Chapter - 2

PRINCIPLES OF PRESERVATION AND VALUE ADDITION OF HORTICULTURAL PRODUCE

OBJECTIVES

After studying this chapter, students will be able to:

- Understand about the importance of processing of horticultural produce
- Know the basic principles involved in preservation and processing of horticultural produce
- Explain the different value added products, which can be made from horticultural produce
- Develop entrepreneurship for processing unit based on raw material obtained from horticultural produce

INTRODUCTION

Whenever you go to any market, you find several products such as jam, jelly, squashes, pickles, *murabbah*, candy and several other such products. I hope that most of students might have enjoyed these products at your homes. Most of us use to purchase these products from shops, however, mothers & sisters of some students might have made some of these products at home. Have you ever thought of their raw material from which these are prepared? How these products keep well for long periods? What processes are involved in their preservation? I hope you might have never thought of it. All such products are prepared through processing, preserved for long time by using several techniques, which are based on certain principles. In this chapter, you will come to know about processing, several principles involved in preservation of fruits and vegetables and different value added products, which can be made from horticultural produce.

HISTORY OF FOOD PROCESSING

Food processing dates back to the prehistoric age when crude processing including various types of cooking, such as over fire, smoking, steaming, fermenting, sun drying and preserving with salt were in practice. Foods preserved this way was a common part of warriors' and sailors' diets. These crude processing techniques remained essentially the same until the advent of the Industrial Revolution. Nicolas Appert developed a vacuum bottling process to supply food to troops in the French army, which eventually led to canning in tins by Peter Durand in 1810. Modern food processing technologies, in the 19th century were also largely developed to serve military needs. In the early 20th century, the space race, change in food habits and the quality consciousness of the consumers in the developed world further added to the development of food processing with advancements such as spray drying, juice concentrates, freeze drying and the introduction of artificial sweeteners, colourants, and preservatives. In the late 20th century, products including dried instant soups, reconstituted fruit juices, and self cooking meals such as ready-to-eat food rations etc., were developed.

IMPORTANCE, SCOPE AND BENEFITS OF PROCESSING OF HORTICULTURAL CROPS

Horticulture sector primarily includes fruits, vegetables, and floricultural crops. Due to lack of adequate post harvest handling, processing and infrastructure facilities, post harvest losses caused by spoilage are very high. It is estimated that post harvest losses of horticultural produce range between 30-35 per cent. Generally losses occur during pre-harvesting, harvesting, transportation, storage, processing, packing, marketing and distribution stages. Even if 10 per cent of these losses could be saved by converting the surplus into processed products, there will be considerable saving to the horticultural wealth in the country. The international trade in preserved horticultural crops consists largely of fruit juices, nectars, juice concentrates, canned pineapple, canned pulps, canned and dehydrated vegetables, instant chutneys and ready-to-use products. Tropical vegetables, fruits, spices and aromatic plants grown in India having nutritional and appetizing appeal have great export potential to the rest of the world because of their medicinal, therapeutic and antioxidant properties as health foods. There is further scope for augmenting exports with respect to tropical fruit juices, pulps and concentrates. Products obtained from fruits like mango, guava, papaya, pineapple and large number of other highly nutritive indigenous fruits, vegetables as well as from floral and medicinal crops have great demand for domestic and export market.

Benefits of Processing

- By processing, raw food and other farm produce is converted into edible, usable and palatable form.
- Processed products can be stored for a longer time.
- There is a significant reduction in post harvest losses.
- Produce is available even during off-season.
- Processing helps to generate employment for rural youth.
- Helps in improving palatability and organoleptic quality of the produce by value addition.
- Helps in easing marketing and distribution tasks.
- Increases seasonal availability of many foods.
- Enables transportation of delicate perishable foods across long distances.
- Makes foods safe for consumption by checking of pathogenic microorganisms.
- Food processing can also bring nutritional and food security.
- Food processing has great potential for export and thereby to fetch foreign exchange.

Importance of processing

The main causes of spoilage of horticultural produce are microbiological (bacteria, yeasts, moulds), chemical (enzymatic discolouration, rancidity, oxidation) and physical (bruising) factors. There are many reasons for processing foods besides the development of a business with a good return on investment for the owners such as to prevent post harvest losses, to eliminate waste, to preserve quality, to preserve the nutritive value of the raw materials, to make seasonal horticultural produce available throughout the year, to put them in convenient form for the user, to safely put the food away for emergencies and to develop new products and to increase the value of the product.

A view of bottling in a fruit processing plant

Food preservation, in the broad sense, refers to all the measures taken against any kind of spoilage in food. It is the process of treating and handling food in such a way so as to stop or greatly slow down spoilage to prevent foodborne diseases while maintaining nutritional value, texture and organoleptic quality as well as increasing shelf life. Proper packaging and storage of processed/preserved products are also important aspects of agro-processing to retain quality of fresh horticultural produce which could be adversely affected by physical damage, chemical reactions, microbiological changes and attack by insects and rodents.

Principles of Preservation

The following principles are involved in preservation of fruit and vegetables

1. Prevention or delay of microbial decomposition

- By keeping out microorganisms (asepsis)
- By removal of microorganisms, e.g., filtration
- By hindering the growth and activity of microorganisms, e.g. by low temperature, drying, anaerobic conditions or use of chemicals
- By killing the microorganisms, e.g., use of heat or radiation

2. Prevention or delay of self-decomposition of the food

- By destruction or inactivation of food enzymes e.g. blanching
- By prevention or delay of purely chemical reactions e.g. prevention of oxidation by means of an antioxidant

3. Prevention of damage caused by insects, rodents, mechanical damage etc.

(I) Physical Approaches to Food Preservation

- Removal of microorganisms, e.g., asepsis and filtration
- Raising the temperature of food, e.g., heating (blanching, pasteurization/ sterilization, flash pasteurization/HTST (high temperature & short time processing)
- Controlled reduction of product temperature, e.g., chilling and freezing
- Controlled reduction in the water content of food products, e.g., dehydration, freeze drying, osmotic dehydration

- Use of protective packaging such as prepackaging and use of modified atmosphere packaging

- Use of radiations such as ionizing radiations

a) Asepsis and filtration: Asepsis means preventing the entry of microorganisms. Maintaining of general cleanliness while harvesting, grading, packing and transportation of horticultural produce increases their keeping quality. Washing and wiping of the fruits and vegetables before processing should be strictly followed to reduce the soil particles, pesticide residues and initial contamination by microorganisms. Filtration of liquid foods through 0.45micron seitz filters helps to remove microorganisms and thus minimizes the chances of spoilage.

b) Thermal Processing: Since many of the processes utilized to preserve food products depend on the addition of thermal energy, it is important to understand its underlying principles. The design of a thermal process to achieve food preservation involves two principles: (a) the use of elevated temperatures to increase the rate of reduction in the microbial population present in the raw food material (Microbial population may refer to the number of vegetative cells existing in food product or to the number of microbial spores in a given mass of food) and (b) the transfer of thermal energy into the food products as required for achieving the desired elevated temperatures.

Points to remember

Blanching is done at about 100°C, pasteurization below 100°C and sterilization above 100°C. Blanching is primarily done to inactivate enzymes, pasteurization to kill maximum harmful microbes, and sterilization for complete killing of microorganisms

Thermal processing used for preservation is usually classified as follows:

i) Blanching : Blanching is a heat treatment given to a fruit or vegetable either in boiling water or microwave above 100°C. Blanching is used to destroy enzyme activity in fruits and vegetables, prior to processing. Blanching helps in several ways as it inactivates enzymes, which prevents undesirable changes in sensory characteristics and nutritional properties that take place during storage, reduces the number of contaminating microorganisms on the surface of foods, leads to softening of vegetable tissues thus facilitating can filling and helps in removal of air from intercellular spaces.

ii) Pasteurization: Pasteurization is a process of heat treatment used to inactivate enzymes and to kill relatively heat sensitive pathogenic microorganisms that

cause spoilage. It is a mild heat treatment, usually performed below 100°C. Pasteurization kills only harmful microorganisms. In practice, therefore, most of the canned foods produced locally in developing countries such as canned peas tomatoes, canned pineapple slices etc. are heated within the package. There are two categories of pasteurization process:

a) Low temperature long time (LTLT): 62.7°C for 30 minutes

b) High temperature short time (HTST): 71.7°C for 15 seconds

iii) **Sterilization:** In this process, food is heated at a sufficiently high temperature (121°C) and for long time (10-15 minutes) to destroy microbial and enzyme activity. As a result, sterilized foods have a shelf life of more than six months. Higher temperature for a short time (140°C/3-4 seconds) is possible if the product is sterilized before it is filled into pre-sterilized containers in a sterile atmosphere. This forms the basis of Ultra High Temperature (UHT) processing (also termed aseptic processing). It is used to sterilize a wide range of liquid foods (fruit juices and concentrates, wine, etc.) and foods that contain small discrete particles (tomato products, fruit and vegetable soups).

Advantages of thermal processing

- Food becomes more tender and pliable with the desired cooked flavour and taste.
- Preservative effect on foods owing to destruction of microorganisms, enzymes, insects and parasites.
- Significant destruction of antinutritional components in food.
- Improvement in bioavailability of some nutrients (for example improved digestibility of proteins and gelatinization of starches etc.).
- Relatively simple control of processing conditions.

c) **Drying/Dehydration:** Preservation of foods by drying is perhaps the oldest method known to us. The weight of the product by drying is reduced to the extent of 1/ 4^{th} to $1/9^{th}$ of its original fresh weight. Drying of foods and biological products is a widely applied process for different purposes such as increasing shelf life, reducing packaging costs, making food available during off-season, and maintaining nutritional value. Drying or dehydration of fruits and vegetables can be accomplished with little capital while maintaining high quality and obtaining less perishable food products.

Drying Techniques: Several types of dryers and drying methods, each better suited for a particular situation are commercially used to remove moisture from a wide variety of food products including fruits and vegetables. There are different types of drying processes are as follows:

- Solar drying
- Atmospheric drying including batch (mechanical/cabinet drying) and continuous (fluidized bed, spray and drum drying)
- Osmotic dehydration
- Sub-atmospheric dehydration (freeze drying)

II) Chemical Preservation

- Use of chemical additives such as sugars, salt, acids, spices etc.

a) High sugar preservation: In the food preservation with sugar, the water activity cannot be reduced below 0.70. This value is sufficient for bacteria, yeasts and molds inhibition but does not prevent osmophilic yeasts and xerophillic molds attack. For this reason, various means are used to avoid mould development such as finished product pasteurization (jams, jellies, etc.) and use of chemical preservatives.

b) Use of salt/acid/spices (Pickling): Pickle is an edible product preserved and flavoured in a solution of common salt and/or vinegar. The preservation of fruits and vegetables in common salt and/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. Apart from having nutritional and therapeutic value, they have appetizing appeal.

c) Use of chemical additives: The Food and Drug Administration (FDA) has defined food additive as a substance or a mixture of substances, other than the basic foodstuff, which is present as a result of any aspect of production, processing, storage or packaging. It comprises of preservatives, antioxidants and many others. According to FDA, 'chemical preservative is any substance which is capable of inhibiting, retarding or arresting the process of fermentation, acidification or other decomposition of food or masking any of the evidence of any such process or of neutralizing the acid generated by any such process but does not include salt, sugars, vinegar, spices or oils extracted from spices'. Chemical food preservatives are added in very

small quantities (up to 0.2 per cent) and they do not alter the organoleptic and physico-chemical properties of the foods. Preservation of food products containing chemical food preservatives is usually based on the combined or synergistic activity of several additives, intrinsic product parameters (e.g. composition, acidity, water activity) and extrinsic factors (e.g. processing temperature, storage atmosphere and temperature). This approach minimizes undesirable changes in product properties and reduces concentration of additives and extent of processing treatments. Chemical food preservatives are applied to foods as direct additives during processing, or develop by themselves during processes such as in fermentation. Certain preservatives have been used either intentionally or accidentally for centuries, which include sodium chloride (common salt), sugar, acids, alcohols and components of smoke. In addition to preservation, these compounds contribute to the quality and identity of the products.

III) Biological Preservation (Fermentation)

- Fermentation technology involving alcoholic or acidic fermentations using selected desirable microorganisms

The various preservation methods discussed so far are based on the application of heat, removal of water, freezing etc. All these methods have the common objective of reducing the number of living microorganisms in foods or at least holding them in check against further multiplication. Fermentation processes for preservation purposes, in contrast, encourage the multiplication of lactic acid forming bacteria and their metabolic activities in foods. But the organisms that are encouraged are from a selected group and their metabolic activities and end products are highly desirable.

IV) Combined Method of Preservation (Hurdle Technology)

- A judicious combination of more than one method mentioned above for synergistic preservation is called hurdle technology.

The trend of using a wide range of mild preservation techniques has emerged to be known as combined preservation or barrier (Hurdle) technology. Hurdle in food is defined as the substance or the processing step or various preservation factors, inhibiting the growth of various microorganisms resulting in the death of microorganisms. It advocates the deliberate combination of existing and novel preservation techniques in order to establish a series of preservative factors (hurdles) that any microorganisms present should not be able to overcome. It requires a certain amount of effort from a microorganism to overcome each hurdle. Higher the

hurdle, greater the effect. Several tropical and sub-tropical fruits and vegetables like carrot, capsicum and coconut are processed by hurdle technique by slight reduction of water activity (a_w 0.92-0.95), lowering of pH (below 4.5) and mild heat treatment (in-pack pasteurization at 85^{0}C) or treatment with antimicrobial additives with a view to control microbial growth, packed in flexible polymeric pouches and are evaluated for their shelf stability under ambient conditions.

Value Added Products from Horticultural Crops

1. Fruits and Vegetables

i) Jam, Jelly, Marmalade and Preserve: Preparation of jam, jelly and marmalade is based on concentrating fruits to nearly 70 per cent solids (TSS) by addition of sugar and heat treatment. The high osmotic pressure of sugar creates unfavourable conditions for the growth and reproduction of most species of microorganisms i.e. yeasts, molds and bacteria, responsible for the spoilage of food. At this concentration of solids, the water activity is reduced (a_w of 0.60-0.75), which ultimately decreases the chances for microbial spoilage.

Jam is prepared by boiling the fruit pulp with sufficient quantity of sugar to a reasonably thick consistency, firm enough to hold fruit tissues in position. It should contain not less than 68.5 per cent soluble solids as determined by a refractometer. Jam may be made from a single fruit (apple, strawberry, banana, pineapple etc.) or from a combination of two or more fruits. The preparation of jam requires several unit operations viz., selection of fruit, preparation of fruit, addition of sugar, addition of acid, mixing, cooking, filling, closing, cooling and storage.

Mixed fruit jam

Jelly is a semi-solid product prepared by boiling a clear, strained solution of pectin containing fruit extract with sufficient quantity of sugar and measured quantity of acid. A perfect jelly should be transparent, well set, but not too stiff and should have the original flavour of the fruit. It should be firm enough to retain a sharp edge but should be tender enough to resist the applied pressure. It should not be gummy, sticky or syrupy or have crystallized sugar. Different fruits like guava, plum, papaya, gooseberry etc. are used for jelly preparation. Low pectin fruits such as apricot,


Amla murabbah

pineapple, raspberry etc. can be used only after adding small amount of pectin powder. The essential substances for manufacture of jelly are pectin, water, acid and sugar. Formation of jelly takes place when the concentrations of water-sugar-acid-pectin mixture attain a certain minimum value.

Marmalade is a fruit jelly in which slices of the citrus fruit or its peels are suspended. Marmalades are generally made from citrus fruits like oranges and lemons in which shredded peels are suspended.

Preserves (*Murabbas*) are prepared from whole fruits and vegetables or their segments by addition of sugar followed by evaporation to a point where microbial spoilage can't occur. The final soluble solids concentration reaches to about 70 per cent. The finished product can be stored without hermetic sealing and refrigeration.

ii) **Chutneys and Sauces:** Chutney is a mixture of fruit or vegetable with spices, salt and/or sugar, vinegar etc. A good chutney is smooth, palatable and appetizing, and has the true single flavour of the fruit or the vegetable used for its preparation. Most popular chutneys are those from tomato, mango, *aonla* etc. On the other hand, a good **sauce** has a continuous flow with no peel, seeds and stalks of fruits and/or vegetables. It possesses pleasant taste and aroma. Sauces are sieved and as a result, are thinner and have smooth consistency than chutneys. Sauces can be prepared from tomato, papaya etc. Vinegar, salt, sugar and spices are the common preservatives, used for the preservation of these products. The chemical preservatives, such as sodium benzoate and potassium metabisulphite are used for long-term storage, wihich helps in retarding the growth of microorganisms without interfering with other physico-chemical and sensory characteristics of the product. Some factors taken into consideration for the selection of a chemical to be used as a preservative include type of organism to be controlled, pH of the product, length and conditions of product storage and physical and chemical characteristics of the food.

Fruit juices prepared from different fruits

iii) **Fruit Juices/Beverages**: Fruit juices are preserved in different forms such as pure juices and beverages. **Fruit beverages** can be classified into two groups:

a) **Unfermented beverages**: Fruit juices that do not undergo alcoholic fermentation are termed as unfermented beverages. They include natural and sweetened juices, ready-to-serve beverage, nectar, cordial, squash, crush, syrup, fruit juice concentrate and fruit juice powder. These beverages can be distinguished on the basis of the differences in total soluble solids (TSS) content and minimum juice percentage as given in (Table 1).

Table 1: Fruit Product Order (FPO) specifications for fruit beverages

Product	Minimum % of total soluble solids (TSS) in final product (w/w)	Minimum % of fruit juice in final product (w/w)
Unsweetened juice	Natural	100
Fruit syrup	65	25
Crush	55	25
Squash	40	25
Fruit nectar (excluding orange and pineapple nectars)	15	20
Orange and pineapple nectars	15	40
Cordial	30	25
Sweetened juice	10	85
Ready-to-serve (RTS)	10	10
Fruit juice concentrate	32	100
Synthetic syrup/sherbet	65	-

b) **Fermented beverages**: Fruit juices, which have undergone alcoholic fermentation by yeast and lactic acid fermentation by bacteria. They include wine, champagne, port, sherry, cider and *kanji*.

Methods of preservation of fruit juices/beverages

A. **Pasteurization**: Preservation by heat is the most common method of fruit juice preservation. It may be done in three ways:

a) **Holding pasteurization:** After filling of the juice in bottles, the bottles are pasteurized at 85°C for 25-30 min. This is usually done at home scale.

b) **Over-flow method:** In this case, juice is heated at a temperature of about 2.5°C higher than the pasteurization temperature and filled into hot sterilized bottles upto the brim. The sealed bottles are then pasteurized at a temperature of 2.5°C lower than the filling and sealing temperature. It thus minimizes the adverse effect of air on quality of the juice.

c) **Flash pasteurization:** In this method, fruit juice is heated for a short time at a temperature higher than the pasteurization temperature and held at that temperature for about a minute and filled into the containers, which are sealed airtight.

B. **Carbonation***:* It is the process of incorporating carbon dioxide in a beverage to impart a characteristic taste. Apart from the distinctive taste, carbon dioxide also inhibits the growth of certain undesirable microorganisms.

C. **Chemical Preservation:** For preserving juices chemically, the addition of 700 ppm potassium metabisulphite or 720 ppm of sodium benzoate (for coloured products) is employed. Chemically preserved juices are bottled leaving a head space of 1.5 to 2.5 cm followed by crown corking/sealing.

iv) **Fermented products:** Fermentation of fruits and vegetables can be classified into three types:

(i) **Alcoholic fermentation-** which has already been discussed under fermented beverages earlier

(ii) **Lactic fermentation** – which involves fermentation of carbohydrates into lactic acid to prepare fermented pickles such as sauerkraut, gherkins, fermented olives etc.

(iii) **Acetic fermentation** – It involves alcoholic fermentation followed by acetic acid fermentation for the manufacture of vinegar, which is used as a condiment. Vinegar contains about 4 per cent of acetic acid in water and can be prepared from a number of fruits such as grapes, apple, oranges etc.

v) **Pickles :** The process of preservation of food in common salt or in vinegar is called pickling. Spices and edible oil may also be added to the product. Pickles may be sour, sweet or mixed and can be prepared easily from different fruits and vegetables at home. They can be grouped as unfermented pickles and fermented pickles. Fermented pickles undergo lactic acid fermentation as discussed

Mixed pickle

earlier. On the other hand, in unfermented pickles, the raw material is preserved by use of various spices and oil. Most popular unfermented pickles are mango, lime and mixed pickles.

vi) **Dried products:** Fruits or vegetables may be dried mechanically or under the sun for increasing their shelf life and for further use. Grapes are dried and converted into raisins, which are very popular high-energy foods. Also dehydrated powders of various citrus fruits are available for reconstitution into a refreshing beverage. Onions and ginger are sold in dehydrated form for use in various curried food preparations.

Amchur : a dried mango product

Floricultural Crops

i) **Dry flowers and pot pourri:** Dry flowers are becoming more popular due to their longer indoor life and non-perishability. The two easiest and least expensive methods to dry flowers are sand drying and air-drying. Another product, pot pourri is a mixture of dried, sweet scented plant parts including flowers, leaves, seeds, stems and roots. These are rich in aromatic oils, which are not confined to the flower only. These are used in naturo-therapy for common ailments (aromatherapy). Fixatives such as salt, gum benzoin etc., are added to make the scent to last longer.

Dried flowers

ii) **Essential oils, flavours and fragrances:** Floral extracts like essential oils, alkaloids, pigments, dyes etc., have tremendous demand in both domestic and international markets. In order to produce the highest quality extracts, highly sophisticated extraction methods such as those based on high pressure extraction and super critical fluid extraction are used. Such methods produce very high purity flavour and spice extracts, fragrant chemicals as well as pharmaceutical substances. Compressed gases like CO_2, combine the advantages of both gas and liquid solvents. They have the density of

Essential oils made from flowers

a liquid but diffuse as a gas and therefore, function like a solvent. This enables the extraction of sensitive raw materials at gentle temperatures. The resulting extracts are further purified by fractionation and separation procedures.

iii) **Pharmaceutical and neutraceutical products:** Plants produce pharmacologically valuable compounds, which are used in medicine and as dietary supplements. Such compounds include pigments, oils and alkaloids.

iv) **Pigments and natural dyes :** The anthocyanins, flavanols, carotenoids and xanthophylls are common plant pigments that are responsible for a variety of hues we normally observe. These valuable pigments can be isolated and used for varied applications including pharmaceuticals.

v) *Gulkand,* **rose water, vanilla products etc.:** *Gulkand* is prepared by mixing rose petals and sugar in the ratio of 1:2 followed by mashing and drying the mixture in sun. It is a laxative and used for flavouring and sweetening pan. It is good for memory, eyesight and blood purification. Rose water is prepared by boiling the rose flowers in water and condensing the steam. It is used as *sherbet*, eye lotion and eye drops.

vi) **Insecticidal and nematicidal compounds:** Natural plant products (secondary metabolites) are insecticides and nematicides. They act as fly and mosquito repellents, kill insects and may be toxic to bees, aphids, caterpillars etc.

ACTIVITIES/EXERCISES

1. Plan a visit to a food processing industry of your area. Note down the products, which are made there. Make a list of raw material used for their manufacturing. Also note down the method of preservation being used.
2. Visit a shop that deals with processed products of fruits and vegetables. Make a list of products. Note down their chemical composition.
3. Attempt to make some products such as tomato ketchup, fruit jam or vegetables pickle at home. Take help of you mother or sister if they know the preparation of any such products.
4. Purchase some samples of jam and jelly and try to differentiate them.

CHECK YOUR PROGRESS

1. What is thermal processing? Describe different methods of thermal processing.

2. Describe briefly different methods of preservation of fruit juices and beverages.

3. Enlist the value added products that can be made from fruits.

4. Breifly discuss about the principles involved in preservation of fruits and vegetables.

FILL IN THE BLANKS

- Jam is cloudy while jelly is .....
- Sterilization of food can be achieved after exposing the food to about ..... degree centigrade temperature.
- Blanching is done to inactivate .....
- *Gulkand* is processed product obtained from.....
- Jam contains .....sugars.
- The process of food preservation in salt or vinegar is called as .....
- RTS should have a minimum of .....fruit pulp.
- In drying/dehydration, the weight of the product is reduced to .....of original weight.
- For preparing carbonated drinks, ... gas is used.
- .....is called as father of canning.

FURTHER SUGGESTED READINGS

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