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Subjective and Objective Effects of Natvia and Whey-Low Sugar Substitutes on a Frozen Hot Chocolate Beverage

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Abstract

The substitution of sugar substitute ingredients in a frozen hot chocolate beverage experiment measured the taste, mouth feel, overall acceptability, hardness, melting time, and nutrient content of three variations of frozen hot chocolate recipes. One recipe was the control recipe, the second recipe utilized the sugar substitute called Natvia instead of white granulated sugar and brown sugar, and the third recipe contained the sugar substitute Whey-Low instead of white granulated sugar and brown sugar. The sensory testing of each variation measured the taste, mouth feel, and acceptability with a convenience panel of 30 non-trained college students. The objective testing measured the hardness and melting time of each variation. The nutrients analysis of each variation analyzed the total calories, total fat, protein, and sugar. Participants rated the Nativa variation significantly lower in taste, mouth feel, and overall acceptability. The Control measured the hardest and had the longest melting time. Whey-Low received the highest ratings for overall acceptability and mouth feel. The nutrient analysis verified the low sugar values for the Natvia and Whey-Low variations. The results from the study revealed sensory, objective, and nutritive evaluations on a control frozen hot chocolate beverage recipe and two variations using Natvia and Whey-Low as sugar substitutes.

Keywords: Sugar substitute; Whey low; Taste test; Natvia

Introduction

The overconsumption of sugary foods in America is becoming a growing problem. Added sugars do not contain any beneficial nutrients, but do contribute excess calories [1]. As a percent of calories from total added sugars, the major sources of added sugars in American diets are soda, energy drinks, and sports drinks, grain-based desserts, sugar-sweetened fruit drinks, dairy-based desserts, and candy [1]. With the increase of high sugar diets due to added sugars, several health effects and diseases are becoming more prevalent in Americans, such as Type II Diabetes and obesity. To reduce a high sugar intake and ultimately these diseases, the overall amount of added sugar needs to be reduced or replaced with a different type of sweetener. However, there is no predetermined definition of "low sugar" [2]. In this study "low sugar" was defined as a product that contains less than or equal to five grams of sugar per serving [2].

The purpose of this study was to determine the acceptability of the frozen hot chocolate beverage made with Nativa and Whey-Low as sugar substitutes compared to a control frozen hot chocolate beverage made with white granulated sugar and brown sugar. The goal was to reduce the sugar content in a frozen hot chocolate beverage to less than or equal to five percent of the minimum recommended amount of total carbohydrates which is 130 grams/day. The independent variables in the experiment were the 100% Nativa substitution for the white granulated sugar and the brown sugar and the 100% Whey-Low substitution for the white and brown sugar. The sensory dependent variables were the overall acceptability, mouthfeel, and taste. The objective dependent variables were the melting point and viscosity. The objective of this study was to create a low sugar frozen hot chocolate beverage.

Added sugars are major contributors to the rise of obesity in America because excess sugars are stored as body fat. Obesity is a growing epidemic in the United States, affecting people of all different ages [3]. "More than one-third of U.S. adults (35.7%) and approximately 17% (or 12.5 million) of children and adolescents aged 2-9 years are obese" [3]. Consuming fresh fruits, sugar-free and low-calorie food and beverage options, and enhancing foods with spices instead of sugars could decrease weight gain [1]. If diets high in sugar are not altered or changed, risk for heart disease, stroke, type II diabetes, and possibly death could occur [1]. Reducing the consumption of added sugars can prevent obesity and ultimately type II diabetes in America [4-6].

The natural sweetener, stevia, is a newer sugar substitute in the United States. Stevia originated in the South American country, Paraguay [7]. The sugar alternative comes from the stevia plant, *Stevia rebaudiana*, which grows leaves containing large amounts of super-sweet compounds [7]. "Stevioside is one of several steviol glycosides that can be derived commercially from *Stevia rebaudiana*, a South American plant" [8]. Stevia is a zero-calorie sweetener available in natural stevia leaves, dried stevia leaves, leaf powder, and liquid concentration and is not metabolized in the body, making it an ideal option for diabetics [7].

There are several stevia derivatives as well, such as the product natvia. Stevia is 300 times sweeter than sucrose and has an astringent quality [9]. Astringency is defined as a drying, puckering mouthfeel after consumption [10]. Due to the increased sweetness possessed by stevia, the amount of stevia used during baking and cooking in replace of sugar is less than the total amount of sugar used in the recipe. The stevioside sweetener brand, Sun Crystals® for example, has a substitution equivalent of a half cup of stevioside for one cup of sugar [8]. A study in the Indian Journal of Science and Technology compared blood glucose levels of six women with type II diabetes after the consumption of glucose, a high carbohydrate meal called chapathi, and chapathi made with stevia [7]. "Blood glucose concentration of diabetic women was less after the intake of Stevia chappathia when compared

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to control chapathi and reference food (glucose) intake" [7]. Stevia can help diabetics consume sweet-tasting foods without the actual sugar.

The product Whey-Low is a newer natural sweetener on the market. Whey-Low contains 75% fewer calories than sugar and has a 70%-80% lower glycemic index than sugar [11]. Whey-Low is also a low calorie and low carbohydrate product with only one calorie per gram and one gram of carbohydrate per teaspoon [11]. It replaces the amount of sugar in a recipe one-for-one [11]. These characteristics make Whey-Low ideal for individuals who are diabetic, obese, dieting, or at risk for heart disease or stroke [11]. It can be added to many different types of foods, such as ice cream, cakes, pastries, and syrup. Whey-Low is made up of a combination of the simple sugars sucrose, fructose, and lactose [11]. The combinations of the simple sugars work together in the small intestine to interfere with normal absorption into the bloodstream [11]. Fructose interferes with the absorption of lactose, and lactose interferes with the absorption of sucrose [11]. Due to the various types of Whey-Low products, such as Whey-Low for Ice Cream, Whey-Low Granular, or Whey-Low Powder, Whey-Low will have the same effect on food items as sugar does, as long as the correct Whey-Low product is used within a specific recipe [11]. The product Whey-Low can be a healthy alternative to using added sugars in foods and beverages.

By using natural sugar substitutes, such as stevia and Whey-Low, the obesity and diabetes problems in the United States could decrease exponentially. The research questions that guided this study included: 1.) Is there a statistically significant difference in the desired sensory properties of mouthfeel, taste, and overall acceptability for a frozen hot chocolate beverage made with a.) the control, b.) Nativa, and c.) Whey-Low and 2.) Is there a significant difference in the desired objective variables of melting time and hardness for a frozen hot chocolate beverage made with a.) the control, b.) Nativa, and c.) Whey-Low.

Materials and Methods

Ingredients

The ingredients listed in Table 1 were used in the preparation of a frozen hot chocolate beverage.

Sample population

The sensory evaluation for this experiment was tested on a panel of 30 non-trained students who attended a large, midwestern university. They assessed mouth feel, taste and overall acceptability using a scorecard.

Methodology

One week in advance of this experiment, the freezer bowls of three Cuisinart Ice Cream makers were placed into a freezer unit to chill for optimal results. The temperature of the freezer unit was checked to ensure that it was 0°F.

The ice cream variations were prepared according to the ingredients listed in Table 1. For the control recipe the unsweetened Hershey's cocoa powder, white granulated sugar, and brown sugar were added to one medium glass bowl and were thoroughly combined. The whole milk was added to the sugar and cocoa mixture and all ingredients were mixed using an electric mixer with wire whisk attachments at medium speed until blended. The heavy cream and pure vanilla extract was added to the cocoa, sugar, and milk mixture. All ingredients were thoroughly mixed until a smooth consistency was achieved. The freezer bowl was removed from the freezer unit and the ice cream mixture was immediately poured into the bowl. The freezer bowl was placed and locked into the Cuisinart Ice Cream maker base and the machine was turned on. The mixture was allowed to blend for twenty-five minutes. Once finished, two tablespoons of the frozen hot chocolate beverage were placed into plastic sample cups. All samples were placed in the freezer unit to retain consistency. The samples were removed and various tests were performed. When creating Variation 1 all methods performed were the same as the control with the exception of a substitution of the white granulated and brown sugars for 237 grams of Natvia. When making Variation 2 all methods performed were the same as the control with the exception of a substitution of the white granulated and brown sugars for 237 grams of Whey Low.

Sensory evaluation

The sensory evaluation test for this experiment assessed mouth feel, taste and overall acceptability using a 4-point Likert scale ballot. Consent forms were distributed to all participants and a description of the products was given. No information regarding the variables was revealed. The samples were randomly numbered to ensure unbiased results. The ballots and samples were distributed to each participant in random order. The results were collected and were used for statistical analysis.

Objective evaluation

The objective evaluations for the frozen hot chocolate were based upon hardness and melting time. Both objective tests were conducted on each beverage variation. Hardness was tested using the Brookfield CT3 Texture Analyzer Pro. Three samples of each variation were utilized. Melting time was tested by a stopwatch method. Three samples of each variation were utilized. Samples were placed in the freezer for approximately fifteen minutes and then removed. Three samples of each variation were individually placed in glass pie pans. The samples were allowed to sit at room temperature and were timed until a complete transition from solid to liquid phase was observed. An average of the three recorded melting times for each sample was used for the results.

Statistical analysis

Inferential and descriptive statistics were used to calculate the ratings recorded by the students. All data were compiled into a table for analysis using the program the Statistical Package for the Social Sciences. The resulting analysis determined the mean and standard deviation for the objective and sensory data. Statistical significance for the sensory data was calculated using paired-sample *t*-test, looking at the factors of taste, mouth feel and overall acceptability. Objective data were calculated using descriptive statistics for hardness and melting time.

Nutritional analysis

Nutritional analysis was conducted using www.caloriecount.about.

	Hershey's Coca Powder	White Granulated sugar	Brown sugar	Natvia	Whey-low	Whole Milk	Heavy Cream	Vanilla Extract
Control	128 g	131 g	106 g	-	-	335 ml	769 ml	15 ml
Variation 1	128 g	-	-	237 g	-	335 ml	769 ml	15 ml
Variation 2	128 g	-	-	-	237 g	335 ml	769 ml	15 ml

Table 1: Ingredients List of the Control and Variations of Frozen Hot Chocolate.

com. The nutritional components of calories, total fat, protein and sugar were calculated per one-half cup serving.

Results

Sensory results

The sensory evaluation, conducted with the sample of 30 non-trained students, evaluated the taste, mouthfeel, and overall acceptability of the frozen hot chocolate beverage on a 4-point Likert scale ballot. Each variable was given a detailed definition on the ballot. Taste was defined as 'the frozen hot chocolate beverage has an appropriate sweet and creamy chocolate taste.' Mouth feel was defined as 'the textue is smooth, creamy, and of an appropriate consistency.' Overall acceptability was defined as 'I would enjoy eating this frozen hot chocolate beverage.'

The mean value of the taste of Variation 1 (Natvia) (M=2.83) was statistically significantly lower ($p<0.05$) than the taste of the Control (M=3.40) and Variation 2 (Whey-Low) (M=3.37). The mean value of taste for the Control was 3.40 and the mean value for Variation 2 was 3.37. The mean scores of taste for these variations were statistically significantly higher ($p<0.05$) than the taste of Variation 1 (M=2.83).

The mean value of the mouthfeel for Variation 1 (M=2.37) was statistically significantly lower ($p<0.05$) than the mouthfeel of the Control (M=3.27) and Variation 2 (M=3.50). Based on the data, the value for the mouthfeel of the Control was 3.27 and Variation 2 was 3.50. Thus, the participants rated Variation 2 to have the best mouthfeel.

The mean value of the overall acceptability for Variation 1 (M=2.67) was statistically significantly lower ($p<0.05$) than the overall acceptability of the Control (M=3.33) and Variation 2 (M=3.37). The value for the acceptability of the Control was 3.33 and Variation 2 was 3.37. The participants felt that Variation 2 (M=3.37) had a higher overall acceptability than any of the other variations.

Based on the paired sample T-tests of the mean values for the taste, mouthfeel, and overall acceptability of the Control (M=3.40; M=3.27; and M=3.33 consecutively) and Variation 2 (M=3.37; M=3.50; and M=3.37 consecutively), the participants felt that the Control and Variation 2 were very similar. However, based on the mean values of Variation 1, the participants felt it was lacking in taste (M=2.83), mouth feel (M=2.37), and overall acceptability (M=2.67). Table 2 contains the results of the paired sample T-tests of the variables.

Variable	Mean n=30	SD
Taste		
Control	3.4	0.675
Variation 1a	2.83 c	0.834
Variation 2b	3.37	0.556
Mouthfeel		
Control	3.27	0.868
Variation 1a	2.37d	0.809
Variation 2b	3.5	0.63
Acceptability		
Control	3.33	0.802
Variation 1a	2.67 e	0.884
Variation 2b	3.37	0.615

[a]Variation 1 – Natvia
[b]Variation 2 – Whey-Low
[c]Taste – Mean of Variation 1 was significantly lower (p<0.05) than Control and Variation 2
[d]Mouthfeel – Mean of Variation 1 was significantly lower (p<0.05) than Control and Variation 2
[e]Acceptability – Mean of Variations 1 was significantly lower (p<0.05) than Control and Variation 2

Table 2: Paired-Sample t-Test for Taste, Mouthfeel, and Acceptability of Frozen Hot Chocolate Variations.

Variable	Mean n=3	SD
Hardeness (Grams)		
Control	19.00	3.500
Variation 1a	13.00	1.500
Variation 2b	11.50	0.500
Melting time (minutes)		
Control	13.75	1.937
Variation 1a	8.87	3.799
Variation 2b	2.62	1.028

[a]Variation 1- Natvia
[b]Variation 2 – Whey-Low

Table 3: Mean and Standard Deviation for Objective Testing of Frozen Hot Chocolate Variations.

	Control	Variation 1: Natvia	Variation 2: Whey-Low
Serving Size	1/2 C	1/2 C	1/2 C
Calories	318	253	260
Total Fat	24 g	24 g	24 g
Protein	3.8 g	3.8 g	3.8 g
Sugar	18.1 g	1.5 g	8 g

Table 4: Nutritional Analysis of Frozen Hot Chocolate Variations.

Objective results

The Brookfield CT3 Texture Analyzer Pro utilized the TA43 25.4 millimeter sphere attachment to measure the hardness of the frozen hot chocolate variations. Hardness is defined as the force required to compress a food item between the molars and is the force necessary to attain a given deformation [12]. Three samples of each variation were measured and the mean was calculated. The Control had the highest value for hardness measuring 19.00 g. The mean values of the hardness of Variation 1 (Natvia) (M=13.00) and Variation 2 (Whey-Low) (M=11.50) were lower than the control (M=19.00).

The melting time test used a stopwatch to measure the length of time the beverage transformed to a completely a liquid state. The Control took the longest time to melt, at 13.75 minutes. Variation 2 took the shortest amount of time (2.62 minutes) to melt to a completely liquid state. The Control had both the highest measurement for hardness and the highest melting time and Variation 2 had both the lowest measurement for hardness and the lowest melting time. Table 3 provides a comprehensive analysis of the objective testing.

Nutritional results

The website www.caloriecount.about.com was used to conduct the nutrient analysis. The serving size of one frozen hot chocolate beverage is a half-cup serving. The Control had the highest amount of calories per serving with 318 calories. Variation 1 (Natvia) contained the least amount of calories per serving with 253 calories. The total fat and protein remained the same in each variation. The sugar content in the Control was the highest, containing 18.1 g per serving. Variation 1 contained the smallest amount of sugar with 1.5 g per serving. Variation 2 (Whey-Low) had 8 g of sugar. Table 4 provides complete documentation of the nutritional analysis of the frozen hot chocolate variations.

Discussion

The first research question that asked if there is a statistically significant difference in the desired sensory properties of mouth feel, taste, and overall acceptability for a frozen hot chocolate beverage made with a.) the control, b.) Nativa, and c.) Whey Low was answered in the research study. Variation 1 (Natvia) was statistically significantly lower ($p<0.05$) than Variation 2 (Whey-Low) and the Control in the sensory properties of mouth feel, taste, and overall acceptability.

The second research question that asked if there is a significant difference in the desired objective variables of melting time and hardness for a frozen hot chocolate beverage made with a.) the control, b.) Nativa, and c.) Whey Low was not answered in the objective evaluation because a statistically significant difference could not be determined in the study since the objective tests were only performed three times.

The mean values from the sensory evaluation of the frozen hot chocolate Control and Variation 2 showed close relationships between the taste, mouth feel, and overall acceptability. Both of these variations were statistically significantly higher ($p<0.05$) than the taste, mouth feel, and overall acceptability for Variation 1. The participants rated Variation 2 to have the best mouth feel and highest overall acceptability scores than any of the other variations. Based on the results, Variation 2 would be the most likely consumed beverage compared to the other variations, while Variation 1 would be the least likely consumed frozen hot chocolate beverage. A previous study by Fujimaru et al. [10] showed outcomes similar to the outcomes in this study. In their study, the low-sugar sweetener, rebaudioside A, had more negative feedback than the other sweeteners used. The other sweeteners had similar sensory characteristics to sucrose control [10]. In this current study, based on the correlation between the mean values for the taste, mouth feel, and overall acceptability of the Control and Variation 2, the participants felt that the Control and Variation 2 were very similar. However, based on the mean values of Variation 1, the participants felt it was lacking in taste, mouth feel, and overall acceptability.

The mean values from the hardness and melting time objective evaluations of the frozen hot chocolate variations provide differences in each product primarily due to the substituted item in each variation. Melting time must be taken into consideration when planning for consumption of the frozen hot chocolate beverage. The Control had both the highest measurement for hardness and the highest melting time and Variation 2 had both the lowest measurement for hardness and the lowest melting time. Thus, using sugar will yield the hardest product with the longest melting time. Variation 2 produced a product with the least amount of hardness and the lowest melting time. Variation 1 yielded a hardness measurement and melting time between those of the Control and Variation 2. This being said, each frozen hot chocolate variation will change in a different way depending on the length of time spent outside of the freezer and should be taken into consideration when serving the beverage.

The nutritional analysis of the frozen hot chocolate variations provided the total calories, total fat, protein, and sugar in each half-cup serving size of each frozen hot chocolate variation. The goal of reducing the sugar content in a frozen hot chocolate beverage to less than or equal to five percent of the minimum recommended amount of total carbohydrates, which is 130 grams/day, was achieved in Variation 1. Five percent of the one hundred thirty grams of total carbohydrates/day is 6.5 g. Variation 1 was under this amount, but Variation 2 was only over by 1.5 g. Therefore, Variation 1 would be the best option for diabetic individuals because it contains the lowest amount of sugar. Variation 2 could also be a better alternative for diabetic individuals over the Control because it contains a significantly lower amount of sugar, as well.

The findings from the low sugar frozen hot chocolate beverage study agree with the study conducted in the Indian Journal of Science and Technology on stevia [7] as the stevia used on the type II diabetics in the study ultimately allowed the participants to continue consuming the chapathi with stevia because it contained an extremely low amount of sugar. Despite containing low amounts of sugar in Variation 1 and Variation 2, consuming any of the frozen hot chocolate beverages in large quantities would not benefit any individuals who are seeking to lose weight or who are overweight or obese due primarily to the high fat content in each variation.

Limitations

There were several limitations that were determined at the conclusion of the study. One limitation was the gender of the participants. Only three out of the thirty participants were male. Having an equal male to female ratio may have increased the validity of the data. During sampling of the sensory analysis, the participants did not cleanse their palate in between sampling each variation. Not having a cleansed palate could have interfered with the taste, mouth feel, and acceptability of each sample. Providing each participant with water in between each sampling could eliminate any other extraneous variables. Another limitation was the lack of the ability of the ice cream maker to scrape the sides of the frozen ice cream container within the ice cream maker. The areas that the ice cream maker could not mix thoroughly ended up being along the edges of the container, creating a harder, more frozen end product. This could have affected the melting time and hardness data because some of the samples used could have been taken from the product along the edges of the container. The personal chocolate and sweetener preference of each participant are two more limitations found in the study. Each participant has differing taste buds, sometimes resulting in particular preferences to either chocolate or sweeteners. Both of these possible participant preferences could have interfered with the taste, mouth feel, and acceptability data. An additional limitation refers to the data from the nutrient analysis that yielded 24 g of total fat for each variation, including the Control. The high fat content in the frozen hot chocolate is not recommended for the obese individuals target group. Substituting the whole milk in the frozen hot chocolate recipe for either fat free milk or 1% milk could help decrease the amount of fat in each variation. Researchers suggest controlling for these limitations where appropriate for increased validity and reliability of results.

Conclusion and Suggestions

As a result of the study, variation 1 (Natvia) was statistically significantly lower than both the Control and Variation 2 in taste, mouth feel, and overall acceptability when tested with the sample of 30 non-trained students. The Control had the largest hardness measurement as well as the longest melting time, followed by Variation 1 and Variation 2. Thus, sugar increases the hardness and melting time of the frozen hot chocolate. The data from the nutrient analysis confirmed that both Variation 1 and Variation 2 were lower in sugar than the Control. As a result, the low sugar content in both variation 1 and variation 2 allow for more diabetic-friendly alternatives. However, the fat content in all variations, including the Control, was high, making each variation not ideal for individuals hoping to lose weight or those who are overweight or obese.

One goal of the study was to reduce the sugar content in a frozen hot chocolate beverage to less than or equal to five percent of the minimum recommended amount of total carbohydrates. Natvia in Variation 1 reduced the sugar percentage to about 1.16%, while Whey-Low in Variation 2 reduced the sugar percentage to only about 6.2%. Both of these variations, however, are lower in sugar compared to the Control and complete the ultimate goal of creating a low sugar beverage.

Further research should be conducted testing the taste, mouth feel, and overall acceptability of the Whey-Low and Natvia in other frozen beverages or food items. The Whey-Low and Natvia sugar replacing products could have differing effects in other recipes, thus altering the taste, mouth feel, and overall acceptability. More sensory and objective variables should also be tested with each product in various recipes. Testing a wider variety of variables will provide more data and information on how Whey-Low and Natvia affect the outcome of various recipes.

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