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# Preparation of Value-Added Products Through Preservation

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M. Preema Devi, N. Bhowmick, M.R. Bhanusree,  
and S.K. Ghosh

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## Abstract

Fruits and vegetables provide an abundant and inexpensive source of energy, body-building nutrients, vitamins, and minerals. However, most fruits and vegetables are only edible for a very short time unless they are promptly and properly preserved. To make foods available throughout the year, humans have developed methods to prolong the storage life of products, that is, to preserve them. The rotting process can be postponed by adding preservatives, optimizing storage conditions, or applying modern techniques. Preservation in one form or another has been practised in all parts of the world since time immemorial, although scientific methods of preservation were developed only about a hundred years ago. Preservation also assures a stable market to farmers and horticulturists and enables them to expand their production without fear of a fall in demand. Fruits and vegetable preservation industry are still in its infancy in this country. Until about 50 to 60 years ago, other well-known methods of preservation such as jam, jellies, marmalades, etc. were confined to only a few larger industries. One of the main difficulties in the path of the growth of the fruit and vegetable industry has been the inadequacy of knowledge of the modern methods and techniques of preservation. So, to overcome these difficulties, an attempt is made in this chapter to highlight various aspects of the importance of various preservation methods and limitations to be considered during preservation of fruits and vegetables.

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## 2.1 Introduction

Preservation is a process of keeping food materials in an altered condition for a long time without impairing their quality to the utmost extent, with the objectives to preserve fruits and vegetables at the stage of maximum palatability, taste, colour, flavour, quality, and nutritive value; to check

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M.P. Devi (✉) • N. Bhowmick • M.R. Bhanusree •  
S.K. Ghosh  
Uttar Banga Krishi Viswavidyalaya,  
Pundibari, Cooch Behar, West Bengal, India  
e-mail: [preema.horti@gmail.com](mailto:preema.horti@gmail.com)

wastage of local or seasonal surplus; to make the product available for a longer period even in places where it is not produced; to preserve food materials during transit from producer to consumer; and to facilitate handling of food materials, which is done primarily through various methods of packaging (Lal et al. 1959).

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## 2.2 Importance of Fruit and Vegetable Preservation

Horticulture is concerned with perishable crops such as fruits and vegetables. Unless the preservation industry develops with the development of horticulture, it will be uneconomical. Preservation takes care of surplus produce and thereby checks wastage from rotting: that is, the more we preserve, the more we are able to consume in the future. Preservation helps the farmers to obtain a better return by checking wastage during a market glut. It keeps the products in proper condition, which is not possible under ordinary or cold storage conditions. Hence, preservation is a suitable substitute for storage. It allows fruits and vegetables to be available during off seasons and in locations where these are not grown. Also, preservation has the additional benefit of foods being more palatable. Several ancillary industries such as the productions of cans, bottles, caps, cardboard, etc. may be established, which will generate employment opportunities.

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## 2.3 Scope of Fruit and Vegetable Preservation in India

Fruits and vegetables are important supplements to the human diet, as they provide minerals and vitamins essential for maintaining health and protecting us from different diseases and disorders. According to human dieticians, an adult person working moderately requires 85 g of fruits and 300 g of vegetables every day, in addition to cereals, fish, meat, milk, etc. Fortunately, India, with its wide range of soil and climatic conditions, is ideal for growing varieties of fruits and vegetables and is the second largest producer of

fruits and vegetables, producing about 81.2 million tonnes of fruits and 162.2 million tonnes of vegetables, of which about 25 % to 30 % of the total produce is wasted because of spoilage (Anonymous 2013). Most fruits and vegetables are seasonal and perishable in nature. During the peak harvesting time there may be a market glut, but because of insufficient transport facilities and poor availability of packaging materials, the surplus cannot be taken quickly to the markets in urban areas. Moreover, the surplus often cannot be stored for sale in the off season because of inadequate local cold storage facilities; thus, the cultivators do not get a good price for their produce because of the glut, and some of it is spoiled, resulting in complete loss. Preservation of fruits and vegetables can help to solve these problems. Small, poorly shaped, overripe, and infected fruits and vegetables that are unacceptable in the market and fetch a lower price can be utilized successfully in the preservation industry. With increased urbanization, rise in middle-class purchasing power, changes in food habits, and decrease in the practice of making preserved products in individual homes, there is increasing demand for industry-made products in the domestic market. Moreover, some of these preserved products such as canned mangoes, fruit juices, salted cashews, dehydrated foods, and frozen fruits are gaining popularity in the foreign market and are good foreign exchange earners. In spite of all these reasons, only 2.2 % of the total produce is processed in India as compared to 40 to 83 % in developed countries.

Thus, there is considerable scope for expansion of the fruit and vegetable preservation industry in India, which in turn will help in the development of horticulture and in earning more foreign exchange.

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## 2.4 Limitations of the Fruit and Vegetable Preservation Industry in India

*Lack of coordination between growers and processing units.* It is necessary to supply fruits and vegetables continuously for the processing

industries to run effectively. A contract between growers and the processing units would ensure continued availability of good-quality raw materials to the industry.

*Lack of skilled manpower.* Although India is an advantageous position in having a large reservoir of manpower, skilled manpower is in short supply. Workers should be properly trained.

*Lack of awareness.* Because most of the available knowledge regarding preservation is scattered in scientific papers, departmental reports, and other highly technical publications, people in general are not aware of the modern methods and techniques of preservation. To overcome this problem, this information has to be disseminated on a country-wide scale so that full advantage of it can be taken by all those interested in the industry.

*Lack of marketing facilities.* Although there is a demand for preserved products, there are not readily available in small towns because shopkeepers are unwilling to stock such items. The establishment of a growers' cooperative society would help in the marketing of such products.

*Difficulty in the availability of containers.* Bottles and cans are the two major types of containers required by the food processing industry. The initiative has already been taken up by a number of factories for manufacturing bottles of required specification, but there is great difficulty in the availability of cans because there are few factories for their manufacture. There is a need to set up more factories to meet the demand for cans.

with one another and spoil the taste and aroma; (4) air coming in contact with the product may react with glucosidal materials present in it and render the product bitter; and (5) traces of metal from the processing equipment may get into the product and spoil its taste and aroma.

All that inactivates the enzymes as well as microorganisms to control spoilage forms the basis of preservation techniques. In the preservation of foods by various methods, the following general principles are involved (Khurdiya and Roy 1986).

1. *Prevention or delay of microbial decomposition:*
  - (a) By keeping out microorganisms (asepsis)
  - (b) By removal of microorganisms, such as by filtration
  - (c) By hindering the growth and activity of microorganisms, for example, by low temperature, drying, anaerobic conditions, chemicals, or antibiotics
  - (d) By killing the microorganisms, for example, by heat or radiation
2. *Prevention or delay of self-decomposition of the food:*
  - (a) By destruction or inactivation of enzymes, as by blanching
  - (b) By prevention or delay of chemical reactions, for example, prevention of oxidation by means of an antioxidant
3. *Prevention of damage by insects, animals, mechanical causes, etc:*

If all these principles are followed properly, the preserved products will remain in good condition by retaining the natural taste and aroma for a longer period.

## 2.5 Principles of Preservation

If prepared products of fruits and vegetables are kept for some time, the taste, aroma, and appearance of the products deteriorate rapidly (Amerine et al. 1965) for several reasons: (1) fermentation caused by microorganisms such as molds, yeasts, and bacteria; (2) enzymes present in the product may affect the colour and flavour adversely; (3) chemicals present in the pulp/juice may react

## 2.6 Different Processes or Forms or Methods of Fruit and Vegetable Preservation

### 2.6.1 Liquid Form

#### 2.6.1.1 Beverage

All drinks, unfermented or fermented, sweetened or unsweetened, are designated as beverages. Among these, fruit juices have an eminent place

as they are rich in essential minerals and vitamins and other nutritive factors. At present, synthetic beverages are becoming available and are produced in large quantities by aerated water bottlers in this country.

#### 2.6.1.1.1 Unfermented Beverages

Fruit juices that do not undergo alcoholic fermentation are termed unfermented beverages.

1. *Pure fruit juice*: The natural juice pressed out of a fruit, then strained, that remains particularly unaltered in its composition during its preparation and preservation. Edible acid may be added before use for improving taste (citric acid), and the juice may be diluted also: for example, mango, pineapple, citrus, grape, apple, pomegranate, mulberry, jamun, phalsa, passion fruit.
2. *Fruit juice beverage*: A natural, coarsely strained fruit juice, pressed from a fruit, with a moderate quantity of fruit pulp, that is considerably altered in composition by adding water and a small amount of sugar during processing and preservation. Acid and chemical preservatives are also added according to requirements. It may be further altered in composition and diluted before consumption, as pineapple and papaya.
3. *Squash*: Squash is a type of fruit beverage containing 25–33 % fruit juice or pulp, 40–50 % total soluble solids (TSS), 1.0 % acid, and 350 ppm sulfur dioxide. This beverage is diluted with chilled water before serving (Jood and Ketarpaul 2002); for example, orange squash, lemon squash, mango squash, pineapple squash.
4. *Cordial*: A sparkling clear fruit juice derived either from fruit juice or from squash, from which all the pulp and suspended materials are removed completely by the siphon method. It may be sweetened by adding sugar. It contains at least 25 % fruit juice, 30 % TSS, 1.5 % acid, and 350 ppm SO<sub>2</sub>: examples are lime, orange, almond.
5. *Crush*: A fruit squash or fruit beverage that contains at least 25 % fruit juice or pulp and 55 % TSS. It also contains 1.0 % acid, and is diluted before use, such as pineapple crush.
6. *Fruit juice concentrate*: Fruit juice that has been concentrated by removal of water by either heat or freezing. Carbonated beverages and other products are made from the concentrate, which contains at least 32 % TSS.
7. *Ready-to-serve (RTS)*: This fruit beverage contains at least 10 % fruit juice and 10 % TSS plus about 0.3 % acid. It is not diluted before use: ber, jamun, custard apple.
8. *Nectar*: Also a coarsely strained fruit beverage that contains at least 20 % fruit juice/pulp, 15 % TSS, and about 0.3 % acid. It is not diluted before use: jamun, bale, custard apple.
9. *Syrup*: A fruit beverage containing at least 25 % fruit juice or pulp and 65 % TSS. It also contains 1.3–1.5 % acid and is diluted before serving (Sharma et al. 1988): grape, pomegranate, jamun, pineapple, orange, strawberry, raspberry, mulberry, etc.
10. *Synthetic syrup or sarbat*: A heavy sugar syrup of 70–75 % strength when flavoured and coloured with artificial essence of fruits, herbs, and colours is known as synthetic syrup or sarbat.
11. *Barley water*: A fruit beverage that contains at least 25 % fruit juice, 30 % TSS, and 0.25 % barley starch.  
Barley water is prepared from citrus fruits such as lime, lemon, grapefruit, and orange: lime and lemon are mostly used.
12. *Carbonated beverage*: When fruit juice or syrup is preserved in CO<sub>2</sub> gas, it is then called a carbonated beverage. Orange juice preserved in this method is known as orangeade, and, similarly, lemon juice as lemonade.

#### 2.6.1.1.2 Fermented

Fruit juices that have undergone alcoholic fermentation by yeasts include wine, champagne, port, sherry, tokay, muscat, perry, orange wine, berry wine, nira, and cider.

- (a) *Alcohol*: When any fruit juice having 10 %–12 % fermentable sugar is allowed to ferment with yeast (*Saccharomyces ellipsoideus*, *S. malei*, *S. cerevisiae*) in anaerobic

conditions and at 25–27 °C, after its sterilization ethyl alcohol is produced, which is then filtered and stored in an airtight container to check further infection and thereby fermentation with vinegar bacteria. It is also a sparkling clear liquid. The product contains varying quantities of alcohol. The alcohol content of wine varies from 7 to 20 %. Wines with 7–9 % alcohol are called light liquor or light wine, those with 9–16 % are termed medium wines, and those with 16–20 % are strong wines. Liquors contain 40–60 % alcohol, although in fruit brandy only 4–6 % alcohol is present: grape wine, apple cider, cashew apple feni, palm tree nira, aonla wine, etc.

- (b) *Vinegar*: Vinegar is perhaps the oldest known fermentation product. It contains about 5 % acetic acid in water, a varying amount of fixed fruit acids, colouring matter, salts, and a few other fermentation products that impart a characteristic flavour and aroma to it.

Vinegar is a liquid derived from various substances containing sugar and starch by alcoholic, and subsequently acetic acid, fermentation. In the trade, vinegar is labelled according to the material used in its manufacture: vinegar made from malt is called malt vinegar, that from apple juice is called apple cider vinegar, and that from grape is called grape vinegar.

### 2.6.1.2 Other than Beverages

1. *Puree*: Puree is a concentrated fruit/vegetable pulp without seed and skin; 3–10 % sugar and 1 % salt are added with the chemical preservative, so that the concentration of total solid should be 12 %, of which 8.37 % is the salt-free fruit/vegetable solid.
2. *Sauce*: Sauce is the concentrated fruit/vegetable pulp without seed and skin. Sugar, salt, and various spices are added to the content so that one should not be dominant over another. The finished products should have not less than 18 % total solids. Vinegar may or may not be added along with a requisite amount of chemical preservatives: tomato, aonla.
3. *Ketchup*: Ketchup is made by concentrating fruit/vegetable juice or pulp without seeds and skins. Spices, salt, sugar, vinegar, onion, garlic, etc. are added to the extent that it contains not less than 12 % fruit/vegetable solid and 28 % total solid. Chemical preservatives may be added (30 mg/l of product)

### 2.6.2 Semisolid Form

- (a) *Pulp*: Pulp of low pectin content fruit when concentrated with acid and a sufficient amount of sugar without addition of water is known as pulp. A chemical preservative is added.
- (b) *Jam*: Jam is a mixture of fruit and sugar cooked to the consistency of a jelly, firm enough to hold the fruit tissues. It contains all the fruit pulp in its composition and is therefore not clear. A good jam must have a bright colour and true fruit flavor; it should be neither syrupy nor stiff, but of a proper jelly consistency, with evenly distributed fruit particles. It should be free from crystallization of sugar and must keep well. Examples: mango, pineapple, aonla, apple, pear, peach, plum.
- (c) *Jelly*: Jelly is prepared by cooking essentially a clear fruit extract, strained, free from insoluble matter and sugar, as in case of a jam. A perfect jelly should be sparkling, transparent, and attractive in colour and should have a strong flavour of the original fruit. It should not be gummy, sticky, or syrupy or have sugar crystallized on it. It may be thick or soft set, but should be firm enough to retain a sharp edge when cut with a knife. Examples: guava, karonda, sour apple, jamun, wood apple, plum, loquat, papaya.
- (d) *Marmalade*: A jelly in which pieces of fruits are suspended. The term marmalade in this country is usually associated with a product made from citrus fruit (orange, lemon, grapefruit, etc.); in this case, the suspension in the jelly is the shredded peels of the fruit. A good marmalade must have the shreds (10–15 %) evenly distributed in the whole mass, in addition to all the characteristics of a good jelly.

- (e) *Chutney*: When fully matured green fruits or matured but tender vegetables are peeled, boiled, crushed, and mixed with acid, sugar, salt, coarsely powdered spices, and herbs and cooked to a reasonably thick consistency, this is known as chutney. Vinegar may or may not be added. Here the high percentage of sugar, acid, and spices with vinegar collectively act as preservatives. Hence, addition of chemical preservatives is not necessary. Finished product should contain 40 % fruit juice and 50 %TSS: mango, ber, aonla, jack fruit.

### 2.6.3 Solid Form

- (a) *Canning*: Whole fruits or pieces of fruits are placed in a 33–50 % sugar solution, which is known as syrup; vegetables are placed in a 3–5 % salt solution after blanching, known as brine solution; or the vegetables may be suspended in juice of that vegetable containing 0.5 % salt and 1 % acid. When packed in cans, this is known as canning: mango, orange, papaya, pineapple, apple, pear, peach, etc.
- (b) *Drying*: When 85–88 % moisture is evaporated artificially from fruits or vegetable slices, either by keeping them in the sun or under controlled temperature and humidity conditions inside an oven, this is known as drying. Drying done by sun exposure is sun drying; when done under controlled temperature and humidity in a closed chamber (dehydrator), this is known as dehydration: dehydrated ber, banana, plum, apricot.
1. *Leather*: Drying of strained fruits or vegetable pulp after adding a small amount of sugar then spreading on an aluminum plate until dried produces leathers. Fruit leather can be dried in a thin layer in a solar or cabinet drier. Spreading of the pulp can be repeated again on previously dried pulp and drying continued until the thickness reaches 2–3 cm. Finally, the leather is fumigated in a sulfur chamber and stored by wrapping tightly in butter paper: mango leather, tomato leather, papaya leather, custard leather, jackfruit leather, palm leather, jamun leather, etc.
  2. *Flake*: Drying of a single layer of pulp until fully dried and taken from an aluminum plate as dry thin pieces is known as flake: tomato flake, papaya flake, corn flake, etc.
  - (c) *Preserves*: A preserve is made from properly matured fruit pieces or mature, tender vegetable pieces by cooking in heavy syrup until tender and transparent. In its preparation not less than 40 lb of fruits is used for every 55 lb of sugar; cooking is continued until a concentration of at least 60 % of soluble solid is obtained: Bael preserves, Karonda preserve.
  - (d) *Candy*: Fruit or vegetable pieces when impregnated with heavy sugar and subsequently drained and dried are called candied fruits. The total sugar content of the impregnated fruits or vegetables is kept at 75 % sugar to prevent fermentation. Candied fruits covered with a thin, transparent coating of sugar that imparts a glossy appearance are called glazed fruits. Candied fruit is coated with crystals of sugar by rolling on a mild steel plate having 0.64-cm-diameter holes to allow air to enter the box for evaporation of moisture. Examples: karonda, cherry, amla, ber, jackfruit
  - (e) *Pickles*: Fruit or vegetable pieces are mixed with 8–10 % salt and 3 % acid, then kept for 6–8 days in the sun at about 29.4–30 °C for fermentation with the help of lactic acid bacteria, and finally mixed with coarsely powdered spices with or without vinegar and sealed by covering fully with moisture-free edible oil to produce pickle. Pickles should be kept another 3 weeks in the sun: lime, mango, cauliflower, ber.

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## 2.7 Preparation and Preservation of Unfermented Beverages

Fruit juices that do not undergo alcoholic fermentation, termed unfermented beverages, include natural and sweetened juices, RTS, nectar, cordial,



squash, crush, syrup, fruit juice concentrate, and fruit juice powder. Barley waters and carbonated beverages are also included in this group (Girdhari et al. 2010).

1. *Selection and preparation of fruit:* Not all fruit juices are suitable for making fruit juice, either because of difficulties in the extraction of juice or because the juice obtained is poor in quality. Even some of the juicy fruits are not quite suitable as they do not yield juice of good beverage quality. The best juice is extracted from freshly picked, sound and suitable varieties at the optimal stage of maturity. Fully ripe, mid-season fruits, particularly citrus fruits, generally yield juice superior to that of fruits picked early or late in the season.
2. *Sorting and washing:* Decayed or damaged fruits do not yield juice. Small cull fruits, such as undersized, oversized, malformed, or blemished fruits, which do not fetch a good price in the fresh fruit market, are rejected. The fruits should be washed thoroughly with water, and in some cases scrubbed also while washing to remove any adhering dust and other extraneous matter. Residues of sprays of arsenic and lead should be removed: dilute HCl (23 l HCl in 455 l water) is adequate for this purpose.
3. *Juice extraction:* Juice from fresh fruits is extracted by crushing and pressing them. During extraction, the juice should not be unduly exposed to air, as oxygen in the air will adversely affect the colour, taste, and aroma and also reduce the vitamin content of the juice. Citrus juices, tomato juice, and even the more stable juices such as those of apples and grapes, deteriorate rapidly in quality when they are extracted by methods that expose them to air for unduly long periods. For products such as tomato juice, special extraction equipment has been designed recently to reduce incorporation of air to a minimum.
4. *Deaeration:* Fruit juice contains some air. Most of the air is present on the surface of the fruit particles and some is dissolved in the juice. In the case of citrus juices, particularly orange juice, which is highly susceptible to the adverse action of residual air, immediately after extraction the juice is subjected to a high vacuum whereby most of the air as well as other gases are removed. This process is known as deaeration. The equipment employed is fairly expensive. It is, however, necessary for large-scale production of orange and other pure fruit juices.
5. *Straining, filtration:* Fruit juices after extraction always contain varying amounts of suspended matter, which consists of broken fruit tissue, seed, and skin, and also various gums, pectic substances, and proteins in colloidal suspension. Usually coarse particles of pulp, seeds, and pieces of skin are removed by means of screens from almost all juices as their presence generally causes deterioration in the quality of the product. In the early years of the fruit juice industry, it was a common practice to completely remove all the suspended matter, including colloidal suspensions, before packing the juice in containers. Although this method no doubt improved the appearance of the product, it quite often resulted in lack of fruit character and flavour. The present trend is to let fruit juices and fruit beverages remain reasonably cloudy or pulpy in appearance. The recent comminuted fruit beverages, employing the whole fruit for extraction, are based on this concept and are claimed to be more nutritive than the clear juices.
6. *Clarification:* Complete removal of all suspended material from juice, as in lime juice cordial, is known as clarification, which is closely related to the quality of appearance and flavour of the juice.
7. *Addition of sugar:* All juices except those of grape and apple are sweetened by adding sugar. Sugar also acts as a preservative for flavour and colour and prolongs the keeping quality. Sugar-based products can be divided into three groups on the basis of sugar content: low (30 %), medium (30–50 %), and high (>50 %).

Sugar can be added directly to the juice or as syrup made by dissolving it in water, then clarifying by addition of a small quantity of citric acid or a few drops of lime juice and filtering.

8. **Fortification:** Juices, squashes, syrups, etc. are sometimes fortified with vitamins to enhance their nutritive value, to improve taste, texture, or colour, and to replace nutrients lost in processing. Usually ascorbic acid and beta carotene are added at the rate of 250–500 mg and 7–10 mg/l, respectively. Ascorbic acid acts as an antioxidant and beta carotene imparts an attractive orange colour. For a balanced taste some acids are added. Citric acid is often used for all types of beverages and phosphoric acid for the cola type of drinks.
9. **Preservation:** Fruit juices, RTS, and nectars are preserved by pasteurization, but sometimes chemical preservatives are used. Squashes, crushes, and cordials are preserved only by adding chemicals. The sugar concentration of syrup is sufficient to prevent its spoilage.
2. **Crushing:** Before crushing the fruit stems and stalks are removed. Crushing is done with a basket press.
3. **Addition of sugar:** Cane sugar is added to maintain at least 20 % total soluble solids but not more than 24 %. If the fruits are sour, 70 g sugar is added for each kilogram of fruit, at the rate of 1.5 g for every 10 kg fruits, then mixed and allowed to stand for 2–4 h. The preservative potassium metabisulfite (KMS) (1.5 g/10 kg fruit) inhibits growth of wild yeasts and spoilage organisms (Srivastava and Kumar 1994).
4. **Addition of wine yeast:** Wine yeast, such as *Saccharomyces ellipsoideus* inoculum, is added at 20 ml for every 5 kg fruits, about an hour after the addition of preservative. If the yeast is not available then potassium metabisulfite is not added. The yeast present in the skin of fruits can also ferment and produce wine but it is not of good quality.
5. **Fermentation:** Fruits are allowed to ferment for 2 days in a cool place, that is, at 22–28 °C. The mouth of the jar is covered with cloth during fermentation.
6. **Filtration:** The contents are filtered through a thin muslin cloth or a filter aid on the third day and the filtrate is again allowed to ferment in a cool place for another 10 days without any disturbance. During this period yeast cells and other solids settle at the bottom.
7. **Racking:** Siphoning off the fermented wine to separate it from the solid deposits is known as racking.
8. **Fining and filtration:** The newly prepared wine is sometimes not clear and requires fining and filtration. A suitable fining agent, such as bentonite, is added. All the colloidal material settles with the bentonite. The clear wine is siphoned off and filtered if necessary. Alternatively, the wine is stored in a refrigerator for about 2 weeks and thereafter the clear wine is siphoned off.
9. **Maturation:** When fermentation is complete, the clear wine is siphoned; the containers are filled completely and sealed airtight to exclude all air. In the course of

## 2.8 Preparation and Preservation of Fermented Beverages

Fermented beverages have been known to mankind from times immemorial. Grape wine is the most important among these. Wines made from fruits are named after the particular fruit employed. Thus, we have apple cider from apples, perry from pears, and orange wine from orange. Starch and sugar also are fermented to produce special types of liquors. In India, such liquors are known as neera juice of palm.

### 2.8.1 Alcoholic Fermentation

#### 2.8.1.1 Preparation of Wine

1. **Selection of raw material:** Fruits intended for wine making are sorted to remove moldy and diseased fruits, then crushed between fluted rollers. Fruits are fermented slightly before pressing the juice, which helps in the extraction of colour and also facilitates pressing of the juice. Generally, the yield of juice is 60–70 %.



time, the wine matures. During this maturing process, which takes from 6 to 12 months, the wine loses its raw and harsh flavour and mellows considerably, acquiring a smooth flavour and characteristic bouquet and aroma. Barrels of oak wood are generally preferred for maturing as they impart a finer bouquet to the wine.

During the maturation process, there is natural clarification of the wine. Filter aids, such as egg white, can also be employed to bring about the clarification.

10. **Packing:** The volatile acidity of wine, which is mainly the result of acetic acid, should be low. High volatile acidity of 0.09–0.20 g/100 ml, expressed in terms of acetic acid, indicates the activity of acetic acid bacteria during the fermentation: this is not desirable. It is desirable to pasteurize the wine to destroy spoilage organisms and coagulate the colloidal materials which cause cloudiness in the wine. Wines are generally pasteurized for 1–2 min at 82–88 °C and then bottled. The bottles are closed with bark corks of good quality (Girdhari et al. 2010). Many wines are made from fruits having medicinal value (Tapsell et al. 2006). The following are well-known wines produced in various countries.

**Champagne:** A sparkling wine, made chiefly in France, from certain varieties of grapes such as Chardonnay and Pinot Noir: it is made in other countries as well. The fermentation is allowed to proceed to completion in bottles that are specially made to withstand the high pressure of gas produced during fermentation.

**Neera:** A wine made from juice of the palm tree. Varieties of palm wines or toddy are consumed all over the world (Steinkraus 1996). In India, the fermented palm sap is known as toddy or kallu.

**Port:** A fortified, sweet red wine made originally in Portugal but now produced in other countries also.

**Sherry:** A Spanish wine, matured by placing the barrels in sunlight for 3 to 4 months, where the temperature is as high as 54–60 °C.

**Jack fruit wine:** An alcoholic beverage made by fermentation of jack fruit pulp (Dahiya and Prabhu 1997).

**Tokay:** A very famous fortified wine made in Hungary.

**Muscat:** Prepared from Muscat grapes in Italy, California, Spain, and Australia.

**Perry:** Wine made from pears is known as perry. Its method of preparation is similar to that of apple cider. Wastes, culled fruits, and trimmings left over from canning may also be used for making perry.

**Soor:** A type of alcoholic beverage made by fermentation of fruits such as apricot, peach, pear, and apple, it contains 35–40 % alcohol (Rana et al. 2004).

**Orange wine:** Orange juice is sweetened by adding sugar and then allowed to ferment. The method of preparation is similar to that of grape wine. Orange oil should not be added to the juice as it hinders and sometimes stops fermentation.

**Berry wine:** Wines prepared from berries such as strawberry and blackberry are known as ‘Berry wines.’ These products are generally popular in other countries but are not common in India.

**Feni:** Cashew apple juice is fermented into a strong liquor known as ‘feni.’ It is registered, according to geographic indication, in places around Goa (Serkar and Mariappan 2007).

## 2.8.2 Lactic Acid Fermentation

### 2.8.2.1 Preparation of Pickles

The preservation of food in common salt or in vinegar is known as pickling. It is one of the most ancient methods of preserving fruits and vegetables. Pickles are good appetizers and add to the palatability of a meal. They stimulate the flow of gastric juice and thus help in digestion.

Several kinds of pickles are sold in the Indian market. Mango pickle ranks first, followed by cauliflower, onion, turnip, and lime pickles. These pickles are commonly made in homes as well as being commercially manufactured and exported. Fruits are usually preserved in sweetened and spiced vinegar, whereas vegetables are preserved in salt.

Pickling is the result of fermentation by lactic acid-forming bacteria, which are generally present in large numbers on the surface of fresh vegetables and fruits. These bacteria can grow in an acid medium and in the presence of 8–10 % salt solution, whereas the growth of a majority of undesirable organisms is inhibited. Lactic acid bacteria are most active at 30 °C, so this temperature must be maintained as much as possible in the early stage of pickle making. When vegetables are placed in brine, it penetrates into their tissues, and soluble material present in them diffuses in the brine by osmosis. The soluble material includes fermentable sugars and mineral. The sugars serve as food for lactic acid bacteria, which convert them into lactic and other acids. The acid brine thus formed acts upon the vegetable tissues to produce the characteristic taste and aroma of pickle.

In the dry salting method, several alternating layers of vegetables and salt (20–30 g dry salt/kg vegetables) are kept in a vessel that is covered with a cloth and a wooden board and allowed to stand for about 24 h. During this period, by osmosis, sufficient juice comes out from the vegetables to form brine. Vegetables that do not contain enough juice (e.g., cucumber) to dissolve the added salt are covered with brine (steeping in a concentrated salt solution is known as brining). The amount of brine required is usually equal to half the volume of vegetables. Brining is the most important step in pickling. The growth of the majority of spoilage organisms is inhibited by brine containing 15 % salt. Lactic acid bacteria, which are salt tolerant, can thrive in 8–10 % brine although fermentation takes place fairly well even in 5 % brine. In a brine containing 10 % salt, fermentation proceeds somewhat slowly (Pederson 1963). Fermentation takes place to some extent up to 15 % brine, but stops at 20 % strength. It is, therefore, advisable to place the vegetables in 10 % salt solution for vigorous lactic acid fermentation.

As soon as the brine is formed, the fermentation process starts and carbon dioxide begins to evolve. The salt content is now increased gradually, so that by the time the pickle is ready, salt concentration reaches 15 %.

Fermentation is completed in 7–10 days. When sufficient lactic acid has been formed, lactic acid bacteria cease to grow and no further change takes place in the vegetables. However, precautions should be taken against spoilage by aerobic microorganisms, because in the presence of air a pickle scum is formed that brings about putrefaction and destroys the lactic acid. Properly brined vegetables keep well in vinegar for a long time.

At present, pickles are prepared with salt, vinegar, or oil or with a mixture of salt, oil, spices, and vinegar. These methods are discussed below.

1. *Preservation with salt*: Salt improves the taste and flavor, hardens the tissues of vegetables, and controls fermentation. Salt content of 15 % or more prevents microbial spoilage. This method of preservation is generally used only for vegetables that contain very little sugar, and hence sufficient lactic acid cannot be formed by fermentation to act as a preservative. However, some fruits, such as lime, green chili, mango, etc. are also preserved with salt.
2. *Preservation with vinegar*: A number of fruits and vegetables are preserved in vinegar whose final concentration, in terms of acetic acid, in the finished pickle should not be less than 2 %. To prevent dilution of vinegar below this strength by the water liberated from the tissues, the vegetables or fruits are generally placed in strong vinegar of about 10 % for several days before pickling. This treatment helps to expel the gases present in the intercellular spaces of the vegetable tissue.

Vinegar pickles are the most important pickles consumed in other countries. Mango, garlic, chilies, papaya, etc., are preserved as such in vinegar.

3. *Preservation with oil*: The fruits or vegetables should be completely immersed in edible oil. Cauliflower, lime mango, and turnip pickles are the most important oil pickles. Methods of preparation of some oil pickles are given next.

*Mango pickle*: Use 1 kg mango pieces, 150 g salt, 25 g fenugreek (powdered), 15 g turmeric (powdered), 15 g nigella seeds,

10 g red chili power, eight cloves (headless), 15 g each black pepper, cumin, cardamom (large), and aniseed (powdered), 2 g asafoetida, and 350 ml mustard oil (just sufficient to cover pieces).

4. *Preservation with mixture of salt, oil, spices, and vinegar:*

*Cauliflower pickle:* Use 1 kg cauliflower pieces, 150 g salt, 25 g ginger (chopped), 50 g onion (chopped), 10 g garlic (chopped), 15 g each red chili, turmeric, cinnamon, black pepper, cardamom (large), cumin, and aniseed (powdered), six cloves (headless), 50 g tamarind pulp, 50 g mustard (ground), 150 ml vinegar, and 400 ml mustard oil.

### 2.8.2.2 Problems in Pickle Making

1. *Bitter taste:* Use of strong vinegar or excess spices or prolonged cooking of spices imparts a bitter taste to the pickle.
2. *Dull and faded product:* Caused by use of inferior quality materials or insufficient curing.
3. *Shrivelling:* Occurs when vegetables (e.g., cucumber) are placed directly in a very strong solution of salt or sugar or vinegar. Hence, a dilute solution should be used initially and its strength gradually increased.
4. *Scum formation:* When vegetables are cured in brine, a white scum always forms on the surface because of the growth of wild yeast. This scum delays the formation of lactic acid and also encourages the growth of putrefactive bacteria, causing softness and slipperiness. Hence, it is advisable to remove scum as soon as it is formed. The addition of 1 % acetic acid helps to prevent the growth of wild yeast in brine without affecting lactic acid formation.
5. *Softness and slipperiness:* A very common problem, caused by inadequate covering with brine or the use of weak brine. The problem can be solved by using a brine of proper strength and keeping the pickles well below the surface of the brine.
6. *Cloudiness:* When the structure of the vegetable used in pickling, such as onion, is such that the acetic acid (vinegar) cannot penetrate

deep enough into its tissues to inhibit the activity of bacteria and other microorganisms present in them, fermentation starts from inside the tissues, rendering the vinegar cloudy. This microbial activity can only be checked by proper brining. Cloudiness may also be caused by using of inferior quality vinegar, causing a chemical reaction between vinegar and minerals.

7. *Blackening:* Caused by the iron in the brine or in the process equipment reacting with the ingredients used in pickling, blackening is also caused by certain microorganisms.

## 2.8.3 Acetic Acid Fermentation and Vinegar Fermentation

Vinegar is a liquid substance consisting mainly of acetic acid in water, varying amounts of fixed fruit acids, colouring matter, salt, and a few other fermentation products which impart a characteristic flavour and aroma to the product. In the trade, vinegar is labelled according to the material used in its manufacture. For instance, vinegar made from barley or other cereals is called 'malt vinegar,' that made from grape juice is 'grape vinegar,' and so on.

### 2.8.3.1 Quality Standards

Vinegar is a liquid derived by alcoholic and acetic fermentation. It contains about 5 % acetic acid and has germicidal and antiseptic properties. It should not contain arsenic in amounts exceeding 0.0143 mg/100 ml nor any mineral acid, or lead except caramel. The amount of acid in the vinegar is expressed as 'grain strength,' which is ten times the percentage of the acetic acid present in it; a vinegar containing 5 % acetic acid is spoken of as vinegar of '50 grain strength.'

### 2.8.3.2 Types of Vinegar

Vinegar is made from various fruits and also from sugars. Two important types of vinegar are described here.

(A) Breved vinegars and, (B) Artificial vinegar

- (A) *Breved vinegars*: Breved vinegars can be made from various fruits and sugar containing substances (molasses, honey) by alcoholic and subsequent acetic fermentation. Examples are fruit vinegar, potato vinegar, malt vinegar, molasses vinegar, and honey vinegar.
- (B) *Artificial vinegars*: Artificial vinegars are prepared by diluting synthetic acetic acid or glacial acetic acid to a standard of 4 % and are coloured with caramel.

### 2.8.3.3 Steps Involved in Vinegar Production

Two important steps are involved in the preparation of vinegar: (1) transformation of the sugary substances of fruits etc., into alcohol by yeast (alcoholic fermentation), and (2) changing of the alcohol into vinegar by acetic acid bacteria (acetic acidification) (Girdhari et al. 2010). The chemical reactions involved in these two processes can be represented as follows:

- 
1. Fermentable sugar ( $C_6H_{12}O_6$ )  $\rightarrow$  Ethyl alcohol ( $2C_2H_5OH$ ) + Carbon dioxide ( $2CO_2$ ) (under the presence of yeast)
  2. Ethyl alcohol ( $2C_2H_5OH$ ) + Oxygen ( $2O_2$ )  $\rightarrow$  Acetic acid ( $2CH_3COOH$ ) + Water ( $H_2O$ ) (under the presence of vinegar bacteria)
- 

### 2.8.3.4 Preparation of Vinegar

Vinegar is prepared by the following methods.

- (A) Slow process
- (B) Orleans Slow process
- (C) Quick process
- (A) *Slow process*: The slow process, covering a prolonged period, is generally adopted in India. The fruit juice or sugar solution is filled into barrels and allowed to undergo alcoholic and acetic fermentation slowly for at least 5–6 months in a warm, damp room. No special care is taken. To screen off dust and flies, the bung hole of the barrel is covered with a piece of cloth. The main drawbacks of this method follow:
1. Yield is low
  2. Alcoholic fermentation is often incomplete
  3. Acetic fermentation is very slow
  4. Quality of the vinegar is inferior
- (B) *Orleans slow process*: In this process, about three-fourths of the barrel is filled with the juice, inoculated with mother vinegar, and the barrel placed on its side. Two holes, each about 2.5 cm in diameter, are made on either side of the barrel just above the level of the juice in addition to the bung hole. These holes are screened with wire gauze or cheesecloth to exclude insects.

The barrels are kept in a warm place at 21–27 °C, and fermentation is allowed to proceed until the acid reaches its maximum strength. Under favourable conditions, it usually takes about 3 months for the complete conversion of the liquid into vinegar. About three-fourths of the vinegar is then withdrawn, and an equal quantity of fermented alcoholic juice is added for further vinegar fermentation. Vinegar produced by the Orleans slow process ages during the process of fermentation and is clear and of superior quality.

- (C) *Quick process*: In this process an additional supply of oxygen is made available for the bacteria and the surface of the bacterial culture is also increased, resulting in rapid fermentation. The equipment used, known as an “upright generator,” is a cylinder 3.6–4.2 m high and 1.2–1.5 m in diameter (Srivastava and Kumar 1994). The details of the three compartments are as follows:

1. *Distributing compartment*: This is about 30 cm above the central compartment and is separated from it by a partition that is perforated with a number of small holes. In this compartment, a revolving sparkler is fitted to allow the liquid to

trickle slowly over the material in the central compartment.

2. *Central compartment*: This is filled with beech wood shavings, pumice stone, rattan shavings, or straw to increase the surface area. This chamber is fitted with an adjustable opening near the bottom for admission of air.
3. *Receiving compartment*: This is the bottom chamber of the generator in which vinegar is collected. It is separated from the central compartment by a perforated partition about 1.5 m from the bottom of the generator.

The material in the central compartment is sprinkled and wetted with unpasteurized vinegar containing acetic bacteria. A mixture of the alcoholic fermentation product and vinegar (2:1) is then slowly trickled through the generator to promote the growth of vinegar bacteria. Within a few days the bacterial growth is enough for efficient functioning of the generator. The alcoholic fermentation liquid is now mixed with mother vinegar in the ratio of 1:2 to increase its acidity from 3 to 3.5 % and passed through the generator, where it is converted into acetic acid in a single passage.

### 2.8.3.5 Problems in Vinegar Production

1. *Insects and worms*: Vinegar flies (*Drosophila cellaris*), vinegar eels (*Anguillula* spp.), and the vinegar louse are important; these contaminants can only be avoided by maintaining proper sanitary conditions.
2. *Wine flowers*: A kind of film yeast; if the fermented juice is unnecessarily exposed to air, wine flowers grow on the surface of the liquid. This growth can be avoided by spreading a neutral oil such as liquid paraffin over the surface of the fermented liquid or adding 20–25 % of unpasteurized vinegar.
3. *Lactic acid bacteria*: Lactic acid bacteria are generally found in fermented juice. The bacteria interfere with acetic acid fermentation, cause cloudiness, and decrease the quality of the vinegar. This infestation can be avoided by using 20–25 % unpasteurized vinegar.

## 2.9 Preparation and Preservation of Other than Beverages

### 2.9.1 Selection of Fruits

For this product preparation, only plant-ripened and fully red tomatoes should be used. No green, blemished, and overripe fruits should be used. All green, blemished, and overripe fruits should be rejected as these adversely affect the quality of the product.

### 2.9.2 Washing and Trimming

Mere rinsing of fruits in water is not enough, because mold filaments and other microorganisms found in the cracks, wrinkles, folds, and stem cavities are not easily dislodged by gentle washing alone. For thorough cleaning, fruits should be washed in plenty of running water. For commercial production, rotary washers or through washers and soft roller brushes are generally used.

### 2.9.3 Pulping

Fruits can be pulped by the hot pulping process or cold pulping process.

#### 2.9.3.1 Preparation of Puree and Paste

Fruit/vegetable pulp without skin or seeds, with or without added salt, and containing not less than 9.0 % of salt-free fruit/vegetable solids, is known as 'medium puree.' It can be concentrated further to 'heavy puree,' which contains not less than 12 % solids. If this is further concentrated so that it contains not less than 25 % solids, it is known as paste. On further concentration to 33 % or more of solids, it is called concentrated paste.

Cooking for concentration of the pulp can be done either in an open cooker or a vacuum pan. In an open cooker most of the vitamins are

destroyed and the product become brown. Use of the vacuum pans, which are expensive, helps preserve the nutrients and also reduces the browning to a great extent. In vacuum pans the juice is boiled at about 71 °C only. Ordinarily fruit/vegetable juice can be concentrated to 14–15 % solids in an open cooker, but for obtaining higher concentrations a vacuum pan is required. Moreover, sterilization of the product is also possible in a vacuum pan. While cooking in an open cooker, a little butter or edible oil is added to prevent foaming, burning, and sticking. If, after cooking, the total solids content of the juice is higher than required, more juice is added to lower it; if it is lower, cooking is continued until the desired concentration is reached.

#### 2.9.3.1.1 Judging the End Point

The total solids in the juice, in the beginning, during boiling, and at the finishing point can be determined with either a specific gravity hydrometer or refractometer or by drying the juice in vacuum at 70 °C or by measuring the volume (a known volume of juice is concentrated to a known volume of final product) with the help of a measuring stick.

#### 2.9.3.1.2 Packing

The product can be packed in plain as well as lacquered cans. The prepared product is poured into the cans, scalding hot, at 82–88 °C, and the cans closed.

#### 2.9.3.2 Preparation of Sauces and Ketchups

There is no essential difference between sauce and ketchup. However, sauces are generally thinner and contain more total solids (minimum, 30 %) than ketchups (minimum, 28 %). Tomato, apple, papaya, walnut, soybean, mushroom, etc., are used for making sauces.

Sauces are of two kinds: (1) *thin* sauces of low viscosity consisting mainly of a vinegar extract of flavouring materials such as herbs and spices, and (2) *thick* sauces that are highly viscous.

Sauces/ketchups are prepared from more or less the same ingredients and in the same manner

as chutney, except that the fruit or vegetable pulp or juice used is sieved after cooking to remove the skin, seeds, and stalks of the fruits, vegetables, and spices and to give a smooth consistency to the final product. However, cooking takes longer because fine pulp or juice is used. Some sauces develop a characteristic flavour and aroma on storing in wooden barrels. Freshly prepared products often have a raw and harsh taste and must, therefore, be matured by storage. High-quality sauces are prepared by maceration of spices, herbs, fruits, and vegetables in cold vinegar or by boiling them in vinegar. The usual commercial practice is to prepare cold or hot vinegar extracts of each kind of spice and fruit separately, and then blend these extracts suitably to obtain the sauces, which are then matured. Thickening agents are also added to the sauce to prevent sedimentation of solid particles. Apple pulp is commonly used for this purpose in India, but starch from potato, maize, arrowroot (cassava), and sago is also used. A fruit sauce should be cooked to such a consistency that it can be freely poured without the fruit tissues separating out in the bottle. The sauce should be bright in colour. Sauces usually thicken slightly on cooling. By using a funnel, hot ketchup is filled in bottles, leaving a 2-cm head space at the top, and the bottles are sealed or corked at once. The necks of the bottles, when cold, are dipped in paraffin wax for airtight sealing. It is advisable to pasteurize sauces after bottling because there is always a danger of fermentation, especially in tomato- and mushroom-based sauces. Other sauces are more acidic and less likely to ferment but should be pasteurized nonetheless. For this purpose the bottles are kept in boiling water for about 30 min (Srivastava and Kumar 1994).

#### 2.9.4 Problems of Making Other than Beverages

##### 2.9.4.1 Black Neck

Formation of a black ring in the neck of bottles is known as black neck. It is caused by iron that gets into the product from the metal of the equipment and the cap/crown/cork through the action



of acetic acid. This iron coming into contact with tannins in spice forms ferrous tannate, which is oxidized to black ferric tannate. This problem can be prevented by the following:

1. Filling hot product at a temperature not less than 85 °C
2. Leaving very little head space in bottles (the more the air, the greater is the blackening)
3. Reducing contamination by iron, sources of iron being salt and metal equipment
4. Partial replacement of sugar by corn syrup or glucose syrup, which contain sulfur and prevent blackening
5. Addition of 100 ppm sulfur dioxide or 100 mg ascorbic acid
6. Storing bottles in horizontal or inverted position to diffuse the entrapped air (O<sub>2</sub>) throughout the bottle, thus reducing its concentration in the neck sufficiently to prevent blackening
7. Using cloves only after removing the flower/head

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## **2.10 Preparation and Preservation of Jelly, Jam, and Marmalade**

### **2.10.1 Jelly**

#### **2.10.1.1 Principles of Jelly (Gel) Formation**

Sugar, acid, pectin, and water are the four important constituents of jam, jelly, and marmalade and must be present approximately in the following proportions: pectin, 1.0 %, acid, 1.0 %, sugar, 60–65 %, and water, 33–38 %. Pectin is a complex organic compound of the CHO class present in varying amounts in practically all fruits and possessing the property of entering into a sort of equilibrium in presence of the other three ingredients either added to or present in a fruit pulp, juice, or the water extract of fruit. At a definite range of equilibrium of these ingredients, the compound formed has the consistency of a gel, which is the basic characteristic of jam, jelly, and marmalade. If any one of these is more or less than the required amounts, good gel will not form.

#### **2.10.1.1.1 Pectin**

Pectic substances, present in the form of calcium pectate, are responsible for the firmness of fruits. Pectin is a commercial term for water-soluble pectinic acid. In the early stage of development of fruits (unripe), the pectic substance is a water-insoluble proto-pectin that is converted into pectin by the enzyme protopectinase during ripening of fruit. In overripe fruits, because of the presence of the enzyme pectic methyl esterase (PME), the pectin is largely converted to pectic acid, which is water insoluble; this is one of the reasons both immature and overripe fruits are not suitable for making jelly and only ripe fruits are used.

Usually, about 0.5–1.0 % pectin in the extract is sufficient to produce a good jelly. If the pectin content is in excess, a firm and tough jelly is formed, and if it is less, the jelly may fail to set.

#### **2.10.1.1.2 Sugar**

This essential constituent of jelly imparts to it sweetness as well as body. If the concentration of sugar is high, the jelly retains less water, resulting in a stiff jelly, probably because of dehydration.

When sugar (sucrose) is boiled with an acid, it is hydrolyzed into dextrose and fructose, the degree of inversion depending on the pH and duration of boiling. Because of partial inversion of the sucrose, a mixture of sucrose, glucose, and fructose is found in the jelly. This mixture is more soluble in water than sucrose alone and hence the jelly can hold more sugar in solution without crystallization.

#### **2.10.1.1.3 Acid**

The finished product should contain at least 0.5 % but not more than 1.0 % total acids because a larger quantity of acid may cause syneresis. Jelly strength increases with the increase in pH until an optimum is reached. In general, the optimal pH value for jelly is 3.2.

### **2.10.1.2 Preparation of Jelly**

#### **2.10.1.2.1 Selection of Fruit**

The fruit should be fresh, just ripe, and firm. It is often useful to use one-fourth ripe fruits and three-fourths just-ripe fruits for imparting flavour

as well as for good setting of the jelly. Guava, sour apple, plum, karonda, wood apple, loquat, papaya, and gooseberry are generally used for preparation of jelly. Apricot, pineapple, strawberry, raspberry, etc., can be used but only after addition of pectin powder because these fruits have low pectin content.

#### 2.10.1.2.2 Grading of Fruit

Grading should be done according to variety, size, and colour to make a uniform-quality product.

#### 2.10.1.2.3 Preliminary Treatments

Fruits are to be washed thoroughly in running tap water. It is better to wash the fruits in diluted HCl (1:20) followed by washing in running tap water to remove dirt and residual spray materials.

#### 2.10.1.2.4 Preparation of Fruits

Fruits are cut into small, 1.5-cm pieces along with edible seeds and skin with a sharp stainless steel knife. During preparation, the fruit pieces are placed in an aluminium container containing the required quantity of water to check surface oxidation. Usually no water is required to be added for very soft and juicy fruits (grape, orange, tomato, etc.). However, for soft, semi-hard, and hard fruits, 3/4 to equal, equal to 1.5 times, and 1.5–2.0 times water, respectively, is required during pectin extraction.

#### 2.10.1.2.5 Extraction of Pectin

These fruit pieces along with water and half the total requirement of acid are cooked to soften and break down the fruit tissues and to release pectin. Lime juice can be used instead of citric acid. Addition of acid helps to release pectin from the fruit pieces, acts as a preservative, and improves the colour. The remaining amount of citric acid is added before reaching the end point.

#### 2.10.1.2.6 Pectin Test

A pectin test is essential to calculate the quantity of sugar to be added per litre of pectin water extract, which can be done by the following methods.

#### 1. *Gelmetre test or viscosity test*

This test uses a 28-cm-long pipette-like glass apparatus with both sides open having downward graduations from 1.25 to 0.5. The clear pectin water extract is poured into the gelmeter up to the brim at a temperature ranging between 21 and 26 °C by blocking the lower end. The extract is then allowed to drop for only 60 s by removing the finger from the lower end. The graduation that the upper surface of the extract reaches is recorded. Dropping of extract depends on the concentration. If higher pectin is present in the extract, the higher will be the viscosity, resulting in slow dropping and a higher reading, that is, a higher amount of sugar is needed. Similarly, a lesser amount of sugar is needed if less pectin is present in the extract.

#### 2. *Spirit test*

A teaspoonful of strained pectin extract is placed in a test tube, three teaspoonfuls of methylated or rectified spirit added: the pectin present in the extract will be precipitated. If the precipitate formed consists of a big clot, the extract is rich in pectin; if the clot breaks up into two to three small pieces, the pectin content is medium; and if the precipitate consists of several small clots, the pectin content is very poor. In case of poor pectin content, the pectin extract may be concentrated further until it indicates medium pectin content or mixed 10–15 g pectin powder/l extract.

#### 2.10.1.2.7 Addition of Sugar

Half the calculated amount of sugar is added when the mixture starts boiling. Addition of the full amount of sugar will unnecessarily increase the volume, resulting in charring of sugar and consumption of much heat energy. The first addition of sugar will partially invert and form glucose and fructose (both are monosaccharides) and which do not crystallize at such a concentration when glucose as crystal recrystallizes on the surface of the jelly. The remaining half of the sugar is added at 102 °C during the frothing period. Inversion of sugar takes place in presence of enzyme (invertase) present in the fruit.

### 2.10.1.2.8 Boiling of Mixture

High temperature is to be applied to complete the processes within 45 min so that the pectin does not lose its jelling property.

### 2.10.1.2.9 Addition of Pectin Powder

When it is necessary, pectin powder is added at 10–15 g/l pectin extract with eight to ten times the amount of sugar. Both sugar and pectin are dissolved in a sufficient quantity of water at 60–70 °C and mixed with the product during boiling before addition of the second dose of acid.

### 2.10.1.2.10 End Point Test

- (a) Temperature test: 105.6 °C at mean sea level. With every 150 m rise in altitude, the end point temperature drops by 0.6 °C.
- (b) Sheet test or flake test
- (c) Ball test
- (d) Refractometer test
- (e) Cold plate test
- (f) Volume test
- (g) Eye estimation or colour test

### 2.10.1.2.11 Filling Bottles

Fill the prepared jelly with the help of a glass rod or spoon into hot sterilized wide-mouthed bottles up to the brim, cover with a thin cloth, and leave undisturbed for 8–10 h.

### 2.10.1.2.12 Sealing

When the product in the bottles has settled and cooled, a thin layer of molten paraffin wax about 0.5 cm thick is to be poured over the surface of the jelly to seal the bottle airtight.

### 2.10.1.2.13 Labelling and Storing

Bottles are labelled properly with the date of preparation, name of product, recipe, and name of manufacturer. The bottles are then stored in a cool, dry, shaded place.

## 2.10.1.3 Problems in Jelly Making

### 2.10.1.3.1 Failure of Jelly to Set

1. Lack of acid or pectin or both in the finished product.
2. Addition of lesser amount of sugar, resulting in syneresis or weeping jelly.

3. Addition of excess amount of sugar, resulting in crystalline jelly.
4. Cooking below the end point, resulting in soft or syrupy jelly.
5. Cooking beyond the end point, resulting in tough or gummy or sticky jelly.
6. Cooking slowly for a longer period results in syrupy jelly because of destruction of the elasticity and jelling property of pectin and much inversion of sugar.
7. Addition of sugar at a time resulting in blackening of the product and complete inversion of sugar.
8. Disturbing filled container during setting of jelly may cause failure of jelly to set.
9. Using immature or overripe fruits that have no jelling property.
10. Addition of ingredients at an improper ratio.

### 2.10.1.3.2 Cloudy Jelly

When a jelly shows a cloud-like appearance and is not quite transparent, it is known as cloudy jelly.

#### Causes

1. Filling of jelly without the help of a glass rod, resulting in incorporation of air bubbles.
2. Use of immature fruits having insoluble starchy matter.
3. Crushing of fruits pieces either during extraction of pectin or during squeezing, resulting in mixing of fine insoluble fruit particles with the product.
4. Pectin extract when not properly clarified by sedimentation and by siphoning, resulting in cloudy jelly.
5. Scum if not removed properly during cooking (frothing time).
6. Premature gel formation: in extract with excess pectin content, lesser amounts of both sugar and acid are to be added and preparation should be completed promptly by adding more water.
7. Overcooking causes gel action to start before filling.

### 2.10.1.3.3 Crystalline Jelly

When on the surface or throughout the jelly sugar crystals appear because of recrystallization of sugar or when sugar does not have sufficient time to dissolve, this is known as crystalline jelly.

### Causes

1. Addition of excess sugar
2. Overcooking or overconcentrating the product
3. Concentrating the pectin extract before addition of sugar so it does not have sufficient time to dissolve
4. Late addition of sugar and in one lot causing noninversion of sugar
5. Excess concentration of pectin extract where acid is less

#### 2.10.1.3.4 Weeping or Syneresis Jelly

Spontaneous exudation of fluid from upper surface of jelly.

### Causes

1. Addition of excess acid, which breaks down the pectin and thereby the jelly structure
2. Formation of tough jelly, causing premature gelation
3. Presence of less pectin in the finished product
4. Addition of less sugar

### Precautions During Preparation of Jelly

1. Fruits used for jelly preparation should have 0.5–1.0 % pectin.
2. Just-ripe fruits should be selected.
3. Fruits should always be washed in running cold water before trimming.
4. Peeling should be avoided.
5. Utensils or knives made from iron or copper should not be used.
6. Ingredients should be used in proper amounts and at the proper time.
7. Boiling should be completed within 45 min after addition of first half quantity of sugar.
8. End point should be judged properly.
9. Bottles along with lids should be sterilized properly
10. Hot product should be filled into hot bottles with the help of a glass rod or spoon.

## 2.10.2 Preparation of Jam

The procedure of making jam is similar to jelly making, except that after the pectin test it is necessary to boil the pectin extract without straining

of edible seed and skin. Apple, pear, sapota, apricot, loquat, peach, papaya, karonda, carrot, plum, strawberry, mango, tomato, and grape are used for the preparation of jam.

### 2.10.2.1 Problems in Jam Production

1. *Crystallization*: The final product should contain 30–50 % invert sugar. If the percentage is less than 30 %, cane sugar may crystallize out on storage, and if it is more than 50 % the jam will become a honey-like mass because of the formation of small crystals of glucose. Corn syrup or glucose may be added along with cane sugar to avoid crystallization.
2. *Sticky or gummy jam*: Jams tend to become sticky or gummy as a consequence of a high percentage of total soluble solids. This problem can be solved by addition of pectin or citric acid or both.
3. *Premature setting*: This is caused by low TSS and high pectin content in the jam and can be prevented by adding more sugar. If this cannot be done, a small quantity of sodium bicarbonate is added to reduce the acidity and thus prevent precoagulation.
4. *Surface graining and shrinkage*: This is caused by evaporation of moisture during storage of jam. Storing in a cool place can reduce it.
5. *Microbial spoilage*: Sometimes molds may spoil the jam during storage, but they are destroyed if exposed to less than 90 % RH. Hence, jams should be stored at 80 % RH. Mold growth can also be prevented by not sealing the filled jar and covering the surface of jam with a disc of waxed paper because mold does not grow under open conditions as rapidly as in a closed space. It is also advisable to add 40 ppm sulfur dioxide in the form of KMS.

## 2.10.3 Marmalade

Marmalade is a fruit jelly in which slices of the fruit or its peel remain in suspended condition. Marmalade is generally prepared from citrus fruits such as oranges and lemons in which shredded peel is used as suspended material. Citrus

marmalades are classified into jelly marmalade and jam marmalade.

### 2.10.3.1 Problems in Marmalade Making

Browning during storage, which is very common, can be prevented by addition of 0.09 g KMS/kg marmalade and not using tin containers. KMS, dissolved in a small quantity of water, is added to the marmalade while it is cooling. KMS also eliminates the possibility of spoilage caused by molds.

## 2.11 Preparation and Preservation of Dried/Dehydrated Products

Drying is one of the earliest methods employed in the preservation of food. There is a minimum level of moisture necessary for each kind of spoilage organism to feed, grow, and develop and thus cause decomposition of food. In drying, the moisture content of a food is reduced to such a level that no organisms can grow in it; those present originally either remain dormant or die from lack of nourishment. Further reduction of moisture in certain types of foods is sometimes necessary to avoid other undesirable changes during storage.

### 2.11.1 Methods and Equipment for Drying

Foods can be dried either in the sun, called sun drying, or by artificial heat under controlled temperature and humidity conditions in specially constructed chambers called dehydrators, known as dehydration.

Dehydration, in general, has the following advantages over sun drying:

1. Drying is quicker and much time is saved
2. Deteriorative changes caused by the action of enzymes, etc., are much reduced
3. It can be practised in all places and under all climatic conditions
4. Product remains free from dust and attack of insects

5. The products will remain in better condition and will be more uniform in quality

#### 2.11.1.1 Sun Drying

The only equipment required in sun drying is some suitable type of drying trays. These may be made of wire gauze, wooden strips, or bamboo strips fitted to wooden frames. The last two types, commonly known as slat bottom trays, are suitable for almost all kinds of fruits but not generally convenient and useful for vegetables, whereas galvanized wire gauze trays are suitable for practically all kinds of vegetables. The convenient size of trays for drying in the home is 53.34 cm×80 cm×3 cm. The strips are 3–4 cm wide and are fixed to the frame so as to provide space between two strips. Wire gauze of 8–10 mesh may be used.

#### 2.11.1.2 Dehydration

The simplest form of equipment for dehydration on a small scale or in a home is called a home drier (Biaugeaud 1994). It consists of a galvanized iron sheet box 90 cm×60 cm×90 cm of which the sides and top are enclosed in a wooden frame. It is fixed on an angled iron stand about 40–45 cm high. The bottom of the box is made of mild steel plate 0.32 cm thick, having 0.64-cm-diameter holes all round to allow air to enter the box. About 10 cm below the top on both sides, there are metallic flaps 60 cm×7 cm along the sides, to control the flow of moisture going out. Inside the box along both sides are suitable runways 3 cm wide, 3 cm thick, and 90 cm long; the lowermost is fitted at about 18 cm from the bottom of the box. The box has a suitable shutter and a hole for placing the thermometer in the top of the box. The dryer can hold seven trays. It may be heated by a stove, coal furnace, or any other suitable means.

### 2.11.2 General Procedure for Sun Drying and Dehydration

1. *Preparation of the materials:* The fruits and vegetables are, in general, selected and prepared by washing, peeling, trimming, etc.

Green mangoes are peeled with a knife, sliced; outer leaves and cores of cabbages are removed, shredded longitudinally into 0.50-cm-thick shreds; stalks, covering leaves, and stems of cauliflowers are removed, flowers broken into pieces of suitable size; potatoes are peeled and cut into 0.50-to 0.75-cm-thick slices; peas are collected from their pods. The materials should be washed thoroughly in running water.

2. *Pretreatments*: Fruits and vegetables are living tissues in which changes caused by the action of enzymes continue unless the activity of agents responsible for these changes is checked. These changes manifest themselves by affecting adversely the colour, flavour, etc. of the product. In many cases, after peeling and cutting the materials rapidly undergo discolouration. A variety of nonenzymatic chemical changes taking place in certain materials during drying also affect adversely the quality of the finished product. This type of deterioration during drying can be minimised or checked by one or more of the following treatments.

- (a) *Blanching*: Most vegetables are blanched to destroy the activity of enzymes, although fruits are not generally blanched because of danger of the loss of the soluble constituents of the fruit. Blanching of vegetables fixes the natural colour and imparts a bright appearance to the product. Blanching means dipping of vegetable pieces (tied loosely in a cloth) in boiling water (100 °C) for 2–3 min and then cooling them in water. It accelerates drying by softening their texture by partial cooking and thereby facilitating easy escape of moisture. Blanching also done in steam. Blanching in steam has a definite advantage over blanching in boiling water; the loss of soluble elements from the material is much less, resulting in better retention of flavour and nutrients. But for green peas, cabbage, and cauliflower, blanching in water is more useful.

- (b) *Lye peeling*: Certain fruits and vegetables such as peaches, apricots, guava, orange

segments, sweet potatoes, and carrots can be more conveniently peeled by the action of boiling hot lye solution (1–2 % caustic soda solution; sodium hydroxide) for about 30 s to 4 min, depending on the thickness of the skin. Dipping of fruits in lye solution cracks their skins or peels, thus permitting a higher rate of drying, and also helps in better retention of sulfur dioxide.

- (c) *Sulfuring*: Sulfuring is the treatment of materials with sulfur dioxide, for fruits only. It bleaches the colour of the product, minimises enzymatic and oxidative changes leading to discolouration and off-flavour development and loss of nutritive value, and also acts as a preservative and helps against insect infestation. Fruits and vegetables may be sulfured by dipping into solutions of sulfurous acid or of salts such as sodium metabisulfite or potassium metabisulfite (0.2–1.0 % for 20–30 min) or by exposing the prepared material to the fumes of sulfur dioxide obtained by burning of sulfur (40–80 g/10 kg fruit slices for 30 min to 2 h) in a closed chamber or room (airtight). A typical sulfur box-like home dryer is also usable for sulfur fumigation. For fruits, fumigation with sulfur dioxide fumes is the most satisfactory method of sulfuring.
3. *Drying*: After preparation and suitable pretreatment as necessary, the fruits and vegetables are spread on trays and dried in the sun or a dehydrator. In sun drying, the trays must keep sufficiently raised from the ground level and their bottoms left open for free circulation of air. For protection against flies and other insects, the trays may be covered with galvanized wire gauze trays inverted over them or with a net of nylon or thin cloth. At night, the trays must be kept under a roof in a dry situation (Ingegno 1992). Generally, 4–7 days are required for complete drying.

In dehydration, the temperature of the dehydrator during drying may be maintained between 60 and 70 °C according to the need of



the product, and the trays should be inspected and interchanged occasionally.

4. *Testing of dryness*: Fruits when properly dried should be such that no moisture can be pressed out of any freshly cut ends and no natural grain of the fruit (as when fresh) will be seen if a cross section is made. Fruit should not also be so dried that it breaks off when bent or acquires a brown colour and burnt flavour. It should not be brittle and crisp. There should be no trace of moisture in the centre of larger vegetables when cut open.
5. *Sweating (conditioning)*: After drying, fruits and vegetables must be conditioned for equalization of moisture by storing for a few days in a box or friction top tins, in a cool place, shaking the product occasionally.
6. *Packing and storing*: The dried fruits and vegetables for use in the home can be packed in sterile airtight jars or tins. For sale, they may be conveniently packed in a polythene bag sealed by a heated metal rod and further packed in large-sized containers (Colin 1992).

Name of fruits	Preparation	Sulfuring	Drying temperature
Banana (green)	Blanched in boiling water after peeling and slicing to 12-mm-thick slices, during slicing kept in 0.1 % ICMS solution to avoid discolouration	Sulfured in box for 2 h in fumes	60 °C for 20 h, ratio 5:1
Mango (green)	Peeled and cut into pieces of 12-mm-thick slices, sulfured for 2 h in fumes and then dried	Do	45–50 °C for 30 h or sun drying
Cabbage	Outer leaves and cores removed, shredded longitudinally into 0.5-cm-thick shreds	Blanched for 2–3 min in 1.0 % boiling sodium bicarbonate solution	60–65 °C for 12 h or sun drying, ratio 18:1
Cauliflower	Stalks, covering leaves, and stems removed, flowers broken into small pieces	Blanched 4–5 min in boiling water, steeped 45 min in 1 % KMS solution, and washed	55–60 °C for 12 h, ratio 35:1
Pea	Pods shelled to get grains (1 kg pod = 500 g seed = 135 g dried pea)	Blanched 1–2 min in boiling water	60–65 °C for 20 h, ratio 7.4:1
Potato	Peeled and cut into 0.25-cm-thick slice for fries and 0.5–1 cm thick pieces for curry	Blanched for 3–5 min in boiling water	60–65 °C for 8 h, ratio 7:1

Source: Magee and Wilkinson 1992; Matz 1984; Torres 1974; Thompson 1989

## 2.12 Preparation and Preservation of Canned Products

### 2.12.1 Definition

The process of storing fruit pieces in 33–50 % sugar solution (known as syrup) and vegetable pieces after blanching in 2–3 % salt solution (known as brine) together with 0.5 % citric acid, and if required ascorbic acid, is termed canning or bottling. The nutritive value and quality of the product remain unchanged.

### 2.12.2 Selection of Material

Fruits should be ripe, firm, and evenly matured, free from malformation, cracks, or insect damage. Overripe fruits are generally infected with microorganisms, but underripe fruits are shriveled and tough and would yield a pack of inferior quality on canning.

Similarly, vegetables should be tender, fully matured, firm, and deep in colour. Freshness in vegetables is one of the important factors (an hour from the field to canning factory is considered ideal).

### 2.12.3 Sorting and Grading

Sorting and grading are necessary to obtain a pack of uniform quality in variety, shape, size, flavor, and colour. After preliminary sorting, grading may be done by either hand or machine. A mechanical grader may be the screw or roller type.

### 2.12.4 Washing of Raw Materials

Microorganisms harbour mostly on the surface of damaged fruits and vegetables. Vegetables are produced near the soil and they contain less acid than fruits, so it is obvious that more infecting microorganisms will be on them. Nearly 80–100 % of the micro-organisms can be washed off by only steeping the material in hot water for a few minutes.

Washing may be done in different ways. Washing in a bucket of cold water is a common practice, which is not at all a proper method as dust and microorganisms from infected fruits or vegetables may spread to a fresh bucket. Washing in running tap water is a better method. Washing in hot water supplemented by compressed air through a jet is the best method. Fruits are sometime washed with a dilute solution of HCl at 1:20 ratio to remove residual spray materials. In all cases washing should be done separately by rubbing the produce thoroughly, especially for vegetables.

### 2.12.5 Blanching

Blanching is done in case of vegetables only. Treatment of vegetables by dipping for about 2–5 min in boiling water followed by rapid cooling before canning is known as blanching.

In special cases, sodium chloride (NaCl) or sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) is used in the water during blanching.

### 2.12.6 Preparation of Materials

The fruit and vegetables after washing are prepared for canning by the use of different types of

knives such as a plain stainless steel knife with a sharp edge; peeling is done in different ways:

1. Hand peeling with knife
2. Machine peeling
3. Heat treatment (potato)
4. Dipping in lye solution (peach, apricot, guava)
5. Flame peeling (onion, garlic)

A peeling knife has a curved blade and guard to regulate the depth of peeling. It can be used for many fruits and vegetables. A pitting knife is used to remove the stone in litchi. A coring knife is used to remove fine pieces of fruit flesh. A coring loop is used to remove the seeds of oranges. Fruits or vegetables are then cut into pieces of 0.25–0.50 cm.

### 2.12.7 Different Types of Cans

#### (A) *Can*

1. Handmade can.
2. Hole and cap can have small holes for exhausting air.
3. Open-top sanitary can, slightly soldered at one side only. Cap has the same diameter as the can.
4. Black steel plate cans introduced during the war period when tin was scarce.
5. A string-opening composite can with a ripcord strip of tin that can open the can by a ring-type cord as developed by Metal Box of Calcutta.
6. Self-heating can: just by opening the cans the temperature of the product inside can be raised to 50 °C within 4 min, which is made possible by the use of calcium silicate and  $\text{Fe}_2\text{O}_3$ ,  $\text{Fe}_3\text{O}_4$ . This mixture is placed at the centre of can, and just by opening it, the temperature is increased by the reaction of the chemicals.

#### (B) *Glass container*

1. Narrow-neck glass bottle with ordinary or velvet cork, crown cork, or pilfer-proof (pp cap) having a cork or polythene sheet inside the crown or pp cap for better sealing.
2. Wide-mouth glass jar with metallic or polythene (polyethylene) screwed lid or

cap. The cap has a rubber or polythene ring inside it to provide a good seal.

(C) *Plywood container*

This type of can is mainly used for a product that is consumed daily, but now it is used for temporary preservation of cordial and guava juice for future processing and known as a carboy.

(D) Shellac-laminated polythene container generally used for drugs and being used in preservation. In the future it may replace tin containers because of its low cost.

(E) Polyvinyl chloride container.

(F) Flexible container.

(G) Expanded polythene container.

(H) Silver-lined aluminum container.

(I) Laminated pouch: aluminum-lined paper or polythene pouch.

(J) Polythene tube.

(K) Metallic tube (aluminum, flexible).

(L) Lacquered can.

It is difficult to coat steel plate uniformly with tin during the process of manufacture. It is necessary, therefore, to coat the inside of can with some material such as lacquer that would prevent discolouration but would not impart its own flavour or injure the wholesomeness of the contents; this is achieved by lacquering the tin plate.

There are two types of lacquers:

(a) Acid resistant

(b) Sulfur resistant

The acid-resistant lacquer is ordinary gold colour enamel, and cans treated with it are called R-enamel cans. These cans are used for packing fruits of the acid group with soluble colouring mater. Acid fruits are of two kinds:

(a) Those in which the colouring matter is insoluble in water.

(b) Those in which the colour is water soluble. The first group, including peach, pineapple, apricot, grapefruits, etc., can be placed in plain cans. The second group, including raspberry, strawberry, red plum, and coloured grapes, are packed in lacquered cans.

(c) The sulfur-resistant lacquer also is of golden colour and the cans coated with it are called C-enamel or S.R. cans. These cans are used for non-acid products such as pea, corn, lima

bean, and red kidney bean to prevent discolouration of the contents and staining of the inside of the container.

## 2.12.8 Can Filling

Cans are washed and sterilized by 2–3 min in boiling water or in hot air vacuum. Water is then drained. Ordinary tin cans are generally used for vegetables and for noncolour fruits and lacquer cans are used for coloured fruits. The cans are filled with the material by a filling machine.

## 2.12.9 Pouring of Covering Liquid: Syrup and Brine

Sugar/salt is then mixed with water according to requirement, heated, strained through a thick muslin cloth, and poured on the material when still hot, mixing with 0.5 % citric acid or lemon juice for vegetables.

### 2.12.9.1 Objectives of Pouring Covering Liquid

- (a) To remove air from spaces within the material and from unfilled space present within slices of the packed material
- (b) To check oxidation, thereby preventing discolouration and loss of flavour
- (c) An aid in further processing because it is a carrier of heat by which processing can be done rapidly and uniformly
- (d) Reduces exhaust time
- (e) Acts as preservatives
- (f) Acts as shock absorber
- (g) Improves the taste
- (h) Checks enzymatic action
- (i) Acts as soaking medium
- (j) Prevents further entry of microorganisms

Apple, peach, pea, guava, and banana should be stored in acidified covering liquid, otherwise discolouration may start. Cans are filled with 175–180 °F hot covering liquid. Further high temperature will result in shrinkage of the pieces. A suitable head space should be left, so that when the lid is fitted, the space left inside the can between

the surface of the covering liquid and inner surface of the lid is between 1/8 and 3/16 inch.

### 2.12.10 Lidding and Clinching

After being filled the cans are covered with a lid that is clinched by the first roller action of a double-roller can sealer. The lid remains sufficiently loose to permit air to be expelled. Exhaustion of air from the container is done by keeping the clinched can in a hot water bath. After clinching, the counting coding device is also incorporated in this machine.

### 2.12.11 Exhausting

The removal of air from the head space of a filled container is known as exhausting. It is important in canning: a good exhausting ensures a satisfactory vacuum in the can and thereby minimises oxidative changes that lead to discolouration of the product and loss of vitamins. Exhausting also releases the strain on the cans during processing and storing. Cans are exhausted either by heat treatment or a mechanical method.

In the first method, the cans are placed in 180 °F hot water contained in a tank for 10 min. The tops of the cans are kept 1/2–1 1/2 inches above the water level. The air will exhaust from the clinched portion. At the end of exhaustion the temperature at the centre of the can should be 175 °F. The partial vacuum created inside the can preserves the taste and flavour of the material and keeps the product in hygienic condition for a longer period.

### 2.12.12 Sealing

After exhausting, the cans are sealed by the second roller action of the can sealer while the product inside the can is hot.

### 2.12.13 Processing

The term processing in canning means heating of the canned food to a certain extent that would

sufficient to eliminate all possibilities of fungal and bacterial growth. Sealed cans are placed in the tank containing water. A false bottom of thick cloth is placed, and the tank is then boiled until the temperature at the lowest heating point inside the centre of a can reaches 80 °C. Acid fruit requires less heat for processing, whereas nonacid vegetables require a much higher temperature. The dividing line between acid and nonacid foods is regulated at pH 4.5. So, a canned product of less than 4.5 pH can be processed at 10–15 lb pressure at 240 °F for 40 min. Processed cans are cooled rapidly to 100 °F in running water, or hot cans are passed through a tank containing cold water to stop further cooking, and thereby central browning of the product inside the can should be checked.

Can may be cooled

- (a) By spraying of cold water through a water jet
- (b) By exposing cans to air, which is time consuming
- (c) Immersing hot cans in a tank containing cold water

Bottles are cooled as quickly as possible by keeping them in a well-ventilated space; this facilitates quick drying of the can's outer surface, thereby avoiding rust.

### 2.12.14 Testing of Defects

Finished cans are finally tested for leakage or improper sealing in the factory in batches.

### 2.12.15 Labelling and Storing

The cans are then dried, labeled, and stored in cool, dry, dark places.

#### 2.12.15.1 Canning of Some Fruits and Vegetables

##### 2.12.15.1.1 Mango

Juicy and fibrous varieties are not preferred. Suitable varieties are Langra, Bombai, or Himsagar. Firm but fully ripe mangoes are picked and ripened in straw. Mangoes are washed, peeled, and the fleshy portion is cut into six to eight longitudinal slices or into 2-cm cubical

pieces that are kept in 2 % brine (2 % sodium chloride) solution to check oxidation.

Pieces are then filled into a can. The covering liquid contains 35–40 % hot syrup (sugar) after mixing with 0.25 % citric acid. Clinched cans are then exhausted at 175 °F for 10 min by keeping them in water. The sealed cans are processed for 20 min. Plain cans are recommended for filling, and from 1.5 kg of raw materials 1 kg finished product can be prepared (Khurdiya and Roy 1986).

#### 2.12.15.1.2 Litchi

Tree-ripened fruits are taken: freshness of fruit is the most important criterion for litchi canning. Bedana is a suitable variety. Outer shells are cracked, the fleshy portion is cut longitudinally at one side, and the stone is removed. Covering liquid contains 40 % sugar syrup, 0.5 citric acid, and 2 % ascorbic acid to inactivate the enzymatic action that causes browning. Prompt cooling of the can is essential as the fleshy portion of the fruit is white and tender. Plain cans are used.

#### 2.12.15.1.3 Pineapple

The varieties Giant Kew and Kew are most suitable for canning as the fruits are larger in size with flat eyes. The Queen variety is also good for a quality product for its colour and flavour. Slicing is done at first with a pineapple slicer, then slices are made round shaped by using a pineapple puncher. Fruits also may be cut in cubes, triangles, etc. Different types of cans and other containers may be used in preservation. Covering liquid and other methods are same as for mango.

(a) Tin containers	1. Handmade can
(b) Glass container	2. Hole-and-cap type can
	3. Open-top sanitary can

#### 2.12.15.1.4 Garden Pea

Uniformly matured, good-texture peas are suitable. Large-sized peas such as telephone, phenomenon, and bonnevel are suitable for canning. They are graded after shelling using sieves with hole diameter ranging between 9/32 and 13/32 of an inch. Peas may be graded by dipping in 1.04–1.07 specific gravity brine solution and discarding the

floating ones. The peas are then blanched in boiling water for 3–5 min. Plain cans are used with covering liquid containing 57 g sugar and 35 g salt in 2.8 l water (or 1.25 kg sugar with 750 g salt in 45 l water). Sometimes edible green colour and mint flavour are added with the covering liquid.

The cans are filled, exhausted, sealed, and processed under 10 lb pressure for 40–50 min. Canned fresh peas are commonly known as garden peas. Dried peas when soaked in water overnight and then canned are known as processed peas. For dried peas, the covering liquid is prepared by mixing 625 g salt with 2.5 kg sugar/l water. A 0.2 % solution of edible green colour is used with that covering liquid; 150 g is necessary for 45 l of covering solution.

#### 2.12.15.1.5 Bean

Tender stringless beans are cut into 1-in. pieces, blanched, and preserved in brine solution. Plain cans are used.

#### 2.12.15.1.6 Potato

Potatoes can be canned as whole or as slices. They should be sufficiently firm, blanched for 5–6 min, then peeled by hand or on a rotary vegetable peeler known as a potato baller. Slices are made 0.5 cm thick and placed in 2 % brine solution to prevent discolouration. The softer varieties of potato before canning are placed in 2.5 % calcium chloride solution for 1 h for firming. They are then washed well before filling into cans. Plain cans are used and covered with 2 % brine solution.

## 2.13 Spoilage in Preserved Food Products

In storage, food products are liable to spoilage for various reasons. After spoilage, the products may become unsuitable for consumption, or the product may have lost its normal colour yet may remain fit for consumption. Spoiled canned food exhibits characteristic differences in appearances, taste, and odour from normal canned food. It usually possesses a flat sour taste and offensive flavour, odour, and smell. Spoilage of product may be caused either by the activities of the

microorganisms that contaminate the product or the bodies of microorganisms after their decay, causing poisoning of the food content.

### Type of Spoilage

(A) *Internal spoilage*

(B) *External spoilage*

(A) *Internal spoilage may be of the following types:*

1. *Internal microbial spoilage*

(a) *Gaseous spoilage*

1. *Nonpoisoning*

2. *Poisoning*

(b) *Nongaseous spoilage*

2. *Internal physicochemical spoilage*

3. *Internal biological spoilage*

## 2.13.1 Internal Microbial Gaseous Spoilage

### 2.13.1.1 Internal Microbial Nonpoisoning Gaseous Spoilage

Spoilage may be further classified as aerobic and anaerobic in type. The presence of yeast cells in fruit products are evidence of this type of spoilage with the production of alcohol and carbon dioxide. The rapid production of CO<sub>2</sub> accounts for frequent bursting of cans: this is an anaerobic type. Vegetables usually undergo anaerobic types of decomposition caused by low oxygen content. In canned vegetables of low acidic media, the spore-bearing gas formers *Bacillus sporogenes* and *Bacillus welchii* produce a very disagreeable putrid odour. Tomatoes are spoiled by anaerobic spore-bearing acid-tolerant bacteria such as *Clostridium pasteurianum* that produces a butyric odour. Tomato juice is occasionally spoiled by acid-tolerant, heat-resistant, flat-sour-producing thermophilic bacteria known as *Bacillus thermoacidurans*.

### 2.13.1.2 Internal Microbial Poisoning: Gaseous Spoilage

This spoilage is generally caused by sporophytic bacteria and produces a heavy amount of gas. *Bacillus botulinus* (i.e., *Clostridium botulinum*)

became a grave concern to the canning industry, and even caused a 70 % death rate, because an outbreak of botulism means poisoning, for both commercial and home-canned products. In recent years, community canned foods are not affected by botulism (poisoning) but home-canned foods continue to do so. Usually canned foods are so badly decomposed as to be unfit for consumption. In most media, this spoilage produces a very characteristic penetrating odour resembling that of rancid butter: this is most pronounced in peas and least noticeable in fruits.

## 2.13.2 Internal Microbial Nongaseous Spoilage

Most of the flat sour spoilage in canned products is caused by the growth of thermophilic bacteria without production of gas, which develops only above 38 °C when canned products are not properly cooled and are allowed to stand in large stacks, which prevents rapid radiation of heat. Thus, the cans were provided with a favourable incubating temperature for the growth of bacteria. H<sup>+</sup> ion concentration also has a marked influence on the thermal death point of the thermophiles.

The usual source of contamination for thermophilic spoilage are the tanks of hot water used for blanching, hot brine, or cooling tanks. Sugar might be another source of contamination as in some stage of sugar manufacture it provided an opportunity for the growth and sporulation of thermophiles.

The growth of these bacteria is found even in 65 % sugar or in 10 % salt concentration. The bacteria grow more rapidly on glucose media. These organisms prefer media that are neutral or faintly alkaline and are readily inhibited by 1 % sodium benzoate at a pH value below 4.5. When pH is above 5.0, it is impractical to preserve the food. Spoiled food with this bacteria should never be tested, should not even be touched by the tongue, as this is very poisonous. If any food product is infected by this bacteria, prolonged boiling is necessary to destroy it. In the presence of oil, spores greatly increase their resistant power against heat.



Spoilage of canned foods caused by heat-resistant mold has also been found. The organism is *Byssoschlamys fulva*, which can withstand 86–88 °C for 30 min in some fruit syrup. The content of the can is partially liquidified by these organisms. Occasionally, jam, jelly, and bottled juice are spoiled by *Penicillium* mold, whose spores survive the pasteurization temperature, although most of them are killed at 82 °C.

### 2.13.3 Internal Physicochemical Spoilage

1. *Defective tin plate*: Swelling in cans is caused by formation of H<sub>2</sub> gases inside the container, resulting from the acid content of covering liquid or fruit pieces contacting the corrosive tin plates. Plain cans are less susceptible to H<sub>2</sub> swell than the lacquered cans. Cane sugar promotes the reaction and production of H<sub>2</sub> gases. H<sub>2</sub> swelling is of two types:
  - (a) *Flipper*: A mild positive pressure or sometimes a mild swelling where the lid can be brought down to its original position with finger pressure and the lid remains in that place even after removal of the finger pressure.
  - (b) *Springer*: Also a mild swelling which can be replaced with finger pressure but the lid will return to its swollen position after lifting the finger from the lid. Corrosion may form pinholes and the can may leak. The content remains usable and fit for consumption.
2. *Improper washing*: This may cause residual spray material to remain, thereby poisoning.
3. *Low acidity of covering liquid*: Products when preserved in low acidity can produce H<sub>2</sub> gas. At low acidity up to pH 4.5, a chemical preservative such as sodium benzoate can check the growth of such bacteria as *Clostridium botulinum*. At pH 5, however, this preservative has no action and microorganisms may cause rapid production of H<sub>2</sub> gas and thereby swelling.
4. *Following improper processing technique*: Insufficient curing of the product will result in dull to faded colour.
5. *Using strong covering liquid*: Pieces may be toughened and shrivelled when placed in strong covering liquid.
6. *Production of bitter taste*: Results from use of stronger vinegar, prolonged cooking, or high amount of spices which also released tannins.
7. *Insufficient head space*: If the container is overfilled, any gas evolved inside the sealed container caused by a chemical or organic reaction will not have sufficient space for expansion and may cause flipper swell.
8. *Providing improper exhausting period and temperatures*: When exhausted for a longer period or in higher temperature than is recommended, a product may become browned. When a product is not fully exhausted, this may caused aid microorganisms to get an O<sub>2</sub> supply and thus survive.
9. *Improper sealing*: Faulty sealing may cause development of yeast spores inside the container with the production of CO<sub>2</sub>. Bacteria such as *Bacillus coagulans* survive in a leaky can, but because they do not form spores they rarely survive the processing temperature. Similarly, improper sealing and insufficient oil may sometimes cause pickles to spoil by action of aerobes.
10. *Covering with insufficient or weak liquid*: Bacteria may survive, resulting in softening of the product. The product may become partially solidly packed so that heat penetration during processing is not adequate to kill the microorganisms.
11. *Insufficient processing temperature*: Spores of yeast may survive if the processing temperature is too low or too short in duration.
12. *Improper cooling*: When the product is not cooled promptly and allowed to stand in at temperatures that allow incubation of very harmful thermophilic bacteria, their rapid multiplication can occur rapidly. This temperature is 54 °C, resulting in the production of flat sour, and the product should never be tasted.

13. *Improper storage temperature*: The higher the storage temperatures, the more rapid will be the formation of  $H_2$  gases, resulting in much corrosion of the tin plate.
14. *Metallic reaction with spices*: When iron of a corroded tin plate reacts with tannin of spices, this may produce ferrous tannate which by oxidation produces ferric tannate, causing blackening of the product. Similarly, with brass, iron, and copper, the content may be spoiled by oxidation, causing a greenish or blackening colour of the product.
- (c) *Use of improper cooling water*: If chemicals such as sodium chromate are present in cooling water, leaky cans may result. Cooling water is generally infected with spores of microorganisms that may cause initial infestation in leaky cans.
- (d) *Improper storing*: Coloured products when preserved in transparent glass or polythene containers and stored in direct or diffused sunlight or in an open place readily lose their normal colour. Tomato products, especially ketchup, should not be kept in light even if diffused.

### 2.13.4 Internal Biological Spoilage

- (a) *Blackening caused by oxidation*: Cut fruit and vegetable surfaces release enzymes which by oxidation turn the food brown. The action is accelerated in higher light and temperature. Browning of the cut surface is very often observed in apple, banana, guava, and mango.
- (b) Browning may be caused by high exhausting and processing temperature because of partial charring of the cut surfaces.

The brown colouration of a cut surface may also be caused by other enzymes or charring, including (1) reaction between nitrogenous matter and sugar, (2) reaction between nitrogenous matter and organic acid, (3) reaction between sugar and organic acid, and (4) reaction within different organic acids, which is known as the Maillard reaction.

- (B) *External spoilage*: Mainly caused by inferior quality of steel used in cans, its covering by tin, and by lacquering. The quality of the can depends mainly on the porosity of its surface when it has not been covered properly.

- (a) *Quality of the tin plate*: Rusting for any reason from oxide; pinholes may occur, producing a leaky can and thereby allowing yeast to ferment.
- (b) *Improper drying*: If cans are not dried properly, corrosion of the tin plate may result.

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