# UNIT 10 JAMS, JELLIES, MARMALADE AND OTHER SUGAR-BASED PRODUCTS

**Structure**



## 10.0 OBJECTIVES

By the time you have studied this unit, you should be able to describe:

- importance of sugar, sweeteners, confections and sugar substitutes;
- types and sources of sugar and its role in food systems;

- methods of preparation of fruit jam, jelly, marmalade and other sugar-based products; and
- special care to be taken during the preparation of these sugar based products.

## 10.1 INTRODUCTION

Though India ranks first in the total production of fruits and vegetables, an appreciable amount of the produce is culled or of inferior quality. These culled fruits can be effectively utilised for the preparation of value added products like jam, jelly, marmalade, preserves, candies and other sugar based products.

The preparation of such sugar based products is one of the most important aspects of home scale preservation as well as industrial level processing of fruits. This method of preservation with high sugar concentration is principally based on the reduction in moisture content so as to arrest the microbial spoilage.

In this unit, first we'll learn about the various types of sugars, sweeteners, and their sources. The role of sugar in food system is dealt with. The preparation of the sugar based products and the special care taken during processing is described in detail. The quality aspects and packaging are also briefed in this section.

## 10.2 SUGAR

Sugars are carbohydrates, an important source of energy for the body. When we talk about sugar we usually refer to table sugar or sucrose, from cane or beet. There are many other types of sugars. Some occur naturally in fruits, vegetables and milk.

All sugars provide the same amount of calories (approximately 4 kilo calories or 16 kilo Joules per gram) and impart sweetness. There are two general classes of sweeteners – nutritive and non-nutritive. Nutritive sweeteners contain calories and provide energy, while non-nutritive sweeteners have no calories and provide no energy. Sucrose is the major nutritive sweetener; other sweeteners of this group are starch hydrolysates HFCS, glucose, fructose, lactose, polyols, maple syrup and honey. Examples of non-nutritive sweeteners are saccharin, acesulfame K, aspartame, etc.

### 10.2.1 Sources of Sugar

Sucrose is available in a variety of plant sources. However, the two most important sources of sugar for commercial production include sugarcane and sugar beet. In India, sugar is manufactured from sugarcane in the form of jaggery, open pan sugar, and vacuum pan sugar.

**Sugar from Sugarcane**

***Jaggery:*** It is obtained mostly from sugarcane and also from palmyra, date palm and coconut. The harvested sugarcane is crushed to obtain juice. The sugarcane juice so obtained is freed from coarse suspended impurities and boiled in open pans. Jaggery has a light colour, good flavour, hardness and crystalline structure with good keeping quality. It contains about 65-85% sucrose, 10-15% invert sugar and 2.5% ash. Jaggery finds use in the preparation of non -crystalline candies and a variety of sweets.

***Khandasari sugar:*** This is obtained by boiling the clarified sugarcane juice quickly to a required consistency to introduce the crystallization of sugar. The crystals are recovered by centrifugation and dried.

***Sugar:*** It is manufactured from sugarcane juice in three different form, raw sugar, refined sugar and white sugar. The juice obtained by pressing the sugarcane is dark green in colour and turbid. It is mildly acidic with a pH of 5-5.4 and the sucrose content is 10-18%. This juice on filtration, evaporation and centrifugation will give raw sugar, which contain 96-97% sucrose. This raw sugar on refining will give refined and white sugar. The recovery of sugar is about 10-11%weight of sugarcane.

**Sugar from Sugar Beet**

Beet sugar is obtained from sugar beet. The clear liquid extracted from sugar beet on evaporation with controlled temperature yields a thick syrup. Raw sugar crystals are obtained from this thick syrup. The raw sugar on purification gives white sugar. Powdered sugar for icing of confectionary, cake and bakery products is made by pulverizing granulated sugar with or without edible starch.

### 10.2.2 Sweeteners

They are manufactured mainly from any starch source such as wheat, maize or corn, and are liquefied in the presence of enzymes. The liquid then undergoes saccharification after it is cooled to about 60$^{o}$C or so. Various types of sweeteners of this group are discussed below.

***Starch hydrolysates:*** Starch syrup (glucose or maltose syrup), dried starch syrup, glucose and high fructose syrup are some of the sweeteners derived from starch degradation. Starch saccharification is carried out by either acidic or enzymatic hydrolysis under controlled processing conditions to yield starch hydrolysates with different composition to suit the diversified requirements. Their industrial uses include manufacture of soft caramel candies, alcoholic beverages and soft drinks, canning and processing of fruits and vegetables.

***High fructose corn syrup:*** The commercial value of high fructose corn syrup (HFCS) is based on their increased sweetness as compared to the starting material, glucose, obtained from starch. The manufacturing process of HFCS include the use of specific enzymes for the liquefaction of starch, saccharification and isomerisation. The refined dextrose liquor is concentrated or blended to a dry solid level of 40-50%.

***Glucose (Dextrose):*** Starch from corn, potatoes or wheat is saccharified enzymatically by $\alpha$-amylase and /or microbial amyloglucosidase. After starch hydrolysis the product will contain 95% glucose. The syrup is purified and evaporated to crystallize glucose as $\alpha$-D-glucose mono hydrate. Drying or crystallization gives the anhydrous form. Glucose is used as invigorating and strengthening agent in many nourishing formulations.

***Fructose:*** Fructose is obtained by acid hydrolysis of inulin, a natural polymer of fructose found in tubers. Fructose is 1.5 times sweeter than sucrose and is used as sugar substitute for diabetics.

***Lactose:*** Lactose is prepared from whey concentrates. The concentrate is heated, filtered, and evaporates to yield a yellow lactose. This raw lactose on filtration and crystallization will give α-D lactose monohydrate. β-lactose which is more soluble and easily digestible compared to α-lactose is also obtained by heating lactose solution.

***Sugar alcohols:*** Polyols are so-called sugar alcohols. They do occur naturally but most are made commercially by the transformation of sugars. Isomalt is the most commonly used polyol and is derived from sucrose. Polyols are sweet and can be used in foods in a similar way to sugars although they can have a laxative effect when eaten in large quantities. Sugar alcohols are slightly lower in calories than sugar and do not cause a sudden increase in blood glucose. They include sorbitol, xylitol, lactitol, mannitol, and maltitol and are used mainly to sweeten sugar-free candies, cookies, and chewing gums.

***Maple syrup:*** Maple syrup with sugar content of about 65% is obtained by evaporating the sap of maple tree. The sap from the tree has no flavour but develops a special flavour during evaporation. Maple syrup is used as a sweetener and as a flavouring agent.

***Honey:*** Honey is produced by honeybees which suck up the nectar and honey due from flowers and other sweet saps of plants and store the nectar in their honey sac or pouch. Based on its end use, honey is classified as honey for domestic use of highest purity and bakery honey of less purity. Honey is marketed as liquid or as semisolid creamed honey and contains about 38% fructose, 31% glucose and 2% sucrose.

### 10.2.3 Confections

***Chocolate confectionery:*** Chocolate is made from non-alkalized cocoa liquor by mixing with sucrose, cocoa butter and aroma substances including milk solids, nuts, coffee paste etc.. The ingredients are processed through several steps to yield a final product. The various processing steps include mixing, refining, ripening, conching, tempering and molding. The finished chocolate contains at least 40% cocoa liquor or a blend of liquor and cocoa butter and up to 60% sugar. Cocoa and chocolate products require careful storage condition of dry (55-65% humidity), cool (10-12$^{o}$C), well aerated space protected from light and odourous substances.

***Sugar confectionery:*** Sugar confectionery includes both crystalline and amorphous types made from boiled sugar syrup. The temperature of boiling sugar solution and ingredients used will determine the nature of the end product. Crystalline confectionery or candies have a smooth texture, amenable for cutting with knife and easily chewable. Amorphous candies have a heterogeneous soft structure and break into pieces rather than be cut with knife.

Crystalline confectionery is made by adding ingredients such as invert sugar, glucose or corn syrup, which aid the formation of fine sugar crystals from sugar syrup. Amorphous confectionery is made by preventing crystallization of the sugar either by cooking the sugar solution at high temperature and allowing the product to harden quickly or by adding large amounts of ingredients, which inhibit crystallization.

### 10.2.4 Role of Sugar in Food Systems

Sugar (glucose) is the primary energy source. Sugar is used to improve the palatability of many foods and can thereby encourage a more varied diet. Using sugars can improve the texture and colour of baked goods. Sugars produce the moistness, attractive colour and crispy texture to food products. The various functional properties of sugar in food system include:

- Source of energy
- Nutritional aspects
- Flavour and colour production
- Sweetening
- Texturing
- Plasticizing action and
- Humectancy

### 10.2.5 Types of Sugar

Because of its diverse functional characteristics, sugar is used in many types of food preparation. Although this handbook focuses on the functions of "regular" sugar, the most common type used in the home, sugar is available in many other forms.

#### Granulated Sugar

There are many types of granulated sugar. Most of them are used only by food processors and professional bakers and are not available in the market. The types of granulated sugars differ in crystal size. Each crystal size provides unique functional characteristics that make the sugar appropriate for the food processors' special need.

***Regular sugar, extra fine or fine sugar:*** "Regular" sugar, as you know, is the sugar found in every home's sugar bowl and most commonly used in home food preparation. It is the white sugar called for in most cookbook recipes. The food processing industry describes "regular" sugar as extra fine or fine sugar. It is the sugar most used by food processors because of its fine crystals that are ideal for bulk handling and are not susceptible to caking.

***Fruit sugar:*** Fruit sugar is slightly finer than "regular" sugar and is used in dry mixes such as gelatin desserts, pudding mixes and drink mixes. Fruit sugar has a more uniform crystal size than "regular" sugar. The uniformity of crystal size prevents separation or settling of smaller crystals to the bottom of the box, an important quality in dry mixes and drink mixes.

***Bakers special:*** Bakers Special's crystal size is even finer than that of fruit sugar. As its name suggests, it was developed specially for the baking industry. Bakers Special is used for sugaring doughnuts and cookies as well as in some commercial cakes to produce fine crumb texture.

***Superfine, ultra-fine, or bar sugar:*** This sugar's crystal size is the finest of all the types of granulated sugar. It is ideal for extra fine textured cakes and meringues, as well as for sweetening fruits and iced-drinks since it dissolves easily.

***Confectioners/powdered sugar:*** This sugar is granulated sugar ground to a smooth powder and then sifted. It contains about 3% cornstarch to prevent caking. Confectioners sugar is available in three grades ground to different degrees of fineness. The confectioners sugar available in supermarkets is the finest of the three and is used in icings, confections and whipping cream. Industrial bakers use the other two types of powdered sugar.

***Coarse sugar:*** The crystal size of coarse sugar is larger than that of "regular" sugar. Coarse sugar is normally processed from the purest sugar liquor. This processing method makes coarse sugar highly resistant to colour change or inversion (natural breakdown to fructose and glucose) at high temperatures. These characteristics are important in making fondants, confections and liquors.

***Sanding sugar:*** Another large crystal sugar, sanding sugar, is used mainly in the baking and confectionery industries to sprinkle on top of baked goods. The large crystals reflect light and give the product a sparkling appearance.

**Jaggery**

Brown sugars come in many different styles but are essentially one of the two types: sticky browns and free-flowing browns. The sticky browns were originally the sort of mixture that comes out of a cane sugar crystallizing pan. The extreme of this, still made in India today, is "jaggery" or "gur" which is essentially such a mixture boiled until dry. Brown sugar consists of sugar crystals coated in a molasses syrup with natural flavour and colour. Dark brown sugar has more colour and a stronger molasses flavour than light brown sugar. Lighter types are generally used in baking and making butterscotch, condiments and glazes. Dark brown sugar has a rich flavour that is good for gingerbread, mincemeat, baked beans, plum pudding and other full flavoured foods.

***Free flowing brown sugars:*** These sugars are fine, powder-like brown sugars that are less moist than "regular" brown sugar. Since it is less moist it does not lump and is free-flowing like granulated white sugar.

***Burnt sugar / caramelized sugar:*** Sugar caramelized by cooking at high temperature. Prepared in specialty items requiring a special flavour and colour. Not available for purchase, but can be made at home.

**Liquid Sugars**

***Liquid sugar syrup:*** There are several types of liquid sugar. Liquid sucrose (sugar) is essentially liquid granulated sugar and can be used in products wherever dissolved granulated sugar might be used. Amber liquid sucrose is darker in colour and can be used where the cane sugar flavour is desirable and the non-sugars' are not a problem in the product. Granulated white sugar dissolves in water. They are used in beverages, jams, candy, ice cream, syrups, and cooked fondants.

***Invert sugar:*** Inversion or chemical breakdown of sucrose results in invert sugar, an equal mixture of glucose and fructose. Available commercially only in liquid form, invert sugar is sweeter than granulated sugar. One form of liquid invert was specially developed for the carbonated beverage industry and can be used only in liquid products. It is used mainly in food products to retard crystallization of sugar and retain moisture. This can also be used in confectionery, canning and baking

### 10.2.6 Sugar Substitutes

Artificial sweeteners are non-nutritive (zero calories per serving), high intensity sugar substitutes. These are sweet synthetic substances, often used in place of other sugars in food manufacturing and cooking. One packet of these sweeteners is equivalent to the sweetness of 2 tones of table sugar. No low calorie sweetener is perfect for all uses. They provide products with increased stability, improved taste, lower production costs and more choices for the consumer. They have very long shelf lives and can be stored in original packaging in a dry location at room temperature. Some of the non-nutritive sweeteners used in food are saccharin, acesulfame K, aspartame, sucralose, Alitame, Cyclamate and stevia.

Saccharin is 300 times sweeter than sugar, but has a slightly bitter or metallic aftertaste. Saccharin is available under the trade name "*Sweet'N Low*". It is currently produced from a purified compound found in coal tar. It is not metabolized in the digestive tract and is excreted rapidly in the urine. As a result, saccharin does not contribute calories to the diet. Saccharin continues to be important for a wide range of low-calorie and sugar-free beverage applications. Saccharin also is used in cosmetic products, vitamins and pharmaceuticals.

***Acesulfame K:*** Acesulfame K Acesulfame potassium) is 200 times sweeter than table sugar. Its trade name is *Sunette*. The chemical structure is similar to saccharin. This is used in baked goods, frozen desserts, beverages, and candies. It has excellent shelf life and does not break down when cooked or baked. It does not provide calories since the body does not metabolize it and it is excreted in the urine without being changed. Acesulfame-K is usually used in combination with aspartame or other sweeteners because it enhances and sustains the sweet taste of foods and beverages and helps to extend the shelf life of the food product.

***Aspartame:*** It is produced from two amino acids aspartic acid and *phenylalanine* and is 180 times sweeter than sucrose. The trade name of Aspartame is *"NutraSweet"* and *"Equal*". During digestion, aspartame is broken down into these two individual amino acids. It is also broken down when exposed to heat, resulting in a loss of its sweet taste.

***Sucralose:*** It is known by its trade name, "*Splenda*". It is 600 times sweeter than sugar and is used in baked goods, beverages, gelatin, and frozen dairy desserts. Sucralose is derived from sucrose (table sugar). It closely resembles table sugar in taste, is highly water-soluble, and is exceptionally stable at high temperatures. Sucralose is not absorbed from the digestive tract, so it adds no calories to consumed food. In addition, sucralose does not increase blood sugar levels. Because sucralose is so much sweeter than sugar, it is bulked up with malto-dextrin, a starchy powder, so it will measure more like sugar. It has good shelf life and doesn't degrade when exposed to heat.

***Alitame:*** Like aspartame, alitame is made from amino acids, D-alanine and L-aspartic acid. Alitame is 2,000 times sweeter than sugar. It is currently approved for use in Australia, New Zealand, Mexico, and China.

***Cyclamate:*** It was initially marketed as tablets that were recommended for use as a tabletop sweetener for people with diabetes and others who had to restrict their intake of sugar. Although it is approved for use in many countries, cyclamate is banned in the United States due to concerns over potential carcinogenicity.

***Stevia:*** This is derived from a shrub. The cultivation of this plant in our country has increased in recent years. Though it can impart a sweet taste to foods, it cannot be sold as a sweetener because it is an unapproved food additive. However, stevia can be sold as a "dietary supplement", though it cannot be promoted as a sweetener.

### 10.2.7 Role of Sugar in Jams, Jellies and Other Sugar-based Fruit Products

Recipes use just about one part fruit to one part sugar in jams, jellies, and preserves. In these foods, sugar helps to retain the original flavour, aroma, colour and other quality attributes of the fruit. Fruit flavours are condensed and strengthened, resulting in the distinctive texture and pleasant appearance of jellies and preserves.

During gel formation, pectin, a natural component of fruits, forms a gel only in the presence of sugar and acid. Sugar prevents spoilage of jams, jellies, and preserves after the container is opened. Once the jam jar is opened, sugar attracts all water and water is transferred from the microorganisms into the concentrated sugar syrup. The micro flora is dehydrated and laid up, and cannot multiply further.

---

**Check Your Progress Exercise 1**

**Note:** a) Use the space below for your answer.

b) Compare your answers with those given at the end of the unit.

1. What is the role of sugar in food products?

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

2. What do you mean by sugar alcohol? Give any two examples.

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

3. What are artificial sweeteners? Give any two examples.

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

## 10.3 FRUIT JAM

Jam is a product with reasonably thick consistency, firm enough to hold the fruit tissues in position and is made by boiling fruit pulp with sufficient sugar. Jams contain 0.5-0.6% acid and invert sugar should not be more than 40%. FPO specifications for jam are given in section no. 2.14.

### 10.3.1 Preparation of Jam

Jam can be prepared from one kind of fruit or from two or more kinds. It may be made from practically all varieties of fruit. Apple, papaya, carrot, strawberry, mango, grapes, pineapple, etc. are used for the preparation of jams. Various combinations of different varieties of fruit can be often made to advantage, pineapple being one of the best for blending purposes because of its pronounced flavour and acidity.

***Preparation of fruit pulp:*** Sound fruit is sorted, washed in running water or, preferably, brush-washed and prepared. The mode of preparation varies with the nature of the fruit. For example, mangoes are peeled, steamed and pulped; apples are peeled, cored, sliced, heated with water and pulped; plums are scalded and pulped; peaches are peeled and pulped; apricots are halved, steamed and pulped; berries are heated with water and pulped or cooked as such.

***Addition of sugar:*** To make jams and jellies, up to a maximum of 25% of corn syrup for sweetness can be utilized. Generally, cane sugar 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. A fruit pulp to sugar ratio of 1:1 is generally followed. This ratio is usually suited to fruits viz., berries, currants, plums, apricots, pineapple and other tart fruits.

***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. The recommended pH for the mixture of fruit juice and pectin is 3.1. The acidity of 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 acid is added in the beginning, it will result in poor set.

***Processing/boiling:*** Fruit pulp is cooked with the requisite quantities of sugar and pectin, and finished to 69% Total Soluble Solids (TSS). Permitted food colours, requisite amount of citric acid and flavourings are added at this stage. The boiling process, in addition to excess water removal, also partially inverts the sugar, develops the flavour and texture. During jam boiling, all micro-organisms are destroyed within the product. When this is filled hot into clean receptacles which are subsequently sealed, and then inverted the hot jam contacts the lid surface, thus prevents the spoilage by micro-organisms during storage.

### 10.3.2 Judging of End Point

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

***Drop test:*** This method 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. Settling down of the drop without disintegration denotes the end point (Figure 10.1).

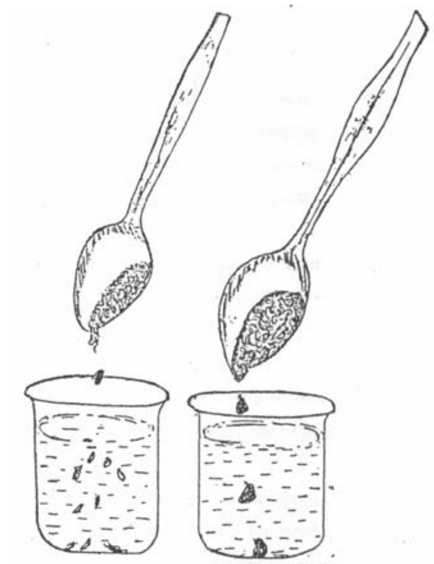
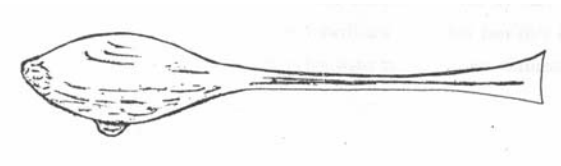
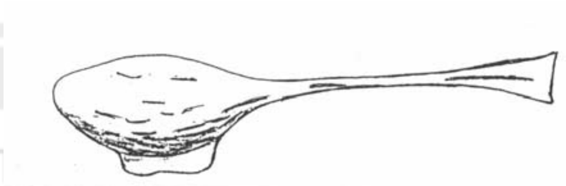



**Figure 10.1: Determination of end point of jam/jelly drop test. a) Unfinished; b) End point**

***By sheet test:*** In this test, a small portion of jam is taken with a large spoon or wooden ladle, cooled slightly and then allow to drop off keeping the spoon or ladle in horizontally inclined position. If the jam drops like syrup, further concentration is needed. If it is in the form of flake or forms a sheet, the finishing point is attained (Figure 10.2).



**(a)**



**(b)**

**Figure 10.2: Determination of end point of jam/jelly sheet test. a) Unfinished; b) End point**

***Refractometer method**:* This is the most common method used by small and large scale fruit processing industries for jam making (Figure 10.3). The cooking is stopped when the refractometer shows 69 $^{o}$Brix.

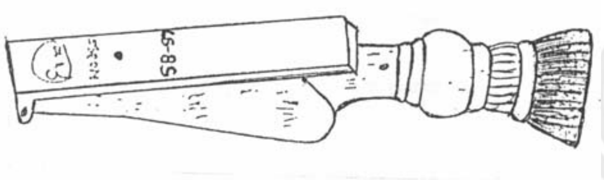


**Figure 10.3: Refractometer**

***Boiling point method**:* Jam containing 69% TSS boils at 106 $^{o}$C at sea level. This method is simplest and best to determine the finishing point of jam.

***By weighing method:*** Weighing method is more laborious and time consuming. Here the boiling pan is weighed before and again after transferring the extract and sugar in to it. The end point is attained when the net jam weight is one and a half times of the quantity of sugar added.

### 10.3.3 Packaging

The product is packed in cans or glass jars, and cooled, followed by labelling and packaging. Containers including can or jar gets sterilized when hot jam (not less than 85$^{o}$C) is poured in them. Boiling the containers in hot water can also effect sterilization.

### 10.3.4 Special Care/ Problems in Jam Production

***Crystallization:*** The final product should contain 30–40% 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 due to high inversion of sugar into glucose. Corn syrup or glucose may be added along with cane sugar to avoid crystallization.

***Sticky or gummy jam:*** Because of high percentage of total soluble solids, jams tend to become gummy or sticky. This problem can be solved by addition of pectin or citric acid, or both.

***Premature setting:*** This is due to low total soluble solids 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 pre-coagulation.

***Surface graining and shrinkage:*** This is caused by evaporation of moisture during storage of jam. Storing in a cool place can reduce it.

***Microbial spoilage:*** The mould attack on jam can be eliminated by storing them at less than 90% RH (Preferably at 80% RH). It is also advisable to add 40 ppm sulphur dioxide in the form of KMS. In the case of cans, sulphur dioxide should not be added to the jam as it causes blackening of the internal surface of the can.

## 10.4 FRUIT JELLY

A jelly is a semisolid product prepared by boiling a clear, strained solution of pectin containing fruit extract, free from pulp, after addition of sugar and acid. A perfect jelly should be transparent, well set, but not too stiff, and should have the original flavour of the fruit. It should be of attractive colour and keep its shape when removed from the mould. It should be firm enough to retain a sharp edge but tender enough to quiver when pressed. It should not be gummy, sticky, or syrupy or have crystallized sugar. The product should be free from dullness with little or no syneresis, and neither tough nor rubbery.

### 10.4.1 Preparation of Jelly

Jellies are gellified products obtained by boiling fruit juices with sugar, with or without the addition of pectin and food acids. Jellies are usually manufactured from juices obtained from a single fruit species only, obtained by boiling in order to extract as much soluble pectin as possible.
***Selection of fruits:*** Guava, sour apple, plum, papaya, certain varieties of banana and gooseberry are generally used for preparation of jelly. Other fruits can also be used but only after addition of pectin powder, since these fruits are low in pectin content. Fruits can be divided into four groups according to their pectin contents. This classification is highly useful in preparation of jelly, because pectin is the important component, which is responsible for the texture of the jelly. The classification is as follows.

- Rich in pectin and acid: sour apple, grape, lemon, sour oranges, jamun, sour plum.
- Rich in pectin but low in acid: apple, unripe banana, pear, ripe guava, etc.
- Low in pectin but rich in acid: sour apricot, sweet cherry, sour peach, pineapple and strawberry.

- Low in pectin and acid: ripe apricot, peach, pomegranate, strawberry and any other overripe fruit.

***Extraction of pectin/boiling:*** After selection, the fruits are washed thoroughly as with jam preparation discussed earlier. Most of the fruits are boiled for extraction of the juice in order to obtain maximum yield of juice and pectin. Boiling converts protopectin into pectin and softens fruit tissues. Very juicy fruits do not require the addition of water and are crushed and heated to boiling only for 5 min. Firm fruits are cut or crushed and boiled with water for 5 min. The length of boiling will vary according to the type and texture of fruit. The amount of water added to the fruit must be sufficient to give a high yield of pectin e.g. apples require one half to an equal volume of water, where as citrus fruits require 2-3 volumes of water for each volume of sliced fruits.

***Straining and clarification:*** Pectin extract is obtained by straining the boiled fruit mass through bags made of linen, flannel, or cheese cloth folded several times. For large scale production, the fruit extract is made to pass through filter presses for clarity.

***Analysis of extract:*** Clarified extract is analysed for pH, acidity, soluble solids and pectin content by common laboratory methods. For determining pectin content the easiest way adopted is precipitating the pectin with alcohol. A rapid test for evaluation of juice pectin content is by mixing a small sample of juice with an equal volume of 96% alcohol in a tube. The mixture from the tube is then emptied on a plate. The appearance of a compact gelatinous precipitate indicates a sufficient pectin content for jellification (Figure 10.4). Insufficient pectin will remain in numerous small granular lumps.

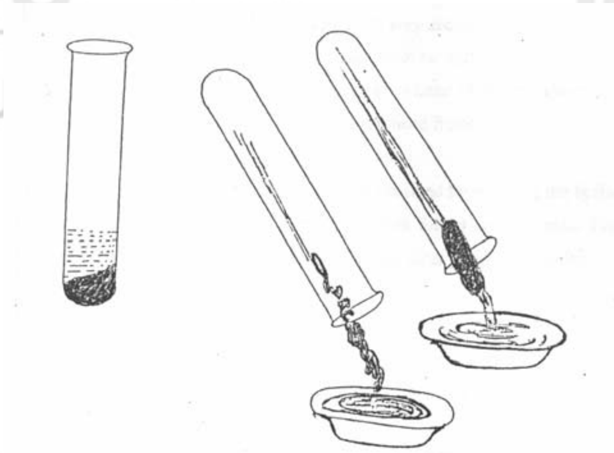


**Figure 10.4: Pectin test for jelly extract. a) Low pectin extract; b) High pectin extract**

***Addition of sugar and pectin:*** Based on the pectin test of the fruit extract, quantity of sugar to be added is worked out. For the extract rich in pectin, sugar equal to the quantity of the extract is added. To the extract with moderate pectin 650 – 750 g of sugar should be added to each kg of extract. For juices rich in pectin, jellification will occur without pectin addition. If pectin content is less, 1-2% powder pectin will be added to the juice.

***Addition of acid:*** Jelly strength increases with increasing hydrogen ion concentration until an optimum pH is reached which is generally 3.2 at 65%

sugar concentration. Jellying strength depends on the quantity of pectin and the acid present in the original fruit extract.

***Processing/boiling:*** The juice is boiled up to remove about half of the water that has to be evaporated. Then the calculated sugar quantity is added gradually. The remainder of the water is evaporated until a TSS (refractometric extract) of 65% is reached. During boiling it is necessary to remove foam / scum formed. Product acidity must be brought to about 1% (malic acid) corresponding to pH > 3. Any acid addition is performed always at the end of boiling. Boiling of jellies is performed in small batches (25-75 kg) in order to avoid excessively long boiling time which brings about pectin degradation.

### 10.4.2 Judging of End Point

Boiling of jelly should not be prolonged, because excessive boiling results in greater inversion of sugar and destruction of pectin. The end point can be judged by sheet test, drop test, refractometry, thermometer, and by weighing the boiling mass. Methods like sheet test, drop test, and weighing of the boiling mass can be done in the similar way as in the case of jam preparation.

***Refractometer method:*** This is the most common method used in fruit processing industries for jelly making. The cooking is stopped when the refractometer shows $65^{o}$ Brix.

***Temperature test:*** A solution containing 65% TSS boils at $105^{o}$C. Heating of the jelly to this temperature would automatically bring the concentration of solids to 65%. Endpoint of finishing jelly should be $4.5\text{-}5^{o}$C higher than that of the boiling point of water at that place.

### 10.4.3 Packaging

After jelly is ready, it is skimmed to remove foam. It is cooled slightly before pouring into dry and hot glass jars. Cooling is optional and is carried out up to $85^{o}$C, in double wall baths with water circulation. Filling is performed at a temperature not below $85^{o}$C in receptacles (glass jars, etc.), which must be maintained still for about 24 hours to allow cooling and product jellification.

### 10.4.4 Important Considerations in Jelly Making

Pectin, acid, sugar (65%), and water are the four essential ingredients in jelly. Pectin test and determination of end point of jelly formation are very important for the quality of jelly.

***Pectin:*** Pectin is the most important constituent of jelly. Stiffness of the gel increases with increasing concentration of pectin up to a certain point beyond which the addition of more pectin has little effect. Too little pectin gives a soft syrup instead of gel. Pectin tends to keep the sugar from crystallizing by acting as a protective colloid, but is not effective when the concentration of sugar is 70% or more. The amount of pectin extracted varies with the method of extraction, the ripeness of the fruit, the quantity of the water added for extracting the juice and the kind of fruit. Usually about 0.5-1.0 % of pectin in the extract is sufficient to produce good jelly. If the pectin content is higher a firm and tough jelly is formed and if it is less the jelly may fail to set.

***Acid:*** The jellying of extract depends on the amount of acid and pectin present in the fruit. Tartaric acid gives a better result compared to citric and malic acid. The final jelly should contain at least 0.5% but not more than 1% total acid. Higher percentage of acid may cause syneresis of jelly.

***Sugar:*** This is an essential constituent of jelly, which imparts to it sweetness as well as body. If the concentration of the sugar is high, the jelly retains less water resulting in a stiff jelly. When sugar is boiled with an acid it is hydrolysed into dextrose and fructose. Because of this partial inversion of the sucrose, a mixture of sucrose, glucose and fructose are 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.

### 10.4.5 Problems in Jelly Making

The most important difficulties that are experienced are as follows:

- ***Failure to set:*** This may be due to the addition of too much sugar, lack of acid or pectin, cooking below/ beyond the end-point.
- ***Colour changes:*** Darkening at the top of the jars can be caused by storing them in too warm place or by an imperfect jar seal.
- ***Gummy jelly:*** It is the result of prolonged or over cooking in which more than desired inversion of sugar occurs
- ***Stiff jelly:*** Over cooking or using too much pectin makes too tough jelly which fails to spread when applied on bread.
- ***Cloudy or foggy jellies:*** It is due to the use of non-clarified juice or extract, use of immature fruits, over-cooking, over-cooling, non-removal of scum, faulty pouring, and premature gelation.
- ***Formation of crystals:*** It is due to addition of excess sugar and also due to the over-concentration of jelly. This excess sugar comes from over cooking, too little acid or from under cooking.
- ***Syneresis or weeping of jelly:*** The phenomenon of exudation of fluid from a gel is called syneresis or weeping and is caused by several factors. The factors include; excess of acid, too low concentration of sugar, insufficient pectin, premature gelation, and fermentation
- ***Presence of mold:*** Due to imperfect sealing and insufficient sugar.
- ***Colour fading:*** This is due to high temperature and bright light in storage room. Another possible cause could be the insufficient processing to destroy the enzymes affecting colour or the elevated processing temperature, which might cause colour fading. Trapped air bubbles can also contribute to the chemical changes by oxidation.

**Check Your Progress Exercise 2**

**Note:** a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What are the problems in jam preparation?

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

2. How will you judge the end point of a jelly?

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

## 10.5 MARMALADE

This is fruit jelly in which slices of the fruit or its peel are suspended. The term is generally used for products made from citrus fruits like oranges and lemons in which shredded peel is used as the suspended material. In the preparation of marmalade, pectin and acid contents are kept on higher side than jelly. Bitterness is regarded as desirable characteristic of product. Marmalades are classified into two: jelly marmalade and jam marmalade.

### 10.5.1 Jelly Marmalade

Good quality jelly marmalade can be prepared from a combination of Sweet orange/ Mandarin orange and sour orange in a 2:1 proportion. Shreds of sweet orange (Malta) peel are used in the preparation.

### 10.5.2 Preparation of Jelly Marmalade

Sound, ripened fruit is sorted, washed, and prepared. The mode of preparation varies with the nature of the fruit. The fruits are then cut in to slices and are boiled for the preparation of extract.

***Preparation of extract:*** The extraction of pectin, filtration/ straining of the extract and analysis of the extract is carried out in the same way as that of jelly preparation. This is explained under the headings 2.4.1.

***Preparation of peel shreds:*** The outer layer of yellow portion of citrus fruits is peeled off carefully. The stripped-off peel is cut into slices of about 2-2.5 cm long and 1-1.2 mm thick. Boiling in water with 0.25% sodium bicarbonate or 0.1% ammonia solution can soften the shreds. Before addition to the jelly, the shreds may be kept in heavy syrup for some time to increase their bulk density to avoid floating on the surface when it is mixed with jelly.

***Boiling:*** The fruit extract is boiled before the addition of sugar. During boiling, the impurities in the form of scum, are occasionally removed. When the temperature of the mixture reaches 103$^{o}$C, the prepared shreds of peel are mixed in it at the rate of 5-7% of the original extract. Boiling is continued till the end point is reached. The end point is judged in the same way as in the case of jelly. Like jelly, marmalade also contains 65% TSS at 105$^{o}$C. Boiling should not prolong for more than 20 min, after the addition of sugar to get bright and sparkling marmalade.

***Cooling:*** The marmalade is cooled to permit the absorption of sugar by the shreds from the surrounding syrup. If the marmalade is filled in hot, the shreds may come to the surface instead of remaining in suspension. During cooling, the product is gently stirred occasionally for uniform distribution of shreds. When marmalade temperature reaches around 85$^{o}$C, viscosity of syrup increases and a thin film begins to form on surface, which prevents shreds from coming to surface.

***Flavouring:*** This is done by adding some flavour or orange oil to the product near the end of boiling to supplement the flavour lost during boiling. Generally, a few drops of orange oil are mixed in marmalade before filling into containers.

***Packaging and Storage:*** Like jams and jellies, marmalade is also filled into jars and cans at a temperature around 85$^{0}$C. Storage of marmalade must be done in dry rooms (relative humidity at about 75%), well ventilated, medium cool places (temperature 10-20$^{o}$C), disinfected and away from direct sunlight and heat. These measures are necessary because marmalade is a hydroscopic product and, by water absorption, favourable conditions for mould development are created.

### 10.5.3 Jam Marmalade

Jam marmalade is practically made by the method used for preparation of jelly marmalade except that the pectin extract is not clarified. The orange peel after removing albedo portion is sliced into 0.3 cm thick pieces and treated in the same way as recommended for jelly marmalade. The sliced fruit of orange, lemon, or grape fruit after removing peel is mixed with little quantity of water and boiled to soften. The boiled mixture is pressed through coarse pulper to remove seed and to get thick pulp. The pulp is mixed with equal quantity of sugar and cooked to a consistency of 65$^{o}$ Brix or consistency of jam. The treated shreds are mixed in the jam when it is slightly cool. Some orange oil is also mixed in the marmalade before filling into containers. Filling and packaging is done in the similar way as adopted for packaging of jelly and jelly marmalade.

### 10.5.4 Problems in Marmalade Making

Browning during storage is very common which can be prevented by the addition of 0.09g of potassium metabisulphite (KMS) per kg of 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 due to moulds.

## 10.6 PRESERVES

A mature fruit/ vegetable or its piece impregnated with heavy sugar syrup till it becomes tender and transparent is known as preserve. When fruits are placed in a concentrated sugar syrup, the water moves out of the fruit and sugar moves into it until equilibrium is reached by osmosis. Apple, Cherry, anola, pineapple, pear, mango, papaya, strawberry, etc., can be used for making preserves. FPO specifications for preserves are given in Quality section (2.14).

### 10.6.1 Preparation Methods

Preparation involves primary operations like, selection of fruits, peeling, puncturing (to promote sugar penetration) and blanching. Blanching may be done with or without addictives to inactivate natural enzymes and to reduce the oxidative discolourisation. The blanched fruits are then treated for firming the texture of product. Now, sugar is added concentrated, and packed after the addition of preservatives. Different processes employed for the preparation of preserves from fruits and vegetables at commercial level are explained below.

***Rapid process:*** Fruits are cooked in a low sugar syrup. Boiling is continued with gentle heating until the syrup becomes sufficiently thick. Rapid boiling should be avoided as it makes the fruit tough. The final concentration of sugar should not be less than 68 % which corresponds to a boiling point of 106 $^{o}$C. This is simple and cheap process but the flavour and colour of the product are lost considerably during boiling.

***Slow process:*** In this method, the fruits are blanched until it becomes tender. Sugar, equal to the weight of fruit, is then added to the fruit in alternate layers and the mixture allowed to stand for 24 hours. Then by boiling on second, third, and 4$^{th}$ day consecutively the strength of syrup is raised to 70 % TSS. A small quantity of citric or tartaric acid is also added to invert a portion of the cane sugar and thus prevent crystallization. The prepared preserve is then packed in containers.

***Vacuum process:*** The fruit is first softened by boiling and then placed in the syrup which should have 30-35% TSS. The fruit syrup blend is then transferred to a vacuum pan and concentrated under reduced pressure to 70 % TSS. Preserves made by this process retain the flavour and colour of fruit better than by the other two methods.

***Packaging of preserve:*** The preserve is cooled quickly, drained free of syrup and then filled in dry containers. Freshly prepared boiling syrup containing 68% TSS is then poured into the jars/containers which are then sealed air tight. In commercial scale production, however, it is better to sterilize the cans to eliminate any possibility of spoilage of product during storage.

## 10.7 CANDIED FRUIT/ VEGETABLE

A fruit or vegetable impregnated with cane sugar or glucose syrup, and subsequently drained free of syrup and dried, is known as candied fruit/vegetable. The most suitable fruits for candying are pineapple, cherry, anola, karonda, papaya, apple, peach, peels of orange, ginger etc.

***Preparation:*** The process for making candied fruit is practically similar to that for preserves. The only difference is that the fruit is impregnated with syrup having a higher percentage of sugar or glucose. A certain amount (25-30 %) of invert sugar or glucose is substituted for cane sugar. The total sugar content of the impregnated fruit is kept at about 75% to prevent fermentation. It is desirable that cane sugar and invert sugar in the final syrup should be in equal proportion approximately. The syrup left over from the candying process can be used for candying another batch of the same kind of fruit.

***Draining and drying:*** The fruit removed from the syrup is drained for about half an hour and unwanted pieces are removed. The fruit or peel is then wiped with a wet sponge or dipped for a moment in boiling water to remove adhering syrup. Then it is dried in shade or in a dryer at about 66$^{o}$C for 8 to 10 hours until the fruit is no longer sticky to handle.

## 10.8 GLAZED FRUIT/ VEGETABLE

Covering of candied fruits /vegetables with a thin transparent coating of sugar, which imparts them a glossy appearance is known as glazing. The FPO specifications for glazed fruits are given in quality section.

***Preparation:*** Glazed fruits are prepared by passing the dried candid fruit through a sugar syrup. The sugar syrup is prepared by boiling a mixture of cane sugar and water (2:1) in a steam pan at 113 to 114 $^{o}$C and skimming the impurities as they come up. Heating is then stopped and syrup is cooled to 93$^{o}$C. Granulation of sugar is achieved by rubbing the syrup with a wooden ladle on the side of the pan. Granulated candies are then placed on trays in warm dry room. To hasten the process, fruits may be dried in a dryer at 49$^{o}$C for 2 to 3 hours till they become crisp. These are then packed in air tight containers for storage.

## 10.9 CRYSTALLIZED FRUITS/ VEGETABLES

Candied fruits/ vegetables when covered or coated with crystals of sugar, either by rolling in finely powdered sugar or by allowing sugar crystals to deposit on them from a dense syrup are called crystallized fruits.

***Preparation:*** The candied fruits are placed on a wire mesh tray which is placed in a deep vessel. Cooled syrup (70% TSS) is gently poured over the fruit so as to cover it entirely. The whole mass is left undisturbed for 12 to 18 hours during which time a thin coating of crystallized sugar is formed. The tray is then taken out carefully from the vessel and the surplus syrup drained off. The fruits are then placed in a single layer on a wire mesh trays and dried at room temperature or at about 49 $^{o}$C in dryers.

## 10.10 FRUITS BAR/LEATHER

Fruit bar or leather can be prepared from different fruit pulps like mango, peach, plum, apricot, papaya, etc. The fruit pulp is taken and its TSS is raised to 30 $^{o}$ Brix by adding sugar. This pulp is then spread on stainless steel trays smeared with glycerol which are dried in a mechanical dehydrator at 60 $\pm$ 5 $^{o}$C for 2 hours. Usually five layers are dried one above the other and the final product is packed in polythene bags.

## 10.11 FRUIT TOFFEES

This is made by mixing fruit pulp with other ingredients like glucose, milk powder and edible fat. The fruit pulp is first concentrated to half its volume. Generally, for one kilo gram of concentrated pulp, 160 g of glucose, 320 g of milk powder and 200 g of edible fat is added. This mixture is further heated to a thick consistency (75- 80 $^{o}$Brix) followed by spreading it as a sheet of one cm thickness on a glycerol smeared flat tray and allowed to cool. Then these are cut into pieces (called as toffees) of desired size, wrap and store it in cool dry place.

## 10.12 PACKAGING OF THE FINISHED PRODUCT

Since candied and crystallized fruits are hygroscopic, they require waterproof packaging. These are packed in paper cellophane cartons. But with the development of packaging technology various types of flexible films are used, which are cheaper and highly effective in controlling moisture absorption and entry of other undesirable material from outside atmosphere into the food.

## 10.13 PROBLEMS IN PREPARATION OF PRESERVES/ CANDID FRUITS

- **Fermentation**: It is due to the low concentration of sugar used in the initial stages of preparation.
- **Floating of fruits in jar**: It is due to filling of the preserve without cooling.
- **Toughening of fruit skin or peel**: This is due to inadequate blanching or cooking.
- **Fruit shrinkage**: This is due to cooking of fruits in heavy syrup.
- **Stickiness**: It is due to insufficient consistency of the syrup, poor quality packaging and damp storage conditions.

## 10.14 QUALITY PARAMETERS

Quality is a measure of the degree of excellence or degree of acceptability by the consumer. The quality characteristics of a product may be due to sensory (colour, texture and flavour), hidden (nutritive value, toxicity, etc.), and quantitative characteristics (yield of jam, jelly etc.). Food quality control is generally defined as the regulation by law of food manufacture, distribution and sale, in order to prevent health hazards and fraud to the consumer. FPO act regulates the manufacture, storage and sale of fruit and vegetable products. The details of FPO and other aspects of quality are detailed in Unit 1.

The FPO specifications includes: methods of preservation, permissible colours in the preparations and also the minimum quality requirements of the final products. FPO specifications for jam jelly, marmalade, preserve, candy and other sugar based products are as follows:

| **Product** | | **Specifications** | |
|---|---|---|---|
| | | **Minimum % of TSS in final product** | **Minimum % of prepared fruit in final product** |
| 1. | Fruit jam | 68 | 45 (25% in case of strawberry jam) |
| 2. | Fruit jelly | 65 | 45 |
| 3. | Marmalade | 65 | 45 |
| 4. | Fruit preserve | 68 | 55 |
| | **Product** | **Specifications** | |
| | | **Total Sugar (%)** | **Reducing sugar as % of total sugar** |
| 1. | Candied and crystallized or glazed fruit and peel | Not less than 70 | Not less than 25 |

**Permissible limits of preservatives in fruit beverages**

| **Sl. No.** | **Product** | **Preservative** | **Parts per million (ppm)** |
|---|---|---|---|
| 1. | Fruit jam, jelly, marmalade and preserve | Sulfur dioxide | 150 |
| 2. | Crystallized, glazed fruits (including peel) | Sulfur dioxide | 150 |

**Some important quality considerations**

- Jelly made from sugar and chemical pectin shall be clearly declared as synthetic jelly.
- When dry fruit is used for making jam it shall be clearly declared on the label.
- When preserves are packed in sanitary top cans, the contents shall not be less than 85% of the total space of the can.

## 10.15 LET US SUM UP

You must have now well understood that the basic principle behind the preparation of sugar based products is the addition of sugar and concentrating them by evaporation to a point where microbial spoilage is arrested.

We have also seen the importance of sugar and various sweeteners and their role in processed foods like jam, jelly etc. The methods for preparation of jam, jelly, marmalade and other sugar based products are detailed in this unit. The special care taken during their preparation are also traced out. A brief note of quality standards and packaging is also included.

## 10.16 KEY WORDS

**Artificial sweeteners** : They are synthetic, calorie free, high intensity sugar substitutes, sometimes used in place of other sugars in food manufacturing and cooking.

**Glazing** : Coating candied fruit with a thin transparent layer of sugar, which imparts them a glossy appearance, is known as glazing.

**Crystallized fruit** : These are candied fruits covered or coated with crystals of sugar.

**Jam** : Jam is a product with reasonably thick consistency, firm enough to hold the fruit tissues in position, and is made by boiling fruit pulp with sufficient sugar.

**Jelly** : Jelly is a semi solid product prepared by boiling a clear, strained solution of pectin containing fruit extract, free from pulp, after addition of sugar and acid.

**Humectancy** : Ability to retain water.

**Inversion of sugar** : Inversion is a chemical process in which sucrose breaks down to its constituent sugars: glucose and fructose.

**Marmalade** : Marmalade is a fruit jelly in which slices of the fruit or its peel are suspended.

**Preserve** : A mature fruit or its piece impregnated with heavy sugar syrup till it becomes tender and transparent is known as preserve.

## 10.17 SELF TEST FOR THE COMPLETE UNIT/ ASSIGNMENT

1. List out the various types of sugars.

2. How is marmalade different from jelly?

3. What is preserve? Why vacuum process is better compared to rapid and slow process?

4. What is a glazing? How it is different from crystallized fruit?

## 10.18 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

**Check Your Progress Exercise 1**

1. The various functional properties of sugar in food system include: source of energy, nutritional aspects, flavour and colour production, sweetening, texturing, plasticizing action and humectancy. Sugars provide readily accessible fuel for physical performance.

2. Sugar alcohols or polyols are slightly lower in calories than sugar and do not cause a sudden increase in blood glucose. Polyols are sweet and can be used in foods in a similar way to sugars although they can have a laxative effect when eaten in large quantities. Commercially they are made by the transforming sugars and are used mainly to sweeten sugar-free candies, cookies, and chewing gums. Eg: sorbitol, and mannitol.

3. Artificial sweeteners are non-nutritive or calorie free, high intensity sugar substitutes. These are sweet synthetic substances, often used in place of other sugars in food manufacturing and cooking. Eg: aspartame and saccharin.

**Check Your Progress Exercise 2**

1. The various problems encountered in the production of jam includes: Crystallization: due to the lower percentage of invert sugar($<30$ %), Sticky or gummy jam: due to high percentage of TSS, Premature setting: due to low TSS and high pectin content, Surface graining and shrinkage: caused by evaporation of moisture and microbial spoilage during storage.

2. The end point of jelly can be judged by sheet test, drop test, refractometry, thermometer, and by weighing the boiling mass. Refractometer method is the most common method used in fruit processing industries for jelly making. The cooking is stopped when the refractometer shows 65 $^{o}$Brix.

**Answers to Assignments**

1. Various types of sugars are available for different food preparations. They are Granulated Sugar, Brown Sugars and Liquid Sugars. Granulated sugar includes: Regular sugar, Fruit Sugar, Bakers Special, Superfine, Ultra -fine, Bar Sugar, Confectioners Sugar, Coarse Sugar, Sanding Sugar, where as Brown Sugars includes: Free Flowing Brown Sugars and Caramelized Sugar. The Liquid Sugars includes Liquid Sugar syrup and invert Sugar.

2. Marmalade is a fruit jelly in which slices of the fruit or its peel are suspended. The term is generally used for products made from citrus fruits like oranges and lemons in which shredded peel is used as the suspended

material. In the preparation of marmalade, pectin and acid contents are kept on higher side than jelly.

3. A mature fruit/ vegetable or its piece impregnated with heavy sugar syrup till it becomes tender and transparent is known as preserve. Since the concentration process is done under vacuum, i.e., at low temperature, the flavour and colour retention will be more in vacuum process. Where as the same will be lost at higher operating temperature in rapid and slow process.

4. Covering of candied fruits /vegetables with a thin transparent coating of sugar, which imparts them a glossy appearance is known as glazing. Where as crystallized fruits are candied fruits/ vegetables covered or coated with crystals of sugar, either by rolling in finely powdered sugar or by allowing sugar crystals to deposit on them from a dense syrup.

## 10.19 SOME USEFUL BOOKS

1. Girdhari Lal, Siddappa, G.S. and Tandon, G.L. (1995) Preservation of Fruits and Vegetables, ICAR, New Delhi.

2. Sivasankar, B. (2002) Food Processing and preservation, Prentice–Hall of India Pvt. Ltd., New Delhi- 110 001.

3. Verma, L.R. and Joshi, V.K. (2000) Post harvest Technology of Fruits and Vegetables: Handling, processing, fermentation and Waste management, Volume-1, General Concepts and principles, Indus Publishing company, New Delhi.