Chocolate Behavior — What Influences Your Selection?

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Chocolate behavior—what do we mean when we say this? How does chocolate act in the many processes used in the confectionery industry? I will be touching on some of the issues that relate to changes in chocolate behavior and that influence your chocolate selection.

What issues need to be considered for chocolate selection based on application and what influences chocolate behavior in these applications? What should we be looking for? Many of these issues have been talked about before, but I want to try to give the practical aspects of why chocolate acts the way it does.

CHOCOLATE SELECTION

First, let's talk about chocolate selection. The main issues to consider when selecting a chocolate are application, chocolate type, viscosity, fineness, color and flavor. Each of these items has an influence on how the finished piece will appear to the consumer.

The first consideration is the chocolate application. Is it for hollow or solid molding, enrobing, hand-dipping, one-shot depositing, panning or for the manufacture of chocolate chips?

The chocolate type in any application needs a balance between the chocolate and the center. Milk chocolate can stand on its own and goes well with peanut butter, caramel, nuts and inclusions. White cocoa butter based chocolate coating with just a hint of chocolate aroma is often used for contrast in boxed goods or for its rich dairy, vanilla flavor. Dark chocolate is more robust and aromatic and pairs better with tart fruits, strong coffee, liqueurs and mint centers. Compound coatings are used for their cost, functionality and support in confections.

Viscosity, or how the product flows, is key to many confectioners when selecting a chocolate. The correct flow properties influence how the product will work in the given application.

Fineness selection is typically based on what the chocolate will be used for and what market is being targeted. For example, if a smooth, creamy center is being coated, one could easily be distracted if a coarse

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coating is used. On the other hand, a coarse coating would not be noticed on chocolate containing noisy inclusions such as crisp rice, oats or nuts.

The next item to be considered in chocolate selection is color. Since our first taste of any food is with our eyes, the color of a chocolate gives us some indication of what to expect. Color is determined by the type and amount of chocolate liquor, sugar and dairy ingredients in a chocolate coating, hence formulation.

Flavor is often considered to be the determining factor of whether or not a product will make it in the market. The correct balance of acceptable attributes helps to determine the success of any product. There are some 9,000 taste buds on the human tongue, each containing 15–18 sensory cells. Flavor perception and preference might be completely different from one consumer to another, so pleasing flavor is definitely an important issue for the correct chocolate selection.

CHOCOLATE BEHAVIOR

What determines behavior of chocolate or how the chocolate will perform? Following are some factors determining the behavior of chocolate:

- Product flow
- Fat content
- Particle size and distribution
- Equipment
- Moisture

Let's concentrate on flow properties of chocolate and particle size due to their great influence on chocolate behavior and also chocolate selection.

Viscosity

Viscosity is a measurement used to describe the flow properties of a product. Some ways of measuring viscosity are the MacMichael, Brookfield and Haake methods. All of these methods are used in industry today, with Brookfield being the most common.

The MacMichael is a single-point system. The product is measured at a specific temperature, using a specific bulb diameter and depth. It gives a number indicating how thick or thin a product is, but does not tell a lot about the flow characteristics of the product. This is not as commonly used today, but the original numbers generated from this method are still referred to when selecting a specific coating. For example, a 65 viscosity refers to hollow molding, a 145 viscosity might be used for enrobing and a 200 viscosity for solid molding.

The Brookfield viscometer or rheometer can give MacMichael numbers, but it can also give a more complete measurement of the chocolate performance or flow properties. Brookfield and Haake take a sample at a specific temperature and then readings are taken at increasing rates of shear ranging from 1 to 50 rpm, followed by similar readings at decreasing speeds. Using Casson's calculations, viscosity is determined.

Rheology is defined as the study of the deformation and flow of matter with stress. Viscosity is the name given to the internal friction of fluids. Essentially, there are two types of liquids — Newtonian and non-Newtonian. Newtonian fluids are independent of shearing. Examples would be water, alcohol, liquid fat or glycerol.

Chocolate is non-Newtonian and its viscosity is affected by the presence of solids in suspension. Chocolate is often referred to as a suspension of particles in a fat phase. Therefore chocolate viscosity will decrease with increasing rates of shear. This is why the Brookfield and Haake rheometers will give more accurate measurements of flow properties due to procedural shearing at a given rpm indicating a product's resistance to flow. The MacMichael will not be able to shear the entire sample between the gap and the wall of the sample cup; it is only measuring the torque at a given rpm. Think of the friction created when sliding a deck of cards back and forth or the friction created between sugar and cocoa particles in a fat phase. These products need a force to start them to flow. This is known as yield value. More specifically, the yield point should be redefined as the shear stress at which not only deformation occurs but stationary flow begins.

Yield value is reported in dynes/square centimeter. Plastic viscosity is then the force needed to maintain this flow once it is moving, which is known as poise. Brookfield can measure these values, known as Casson values. Yield value has a number of practical aspects. For example, a high yield value is needed for drops so the curl will stand up on the drop and not produce a flat-looking drop like a disc. Also, a high enough yield value is needed in enrobing to prevent decorations from collapsing and to avoid feet formation on the bottom of pieces, in other words, so chocolate will flow over the piece and not off the center. A lower yield value is desired for molding, especially with inclusions, so proper shakeout can occur and removal of air pockets is successful. A low yield value is also desirable for enrobing bakery items.

Yield Value Influences

Proper emulsification in the chocolate mass is necessary to aid in yield value reduction. Lecithin was introduced to the industry over fifty years ago. It is primarily extracted from soybean oil. Lecithin has both lipophilic (fat loving) and hydrophilic (water loving) properties. This surface-active agent greatly affects chocolate fluidity. The degree of flow is dependent on the ease with which the solid particles are able to move over one another within the liquid phase, which is cocoa butter. Lecithin is an economic value to chocolate due to the ability to manufacture chocolate with less cocoa butter. The time and amount of lecithin is critical for its full effect on changing viscosity. It is best to add lecithin as late in the process as possible so it does not bind up moisture and maximum cocoa butter has been made available through the conching process. An addition of 0.1–0.3 percent has the same viscosity-reducing ability as ten times the amount of cocoa butter. Too much lecithin will cause the viscosity to increase (>0.5 percent). Polyglycerol polyricinoleate (PGPR) and ammonium phosphatides (YN)—manufactured from rapeseed oil—are also known to greatly reduce viscosity. Their usage depends on the legislation of the particular country.

Percent moisture, fat content and particle size also influence yield value. Figure 1 shows a comparison of percent fat in chocolate, plastic viscosity, yield value and MacMichael number. As you can see in Figure 2, the yield value and plastic viscosity for solid items are the highest. The yield value and plastic viscosity decrease with increased fat, which would correlate to different applications in confectionery manufacturing such as enrobing, hollow items and panning. Actual values for yield value and plastic viscosity need to be determined based on what will work best in your specific application and equip-

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Percent Fat versus Viscosity Measurement

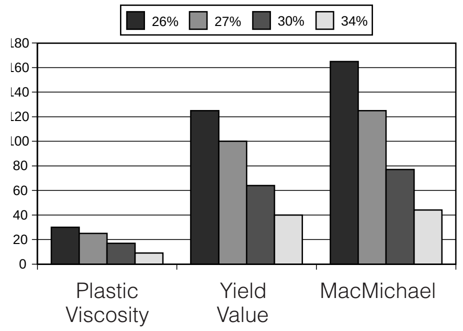
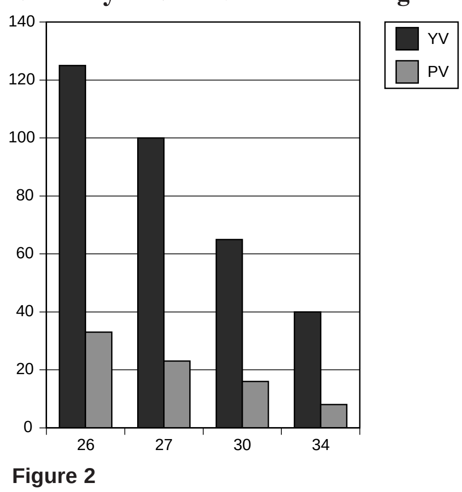


Figure 1

Viscosity at Various Fat Percentages



Four samples

Decreasing yield value with added fat

26 percent solid items
27 percent enrobing
30 percent hollow
34 percent panning

Figure 2

If the particle size distribution shows large amounts of fines in the analysis, more cocoa butter will be needed to get to a specified viscosity.

ment. An experimental design might be to measure the plastic viscosity and yield value when a product line is operating within tolerating limits. This way you can develop a range of values that will work for the given application. Working with manufacturers of ingredients and equipment will also help this be successful. The following issues also influence the flow-property behavior of chocolate:

Temper — the lack of control of temper can destroy any specifications already set for plastic viscosity and yield value.

Vibration — this is needed to remove excess chocolate and air bubbles; it is the level of vibration that is important, based on the yield value of the product.

Method of manufacture — whether the product is one-stage or two-stage refined.

Degree of conching — releasing the most available cocoa butter for viscosity reduction.

Particle Size

Next, let's look at particle size and distribution and how they can influence chocolate behavior. We have already discussed how particle size can influence our selection of a given chocolate for the application and the sensory experience, so let's look into what this means when we talk about chocolate performance. A particle is any object having definite physical boundaries in all directions without respect to size. Traditionally, fineness (how coarse or fine) of chocolate was determined by a handheld micrometer measuring only the largest particle in the sample. The chocolate is mixed with mineral oil and placed on one anvil of the micrometer. The anvils are then closed to a certain pressure to give a fineness in either ten thousandths of an inch or in microns. This method measures the diameter of some of the larger particles in the chocolate. This is used to evaluate refining grade if the primary concern is mouthfeel. It does not, however, describe anything about the size, shape or amount of fine particles. This number is still used today to specify how coarse or fine the chocolate needs to be.

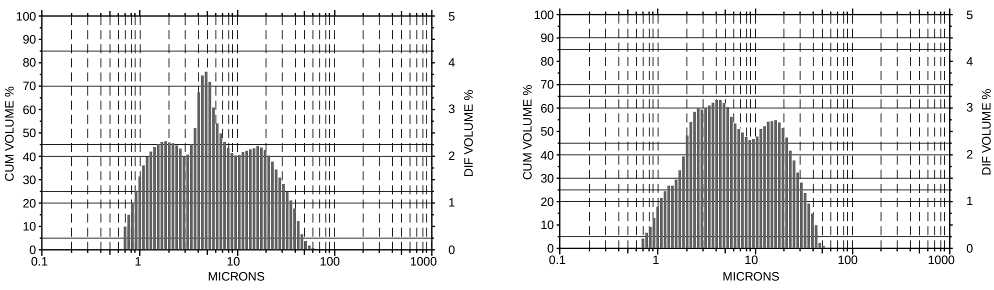
Laser light-scattering measuring equipment has been developed and is widely used for determining the particle size distribution of a mass. This will identify the size and amount of all particles within the determining range of the instrument. The mass is suspended in a surfactant and injected into the unit. Particles will diffract the laser beam at different angles depending on their size. The laser beam is focused on a field of particles and then the angle of diffraction is observed. Smaller particles diffract light at wider angles and different intensities than larger particles. This type of analysis can tell us the distribution of the particles, information that is needed to evaluate fat requirements, yield value and mouthfeel.

Let's look at these three issues with respect to particle size. Cocoa butter is the most expensive ingredient a chocolate manufacturer has in a chocolate formulation. If the particle size distribution shows large amounts of fines in the analysis, more cocoa butter will be needed to get to a specified viscosity. This difference in grind could be related to equipment used to manufacture the chocolate.

Single-stage refining, for example, will give more fines than two-stage refining, as shown in Figure 3. The amount of fines will contribute to more surface area and create a system that will need more fat to coat all of the particles. On the extreme, large amounts of coarse particles will contribute to a lower fat content. A bimodal particle size distribution is what the chocolate manufacturer is looking for due to different particles having different strengths and breaking down differently.

In a paste to be refined, there are particles of chocolate liquor, sugar and possibly milk. The chocolate liquor will most likely already be ground to release available fat, therefore, particles to be ground by the refiner are sucrose and milk powder. Sucrose particles are typically ground by abrasion (friction) and milk powder principally by fracture (rupturing cells).

Single-stage versus Two-stage Refining



Single-stage

Two-stage

Figure 3

It is important to select the chocolate that complements the end product to be manufactured.

Due to these differences, a bimodal particle distribution will be seen during refining. Because of this, some fine particles are needed to fill the voids created by the larger particles, referred to as packing efficiency. The total fat content can be altered by this particle packing. If particles can pack tightly, not as much cocoa butter will be required.

Yield value in products is also directly affected if the particle size distribution is altered. It will pretty much be changed the same way when total fat has to be increased, as shown in the discussion on flow properties. There are times and certain applications that are ideal for generating more fines, to help increase yield value.

Mouthfeel may not be considered a behavior of chocolate, but it does influence how the product melts in your mouth. Typical fineness values shown in Figure 4 give an idea of what specifications might be required for mouthfeel. This is more for what the palate will detect. Most individuals will not detect particles less than 20–25 microns on their tongue.

When the amount of fines—meaning smaller than 10 microns—increases too much, you will get a gummy or clawing feel in your mouth similar to peanut butter. This could be objectionable and would need to be considered for the specific application.

CONCLUSION

As you can see, some of the issues in selecting a chocolate for a given application are also issues in chocolate behavior—mainly flow properties and particle size. It is important to select the chocolate that complements the end product to be manufactured, and decide the quality parameters necessary together with the ingredient and equipment manufacturers that will best meet your needs. The final evaluation of the chocolate, of course, will be in the actual piece intended for consumption. So go forth, with ideal chocolate behavior, and make sweet confections!

Typical Fineness Values

	Microns
Truffles	10–15
Boxed goods	10–20
Solid bars	10–25
Panning	15–30
Chocolate chip	15–35
Inclusions	20–40
Hollow	15–45

Figure 4

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