EFFECTS OF CONCHING TIME AND INGREDIENTS ON PREFERENCE OF MILK CHOCOLATE

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ABSTRACT

The objective of this study is to determine how the conching time and the quantity of sucrose, lecithin, cocoa butter and whole milk powder affect consumer preference for milk chocolate. Untrained panelists performed a sensory study consisting of acceptability, preference and attribute intensity. Longer conching time produced significantly smoother chocolate with smaller particle size. The longest conche times had the smallest particle size and were the most mouthcoating. There was no change in flavor with conching. The longer conche times were preferred. Panelists preferred higher sucrose levels, and increasing sucrose decreased bitterness and increased chocolate flavor. Increasing lecithin increased smoothness, but less lecithin was preferred, possibly due to off-flavors at high levels of lecithin. Increasing cocoa butter yielded softer chocolate but did not affect bitterness. Panelists preferred 10% over higher levels of cocoa butter. More milk powder produced smoother chocolate with more caramel flavor and was preferred.

PRACTICAL APPLICATIONS

The perceived quality of milk chocolate is affected by conching time, sucrose, lecithin, cocoa butter and whole milk powder. Texture was affected the most by conching, milk powder, lecithin and cocoa butter. Flavor was affected the most by milk powder and sugar. The only variable that did not affect acceptability and preference of milk chocolate was time for under-conched samples. While this study did not determine the optimum conditions for milk chocolate, the most preferred and/or acceptable samples were

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conched for at least 12 h, had 35 to 50% sucrose, 0–0.5% lecithin, 5–10% cocoa butter and 13–30% milk powder.

INTRODUCTION

Consumer preference is crucial in determining the success of a product in the market, including chocolate. Chocolate is consumed more as an indulgence rather than need; therefore, it is important to know which attributes and parameters drive consumer liking of chocolate.

Conching is a mixing step that involves volatilization of fatty acids and aldehydes and development of smooth texture. Volatilization reduces the bitterness of the chocolate and develops the typical chocolate flavor. The solid particles such as sugar, nonfat cocoa and milk powder are coated with fat, dissociated by friction and become rounded. The coating of particles by fat promotes the smooth texture and snap desired in chocolate.

Sucrose is added to promote sweetness in chocolate but also affects other flavors. Increased level of sucrose results in a decreased level of bitterness (Guinard and Mazzucchelli 1999). More sucrose creates a more intense chocolate flavor perception in chocolate puddings (Geiselman et al. 1998).

Lecithin is an emulsifier that is commonly added in chocolate. It is added at approximately 0.5% to reduce the viscosity during processing, increasing the efficiency of conching. The addition of lecithin reduces the amount of cocoa butter needed to achieve the desired texture. Thus, addition of lecithin can reduce the production cost. Addition of 0.3% lecithin reduces chocolate viscosity and increases chocolate’s tolerance to moisture (Afoakwa et al. 2007). However, too much lecithin causes off-flavors and increases the viscosity of chocolate. Above 0.5% lecithin, yield value and viscosity increases (Chevalley 1994; Rector 2000).

Cocoa butter is added to give smooth texture in chocolate. Increasing fat content is related to a richer mouthfeel, faster melting rate and thus, smoother chocolate (Talbot 2005). The addition of cocoa butter coats the bitter compounds, and thus bitterness level decreases as the level of cocoa butter increases (Guinard and Mazzucchelli 1999). Cocoa butter is solid at room temperature and liquid at mouth temperature. This enables maximum release of chocolate flavor during consumption.

Milk powder is added for milky and caramel flavor in chocolate. The caramel flavor in dairy products is caused by caramelization of sugars and Strecker degradation of casein in milk (Patton 1955). The addition of milk fat reduces the hardness of chocolate since it dilutes the cocoa butter, and thus increases the amount of the liquid phase (Full et al. 1996). Both instrumental and sensory evaluation of the hardness of milk chocolates decreased with
increasing milk fat content (Bolenz et al. 2003). This study was done to investigate the effects of conching time and adding different amounts of sucrose, lecithin, cocoa butter and milk powder on acceptability, preference and attribute intensity of milk chocolate.

**MATERIALS AND METHODS**

**Materials and Methods**

A monolayer of approximately 1,000 g of cocoa beans (Conacado, Dominican Republic) was roasted using a convection oven (Doyon JA 14, Inc., Saint Come de Kennebec, Quebec, Canada) at 149°C for 10 min. The beans were cracked (Crankandstein Cocoa Mill, Chocolate Alchemy, Yoncalla, OR) and winnowed. Granulated sucrose was refined using a blender for 2 min to reduce the particle size to 180 μm. The rest of the ingredients: granulated lecithin (Soy, Chocolate Alchemy), cocoa butter (Natural, Dominican Republic, Organic and Fair Trade Certified, Chocolate Alchemy), vanilla (Beanilla Trading Company, Holt, MI) and spray-dried whole milk powder (All American Dairy Products, Inc., Malvern, PA) were weighed. The nibs were ground using a grinder (The Champion Juicer, Plastaket Manufacturing Corp., Inc., Lodi, CA).

Each batch was 1,000 g to accommodate sufficient volume for conching and sensory evaluation. The preheated chocolate liquor and cocoa butter were poured into the conching equipment (Alchemist’s Stone Chocolate Melanger, Santha, Chocolate Alchemy). The powdered ingredients – lecithin, sucrose, vanilla and milk powder – were put into the microwave for 3 min to preheat them, and then mixed thoroughly. The powdered ingredients were poured slowly into the conching equipment, letting the dry ingredients incorporate before adding more ingredients. After the conching process was done, the chocolate was transferred into the tempering machine (Revolution 2, Chocovision Corp., Poughkeepsie, NY). The finished chocolate product was poured into molds and shaken for approximately 2–3 min. The mold was 159 × 72 × 6 mm polycarbonate that holds 113 g of chocolate and can be broken into 28 squares. The molded chocolate was immediately put into a refrigerator at 5°C. The chocolate was allowed to solidify and taken out to sit at room temperature overnight before sensory evaluation tests.

The basic control utilized 0.5% lecithin, 16% cocoa butter, 13% milk powder, 26% cocoa liquor, 44.3% sucrose, 0.2% vanilla and 21 h conching time. The fat content is equal to the cocoa butter plus 55% of the cocoa liquor (Carver and Meylan 1970) and 26% of the whole milk powder (Fitzpatrick et al. 2004). As each variable was adjusted, the other ingredients were kept in
the same proportion to each other. Table 1 shows the ingredient formulation for each set. The sets tested were short conching time (3, 4, 5, 6 and 7 h), longer conching time (8, 12, 21 and 76 h), sucrose level (30, 35, 40, 44.3 and 50%), lecithin content (0, 0.5, 1 and 2%), cocoa butter content (5, 10, 16 and 20%) and milk powder content (5, 10, 13, 20 and 30%).

The particle size of the powders was measured using a Malvern Particle Size analyzer X (Malvern, Westborough, MA). Three replicates were performed and the average mean diameter over the volume distribution, D[4,3], was reported. The particle size of the chocolates was measured using a micrometer (Dignimatic Outside Micrometer, Mitutoyo, Japan). Micrometer readings correspond to the 90th percentile of the volume diameter of

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The numbers in bold represent the control value and the gray cells represent the variables tested. The ingredients not being tested remain in the same proportions to each other in all tests.
chocolate, as measured by laser light scattering (Ziegler et al. 2001). The finished chocolate samples were melted using a microwave for approximately 2 min and stirred. A small amount of the liquid chocolate was placed in the jaw of the micrometer and the diameter was recorded. Two replicates were performed and the average diameter was recorded.

**Sensory Experimental Design**

The sensory tests were conducted at The Ohio State University Department of Food Science and Technology sensory booths. Each booth was well-lit, climate controlled and odor-free. The 50 panelists were given the samples, sensory ballot and a glass of spring water (Naturally Preferred Pure Mountain Spring Water, Cincinnati, OH) for palate cleansing in between samples. Panelists were recruited through email invitations, personal communications and board advertisement.

One variable was tested on each day. Samples were blind-labeled with three-digit codes to avoid bias, and sample order was randomized so that each sample appeared in each position the same number of times to avoid artifacts because of the order of presentation (Lawless 1998). The randomization of sample order was divided into five groups, i.e., the first 10 people were assigned to the first group and so on. Panelists were presented with 4–5 samples per day to avoid fatigue and saturation. Each panelist was given four small pieces of chocolate (1.9 × 2.5 cm each) per sample number. The samples were placed in 59-mL plastic cups with lids (GFS Plastic Portion Cup Lids, Gordon Food Service, Grand Rapids, MI).

Panelists were asked two screening questions before each test started: gender and preference for type of chocolate. Panels averaged 46% males. There were three different parts of the sensory questionnaire: 9-point hedonic scale, ranking and attribute-by-attribute evaluation. For the 9-point hedonic scale, panelists were asked to rate each sample from dislike extremely to like extremely. The second part was ranking the samples from 1 being the best and 4 or 5 (depending on the number of samples), being the worst. The last part of the questionnaire was the attribute-by-attribute evaluation. Panelists had to rate each sample according to the attribute given from none (equal to 1), to moderate to very (equal to 9).

**Statistical Analysis**

Analysis of variance was utilized to evaluate whether the samples were significantly different from each other. Tukey’s honestly significant difference test was carried out if the variables were significantly different from each other ($P$ value $\leq 0.05$) to determine which of the variables were different. Tukey’s honestly significant different test was chosen because of its conservative characteristics (O’Mahony 1986).
For statistical analysis of data, each variable tested was evaluated utilizing all data, female-only data, male-only data and panelists that preferred milk chocolate. In most cases, all of the data sets produced the same results. Only for lecithin, which had 50% female panelists, did female-only data produce different results.

RESULTS AND DISCUSSION

Conching Time: Underconched Versus Conched for the Recommended Time

The underconched chocolate samples were not conched as long as is recommended, which is 10–14 h (Nanci 2007). Longer conching time results in smoother chocolate with smaller particle size. A few commercial chocolates are considered to be underconched. The underconched chocolate samples were conched for 3, 4, 5, 6 and 7 h. The chocolate conched for 7 h was rated as significantly smoother than the chocolate conched for 3 or 4 h (Fig. 1).

![Graph showing smoothness and chocolate flavor for underconched samples after 3, 4, 5, 6, and 7 h of conching. Samples with different letters are significantly different.]
conching, the solid particles such as sugar, nonfat cocoa and milk powder are coated with fat, therefore, too short of a conching time does not allow all of the solid particles to be covered with fat (Mentink and Serpelloni 1994). The measured particle sizes of 3, 4, 5, 6 and 7 h were 69.5, 49.5, 45, 38.5 and 32.5 µm, respectively (Fig. 2). According to the particle size, all of the under-conched samples should be gritty since the particle size of the solids was not reduced to the ideal size of less than 20 µm where the tongue can no longer detect them (Afoakwa et al. 2007). During conching, solid particles are ground, disassociated by friction and become rounded, (Mentink and Serpelloni 1994) thus the particle size of the solid particles in the chocolate is steadily reduced (El-Deep et al. 2000). As particle size is reduced, the texture of the chocolate becomes smoother (Liang and Hartel 2004).

In the longer conching time set (8, 12, 21 and 76 h), panelists similarly rated the samples with the longer conching time, 12 to 76 h, as significantly smoother (Fig. 3). Based on the particle size, at 8 h conching time, panelists should still be able to detect the grittiness while at the longer times, they should no longer be able to detect grittiness, since the particle size had
decreased below 20 μm. The samples conched for 12 h and longer were conched for an acceptable conching time, and thus the textures of those samples should not be perceived as gritty.

Mouthcoating is the afterfeel, or film covering the mouth surfaces (Guinard and Mazzucchelli 1999). Chocolate conched longer develops a smoother texture; however, it can also develop a greasy or oily mouthfeel. Conching times of 21 and 76 h were rated as more mouthcoating than 8 h conching time (Fig. 3). At a particle size of less than 2 μm, the chocolate develops a greasy texture (Liang and Hartel 2004). Both 21 and 76 h had particle size of ≤2 μm, and thus a greasy texture may have developed that panelists perceived as mouthcoating.

The chocolate flavor for the underconched samples (3, 4, 5, 6 and 7 h) was not affected by conche time (Fig. 1). Panelists also did not detect a significant difference in chocolate flavor in the longer (8 to 72 h) conching time set (Fig. 3).

There was no significant difference in either acceptability or preference for the underconched samples (Fig. 4). With shorter conching time (3, 4, 5, 6 and 7 h), the conching process is not sufficient for the fat to cover the solid
particles in the chocolate; and the particle size is large, causing all of them to be gritty. In addition, there was no significant difference in chocolate flavor (Fig. 1). So while the longest conche time was smoother in this set, this did not translate into a difference in preference. Maniere and Dimick (1979) found no significant change in flavor acceptability during the first 12 h of conching for dark chocolate.

After 8, 12, 21 and 76 h of conching, there was no significant difference in acceptability; however, there was a significant difference in preference (Fig. 5). Panelists ranked the longer conching time samples, 21 and 76 h, significantly better than the shortest conching time. Samples conched for 21 and 76 h may have been ranked significantly better than 8 h conching time since they were significantly smoother and had the smallest particle size. There was no difference in ranking between 12, 21 and 76 h, and similarly Maniere and Dimick (1979) found no difference in preference between 24 and 44 h for dark chocolate. Conched chocolate samples should have stronger chocolate flavor than unconched samples; however, Maniere and Dimick (1979) only found differences in acceptability between 0 and 24 or 44 h conche times. At 20 and 24 h, the samples have a moderate chocolate flavor compared to 0 h that has only basic chocolate notes (Maniere and Dimick 1979).
Sucrose

Commercial milk chocolate has a sugar content of 43 to 58%, while the samples in this study were 30 to 50% sucrose. The main purpose of adding sucrose is to add sweetness. However, increasing sucrose content is also related to a stronger flavor perception in chocolate pudding (Geiselman et al. 1998) and chewing gum (Davidson et al. 1999). Thus, increasing sucrose content should be related to a stronger chocolate flavor. In this study, the chocolate flavor was rated significantly different with increasing sucrose content (Fig. 6). The chocolate with 40% sucrose was significantly higher in chocolate flavor than 30% sucrose despite containing less cocoa liquor (Table 1).

The bitterness attribute was also significantly affected by sucrose levels (Fig. 6). Panelists rated 30% sucrose significantly bitterer than 44.3 and 50% sucrose. Milk chocolates with lower sucrose were also rated as more bitter than samples with higher sucrose by a trained panel (Guinard and Mazzucchelli 1999). Increased sugar level results in a decrease in the perception of bitterness by masking the bitter compounds in chocolate (Guinard and Mazzucchelli 1999). Similarly, lower sugar chocolate puddings were more bitter compared to higher sugar chocolate puddings (Geiselman et al. 1998). However, it should be noted that in those studies, the samples with the lowest sucrose also contained the most cocoa liquor.
There was a significant difference in both acceptability and preference of the different sucrose levels (Fig. 7). Samples with 44.3% sucrose were significantly more acceptable than 30% sucrose, and 35 to 44.3% was preferred over 30%. The least preferred sample, 30%, was perceived to have the least amount of chocolate flavor and highest in bitterness (Fig. 6).

**Lecithin**

Lecithin is added to replace some of the cocoa butter and is legally limited to 1% of the chocolate, with 0.5% being typically added commercially. The smoothness of the samples with different amounts of lecithin was significantly different (Fig. 8); however, Tukey HSD multiple comparisons found no difference between the samples. When the data for the females-only group were evaluated, 2% lecithin was significantly smoother than 0% lecithin (Fig. 8). Women perform better in distinguishing differences in foods than men because of their better sensory memory (Mojet and Koster 2002). Lecithin is an emulsifier that is added in chocolate to create a smooth texture instead of having to add more cocoa butter, and hence lowers the production cost (Nebesny and Żyżelewicz 2005). Lecithin forms a hydrophobic surface around the sugar and cocoa particles that help the cocoa butter efficiently coat the
sugar particles (Dimick and Hoskin 1981). A 0.5% amount of lecithin is the best level for forming an interface between the fat and solid particles and to produce smooth chocolate (St John et al. 1995).

Panelists did not find any significant difference in chocolate flavor for different lecithin contents (Fig. 8). Panelists found 0 and 0.5% lecithin to be significantly more acceptable and preferred over 2% lecithin (Fig. 9). The lower preference for the 2% lecithin might be due to off-flavors that can be produced when more than 1% lecithin is used (St. John et al. 1995).

**Cocoa Butter**

The cocoa butter levels evaluated were 5, 10, 16 and 20%, which corresponds to 24.5, 28.7, 33.8 and 37% total fat content. Commercial milk chocolates contain 29 to 36% total fat. In general, increasing fat content is related to a richer mouthfeel, faster melting rate and smoother chocolate (Talbot 2005). An increase of 1% at 28% fat content greatly reduces plastic viscosity; however, at a fat content above 32%, there is no significant effect on viscosity.

![Figure 7. Acceptability and ranking at different sucrose contents](image-url)

Samples with different letters are significantly different.
FIG. 8. SMOOTHNESS AND CHOCOLATE FLAVOR AT DIFFERENT LECITHIN CONTENTS
Samples with different letters are significantly different.

FIG. 9. ACCEPTABILITY AND RANKING AT DIFFERENT LECITHIN CONTENTS
Samples with different letters are significantly different.
In this study, the hardness of the samples decreased with increasing cocoa butter content (Fig. 10). Cocoa butter levels of 5 and 10% were significantly harder than 16 and 20%. The smoothness attribute was found to be significantly different between the samples (Fig. 10); however, when Tukey’s HSD multiple comparisons were performed, none of the samples were different from each other.

Varying cocoa butter level had no significant effect on bitterness (Fig. 10). Fat suppresses bitterness (Preininger 2006), thus high-fat chocolate puddings are less bitter than low-fat chocolate puddings (Geiselman et al. 1998). The addition of cocoa butter coats the bitter compounds, and thus a previous study using a trained panel found that the bitterness level decreases as level of cocoa butter increases in chocolate (Guinard and Mazzucchelli 1999).

Panelists rated the cocoa butter samples significantly different from each other in terms of acceptability and preference (Fig. 11). Samples with 5% cocoa butter was significantly more acceptable than 20%, 10% was significantly more acceptable than 16 and 20%, and 5 and 10% samples were significantly preferred over 20%. The middle samples, 10 and 16%, fall within the range of fat in commercial milk chocolate. Theoretically, liking of
chocolate should increase with increasing fat content since it gives a richer mouthfeel and faster melting rate in the mouth (Talbot 2005). However, in this study, panelists did not detect a difference in the bitterness or smoothness attributes for samples with different fat contents, which might have caused them to prefer the higher fat samples. Instead, they preferred the samples with lower fat, which were perceived to be harder.

**Milk Powder**

Milk chocolate with higher milk fat content is significantly softer than milk chocolate with lower milk fat content (Subramaniam and Murphy 2001). The addition of milk fat reduces the hardness of chocolate since it dilutes the cocoa butter and thus increases the amount of the liquid phase (Full et al. 1996). Samples with 5, 10 and 20% milk powder were significantly less smooth than 30% milk powder (Fig. 12). The chocolate with the highest milk fat (30% milk powder) was perceived as the smoothest.

In terms of caramel flavor, the 5%-milk-powder sample was significantly lower than 30% milk powder (Fig. 12). Increasing the milk powder content

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**FIG. 11. ACCEPTABILITY AND RANKING FOR DIFFERENT COCOA BUTTER CONTENTS**

Samples with different letters are significantly different.
should be directly proportional to increasing the caramel flavor. The caramel flavor in milk is caused by sugar decomposition and Strecker degradation of amino acids in casein (Patton 1955).

The 13%-milk-powder samples were significantly more acceptable than the 5%-milk-powder samples and the 13- and 30%-milk-powder samples were significantly preferred to the 5%-milk-powder samples (Fig. 13). The preferred samples, with more milk powder, had smoother texture and a stronger caramel flavor.

CONCLUSIONS

The attribute texture was affected the most by conching, milk powder, lecithin and cocoa butter. The flavor attribute was affected most by milk powder and sugar. All of the variables affected acceptability and/or preference of milk chocolate except for time for underconched samples.

Longer conching produced smoother, more mouthcoating chocolate with no change in flavor. The 7 h period of conching produced smoother chocolate than 3 h of conching. Conching times of 12, 21 and 76 h were smoother than 8 h of conching. Both 21 and 76 h of conching were more mouthcoating than

FIG. 12. SMOOTHNESS AND CARAMEL FLAVOR FOR DIFFERENT MILK POWDER CONTENTS
Samples with different letters are significantly different.

![Graph showing smoothness and caramel flavor vs. milk powder content](image-url)
8 h of conching and also had a very small particle size that causes greasiness. There was no significant difference in either acceptability or preference of the underconched samples. Samples conched for longer, 21 to 76 h, were preferred to 8 h of conching. Sucrose masked bitterness in chocolate. Increasing sucrose from 30 to 40% resulted in an intensified chocolate flavor in the samples despite having less cocoa liquor. Panelists preferred the higher sucrose samples over the lower sucrose samples. With lecithin, no differences were found in smoothness and chocolate flavor; however, the female-only data found that 2% lecithin was significantly smoother than 0% lecithin. The 0 and 0.5% lecithin samples were significantly preferred over 2% lecithin, possibly due to off-flavors. Increasing the cocoa butter content led to softer chocolate. No significant differences were found in smoothness and bitterness. Panelists preferred 5 and 10% cocoa butter to 20% cocoa butter. The 30% milk powder was smoother than 5, 10 and 20% and had the most caramel flavor. The 13 and 30% milk powder samples were most preferred.

REFERENCES


