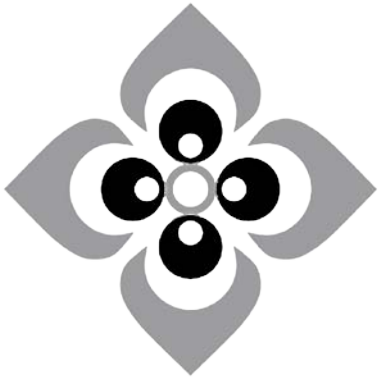

Consortium for Educational Communication

Module
on
Fruit Jam

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Text

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

Preparation of Jam

Jams may be made practically from all varieties of fruits and some vegetables containing sugar. In the United States and Britain, small fruits and berries are most popular for jam making. Fresh fruits generally give the best jams. As pectin is the main ingredient in the fruit that gives a set to the jam, it is preferable to use a slightly underripe fruit that is rich in pectin along with the ripe fruit to secure the desirable gelling effect in the jam. Apple, pear, sapota, apricot, loquat, peach, guava, papaya, karonda, plum, strawberry, mango, tomato, grapes, muskmelon, etc. have been used for preparation of jams.

Preparation of fruit pulp

A jam is more or less a concentrated fruit, possessing a fairly thick consistency. To possess rich natural flavours, only fruits which have attained full maturity should be used. Generally, good quality fruits are sold for table purpose whereas, the culled ones used for jam and other processed products preparation. A jam manufacturer can choose a fruit from among the following five categories:

A. Fresh fruit

B. Frozen, chilled, or cold stored fruit

C. Fruit or fruit pulp preserved by heat

D. Sulfited fruit or fruit pulp, i.e., fruit preserved with sulfur dioxide

E. Dried dehydrated fruits

A. Fresh fruit pulp

Peaches, pears, apples, apricot, plums, prunes are washed with acidified water (0.1% HCl) to remove dust and dirt after removing leaves, stalks and other undesirable portions from the fruit. Strawberries are crushed between rollers. Raspberries are steamed, crushed and passed through sieves to remove the hard core. Plums, apricots and peaches are heated with about 10% water until they become soft and are passed through a wide mesh sieve of the pulper which is used with rubber to separate the stone and skin. Gooseberries are whirled in a rotary vertical cylinder lined with carborandum to rub-off the tops and tails. They are then passed through sieves to separate the stalks. Mangoes are peeled, stone separated and then passed through a pulper. Pineapples are peeled, sliced and then core punched. The cut slices are then passed through a screw type crusher to get fairly coarse pulp. In case of loose skinned oranges, the segments are separated and lye dipped to remove the outer covering and then passed through a screw type extractor to get pulpy juice fit for making orange jam. Bananas are peeled and crushed in screw type extractor fitted with coarse sieve. Grapes are heated and passed through screw type juice extractor for getting coarse, juicy pulp. Papayas are peeled, sliced and core removed before cooking with 10% water and passing through coarse sieved pulper to get thick pulp. Other fruits are suitably treated to get desirable pulp for making jam.

B. Frozen fruit pulp

Freezing is the recent method of preserving fruits and vegetables to retain natural aroma, flavour and many other quality attributes. In a modern fruit processing factory, attached cold store is considered as a necessary adjunct. During the production season when fruits are in glut, surplus fruits are cold stored to ensure regular supply during the off-season. Fruits which cannot be kept in cold storage for longer period are kept in a frozen state. Frozen fruits are allowed to defrost at ambient temperature before preparation of pulp on the analogy of fresh fruits. Jams prepared from frozen fruits are as good as prepared from fresh fruits. But in India, jam is seldom prepared from frozen or cold stored fruits due to economic reasons.

C. Pulp preserved by heat treatment

Pulps preserved by heat treatment are rarely used for jam making. Rather fruit pulps

preserved by heat are often used for preparation of RTS beverages in which residual chemical preservatives are not allowed legally. However, there appears to be economic possibility of using pulp stored aseptically in bulk packages for preparation of jam.

D. Pulps preserved by sulphur dioxide

For preserving fruit pulps in bulk during peak production season, sulphur dioxide is used universally in the form of potassium metabisulphite, sodium sulphite, or calcium sulphite. Most of the pulps are preserved in 1000-1500 ppm SO_2. Sulphur dioxide bleaches the colour of some red coloured fruits like red plums, strawberries and raspberries but the colour is restored after SO_2 is driven-off by boiling. Although SO_2 completely stops the enzymatic activities of the fruit, yet it simultaneously causes breakdown of fruit pectin into pectic acid, thereby practically destroying the jellying power of the fruit pectin. Before addition of sugar to the pulp, excess of SO_2 is removed by addition of water and boiling the sulphited pulp, till SO_2 is not perceived.

E. **Pulps from dried fruits**

Pulps can be prepared from the dried fruit like apple and pear rings, dried apricots and prunes after soaking them in appropriate quantity of water, boiling and then filtering through coarse sieves. But incidentally dried fruits are not being used for jam making for obvious reasons.

Addition of Sugar

To make jams and jellies, upto a maximum of 25% of corn syrup for sweetness can be utilized. Generally, cane sugar (sucrose) of good quality is used in the preparation of jams. The proportion of sugar to fruit varies with type and variety of fruit, its stage of ripeness and acidity. Sweet fruits require less sugar than tart fruits, although fruit pulp and sugar ratio of 1:1 is generally acceptable. This is usually a suitable ratio for berries, currants, plums, apricots, pineapple and other tart fruits. To make jam 24.9 kg of sugar for every 20.4 kg of fruit taken for ensuring 68.5% sugars in jam is recommended. The ratio is suitable for apple, pear and cherry jams. The finished jam should contain 30-35% invert sugar or glucose to avoid crystallization of cane sugar which may crystallize out during storage leaving syrupy jam. Corn syrup or glucose should be added along with cane sugar to avoid crystallization.

Addition of acid

Citric, malic or tartaric acids are present naturally in different fruits. These acids are also added to supplement the acidity of the fruits deficient in natural acids during jam making. Addition of acid becomes necessary as adequate proportion of sugar-pectin-acid is required to give good set to the jam. A pH of 3.1 of fruit juice and pectin before the addition of sugar was recommended. The acidity of the finished jam varies between 0.5 to 0.7% depending on the type of the jam. It is often advisable to add acid at the end of cooking which leads to more inversion of sugar, when added in the beginning resulting in poor set. To avoid high acidity problem in finished jam, sometimes baking soda (Sodium bicarbonate) is also added during cooking to neutralize the excess acid.

Processing techniques

Traditional concentration

The traditional process used for boiling jam is the open kettle, batch boiling technique. Steam jacketed preferably, stainless steel, or aluminium kettles are commonly used commercially to prepare the jam. The kettles are steam heated at 60 to 80 psi (4.20 to 5.60 kg/cm^2) pressure. The fruit pulp and sugar are weighed separately before mixing in the kettle which is then boiled rapidly to concentrate to the end point. The boiling process in addition to excess water removal also partially inverts the sugar, develops the flavour and texture and destroys microorganisms (yeast and mold).

Vacuum Concentration

Some modern fruit processing units use vacuum pans with increased output, for boiling which work under reduced pressure at a low temperature of 65 to 76 ^{o}C. The vacuum boiling has advantage of minimizing the undesirable changes in flavour, colour and nutrients. Volatile esters are collected by process of recovery and put-back in the jam.

Plate evaporation process

This process is particularly suitable for jams that do not have large particles in suspension, where there is need for a high quality products and process economy. In a typical plate evaporation plant, first stage is the mixing together of ingredients which would normally include fruit pulp, sugar, pectin and possibly corn syrup. The ingredients may be weighed into the batch premix vessels. The premix then goes

through a paraflow plate heat exchanger where it is heated by condensate and steam. If sulphited fruit pulp is used, the hot mix enters a de-sulphiting column. The hot mix is fed to the APV plate evaporator, held under vacuum. This is a rising and falling film type evaporator. Typically the temperature of evaporation is 60-65 ^{o}C.

The concentrated jam and vapours are discharged through a large rectangular part to a snail separator where jam is separated from the vapour. The jam is extracted by a rotary pump. In line pH metering allows control of citric acid solution, added for acidity reduction. Jam for the rotary pump also passes through online refractometer to control TSS. Post process addition of any flavourings compensated volatile loss during evaporation. The product then passes through scrapped surface cooler before passing to bottle storage and to filling.

Addition of pectin

Fruits possess gel forming characteristic due to the presence of a substance called pectin. Originally, jam or jelly production relied on the native pectin of fruits for gel formation. Inspite of the current availability of other gelling agents, pectin remains the universal choice for jam and jellies, because of its natural occurrence as fruit ingredient and the characteristic consistency imparted by it to the gel. In the fruit pulps preserved with sulfur dioxide, pectin is degraded resulting in poor jam setting. Pectin deficiency is remedied by addition of commercial pectin at the rate of 0.1 to 0.2% depending on the pectin grade. But pectin need to be dispersed with sugar to ensure uniform distribution. Either liquid or dry sugar is added for dispersion. Generally one part of commercial pectin is mixed with 10 parts of dry sugar before dispersion in the boiling mixture normally added after the jam attained 60 ^{o}Bx solids.

Addition of colour

To give attractive appearance to the jam, only the permitted colours such as carmosine for mixed fruit jam should be added at the end of the preparation. Colour should be dissolved in minimum quantity of water and poured dropwise over the prepared jam with constant stirring.

Addition of essence

When jam is prepared from fresh fruit, ordinarily no flavour is required. But when

preserved pulps are used to make jam, commercially available fruit essences are added at the end of preparation and mixed well in the jam formulation.

Finishing point

Concentration of jam is finished at an optimum point avoiding over cooking which leads to economic losses because of less yield. But undercooking will result in the spoilage of jam during storage due to fermentation. The finishing or end point of jam concentration can be determined by any of the following methods:

a. **Drop test**

This test is the simplest way to determine the finishing point of jam, commonly used by housewives where no other facilities are available. In this method, a little quantity of jam is taken from the boiling pan in a tea spoon and allowed to air cool before putting a drop of it in a glass filled with water. If the drop of jam touches the bottom of glass without disintegrating in the water, jam is considered to be ready. The only drawback of this method is that jam sometimes gets overcooked while it is being cooled for testing.

b. **Refractometer method**

This is the most common method used by small and large scale fruit processing industries for jam making. The cooking of jam is stopped when the refractive index reading of Abbes refractometer indicates 68.5^{o}Bx. The jam should be immediately cooled before putting a drop of it on the refractometer glass as the reading is calibrated at 20^{o}C. The main advantage of the method is its ease of handling.

C. Boiling point method

Most jams should be concentrated to a boiling point of 106^{o}C at sea level. Correction will however, be necessary for higher locations as the boiling point decreases with increase in altitude. Generally end point for making jam should be 13^{o}C higher than the boiling point of water at that location. A jelly thermometer may be used with advantage for determining the boiling point of jam. The method is simplest and best to determine the finishing point of jam.

d. **By weighing method**

The weight of the jam prepared from the fruits rich in pectin is one and half times the weight of the sugar taken. The disadvantage of the jam is that weighing is required frequently at the end of boiling which is practically time consuming and uneconomic as heat energy is wasted during weighing.

Packaging

Jams are packed in the cans and glass jars. Containers including can or jar gets sterilized when hot jam (not less than 85 ^{o}C) is poured in them. But the lids or caps and the space between top of jam and lid or cap may support the microorganisms which often lead to microbial growth on the surface resulting in spoilage of jam. For complete sterilization of the container, following methods are practiced:

a. **Hot filling**

When cans or jars are filled hot at a temperature of not less than 85 ^{o}C, there is no need for pasteurization to prevent mold growth. After filling, the cans or jars should be inverted for a couple of min to sterilize the lids or caps and then returned to the upright position.

b. **Hot water technique**

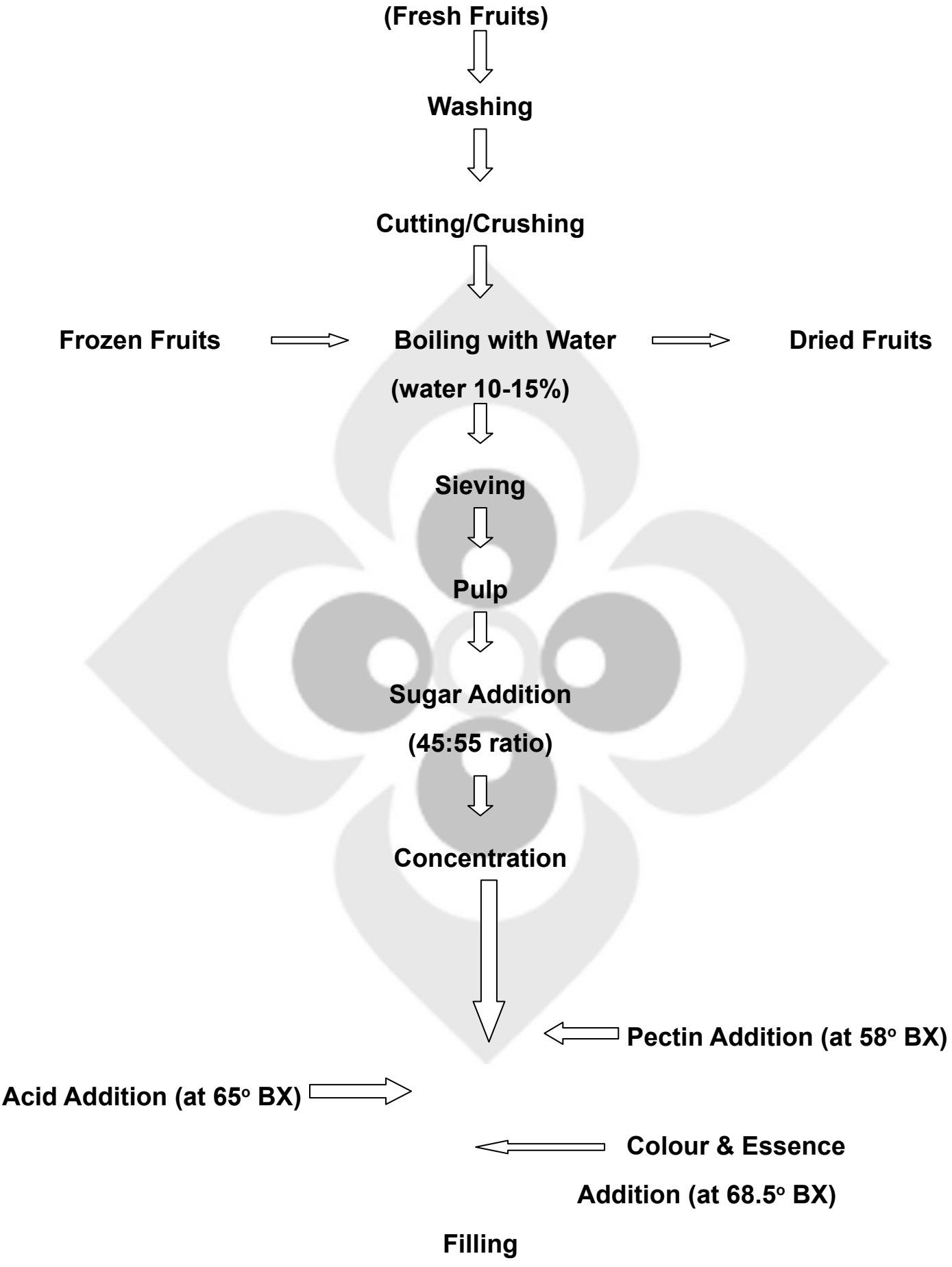
The jars are placed in water bath and boiled for 5-10 min depending on the size of container but is practicable on home scale only.

c. **Waxing**

The USDA sanctions the use of paraffin wax. The molten wax is put on the jam surface. On cooling the wax forms a seal on the surface.

d. **Use of preservatives**

In case of jars with jam made from fresh unsulphited fruit pulps, it is advisable to add 40 ppm of sulphur dioxide as KMS. This also acts as safeguard against any possible molding on the surface of jam. In cans, however SO_2 may corrode the internal surface of the cans so should be avoided. Sodium benzoate may be substituted for SO_2 for jams filled in cans. The entire process of jam making is depicted in Fig. 1.


(Fresh Fruits)
Washing
Cutting/Crushing
Frozen Fruits
Boiling with Water
(water 10-15%)
Dried Fruits
Sieving
Pulp
Sugar Addition
(45:55 ratio)
Concentration
Pectin Addition (at 58° BX)
Acid Addition (at 65° BX)
Colour & Essence
Addition (at 68.5° BX)
Filling

(at 85 °C or above)

⇩

Sealing

⇩

Labelling & Storage

Fig. 1: Flow sheet for preparation of jam

Modern Processing Techniques

Microwave oven cooking is the latest method for processing of jams and jellies for home makers. An oversized container must be used for this purpose to avoid boiling over. Fruit, sugar and some butter are mixed and allowed to stand for 30 min. Butter will avoid frothiness development. The mixture is microwaved until it boils, with frequent stirring with further cooking for 10 min more. Jams produced from this mixture keep well in the refrigerator for several months or can be canned.

Freezer jam

The no cook freezer jams are by far the easiest of these processing techniques. The fruit is mixed with an appropriate amount of sugar, lemon juice if any, is added to the pectin and then it is stirred into the fruit-sugar mix. The mixture is placed in sterilized containers and covered with 2 piece metal lids and kept at room temperature for 24 hrs before placing in the freezer. Once opened, it can be stored upto 3 weeks in the refrigerator.

Mixed fruit jam

According to 1994 USDA standard, following combinations of fruit ingredients have been recommended for mixed fruit jam:

a. A combination of two, three, four or five of such fruits in which the weight of each is not less than one-fifth of the weight of combination, except that the weight of pine

apple may not be less than one-tenth of the weight of combination.

b. Any combination of apple and one, two, three or four of such fruits in which the weight of each is not less than one-fifth and weight of apple is not more than one-half of the weight of combination, except that the weight of pineapple may be not less than one-tenth of the weight of the combination.

Blends of mango, pineapple, orange, apricots, papaya, guava, etc. pulps as available in different proportions to meet the consumer acceptance.

Sugar: Equal in weight to that of blended pulp taken.

Citric acid: Citric acid to the extent of about 0.75 to 1.0 per cent by weight of blended pulp.

Pectin: Pectin to the extent of 0.5 to 1.0 percent by weight of blended pulp, depending upon the fruits used.

Essence: Blend of appropriate essences to be added to the desired extent.

Colour: A blend of predominantly red food colours may be added to the extent desired.

Typical recipes

Some typical recipes found useful in large-scale manufacture of jams mentioned by Giridhari Lal et al. (1986) are given below.

To prepare jam, the requirement of pulp (fresh or canned) is 75 kg, with sugar 75 kg, citric acid 35 g, pectin 150 grade 565 g, and pineapple essence 75 ml.

To prepare orange jam, 50 kg of lye peeled segments require 50 kg of sugar, citric acid 250 g, pectin 150 grade 375 g, and sweet orange essence 50 ml.

To prepare mango jam, 40 kg of mango pulp requires sugar 40 kg, pectin 150 grade 500 g, citric acid 400 g and mango essence 70 ml.

To prepare apple jam, 40 kg of apple pulp requires sugar 44 kg, pectin 150 grade 400 g, citric acid 500 g and apple essence 60 ml.

To prepare mixed fruit jam, blends of mango, pineapple, orange, apricots, papaya, guava, etc., and equal weight of sugar to that of blended pulp taken and citric acid

to the extent of about 0.75–1.0% by weight of blended pulp containing pectin to the extent of 0.5–1.0% by weight of blended pulp are required depending upon the fruits used. A blend of predominantly red food grade colors may be added along with an appropriate essence to the desired extent.

Jams from cherry, mulberry, strawberry, muskmelon, jack fruit, cashew apple, etc. also can be made in the usual way. It may, however, be necessary to vary slightly the fruit sugar ratio and the percentage of acid added. In some cases, it maybe useful to supplement the flavor of the jam by adding extra fruit flavor.

Controlled manufacture

Analytical control in the manufacture of jams as well as of jellies is highly important to ensure standards of quality. The various methods of control are as follows:

a. **Soluble solids**

Determination of soluble solids is of great importance in the chemical control of jam manufacture. Soluble solids can be determined easily with a refractometer or by means of a specific gravity hydrometer, or even by a thermometer, as the boiling point of the product depends upon the soluble solids in the product.

b. **Refractometer method**

Percentage of soluble solids can be determined easily with an Abbe or Zeiss type refractometer or with a pocket refractometer, while the boiling is in process.

c. **Specific gravity method**

Fifty grams of the product are stirred with a little warm water to dissolve the jelly portion. The solution thus made is poured off from the sediment of fibre and seeds, and collected in a 250 c.c. (ml) volumetric flask. The residue is boiled two or three times with a small quantity of water, decanted and the clear extract mixed with the first extract. The combined extract is cooled to room temperature and made up to 250 c.c. (ml). It is then filtered through a coarse filter paper. The specific gravity of the solution is determined at 20 ^{o}C using a specific gravity hydrometer.

d. **Total soluble solids**

The refractometer and specific gravity methods are useful for the determination of soluble solids content of fruit pulps, which is required to work out recipes.

e. **Invert sugar**

Invert sugar is generally determined by the volumetric method of Lane and Eynon. The solution prepared for the determination of specific gravity is further diluted so that the diluted solution contains about 0.2 per cent of soluble solids. It is then titrated with Fehling's solution, using methylene blue as internal indicator. The amount of sugar can be calculated from the corresponding titration value. Ten c.c. (ml) of standard Fehling's solution is equivalent to 0.05 gram of invert sugar of 0.0475 gram of cane sugar (sucrose).

f. **Sulphur dioxide**

Estimation of sulphur dioxide is highly important when the jam has been made from pulp preserved with sulphur dioxide. According to Fruit Product Order (1955), the residual sulphur dioxide in the jam should not exceed 40 ppm. Sulphur dioxide is generally determined by the distillation procedure of Monier-Williams according to AOAC method.

g. **Acidity**

Ten grams of the sample are dissolved in water and the solution brought to a boil and titrated with standard N/10 sodium hydroxide solution, using phenolphthalein as indicator. When the end point is not sharp, the solution should be diluted further and phenolphthalein paper used as external indicator.

h. **Regulating pH of the material**

The pH of the material has great influence on the inversion of sugar and the set of jam. The pH necessary to produce a good firm set in pectin jelly is 3.30, but in jams, it varies with the kind of fruit used.

i. **Use of buffer salts**

As the pH is the controlling factor in the setting of jams, it is sometimes necessary to adjust it to the optimum. This is done generally by adding salts of citric or tartaric acids or alkalies like sodium bicarbonate or calcium carbonate. The addition of about 28

grams of the buffer salt to 45.3 kg of the jam will generally change the pH by about 0.1 unit. The pH can be determined with any standard pH meter having a glass electrode.

j. **Estimation of pectin**

Pectin does not have a definite composition, because pectin from different sources behaves differently. Even if pectin is determined quantitatively, employing elaborate analytical methods, that alone will not be sufficient to guarantee or predict the set of the jam. On the other hand, the alcohol precipitation test for pectin, which is very simple and quick, is highly useful. From the general appearance of the pectin precipitate, one can judge fairly and accurately its sugar carrying capacity and hence the jellying power.