (Murrabbas) : It is a matured whole or in large pieces of fruit in which sugar is impregnated till it becomes tender and transparent. It retains the shape of the fruit and does not break or pulped. The preserve should have enough sugar (more than 68% TSS). Murabba can be prepared from amla, apple, mango, petha, grapes, muskmelon, and watermelon.

Glazed fruit candy

Candied fruit: A fruit impregnated with sugar, drained and

dried is named as candied fruit. They are not sticky and are plump, tender and exceedingly sweet with high flavour.

Glazed fruit*:* A candied fruit dipped for a moment in boiling syrup to impart a glossy finish to it, drained and dried- is called glazed fruit.

Crystallized fruit*:* Candied fruit drained, dried and rolled in crystal sugar is called a crystallized fruit.

Canning and bottling of fruits

Canning is a process of preserving the fruits by application of heat high enough to destroy essentially all microorganisms present together with sealing the food in air-tight sterilized cans to prevent recontamination and to preserve the food in the condition in which it is ready to eat or cook. When glass jars are used as containers in place of cans, the process is called bottling. Tin cans are most commonly used because they are unbreakable, easy to handle, strong to withstand heat processing, light in weight, permit quicker heat penetration and can be cooled quickly. Cans require can sealer or seamer for hermetic sealing.

Fermented products

Wine*:* Wine is made by fermenting grape juice with the help of yeasts. Wine can also be prepared by fermentation of other fruit juices such as mango, pineapple, guava, plum, kiwi, apple etc., which will be referred to as wine of that specific fruits (mango wine, pineapple wine etc.). Wine represents a non-toxic healthful beverage, which provides calories, vitamins, minerals and other nutrients.

Vinegar*:* The product made from carbohydrates obtained from different fruits by acetic fermentation is called vinegar. It can be manufactured as a byproduct from the pomace after extracting the juice from fruits. Fruit vinegars will have a unique flavour of the fruits used. Vinegar can be made from apple, grape or other fruits.

Wine *Cider* *Vinegar*

Pickles and chutneys

Pickles: The preservation of food in common salt or vinegar is called pickling. Spices and oil may also be added in pickles. Pickles are good appetizer aid to digestion and add to the palatability of the meal. In oil pickles, oil provides protection against outside infection. In other pickles, 15 to 20 % common salt is added to prevent spoilage caused by microbes. Moulds and even lactic acid forming bacteria do not grow at this high salt concentration, as a

results pickle remains safe for several months.

World famous Pachranga pickle

Chutneys: In general, hot and sweet chutneys are relished by all. Mo employed for preparing chutneys. A good chutney is smooth and has a mallow flavour and is spicy. Chutney is mostly prepared from mango.

Dried products of fruits

It is an oldest and cheapest form of preservation of fruits. Drying can be carried out either in sun or by artificial heat (dehydration). Sun drying is practiced in tropical and sub-tropical regions where there is plenty of sunshine. However, nowadays, drying is done by mechanical dryers because of faster rate of drying and hygi dry form.

Anardana *Amchur*

***Anardana*:** It is a form of dried sour pomegranate arils used as a souring agent in food preparations. Anardan is prepared from a special wild form of pomegranate, which are highly acidic.

Amchur: It is a product obtained by powdering dry unripe mango pieces of sour nature. It is used as souring agents in food preparations.

Apple leather

Fruit bar*:* Fruit bar can be prepared from the pulp extracted from fully ripe fruits. Fruit pulp dried with suitable quantity of sugar and citric acid along with specified level of chemical preservatives. This product is called as intermediate fruit product but commonly called as leather/papad in our country.

Primary processing of fruits and vegetables

The processing that occurs after harvesting to make food ready for consumption or use in other food products.

Primary processing ensures that foods are:

- Easily transported
- Ready to be sold
- Ready to be eaten
- Ready to be processed into other products (e.g. after the primary processing of peeling

A view of fresh-cut fruits

and chopping, an apple can be stewed)

Secondary processing

Secondary processing converts primary processed food into other food products.

Secondary processing ensures that foods:

- Can be used for a number of purposes
- Do not spoil quickly
- Are available all year (e.g. seasonal foods)

Steps involved in primary processing

Cleaning/ Washing

Washing machine for fruits and vegetables

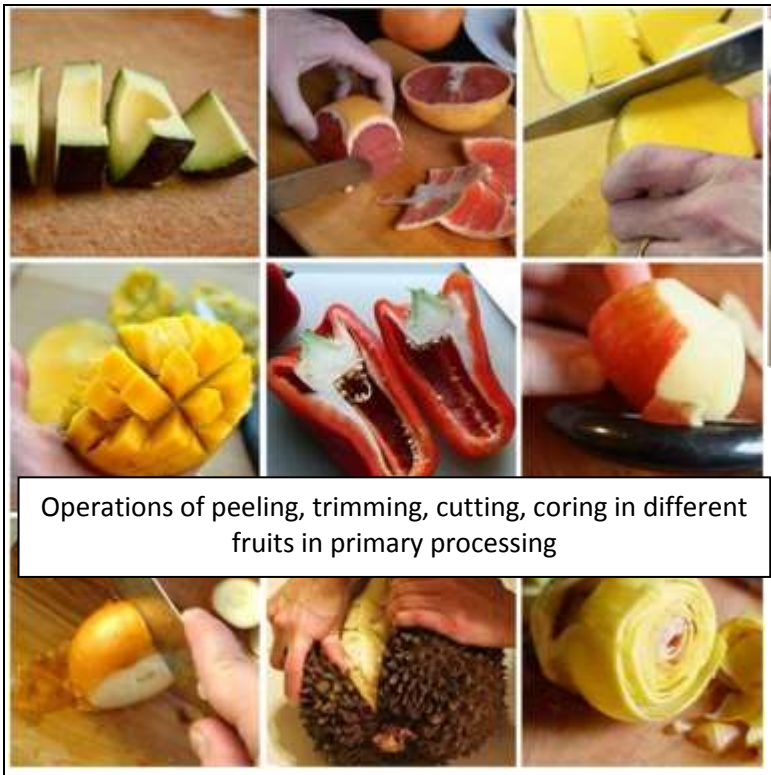
Harvested fruit is washed to remove soil, micro-organisms and pesticide residues. Fruit washing is a mandatory processing step; it would be wise to eliminate spoiled fruit before washing in order to avoid the pollution of washing tools and/or equipment and the contamination of fruit during washing. Washing efficiency can be gauged by the total number of micro-organisms present on fruit surface before and after washing - best result 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.

Ozone fruit and vegetable washing machine – a new introduction

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.).



Operations of peeling, trimming, cutting, coring in different fruits in primary processing

Mechanical grading of fruits

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:

a. Mechanically;

b. By using water steam;

c. 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.

Cutting

This step is performed according to the specific requirements of the fruit processing technology.

Preservation of fruits and vegetables

Food preservation may be defined as the set of treatment processes that are performed to prolong the shelf life of foods, preparation of value added products and at the same time retain the features that determine their quality, like colour, texture, flavour, palatability and especially nutritional value. Preservation is done to prevent spoilage of fruits and vegetables mainly manifested by physical, chemical, microbial and enzymatic changes.

Preparation of Pickles

The preservation of fruits and vegetables in common salt or in vinegar is called pickling. Spices and edible oils may be added to the product. Raw mango, lime, turnip, cabbage, cauliflower, etc. are preserved in the form of pickles, which have become popular in several countries. Pickling can be done in three ways:

1. *Curing/fermentation by dry salting*: In this technique, alternate layers of vegetable and salt are filled inside the barrels till $3/4^{th}$ of the container is filled. A layer of muslin cloth and wooden board are placed on top. In order to press the vegetables, a clean stone is also placed on the wooden board. The salt extracts juice from the vegetables so as to form brine. Brine is formed in 24 hours. The extracted brine is fermented by naturally occurring lactic acid bacteria. Lactic fermentation is completed in 8-10 days at a temperature of 27-32°C to produce lactic acid that acts as a preservative.
2. *Fermentation in brine*: Vegetables are preserved in a salt solution of suitable concentration (8-10 per cent) for a certain period of time. This process is called brining. The brine and vegetable ratio is kept as 2:1. Vegetable such as cucumber (gherkins), which do not contain sufficient juice to form brine with dry salt are fermented in brine.
3. *Salting without fermentation*: In unfermented pickles, the raw material is preserved by salt, spices, oil and vinegar. This is carried out by adding salt in washed and prepared vegetables in the ratio of 1:5. Such high concentration of salt inhibits fermentation, acts as preservative and the vegetables get cured. Excess salt is drained by soaking in warm water. Thereafter the vegetables are pickled by storing in sweetened or spiced vinegar of 10 per cent strength for several weeks. The cured vegetables can also be prepared by addition of spices and oil along with salt.

References

- Alzamora, S.E., Tapia, M.S., and López-Malo, A. (2000). Minimally Processed Fruits and Vegetables: Fundamental Aspect and Applications. Aspen Pub. Co., Inc., Maryland, US.
- Kaur, Charanjit (2005). Minimal Processing. Block 4 Processing and Preservation. BPVI-002, Principles of Post Harvest Management of Fruits and Vegetables. Published by IGNOU, New Delhi.
- Lamikanra, Olsuola (2002) Fresh Cut Fruit and Vegetable Science, CRC Press.
- Ohlsso, Thomas and Bengtsson, Nils (2004). Minimal Processing Technologies in Food Industry CHIPS.
- Pulle, Mervyn (2004). Food Processing Insights into Food Manufacturing Food Technology, Part 4, Part 4KBS publishers.
- Rosen, C. J. and Kader, A. A. (1989). Postharvest Physiology and Quality Maintenance of Sliced Pear and Strawberry Fruits. *J. Fd Sci*. **54**: 656-659.
- Sharma, S.K. and Nautiyal, M.C. (2009). Postharvest technology of Horticultural

crops. New India Publishing Agency, New Delhi

- Siddappa, G. and Tandon, D.K. (1998). PresErvation of Fruits and vegetables. ICAR, New Delhi
- Singh, R.P. and Oliveira, F.A.R (1994). Minimal Processing of Foods and Process Optimization, CRC.
- Srivastava, R.P. and Kumar, S. (2001). Fruit and vegetable preservation: Principles and practices. International Book Distributing Co., Lucknow, India.
- Verma, L.R. and Joshi, V.K. (2000). Post harvest technology of fruits and vegetab Volume 1 and 2. Indus Publishing House, New Delhi.
- Wiley, R.C. (1994). Minimally Processed Refrigerated Processed Fruits and Vegetables, CRC.

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