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Fruit Jellies

Food Processing for Entrepreneurs Series

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This publication provides definitions for standard products, gives help in calculating amounts of ingredients required for successful manufacture and provides suggestions for ensuring product quality.

Jellies, jams, fruit butters and marmalades often are produced by entrepreneurs who encounter quality problems or do not meet the legal standards for these products. A person selling a product to the public must understand the scientific basis for producing a superior product and have the necessary equipment (pH meter and refractometer) to assure the quality of the product. More advanced help is available from the University of Nebraska–Lincoln Food Processing Center and extension educators.

Preservation — Why Fruit Jellies are Stable

Jelly, jam, fruit butters, marmalades and preserves are products that are stable because they are high in solids (sugar) and high in acids. A food substrate concentrated to 65 percent or more soluble solids (sugar) and which contains substantial acid may be preserved with relatively minor heat treatment provided that food product is protected from air. The high fruit solids and the pectin bind or tie-up the moisture sufficiently to lower the water activity (A_w) to a level where only molds can grow. Hermetic sealing protects the product from moisture loss, mold growth and oxidation.

Jelly

Jelly is strictly defined in the United States as: That semisolid food made from not less than 45 parts by weight of fruit juice ingredient to each 55 parts by weight of sugar. This mixture is concentrated to not less than 65 percent soluble solids. Pectin and acid may be added to overcome the deficiencies that occur in the fruit itself. Flavoring and coloring agents may also be added. The name of the fruit used in making the jelly must be stated with other ingredients, in order of declining by weights, on the label of such products offered for sale in the United States.

Jam

A jam is similar to a jelly except that the crushed or pulped fruit ingredient is used rather than the fruit juice. Concentration is carried to at least 65 percent for all jams, with some requiring up to 68 percent solids to achieve the desired qualities. Not less than 45 parts of fruit are permitted for each 55 parts of sugar.

Fruit butter

Fruit butter is the smooth, semisolid food prepared from a mixture containing not less than five parts of weight of fruit ingredient to each two parts of sugar.

Marmalade

Marmalade usually is made from citrus fruit, may contain a citrus peel ingredient, and is a jelly-like product made from properly prepared juice.

Manufacturing Procedure for Fruit Jelly Products

Four substances are necessary for the preparation of fruit gels. These are: pectin, acid, sugar and water.

Successful manufacture of fruit jellies requires the combination of these components within rather narrow limits. The continuity of the gel structure is determined by the concentration of pectin which may range from 0.5 percent to 1.5 percent by weight depending upon the type of pectin utilized. This percentage of pectin is pure pectin as supplied for commercial jelly manufacture. Home use pectins usually contain up to 18 parts of sugar for each part of pectin. The rigidity of the gel is defined by the sugar concentration and the acidity. Most common pectins will form a weak gel at 63 percent to 64 percent solids. The optimum gel will form between 65 percent and 68 percent soluble solids. A hard gel will result as the solids level surpasses 70 percent. Optimum gel sets are normally obtained in a pH range of 3.1 to 3.3. A pH above 3.5 often results in poor gel formation, while a pH below 3.0 often results in hard gels subject to synergesis or "weeping."

Pectin

One should always assume that juices will be deficient in pectin and supplement the jelly with commercial pectins. Pectin is a group of substances derived from the cell walls of fruit. These pectins form gels when dissolved in water under suitable conditions.

Adding dry pectin (without blending the pectin with sugar) to water results in the formation of paste-like lumps that are nearly impossible to dissolve. Solution is greatly facilitated by heating the water or juice, then adding a pectin and sugar mixture. Pectin that has been thoroughly mixed with 10 times its weight in sugar will readily go into solution in hot water forming a nearly clear solution.

For the preserving trade various pectins are produced that may be classified as rapid-set, slow-set or by the pounds of finished jelly one pound of pure pectin will produce. Rapid-set forms gels at higher temperature than does slow-set. Rapid-set

is preferred for jams and preserves because it reduces the likelihood that the fruit component will rise to the surface before the gel is set. For jelly making a slow-set pectin often is preferred because after the jelly has firmly but not finally set, handling of the jars is less apt to damage the jelly's texture and firmness. The grade value of pectin refers to the pounds of sugar which one pound of pectin will gel. The most common commercial pectin is l50-grade pectin, meaning that with water, sugar to give 65 percent solids, and acid to give the optimum pH, one pound of pectin will give a perfect jelly with 150 pounds of sugar. Pectin of 100 grade is also popular.

Low-methoxyl pectins

The low-methoxyl pectins differ from normal pectin in that they will form gels at low sugar concentrations or in the absence of sugar and over a wide range of acidity or pH values. Calcium ions are necessary for gel formation with low-methoxyl pectins. Calcium bridges crosslinking pectins form a matrix able to hold moisture and support the gel.

The Role of Acid in Jelly Making

Gel firmness is dependent upon the jelly pH. Optimum firmness is achieved within definite pH ranges for the particular pectin utilized. Pectins are increasingly identified by their degree of methylation (DM) although the terms slow-set and rapid-set still are widely used in the trade. Slow-set refers to a pectin within the 60 to 65 DM range, while rapid-set refers to pectins within the 68 to 75 DM range. Slow-set pectins often are used in commercial jelly manufacture and attain a maximum firmness at pH 3.0 to pH 3.15. Rapid-set pectins are used for jams and preserves because they set at a higher temperature before fruit components float to the top of the jar and attain maximum firmness at pH 3.30 to 3.05. The upper limits for successful gel set are pH 3.4 and pH 3.6 for slow set and rapid set pectins respectively.

pH also is critical in determining the temperature at which jellies set. With rapid set pectins the setting temperature can be raised by approximately 25°F by lowering the pH (making more acid) from pH 3.3 to pH 3.1. Slow-set pectin generally gels 50° to 60°F lower than rapid set pectin in the pH 3.0 to 3.25 range. Acidifying a slow-set pectin jelly from pH 3.25 to pH 3.0 lowers the setting temperature by approximately 50°F.

Jelly Preparation

Choice of metals for utensils

Iron or steel are liable to darken some juices by the solution of a small amount of iron, which reacts with juice tannins and colors to produce a black or dark brown color. Copper and tin are objectionable because even small concentrations of their salts adversely affect the flavor and color of most juices and catalyze undesirable changes. Galvanized (zinc coated) vessels should never be used for fruit juices because toxic levels of zinc can be dissolved in the juice.

Stainless steel is quite resistant to the action of fruit juices and is preferred for equipment. Aluminum or enameled containers also may be used for some fruit juices. However, aluminum can result in product darkening.

Juice extraction

Fruit that is to be used for the preparation of jellies and other preserved products should be of agreeable flavor and aroma, and be of tart flavor. The juice should retain this character satisfactorily during processing and during storage as jelly.

The highest quality products are attained only from sound firm fruit. Even the slightest fermentation or mold growth will affect flavor. This necessitates the use of only clean containers, free from mold and soil, in picking and transporting the fruit. The fruit should be picked at the proper stage of maturity for the preparation of juice. The flavor, sugar control and pectin levels of the juice will vary with the maturity of the fruit.

Sorting usually is desirable to remove defective or insect infested fruit. Most fruits accumulate some dust in the field or during transportation. They should thus be rinsed thoroughly by sprays of water before crushing.

Fruit juices are most palatable when first expressed from the fresh fruit, and any treatment applied to preserve or clarify the juices results in injury to quality. Preservation should be accomplished with as little injury as possible to the fresh flavor, color and other desirable quality characteristics. Because of this the traditional methods of jelly production often are less than desirable.

In the traditional production methods most fruits are boiled to extract the juice. Very juicy fruits such as berries do not require the addition of water and need only be crushed and heated to the boiling point for two or three minutes. For most fruits the shorter the period of boiling, the better the flavor of the resulting jelly. Firm fruits such as apples are cut or crushed and require additional water. The length of boiling varies according to the variety and texture of the fruit. Apples often require 20 minutes. The fruit should be heated long enough only to soften it sufficiently to permit thorough extraction of juice and not so long as to render it mushy. That will result in a cloudy juice that is difficult to filter (due to solubilization of pectin) and usually results in considerable loss of flavor.

Pressing

Traditionally jelly making in the home was usually done without pressing the fruit. The heated pulp and juice were placed in a cloth jelly bag and allowed to drain in order to obtain a clear juice. Commercially, rack and cloth presses have been used to extract juice from the hot fruit. If the juice is clarified after pressing it must be filtered prior to the addition of sugar which increases the viscosity of the juice and causes filtering difficulty.

Preferred Juice Extraction Methods

Juices of superior flavor and clarity can be produced by improved extraction methods if equipment is available.

The method of extraction depends upon the structure of the fruit, location and character of the tissues in which the juice is located, and the character of the finished juice. Some fruits such as grapes and apples have the juice located throughout. The juice is readily recovered by crushing and pressing.

Undue aeration must be avoided during the extraction of juices from fruits that have not been heated to destroy enzymes, since destruction of vitamin C and oxidative changes in flavor are very rapid in many juices, such as apple juice. These changes are catalyzed by traces of copper and iron in solution.

Hot break vs cold pressing

Temperatures below the boiling point often are used to inactivate enzymes and aid in extraction of juice and color from fruits. The juice generally has a "cooked" flavor when compared to optimally handled, cold pressed juice, but this method provides excellent quality juice for jelly manufacture.

Grapes

Stemmed and crushed red grapes often are heated to extract the color and aid in extraction of the juice. Temperatures of 145°F to 160°F for five minutes are used. Higher temperatures extract tannins from the seeds and skins, thus yielding a harsh

flavor. When pressed in a rack and cloth press approximately 85 percent of the weight of the original grapes is extracted, while approximately 80 percent of the weight of unheated grapes is extracted. Excellent quality juice also can be extracted from grapes crushed and frozen for later pressing.

Apples

The color and much of the flavor of fresh apples may be retained in juice from unheated apples by spraying a small amount of ascorbic acid (vitamin C), which is a natural component of the fruit, on the apples as they are crushed or immediately following crushing. Ascorbic acid applied at 6 to 7 grams per bushel (40 to 45 lb.) of apples is sufficient to protect the juice if it is quickly frozen or processed. This cold pressed juice is excellent in quality.

Berries

Berries that are fully mature and have attained their maximal sugar content and color are very susceptible to fermentation and must be quickly and properly handled. Berries are usually crushed, heated and pressed. In most cases the berries are heated to 160°F before pressing. Heating helps to attain a juice of more intense color and to increase the yield of juice, but heating also solubilizes pectin and renders the juice more difficult to filter.

Formulating a Standard Jelly

A jelly meeting the established standards of identity can be easily formulated with the aid of a refractometer and the data in *Table I*. The percentage of fruit sugar in the juice is read with a refractometer. Multiplying the refractometer reading by the weight of the fruit juice gives the weight of the fruit sugar (soluble solids) in the juice. The weight of the sugar to be added as a jelly ingredient is attained by multiplying the weight of sugar required per unit weight of fruit solids (column 2 of *Table I*) by the weight of the fruit sugar in the juice. The sum of the weights of the fruit sugar, plus the ingredient sugar will equal 65 percent of the finished weight of the jelly. Thus

$$\frac{\text{weight of fruit soluble solids} + \text{ingredient sugar}}{.65} = \text{weight of the batch of jelly}$$

The weight of the batch of jelly minus the sum of the weight of fruit soluble solids plus the weight of the ingredient sugar equals the weight of water in the jelly.

The weight of the fruit juice minus the weight of fruit soluble solids equals the weight of the water in the juice.

The weight of the water in the juice minus the desired weight of the water in the jelly equals the excess water which must be evaporated during jelly manufacture. A skilled kettle operator will be able to accurately judge the evaporation rate from his kettle. Soluble solids should be carefully monitored with a refractometer as the jelly approaches the desired level of soluble solids.

Jelly processing

The clarified juice should be heated rapidly and the pectin dissolved in the quantity specified in the recipe or formulation. Pectin now is universally added to jelly juices, jams and preserves to improve consistency and to ensure the manufacture of products of uniform quality and appearance. This also allows the production of jelly without excessive cooking.

Pectin is best added by vigorously stirring while slowly adding the pectin to a heated but not boiling fruit juice. A temperature of 170 to 180°F is preferable for pectin addition, because at the boiling point sugar dissolves more rapidly than pectin and the pectin may form lumps which are nearly impossible to dissolve. A portion of the sugar may be thoroughly mixed with pectin before adding to the juice to aid in dispersing and dissolving the pectin. After the pectin is dissolved the remainder of the sugar required for the batch is dissolved and the temperature is raised to the boiling point.

Refined cane or beet sugar (sucrose) is generally the preferred sugar source for jellies and jams. However, glucose syrups have been widely used for a part of the sugar source in recent years. High dextrose equivalent glucose syrups are used because they often are less expensive than sucrose, and because they eliminate the need to reduce sucrose to invert sugar through boiling. Invert sugar is necessary to prevent sucrose crystallization of high solids jellies and jams during storage. Such crystallization is rare in products below 68 percent in solids.

Boiling

Boiling is one of the more important steps in jelly making. Its principle purpose is to increase the concentration of the sugar to the point where gelling will occur. The boiling process should not be prolonged because of the resultant loss of flavor and color to the product.

During boiling the juice should be skimmed if necessary to remove coagulated material and should be stirred to insure thorough mixing and uniform heating.

The boiling is continued until the product will form a jelly of the desired consistency upon cooling. The finished product should be of the consistency described in the definition of jelly.

The traditional method of determining the end point is by allowing the liquid to sheet from a large cooking spoon. The process is not complete if it drips from the spoon as a thin syrup. If it partly congeals and breaks from the spoon, the boiling is complete. Even so, the sheeting test is unreliable because of the variation in behavior of different juices, and requires considerable experience.

The preferred method of determining the end point is by reading the sugar content with a refractometer. The refractometer determines the sugar content by the angle that the solution refracts or bends light. The procedure is fast and accurate. A drop of the liquid is placed on the instrument. The operator peers into the refractometer while aiming it toward a light source and reads the percent sugar or ºBrix directly from the scale. The entire procedure requires only a few seconds. A decision can then be made whether to package or to cook the jelly further.

Vacuum evaporation often is utilized in commercial jelly and jam manufacture. Reduced pressure allows the evaporation to proceed at lower temperatures than atmospheric cooking, and thus allows larger batches to be rapidly processed without heat-induced chemical changes.

Superior quality jellies and jams can be processed by non-evaporative methods. Such methods involve blending the ingredients from which the required amount of water has previously been removed. Multi-fold juice concentrates often are used. Continuous processes may be utilized in such a blending operation.

Regardless of the method of evaporation utilized in jelly production, frequent quality checks should be conducted to determine if adjustment is needed and to determine the proper end point of the process.

Acidity of jelly

Insufficient acid is one of the most common causes of jelly failure. The pH value (a measure of hydrogen ion concentration or acidity) of the jelly should be taken when the jelly is concentrated sufficiently to pour. If the pH is above 3.3, citric acid should be added to reduce the pH to the range of 3.1 to 3.2.

Table I. Formulating Standard Jellies[1]

Fruit	Standard[3] Juice °Brix (% sugar)	Wt units of Sugar per weight unit of Fruit Soluble Solids Needed For a Standard Jelly	Formulations per 100 wt units (kg or lb) of Finished Jelly[2]: Fruit Soluble Solids Wt units	Sugar[4] Added Wt Units	Excess Water[5] From Standard Juice Which Must Be Removed Wt Units
Apple	13.33	9.17	6.39	58.61	6.57
Apricot	14.29	8.55	6.81	58.20	5.82
Blackberry	10.00	12.22	4.92	60.09	9.25
Black raspberry	11.11	11.00	5.42	59.58	8.34
Boysenberry	10.00	12.22	4.92	60.09	9.25
Cherry	14.29	8.55	6.81	58.20	5.82
Crabapple	15.38	7.95	7.27	57.74	4.98
Cranberry	10.53	11.61	5.16	59.85	8.82
Currant	10.53	11.61	5.16	59.85	8.82
Fig	18.18	6.72	8.42	56.58	2.88
Grape (Concord)	14.29	8.55	6.81	58.20	5.82
Grapefruit	9.09	13.44	4.50	60.50	10.01
Gooseberry	8.33	14.67	4.15	60.85	10.65
Guava	7.69	15.89	3.85	61.15	11.19
Loganberry	10.53	11.61	5.16	59.85	8.82
Orange	12.50	9.78	6.03	58.97	7.23
Peach	11.76	10.39	5.71	59.29	7.81
Pineapple	14.29	8.55	6.81	58.20	5.82
Plum	14.29	8.55	6.81	58.20	5.82
Prickley Pear	9.09	13.44	4.50	60.50	10.01
Pomegranate	18.18	6.72	8.42	56.58	2.88
Quince	13.13	9.17	6.39	58.61	6.57
Raspberry	10.53	11.61	5.16	59.85	8.82
Strawberry	8.00	15.28	3.99	61.01	10.93
Youngberry	10.00	12.22	4.92	60.09	9.25

[1]USDA standards of identity for jellies (ratio of 45 wt units of standard fruit juice to 55 wt units sugar concentrated to yield a 65°Brix (% sugar) finished jelly.
[2]Formu1ation for approximately 100 units (kg or 1bs) of finished jelly. The weight would theoretically be increased by 1.54 x weight of pectin and acid supplements used.
[3]The USDA has established standards which define the percent of naturally occurring fruit sugars in many fruit juices.
[4]Exc1udes water contained in the sugar source used, if any.
[5]Water from the standard single strength juice in excess of the 35 wt units needed in a finished jelly. More water must be removed if a substandard juice is used or if the sugar, pectin or other ingredients contain water. Less water is removed if the juice is concentrated or above standard.

Citric acid is a natural fruit acid commonly extracted from lemons. Adding the citric acid at the end of the boiling period gives better control of the pH and minimizes pregelling of the batch and hydrolysis of the pectin. Different juices will require different amounts of additional acid, depending upon the original acidity of the juice and the buffering capacity of the juice. The pH may be adjusted to attain optimum flavor, to control or modify the rate of setting, and to modify the degree of sugar inversion.

Packaging

Jelly should be hermetically sealed in glass containers. Containers filled scalding hot (in excess of 180°F) need not be pasteurized as the hot jelly itself will sterilize the container. The jars should be filled to at least 90 percent full, leaving not more than one-half inch space at the top of the jar (headspace). The scalded lids should be loosely placed on the containers immediately following filling, then tightened firmly within two to three minutes. This allows time for exhausting of air from the headspace. The steam in the headspace condenses when the jelly cools, creating a vacuum seal on the jar. Capping with superheated steam injection often is used in commercial production to attain a hermetic seal. A post-capping sterilization treatment is unnecessary when the containers are hot filled.

Some jellies foam during boiling and filling, forming a layer of bubbles on the surface of the jar of hot jelly. The jelly should be quickly skimmed while in the kettle just prior to pouring. If the jelly can be drawn from the bottom of the kettle, clear jelly can be filled into the jars without skimming.

Causes for Jelly Making Failure

Insufficient acid

The most common cause for failure of jellies to gel is insufficient acid. Commercial jelly makers should read the pH of each batch when it is ready to pour into containers and acidify with citric acid if the jelly is deficient. Quality control pH meters are available from most scientific supply companies, and are priced from $150 to $1,000.

Prolonged boiling

Excessive boiling results in the hydrolysis of the pectin and in the formulation of a syrupy caramelized mass devoid of natural fruit flavors. The juice and sugar should be concentrated to the gel point as rapidly as possible to avoid hydrolysis of pectin. The solution should be tested with a refractometer as it nears the 65°Brix end-point.

Crystals

At ordinary temperatures jelly may develop sugar crystals if the concentration of the finished product exceeds 70°Brix. Monitoring the solids of the boiling fruit solution with a refractometer as the end point is approached should eliminate over-concentration and crystallization of sugars.

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