13 Sugar and Sugar-Free Panned Confections

13.1 Introduction

Sugar-panned candies may be broadly defined as candies where a sugar shell has been applied to a center (sometimes called comfit or dragees) through sequential addition of syrup as the piece is tumbling in a revolving pan. Sugar shells may have either a hard, brittle texture (hard panning) or a soft, easily broken texture (soft panning), with the shell characteristics related to the syrup composition and the nature of sugar crystallization as the shell material is applied. Although the term sugar is often used here, sugar-free components are also panned as well. Specific details related to sugar-free applications are noted as pertinent. A third type of panning involves application of a chocolate coating; chocolate panning is covered in Chapter 17. Preparation of centers is generally described in the chapters related to that particular candy category (e.g., jelly candies for jelly bean centers).

Sugar panning reputedly has its origins in seventeenth century France, when nut pieces were coated in sugar by rolling them in a pan of molten sugar, although there is evidence that seeds or thin strips of cinnamon were coated in sugar in a process similar to panning well before the seventeenth century. The nuts (or seeds, etc.) were rolled back and forth through the hot sugar syrup as the pan, suspended over a fire for heating, was manually tilted back and forth. A crystallized sugar shell slowly built up as the water evaporated from the syrup layer. Development of the rotating pan allowed better control of tumbling of the centers and enhanced the panning process by allowing one operator to control multiple pans. More recently, many panning operations have been automated on a large scale, with syrup addition and air handling being computer controlled.

Sugar panned candies may be distinguished by the nature of the sugar shell that is applied to the center, with the main distinction between hard and soft-panned candies being the texture of the sugar shell. In soft panning, the relatively larger crystals that make up the sugar shell, as shown schematically in Figure 13.1, provide little resistance to breakage during consumption. The shell fractures easily, with little force needed. Examples of soft-panned candies are jelly beans and fruit sours. In hard panning, the shell is highly crystalline with many small crystals fused together, as shown schematically in Figure 13.2. Thus, it takes on a hard, brittle character and requires relatively more force applied by the teeth to break through the shell. This hard, brittle shell often provides a textural contrast with the candy piece inside (e.g., chocolate). This hard sugar shell is one way to prevent chocolate from melting in your hand. Examples of hard panned candies are sugar-coated chocolate lentils, nuts (e.g., Jordan almonds), licorice bits, and gum balls. Some panned candies have mixed sugar shells, with a soft-panned layer(s) applied first, prior to finishing with hard-panned sugar shells. With limited exceptions, mixing soft and hard-panned shells is typically a convenient way to

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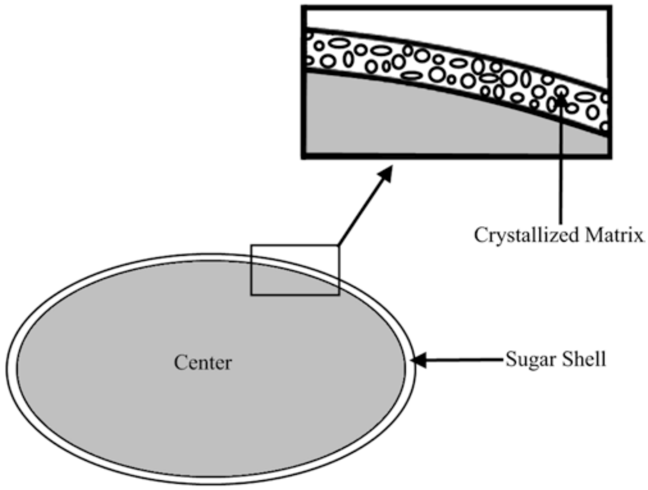

Figure 13.1 Schematic cross section of soft panned sugar shell

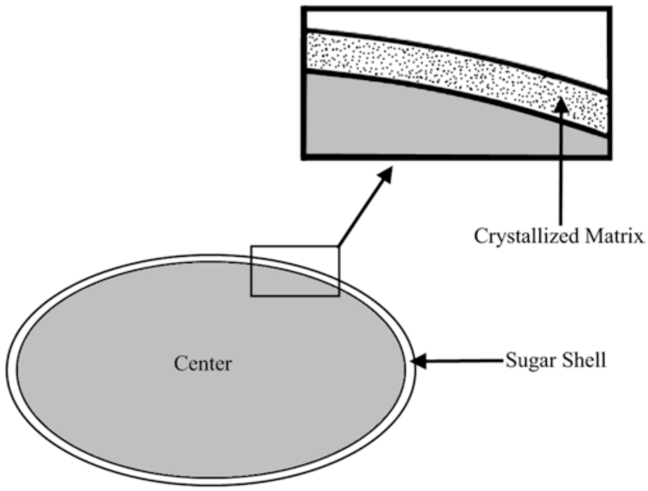

Figure 13.2 Schematic cross section of a hard-panned sugar shell

speed the hard panning process. However, the risk is that the hard, brittle texture desired in a hard-panned candy may be compromised with too much of a soft-shell; thus, this approach of speeding the hard panning process must be used with caution.

Another way to distinguish between soft and hard panning is from a crystallization standpoint. Hard panning refers to the process of creating a thin layer of crystallizing syrup and allowing that syrup to crystallize. Soft panning is often considered to be noncrystallizing, where the engrossing syrup is simply the glue that holds the sugar particles added to complete the coating layer.

To make panned candies, sequential layers of sugar syrup are applied to the centers as they tumble in a revolving pan or drum. In hard panning, a supersaturated sugar syrup is applied to the center and allowed to crystallize as it dries in the pan, leaving a hard and brittle layer composed of numerous small crystals. Sequential syrup applications followed by a drying period allow the shell to build up to the desired thickness. Depending on the desired shell thickness, 30 or more sequential applications may be needed to build the shell. In soft panning, a noncrystallizing sugar syrup is applied to the center followed by addition of sugar powders. The shell is built up by packing dry powders into the noncrystallizing syrup to make a firm coating. The sequential application of sugar syrup and powdered sugar to the center is continued until the shell has reached the intended weight or thickness for the desired candy piece. Usually, four to ten sequential applications are sufficient to build the desired shell thickness.

After the shell has completely solidified and moisture has equilibrated between the shell and the center, the panned candy is polished and glazed to give an attractive, shiny appearance. For soft-panned candies, there is usually a smoothing step, with low solids concentration, to dissolve any sugar powders prior to polishing. To apply the polish, the pieces are tumbled, generally in the same pan, as polishes and waxes are added. The polish material is allowed to dry or solidify while tumbling to give a shiny appearance and to protect the shell from environmental conditions.

The sugar shell and polish/glaze layer provide some protection from external conditions, giving panned goods an exceptionally long shelf life. A hard panned candy, in particular, may have shelf life well over a year, with little change in product quality if stored in good conditions. However, changes in the center characteristics may still take place over time, particularly in soft-panned candies where water migration takes place, albeit at a reduced rate. Hardening of jelly centers over time due to moisture loss through the sugar shell remains the primary cause for the end of shelf life for soft-panned candies, although the rate of hardening is much reduced by the sugar shell (as compared to the jelly candy by itself, without the shell).

13.2 Formulations and Ingredients

Panned candies encompass a very wide range of confections; however, the common theme is that they are coated with either a soft or hard sugar shell. This coating gives a distinct texture to these candies and makes them uniquely different from any other candy. Typically, a panned candy center, whether soft or hard panned, is coated with three distinct layers (see Figure 13.3). First, a pre-coating layer is applied to the center to help ensure good adhesion of the sugar shell. This is particularly important when the center contains fats since a sugar shell applied directly to something like nuts or chocolate centers does not readily adhere. The second layer is the sugar shell itself, which is usually the largest/thickest of the three layers. The final layer applied to the surface of the sugar shell is the polish/glaze layer.

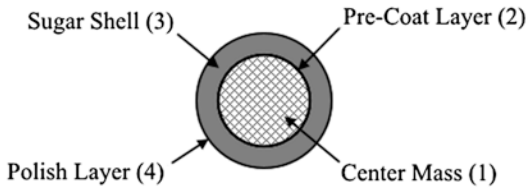

Figure 13.3 General layers found in sugar-panned candies

Table 13.1 Examples of centers used for panned candies

Hard	Soft
Chocolate	Jelly beans/eggs
Nuts	Jelly fruit sours
Grains of sugar	Jelly rods
Gum (balls or dragees)	Caramels
Licorice	Cinnamon centers
Compressed tablet	Baked bean candies
	Marshmallow eggs

13.2.1 Centers

Almost any type of center can be used for panning as long as it can be adequately tumbled in a revolving pan. Table 13.1 gives numerous examples of types of centers that have been used in soft and hard sugar panning, although this list is by no means complete. The list of centers that have been (or can be) panned is quite extensive although not all panned centers are marketed commercially.

To be a candidate for panning, a center must have certain qualities. The center must neither be too heavy nor too light. Either extreme inhibits tumbling ability in the revolving pan and impedes coating of the piece with the sugar shell. It is the force applied during tumbling that provides proper coating; if those forces are too high or too low, problems arise during application of the sugar shell. Size and density of the center are critical to getting a good, uniform coating – it is desirable to have centers that are all the same size and weight (density) so that no segregation occurs during tumbling. Also, the center must be sufficiently robust to stand up to the forces of tumbling without breaking apart or causing excessive dust. This is particularly true in large capacity pans/drums where the tumbling forces can be quite substantial. Brittle centers with sharp edges, for example, are very difficult to pan.

The shape of the center also affects its ability to be sugar coated. Spherical shapes are the easiest to work with since the tumbling forces are applied uniformly over the entire surface, tending to uniformly smooth out the sugar shell. Centers with sharp corners are particularly difficult to coat since the sugar syrup does not build up at the edge. Uneven or ridged centers may result in an unsightly shell. Also, centers with flat surfaces are difficult to pan without sticking together. The large surfaces wetted by the sugar syrup tend to stick together and are nearly impossible to break apart with the tumbling action.

13.2.2 Pre-coat Material

To ensure that the sugar shell adheres uniformly to the center, it is sometimes necessary to apply a pre-coating layer on the center. For example, the lipid surface of a nut or chocolate lentil does not provide good adhesion for aqueous-based sugar syrup. Thus, nuts and chocolate centers are typically pre-coated with a material that serves to bridge the oil and water phases prior to sugar panning to make sure that the sugar shells remains attached to the center. The pre-coat also acts as an oil barrier in this case. The pre-coat layer may also act as a water barrier in cases where water from the engrossing syrup may damage the center (i.e., certain tablets and gums).

Besides enhancing adhesion of the sugar shell and serving as a water barrier, pre-coating also serves to fill in depressions or rough spots in centers to make a smoother surface. It can also enhance the strength of easily deformed centers by providing a more rigid structure. Finally, a pre-coating layer can help improve flexibility of the center by acting as a sort of "shock absorber", thereby minimizing chipping and cracking of a hard sugar shell.

The nature of the pre-coat material depends on the type of center and shell being applied. Jelly centers for soft panning are typically sanded with fine sugar crystals to help adhesion of the engrossing syrup (as well as to prevent the centers from sticking together prior to panning). Coating of centers for sugar-panned candies generally means application of a thin layer of gum (e.g., gum arabic), protein (e.g., gelatin), or long-chain carbohydrates (i.e., dextrin, low DE maltodextrin or modified starches). Aqueous preparations of these materials can be applied directly to the center in the initial stage of panning and allow adhesion of the sugar shell during the subsequent build-up of the shell. These layers may be dried by addition of starch or powdered sugar. Flavor and acid may sometimes be added at this point as well.

13.2.3 Sugar Shell

The nature of the shell material applied during panning is quite different for hard and soft sugar panning. In hard panning, sugar crystals nucleate directly from the supersaturated sugar syrup as each layer is allowed to dry or seeded from the sugar crystal dust that forms as the previous layer dries. Thus, crystallizing sugars are used in the engrossing syrups for hard panning. In soft panning, the sugar syrup acts simply as a glue to hold the sugar crystals added during the dry charge steps, without substantial crystallization.

13.2.3.1 Soft Panning

In soft panning, the sugar syrup acts essentially as a binder to hold together the crystal powder added during the dry charge stages. As such, the engrossing syrup applied to the centers in soft panning is often considered to be noncrystallizing, although in reality a small amount of sugar may crystallize from the solution particularly as temperature or moisture content changes during shell application and curing.

Typically, engrossing syrup for soft panning is a mixture of sucrose and glucose syrup, often at a ratio of about 1:1, on a solids basis, to minimize sucrose crystallization. Either 43 or 63 DE glucose syrup can be used although shell texture will be slightly softer with higher DE. A slightly higher ratio of sucrose to glucose syrup leads to a slightly harder sugar shell since some of the sugar in the syrup crystallizes onto the dry powder charge and leads to bridging of crystals in the shell. Engrossing syrup can be made entirely from glucose syrup with no risk of sucrose crystallization, giving a very soft texture; however, glucose syrup typically needs to be diluted with water (to as low as 65% solids content) to reduce viscosity to a suitable value for application. Specialty syrups with higher levels of dextrose or maltose may also be used. Engrossing syrup concentration is typically between 70% and 78%, with higher concentrations preferred as long as the viscosity of the syrup is appropriate for good coverage. Temperature of application generally falls between 35 and 71 °C (95 and 160 °F), depending on the heat sensitivity of the center and the engrossing syrup viscosity. Higher temperature application generally leads to firmer or crunchier shells as more sugar crystallizes from solution when the syrup cools to room temperature after completion of panning.

The dry powder charge added after each syrup addition may be either fine granulated sugar, Baker's special confectioner's sugar or powdered sugar, with addition typically in decreasing order of particle size. Larger particulate powders (extra fine granular, etc.) are added in the early stages to help build up the shell more quickly. Finer powders (6× and 10× confectioner's sugar) are added last to ensure the smoothest product finish.

Soft sugar shells may be made from dextrose or from sugar-free materials, although the availability of fine-powdered polyols may limit the sweetener choice. Generally, the same principles apply to process dextrose or sugar-free shells: the engrossing syrup should be mostly noncrystallizing and the powder charge should be as fine as possible. For dextrose panning, the engrossing syrup is often comprised of either high fructose or high maltose glucose syrup to minimize excess dextrose crystallization upon addition of the powder charge. Sugar-free, soft panned candies are often made from maltitol syrups packed with either crystalline sorbitol, xylitol or isomalt powders. Addition of a high intensity sweetener to the engrossing syrup may be required for sugar-free coatings. More information regarding soft panning with sugar alcohols can be found in Boutin (1992).

13.2.3.2 Hard Panning

Hard panned shells most often consist of crystalline sucrose, dextrose or sugar alcohols (i.e., sorbitol, xylitol, isomalt, maltitol, etc.). The key factors for the sugar syrup are the viscosity and supersaturation of the syrup as it is applied to the center, as well as the crystallization rate of the sugar. Viscosity of the engrossing syrup should be less than about 200 cP to ensure proper coating. However, too low an engrossing syrup viscosity usually means elevated water content, which is undesirable since longer cycle times are required to remove that excess water and problems with controlling crystallization may arise.

Due to the cyclic nature of hard panning (sequential syrup application followed by drying and crystallization), the syrup must crystallize quickly after application. Primarily, this means that it must have a high supersaturation and high purity. The solubility of the sugar must be appropriate so that it is sufficiently supersaturated (see Sections 2.8 and 2.10) at the conditions of application in the pan without crystallizing prior to application. Note that sucrose-based engrossing syrups should be completely free of crystals. The presence of sucrose crystals in the syrup during panning causes the sugar shell to be uneven. Interestingly, in dextrose-based panning, seed crystals present in the engrossing syrup do not cause problems with shell appearance.

Proper choice of temperature and concentration of the engrossing syrup is required. For sucrose syrups, concentrations of 67–72% are often used, depending on application temperature, which may vary between 18 and 66 °C (65 and 150 °F). For heat-sensitive centers (e.g., chocolate), lower temperatures, 18–27 °C (65–80 °F), are needed to prevent melting. Deformation of gum and chew/taffy centers may occur if application temperatures are above about 38 °C (100 °F). Centers that are not heat sensitive (e.g., jawbreakers) can be panned at temperatures of up about 66 °C (150 °F).

Since sucrose solubility at room temperature is only 67% (Section 2.8), lower engrossing temperatures require lower concentrations to prevent premature crystallization (and to control viscosity). Higher concentrations (75–77%) can be used with hotter syrup application temperatures, as long as sucrose inversion does not occur. Towards the end of shell build-up, when developing a smooth shell is most critical, even lower syrup concentrations are often used. The solids concentration of smoothing syrups is usually less than 67% and perhaps even as low as 55–60% for the final applications to ensure a smooth surface. Smoothing syrups are also added close to room temperature to prevent dissolution and recrystallization of previous layers.

Furthermore, the presence of any impurities, like glucose syrup in a sucrose solution or mannitol in a sorbitol solution, retard crystallization and slow down the panning process. Even excessive inversion of sucrose due to long hold times, low pH or high hold temperatures can slow panning cycles. Thus, the engrossing syrup for hard panning typically has minimal impurities or doctoring agents so as not to inhibit crystallization. Having said that, pan operators sometimes add low levels of certain ingredients to moderate the properties of the sugar shell in hard panning. For example, 1% or 2% dextrose syrup or 0.5–1% gum arabic may be used to make a slightly more pliable hard sugar shell, which may be useful for preventing cracking or coating a center with a sharp edge.

Dextrose and polyol hard panning generally follow the same principles as sucrose panning, although some differences are noted based on the differences in solubility, viscosity and crystallization propensity of each sweetener. Dextrose hard panning has been practiced for several decades with little problem. In fact, in some ways, dextrose hard panning is easier than sucrose hard panning because of the higher solubility of dextrose at elevated temperatures and the lower viscosity of glucose syrups. Higher concentration engrossing syrups can be used in dextrose panning while still retaining the desired syrup viscosity. Crystallization of dextrose under these conditions is sufficiently rapid to promote a hard sugar shell. The dextrose shell is less brittle than the sucrose shell, primarily because of the difference in crystalline network structure.

Various polyols can be used for hard panning, including xylitol, sorbitol and isomalt. However, conditions of use for each polyol change slightly depending on solubility concentration and viscosity. Newer technologies use suspensions to accelerate/facilitate faster crystallization. Boutin (1992) also discusses hard panning with various polyols.

13.2.4 Colors

Either the soluble or lake forms of colors may be used in sugar-panned candy shells. Dyes tend to give brighter colors than lakes but are more likely to bleed, especially if moisture content of the shell is not completely equilibrated. The advantage of using lakes is that any moisture migration within the shell will be less likely to cause color changes (e.g., mottled appearance) than when dyes are used. Lakes also provide more hiding power since they are opaque. In some sugar-panned products, particularly hard-panned candies, titanium dioxide is used in early layers of the shell to provide a richer color. While titanium dioxide helps to provide an excellent finished color, it has become less popular with consumers. There are now compounds based on starches and other materials that can be used as a replacement for titanium dioxide. In hot panning processes, a heat sensitive color must be chosen to prevent fading.

"Natural" (exempt from certification) colors have seen increasing use in recent years. They are available in a variety of forms. Their usage rate, vibrancy and sensitivity to pH may be different than FD & C dyes and lakes. They are frequently heat sensitive and often possess distinct flavors (e.g., red beet). Most exempt colors are dyes and thus, are prone to moisture migration. The addition of rice flour to the color has proven successful and beneficial in improving color intensity and opacity. The exempt from certification colors are generally made from the following materials:

Reds: carmine, iron oxide, anthocyanins;
Oranges: β-carotene, paprika;
Yellows: turmeric, riboflavin, β−carotene;
Blues: anthocyanins, spirulina;
Greens: mixtures of blues and yellows;
Violets: anthocyanins, carmine, mixture of blues and reds;
Blacks: vegetable carbon, iron oxide, caramel;
Whites: titanium dioxide, opacifying agents.

Colors are generally added throughout the soft panning process, but typically only constitute the last 5–15 coats for hard panned candies. Prior to addition of the color layer in hard panning, the surface should be completely smooth. An uneven shell surface will result in uneven thickness of the color layer and thus, an uneven appearance.

13.2.5 Flavors

Flavors are occasionally used in hard-panned shells and are typically added in the shell of soft-panned candies, particularly in products like jelly beans. Sometimes the carrier used to deliver flavors may cause problems in the panning process. For example, the propylene glycol present in certain flavors may hold moisture (as a humectant) in the shell of a soft-panned candy, which can lead to stickiness during storage. Oil-based flavors can be difficult to use in sugar panning because they lubricate the pan, causing the centers to slide instead of tumble, and may separate from the aqueous sugar shell, causing a mottled appearance. With care, however, low levels of oil-based flavors (e.g., mints, certain citrus flavors, etc.) can be used without problems.

13.2.6 Acids

Organic acids (lactic, citric, malic, etc.) can be used in sugar-panned candies to provide tartness. However, problems may arise in sucrose-based shells due to excessive sucrose inversion if liquid acids are added to the engrossing syrup. In hard-panned candies, invert sugar would inhibit crystallization and lead to a softer shell texture. In soft-panned candies, excess invert sugar in the engrossing syrup can cause collapse of the shell, enhance mottling when water-soluble colors are used, and cause glazes to appear dull.

There are several approaches that can be used to prevent problems of inversion due to acid addition to the engrossing syrup. For one, adding the acid to the engrossing syrup at the last possible moment means there will be less time for inversion to occur. Also, using a buffered acid system may moderate the effects of the acid on sucrose inversion. Powdered acids, whether encapsulated or not, can be applied to the center before panning to provide a sour taste without affecting the engrossing operation. Finally, using acid with a sweetener other than sucrose may be a possibility. Dextrose and polyols are not influenced by acids and thus, will not exhibit the same negative effects.

13.2.7 Polish and Glaze

Panned candies are generally polished and glazed to provide a shiny appearance and to protect the piece from subsequent abuse. Although sometimes the terms polish and glaze are used interchangeably (and together), they serve different purposes. A polish provides a glossy surface to a panned confection, whereas a glaze is a sealant that retains the gloss of the polish with a stable film. Since the use of polishes and glazes is often combined, some choose to simply use the term finishing agents to describe polishing and sealing the surface of panned goods. See Section 6.5 for more details.

Numerous finishing agents have been used for panned goods, as listed in Table 13.2. These can be generally categorized as waxes, gums, starches, carbohydrates, proteins or shellacs (confectioners glaze). Although usually applied in liquid form, waxes can also be applied in solid or powdered form. Depending on the nature of the finishing

Table 13.2 Classes of polishing and glazing agents

Solid	Type	Examples	
	Wax	Carnauba, beeswax, candelilla, paraffin, microcrystalline wax	
Liquid	**Type**	**Solvent**	**Examples**
	Gum	Water	Gum arabic, xanthan gum
	Starch	Water	Maltodextrin, starch (wheat, rice, corn, potato, etc.)
	Carbohydrate	Water	Corn syrup, sucrose, pectin
	Wax	Alcohol, vegetable oil, mineral oil	Carnauba, beeswax, etc.
	Shellac	Alcohol	
	Protein	Alcohol	Zein (corn protein)

agent, it may be solublized in water, alcohol or some other solvent (limonene, acetone, mineral oil, vegetable oil, etc.). The choice of solvent is becoming more important as manufacturing facilities must concern themselves with emissions of volatile organic compounds (VOCs).

13.3 Processing

Sugar panning has traditionally been done in revolving batch pans. However, numerous advances in coating technology have changed the nature of the panning room in many confectionery plants. Although it is not uncommon to still see banks of revolving pans, other technologies, like the belt coater and large automated drums, are becoming more and more common in the candy industry. The efficiency, higher production capacity, and automation of these new panning technologies make them an attractive alternative. Newer technologies, such as film coaters from the pharmaceutical industry, are gaining in popularity and have the potential to change the confectionery panning industry.

However, some processes resist automation, requiring careful attention by an experienced operator to ensure a high-quality, consistent product. Perhaps the reason that panning has often been considered more of an art than a science is due to the large number of parameters that influence the panning process. From the engrossing syrup to the polishing procedure, numerous operating parameters and formulation variables can have a significant impact on the quality of sugar-panned goods. Table 13.3 summarizes the various parameters that can impact panning.

13.3.1 Sugar Shell Application

Numerous different types of rotating pans or drums can be used to sugar-pan confections. Although the traditional tulip-shaped pan is still probably the most commonly used, improved and more efficient coating methods are continually being developed. Improved understanding of processes in the coating operation will lead to advances in the field of sugar panning in the next decades.

13.3.1.1 Revolving Pans

The standard revolving pan, either circular or tulip-shaped (Figure 13.4), is used quite extensively for all types of panning and polishing. These can be operated at speeds from about 15 to 35 RPM, with the choice of speed determined by the particular panning operation (size of pan, type of center, hard or soft panning, etc.). Some manufacturers control linear speed of the pan because it accounts for differences in pan size and thus, the forces on the tumbling pieces. The angle of the pan is typically between 18 and 30°, but this may vary slightly in some cases to promote ideal tumbling of the pieces. The shape and angle of tilt cause clumps of pieces that have stuck together to move forward in the pan where they are easily spotted and separated. Pan sizes vary from as small as 30 cm (12 in.) for lab-scale panners to as large as 1.5 m (5 ft) for the largest

Table 13.3 Parameters affecting sugar panning

Pan/center/dry charge	Syrup/air	Polish/glazing
Pan diameter	Application rate	Type of polish/glaze
Pan speed	Application method	Application method
Pan depth	Spray Pressure	Curing time
Pan load	Number of spray nozzles	
Pan size (tumbling height)	Spray nozzle size/orientation	
Center shape	Syrup temperature	
Center size/density	Syrup concentration	
Ribs (or not)	Syrup viscosity	
Center/pan temperature	Syrup composition	
Center precoating	Air flow rate	
Dry charge amount	Air temperature	
Dry charge size	Air humidity	
	Drying time	
	Air pattern (front or side-vent)	

Figure 13.4 Bank of traditional revolving pans for sugar panning(Courtesy of Georgia Nut Co.)

industrial sized units. Many commercial pans are 0.9–1.07 m (36–42 in.) in diameter.

The shape of the pans may also vary with the intended application. Circular pans cause more tumbling action and may be helpful to prevent doubles or clumping of centers with flat sides. Tulip-shaped pans, especially if elongated, hold more centers with increasing bed depth and thus, can handle larger batch sizes. Revolving pans, usually made from stainless steel or copper, can be used with a smooth interior or with ribs to promote tumbling of the centers as they are coated. Ribs are typically used during polishing to ensure proper tumbling of the centers, but may also be used to ensure adequate tumbling for certain types of centers. The drawback of using ribs for sugar panning is that crystallized buildup collects on the back side of the ribs. If this buildup breaks off it will stick to the centers and cause defects in the surface. When a ribbed pan is used for sugar shelling it will need to be cleaned more frequently to prevent this buildup from causing defects.

Panning in revolving pans is a batch operation with the entire process, from pre-coating to polishing, often taking place in the same pan, although some manufacturers use separate pans (and even separate rooms) for polishing. One pan operator is likely to be responsible for multiple pans making candies at the same time. The actions of the pan operator differ slightly for hard and soft panning.

13.3.1.1.1 Soft Panning

The operation for all soft-panned candies generally follows the same process (see Figure 13.5). After pre-coating the centers, a sugar shell is built up on the piece by sequential additions of engrossing syrup followed by dry powder charge. While there is a wide variation in formulations, typical composition of a soft panned candy can be 50–60% center, 30–35% dry charge sugar, 10–12% engrossing syrup and about 2% minor ingredients that include precoat, flavors, acid, colors, polish and seal coat.

The amount of centers loaded into the revolving pans depends on the size of the pan as well as the nature of the center. The correct fill of the pan is necessary to induce proper tumbling of the centers in the pan. If the pan is not adequately full, the centers do not tumble properly and will not be coated uniformly. If the pan is over-filled, there is the possibility that centers will fall out of the pan during the engrossing operation as they grow in size and weight. Furthermore, the added weight of the centers in a pan that is over-filled may cause deformation or even breakage of the centers. Panning speeds of 20–22 RPM are typically used in soft panning, although pan speed must be chosen to provide adequate tumbling forces, depending on pan size, to pack the dry charge into the engrossing syrup.

The soft panning process begins with pre-coating of the centers to ensure adequate adhesion of the sugar shell. For centers produced on a starch mogul, a sugar sanding step at the end of the mogul may serve as a sufficient pre-coat. For those centers that need further treatment, the pre-coat solution (usually gum arabic or dextrins) is applied to the centers, either by ladling or spray coating, as they tumble in the pan. This may be followed by addition of a small amount of dry charge, whether sugar crystals, starch granules or maltodextrin powder, to roughen up the surface to enhance adhesion of the sugar shell.

To build the sugar shell, the engrossing syrup (see Section 13.2.3.1) is applied either by hand ladling or by spray application. Engrossing syrup is added at a net total of about 10% of the weight of the centers in the pan, with individual wettings of 3–6%. If too much engrossing syrup is added at one time, the centers tend to stick together, forming doubles and larger aggregates. If the amount of syrup added is too low, the centers do not get uniformly coated and a rough surface is formed. The exact amount of engrossing syrup varies slightly from start to finish of soft panning since the center surface area increases as the shell is built up. Often, the amount of engrossing syrup to be added is left to operator judgment. Once ongoing production is commercialized, the amount is usually fixed to enhance efficiency and product uniformity.

Once a syrup layer has been applied and allowed to spread evenly on the surface of the centers, the dry powder charges are added. The amount of sugar powder added is crucial to building a satisfactory shell. Just enough powder must be added to dry out the newly applied layer of engrossing syrup. If too little powder is added, the layer is too wet and the centers stick together, whereas addition of too much powder results in

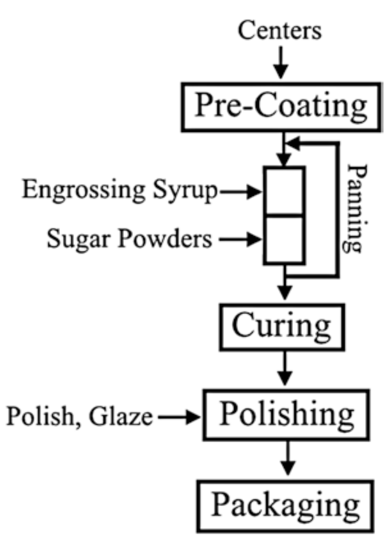

Figure 13.5 General flow process for soft sugarpanning

excess powder in the pan. This can cause problems in later applications. The amount of powder to add is often left to the judgment of the pan operator, but again is usually fixed after production is commercialized. After addition of the first dry powder charge, the centers are tumbled until some of the moisture in the engrossing syrup is pressed to the surface by the force of contacts. This phenomenon is known as sweat-back, where the surface becomes moist again after sufficient tumbling. At this point, another dry powder charge, generally much less than the initial charge, is added. Again, the amount of powder to add is often left to operator judgment. The tumbling process continues and this dry charge addition becomes incorporated within the syrup of the sugar shell. Sweat-back may occur a second time and this must be followed with a third addition of dry charge. Eventually, no further moisture seepage to the surface occurs and the layer is considered complete. At this point, the next dose of engrossing syrup is added and the process of dry charge addition and sweat-back is repeated. In general, a ratio of three parts dry sugar charge to one part engrossing syrup is often used to build a soft sugar shell.

Over the course of the sequence of engrossing syrup applications, the nature of the dry powder charge added to the piece changes. In the early layers, coarser sugar powders may be used to quickly fill in and dry the layer. However, in the final layers, it is important to use the finest powdered sugar available to create the smoothest surface possible. Very fine particles can be packed much more tightly together than larger particles and leave a very smooth surface that, when polished, will give a very nice uniform smoothness to the piece. Regardless of the size of crystals in the dry charge powder, it is important that the particles be of uniform size with a minimum degree of dust. This allows proper packing of the crystals into the sugar shell and results in the best soft-panned texture.

Somewhere between three and ten layers (engrossing syrup charge plus dry powder charge) are applied on the centers with each layer taking roughly 20–40 min to complete. Thus, total panning time to apply the soft-panned sugar shell is from 2 to 4 h. Once the panning process is complete, the moisture remaining in the sugar shell is dependent on the moisture content of the engrossing syrup, how much engrossing syrup is applied in each layer, and the relative amount of powdered sugar charge to the amount of engrossing syrup. If the shell contains three parts dry sugar charge to one part of engrossing syrup with solids content of 76% (24% water), the sugar shell would have moisture content of about 6%. Typically, moisture content of the initial sugar shell is between 4% and 8%.

Proper panning room conditions are needed to ensure a high-quality panned product. Room temperature should be around 21 °C (70 °F) with relative humidity less than about 55–60%. Warmer temperatures and high relative humidity make it difficult to adequately build up a sugar shell with the correct moisture content. Cooler temperatures cause the viscosity of the engrossing syrup to increase, potentially causing uneven coatings.

The end point of panning is often determined by weight. If a pan is on load cells, the engrossed weight is easily calculated as a multiple of the starting weight of centers. When load cells are not available, a count of 10–50 centers is weighed at the beginning of the process and the weights are repeated near the end of the process to identify the finished target piece weight. Once the desired shell thickness is attained by sequential addition of engrossing syrup and dry powder charge, the pieces are removed from the pan, filled into a tray and allowed to sit overnight. The resting time allows moisture to equilibrate between shell and center. The next day, the centers are placed back in a pan and several applications of a finishing syrup are applied to smooth the surface and dissolve any dust. Once the surface is dry after smoothing, layers of wax and/or polish and seal coat are applied. Once polishing and sealing is complete, the pieces are sent to packaging.

Soft-panned candies can also be made with dextrose and polyol (sorbitol, maltitol, xylitol, isomalt, etc.) shells in essentially the same manner as for sucrose. The engrossing syrup must be essentially noncrystallizing and fine powdered sugars added in the dry charge steps. For glucose, the engrossing syrup typically contains soluble dextrose and dextrose syrup and the process is exactly the same as for sucrose panning. For polyols, typically HSH or maltitol syrups are used in the engrossing syrup along with the dissolved form of whatever polyol powder is used in the dry charge.

13.3.1.1.2 Hard Panning

The application of a hard sugar (or sugar alcohol) shell in hard panning requires determined practice and patience. Many candy makers still consider the hard panning process to be somewhat of an art, yet our understanding of the processes occurring during hard panning continues to expand as more and more of the science behind panning is applied. In general, experience and practice is still the best approach to becoming an accomplished panner.

The general steps in hard panning are precoating of the centers and application of sequential doses of the coating syrup each followed by a period of drying to ensure crystallization of the shell (see Figure 13.6). Once the shell is built up to the desired thickness, the pieces are allowed to rest overnight before polishing and glazing the next day. The sequence of syrup addition and drying is critical to making the highest quality hard panned candies.

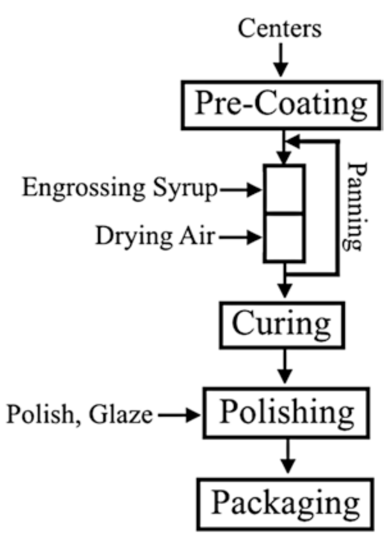

Figure 13.6 General flow process for hard sugar panning

In hard panning, the centers generally must be pre-coated to ensure a high quality sugar shell. If centers like chocolate and nuts are not pre-coated, the oil phase at the surface of the piece prevents adhesion and the shell is easily broken away. Precoating typically involves application of a gum (e.g., gum arabic) or maltodextrin layer, often followed by addition of a powder (i.e., sugar, starch or flour) to provide a layer suitable for adhesion of sugar syrup.

Once pre-coated, the centers tumbling in the pan are coated with a sugar solution of proper viscosity, temperature and concentration. Enough syrup is applied to give a layer of syrup to provide a uniform coating on all pieces, which depends on the surface are of pieces in the pan. If too much syrup is applied, the syrup is transferred to the back of the pan and sticking occurs. It has been estimated that a layer with thickness between 10 and 15 μm is created with each wetting. The engrossing syrup must have the appropriate viscosity to adequately cover the surface of the piece. If viscosity is too high, the pieces do not get completely covered and bare spots will be present. Too low a viscosity generally means that there is excess water in the syrup and this water must be evaporated during drying to promote proper crystallization. Cycle times between syrup applications may be longer when concentration is too low. Typically, the time for each application of syrup and drying cycle is between 5 and 10 min, but this time depends to some extent on environmental conditions, with longer drying times needed for more humid environments.

Sugar syrup viscosity is primarily a function of the temperature and concentration, so controlling these two parameters is generally sufficient to controlling viscosity of the engrossing syrup. The concentration of the syrup should be sufficiently high to minimize the amount of water that must be removed during drying and to promote rapid crystallization, but not too high that excessive viscosity limits the ability to form a uniform coating. Often, a value of about 200 cP is cited as the maximum viscosity for the engrossing syrup in hard panning (Boutin 1992). The temperature of hard panning is governed by the thermal sensitivity of the center. If a temperature-sensitive center, like chocolate or gum, is used, panning temperatures must remain below the softening point. For chocolates, syrup temperatures must be below about 30 °C (86 °F), which is about the same temperature for gum centers. Centers that are not sensitive to temperature can be hard panned at temperatures of 70–80 °C (158–176 °F). In fact, hard sugar panning of certain heat-resistant centers can be done with heat applied directly to the pan to speed drying and crystallization. For example, Jordan almonds are traditionally made in the hot pan process with heat applied to the pan.

After the engrossing syrup is applied, the centers are allowed to tumble for a short while to completely distribute the syrup and coat the centers. At this point, drying air is applied to the centers to promote drying and crystallization. To control drying and crystallization, air parameters must be carefully controlled. Sufficient air velocity across (and/or through) the entire bed of candy 0.00042–0.00057 m^3/s (0.9–1.2 ft^3 per min) per pound of finished product is required to remove the moisture in the engrossing syrup as crystallization occurs. Drying air generally should be as warm as possible, within the limitations of heat-sensitive centers, with low relative humidity (25–45%). Once a layer has completely dried and crystallized, another dose of engrossing syrup is added and the cycle repeated.

The decision point for adding the next dose of sugar syrup is one that is often operator dependent. The usual cues are when the previous layer dries sufficiently to cause a change in sound as the pieces tumble across each other (dry pieces give a different sound than wet pieces), and when a slight dust begins to arise from the pan. When the shell dries sufficiently, small pieces of the shell, which appear as dust, are broken off by the tumbling action in the pan. At the first signs of dust and sound change (from quiet while wet to a tinny, pinging sound of dry pieces tumbling), the experienced operator will apply the next layer of sugar syrup.

To build up a suitable thickness of shell with hard panning requires care and patience. In many hard-panned candies, 40–60 syrup applications (and drying cycles) may be needed to build a shell thick enough, so that it takes over 6 h to build the shell. Some hard panned products, like jawbreakers, require over 300 layers so that it may take a week or two of careful syrup application to build the product to the desired size. Patience is certainly an important attribute for a pan operator making these products.

For centers that are not heat sensitive, a hot panning technique may be applied. Here, the syrups are warmed to temperatures well over 39 °C (102 °F) and additional heat is applied to the pan to warm the centers. Although a gas flame aimed at the bottom of the pan is the traditional method, heating is generally from hot air directed into the pan or steam coils wrapped around the pan. Advantages of hot panning include use of a higher concentration engrossing syrup (higher temperatures allow higher concentration with reduced viscosity) so less water needs to be dried off, more rapid crystallization at the elevated temperature and more rapid drying. Jawbreakers and Jordan almonds, as well as sugar-coated tablet candies can benefit greatly from the more rapid cycles in hot panning.

Because of the long times needed to build up a hard-panned sugar shell, sometimes short cuts are taken to reduce batch times. In particular, a modified soft-panning process may be used in the early stages of hard panning to rapidly build a shell. Here, a dried powdered sugar charge, generally mixed with starch, is applied immediately following application of the engrossing syrup, which may contain cellulose gum, in a similar process to soft panning. This technique is frequently called dry charging. The addition of sugar powder to the engrossing syrup speeds the build up of the shell and the presence of gum and starch helps harden these layers. Although the texture of the hard-panned shell is not as brittle, if done properly, batch time can be reduced significantly (up to 60%) with minimal loss of quality.

Towards the end of the hard-panning process, as the shell nears its final thickness, the engrossing syrup is changed slightly to ensure a smooth surface. Lower dissolved solids (less than 65%) in the engrossing syrup help to create a smooth surface. The higher water content ensures uniform coverage (due to the reduced viscosity) and dissolves some of the crystals in the previous layer, allowing “low points” in the coating to get filled in. Upon drying, an exceedingly smooth surface with minimal perturbations is formed. This results in uniform color intensity and a shiny appearance.

Not all hard panning syrup applications contain colors. In some cases, manufacturers do not add color except to the final coating layers. Color coats are applied in the same way as previous applications, but with color added to the engrossing syrup as either lakes or dyes. To enhance visual color appearance, many manufacturers add titanium dioxide to all or some of the underlying sugar shells. The titanium dioxide particles reflect the light that passes through the color layers, giving a fuller and deeper color than would otherwise be observed.

Once the desired sugar shell has been built up, the candies are stored in cool dry conditions to allow the shell to solidify completely (residual sugar crystallization occurs) and the moisture within the shell to equilibrate. The candies are often stored overnight in shallow trays under cool and dry conditions before being returned to the pans for polishing and glazing.

Although sucrose remains the most important sugar used for hard panning many other sugars can be used. These include dextrose, sorbitol, xylitol, maltitol and isomalt. In general, the processes for hard panning with materials other than sucrose follow an identical process of application of engrossing syrup followed by a period of drying. The main differences in hard panning among the different sweeteners relate to differences in viscosity and the nature of crystallization (rate and type of crystal formed). For example, a concentrated solution of dissolved dextrose is less viscous than an equivalent concentration of sucrose (monsaccharides are less viscous than disaccharides) so higher concentrations can be used for dextrose panning. Dextrose also crystallizes very rapidly into numerous tiny crystals that result in a strong hard shell. Further, dextrose crystallizes as a monohydrate during panning, meaning one mole of water enters the crystal lattice with each mole of glucose, so that correspondingly less water needs to be evaporated from the shell during drying. These effects are also greatly enhanced in hot panning. Dextrose also has a larger positive heat of crystallization than sucrose (see Section 2.3), which provides additional driving force for drying although the released heat must be removed by the drying air (greater cooling effect needed). Additional details on dextrose panning can be found in Horn (1977), Boutin (1988), and Nonaka (1991), while sugar-free panning is explained in further detail by Boutin (1992) and Huzinec (2010).

13.3.1.2 Other Coating Technologies

Over the years, new developments have improved the panning process, making them more automatic and less subject to human variability (Boutin, 2012). One type of coating device often used for panned candies is the belt coater, where the centers are tumbled on a continuous belt while being coated with engrossing syrup from spray nozzles above the bed of candy. High production, fully automated panning systems are also available. Film coating technologies, borrowed from the pharmaceutical industry, may also be used to apply candy shells.

13.3.1.2.1 Belt Coater

Belt-type pan coating systems are most often used for chocolate panning (see Chapter 16), but see some application in soft panned (jelly bean) applications. They operate in a slightly different fashion from the traditional revolving pans. In the belt coater, the pieces to be coated are tumbled by movement of a continuous belt, as seen in Figure 13.7. In this case, the candy pieces are contained within a depression in the continuous belt and the movement of the belt results in uniform tumbling. In this geometry, the entire front of the candy bed is open and available for engrossing syrup application. Sugar syrup is applied across the top of the pieces in the tumbling section. Belt coaters can be 1.5–4 m wide and hold upwards of 300 kg (650 lb) of centers.

One of the main advantages of the belt coater is the level of automation that can be applied. Computer controllers can automate the process and reduce the need for manual labor. Furthermore, unloading of the belt coater is easily accomplished by reversing the direction of belt rotation, with pieces collected in trays or bins at the front of the unit. Facilitated removal of drying air and/or volatiles during polishing through the exhaust system allows more efficient operation than a traditional pan. In general, more efficient operations are found with the belt coater and productivity thereby increased.

Figure 13.7 Belt coater (Courtesy of Driam)

13.3.1.2.2 Cylindrical Drum Panning Systems

In large-scale hard panning operations, it is often most efficient to use fully automated panning units (Figure 13.8). These are typically enclosed cylinders or drums inside which the tumbling candy pieces are coated. The candy pieces tumble inside the drum and are coated with sugar syrup from spray nozzles positioned within the rotating drum (Figure 13.9). Drying air is usually vented through one end of the pan, with air flow either across the pieces and out the other end of the drum or directly through a perforated drum in automated closed-system designs. The improved air handling systems give excellent heat and mass transfer, resulting in very rapid and efficient panning. Cylindrical drum panning systems can handle from 225 kg (500 lb) to 2,700 kg (6,000 lb) of product.

Computer automation of the sequenced steps in panning means high efficiency and increased

Figure 13.8 Drum coater for hard panning (Courtesy of Dumoulin)

Figure 13.9 Sugar spray system inside drum coater (Courtesy of Dumoulin)

productivity. In some cases, detection methods (e.g., moisture content) may be used to determine onset of specific operations.

13.3.1.2.3 Continuous Panning

As a batch operation with intensive labor requirements, panning is an inherently inefficient operation. For many years, people have attempted to develop continuous panning operations to enhance process efficiency. In continuous panning, uncoated centers entering one end of the process and finished panned goods exiting the other end. The sequence of events in the continuous panner simulates the sequence of events found in the batch process. For soft shell panning, continuous panners have been designed to continuously move the centers from section to section, with sequenced dosing of engrossing syrup and powdered sugars as the pieces move from the inlet of the drum to the outlet. Their application has thus far been limited to relatively hard centers with thin coatings (15–25%). As the application of sensor automation improves, the applications for automated soft panning will increase.

Although in principle, continuous coaters can potentially provide efficiency in operation by controlling all panning conditions, cost is often prohibitive, particularly in a manufacturing plant that changes product regularly. These would be most advantageous for large production runs of the same product.

13.3.1.3 Candy Center Motion and Scale-Up

Candy centers tumbling in a pan are subject to various forces depending on the type of product, type of pan, and the operating conditions. As noted in Table 13.2, parameters such as pan or drum diameter, rotational speed, bed depth and weight, center size and density, and center surface roughness can all impact how the centers move during pan rotation. These parameters define the movement of each individual candy piece within the bed. Of primary importance to getting good uniform surface coverage is that each piece be exposed at the surface of the tumbling bed for about the same amount of time during application of the engrossing syrup. Whether ladling or spraying the engrossing syrup onto the bed of candy centers, each piece must receive the same amount of syrup coverage or there is a risk of uneven, bumpy and inconsistent product.

Another concern related to pieces tumbling in the pan is segregation of centers of different size, shape and weight. In tulip-shaped pans in particular, the angle of the pan imparts a downward force on the piece so pieces of different size and weight fall at a different speed, leading to segregation. In general, centers of approximately the same size and weight must be used in pans to ensure uniform mixing of centers. Where segregation is most likely to occur is when doubles or multiples are formed. If, for example, too much engrossing syrup is added at one time, centers are likely to stick together to form multiples. These have larger mass than the single pieces and thus are driven to the front of the pan by the tumbling forces. Even pieces of different shape can experience sufficiently different forces that these are segregated from the main bed in the same way.

Primarily because of these variations in tumbling forces, panned candy developers are continually looking to better understand how to design a product in lab bench panners and scale the process up to commercial-sized pans. The variety of forces important during panning, particularly when increasing the size of the pan and the mass of the candy in the pan, means that scale-up is no simple task. In concept, successful scale-up generally requires geometric, dynamic and kinematic similarity between the smaller and larger size equipment (Pandey et al. 2006). In panning, geometric similarity means panners with similar aspect ratios (pan length to diameter) and also maintaining a constant pan load to pan volume. Without geometric similarity, scale up will be difficult, if not impossible. Dynamic similarity is attained with a constant ratio of inertial forces (due to the rotational speed of the pan) to gravitational forces. Inertial forces are related to the pan's rotational speed and diameter since the pieces move at the same speed as the inside wall of the pan. To maintain dynamic similarity in panning means that pan rotational speed must be decreased as pan diameter increases; this best related to the linear speed at the pan surface (which is what moves the pieces). Kinematic similarity, where the ratios of the velocities of the important factors at different points in the pan is maintained constant between the different scales of operation, is probably the most difficult aspect of scale up for panning operations. Pandey et al. (2006) suggested that, for hard panning operations, the velocity of the tablets (pharmaceuticals) relative to the engrossing syrup spray kinetics should be kept the same, but this concept will not always apply in confectionery panning (especially with hand application of engrossing syrup). They also recommended maintaining constant drying capacity (ratio of airflow to spray rate). For example, in a larger pan, typically the time a piece is in contact with the spray zone is reduced, which means that the effective drying time in larger scale operation is longer. To offset this, the spray zone should be expanded by a combination of changing air velocity in the spray mechanism, increasing the number of spray guns, and adjusting the distance from the spray gun to the tumbling bed. Based on this discussion, it is not surprising that scale up of confectionery panning operations is quite a complex challenge.

13.3.2 Polishing and Glazing

Most panned candies, whether hard or soft sugar coated, are polished and glazed to protect the candy and to give it an attractive, shiny appearance. Polishing is the process of applying a shine to the candy and is followed by glazing with a protective barrier to maintain product quality.

The main purpose of a polishing agent applied to a panned candy is to create a smooth, glossy surface. In doing so, often the color of the piece is also enhanced. The polished candy is significantly more attractive to the consumer than an unpolished piece. Application levels of polish to panned candies are from 0.05% to 0.3% for sugar-panned candies and from 0.4% to 0.8% for chocolate panned products. The main purpose of a glazing agent applied to a panned candy is to protect and seal the surface from the environment, primarily against high temperatures (at least to some extent) and moisture sorption. The sealed surface also prevents pieces from sticking together in the package during shipping. Application levels of glaze are from 0.1% to 0.3%.

Polishes for sugar-panned candies are primarily waxes, including carnauba and beeswax. Waxes are applied either in solid form, with the heat of friction during tumbling allowing the wax to spread and coat, or as a solution in an organic solvent (e.g., alcohol). Glazes are generally shellac in a solvent carrier. Alcohol is the main solvent for glazes, but other solvents are sometimes used because of environmental (volatile organic compounds, VOC) concerns (consult with the pertinent emission guidelines to ensure the process is within code). Single-step coatings that combine wax and shellac in a solvent are also available for use.

Prior to polishing, sugar-panned goods should be fully dried, free from dust and perfectly smooth. In soft panning, the final layers should be packed with the smallest possible grade of crystals to ensure the smoothest finish. It is important to apply a finishing syrup to soft panned goods to smooth out the surface and remove any dust prior to application of the polish. In hard panning, reduced concentration engrossing syrups ensure that the final smoothing layers are as even as possible. It is critical that the panned candies have been allowed to fully dry and crystallize. Often, this means the candies have been stored overnight under controlled conditions (RH and temperature) to ensure complete solidification and moisture equilibration.

The candies to be polished are tumbled in a revolving pan, most often fitted with ribs to enhance the tumbling motion. First the polishing agent is applied to the pieces tumbling in the pan to just wet the surface and this is allowed to dry, usually without the use of drying air unless relative humidity is high (above 60%). A second coat may be added in the same way and allowed to dry. After the final coat has dried, cooling air may be used on the tumbling pieces to develop a deep shine.

Polishing gives an attractive appearance to the panned candy, but does not sufficiently protect the candy from extreme heat and humidity during storage. Thus, many companies choose to apply a glazing agent to the candy for enhanced protection. Prior to application of the glaze, the polished candy should be thoroughly dried, sometimes by storing overnight in cool, dry conditions. It is important to ensure that the pieces are free of dust prior to glazing. The pieces are once again placed in a revolving pan fitted with ribs to enhance tumbling. A glazing solution containing edible shellac dissolved in alcohol is applied to the candy pieces. In some cases, drying of the glaze is done with the pan rotating, but in other cases, static drying is preferred. With static drying, after the pieces have been coated with the solution, the pan rotation is stopped and the glaze allowed to dry under static conditions. The pan is turned about one-half revolution, or jogged, two or three times during the 20–30 min it takes to dry to prevent tack spots from forming. After complete drying, the pieces are tumbled briefly to smooth out the surface.

13.3.3 Special Decorations

Special and unique characteristics can be imparted to panned candies (Gesford 2001). These include pearling, striping, decorating, and silvering. In soft-panning, it is even possible to include particulate inclusions in the sugar shell. It is quite possible that several of these special techniques were discovered by accident, where a "mistake" turned out to have unique and interesting qualities. Many panned candies also have words or logos printed on them to help distinguish them from competitors.

Pearling is the process of intentionally building an uneven surface to a hard-panned candy. Japanese confectioners have become particularly adept at this process, with a unique sugar candy available based on this process. Use of elevated panning temperatures, typically controlled by adding heat to the bottom of a rotating pan, and high concentration engrossing syrups lead to rapid drying and crystallization, even before the syrup can be spread uniformly on the center surfaces. This high concentration and temperature cause nodules or protuberances of thickened, partially-crystalline and sticky syrup to form on the candy surface, particularly as the pieces come apart during tumbling. With careful control of operating conditions, these protuberances are allowed to grow as further additions of engrossing syrup are applied. The result is an irregular surface that can vary from slight dimpling (like the surface of an orange) to the appearance of nodules or spikes several millimeters in length, in the extreme case.

Stripes, or narrow light and dark lines, similar to longitude lines on a globe, provide a unique appearance to sugar-panned goods. Striping is more about the nature of the center than it is about panning techniques. A center with a grooved surface, such as gum or a tablet, holds the engrossing syrups at different thicknesses in the grooves than on the flat surfaces. Thus, the grooves appear to be a darker color than the flat surface and the candy appears striped.

To create a spotted or speckled appearance to the surface of a sugar-panned candy, whether hard or soft panned, a colored solution is either spattered or sprayed onto the finished surface prior to polishing. In one version, an organic solvent like alcohol is used to disperse the color to ensure rapid drying as the solvent evaporates off. Water soluble colors are unsuitable since the water in the solvent would dissolve some of the sugar shell and could potentially remove the base color. Another method of spotting/speckling involves application of a colored, aqueous-based film-forming material (gums, maltodextrin, dextrins, etc.), which quickly dries and sets upon application of heat. Speckling can also be accomplished during polishing, with color pigments incorporated into a confectioner's glaze.

Certain types of decorative hard-panned candies are given a silver metallic finish through a process called silvering. To make silver balls, a gum arabic solution containing silver leaf or powder is applied to the candy while tumbling in a pan (often glass or plastic pans are used to prevent tarnishing of the silver surface). As the moisture in the syrup evaporates, a layer of silver forms on the surface of the candy. Extensive tumbling is needed to prepare a highly polished surface. Silvering is legal only for decorative purposes in the United States.

Certain sugar-panned candies have logos imprinted on the surface of the sugar shell. Typically imprinting is done to establish brand identity, although, recently sugar panned candies are now available with custom-printed slogans, often designed for special occasions (weddings, holidays, etc.). Printing on a sugar shell involves application of edible ink to the surface of the candy. Edible inks typically contain pigments in an alcohol and shellac base, with other additives to moderate the properties of the ink. The rotogravure process, which uses an offset roller to apply the ink, is the most common method of printing on sugar shells. Here, the ink is applied to the lettering on the offset roller, which then contacts the candy with the application surface presented to the roller. The ink is allowed to dry before the candy piece is removed from the conveyor. Recent developments with ink-jet printing technology using edible inks are allowing more sophisticated designs.

13.3.4 Multicomponent Layering

By its nature, soft panning is essentially creating a solid dispersion on the surface of a center. In the classic sense, this is thought of as a syrup phase holding together sugar crystals. For someone experienced in the art of panning, it is clear that the same principles can also be used to create other types of coatings. The addition of calcium carbonate can be used to create a coating that resembles an egg shell. Fruit powders or seeds can be added to make products that more closely resemble fruit. Fibers, vitamins, or other nutraceuticals can be added to create nutritional supplements. Milk or yogurt could be added for their flavor and mouth feel. It is also possible to create distinct layers with a product. For example, a center could first be coated with chocolate and then a sugar layer. A combination of fat, cocoa, and sugar could be added to make a chocolate-like layer in place. Similarly combinations of dairy and carbohydrate ingredients can build a caramel layer into a product. Colloid ingredients can build a jelly layer into a product. A cherry can be coated with sugar, some invertase enzyme, and then chocolate. Once the invertase converts the sucrose to invert syrup, a perfectly round, liquid filled chocolate covered cherry will impress confectionery connoisseurs. Any dispersion of ingredients can be combined in place to produce a layer on or within a product.

13.4 Product Characteristics

As with most confections, sugar panned goods require careful control of water and the state of the sweeteners to ensure optimal quality. The nature of the microstructure, or sugar crystal dispersion (size, number, interconnectedness, etc.), is what determines the texture of the shell and distinguishes between hard and soft panning. In turn, the nature of the sugar crystals is controlled by the formulation of the engrossing syrup, including water content, as well as panning conditions such as. Equilibration of water within the sugar shell and between the various components of panned candies also affects product texture and quality. Changes in water content during storage are often what limit the shelf life of panned confections.

13.4.1 Microstructure of Panned Sugar Shells

The characteristics of hard panned sugar shells are quite different from soft panned shells, particularly related to the number, size and shape of the crystals. Differences in microstructure lead to the different textures of hard and soft-panned candies. Both formulation of the engrossing syrup and panning conditions influence the nature of crystalline microstructure and thereby influence shell texture.

13.4.1.1 Soft Panned Candies

The sugar shell on soft-panned candies is made up of numerous, relatively large crystals, typically from 25 to perhaps 100 µm in size depending on the dry charge added during panning. These crystals are packed into a fluid binder, the engrossing syrup, which holds them together (as shown schematically in Figure 13.1). The tumbling forces in the pan pack the crystals tightly into the syrup layer. Figure 13.10 shows stereomicroscopic cross sections of a soft-panned candy at different magnifications. Individual crystals can be distinguished in this shell, with these crystals held in place by the sugar syrup matrix. This relatively loose structure of large crystals breaks readily under applied force, giving the soft, easily broken texture of a soft-panned sugar shell. Characteristics of the soft-panned sugar shell depend on the nature of the engrossing syrup, the types of sugar powders added during panning, and changes that occur as the shell cools and equilibrates after panning is completed.

The nature of the sugar powders used to build the soft-panned sugar shell significantly effects shell characteristics. Typically, larger crystals give a softer, easier to bite texture, but one that feels coarser in the mouth. When external force is applied to bite through a soft-panned candy, the shell breaks at the weakest points. Larger crystals give fewer junction points between particles (compared to numerous small crystals), making it

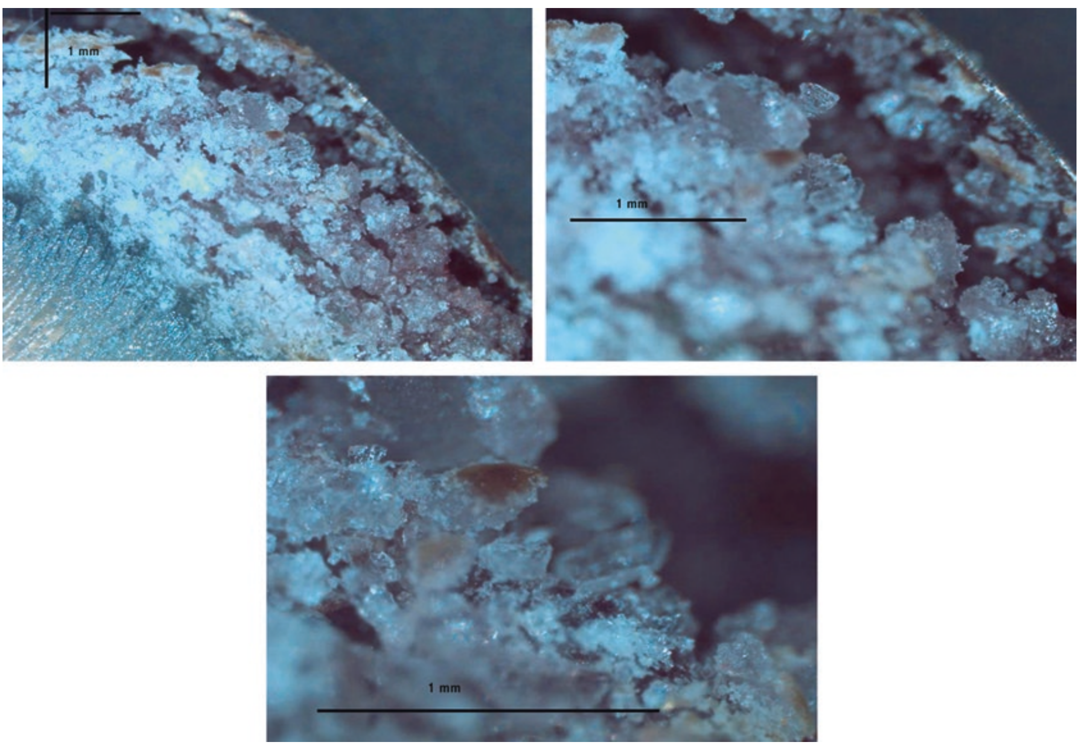

Figure 13.10 Stereomicroscope image of cross-section of soft-panned candies (Pictures courtesy of P. Gesford)

relatively easy to break through the layer. Thus, finer powders give both smoother finish and firmer texture to a soft-panned confection.

However, when bridges form between adjacent crystals, the force required to break through the sugar shell increases substantially. Thus, anything that causes bridging between crystals results in a harder shell. For example, the changing water content of the sugar shell, either during curing (stoving) or storage, results in sugar crystallizing out of the engrossing syrup solution. Since sugar crystallizes under these conditions directly onto existing crystals (rather than forming new nuclei), the crystallization that occurs when the sugar shell dries out leads to crystal bridge formation between adjacent particles. Not only does the lower moisture content mean there is more crystalline mass, any bridged crystals that have grown together also resist breakage. The result is a harder shell.

Temperature changes during processing can also lead to crystal bridging. Although the engrossing syrup is generally considered to be noncrystallizing in soft panning, this is not always entirely true and any crystallization from the engrossing syrup during cooling can induce bridging between crystals. In general, a small amount of crystallization does indeed occur from the engrossing syrup, with the extent dependent on composition and panning temperature. This can be seen from the effect of temperature on the solubility curve of sucrose in the presence of glucose syrup. As shown in Figure 13.11, the solubility of sucrose in a solution with glucose syrup decreases with temperature. The extent of crystallization as a 50:50 solution of sucrose and glucose syrup (saturated at 50 °C with 195 g of each per 100 g of water) cools to 25 °C can be seen as the amount of sucrose that must crystallize out of solution during cooling. At 25 °C, the concentration of sucrose in a saturated solution containing 195 g glucose syrup/100 g water is only about 145 g sucrose/100 g water. Thus, about 50 g sucrose/100 g water must crystallize from the engrossing syrup to maintain phase equilibrium. This crystalline sucrose forms on existing crystals (from the dry powder charge) causing all crystals to get slightly larger, but also causing bridging between adjacent crystals in the shell. Thus, panning under conditions where the engrossing syrup is applied warm results in significant sucrose crystallization and bridging, the result of which is a slightly harder shell (although still nowhere near as hard as a hard panned shell). Further, the engrossing syrup will often dissolve some of the dry charge, resulting in a changing saturation level of the engrossing syrup during panning.

13.4.1.2 Hard Panned Candies

In contrast to soft-panned sugar candies, the shell of a hard-panned candy is made up of numerous very small sugar crystals that are bonded together in some fashion, as shown schematically in Figure 13.2. Figure 13.12 shows the cross-section of a hard-panned sugar shell at different stages

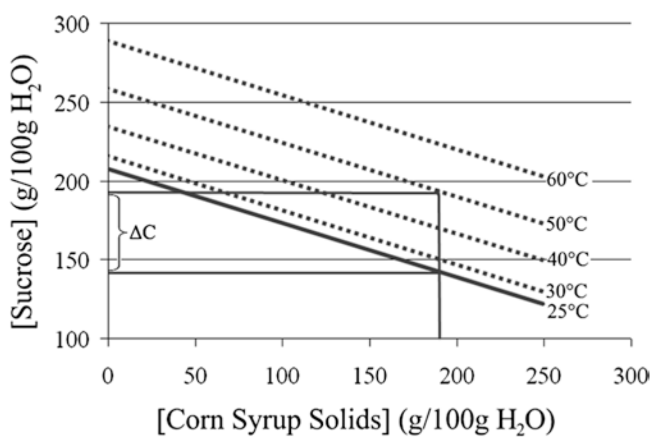

Figure 13.11 Effect of temperature and glucose syrup content on solubility concentration of sucrose

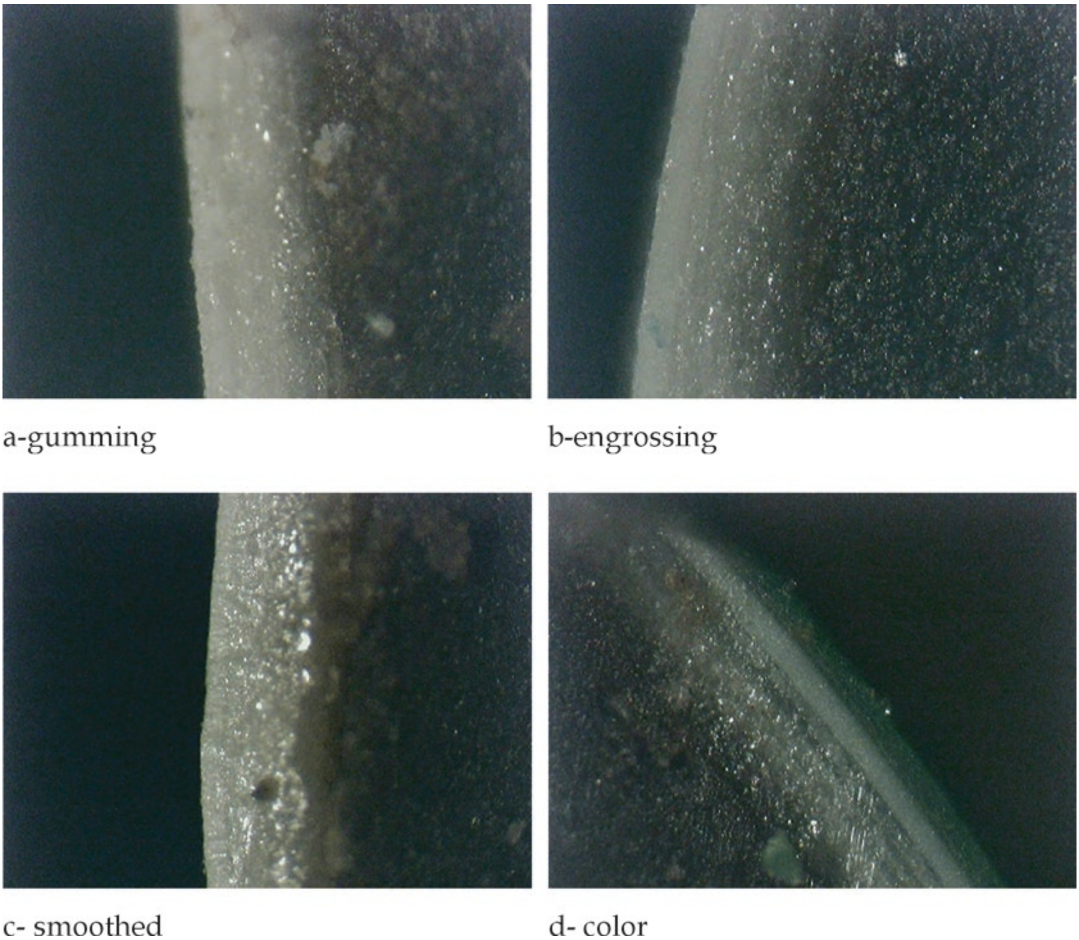

Figure 13.12 Cross-section of a hard-panned sugar shell at different points in the panning process (Courtesy J. Bogusz)

during production. Careful inspection of these cross-sections shows the different layers (gumming, engrossing, smoothing layer, color layer). Although not distinguishable at these magnifications, the hard-panned sugar shell contains numerous small (probably less than 1 μm) crystals, likely bridged together, held in place by a small amount of saturated (sucrose concentration of ≈67% at room temperature) solution with very low water content (<3–4%).

The microstructure of the hard-panned sugar shell depends on multiple processes that occur during panning. After application of the engrossing syrup, the fluid must be uniformly spread across the surface of the centers, after which both crystallization and drying occur as the layer solidifies. It is the relative rates of crystallization and drying that determine the microstructure and texture of the hard-panned sugar shell.

13.4.1.2.1 Crystallization Versus Drying

Arguably the most critical aspect of hard panning is controlling sugar crystallization in each cycle. Once the engrossing syrup is applied, both crystallization and drying start immediately, with each process affecting the other. Controlling these processes is critical to creating a good sugar shell with desirable properties.

In a sense, drying and crystallization are competitive processes since one (drying) leads to an increase in dissolved solids and the other (crystallization) leads to a decrease in dissolved solids in

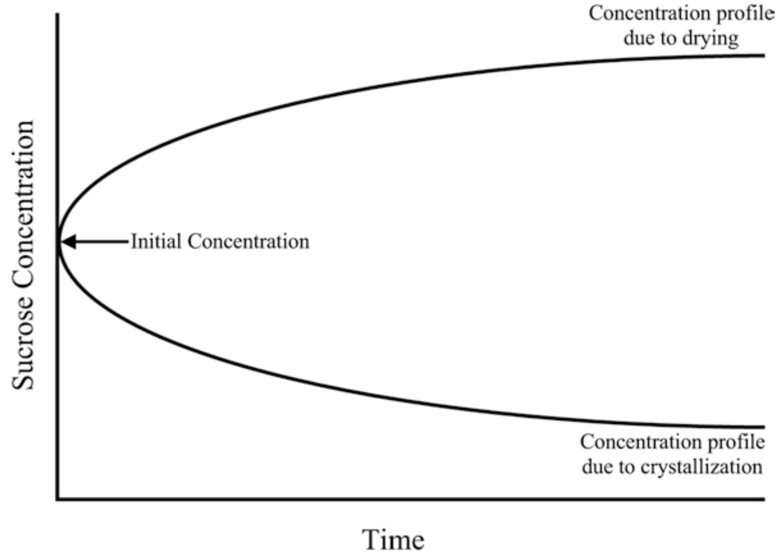

Figure 13.13 Schematic diagram of effects of drying and crystallization on liquid phase concentration

the syrup as molecules are removed from the liquid phase into the crystalline solid. As seen in Figure 13.13, drying causes an increase in solution concentration as water is removed from the film, whereas crystallization causes a decrease in liquid phase concentration as sugar molecules leave the liquid phase to become crystals. In crystallization terms, this decrease in the solution phase concentration is called desupersaturation, which continues until the supersaturation reaches zero at the point when solution concentration reaches the solubility concentration for that system and temperature. Thus, drying and crystallization "compete" in terms of the trend in the solution concentration. Drying leads to increased concentration while crystallization leads to lower concentration.

Yet, each process affects the other since the rates of drying and crystallization depend on the solution concentration and its water activity. For drying, the driving force is the difference in moisture between the air (relative humidity) and the water activity of the wet engrossing syrup layer, which is related to moisture content of that layer. For crystallization, the driving force for crystals to form and grow is proportional to the difference between the actual solution concentration and the solubility concentration at that temperature. Thus, the concentration of the engrossing syrup layer at any point in the process determines the rates of drying and crystallization. In one extreme case, for example, if drying were sufficiently rapid, the sugar solids would increase rapidly to the point where it became glassy and no crystallization would occur (see Section 2.11). Thus, the rate of drying can significantly impact the rate of crystallization (and vice versa).

To promote rapid crystallization of the sugar shell requires that the applied syrup rapidly reach the optimal point of nucleation/growth on the state diagram (see Section 2.2 for more details). The syrup layer should not be too concentrated, where mass transfer is limited by the glassy state, or too dilute, where the supersaturation is too low to promote rapid crystallization. Figure 13.14 suggests a region on the state diagram, somewhere midway between the solubility line and the glass transition curve, which promotes maximal crystallization during hard panning. Thus, both the concentration of sugar in engrossing syrup layer and the temperature during panning are critical to rapid crystallization. Directly after application of the sugar syrup, it would be desirable for the sugar solution to reach a point on the state diagram that resulted in a high rate of nucleation, leading to the numerous small crystals desired for the hard, brittle shell. Once nucleation has been initiated, drying can begin in earnest (some drying is inevitable as soon as the syrup is applied to the center) to remove the water in solution. Drying should not occur so rapidly,

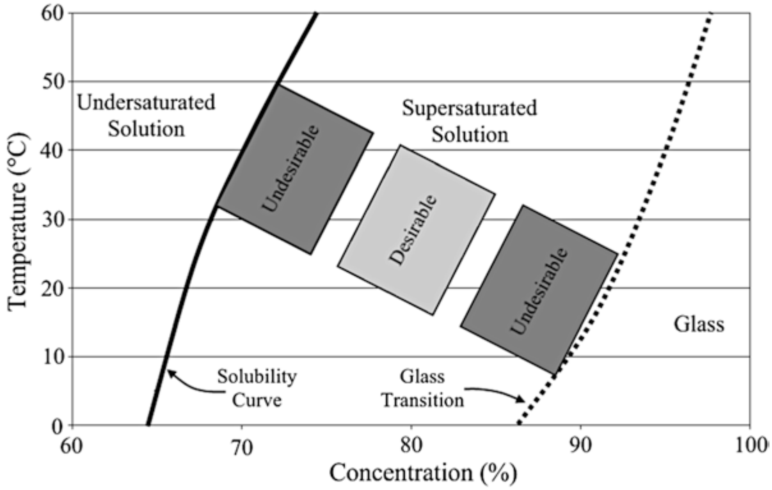

Figure 13.14 Range of desired conditions for satisfactory hard panning

especially early in the cycle, that crystallization is impeded. If done correctly, drying and crystallization occur in concert so that crystallization is nearly complete when the layer has been dried sufficiently for the next syrup application.

The final remaining crystallization, to attain equilibrium between crystal and liquid phase, may take days to complete. Thus, the sugar shell on a hard panned candy after it has just been removed from the pan is slightly softer and less brittle (almost wet) than the end product after several days of equilibration. During this equilibration process is most likely when fusion of crystals occurs to give a hard, brittle texture at the same time the shell equilibrates with the center and with the surrounding ambient air. This can be detected physically as a distinct hardening of the shell over time.

Factors that affect drying include air circulation velocity, air temperature and relative humidity. In general the rate of drying is promoted by an increase in velocity and temperature and a decrease in air humidity. High air circulation rates mean that the air passing across the wet engrossing syrup layer can more efficiently remove moisture through the higher convective mass transfer coefficient. Higher air temperature has two effects on drying. First, increasing temperature of the air causes a corresponding decrease in the relative humidity of the air, which increases the driving force for moisture loss. Second, the higher temperature means faster diffusion of water molecules from the wet layer into the drying air. Because of the two-pronged effect, increasing air temperature is probably the most effective means to speed the rate of drying, although drying air temperature (like engrossing syrup temperature at application) must remain below the point where the center becomes too soft or melts. The relative humidity of the drying air can also be reduced to enhance drying since this increases the driving force for moisture loss (from syrup to air). However, reducing relative humidity too low (below 20%) causes such rapid drying that the glassy state is formed, inhibiting further crystallization. Proper choice of drying air parameters is required to enhance application of the hard-panned shell and increase the efficiency of operation.

One of the primary concerns in traditional batch hard panning is reducing cycle time to reduce total batch time. If only drying was of concern, a logical approach would be to speed drying by applying hotter and dryer air at a higher circulation rate in the pan. However, the end result of this approach would be to delay crystallization, which would lead to quality problems later. Such rapid drying would essentially trap moisture within the shell in the form of a glassy state and prevent proper crystallization. When that water was released by subsequent crystallization, it would take any soluble dyes with it, which would result in an uneven, mottled appearance.

Further details on the competitive processes of drying and crystallization from thin sugar syrup layers can be found in Shastry and Hartel (1996) and Ben-Yoseph and Hartel (1999).

13.4.2 Moisture Migration

As with most confections, controlling water content during sugar panning, both during processing and storage, is critical to controlling product texture, quality and shelf life. Since relatively high moisture content engrossing syrup is applied to the centers tumbling in a pan, it makes sense that moisture changes during processing are important to setting the proper structure of both hard and soft-panned candy shells.

13.4.2.1 Soft-Panned Candies

In soft panning, engrossing syrup with 75–78% dissolved solids content (22–25% water) is applied to a center with varying water content. Jelly centers, probably the most common center for soft panned candies, typically contain water content of 8–15%. Even though the higher water content engrossing syrup is quickly packed with dried powder, this difference in water content (and chemical potential) leads to moisture migration between engrossing syrup and center. To allow for moisture migration and the subsequent crystallization of the shell to attain phase equilibration, many soft-panned candies are held for a time of curing (or stoving) before polishes are applied to the shell surface.

In practice, moisture migration during aging of soft-panned jelly beans is more complex than simple equilibration between shell and center since water within the confection must also equilibrate with the surrounding air (Troutman et al. 2001). As noted in Chapter 3, the parameter that drives moisture migration between two zones (either different regions of a candy or between the candy and the surrounding environment) is not water content, but the chemical potential of water molecules in the two different regions. That is, water activity of the two regions (or more accurately, water vapor pressure) determines which way moisture migrates and when moisture migration will stop.

In the Troutman et al. (2001) study of water migration during aging of starch-based jelly beans, the initial (immediately after panning) water content of the shell was between 4% and 4.5% whereas the jelly bean center had a water content of about 8%. If it was water content that drove migration, water would move from center to shell. However, the initial water activity (ratio of vapor pressures) of the shell was about 0.75–0.76 while that of the jelly center was between 0.60 and 0.65. Thus, moisture migrated initially from the shell to the center. The differences in water activity between shell and center are due to the different sugar composition and the effects of those ingredients on water activity (see Chapter 3 for more details). Different centers (pectin, gelatin, or mixtures of hydrocolloids) may not behave the same way as the starch-based centers in this study.

During aging, moisture initially migrates from shell to center in order to attain a water activity equilibrium – moisture would continue to migrate until the water activities of the two regions were the same. However, a second driving force for moisture migration exists during stoving that alters this balance. Water must also equilibrate between the candy and the surrounding air. In the case of the Troutman et al. (2001) study, the air conditions in the aging room were 21.1 °C (70 °F) and 70 ± 5% relative humidity, typical curing conditions for many operations. The initial water activity (vapor pressure) of the sugar shell was higher than the relative humidity (vapor pressure) of the surrounding air. Thus, in addition to water migration from shell to jelly center, there was also a driving force for water to migrate from the sugar shell into the aging-room air. Water in the shell was driven in two directions, into the jelly center and into the air, resulting in a complex dynamic state that resulted in substantial changes in the jelly bean. After 2 days at curing conditions, moisture had redistributed within the jelly bean. The jelly center had a water content of 6.5–7.0% and a water activity of 0.60–0.62, whereas the sugar shell had water content of 3.4–4.0% and water activity of about 0.68. The entire jelly bean had lost about 0.3% of its initial weight due to moisture loss to the air. And, drying was still occurring even after 2 days, since the jelly bean had not yet equilibrated with either itself (shell to jelly center) or with the surrounding air.

For various reasons (efficient operations and enhanced throughput, etc.), moisture migration during curing is probably never completely attained before the polish layer is applied. Since the polish/glaze layer is usually a good (although not complete) moisture barrier, once the polish is applied, moisture migration to the surrounding air slows dramatically, allowing moisture migration within the candy piece to occur. If the polish/glaze layer is applied before sufficient curing has been allowed, the trapped moisture can potentially cause shelf life problems as it slowly equilibrates during storage. In particular, excessive moisture migration after polishing and glazing leads to problems like sticking and caking of soft-panned goods within the package. A bag of fused jelly beans is generally caused by lack of control of moisture during panning.

Furthermore, since the polish/glaze layer is not a complete water barrier, moisture migration still occurs between the soft-panned candy and the surrounding air. This moisture loss, and the hardening of the candy that accompanies it, is one of the primary modes of product failure in shelf life (see Section 13.4.3).

13.4.2.2 Hard-Panned Candies

The moisture migration that occurs both during and after completion of panning is also important to the quality and shelf life of hard-panned candies. As any experienced pan operator knows, the shell of a freshly-made hard-panned candy has a significantly softer texture than the finished product after moisture equilibration. Despite the drying step in each syrup application cycle, the shell does not complete crystallize during the panning operation nor has it reached its final moisture level. In the same way as soft-panned candies, over time, the water within the shell migrates to reach equilibrium with the center and the surrounding air. Due to the nature of hard-panned centers, however, moisture migration into the candy center may be significantly less important than in soft-panned candies. In particular, chocolate and nut centers take up very little moisture from the sugar shell.

The engrossing syrup in hard panning generally contains up to about 30% moisture (lower for engrossing but higher for smoothing) when it is applied to the tumbling centers in the pan. Since the final water content of the sugar shell is close to 1–1.5% (water activity of 0.3–0.35), almost all of the water applied in the engrossing syrup must be driven off to reach the desired shell conditions. Much of that water is evaporated during the drying cycle, but not all of it. Although no quantitative data have been published on water content at different locations and times during hard panning, it is likely that the water content of the shell is still 3–4%, or higher, at the point when the operator decides another layer should be applied. This water remaining in the shell during panning must diffuse out to the air as equilibration between the sugar shell and the air occurs. If too much moisture remains within the shell, this moisture may carry soluble dyes as it migrates out, leaving the candy surface with a mottled and disfigured appearance. Lake-based colors are often used in hard panned shells to prevent this problem.

Aggressive drying cycles, often used when cycle times must be shortened to enhance product throughput, can cause additional moisture migration problems. When extreme drying conditions (high air flowrates, warm temperatures, and low humidity) are used, each applied layer is likely to contain excess water as the layer approaches the glassy state (Figure 13.14). When the surface becomes glassy, the operator may consider the surface sufficiently dry to warrant the next engrossing syrup application. However, the excess water and incomplete crystallization can lead to moisture migration problems later as the shell goes through the equilibration process.

Moisture migration is also influenced by the continuation of sugar crystallization over time, which further enhances moisture mobility. When sugar crystallizes, the concentration of sugar molecules in the liquid phase decreases (desupersaturation), which allows water molecules greater mobility to migrate through the shell. Thus, both sugar crystallization and moisture loss occur for some time after the candy pieces have been removed from the pan. Adequate time is needed for these processes to be completed before polishing. If the polish layers are applied immediately after panning is completed, before moisture has had a chance to equilibrate, what looks initially like well-polished product quickly becomes dull as moisture interacts with the polish layers. Although waxes and glazes provide some water barrier properties, neither is a complete barrier to moisture. Equilibration with the air occurs even through the polish layers, just more slowly.

In hard-panned candies where the sugar shell and center have different water activities, moisture migration occurs during storage and often leads to the end of shelf life of the product. This will be covered in the next section on shelf life of sugar-panned candies.

13.4.3 Shelf Life

Well-made sugar panned candies can have a shelf life over a year given proper storage conditions. The combination of a tight sugar shell and the polish/glaze layers provides protection against most deteriorative processes. Probably the main mode of deterioration of soft-panned candies is moisture exchange with the environment, most often leading to drying out and hardening of the center. Hard-panned candies are also prone to moisture migration issues if the center has higher water activity than the shell. Other changes (flavor loss, lipid oxidation, etc.) may occur in certain hard-panned confections.

13.4.3.1 Soft-Panned Candies

Soft-panned candies are prone to moisture changes depending on the conditions of storage. With water activities of 0.6 or higher, soft-panned candies like jelly beans and fruit sours are subject to drying out if stored in conditions where relative humidity is lower than about 50%. It is quite common for even a sealed bag of soft-panned candies to get harder over time as moisture is lost to the air. Most candy wrappers are not perfect moisture barriers so that gradual moisture migration through the package occurs during shelf life. As moisture is lost from the candy to the air, the texture of the candy changes. Lower moisture content means harder candy, so soft-panned candies typically toughen during storage until the point where the consumer considers the candy too hard to eat. Use of packaging material with higher moisture barrier properties would allow shelf life to be extended, but the cost of the improved packaging material is often not worth the extension of shelf life.

When stored in excessively high temperatures (35–40 °C; 95–104 °F) and humidity (in excess of 75% RH), soft-panned candies can absorb moisture from the air. Although a good polish/glaze layer provides some level of water barrier properties, over time the moisture can migrate into the shell and cause softening and stickiness. Candy pieces in contact within a bag may then stick together, and when conditions change at a later time (temperature and humidity decrease), the points of contact can cause fusion of candies together. What was initially a bag of free-flowing candies can become a hard lump of candy if exposed to high temperature and humidity for too long a time. Moisture pick up can also lead to running of colors as dye molecules migrate with the water molecules.

Ideal storage conditions for soft-panned candies to minimize moisture migration would be slightly cool temperatures (room temperature or slightly lower) and moderate humidity of about 50–55%.

13.4.3.2 Hard-Panned Candies

Moisture migration is also often an issue for shelf life of hard-panned candies, particularly in those with a water-based center. For example, hard-panned gum centers go through an equilibration process during storage since the gum center typically has higher water activity (0.45–0.5; about 2% moisture content) than the hard-panned sugar shell (water activity of about 0.3 and about 1% moisture content). Over time, moisture from the gum center migrates into the sugar shell as the two tend toward the same water activity, causing the gum to become too firm while at the same time softening the shell. However, external storage conditions can substantially impact moisture migration and shelf life since the candy must also equilibrate with the environment.

Despite the water barrier properties of packaging materials and polish layers, moisture migration between a hard-panned sugar shell and the ambient air also occurs. These barriers slow down the rate of moisture migration, but over long terms of storage, ambient conditions can have significant effect on certain types of hard-panned confections. In principle, an ambient relative humidity above 30% can lead to moisture migration from the air into the hard-panned sugar shell (water activity of about 0.3); however, the rate of migration through the packaging and polish barriers is minimal until ambient relative humidity substantially higher, perhaps as high as 70%. Higher relative humidity of course leads to faster moisture migration.

When exposed to air with relative humidity of 75%, a hard-panned sugar shell can rapidly pick up moisture and soften over time. The crisp bite of the sugar shell is lost as moisture content increases, with the softening due in part to dissolution of sugar crystals, which also dissolves away the inter-crystal bridging of the network of small crystals that give the hard bite. Any moisture migration from the center (as in the gum example) adds to the rate of moisture change and softening of the sugar shell. At the same time, the overall appearance of the candy will change as the polish layer becomes dull and soluble dyes migrate within the shell.

Ideal storage conditions for hard-panned candies are cool (16–20 °C; 60–68 °F) and dry (RH <50%). The low temperatures reduce the rate of moisture migration and low humidity minimizes potential moisture pick up from the air.

13.5 Troubleshooting

Sugar panning is one of the most difficult candy-making practices. Becoming an accomplished panner requires extensive training and practice since there are numerous ways to make mistakes. One trait of primary importance for proper panning is patience. Kitt (1988) provides an excellent summary of panning problems and their remedies.

There are a vast number of parameters that must be controlled during panning and this is, in part, what makes sugar panning one of the most difficult confectionery practices. The parameters that affect panning may roughly be broken down into those that affect the pan or tumbling candy, those that affect the engrossing syrup or the process of syrup application, or those parameters that affect polishing and glazing. Table 13.2 summarizes these parameters.

13.5.1 Soft-Panned Candies

For the novice panner, formation of doubles or clumping is often the most vexing obstacle to making good soft-panned product. Typically, clumping is most often caused either by the addition of too much engrossing syrup prior to addition of the dry powder charge or by addition of engrossing syrup that is too viscous (either too concentrated and/or too cold). Alternatively, engrossing syrup that is too hot can cause double formation from excessive softening of previous layers. Also, centers that were not properly precoated, slow pan speed and delayed addition of the dry powder charge can lead to formation of doubles. Finally, centers with a large flat surface are difficult to pan without forming doubles since it is highly favorable for the flat surfaces of two adjacent pieces to stick together.

A soft or even collapsed shell can be caused by several problems. Soft shells are often due to improper engrossing syrup formulation. Engrossing syrup that is too viscous, improperly formulated (corn syrup ratio too high) or has too much inversion can lead to a soft shell. Collapsed or distorted shells may also be caused by improperly formulated engrossing syrup but is more often attributed to excessive contact forces as the pieces tumble in the pan. Either the candy falls too far onto the bed as it tumbles, bed depth is too high or the pan speed is too high. Very soft or flexible centers are also prone to distortion of the sugar shell, with the tumbling forces causing deformation of the center resulting in excess flexing of the shell.

Rough or uneven surfaces can be caused by numerous factors, generally related either to the engrossing syrup or the dry powder charge. One of the most obvious causes of rough surfaces is that the engrossing syrup does not sufficiently coat the centers. An insufficient amount of engrossing syrup to completely coat the surface may cause rough surface, but addition of too much engrossing syrup may also cause an uneven surface because of the excess amount of dry powder that needs to be added. The engrossing syrup also may be too viscous to coat the surfaces, particularly if it is too cold or at too high a concentration. Rough/uneven surfaces may also be due to improper dry powder charge addition. If too little or too coarse a powder is added, the surface will not reach the desired smoothness. Too much addition of dry sugar can also lead to a rough or lumpy surface since the excess powder collects in the pan, to be picked up with the next charge of engrossing syrup. Finally, a pan rotating too slowly for the nature of the centers may not generate enough collision forces to smooth out the sugar layers, leading to a rough surface.

The texture of a soft-panned sugar shell can vary from very soft to excessively hard depending on the nature of the sugar crystals. Typically, hard shells are caused by excessive crystallization and subsequent bridging as the engrossing syrup equilibrates with the powder charge. Engrossing syrup that is applied at elevated temperature, or has either high sucrose level or water content can lead to excessive crystallization and bridging. Application of drying air during soft panning would also lead to reduced water content, excess crystallization and harder shell. Other potential causes for hard shells may be excessive dust or fines in the pan, use of a sugar granulation that is too small, or too much engrossing syrup addition.

Although typically more a problem with hard panned sugar shells, color mottling may also be a problem in soft-panned candies. Improper dry charge addition may result in excess moisture remaining in shell layers, and later as moisture equilibrates, any soluble dyes will migrate with the water, leading to an uneven color distribution. In certain types of centers with high oil content (e.g., Boston baked beans), oil migration from center to shell can also cause changes in color dispersion. Use of a pre-coat material to seal the centers may be necessary to resolve oil migration issues.

13.5.2 Hard-Panned Candies

Although not as significant a problem as for soft panning, formation of doubles and multiple clumps of centers can also occur in hard panning, and for mostly the same reasons. When more engrossing syrup is added than needed to just coat the centers, the surface becomes excessively sticky and the candies stick together. Clumping may also be due to using engrossing syrup that is too viscous, whether because of high concentration or low temperature. Center shape plays a huge role in double formation in hard panning, with flat-sided centers being most prone to clumping. Finally, sufficient tumbling action is needed to ensure that there are sufficient forces to break up any clumps.

Rough surfaces in hard-panned candies are a common problem, one that can be caused by a number of factors. First, if the center has a rough surface, typically the sugar shell will also be prone to unevenness. Rough-surfaced centers should be adequately precoated to smooth out unevenness to give smooth panned shells. Rough surfaces can also be caused by improper application of engrossing syrup and subsequent drying of the layer. A rough surface can result if the engrossing syrup concentration is too high, if either too much or too little of the engrossing syrup is added or if the applied syrup layer is dried too rapidly (air too fast and/or too hot). Excessive dusting, caused by allowing the product to tumble too long after it has been adequately dried, can also lead to rough surfaces. Factors that cause a rough surface can also lead to formation of holes in the coating. Sucrose-based shells are particularly prone to rough finishes if the engrossing syrup has accidentally grained. When sucrose crystal seeds are applied with the engrossing syrup to the sugar shell, these seed crystals grow to excessively large size during drying and disrupt the microstructure of the shell. Interestingly, if seed crystals are present during dextrose hard panning, the same problem is not observed. Probably the naturally small size of dextrose crystals allows completion of the shell without marring the desired crystalline microstructure.

Cracks that form in the hard-panned sugar shell are often an important concern for candy makers. Any flexing or softening of the center, particularly as temperature changes, can put stress on the sugar shell that can eventually lead to cracking. Controlling and minimizing temperature fluctuations can help alleviate the problem, but pan operators often add low levels (≈1%) of materials like glucose syrup gum arabic or maltodextrin to make a more pliable shell that is better resistant to cracking. Chipping of the sugar shell is also a potential problem, particularly when there are sharp edges and a thin shell is desired. Again, low levels of additives can make the shell more pliable, but reducing tumbling forces can also help minimize chipping.

Another important concern of the hard-panned candy maker is uneven or mottled color. This can be caused by a rough surface, where the color layers take slightly different thickness and impart slightly different hues. However, the problem may also be traced either moisture or oil migration. If the sugar shell is dried too quickly (for example, to reduce cycle time), excess moisture remains within each layer of the shell as the next layer is applied. Over time, each layer of the shell must equilibrate in water content, particularly if additional crystallization occurs over time. When the excess moisture moves to the surface to equilibrate with the environment, it can carry soluble dyes along with it and cause an uneven distribution of the color. Rearrangement of color due to moisture migration is minimized with use of lakes.

If the sugar shell takes an unreasonably long time to dry and/or has a tacky surface, it is most likely caused by impurities in the engrossing syrup that inhibit crystallization. In sugar shells, it is most likely caused by inversion of the sucrose from being held at high temperatures too long prior to use. Acid conditions make inversion worse. In some cases, color dispersions may also impact sugar crystallization.

13.5.3 Polishing and Glazing

A well-polished panned candy is attractive and appealing to the consumer. On the other hand, a poorly polished candy detracts from consumer appeal and negatively affects sales. A dull finish on a polished candy can be caused by any one of several potential problems.

One important consideration in applying a polish or glaze is moisture, both within the shell and in the environment during polishing. It is imperative to make sure the candies have been properly dried and equilibrated after panning has been completed prior to applying a polish or glaze. Often, 1–2 days of curing are needed for soft-panned candies to ensure adequate moisture equilibration. Hard-panned candies can be polished after only a brief period of drying. If panned candies are polished immediately after completion of panning, the migration of water between shell and air causes the polish layer to become dull. As the water molecules slowly diffuse through the polish layer to equilibrate with the air, they disrupt the glaze surface, leading to a dull surface. Polishing is also difficult to perfect when the air in the polish room is too humid. Again, water molecules disrupt the polish layer and make it impossible to attain the desired appearance.

Another enemy of a well-polished panned candy is dust or any other particulate matter on the candy surface. Whether from over-drying or inadequate removal of removal of powdered sugar, the presence of particles on the shell surface disrupts the ability to spread the polish or glaze on the surface. Typically, sugar shells are finished with a low concentration (65%) engrossing syrup to smooth the surface and remove dust and other sugar particles.

Finally, incorrect application of the polish can be cause of a dull surface appearance. Wax layers are particularly sensitive to application levels. If too much wax is applied, it will not develop a satisfactory shine. Wax levels should be about 0.05–0.1% of the batch weight.

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