CHAPTER 3

Production and Description

Many different types of sweeteners are available for product development today. It is important to have an understanding of what each of these sweeteners is in order to understand the functions that it will serve in the food system. The production processes for and types of major carbohydrate-based sweeteners are described below.

In This Chapter:

Sucrose-Based Sweeteners

PRODUCTION

Although other plant sources such as sorghum, date, and palm are available, the industrial production of sucrose is based exclusively on sugarcane and sugar beet processing. Sugarcane is a tropical plant, while the sugar beet is grown in cooler climates. Contrary to popular belief, there are no known structural, chemical, or physical differences between the sucrose obtained from sugarcane and that obtained from sugar beets. However, the processing is different. Processing of cane sugar is normally a two-step operation. It starts in raw-sugar processing plants located in tropical or subtropical regions close to the sugarcane fields. The *raw sugar* is then transported to refineries (built near major areas of consumption) and refined into high-purity products. Beet-growing regions are close to major consumption areas; consequently, beet sugar processing and refining are done at the same location.

Sucrose is contained in cane and beet cells. The first processing step (Fig. 3-1) is the extraction of sucrose from these plant tissues. In the cane mills, extraction is done by a series of roller presses, while beet sugar factories use countercurrent extraction with hot water (a diffusion process).

Solutions obtained by these processes have a purity of 84–86% with retained dry solids (RDS) of 14–16% and contain various amounts of impurities from plant tissues. Some of the nonsugar substances can be eliminated by simple mechanical screening, while others must be flocked and separated by settling and filtering. This part of the processing, called "juice purification," is the most sensitive and demanding part of sucrose manufacturing. In some factories, it is done with lime-carbon dioxide juice-purification systems, while in most refineries it is done with the lime-phosphoric acid flotation process. Further improvements in quality are achieved by activated

Raw sugar—Sugar that has not undergone the refining process.

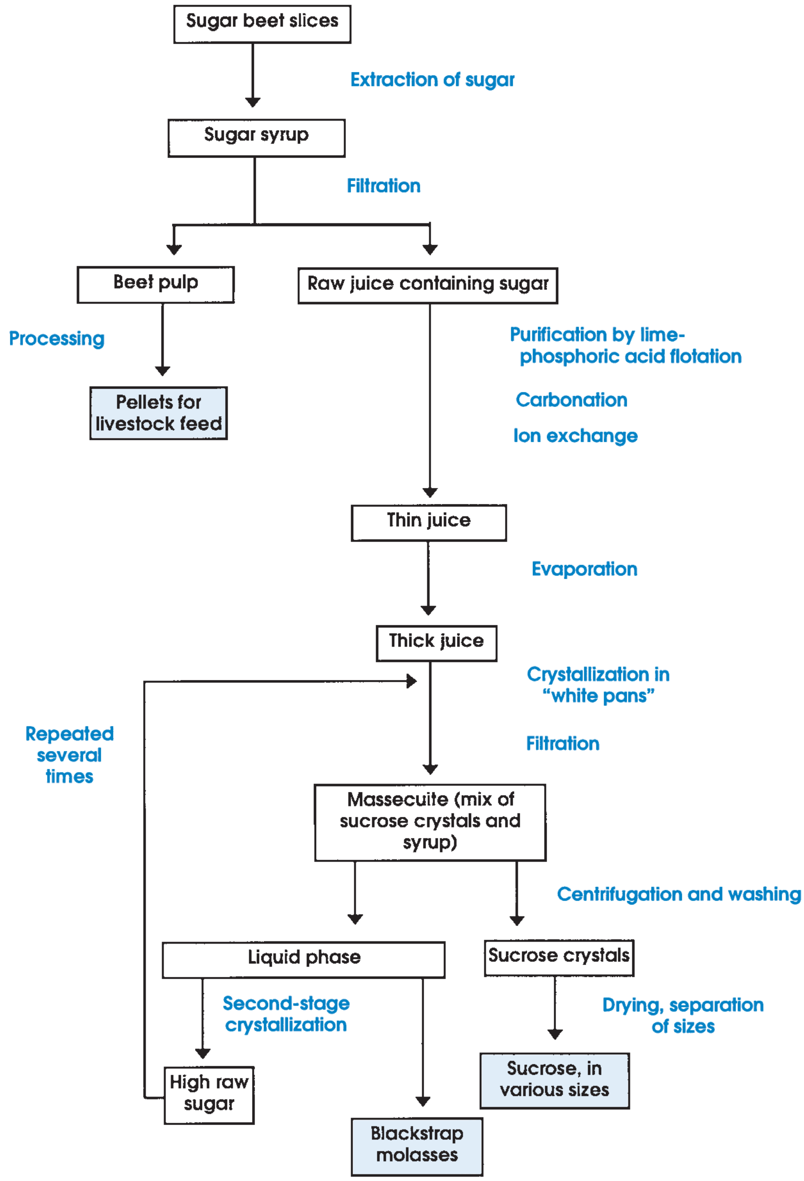

Fig. 3-1. Production process for sucrose.

carbon and ion exchange treatments, which decolorize and demineralize the juice. During this phase, the juice (in both beet and cane plants) has a purity of 91–92% and RDS level of 12–15%.

The next step is evaporation. A large volume of water is evaporated from the juice in multiple-stage evaporators. The goal is to obtain juice with RDS of 65–71%. To achieve this goal, the evaporators must separate 3,000–15,000 tons of water per day (depending on the processing capacity). Multiple-stage evaporation enables modern plants to accomplish this enormous task with high efficiency and economy. The high-density syrup achieved by evaporation is called the "thick juice" (or "standard liquor" if recovery sugar is dissolved in the thick juice).

The thick juice then undergoes crystallization in vacuum pans (also called "white pans"). Here, under controlled conditions (involving, e.g., pressure, boiling temperature, density, purity, and viscosity), the dissolved sucrose is transformed into crystals. The material formed in the vacuum pan is called the *massecuite*. In the massecuite, the sucrose crystals are mixed with a high-density liquid called "mother liquor."

The next step is to separate the crystals from the liquid phase by centrifugation (1,000–2,500 x *g*). The wet sucrose is then dried in a stream of hot air in rotating drums, cooled, classified on vibrating screens, and sent to sugar packaging or bulk storage. The remaining liquid phase is then further processed in second-stage crystallization, which is identical to the first-stage process. The sugar obtained from this stage, which is lower in purity and is called "high raw sugar," is redissolved in water or juice and sent back to the "white sugar" process. The goals of the multiple-stage process are maximum sugar exhaustion from syrups and the production of premium quality sugar. Depending on the particular factory, this multiple-stage crystallization is repeated two to seven times. In principle, the low-purity syrups that result from crystal separation are sent downstream, while the crystals of the various stages are remelted and moved upstream in the production line. Eventually, two products leave the crystallization station: high-purity, crystallized sucrose and the low-purity liquid phase, called "blackstrap *molasses*."

PRODUCT TYPES

Sucrose products manufactured and sold in the United States are generally classified into four categories: granulated sugar, liquid sugars, brown sugars, and specialty products. Some sucrose products are shown in Box 3-1.

Box 3-1. Sucrose Products

High-purity sucrose: From cane refineries and beet sugar plants, 99.90–99.95% purity, 0.02–0.04% moisture content

Brown and soft sugars: From cane refineries and beet sugar plants, 92.00–98.00% purity, 0.4–3.5% moisture content

Raw sugar: From cane raw sugar mills, 96.50–97.50% purity, 0.5–0.7% moisture content

Blackstrap molasses: From cane refineries, 38.00–45.00% purity, 82.0–88.0% retained dry solids

Raw molasses: From beet sugar factories, 56.00–62.00% purity, 82.0–86.0% retained dry solids

Massecuite—A dense mixture of sugar crystals and syrup that is an intermediate product in the manufacture of sugar.

Molasses—A thick, brown, uncrystallized syrup produced during the refining of sucrose.

TABLE 3-1. Selected Properties of Granulated Sugars

Property	Coarse	Sanding	Extra Fine	Fruit	Bakers' Special	Powdered 6X	Powdered 10X
Color, ICU	20–35	20–35	25–50	25–50	25–50	25–50	25–50
Ash, % (max.)	0.015	0.015	0.02	0.03	0.03	0.03	0.03
Moisture, % (max.)	0.04	0.04	0.05	0.05	0.05	0.5	0.5
Starch, %	…	…	…	…	…	2.5–3.5	2.5–3.5

Granulated sugar. Granulated sugar is a pure, crystalline material with more than 99.8% (dry basis) sucrose content. It is produced in a controlled crystallization process in vacuum pans and is classified by the percentage of crystals retained on a particular standard U.S. mesh screen (Table B-1 in Appendix B). Some properties of various types of granulated sugar are shown in Table 3-1.

Liquid sugars. Essentially, liquid sugar is granulated sugar dissolved in pure water. It is produced at minimum concentrations of 67% solids and 99.5% sucrose. The product can be used wherever a dissolved granulated sugar product is needed. All liquid sugars are sold at the highest concentration of solids at which the sugar will remain in solution at 21°C (70°F). Some properties are shown in Table 3-2 and some in Table B-2 in Appendix B.

Brown sugars. Brown sugar is basically a fine-grain, granulated sugar covered with a thin layer of cane syrup from the cane refinery recovery scheme. The sugars are classified according to the processing method: soft brown sugar, coated brown sugar, and free-flowing brown sugar (Table 3-3 and Table B-3 in Appendix B). Brown sugars are used to develop a rich, molasses-type flavor.

Specialty products. Specialty sugars can be defined as sugar products made to meet a specific need, e.g., cube sugar, fondant sugar, cocrystallized sugar, flavored sugar, and agglomerated sugars.

TABLE 3-2. Selected Properties of Liquid Sugars

Property	Liquid Sucrose	Amber Sucrose	Liquid Invert	Total Invert
Solids, %	67.0–67.9	67.0–67.7	76–77	71.5–73.5
Color, ICU	≤35	≤200	≤35	≤40
Ash, %	≤0.04	≤0.15	≤0.06	≤0.09
pH	6.7–8.5	6.5–8.5	4.5–5.5	3.5–4.5

TABLE 3-3. Selected Properties of Brown Sugars

Property	Soft Brown Light	Soft Brown Dark	Coated Brown Light	Coated Brown Dark	Free–Flowing Granulated	Free–Flowing Powdered
Ash, %	1–2	1–2.5	0.3–1	0.3–1	1–2	1–2
Moisture, %	2–3.5	2–3.5	1–2.5	1–2.5	0.4–0.9	0.4–0.9
Color, ICU	3,000–6,000	7,000–11,000	3,000–6,000	7,000–11,000	6,000–8,000	6,000–8,000
Color, reflectance	40–60	25–35	…	…	…	…

Molasses. The beet sugar industry defines molasses as the heavy, viscous liquid separated from the final low-grade massecuite from which no further sugar can be crystallized by the usual methods. In the cane refineries, the same heavy liquid is called “blackstrap molasses.” Another type of molasses, “edible molasses,” is a clear, light brown, 80° Brix syrup of 45–50% purity that is generally sold in bulk for blending. The old-fashioned New Orleans molasses was the by-product of open-kettle boiling. The clarified juice was boiled in an open kettle until sucrose crystals were formed. After the sucrose was separated by centrifugation, the mother liquid was sold as edible molasses. A third type, “high-test molasses,” is a heavy, partially inverted cane syrup. All edible molasses are characterized by dark brown color, distinctive flavor, and high densities (RDS = 85%).

Invert sugar. Invert sugar is produced from sucrose to yield glucose and fructose through the use of the enzyme invertase or by hydrolysis or cation exchange resins. The final product is available as a syrup. Invert sugar is an important raw material in the production of sugar alcohols such as sorbitol and mannitol.

Starch-Based Sweeteners

Many different sweeteners are derived from starch. The starch can come from rice, wheat, oats, and potatoes, but in the United States, the primary source is corn because of its availability and relatively low cost compared with other starch sources. The production methods for the various corn-based sweeteners are fairly similar or at least interrelated.

DEXTROSE-BASED PRODUCTS

Dextrose equivalent (DE) is a measure of the extent of starch hydrolysis. It is determined by measuring the amount of reducing sugars in a sample relative to dextrose. The DE for dextrose is 100, representing 100% hydrolysis. Starch-based sweeteners that are not fully hydrolyzed have a DE of less than 100. The lower the extent of hydrolysis, the lower the DE. Dextrose syrups, which have a high DE (95 and greater), are often referred to as liquid dextrose.

Maltodextrins. The least hydrolyzed starch-based products are maltodextrins. These materials are made by either a one- or two-stage process (Fig. 3-2). In the one-stage process, normally used with waxy corn starch, a starch slurry containing 30–35% solids (Fig. 3-2, step 1) is treated with an α-amylase, heated in a jet cooker (step 2), which produces a very low-DE (0–5) hydrolysate, and held (step 3) until the desired DE is obtained. Enzyme activity is terminated; pH is adjusted to 4.0–5.0; and the hydrolysate is refined by the standard techniques used for corn sweeteners (steps 6–12).

The two-stage process is normally used with regular dent varieties of corn starch. It employs either an acid or an enzyme in a high-

Dextrose equivalent (DE)— A measure of the percentage of glucosidic bonds hydrolyzed. Dextrose has a DE of 100.

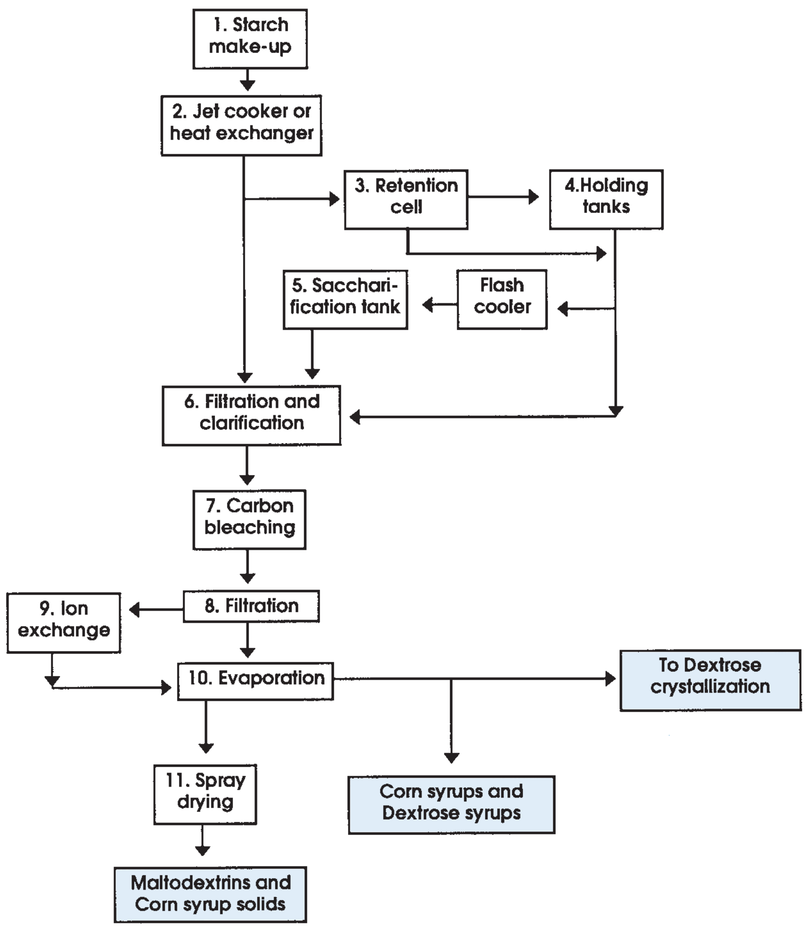

Fig. 3-2. Conversion of starch to maltodextrins, corn syrups, and dextrose.

temperature treatment (above 100°C) through a jet cooker (step 2). The hydrolysate is cooled and then passed through a second stage (step 4) involving enzyme hydrolysis with α-amylase to the desired DE. After the DE is obtained, the hydrolysate is refined as in the one-stage process.

From either of these two processes, maltodextrins are obtained as white, spray-dried solids containing 4–6% moisture. They are soluble in water and yield colorless, very bland solutions. Their characteristics are summarized in Table B-4 in Appendix B. Maltodextrins contain very low levels of dextrose and maltose and are therefore not sweet.

Corn syrups and corn syrup solids. Corn syrups are usually produced by a two-stage process (1). The first step involves the acid hydrolysis of starch to about 42 DE as shown in steps 1–3 of Figure 3-2. If a higher DE is required, the starch is kept in a holding tank (step 4) while a second-stage hydrolysis with enzymes is employed until the desired DE is obtained. The possible acid-enzyme and enzyme-enzyme combinations are endless, and the precise combination used depends upon the desired properties and composition of a syrup for a particular application. Finished syrups are produced by standard refining and evaporation procedures (steps 6–10).

The most common corn syrups have DE levels of 42 and 62, although syrups in the 24- to 82-DE range have been produced. In addition, specialty brewers' syrups are produced for specialty applications. Corn syrups are colorless, viscous liquids containing 74–84% solids. Characteristics of the standard syrups are summarized in Table B-5 in Appendix B.

Corn syrup solids are available at DE levels that range from 20 to 48. The process for manufacturing corn syrup solids depends on the DE level. Products with a higher DE, ranging from 30 to 48, are made from corn syrups that have been further dried and crystallized. Corn syrup solids with a DE of 20–30 are made by a process similar to that

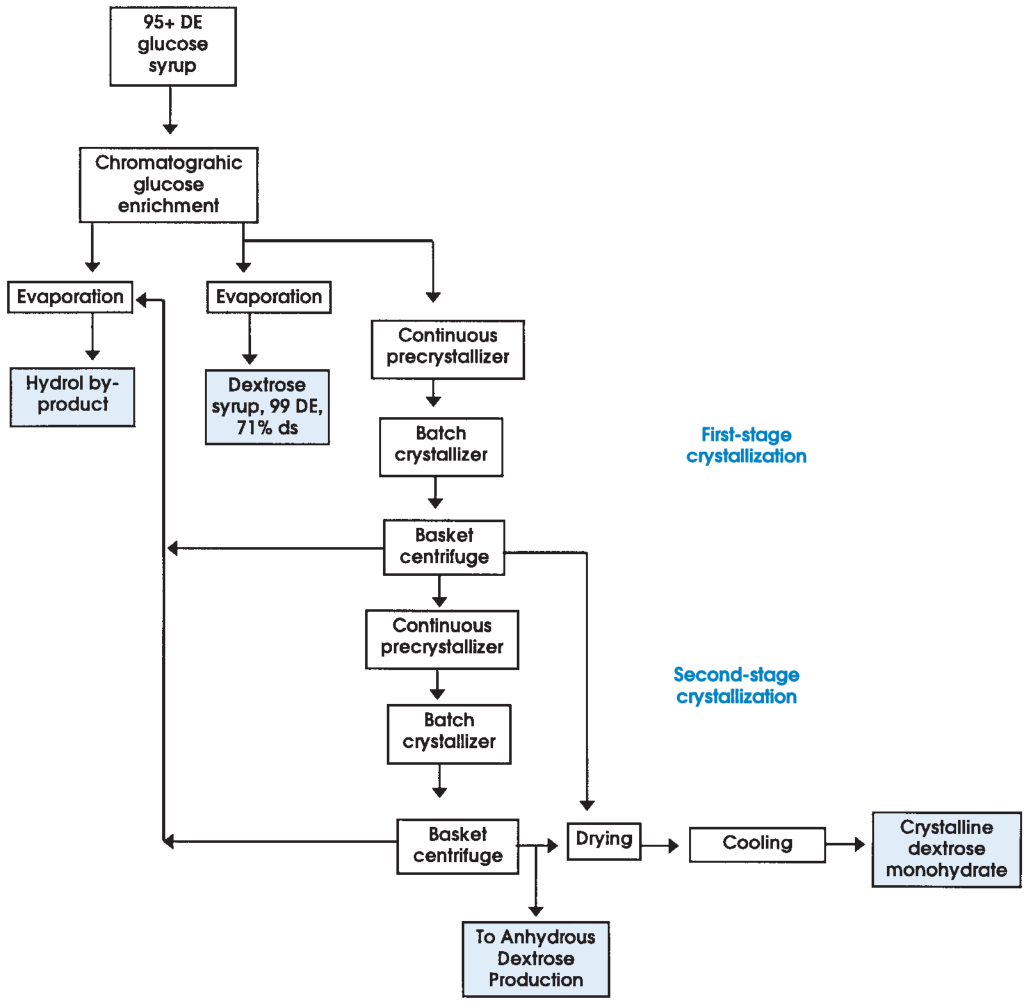

Fig. 3-3. Manufacture of crystalline dextrose. DE = dextrose equivalent.

used to make maltodextrins. Characteristics of corn syrup solids are shown in Table B-5 in Appendix B. All corn syrup solids have sweetness levels similar to those of their corresponding corn syrups. They have an advantage over corn syrups in that they can be used in low-moisture systems or where dry ingredients are required.

Dextrose. Dextrose is the common name for D-glucose, where D-stands for *dextrorotary*. It is the product of the complete hydrolysis of starch by both acid and enzymes, having been treated with α-amylase (Fig. 3-2, step 2) and glucoamylase (step 5). The hydrolysate is first purified and then crystallized to yield dextrose monohydrate (Fig. 3-3). Further drying yields anhydrous dextrose.

Dextrose syrups can be either 95 or 99 DE (Table B-6 in Appendix B). Crystalline products with a DE range of 93–99, a solids range of 91–99%, and pH of 4.5 are available in various granulations.

Dextrorotary—Describing a compound that can cause a plane of polarized light to rotate in a clockwise fashion (to the right). Compounds that cause polarized light to rotate in a counterclockwise direction (to the left) are termed "levorotary."

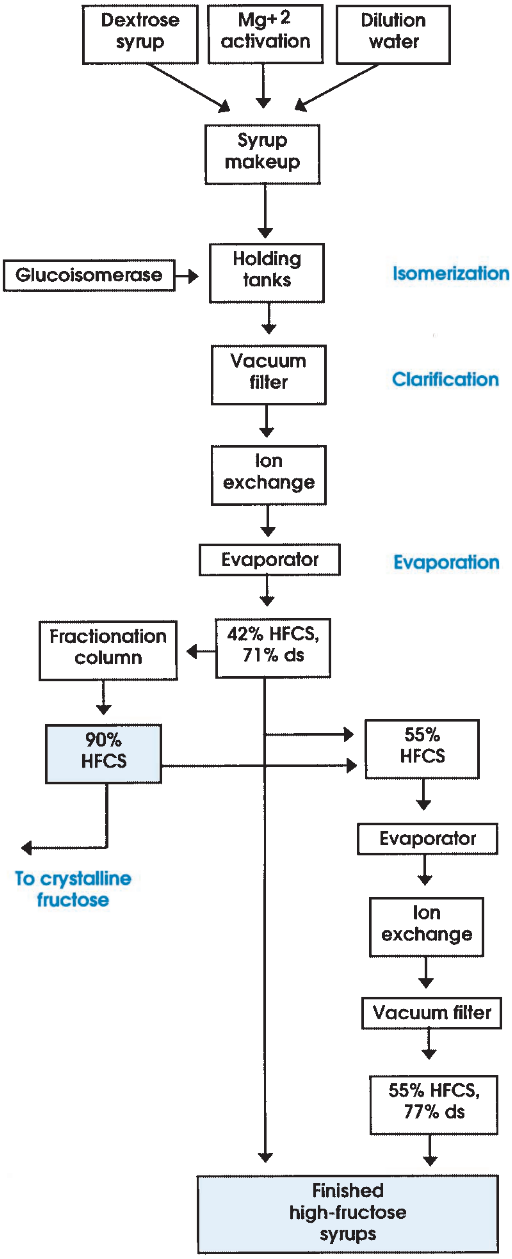

Fig. 3-4. Manufacture of high-fructose corn syrup (HFCS) from glucose syrup.

Hygroscopicity—The ability to attract and retain moisture.

FRUCTOSE-BASED PRODUCTS

High-fructose corn syrup. The various grades of high-fructose corn syrup (HFCS) are produced by the process outlined in Figure 3-4. High-DE (95+) dextrose syrup is first made according to the steps outlined in Figure 3-2. The hydrolysate is then passed over immobilized glucose isomerase, and the glucose is partially converted to fructose. This results in a syrup containing 42% fructose, 53% glucose, and 5% more-complex sugars. This 42% HFCS is passed over specially sized exclusion chromatographic columns, which increases the fructose in the syrup to 90%. The 90% syrup is blended with 42% syrup to give a 55% fructose syrup (55% fructose, 41% glucose, and 5% sugars that are more complex). The 42% fructose syrup is approximately as sweet as sucrose, while the 55% product is 1.2 times as sweet.

All the syrups may then be refined by standard techniques to give finished HFCSs. Part of the 42% syrup is concentrated and sold as 42% HFCS (71% dry substance [ds]). The 55% syrup is also concentrated and sold as 55% HFCS (77% ds) Some of the 90% syrup is used to make crystalline fructose (Fig. 3-5), and some is sold as 90% HFCS. Characteristics of the various types of HFCS are shown in Table 3-4.

Crystalline fructose. The exact process for making crystalline fructose is still somewhat proprietary, since there are few large-scale commercial manufacturers in the United States. However, an outline of the general process for making the product is shown in Figure 3-5. Details of a specific process employing a mixed-alcohol solvent are described in a U.S. patent (2).

In general, the process involves adding a solvent or mixed-solvent system to the 90% fructose syrup originating from the HFCS process. A nonaqueous solvent is apparently needed because of the very high level of *hygroscopicity* associated with fructose and the difficulties in crystallizing fructose from a water solution. This mixture is then evaporated to about 90% solids and fed to the crystallizers. The material is centrifuged, and the fructose crystals are dried, cooled, and packaged.

The physical properties of a crystalline fructose product are shown in Table 3-5. Most fructose is manufactured as the crystalline material, although some is sold as liquid fructose, an 80% solids syrup.

TABLE 3-4. Characteristics of Typical High-Fructose Corn Syrups

Type (% Fructose)	Percent Solids	pH	Composition, %: Glucose	Fructose	Higher DP[a]	Relative Sweetness[b]
42	71–80	4.0	53	42	5	0.9–1.0
55	77	3.5–4.0	41	55	4	1.0–1.2
90	80	4.0	7	90	3	1.4–1.6

[a] Degree of polymerization.
[b] Sweetness relative to sucrose at 1.0.

OTHER STARCH-BASED PRODUCTS

Maltose. Maltose is a disaccharide consisting of two molecules of glucose. Pure maltose is not produced on a commercial scale in the United States. It is usually imported from either France or Japan, where it is manufactured on a large scale and sold in syrup, powder, and crystalline forms in several grades of purity (3).

Maltose is the main component of high-maltose syrups, which are made by treating regular corn syrups or partial starch hydrolysates with β-amylase. Further treatment of these syrups with debranching enzymes (pullulanase and isoamylase) produces syrups containing 70–90% maltose, which is about the upper limit of maltose content. Characteristics of high-maltose corn syrups are shown in Table B-6 in Appendix B. Production of pure maltose can be accomplished with various fractionation techniques. Presently, cation-exchange chromatography and ultrafiltration are used to make high-purity maltose syrups on an industrial scale.

Maltose has many of the characteristics of sucrose but is only 30–40% as sweet. High-maltose syrups and crystalline maltose offer good stability, reduced color formation, and low hydroscopicity, all useful properties in some applications.

Crystalline maltose has two anomeric configurations, α and β. In solution, they equilibrate at an α-β ratio of 42:58. Slow crystallization from water yields three crystalline forms: β-maltose monohydrate, anhydrous α-maltose, and a complex containing both.

Malt syrup. Several malt products are used by the brewing industry in making beers and ales. The main products of interest as sweeteners are malt extract, malt syrup, and rice syrup. Malt extract is made from germinated barley (i.e., malt), which is allowed to become partially hydrolyzed in an aqueous system. It is then extracted, filtered, purified, and evaporated to give a 78–80% solids syrup.

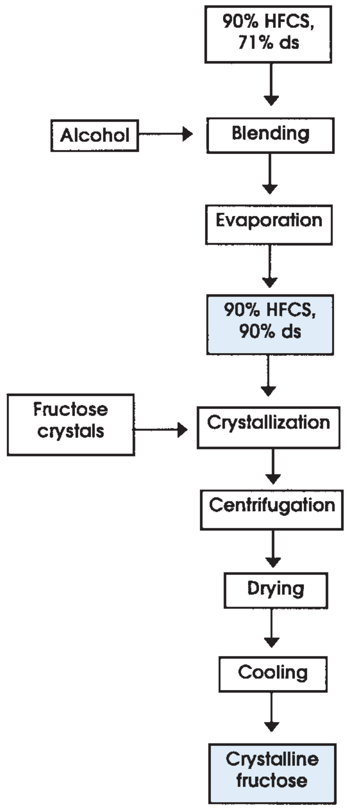

Fig. 3-5. Manufacture of crystalline fructose. HFCS = high-fructose corn syrup.

TABLE 3-5. Typical Properties of Crystalline Fructose

Property	
Molecular formula	$C_6H_{12}O_6$
Molecular weight	180.16
Chemical name	β-D-Fructopyranose
Melting point, °C	102–105
Caloric value, Kcal/g	3.8
Solubility, g/100 g	400
Relative sweetness[a]	1.2–1.6
Composition	
Fructose, %	99.5
Glucose, %	0.5
Moisture, %	0.05
Ash, %	0.1

[a] Relative to sucrose at 1.0.

Malt syrup is made by combining malt and corn grits (or meal), partially hydrolyzing the mixture, and then extracting, purifying, and evaporating the resulting syrup. Rice syrup is available from some of the manufacturers of malt products. It is made by combining malt with rice grits or flour by the same processing steps as used for malt syrup. Malt extract is basically barley syrup, malt syrup is barley and corn syrup, and rice syrup is barley and rice syrup.

The various products are termed either diastatic or nondiastatic, based on the enzyme activity. Diastatic products contain various levels of residual enzyme activity. The properties of several nondiastatic products are summarized in Table 3-6.

TABLE 3-6. Typical Properties of Nondiastatic Malt Extracts and Syrups[a]

	Extracts (all barley)		Malt Syrups (barley/corn)	
Property	Light	Dark	Light	Dark
Solids, %	78–80	78–80	78–80	78–80
Reducing sugars, as maltose, %	53–63	53–63	60–72	60–72
Protein, %	4.5–5.6	4.5–5.6	1.8–3.5	1.8–3.5
pH, at 10% solids	5.0–5.7	5.0–5.7	5.0–5.7	5.0–5.7
Color, Lovibond	100–300	250–425	80–150	225–400

[a] Data from (4).

Others

HONEY AND ARTIFICIAL HONEY

Honey. Honey is the substance made when the nectar and sweet deposits from plants are gathered, modified, and stored in the honeycomb by bees. The unique flavor of each lot of honey is attributable to the floral source from which the honey bees gathered the nectar—there are more than 300 such sources in the United States.

Honey is the only natural sweetener that needs no additional refining or processing to be utilized. However, honey is commonly heated to destroy yeasts and delay crystallization and is usually filtered or strained to remove extraneous material (Fig. 3-6). Honey is generally sold as a liquid but is also available in a thicker, opaque form known as cremed, spun, whipped, or churned honey. This form

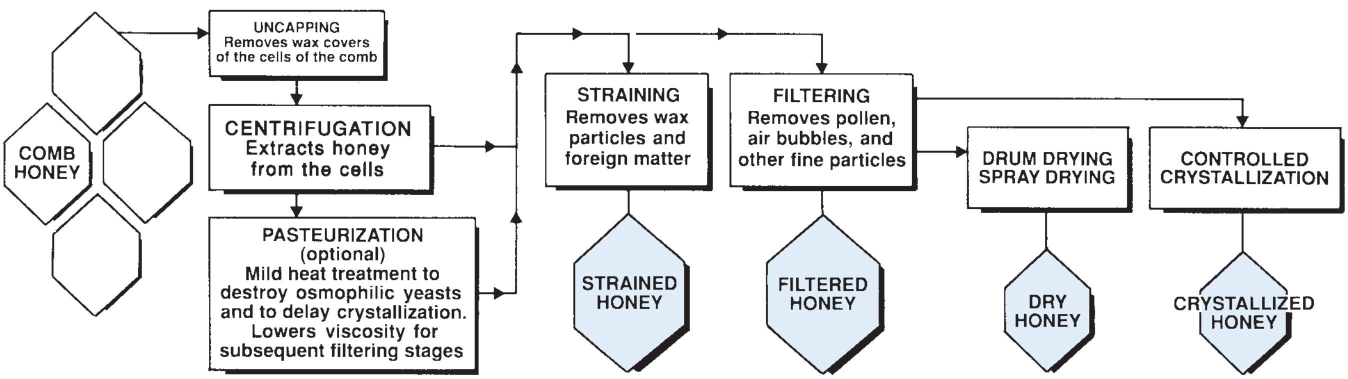

Fig. 3-6. Processing of honey. (Courtesy of the National Honey Board)

is made by closely controlling the moisture of the liquid honey, then heating it, seeding it with fine crystals, and whipping it. Dried honey is also commercially available.

Honey is an invert sugar composed mainly of fructose and glucose (Table 3-7) as well as small amounts of vitamins and minerals (Table B-7 in Appendix B). Its color ranges from nearly colorless to dark brown, varying with the mineral content. As a general rule, lighter-colored honey is milder in taste and darker-colored honey is stronger.

Honey is graded using a point system set up by the U.S. Department of Agriculture based on water content, flavor and aroma, and absence of defects. U.S. Grade A (90 points) and U.S. Grade B (80 points) contain <18.6% water; U.S. Grade C (70 points) contains ≥20% water.

TABLE 3-7. Average Composition of Honey[a,b]

Component	Percent
Moisture	17.1
Fructose	38.5
Glucose	31.0
Maltose	7.2
Sucrose	1.5
Higher sugars	4.2
Protein	0.5
Acids	0.6

[a] pH 3.9.
[b] Data from (5).

Artificial honey. Artificial honey is essentially invert sugar syrup or corn syrups that have been altered in appearance and flavor to mimic natural honey. It is composed of invert sugar, sucrose, water, ash, and a crystallization inhibitor, which is usually a hydrolyzed starch.

LACTOSE

During recent years, there has been considerable interest in the production (6) and utilization of lactose as a by-product from whey, which itself is a by-product of cheese manufacturing. For every pound of cheese produced, approximately 9 lb of whey is also obtained. Whey contains about 6% solids, of which 4.7% is lactose, 0.7% is protein, and 0.5% is minerals. Recently, methods have been developed for removing protein from whey by ultrafiltration. These deproteined whey solutions are ideal sources for the isolation of lactose. After the minerals are removed by ion exchange chromatography, the lactose is then recovered by crystallization from a concentrated solution, followed by centrifugation and drying.

The most common form of lactose is the α-monohydrate, produced from supersaturated solution below 93.5°C. The β-anhydride form is also available but in lesser amounts. It is produced by crystallization above 93.5°C. The α-anhydride form may be produced by drying the hydrate under vacuum at 65°C. When placed into solution, all forms equilibrate to a β-α ratio of 62.25:37.75 at 0°C. The most common uses are in infant formulas, confectionery, and pharmaceuticals. Characteristics of lactose are shown in Table 3-8.

TABLE 3-8. Characteristics of Food/USP Grade Lactose[a]

Component	
Composition	
Lactose, %	≥98.0, db
Protein, %	0.1
Fat, %	0.0
Ash, %	0.1–0.3
Moisture, %	4.0–5.5
pH	4.5–7.5
Color	White to pale yellow
Flavor	Slightly sweet
Microbiology	
Total plate count	<30,000 cfu/g[b]
Coliforms	<10/g
Salmonella	Negative
Listeria	Negative
Coagulase-positive *Staphylococci*	Negative

[a] Data from (7).
[b] Colony-forming units per gram.

TABLE 3-9. Typical Composition of Maple Sugar[a]

Component	Percent
Water	34.0
Sucrose	58–66
Hexoses[b]	0–8
Malic acid	0.09
Citric acid	0.01
Soluble ash	0.3–0.8
Insoluble ash	0.08–0.7

[a] Data from (8).
[b] Including glucose and fructose.

MAPLE SYRUP AND MAPLE SUGAR

Only two of the maple trees native to North America, the sugar maple and the black maple, are important in maple syrup production; their sap is sweeter than that of other species. The region of syrup production extends from Maine west to Minnesota and from Quebec south to Indiana and West Virginia.

Maple syrup is mainly syrup made by the evaporation of maple sap, which is accomplished in flat, open pans to a concentration of 65.5% solids. Special thermometers relate temperature to concentration; e.g., a 65.5% solution boils at 104°C (219°F).

As it comes from the tree, maple sap contains about 2% solids, of which 97% is sucrose. The rest is organic acids, ash, protein, quebrachitol, polysaccharides, and a trace amount of lignin. However, this composition changes during evaporation, producing some glucose and fructose on inversion at low pH plus small amounts of other saccharides.

TABLE 3-10. Grades of Maple Syrup[a]

Grade	Color	Color Index[b]
U.S. AA Fancy	Light amber or lighter	0–0.51
U.S. A	Medium amber or lighter	0.51–0.897
U.S. B	Dark amber or lighter	0.897–1.455
U.S. Unclassified	Darker than dark amber	>1.455

[a] Data from (8).
[b] Color index = $A \times 86.3/\text{cm} = A_{450}(86.3/bc)$, where A = absorbance, A_{450} = absorbance at 450 nm, b = depth of solution (cm), and c = concentration (g of sucrose per 100 ml).

Evaporation times and temperatures must be carefully controlled, since color and flavorants increase as the result of processing and it is the trace materials that give the syrup its characteristic maple flavor. One group of flavorants contains ligneous materials from the sap. A second group is formed by caramelization of the sugars. The composition of a typical maple syrup is shown in Table 3-9. Maple syrup is also graded (Table 3-10).

Maple sugar is a solid product made by further evaporation of the syrup to about 92% solids.

FRUIT-DERIVED SWEETENERS

Some relatively new carbohydrate-based sweeteners, used in food formulations, are made from various fruit and/or fruit juice concentrates or from grain-based syrups such as rice syrup. These fruit-derived sweeteners have good *humectancy* and low water activity and are also useful as fat replacers. They can improve shelf life and can function as emulsifiers and antioxidants because of the presence of fruit components such as pectins. They are often used in "natural" foods because they are not labeled as "sugar," which can have a negative connotation in the natural foods market.

Humectancy—The property of retaining moisture.

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