Research Spurs New Conching Process

READCO KURIMOTO, LLC
Continuous Mixing. Continuous Expertise.

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Much has been written about conching and it may seem as though nothing new can be learned. Academic literature is full of contradictions (Dimick and Hoskin, 1981), and inconsistencies between the published literature and practical observations.

For example, it is often stated that a principle outcome of the conching process is dehumidification of the chocolate mass, however, tests have been run with conched chocolate that show no noticeable change in the moisture content.

At a recent chocolate workshop at Pennsylvania State University, 20 participants, all employed in the confectionery industry, conducted a triangle difference test using conched and unconched (but standardized) milk chocolate and failed to detect a significant difference between the two.

One might conclude from this that, as Fabien De Clercq of OCG Cacao is quoted as saying, "in the U.S., chocolate is often considered a commodity rather than a quality product (Confection, July 1998)."

Subtle changes

However, it may be that any changes in flavor that do occur during conching are subtle. At Chocolate Technology 1994, results were presented of research on the high shear, continuous conching of chocolate. A rational approach to conche design required a comprehensive understanding of the process (Ziegler and Aguilar, 1994a).

On one point most agree - conching transforms chocolate mass from a dry powdery aggregate to a homogeneous fluid by dispersing agglomerates. Ziegler and Aguilar suggested that this deagglomeration and surface wetting was the principle reason for conching dark chocolate. Once accomplished, regardless of the means, the conching process was essentially complete. However, if it were deemed necessary, liquor could be dehumidified and deacidified separately. If Maillard reactions take place, these too could be accomplished by processing the liquor separately. It has since been learned from work on the effect of particle size on sensory properties (Ziegler and Mongia, 1998) that deagglomeration, through its influence on rheology, can impact flavor and texture.

Therefore, it is conceivable that the effective dispersion of particles may be responsible for the flavor changes in dark chocolate during conching even in the absence of any dramatic chemical reactions.

Milk chocolate remains a different story. From previous research (Aguilar and Ziegler, 1993) it was determined that the physical state of the non-fat milk solids can have a dramatic impact on the flow properties and flavor of chocolate, particularly when those solids are derived from spray-dried powders.

Crystallization of amorphous lactose from spray-dried milk powders liberates entrapped milk fat that is then available to become part of the continuous fat phase and reduce viscosity.

Furthermore, crystalline lactose is denser than the amorphous powder from which it is obtained and thereby reduces the relative particular phase volume. Niediek (1991) hypothesized that crystallization of amorphous sugar occurs during conching.

To obtain direct evidence of structural collapse and sugar crystallization it was decided to investigate grit formation in over-conched chocolate. Dark and milk chocolate mass and a white coating were dry conched at 95°C. Initial and final moisture contents of these masses are shown in Table 1.

Moisture Content of Chocolate Mass (%)

Sample	Refined Mass	Dry Conched
Dark Chocolate	.037	0.45
Milk Chocolate	1.30	0.63
White Coating	0.87	0.42

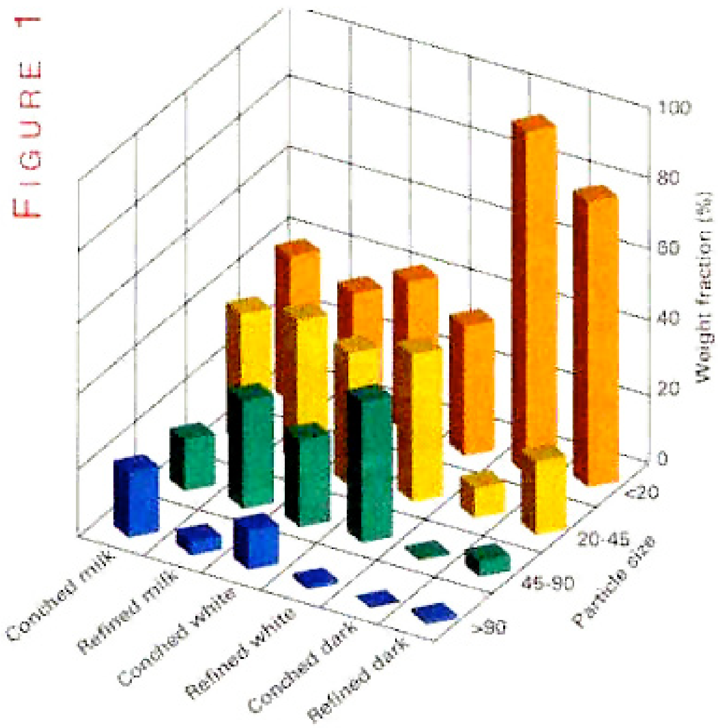
Table 1

The dark chocolate actually gained some moisture during the conching process, though probably not enough to be statistically significant. Both the milk chocolate and white coating lost approximately 50 percent of its initial moisture content.

Only the milk chocolate and white coating became gritty, suggesting some component of the milk powder was responsible. Volume means particle size, d43, changed little during conching, and actually decreased for both the milk chocolate and white coating even though these samples had a gritty mouth feel.

However, a closer look at the particle size distributions revealed increases in particles >90 micron for milk powder containing formulas. The investigation continued with a wet sieve analysis resulting in Figure 1.

FIGURE 1



Little change was observed in the particle size distribution of dark chocolate as a result of conching. There was a slight decrease in the weight of particles retained in the 20-45 micron ranges, with a corresponding increase in the particles below 20 micron, which may indicate mechanical dispersion of agglomerates.

For milk chocolate and white coating there was in increase in very large (>90 181) and small (<20 µm) particles at the expense of those between 45-90 µm. This explains how a chocolate can become gritty even though the mean particle size decreases.

The sugar composition (ratio of sucrose:lactose) in each fraction was analyzed by HPLC (Table 2). Prior to conching, particles <45 µm had a higher proportion of sucrose (less lactose) than particles >45 µm, consistent with observations that sucrose undergoes abrasion (surface erosion) during the roll refining process, producing a larger number of small particles.

Sucrose-to-Lactose-Rations in Milk Chocolate Fractions

Fraction	Refined Mass	Dry Conched
Whole Milk	6.37	7.24
>90 µm	3.37	6.37
45-90 µm	2.97	6.97
20-45 µm	7.45	8.83
<20 µm	13.45	7.55

Table 2

After conching, the ratio of sucrose:lactose was nearly the same in all size ranges, i.e., lactose was now distributed evenly through all particle sizes. X-ray diffraction patterns revealed the presence of #&167;-lactose in conched, but not in unconched samples, and scanning electron micrographs showed fine crystalline material adhering to the surface of what appeared to be sucrose particles (Ziegler and Aguilar, 1994a).

These observations are consistent with the formation an agglomeration of fine #&167;-lactose crystals that aggregate with sucrose to produce grit. The role of milk proteins is unclear. However, W#&255;rsch et al. (1984) proposed that milk proteins play a decisive role in flavoring #&167;-lactose crystallization.

A glass transition observable in refined milk chocolate and white coating by differential scanning calorimetry was eliminated by conching at 95°C. Concurrent with this was crystallization of lactose in the #&167; form. No such glass transition was seen in refined dark chocolate indicating that within the sensitivity of the method no amorphous sugar was present. It was assumed that the changes observed in these excessively conched samples are simply exaggerations of those changes that occur in properly conched chocolate.
It was concluded that for milk powder-based milk chocolate and coating containing amorphous sugar, a glass transition and collapse of the lactose matrix occurs during conching.

Furthermore, it was concluded that it was not necessary to bring about these changes in the milk component in the presence of the remaining chocolate ingredients and that the milk powder could be processed separately.

Conventional process

During conventional spray drying of whole milk, milk fat is entrapped in a glassy matrix composed mainly of amorphous lactose and colloidal protein, such that less than one percent of the fat is extractable with organic solvents at room temperature (20-25°C). This extractable fat is often referred to as free fat.
For example, extraction of a commercial whole milk powder containing 28.5 percent total fat with pentane at room temperature for two hours yielded 0.3 percent free fat.

When used in the manufacture of chocolate products, such dry milk powder leads to undesirably high viscosity in the final product requiring a greater amount of cocoa butter or emulsifier to standardize the flow properties since the entrapped milk fat does not become part of the continuous fat phase.

This results in higher ingredient costs and is one reason why roller-dried milk powder has been preferred for chocolate manufacture (i.e., its greater free fat content). However, commercial sources of roller-dried product have been reduced, and roller-dried milk powder is susceptible to oxidative rancidity. For these reasons, spray-dried milk powder is most often used.

Two approaches have been taken to increase the free fat in dry milk products. Lactose crystallization can be seeded during the concentration and spray-drying process resulting in a product with substantially higher free fat than is typical of spray-dried milk.

However, only 20-90 percent of the available fat is freed and the products are still susceptible to oxidative deterioration. For some products, industry practice is to use skim milk powder (non-fat dry milk) and anhydrous milk fat in a ratio typical of whole milk powder. In this way 100 percent of the milk fat is free.

The flavor of anhydrous milk fat may deteriorate rapidly, however, and its combination with skim milk powder does not result in the same quality of flavor as whole milk powder.

Based on previous work on continuous conching, a completely new process has been developed to manufacture a product with essentially 100 percent free fat, while retaining the positive flavor attributes of a dry whole milk and the availability and storage stability of spray-dried milk powder.

Utilizing a Continuous Processor machine, built by Readco Kurimoto, Inc., the process involves the application of heat and shear forces to a spray-dried milk powder resulting in crystallization of the amorphous lactose and liberation of entrapped fat.

The unique design of the Readco Continuous Processor's mixing and shearing paddles provides the optimum forces to allow this crystallization process to occur in a short period of time.

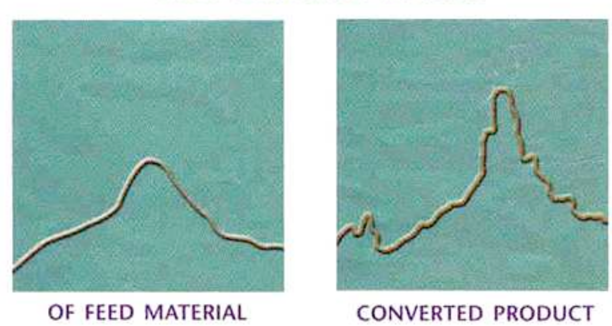
Dry whole milk powder at 28.5 percent fat was fed into the Continuous Processor at a rate of 4-35 kilograms per hour using a dry material feeder. The jacket temperature of the Continuous Processor was maintained at 80-105°C, i.e., above the glass transition temperature of the milk powder (~70°C).

The product exits the Continuous Processor in a form similar to chocolate mass in the pastry phase of conching. This results because the product is now a dispersion of lactose and milk protein in a continuous milk fat phase with the approximate fat content of dry-conched chocolate (26.5-28.5 percent).

When this product was subjected to pentane extraction at room temperature, 90-100 percent of the fat was in the free state. X-ray diffraction revealed that the lactose had been transformed from the amorphous state to the #&167; crystalline form (Figure 2).

X-RAY DIFFRACTION PATTERNS

FIGURE 2



As the lactose crystallized, the crystals can grow in sizes greater than 0.5 mm, and at this point the product looks like wet sand. However, the Readco Continuous Processor is capable of grinding these large crystals to produce a paste with particles less than 100 µm (Figure 3).

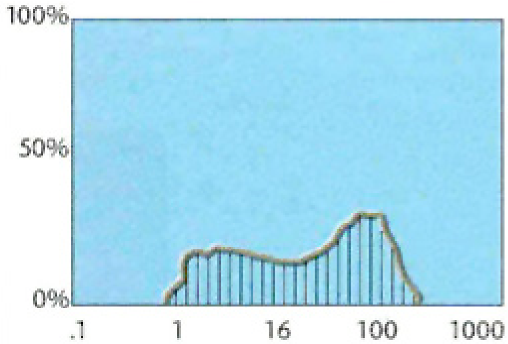


FIGURE 3

Particle size distribution of converted milk paste

This crystallization and grinding generates a significant amount of heat and, consequently, the jacket temperature of the machine may need to be reduced.
The new process that is possible with the Continuous Processor can also produce caramel-like flavors typical of crumb-based chocolates. It has also been noted that adding a very small percentage of a grinding agent, such as soy lecithin or vegetable oil, can greatly improve through-put rates and at the same time improve the handling properties to the product.

In summary, using the Readco Continuous Processor, a dry milk product, having lactose in essentially the crystalline state and containing 20-40 percent of fat by weight of which 80-100 percent are in the free state, can be produced by processing dry whole milk at elevated temperature under the process described earlier. This product is beneficial as an ingredient for confectionery, especially chocolate, to reduce viscosity and improve flavor.

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