17 Chocolate Panning

Traditional chocolate panning is the process of applying layers of chocolate coating to inclusions in a rotating pan or drum until the desired coating thickness is reached and the coating has completely solidified. These coated centers are then polished and sealed. Panned chocolate confections have the advantage of being glossy and more resistant to scuffing and melting than enrobed or molded pieces. Here, the phrase 'chocolate panning' will be used, but various forms of compound coatings can also be used with the same equipment to achieve the same approximate finished products.

17.1 Panning Operations

Although called chocolate panning, this process applies to the coating of various centers with either chocolate, compound or yogurt-based coating. The procedures and important points are essentially the same for all three materials. The process of chocolate coating follows the same basic steps as sugar-based coatings (see Chapter 13). After application of a pre-coating (where necessary), multiple layers of chocolate are built up by sequential addition of liquid chocolate followed by adequate time for solidification. While composition may vary somewhat, two parts chocolate to one part center is typical for panned pieces. Equal proportion of coating to centers is sometimes used to reduce cost and, in some instances, to allow part of the center to show through. Once a sufficient chocolate shell has been built up on the center, the pieces are polished and glazed to give an attractive, shiny appearance. The general cross-section of a chocolate-panned confection is shown in Figure 17.1. The four layers put onto the center include pre-coating (optional), chocolate shell, polish, and seal coating layers.

17.1.1 Centers

Centers for chocolate panning come in a wide variety. They may be fruits (raisins, cranberries, etc.), nuts (peanuts, almonds, cashews, etc.), sunflower seeds, coffee beans, specialty centers (cereal pieces, corn nuts, cookie dough, etc.) or candy. Typical candies that may be used include fondant, caramel, malted milk balls, and jelly candies.

For consistent product quality and an efficient operation, the following parameters should be considered and controlled (where possible):

- Size: Center pieces for chocolate panning may be as small as a few millimeters (e.g., sunflower seeds) to as large as a couple centimeters (malted milk balls). Smaller pieces tend to be a little more problematic to coat well, particularly in terms of tumbling action. Probably most important about size is that all the pieces in the pan are about the same size. Having

R.W. Hartel et al., *Confectionery Science and Technology*, DOI 10.1007/978-3-319-61742-8_17

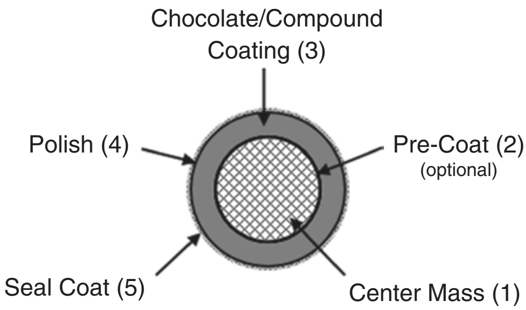

Figure 17.1 Cross-section of typical chocolate-panned candy

consistent sized inclusions makes it easier to maintain individual panned pieces rather than doubles and clusters. It also allows for uniform coating on all pieces. Also, particle segregation within the pan may occur if there are different sized centers, especially in traditional rotating pans.

- Firm texture: Firmer centers make the panning operation more efficient. When panning with soft centers, flexing may occur and the chocolate shell will break away. This is often seen in raisins that are high in moisture or damaged during the cleaning process. Having a smaller bed depth in the pan or pre-coating can help alleviate some of the flexing issues when panning soft centers.
- Density: Center pieces for chocolate panning vary widely in density, from quite low (e.g., malted milk balls) to very high (e.g., almonds). Lighter pieces may result in more problems, particularly if tumbling action is not uniform. Centers should have uniform density to avoid segregation during tumbling.
- Round: Centers should be as round as possible and have minimal flat sides or points. Round centers allow for a uniform spreading of chocolate into a thin layer, uniformly coating the entire piece. It is often difficult to pan centers that have flat sides or points. Centers with flat sides have a tendency to stick together and become doubles. Panning products with pointed ends are often difficult to cover with coating as seen in some almond pieces. This can be solved by using the correct combination of chocolate temperature, viscosity and cooling. Pieces with concave surfaces are notoriously difficult to pan; pre-coating these centers is critical to getting uniform coverage.
- Surface irregularities: Chocolate coating works best on smooth centers, but this is not always possible. Surface irregularities are natural in certain products (e.g., raisins, almonds, coffee/espresso beans, etc.) and must be filled in completely to produce a high quality piece.
- Temperature: To ensure proper setting of the chocolate or coating, the centers should be neither too hot nor too cold. Typically, temperatures between 15 and 25 °C are best. Warmer temperatures do not allow rapid solidification of chocolate, whereas colder temperatures may cause undesired solidification of chocolate into the wrong crystal polymorphic form. Centers should generally be tempered to the panning room temperature.
- Minimal free moisture or fat: Migration of either water or fat into the coating can cause shelf life issues. Moisture is particularly problematic since chocolate does not stick very well to a wet surface, but even liquid oil (e.g., nut oils) can cause adherence problems. These problems are minimized by using a pre-coating layer.
- Dust. Centers should be as free of dust particles as possible. Dust and free powder (often from precoating) should be minimized to prevent an increase in the coating viscosity. This may also lead to an uneven coating shell and small, coated balls of powder that will become waste product.

The ideal center for coating with chocolate would meet all of the above requirements. Unfortunately, most centers for coating with chocolate do not meet all the requirements. In general, the easiest centers to chocolate pan include malted milk balls, caramel balls and round-tipped almonds, with the most difficult being sunflower seeds, espresso beans and cashews.

17.1.2 Chocolates and Coatings

A wide range of coating materials can be found. These include the three main types of chocolate (dark, milk, white) and a variety of compound coatings.

17.1.2.1 Chocolate

Standard of Identity chocolate (see Chapter 15) is often the coating of choice for panned goods. The claim of "real" chocolate on the label is generally a good marketing point. The choice of dark, milk or white chocolate is governed by consumer demands. Many commercial panned products are made with milk chocolate, primarily based on consumer demand. However, dark and white chocolate panned goods are also widely available.

Choice of chocolate for use in panned goods is often based on several factors (Copping 1996). These include the desired quality of the product, based on the target consumer, and at what cost. Viscosity range is also critical (see below for more details). An additional factor is rate of solidification since that is the major determinant in panning times.

Typically, dark chocolate solidifies quite rapidly, but that depends on the nature of the fat phase since cocoa butters from different origins are known to solidify at different rates (Marty-Terrade and Marangoni 2012). Malaysian cocoa butter typically crystallizes more quickly into a harder chocolate than Brazilian cocoa butter, which takes longer to set and gives a softer coating. West African cocoa butter falls between these two, but is generally soft (Copping 1996).

If milk fat is used in the dark chocolate, the rate of solidification is reduced (Metin and Hartel 2012) and the panned layer is softer. Of course, milk chocolate contains milk fat, so it also has a slower rate of crystallization. White chocolate often contains a high level of milk fat and solidifies at a slower rate. In fact, white chocolate is generally quite soft and may be harder to work with than dark or milk chocolate.

17.1.2.2 Compound Coatings

Numerous choices are available if Standard of Identity chocolate is not needed. Compound coatings (see Chapter 16) come in a wide range of flavors, types and formats. In addition to the standard dark, milk and white coatings, other choices include yogurt or carob-based coatings.

Several advantages arise from using compound coating for panned goods over chocolate-based coatings. First, greater control over the fat phase is possible, with a wider range of melting points and solidification rates. The confectioner can select coatings with specific fat composition to enhance solidification rates and control coating hardness. A second advantage is the possibility of adding colors and flavors. However, one of the usual advantages of compound coatings over chocolate, namely that tempering is not needed, does not apply in panning since chocolate can be applied untempered with no negative effects.

Similar factors as discussed above influence choice of coating for panned goods. Quality, consumer demand and cost are still primary choices, as is rate of solidification. Again, the confectioner has a wide range of options from which to choose to find the best coating for use in panned goods.

17.1.3 Pre-coating

Pre-coating needs for different centers depend on the nature of the surface to be coated with chocolate. Of particular concern are moisture (e.g., fruits) and incompatible oils (e.g., nuts), which must not be allowed to come in direct contact with the chocolate coating. If such products are not pre-coated, the candy maker runs the risk of having bloomed product as both moisture and nut oils can migrate into the shell coating and lead to bloom.

Pre-coating of centers for chocolate panning, as with sugar panning (see Section 13.2.2), typically calls for application of a gum or starch solution followed by dry powder addition to seal the center. Regardless of whether the pre-coat is intended to protect against moisture or oil migration, the solution component is typically gum arabic or modified starch. These provide decent barrier properties against both moisture and oil. The pre-coat solution must be at the appropriate viscosity to give good coverage of the center. Typically, solutions of 40–50% dissolved solids content are used. Several layers of coating solution are applied to the centers tumbling in the pan, with dry powder addition between each solution application. Dry powders added may include starch, sugar or cocoa powder. After the pre-coat has been applied and allowed to dry, the chocolate coating application can begin.

17.1.4 Chocolate Coating Application

To ensure good coating and solidification of the chocolate shell, the temperature and relative humidity (RH) of the air applied into the pan must be controlled to insure consistent successful panning. The exact air temperature and RH will be dependent on the coating, centers and equipment, but generally range from 7 to 15.5 °C (45–60 °F) and 35–50% RH. It is essential that there is no condensation of moisture from the air to the product.

Melted chocolate or coating is applied at a temperature that depends on the application method. For chocolate, hand ladling is applied at 32–35 °C (90–95 °F), whereas ≈40.5 °C (105 °F) and ≈43 °C (110 °F) are used for drip and spray nozzle applications, respectively. Compound coatings are usually applied slightly warmer (as high as 46 °C/115 °F) to achieve a smooth finish. Chocolate need not be tempered prior to application in panning since the tumbling process promotes formation of stable cocoa butter polymorphs (see Section 15.5.5) and bloom is usually not a problem. When tempered chocolate is used, it will usually set too fast, resulting in an uneven, rough coat and excessive adherence to the sides of the pan.

A critical parameter to control in chocolate coating, as in sugar coating, is the viscosity of the coating material. Viscosity of chocolate or coating must be of the right fluidity to provide adequate and complete coverage of the pieces. Chocolate is a non-Newtonian fluid and there are two parameters, yield stress and plastic viscosity, that govern flow and coating ability (see Chapter 15 for more details). In panning, both parameters are important, although the yield value, or the force required to initiate flow in the chocolate, is critical to the thickness of the shell being applied (Aebi 2009). Viscosity must not be too low or the centers will not tumble well in the pan nor will sharp edges (on almonds for example) be adequately covered. Conversely viscosity must also not be too high or inconsistent coverage of the centers will occur. Furthermore, application of high viscosity chocolate will cause excessive coating on the inside of the pan, resulting in ingredient losses. The main parameters that affect chocolate viscosity are temperature, fat content, emulsifier type and content, moisture content and particle size of the chocolate or coating. These must be controlled to give the desired viscosity for proper chocolate panning. See Chapter 15 for more details on the effects of these parameters on chocolate viscosity.

Typical viscosity values for chocolates and coatings used depend on the centers being panned, equipment used, and air and room temperatures/relative humidity. However, target values are about 70 Poise (7,000 cP), with a range from 50 to 90 Poise (5,000–9,000 cP; or approximately 35–45 Brookfield reading using the NCA viscosity method; Copping 1996). As noted above, chocolate with a yield stress on the lower side is preferred for panning work to ensure proper spreading of each application onto the center.

Chocolate may be applied by either hand ladling, drip feeding or spray nozzle, depending to some extent on the size of the candy facility. Typically, smaller facilities tend to use hand application and larger facilities favor drip feeding or spraying. Hand ladling involves application of the proper dose of chocolate along (front to back) the base near the top of the tumbling mass in the pan. In drip feeding, the chocolate is pumped through pipes to nozzles just above the bed of tumbling centers in the pan, where the chocolate is allowed to drip onto the centers. Spray feeding requires pumping the chocolate to a spray nozzle where the liquid coating is atomized to coat the centers. The spray nozzle is mounted above the tumbling centers in the pan with the chocolate spray aimed at the tumbling pieces. The advantage of the spray nozzle is that it greatly reduces the tendency to form doubles (or clumping); however, care is needed to ensure that the chocolate does not cool in the nozzle to plug up the lines. Further, the spray pattern must be controlled to achieve even coating. Regardless of the method of chocolate application, but especially in spray or drip feeding, proper temperature control of the coating is critical to good panning (adequate coverage without excessive clumping).

To build the chocolate shell in panning, sequential doses of chocolate are applied to the tumbling centers with each liquid application followed by a period of cooling and solidification. The amount of coating used in each application dose must be high enough to ensure good surface coverage without being too large to cause excessive clumping of the centers. Groves (1992) suggests starting with 2.5 kg (5–6 lb) of chocolate per 45.5 kg (100 lb) of centers, increasing to 4 kg (8–9 lb) per 45.5 kg (100 lb) of centers as the shells builds and surface area increases. These numbers must be modified slightly for different initial surface areas of the centers. After application of the liquid chocolate and sufficient coverage of the centers, cooling air is blown into the pan to promote solidification. Spray systems generally have air blowing at the same time, and the chocolate spray is constantly on throughout the run.

As mentioned earlier, air conditions are important to making high-quality chocolate panned products. Room air should be cool (15.5–18.4 °C; 60–65 °F) and reasonably dry (40–55% RH). Cooling air directed into the pan is generally cooler (7–15.5 °C; 45–60 °F) and drier (<35–50% RH) to ensure proper solidification without the risk of moisture condensation. The air should be filtered to insure products are safe from microbiological or other contaminants. Air velocity must also be controlled since cooling requirements may be different depending on the stage of panning. Generally, a recommended air flow rate is 500–850 m^3 per hour (300–500 ft^3 per minute). Chocolate panning under adverse conditions (warm, humid air) generally results in poor quality products with low production output.

Typically, from 5 to 10 min is needed to ensure adequate solidification of one layer prior to application of the next dose of chocolate. Coating materials should be selected with solidification rate in mind. The application and solidification cycle continues until the desired shell layer is built up on the piece, with panning times anywhere from 0.75 to 2 h. More rapid solidification can be induced by use of a vaporizing refrigerant like carbon dioxide (dry ice) or nitrogen, although this leads to a rough surface that must be smoothed out by tumbling the pieces in the pan to allow frictional heat to melt the rough spots. Furthermore, release of compressed gases requires that safety and environmental codes be satisfied. Condensation can also occur when using this method, which will result in the shell to soften.

Often, a smoothing step is used to ensure an even coating with a smooth surface. Here, the pan is tumbled without air flow to allow any irregular chocolate surface structures to become smoothed out.

Once the desired chocolate shell has been applied, the candies are often held in pans to allow for sufficient solidification time to provide a good base for finishing. When ready, the candies are returned to the pan for polishing and glazing. Some of the large automated panning systems have eliminated this solidification step.

17.2 Pan Types

There are three basic systems for panning: conventional or traditional revolving pans, belt coaters and automated pans. All three methods of panning follow the same basic procedures and processes of building a coating layer, polishing and sealing coating.

Conventional revolving pans (Figure 17.2) come in various sizes and shapes but most common are the round pans and tulip pans. These pans are usually at an angle (about 25°), sometimes with a variable pan rotation speed. The pan rotational speed depends on the pan size and design, the type of centers that are being panned and whether the process is building the chocolate layer or the final polishing stage. Traditional panning rooms have one set of pans for building the coating layer (engrossing) and another set of pans (ribbed) for polishing and final seal coating. While conventional pans are very versatile and economical, they require more operator skill and production is more limited (160–225 kg; 350–500 lb) than panning with a belt or automated drum pans.

Belt coaters are widely used for chocolate panning (Figure 17.3). Belt coaters have an endless belt that forms a 'pocket' for the centers to be

Figure 17.2 Typical tulip-shaped revolving pan (Courtesy of Latini)

Figure 17.3 Belt coater for chocolate panning (Courtesy of Schebler)

coated. The movement of the belt causes the product to fall back upon itself to cause the rotational effect to build up the chocolate layer as the chocolate is applied. After engrossing, the belt is reversed to unload the product. It is then transferred to rotating pans or another belt coater for polishing and sealing. Production volumes are usually higher than rotating pans, but lower than automated pans. Ranges from 225 to 450 kg (500–1000 lb) are common. These pans are well

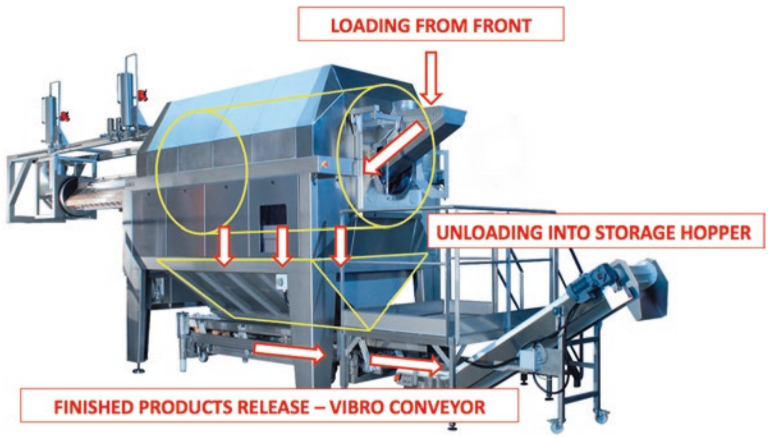

Figure 17.4 Chocolate coating drum (Courtesy of Dumoulin)

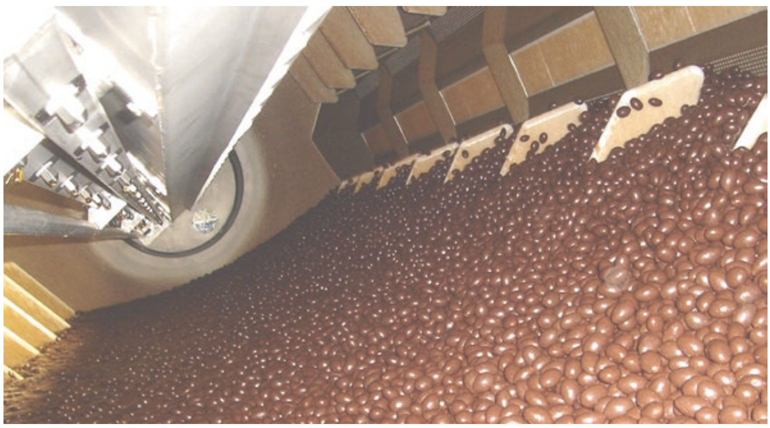

Figure 17.5 Inside of a drum coater showing tumbling pieces. Spray nozzles (not operating) can be seen at *upper left*, above the candy pieces (Courtesy of Dumoulin)

suited for the midsized manufacturer that wants economical, consistent product with less operator artisanal skill required. Polishing results with a belt coater may be more challenging than with a revolving pan.

Automated pans have a large rotating drum with controlled conditions that can supply the needed powders, coating, polishing, conditioned air and sealing agents in a precise manner. They are self-contained units with spray bars, nozzles, feeders, baffles and vents to accomplish this (Figure 17.4). Figure 17.5 provides a glimpse of product tumbling in a drum coater. With their large size, it is possible to have a smaller bed depth that will prevent crushing of centers that are fragile or flexible such as seeds or raisins. While many of the automated pans use one drum for engrossing and one for polishing and sealing, it is possible to do all these operations in one drum. Typical batch sizes for automated pans range from 450 to 2270 kg (1000–5000 lb).

While all three methods can produce high quality candy, product quality will always be dependent upon the consistency of the starting materials, operating conditions, and operator skill.

17.3 Finishing

Once the center has been coated, various finishing options may be chosen. The standard finish is to polish and glaze, but other options exist. These include finishing with powdered sugar, cocoa, a hard sugar-shell, spices, or speckling.

17.3.1 Polishing

Polishing of panned products creates a glossy appearance for customer appeal. A glossy appearance cannot occur unless the panned centers are smooth, firm and free of dust. For batch revolving pans the centers are put into a ribbed pan so that the pieces can be picked up by the sides of the pan to provide adequate tumbling action. This tumbling action with a polishing agent causes a shiny gloss to the finished product. Polishing agents are usually water based and include gums, starches or dextrins. While they can be made in-house, they can also be purchased premade with a blend that contains the desired properties. The dosage for polishing materials depends on its formulation, the size of the centers and equipment used. Typical starting point is 0.20–0.50% polishing solution that is usually about 60% solids.

The polishing solution is applied to the centers and the pan is rotated to evenly spread the solution. Conditioned air is then applied to dry the solution and develop a gloss while tumbling. Two to three doses are usually required to develop a sufficient sheen.

17.3.2 Glaze Coat

Once an acceptable gloss has been obtained it must be protected. The most common method to maintain gloss, provide a moisture barrier and to a small degree some heat resistance to the coating is to use confectioners glaze. Confectioners glaze is an edible shellac dissolved in alcohol that may also contain other minor functional ingredients.

The traditional method is to apply approximately 0.15–0.20% seal coat to the centers and rotate the pan until they are coated. Rotation is stopped and conditioned air is applied to dry the glaze coat. The pans are occasionally turned to prevent massive clumping. When dry, the rotation of the pan resumes for a short time to remove "kiss-marks". The addition of other ingredients to the confectioners glaze, such as oils or mono and diglycerides, will allow for continuous rotation of the pans to seal coat the centers. While seldom used in present panning operations, the use of waxes (beeswax or carnauba) can be used as an alternative to confectioners glaze.

17.3.3 Hard Sugar Shell

Some chocolate panned items will be finished with a sugar shell instead of the typical high gloss appearance. This procedure will make the finished product somewhat heat stable and is often seen on seasonal products such as Robins egg malted milk balls. Chocolate-coated nuts and seeds often have a hard panned sugar shell applied to the outside (Chapter 13). As with any sugar panned chocolate product, panning conditions require temperatures below the melting point of the chocolate layer. It is common to apply polish and glaze layers to the hard panned sugar shell in the same manner described above, but using a wax-based polish rather than a water-based polish.

17.3.4 Powdered Finishes

While the majority of panned items are polished and seal coated for a glossy appearance, some are made with a 'matte' finish. After the engrossing steps are completed and the product has a smooth surface, a powder such as cocoa or sugar is introduced into the rotating pan. These powders, sprinkled onto the last layer of chocolate application, are incorporated into the coating layer by the tumbling forces to give the desired finished appearance.

17.4 Storage and Handling

After the panning process is completed the centers are often stored in pans or totes before packaging. They are typically stored in an area with a temperature range of 15.5–20 °C (60–68 °F) with a RH of 40–50%. Higher RH will result in the pieces sticking together while a lower RH can result in the cracking of the seal coat due to drying. Gentle handling techniques should be employed until the panned confections are packaged where they will have protection from the environment.

Like other chocolate items, they should be stored in sealed packaging with good moisture and oxygen barriers. Storage conditions should be odor free with typical temperatures of 18 ± 2 °C (64 ± 4 °F) with a RH of 45 ± 5%. While chocolate-panned items are more resistant to heat than molded and enrobed chocolate pieces, extreme heat exposure will cause fat bloom and product deformation.

17.5 Trouble Shooting

Consumers expect a consistent high quality product. As in any operation, there are challenges that can result in unacceptable product. The following are some common defects found with chocolate panning and suggested solutions needed to correct the problems (Copping 1996).

17.5.1 Incomplete Coverage

If the pieces are not completely coated with chocolate coating, leaving bare spots, it is likely that the coating was either applied at too low a ratio (coating to center ratio) for the surface area of pieces or it was not able to adequately spread before it cooled and set. If the proper level of chocolate coating was added, perhaps the viscosity of the coating was too high and/or its temperature was too low. Increasing temperature might eliminate the problem. Air flow and temperature may also be the problem, causing the chocolate coating to solidify too rapidly, before it could spread evenly. A pan that is rotating too slowly could also contribute to this problem.

17.5.2 Poor Coverage

Pieces that are not evenly covered could be caused by uneven centers or a low coating to center ratio. For centers that are not uniform in shape or have cracks and crevices, a good pre-coating layer application can help smooth out the surface onto which the chocolate coating is applied. Increasing the amount of chocolate coating applied or reducing coating viscosity might also help spread the coating uniformly before it solidifies.

Exposed surfaces may also be caused by sharp edges, such as the point edge of an almond. If rounded-tip almonds cannot be used, alternatives include ensuring there is good pre-coat for the chocolate coating to adhere to and that the viscosity of the coating is properly set. If the chocolate coating is too warm, it will not adhere to that sharp point. Making sure that the first applied chocolate layers are well set will also help.

17.5.3 Bumpy/Rough Surface

When the chocolate coating layer is rough or bumpy, several factors may be considered. For one, the chocolate coating could be too thick so that it does not spread uniformly before it begins to set. Raising the temperature of the chocolate coating will help reduce viscosity and smooth out the applied layer. Air that is too cold could also cause a rough surface by causing too rapid solidification of the chocolate coating. Rough surfaces may be smoothed out by turning off the cold air and allowing the pieces to tumble. The heat generated during tumbling will soften the coating, allowing it to smooth out.

17.5.4 Chocolate Not Sticking/Peeling

Probably the main cause of a chocolate coating either not sticking or peeling off the center is the lack of a pre-coat. When a chocolate coating is applied on top of a moist surface (as in some fruit centers), it will not adhere to the surface. A good layer of pre-coating to bridge between oil and water should allow the first layer of chocolate coating to adhere and help the problem.

Chocolate coating not sticking to the center can also be caused by too thin a viscosity. Possible causes of this might include coating temperature too high, air temperatures too high or centers being too warm. Other potential causes include pan speed too high, centers too soft, or a heavy load in the pan.

17.5.5 Doubles

A common problem is that pieces stick together to form doubles or even clusters. Not allowing the chocolate to solidify properly before adding more is the most likely reason. Another common cause of doubles is that the chocolate coating is added too fast so that it does not spread into a uniformly thin layer. The proper coating to center ratio is required for proper pan operation. Doubles may also be caused by a chocolate coating that is too thick. Reducing viscosity, for example by raising the coating temperature, or switching to a spray system can both potentially help this problem. Pieces sticking together may also be caused by a pan that is turning too slowly. Check that proper pan rotational speed is being used.

17.5.6 Crushed Centers

Centers that break during application of a chocolate coating are generally caused by having too heavy a load in the pan for the sensitivity of the center. Reducing pan load should help.

17.5.7 Bloomed Pieces

Although bloom on panned chocolate pieces is rare, there are some instances when bloom can appear on panned goods. This is usually related to incompatible fat systems; for example, a nut oil migrating into a chocolate shell. To prevent this, a good pre-coat layer is needed to help limit migration. Another possible source of fat bloom is storage or transportation conditions that are too warm.

Although numerous problems can arise in chocolate coating, it is actually considered the easiest panning method to learn. In general, chocolate coatings are relatively forgiving and problems more easily rectified.

Acknowledgment Thanks to Michelle Frame (Victus Ars) for providing input on this chapter.

References

Aebi M. Chocolate panning. In: Beckett ST, editor. Industrial chocolate manufacture and use. 4th ed. Oxford: Wiley-Blackwell; 2009. p. 374–5.

Copping T. Basics of chocolate panning. In: Proceedings of 50th PMCA production conference, Hershey; 1996. p. 115–23.

Groves R. Chocolate panning. In: Proceedings of the 46th PMCA production conference, Hershey; 1992. p. 135–40.

Marty-Terrade S, Marangoni AG. Impact of cocoa butter origin on crystal behavior. In: Garti N, Widlak N, editors. Cocoa butter and related compounds. Champaign: AOCS Press; 2012. p. 245–74.

Metin S, Hartel RW. Milk fat and cocoa butter. In: Garti N, Widlak N, editors. Cocoa butter and related compounds. Champaign: AOCS Press; 2012. p. 365–92.