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# EFFECT OF SWEETENED CONDENSED MILK, GLUCOSE SYRUP AND WHEAT FLOUR ON THE STRUCTURE AND SENSORY ASPECTS OF MILK CANDY

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**Abstract**

The objective of this research is to invest the impact of main ingredients on structure and sweetness of local milk candy in Dong Nai Province, Vietnam. Samples are prepared with 70 - 80% sweetened condensed milk, 2 – 6% glucose syrup and 16 - 26% wheat flour (w/w). Texture profile analysis was performed using Instron universal testing machine to evaluate hardness of the candy samples. Influence of these ingredients on sensory evaluation has been also studied. Mixture design was used to optimize ingredient composition of the candy. The results showed that sweetened condensed milk and wheat flour are the two main factors which impact structure of product. Candy hardness was significantly increased with increasing amounts of sweetened condensed milk and wheat flour. Moreover, there were also significant interactions between these two components with glucose syrup on structural properties of the samples. Optimum composition of the candy was finally found at 70.62% sweetened condensed milk, 4.62% glucose syrup and 19.76% wheat flour.

**Keywords:** confectionery, caramel, sweetened condensed milk, glucose syrup, milk candy

## 1. INTRODUCTION

Milk candy is a complex blend of gel system of protein – protein, protein – other ingredients such as sugar, water, and water dispersed in fat globules. Sweetened condensed milk, glucose syrup and wheat flour are the factors which impact sweetness of product.

Inclusion of milk solids is the essential feature of a milk candy recipe and it is the milk solids that cause the product to be difference in its properties from other types of confectioneries (Pyrz ,1976; Guelfi, 1988). The presence of milk solids has an effect on texture, flavor and colour of product (Heathcock, 1985; Gilmore, 1988). The higher the level of milk solids contained in candy, the harder will be the candy (Lees và Jackson, 1975; Gilmore, 1988). Milk solid are normally added as full cream as either skimmed sweetened condensed milk or dried whey powders are sometimes used (Gilmore, 1988). The milk proteins in sweetened condensed milks contribute significantly to the emulsification of fats and give body, texture and mouthfeel to final product (Jackson, 1990). Whey protein interaction with casein, this mixture was associated mainly with the fat globular layer. Candy hardness was significantly increased with increasing amounts of protein. However, this is governed by type, concentration and the level of denaturation of milk protein (Chandrani, 1997).

Glucose syrup, also known as confectioner's glucose, is made from the hydrolysis of starch. Glucose syrup is important major in candy processing. Glucose syrup containing over 90% glucose is used in industrial fermentation. However syrups used in confectionery contain varying amounts of glucose, maltose and oligosaccharides with typically 10% to 43% of glucose depending on quality grade. Glucose syrup is used in foods in order to sweeten, soften texture and increase volume of the products. By converting some of the glucose in corn syrup into fructose by using an enzymatic process, a sweeter product of high fructose corn syrup can be produced (Jackson, 1990). Corn syrup can retard the sucrose crystal growth. According to (Hartel and Shastry 1991) potential mechanisms of sucrose growth inhibition by corn syrup fractions are: (1) Corn syrup molecules impede diffusional motion of sucrose molecules to the crystal surface and thereby, slow down crystal growth. (2) Corn syrup molecules adsorb to the crystal surface and inhibit incorporation of sucrose molecules into the crystal lattice. In such case, sucrose molecules would have to displace the oligosaccharide molecules in order for growth to occur. (3) Corn syrup molecules are incorporated into the sucrose crystal lattice. The type and amount of corn syrup used can affect sweetness, texture, color development and moisture uptake (hygroscopicity) of the final product. The most important properties include the DE (dextrose equivalent) value, specific saccharide composition and viscosity. DE is a measure of reducing power of a product calculated as glucose and expressed as percent of total dry substance. 42 DE corn syrup is the most frequently used in confections (Kitt, 1993; Hofberger, 2009). Lower DE corn syrups lead to tougher finished caramels (Steiner et al., 2003; Hofberger, 2009) due to increased viscosity caused by higher amounts of large molecular weight molecules (Steiner et al., 2003; Cakebread, 1970; McMaster et al., 1987). The lower the DE of a corn syrup, the more viscous it is. Excessively high levels of corn syrup lead to the defect 'cold flow' (Cakebread, 1971, 1972), defined as the tendency of a material to deform under its own weight, over time (Warnecke, 1995). Higher levels of corn syrup solids decrease the amount of sucrose that crystallizes out and increase the amount of dissolved solids in the continuous phase (Hartel, 2001).

In confectionery, starches are used to create structure of product so that the viscosity is one of the important properties of the starches. It affects the quality and texture of many food product (James, 2000). Wheat flour is a relatively cheap ingredient and acts both as a bulking and as a gelling agent; it has the property of changing from a thick semifuid cold slurry to a viscous semisolid when gelatinized by heat, and on cooling sets to a firm gel the basis of the manufacture of candy.

A typical wheat flour that can be used satisfactorily in the manufacture of candy include 14% moisture (by mass), max 1.5% fat, 8-10% protein 67-75% carbohydrate max 1.0% ash and 0.5-1.0% fiber.

## 2. Materials and Methods

### 2.1. Materials

Sweetened condensed milk was supplied by local milk candy company in Dong Nai Province, Vietnam. Milk content is 74% min and sugar content varies from 30-32%.

Glucose syrup was supplied by Minh Tung company, Vietnam. Glucose syrup has dry matter concentration from 74-82%, transparent, comparable, colorless or slightly yellow, sweet taste.

Flour (Grade 8) was supplied by VIKYBOMI, Viet Nam.

### 2.2. Research Methodology

#### 2.2.1. Process for the production of candy

Sweetened condensed milk was mixed with glucose syrup and eggs. Then they were co oked at a temperature of about 90-100°C. Adding flour and additive Texim B2 is obtained at nearly the end of the process. A typical composition of 100 g of ingredients contains 6 g glucose syrup, 9 g flour, 4 g egg, 1 g Texim and 75 g sweetened condensed milk (SCM). At the end of the cooking, water content of candy is reduced to 6%. Rolling, cooling, cutting and packaging candy are the next steps of the manufacturing process.

Products were preserved during a week to ensure stability of the structure. Texture profile analysis was performed using Instron universal testing machine to evaluate hardness of the candy samples. Influence of these ingredients on sensory evaluation and hardess of milk product has been also studied.

Sensory analysis was performed using 9-point hedonic scale (Ha Duyen Tu, 2006). Sensory panel include 10 specialists from the local milk candy company in Dong Nai Province.

#### 2.2.2. Optimize candy composition with sweetened condensed milk, glucose syrup and wheat flour

A mixture design was used to optimize ingredient composition of the candy. Ingredient composition levels and coded values for the factors used in developing the experimental data are presented in Table 1. The selected response variable was the hardness (N) of the candy.

**Table 1.** Treatment levels and coded values of the independent factors

| Factor | Coded level | | |
|---|---|---|---|
| | –1 | 0 | +1 |
| Sweetened condensed milk (%) | 70 | 75 | 80 |
| Glucose syrup (%) | 2 | 4 | 6 |
| Wheat flour(%) | 16 | 21 | 26 |

#### 2.2.3. Data Processing

The experimental were evaluated by using JMP 9.0.2 software (SAS Institute Inc., 2011, USA) to analysis of variance ANOVA, comparing average by Tukey's HSD method, Minitab 16.

## 3. Results and Discussion

### 3.1. Effect of sweetened condensed milk on structure and sweetness of candy

The overall trend indicated that the higher the content of sweetened condensed milk, the higher the hardness of a candy (Figure 1). Tukey's HSD post hoc test showed that all of the hardness means were statistically different ($p < 0.05$) except for the candy made with 60% and 65% sweetened condensed milk, which were not statistically different from each other ($p > 0.05$). However, at 75% SCM, the hardness (347.65 N) is closest to that of reference sample (348.77 N). These results agree with the literature where higher SCM content yields a firmer product (Chandrani, 1997)

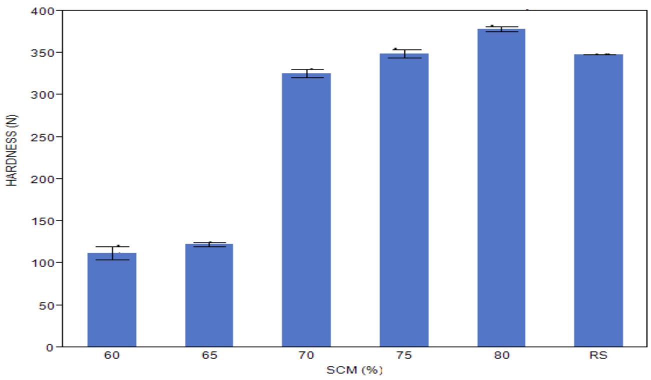


**Fig 1**. Candy hardness at different content of sweetened condensed milk

This result can be explained by three main reasons: the first is the ability to network and interact with other components of the protein in milk, the second is due to the change of the state of sugar molecules in the condensed milk materials and the third is the moisture movement.

In the next steps, the products were assessed the hardness and sweetness by asking assessors from Dong Nai candy company to sort the samples from the less preferred to the most preferred.

Using Friedman test, sample different preferred levels are presented in Table 2. Candy with 60% SCM and candy with 65% SCM had the preferred level of sweetness and structure was the lowest. It was not statistically different from each other ($p > 0.05$). Candy with 70% SCM, 75% SCM and 80% SCM had higher preferred levels of sweetness and structure compared to those of 60% SCM and 65% SCM.

There was not statistically different from 3 higher SCM samples (p> 0.05). However, they had difference in structure preferred level (p <0.05).

Therefore, the content of 75% SCM was selected as fixed factor to conduct the next experiments. The range of SCM content from 70 to 80% was used to optimize the content of the ingredients in the recipe by Mixture design.

**Table 2**: Sensory panel score for sweetness and structure of candy sample

| | Candy with 60% SCM | Candy with 65% SCM | Candy with 70% SCM | Candy with 75% SCM | Candy with 80% SCM |
|---|---|---|---|---|---|
| Sweetness | $14^a$ | $16^a$ | $41^b$ | $45^b$ | $34^b$ |
| Structure | $13^a$ | $17^a$ | $37^b$ | $49^c$ | $34^d$ |

### 3.2. Effect of glucose syrup on structure and sweetness of candy

The overall trend indicated that the higher the content of glucose syrup, the lower the hardness of a candy (Figure 2). The candy with content of 4% glucose syrup had hardness (350,99 N) close to the most reference sample (348.77 N) and there were statistically different from each other ($p < 0.05$).

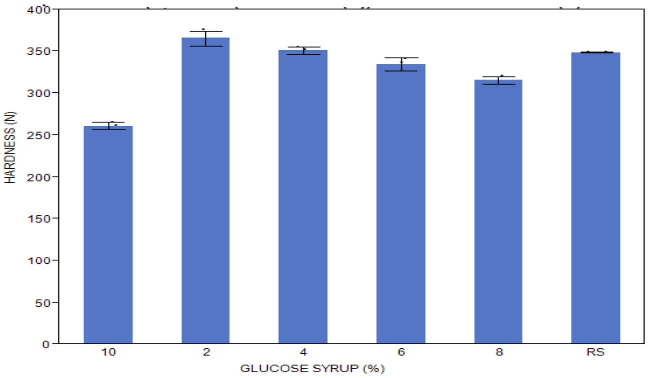


**Fig 2.** Candy hardness at different content of glucose syrup

When the content of glucose syrup increased, the content of maltodextrin also increased while protein and sucrose in product decreased. These made hardness of the candy decrease. On the other hand, glucose syrup contains oligosaccharide which creates plasticity and high hygroscopic to make a softer product.

Influence of this ingredient on sensory evaluation has been also studied. Table 3 shows that candy with 8% glucose syrup or 10% of glucose syrup had lower sweetness and heterogeneous structure due to they are less preferred. Two samples were not statistically different ($p > 0.05$) in sweetness, but there were statistically different in structure ($p < 0.05$). Candy with glucose syrup of 2%, 4% and 6% had higher preferred level than those of 8% and 10%. For structure, candy with 2% glucose syrup had the highest preferred level.

These results showed that 4% glucose syrup was selected as fixed factor to conduct the next experiments. The range of glucose syrup content from 2 to 6% was used to optimize the content of the ingredients in the recipe by Mixture design.

**Table 3.** Sensory panel score for sweetness of candy sample at different glucose syrup content

| | Candy with 2% syrup | Candy with 4% syrup | Candy with 6% syrup | Candy with 8% syrup | Candy with 10% syrup |
|---|---|---|---|---|---|
| Sweetness | $35^a$ | $42^a$ | $41^a$ | $19^b$ | $13^b$ |
| Structure | $35^a$ | $47^b$ | $38^a$ | $20^c$ | $10^d$ |

### 3.3. Effect of wheat flour on structure and sweetness of candy

Figure 3 showed that the higher the content of wheat flour, the higher the hardness of a candy. At the content of 21% wheat flour (349.67 N) candy had hardness close to the most reference samples (348.77 N) and there was statistically different from other sample ($p > 0.05$).

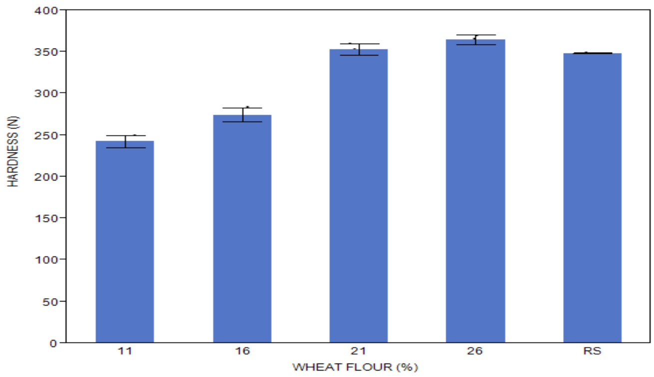

**Fig 3.** Candy hardness at different content of wheat flour

With a low level of starch and suitable amount of water in the mixture, the starch will have gelatinized making candy complex and becomes flexible and softer in the cooking process. When the content of starch in the mixture increases at a constant amount of water, the starch granules will not be completely swollen, candy complex become drier and harder.

On the other hand, there is a competition between wheat flour molecular and sugar molecular in structural stability stages. Due to hygroscopic property of sugar molecules is higher than flour molecular, water molecules will move from flour to sugar. This made the hardness of the product increase during the storage after a week.

**Table 4.** Sensory panel score for sweetness of candy sample at different flour content

| | Candy with 11 % flour | Candy with 16 % flour | Candy with 21 % flour | Candy with 26% flour |
|---|---|---|---|---|
| Sweetness | $12^c$ | $18^c$ | $40^a$ | $30^b$ |
| Structure | $11^c$ | $38^a$ | $26^b$ | $25^b$ |

The results of Table 4 showed that sample 3 (21% wheat flour) had the highest preferred level of sweetness. Tukey's HSD showed that the sweetness of samples was statistically different ($p > 0.05$). But sample 2 (16% wheat flour) had the highest preferred level of structure. There were statistically different ($p < 0.05$) among samples. Therefore, the range of wheat flour content from 16 % to 26 % was used to optimize the content of the ingredients in the recipe by Mixture design.

**3.4. Optimization of ingredient composition of the candy**

Mixture design of JMP 9.0.2 was used to optimize ingredient composition of the candy. The content of ingredient composition is 70 – 80% sweetened condensed milk, 2-6% glucose syrup, 16-26% wheat flour. The result was showed in Table 5.

**Table 5.** Hardess of candy at different ingredient composition

| Run | The ratio of SCM | The ratio of glucose syrup | The ratio of wheat flour | Hardness (N) |
|---|---|---|---|---|
| 1 | 0.7 | 0.055 | 0.245 | 337.36 |
| 2 | 0.73 | 0.02 | 0.25 | 352.33 |
| 3 | 0.8 | 0.06 | 0.14 | 333.58 |
| 4 | 0.7 | 0.05 | 0.25 | 337.36 |
| 5 | 0.715 | 0.035 | 0.25 | 352.21 |
| 6 | 0.8 | 0.02 | 0.18 | 349.99 |
| 7 | 0.75 | 0.06 | 0.19 | 330.05 |
| 8 | 0.8 | 0.04 | 0.16 | 347.29 |
| 9 | 0.765 | 0.02 | 0.215 | 355.73 |
| 10 | 0.7 | 0.06 | 0.24 | 320.37 |

Experimental values and predicted values of hardness had a high degree of compatibility, the value shown in the $R^2 = 0.97$ (Figure 4). This means experimental values distributed near diagonal on the chart and the majority value in the range of 3% margin of error, 97% empirical values are compatible with the value calculated according to a mathematical model to analyze the stiffness. In summary it can be concluded by the mathematical model can be used to represent and explain the relationship between material composition and structure of the finished candy.

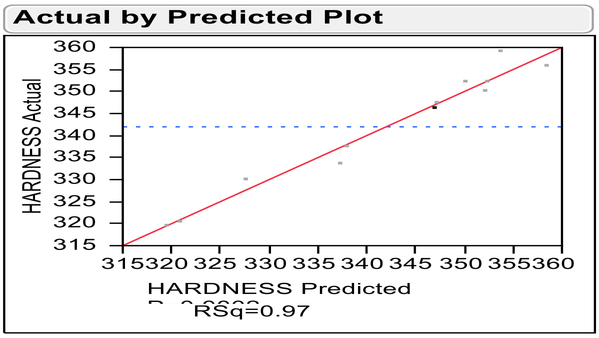


**Fig 4.** Actual by predicted plot

Influence of the ingredients to the hardness of the candy is illustrated in Figure 5. Sweetened condensed milk and flour were the two factors which had significantly affect the structure or the hardness of the product. In Figure 3.5, value of glucose syrup is negative (-1.36) which means that the higher the content of glucose syrup, the lower the hardness of a candy. But with low content of glucose syrup, it has significantly impact on the structure of the candy. Coordinating pairs as shown in Figure 3.5 are an interaction between the milk – glucose syrup, glucose syrup - flour, milk - flour can significantly affect the structure of the product.

**Sorted Parameter Estimates**

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| (SCM-0.7)/0.12 | 343.359 | 5.618007 | 61.12 | <.0001 * |
| (WHEAT FLOUR-0.16)/0.12 | 340.3365 | 5.618007 | 60.58 | <.0001 * |
| GLUCOSE SYRUP*WHEAT FLOUR | 585.81273 | 126.5031 | 4.63 | 0.0036 * |
| SCM*GLUCOSE SYRUP | 570.54676 | 126.5031 | 4.51 | 0.0041 * |
| SCM*WHEAT FLOUR | 66.310298 | 26.08211 | 2.54 | 0.0439 * |
| (GLUCOSE SYRUP-0.02)/0.12 | -108.7473 | 80.15628 | -1.36 | 0.2237 |

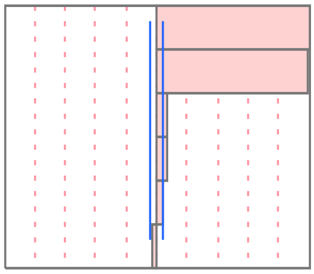

**Fig 5**. Interaction of ingredient composition

The results showed that sweetened condensed milk and wheat flour are the two main factors which impact structure of product.

Under the support of JMP 9.0.2 software it is showed that the ingredient composition of candy is 74.34% SCM, 4.86% glucose syrup, 20.80% wheat flour. It is equivalent to experiment formula of candy with 70.62% SCM, 4.62% glucose syrup, 19.76% wheat flour, 4% egg and 1.0% Texim. The hardness of candy was 349,47 (N) which was not statistically different from the predicted value by the model (348.98 N).

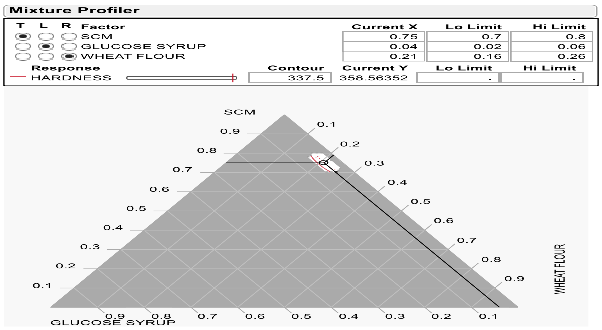


***Fig 6.*** *Mixing formula proposed by software*

Through optimization of ingredient composition of the candy with the support of JMP 9.0.2 software, the optimal formula for the structure has been determined and the hardness of the new developed candy is similar to commercial reference products available in the candy market.

## 4. CONCLUSION

There were also significant interactions between sweetened condensed milk and wheat flour with glucose syrup on structural properties of the candy. Sweetened condensed milk and wheat flour are the two main factors which impact the hardness of candy product. Mixture design was successfully used to optimize ingredient composition of the candy. Optimum composition of the candy was finally found at 70.62% sweetened condensed milk, 4.62% glucose syrup, 19.76% wheat flour 4% egg and 1.0% Texim.

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