International Journal of Food Science, Nutrition and Dietetics (IJFS)
ISSN 2326-3350

Fruit Jam Production

Research Article

Melaku Tafese Awulachew*

Ethiopian Institute of Agricultural Research, EIAR, P.O.Box 2003, Addis Ababa, Ethiopia.

Abstract

Processing of fruits and vegetables offers immense scope for wastage minimization and value addition; thus, can generate significant income and employment in countries of agrarian economy. Jam is the product prepared from sound, ripe, fresh, dehydrated, frozen or previously packed fruits including fruit juices, fruit pulp, fruit juice concentrate or dry fruit by boiling its pieces or pulpor puree with nutritive sweeteners namely sugar, dextrose, invert sugar or liquid glucose to a suitable consistency. Jam making is the most suitable method of preservation.

Keywords: Fruit; Jam; Sugar; Pectin; Acid.

Introduction

Jam is a semi-solid food product, prepared by cooking sugar with fruits or vegetables pulp, pectin, acid and other ingredients to a sensibly consistency. Jam should contain 65% or more TSS and at least 45% pulp.

Jams generally have two types, the one which is developed from pulp of single fruit while the second type is prepared by blending two or more fruits pulp, [9]. In jam, jellies sugar stops growth of microorganisms and prevent spoilage. Sugar holds water due to which shelf life of the products is increased, [1].

Stabilizing, thickening and textural characteristics are improved by pectin in different foods like jam, jelly, bakery products, confectionery and beverages, [18]. Citric acid is essential to accurate balance, which is required in jam and jellies preparation. For the replacement of citric acid lime and lemon juice can be used in the jam preparation because lemon and lime juices have greater amount of citric acid, [3].

Literature Review

Jam is the product prepared from sound, ripe, fresh, dehydrated, frozen or previously packed fruits including fruit juices, fruit pulp, fruit juice concentrate or dry fruit by boiling its pieces or pulporpuree with nutritive weeteners namely sugar, dextrose, invert sugar or liquid glucose to a suitable consistency. Jam making is the most suitable method of preservation Jam is defined as fruits or vegetables pulp or juice to which Sugar, pectin and citric acid are added. The mixture is usually boiled until reach reasonable consistency (spreadable), [13]. Production of jam necessitates availability of raw materials and availability of other ingredients such as pectin, citric acid, sugar and jam jars at reasonable prices.

Jam is one of the most effective means of preservation of fruits and vegetables. It is less time consuming than other means of preservation such as drying and freezing. The results obtained are much more satisfying when jam is prepared properly, (Net)1.

[14] reported that Jam has defined in the United States as that semi-solid food made from not less than 45 parts by weight of the fruit ingredient to each 55parts by weight of sugar. This mixture is concentrated to 68 percent total soluble solids to achieve desired quality. Flavoring and coloring agents may be added.

Raw materials for Jam production

Fruits/vegetables: Jam usually is made from different fruits, vegetables or mixture of them which is considered as the basic ingredient. The amount of other ingredients (sugar, pectin and acid) is usually calculated according to availability of such ingredients in the basic raw material. Due to the differences in chemical composition of fruits and vegetables the amounts of other ingredients are usually calculated according to availability of such

***Corresponding Author**:
Melaku Tafese Awulachew,
Ethiopian Institute of Agricultural Research, EIAR, P.O.Box 2003, Addis Ababa, Ethiopia.
Tel: +251 924 621 018
E-mail: melakutafese12@gmail.com

Received: March 13, 2021
Accepted: March 24, 2021
Published: June 23, 2021

Citation: Melaku Tafese Awulachew. Fruit Jam Production. *Int J Food Sci Nutr Diet.* 2021;10(4):532-537. doi: http://dx.doi.org/10.19070/2326-3350-2100092

ingredients in the basic raw materials, therefore the analysis of the raw materials is pre–requisite for jam making, (Net)1. The raw materials selected for jam manufacture should be fully ripe and free from defects such as mould and bruises.

Sugar: Sugar plays an important role in jam making and responsible for the sweet taste and act as preservative in addition to jell formation. It must be of high quality and having bright white color.

The way it is added and its treatment during the process of boiling are important factors affecting the finished product quality, [15].

Pectin: Pectin is that group of substances derived from some fruits which form a colloidal solution in water, and derive from protopectin in the process of ripening of the fruit. under suitable conditions, pectin forms a gel. Pectin is carbohydrates found to a greater or lesser degree in the cell walls of all fruits and vegetables, (Net) 2.

Pectin is important ingredient in jam manufacture because of its gel–formation property, beside the jelly formation property of pectin it helps in reducing the boiling time, which in turn assist in preserving the volatile substances and prevent the excessive inversion of sugar.

The amount of pectin required for jam making depends on: the quality and quantity of the natural pectin in the raw materials; the contents of the soluble solids in the end product; type of pectin used and the nature of the recipe.

Acid

Citric acid is the most popular acid used in jam manufacture and is added when the mixture reached 64% total soluble solids. Acid is added to jam in order to: Reduce the PH to the value recommended to apple/jelly formation; Increase the total acidity in order to enhance the flavor and taste; and preservative effect, [13].

Natural coloring and flavoring material

Natural coloring and flavoring materials can be used as permitted by law.

Selection of raw materials for jam making: Fruits ideally suited to jam making having three factors in common, a high pectin content, relatively low PH and high total soluble solids. It should be pointed out that, during the maturation of fruit, there is continuous conversion of protopectin in the green fruit to pectin in ripe fruit, and ultimately to pectic acid in over riped fruit. The pectin level in fruit is definitely a far from static value. Any very green fruit is unsuitable for jellies because of the low pectin content although it is true that some of the protopectin in the very green fruit is converted to pectin as the jelly is boiled, this conversion is inadequate to form enough pectin for optimum gel formation, Net2.

As fruit ripes, a natural conversion of propectin to pectin is catalyzed by enzymes, and the pectin content is elevated as the propect in level drops. The pectin, in turn, is gradually trans-formed into pectic acid as the fruit becomes very mature. This increase in pectic acid reduces the gelling ability of fruit. Fruit is optimum for making Jam when it is farely ripe because the pectin content is at its peak and the levels of propectin and peptic acid are low. Even when pectin content is at its peak in a fruit, some types of fruits contain inadequate quantities of pectin for successful gel formation, examples of fruits have low pectin include strawberries, raspberries, peaches, and apricots. Some fruit are naturally low in acid, hence are less suited to Jam preparation. Examples of a low - acid fruit is the banana - Another common fruit in this class is ripe sweet apples. Tart apples, berries, citrus fruits, and grapes are appropriately acidic for Jelly making. Adequate acid and pectin in fruits is importat in fruit selection. Acid may easily be increased in fruit juice by the addition of lemon juice or other acid Commercial pectins, prepared from the skins and cores of apples or the albedo of the skin of citrus fruits are readily available in liquid or powdered forms to supplement the pectin in the fruit. powdered pectin is preferred by some people because it has long shelf life. Liquid pectins are very convenient in use, but an open bottle must be used soon before the pectin begins to break down, Net 2.

Duckworth reported that fresh fruits should be used for jam making at stage of ripeness at which the content of undegraded but soluble pectic materials is at its maximum level since it is important that the product should set to a fairly firm gel, fresh fruits are only available for relatively short season and much of the fruits used for jam making are preserved either as pulp treated with sodium or potassium metabisulphite, more commonly in the United States, or in frozen state.

Factors Affecting Production control of Jam: Rauch (1995) stated that every factory has its own process of production and develops its own peculiar quality, yet there are certain factors applicable to all good quality jams those factors which should be established are: Total soluble solids content (T.S.S); The Sucrose - invert sugar ratio; Acidity & PH value; and Sugar /acid ratio.

(a). Total Soluble solids content of jam: Most of the Food laws of the world provide for a minimum percentage of 66 percent total solids and a minimum fruit content of 45 percent. Jams of total solids below 66 percent will be subjected to spoilage by yeast and moulds due to high water activity content and will have very poor setting.

(b). Sucrose - invert sugar balance of the jam: The sucrose - invert sugar ratio is very important in jam m manufacture otherwise crystallization will occur during storage. Moyle (1962) recommended that jam with total soluble solids of 67 to 70 percent should have 20 to 28 percent reducing sugars, while (15) preferred the figure to be kept within 28 - 32 percent. The PH of the jam, boiling temperature, and time, are factors affecting inversion of sugar.

(c) PH of jam: PH affects the setting of the jam. The PH of the jam should be kept in the range of 3.2 to 3.4 A PH above 3.4 14 may lead to failure of may lead to failure of the jam to set while a PH value of less than 3.0 leads to bleeding of the Jam.

[14] Report that During the process of boiling sucrose solution in the presence of acid, hydrolysis occurs, in which reducing sugars are formed (dextrose and levulose). Sucrose is converted into reducing sugars, and the product is known as inverted sugar. The rate of inversion is influenced by the temperature, the time of heating, and the pH value of the solution.

Inverted sugar is useful in jell manufacturing, as crystallization of sucrose in the highly concentrated substrate is retarded or prevented. A balance is required between the sucrose and invert sugar content in jell formation. The amount of invert sugar present should be less than the amount of sucrose.

As much as the acidity of fruits varies, and boiling conditions vary, the maintenance of a desired invert sugar sucrose ratio is difficult. In vacuum concentration, little inversion of sucrose occurs. In this instance a portion of the sucrose should be replaced with pre-inverted sugar, Invert sugar is available commercially, and is usually acid hydrolyzed, although there are invertase enzymes which can be used to accomplish the hydrolysis.

d) Colouring: According to [12] colors additives are constituents permitted for food. It is probably one of the first characteristics perceived by the senses and is indispensable to the modern-day consumer as means of the rapid identification and ultimate acceptance of food.

Jam Processing Technique

Jam boiling in kettles: The Following is a description of the boiling operation as stated by [15]. The boiling kettles are charged with fresh fruit, pulp or juice, water and half the quantity of sugar and the whole is boiled under continuous stirring for three to four minutes. Steam is then cut off and the remaining sugar should be added. Boiling is continued to near the end - point and then acid and pectin should be added. Flavor and color if needed should be added before filling.

Dissolution of Pectin: Usually when 1Ib jars are used for filling jams, rapid set pectin (150 grade) may be used. The pectin must be completely dissolved in hot water. Most pectin manufacturers give clear instructions on how best to dissolve their product. The most satisfactory procedure for pectin dissolution found is to add to each 10 parts of pectin 70 parts hot water and 20 parts of sugar mix the pectin and sugar in a dry container and add heated water to the mixture slowly with constant agitation till the pectin is completely dissolved

The End points determination:

A) Thermometer method: The thermometer must be accurately calibrated and fast Working. When designed concentration is reached usually the temperature is 105°C.

B) The Refractometer Method: The total soluble solids in jam can be exactly determined in a few seconds. Jam manufactures generally employ an Abbes refractometer for determining the end point. Adrop or two of the liquid is placed on the prism of the instrument, the prism being cooled by water jacket. The scale of the instrument is usually graduated in Brix degrees, consequently it is direct reading instrument [2].

C) Spoon Test: When the jam has been boiled for some times and has reached a reasonable consistency, dip spoon into it and let the product to run off the sides of the spoon. If on cooling the product falls off in form of a unit instead of free flowing readily in single stream, it means that the end point has been reached.

D) By placing some of the jam on dry sheet or surface of jar cover and turning the sheet or the cover upside down after few seconds. If it does not run off that means the end point has been reached.

E) By placing some of the jam in a cup filled with water, if the color of the water did not changed and the drop settled as solid matters at bottoms of the cup that means the end point has been reached.

Processing of Apple Jam

Overview to processing and Health aspect of Apple

Overview to Apple Fruit: Apple (Malusdomestica) is one of the most consumed fruit crops in the world. The major production areas are the temperate regions, however, because of its excellent storage capacity it is transported to distant markets covering the four corners of the earth. Unfortunately, fruits and vegetablesbeing perishable in nature get wasted to the tune of 20-30 per cent in the supply chain due to improper handling, transportation and poor post-harvest management; and only 2 per cent areprocessed in to value added products and the rest is consumed as fresh. Therefore, processing of fruits and vegetables offers immense scope for wastage minimization and value addition; thus can generate significant income and employment in countries of agrarian economy.

The nutritive value of most processed apple products is similar to the fresh raw product. Dried or dehydrated apples have a higher energy value per gram tissue due to the concentration of sugars [7]. The USDA tabulated in Composition of Foods, Handbook No. 8, 1975, that apples are about 84.5% water, 1% fiber, 14.5% carbohydrates, 0.6% fat, and 0.2% protein.

Apples are a rich source of the sebeneficialphy to nutrients that epide miological studies have found to be associated with protection again staging diseases and cancers [16, 18] have highlighted the effects of apple cultivar, harvest year, storage conditions and apple-juice process-ing methods on the concentration of polyphenolics.

Good process quality programs are essential to provide assurance that a safe, sound, whole some product is shipped to the consumer. Quality control is maintained throughout processing, beginning with information on growers' pesticide programs and maturity of fruit, then blending as it relates to finished product specifications, on-line measurements such as trim and coring efficiency, filling volumes, and processing and cooling temperatures. The microbiology of apple products is generally restricted to yeasts, molds, and acid uric bacteria capable of growth at the low pH of apple products [17].

Health Benefits and Nutritional Value of Apple

a) Apple fruit is notable for its impressive list of phtytonutrients, and antioxidants. Studies suggest that its components are essential for optimal growth, development, and overall wellness.
b) Apples are low in calories; 100 g of fresh fruit slices provide just 50 calories. They, however, contain no saturated fats orc holesterol. Nonetheless, the fruitisrich in dietary fiber, which helps

prevent absorption of dietary-LDL or bad cholesterol in the gut. The fiberalso saves the colon mucous membrane from exposure to toxic substances by binding to cancer-causing chemicals inside thecolon.

c) Apples are rich in antioxidant, phytonutrients, flavonoids and polyphenolics. The total measured antioxidant strength (ORAC value) of 100 g apple fruit is 5900 TE. Some of theimportantflavonoids inapples are quercetin, epicatechin, and procyanidin B2.

d) Additionally, they are also good in tartaric acid that gives tart flavor to them. Altogether, these compounds help the body protect from harmful effects of free radicals.

e) Apple fruit contains good quantities of vitamin-C and β-carotene. Vitamin C is a powerful natural antioxidant. Consumption of foods rich in vitamin-C helps the body develop resistance against infectious agents and scavenge harmful, pro-inflammatory free radicals from the body.

f) Further, apple fruit is an ideal source of B-complex vitamins such as riboflavin, thiamin, and pyridoxine (vitamin B-6). Together, these vitamins help as co-factors for enzymes inmetabolismas well as invarious synthetic functions inside the human body.

g) Apples also carry small quantities of minerals like potassium, phosphorus, and calcium. Potassium is an important component of cell and body fluids helps controlling heart rate and blood pressure; thus, counters the bad influences of sodium.

Technology of Jam Making

The production of jam involves three major processing steps: pectin preparation, boiling and filling and sealing processing stages.

Pectin Preparation: The production of pectin solutions by way of a suitable system is the best possibility to add standardized pectin to the cooking process. If only slow-speed mixers are available, the pectin is mixed with about five times the amount of sugar and this mixture is dissolved in water with a temperature of at least 80°C. In this way, a 3-5 % pectin solution can be produced. If a dissolver with high-speed mixer is available (more than 1.500 rpm), pectin is added while the mixer is running and the water temperature is at least 80 °C, directly poured into the mixer flux and dissolved. Depending on the type of pectin, pectin solutions of 5-7 % may be produced. Nowadays, 7-10% pectin solutions can be produced, on modern injection mixers.

The evaporating water volume is clearly smaller when such high percentage pectin solutions are added in the cooking process than it is the case with 3-5% pectin solutions. If sugar solutions or sugar syrups are used, pectin may also be suspended in 10 times the amount of liquid sugar/sugar syrup while stirring slowly. This suspension may then be incorporated into hot water with at least 80°C, which results in a 3-5 % pectin solution. If pectin is directly added to the product batch, i.e. not as pectin solution, this is best achieved with the above mentioned pre-mix of pectin and 5-10 times the amount of sugar or a suspension with liquid sugar or sugar syrups. In this case it is important to observe that the soluble solids content in the batch during the dissolving of pectin is not above 30 %, since it otherwise interferes with the solubility.

Boiling: This concentration of jams is done with the objective to create a finished product with a long shelf-life and with the required soluble solids content. During cooking, a sufficient exchange between sugars, liquid medium and fruits is achieved, which prevents water loss in the finished product during storage. In the large-scale production of jams with cooking kettles two basic types exist for the concentration process: open system boiling and vacuum boiling. Cooking in an open kettle is nowadays practiced only in a few, small companies. Cooking in vacuum systems is done in closed kettles under reduced pressure. The great benefit of this cooking method consists in low cooking temperatures and short cooking times. Both criteria are decisive for an optimal finished product as regards to appearance, colour, flavour and vitamins, since the raw materials are exposed to only minimal stressing. Short cooking times and relatively large cooking batches also guarantee the economic efficiency of the process.

The pre-heated fruit/sugar mix is fed from the pre-heater by negative pressure into the kettle and reduced by boiling under vacuum with constant stirring. To prevent foaming, edible oils and fats such as mono- and diglycerides of edible fatty acids may be added. The pectin solution is then metered and further reduced by boiling under vacuum until the desired final soluble solids content is reached. Due to the low cooking temperatures, which may be as low as 65°C, slow to medium rapid set pectins are applied in this process. Once the final soluble solids content is reached, the batch will be vented and acid is added. The temperature of the cooked material increases in this process, before discharging it should reach 80-85°C in order to guarantee germ-free filling. Sophisticated cooking systems with flavour recovery condense the volatile aroma components from the escaping steam and return them to the cooking batch before its discharge.

Filling of Jams: Jams is discharged from the vacuum kettle by way of pumps or, even more sensitively, by gravity into heated filling troughs with agitators, from which they are fed into filling machines. The temperature of the cooking batch at the time of filling is 70-85°C.

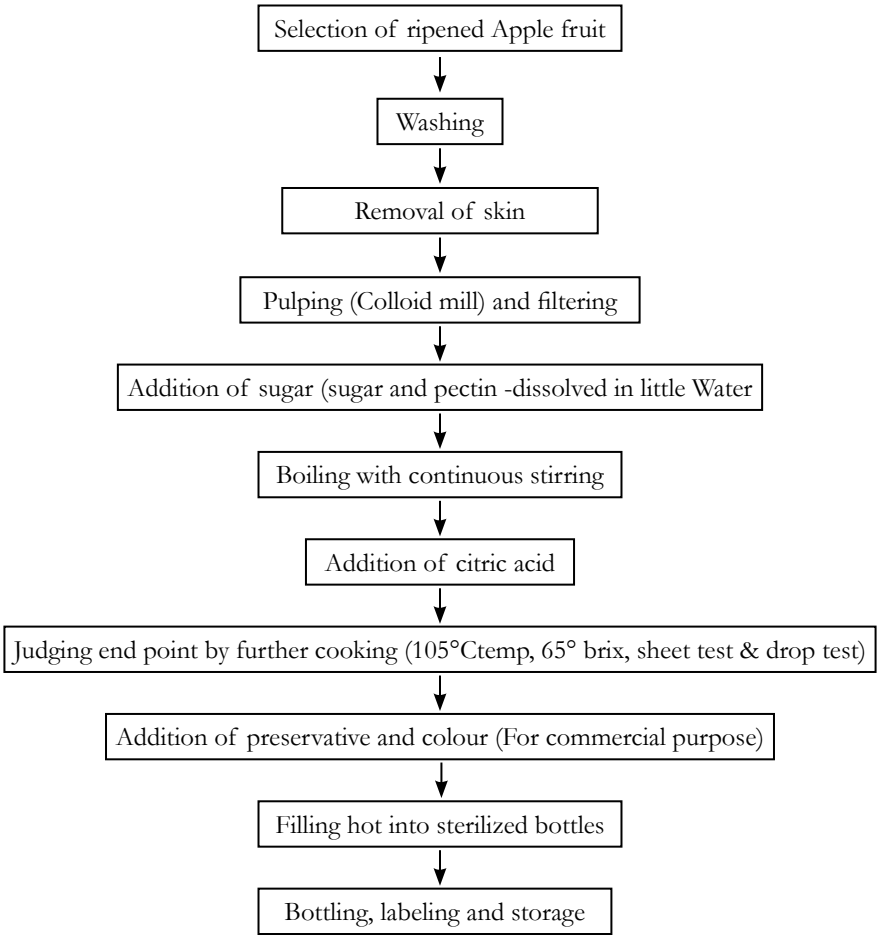
The relatively high filling temperature and capping under vacuum with headspace sterilization guarantees germ-free filling and perfect stability during storage. Before closing the jars, suitable measures for the sterility of the product surface during the filling process are recommended. UV-radiation of the empty jars or the caps before filling is also indicated to protect against secondary infections. After filling and capping, the jars pass through a tunnel cooler and are sprinkled with cold water which lowers their temperature to 40-50°C. The rapid lowering of the temperature prevents caramelization and colour changes in the filled article and brings the product into a temperature range; in which an optimal jam texture may be slowly formed. After cooling and labeling, the products go into packaging.

Process Description of Apple Jam Production

Selection of fruit: Only fully ripe fruits are selected; Overs and green fruits, if used, adversely affect the quality of jam. The verities and maturity of the fruit and locality of cultivation influence the keeping quality of its.

Fruits used in the manufacture also generate an influence on the jam process, depending onvariety, state of ripeness and storage

Figure 1. Process flow chart of Apple jam production.



conditions. The most important factors are the fruit ownpectin content, the sugar and acid content as well as the amount of minerals and other fruit specific constituents. With increasing ripeness, enzymes within the fruit degrade the fruitinherent pectin and the pulp becomes softer. The fruit-own acid amount decreases and the sugar amount increases.

The most important quality criteria for fruits used are: optimal state of ripeness, full fruity flavor, variety-specific color, no blemishes (no spots, no bruises), sufficient consistency (solidity of form), and soluble solids content in agreement with quality standards, perfect hygienic condition of raw materials and packaging.

Sorting and washing: Diseased, damaged or decayed fruits are rejected or trimmed. Fruit is washed thoroughly to remove any-adhering dust and dirt. Dirts are removed by washing with water, rinsed with chlorine water (10-100ppm) and again rinsed with water.

Pulping: The edible portion of the fruitis extracted from fresh fruit Crushing and pressing them. Colloid mill and Screw-type pulpers are mostly used. The Skin can be removed and the fruit can be diced/sliced before pulping.

Addition of pectin: Pectin reduces the boiling time, which in turn assist in preserving the volatile substances and prevent the excessive inversion of sugar. The amount of pectin required depends on the quality and quantity of the natural pectin in the raw materials; the contents of the soluble solids in the end product; type of pectin used and the nature of the recipe.

Addition of sugar: Sugars are one of the main constituents of jams, influence the shelf life of these products decisively through the soluble solids content. At the same time they provide taste, flavor, consistency and coloring. For jam production, mostly refined sugar or white sugar (sucrose) is used. During cooking, sucrose is partially inverted. This intended chemical reaction (splitting of sucrose into glucose and fructose by binding water) is influenced by: the pH-value, temperature and time of boiling. The formation of invert sugar prevents the crystallization of the sucrose in the finished product. On the other hand, a complete inversion of sucrose may lead to crystallization of the glucose in the product.

Addition of Citric Acid: In Apple jam processing citric acid serve for stabilization of the pH-value within strict limits, one profits from the specific properties of fruit acids to form excellent buffer systems with their salts, e.g. in the combination citric acid and sodium citrate. Among these acids, citric acid has been used in fruit jam production due to its taste, antioxidant characteristics, solubility and storage and handling characteristics. Citric acid is naturally present in a great number of fruits. It is crystalline and dissolves well in water. Citric acid is a weaker acid than tartaric acid, but stronger than lactic acid. The flavor of the citric acid is naturally sour and harmonious. This acid, too, is preferred to be added as 50 % aqueous solution. As a rule, fruit acids are added to the cooking batch towards the end of the cooking process. This prevents pre-gelling, which might occur if the temperature of the cooking batch drops below the setting temperature due to the

blending in of the sugar or the pectin solution.

Concentration by heating: Steam jacketed open kettle isused. The fruitpulp is concentrated by continuous boiling and stirring. The required quantity of sugar is added directly during boiling-Sugar also acts as preservative and brix is checked @ 68.5 °B & temperature 105°C.

Addition of colours and preservatives:

• Colours–Natural and Synthetic food colours
• Preservatives–Benzoicacid (used to Inhibits bacterial with pH<4.5); sorbic acid (uses for Avoids oxidation and discolouration); and sulphurdioxide or sulphites (uses for Inhibits bacteria and fungi); and Sorbic Acid (uses for Yeast and fungi inhibition).

Judgement of Endpoint: The final point of jam is judged with one of the following methods;

i. Drop test: A drop of hot jam is put into a beaker of water and if the mass remains as one and undispersed–the jam is done.
ii. Sheet test: A spoon of jam is dropped from a distance on to a plate and if it falls down as a sheet – jam is done
iii. Brix test: By a refractometer

Falling and Storage: Glass Jars are thoroughly washed with hot water and filled with hot jam 1.5 to 2.5cm is head space. Jars are capped and are cooled and stored for 3 – 6 months at ambient temperature.

The relatively high filling temperature and capping under vacuum with headspace sterilization guarantees germ-free filling and perfect stability during storage. UV-radiation of the empty jars or the caps before filling is also indicated to protect against secondary infections.

Conclusion

The fresh fruits have limited shelf life; therefore, it is necessary to process fresh fruits into different value-added products to increase its availability over an extended period and to stabilize the price during the glut season. The processed products have good potential for internal as wellas external trade. Jams from fruit imparts nutrition, health, wellness with natural goodness and sweet test. A perfect kind of jam honours and celebrates the goodness of fruits & value adds and minimizes the post-harvest losses. The widespread and growing intake of apples and applejuice/jam productsand their rich phytochemical profile suggest their important potential to affect the health of the populations.

References

[1]. Clarke MA. Sugars in food processing. Int J Sugar 1997;99: 14-26.
[2]. Cruess WV. commercial Fruit and vegetables. Mc Graw hill Book Co. Inc. 1958.
[3]. Desrosier NW, Desrosier JN. The technology of food preservation. AVI Publishing Company, Inc.; 1978.
[4]. DPRs. weblinks: https://mofpi.nic.in/pmfme/and http://www.iifpt.edu.in/ab-pmfme.php
[5]. Fu, J.T. and Rao, M.A., 2001. Rheology and structure development during gelation of low-methoxyl pectin gels: the effect of sucrose. Food Hydrocolloids, 15(1), pp.93-100.
[6]. Desrosier Norman W. The Technology of Food Preservation. AVI Publishing Company, Incorporated;1970.
[7]. Lee, C.Y. and Mattick, L.R., 1989. Composition and nutritive value of apple products. In Processed apple products (pp. 303-322). Springer, New York, NY.
[8]. Manay SN, Shadaksharaswamy N. Foods, facts and principles. New Age International publishers, New Delhi 2005;pp: 197.
[9]. Net (1) WWW. Food Standards .gov .qu / (March 2005) What in Food. Food additives.
[10]. Net (2) WWW.Home jam /MSN/hot mail. (November 2006).
[11]. Noonan. Color Additives in Food .cited in Furia. 1972.
[12]. Saeed AR, Mubarak A. A guide To Manufacture Of Jams. For Industry. Food Research Center Publications. 1974
[13]. Desrosier Norman W. The Technology of Food Preservation. AVI Publishing Company, Incorporated; 1970.
[14]. Ruach GH. Jam Manufacture (2nd edtn) . Leonard Hill Ltd . London England. 1965.
[15]. van der Sluis AA, Dekker M, de Jager A, Jongen WM. Activity and concentration of polyphenolic antioxidants in apple: effect of cultivar, harvest year, and storage conditions. J Agric Food Chem. 2001 Aug;49(8):3606-13. Pubmed PMID: 11513636.
[16]. Swanson KM. Microbiology and preservation. InProcessed apple products 1989 (pp. 343-363). Springer, New York, NY.
[17]. Van Der Sluis AA, Dekker M, Skrede G, Jongen WM. Activity and concentration of polyphenolic antioxidants in apple juice. 1. Effect of existing production methods. J Agric Food Chem. 2002 Dec 4;50(25):7211-9. Pubmed PMID: 12452634.
[18]. Wang Q, Pagan J, John S. Pectin from fruits: Functional foods. Biochem Process Aspect 2002;2: 263-309.