Stevia Sugar Substitution in Caramels

Abstract:
The sugar content in foods and beverages has become a serious problem in regards to health. High sugar content can lead to type 2 diabetes, obesity and heart disease. Therefore, sugar substitutes have been created in an effort to alleviate this problem. Candy is made up of almost entirely sugar and this food could be improved by replacing sugar with a sugar substitute or making a candy with a combination of sugar and a sugar substitute. Stevia was chosen in this experiment due to the fact that it is new to the market and it is not associated with any negative health effects. However, it is important that color, texture, and overall taste not be compromised because this is vital to consumer acceptance. It was hypothesized that the addition of Stevia sugar substitute to soft caramels would not cause a negative effect on color, texture, and taste. A control of 100% sugar in caramel was made for a comparison along with two additional variables. The first variable consisted of half sugar and half Stevia while the second variable consisted of 100% Stevia. The three samples were measured using a texture analyzer and a Hunter colorimeter along with a sensory panel for taste. The overall results indicated that there was not a large effect on the color or texture but a large effect on consumer preference. Other types of sugar substitutes should be tested due to the fact that this is still a relatively new product and there are so many on the market that may yield better results for consumer acceptance.

Introduction:
Sugar is an ingredient that widely accepted and liked by the general population in the United States. Due to the fact that sugar is used in delicious foods such as desserts, it is hard to pass it up or inhibit the body from wanting sugar in excess amounts. While sugar may be enjoyed by many people it is not the most nutritious for people to consume on a regular basis. Sugar has been linked to tooth decay, diabetes mellitus, and obesity. Sugar consumption is a growing concern and that is why substitution had become increasingly important.

Sugar is a main contributor to dental caries and eventual tooth decay if it is not acted upon. When sugar is consumed it sits on the teeth and forms bacteria. The bacteria can quickly be converted to acid and start to do harm on the teeth. The acid from the sugar will soon form a
plaque and can attack the enamel. This erosion by the plaque can soon leave holes in the teeth that will ultimately form into cavities. This action has led to the increasing desire for artificial sweeteners especially for children who may not brush their teeth adequately.

Obesity is yet another disease that is a growing epidemic among Americans. It can lead to depression and cardiovascular disease. The causes of obesity are excessive intake of high fat foods along with sugar-based beverages and baked products. Sugar substitutes are of growing interest among obese individuals because they do not contribute any calories compared to sugar.

Along with obesity and tooth decay, diabetes mellitus is another addition to the harmful effects of sugar. Diabetes mellitus can occur when the body either stops producing insulin or is unable to utilize insulin as efficiently. Sugar plays a major role with this disease because it will spike blood glucose levels. Individuals who suffer from diabetes must monitor their glucose levels closely. Therefore, sugar substitutes provide ease with this monitoring because they do not cause a sharp increase in blood glucose levels like sugar.

The emphasis of replacing regular sugar with a sugar substitute such as Stevia is important to prevent the development of diseases. It should come as no surprise that there has been an increasing interest in sugar substitutes for this very reason. Caramels are almost entirely made of sugar and can contribute to health implications. The purpose of the study was to make a caramel candy that is composed on the sugar substitute Stevia in an effort to improve the nutritional quality without hindering the taste, appearance, and texture.
The color and texture of candy is improved by sugar content. This is the reasoning for testing these two dependent variables. Sugar causes carmelization and non-enzymatic browning in foods. Heat is one contributor to this browning effect seen with sugar in food. The browning effect of sugar is important to the color and overall appearance of caramels. This is the reason for testing the color of the caramels with the Stevia.

Texture was also measured due to the differences in particle size between sugar and Stevia. It was predicted that sugar has a relatively smaller particle size compared to that of Stevia. This is the reason for measuring texture with the texture analyzer. The texture of candy is another important factor for overall consumer acceptability.

The final factor measured was consumer preference using a hedonic scale. An untrained taste panel was used for this portion of the testing. Due to the fact that an untrained panel was used, it was vital to have as many panelists test the samples as possible. Therefore, a total of 30 panelists participated in taste testing.

**Methods:**

A control caramel was made of 100% sucrose in order to compare against the two variables. One variable consisted of 50% sucrose and 50% Stevia in an effort to conserve some of the beneficial physical effects of sucrose such as texture and palatability while improving the nutrient content. The second variable was made up of 100% Stevia. The control, 50% sucrose and 50% Stevia variable, and the 100% Stevia variable were all tested using the Hunter Colorimeter, Texture Analyzer, and the sensory panel using a hedonic scale. All three trials were completed on the
same day. The three trials were made the exact same way and there was no variation except for
the sugar substitution.

Recipes for caramels:

Control: 100% sucrose

- 473.18ml heavy cream
- 118.29ml condensed milk
- 473.18ml light corn syrup
- 118.29ml water
- 32 Tbsp. granulated sugar
- 8 Tbsp. softened butter, cut into small cubes

Variation 1: 50% sucrose 50% Stevia

- 473.18ml heavy cream
- 118.29ml condensed milk
- 473.18ml light corn syrup
- 118.29ml water
- 12 Tbsp. granulated sugar
- 12 tsp. Stevia
- 8 Tbsp. softened butter, cut into small cubes

Variation 2: 100% Stevia

- 473.18ml heavy cream
- 118.29ml condensed milk
- 473.18ml light corn syrup
- 118.29ml water
- 24 tsp. Stevia
- 8 Tbsp. softened butter, cut into small cubes

Procedure:

The following are steps and/or procedure to prepare the caramels. The same procedure was
followed for all three trials:
- Prepare a 9x9 pan by lining it with aluminum foil and spraying the foil with nonstick cooking spray
- Combine the cream and condensed milk in a small saucepan, and place the saucepan on a burner set to the lowest heat setting
- In a medium-large saucepan combine the corn syrup, water, and granulated sugar over medium-high heat
- Stir the candy until the sugar dissolves, then use a wet pastry brush to wash down the sides of the pan to prevent sugar crystals from forming and making the candy grainy
- Insert a candy thermometer and reduce the heat to medium
- Allow the mixture to come to a boil and cook until the thermometer reads 25 degrees Fahrenheit
- Add the softened butter chunks and the warm milk-cream mixture
- The temperature should go down about 30 degrees Fahrenheit
- Continue to cook the caramel, stirring constantly so that the bottom does not scorch
- Cook it until the thermometer reads 244 degrees Fahrenheit and the caramel is a beautiful dark golden brown
- Remove the caramel from the heat and immediately pour it into the prepared pan
- Do not scrape candy from the bottom of the saucepan
- Allow the candy to sit overnight to set up and develop a smooth, silky texture
- The caramels were cut into one-inch squares when they were hard
The Texture Analyzer, it was necessary to calibrate the equipment properly. The type of probe used was the cone due to the softness of the caramel. It is required that a type of food be selected that best represents the food being tested. There was no caramel or candy type of food that could be selected. Therefore, fudge was used as the type of food to be measured by the Texture Analyzer. The probe was slowly inserted into the caramel and a reading was given for the texture. The readings for the Texture Analyzer are given in the results section of the report.

The Hunter Colorimeter required calibration before any testing could be accomplished as well. It was calibrated by placing a black tile on the machine and pressing scan. The same was done after using a white tile. The experiment proceeded after the machine read “Sensor Successfully Standardized” and was ready to analyze each sample. Each sample was place on a Petri dish and place on the scanner. The results were given in L, a, and b values.

The final test was the sensory evaluation conducted by the panelists. Each sample was place on a paper plate and labeled with a designated three digit code. The purpose of the three digit codes was to eliminate any bias between the samples. All of the panelists were chosen at random and asked to taste each of the samples and rate them using the hedonic scale provided. An example of a sensory evaluation is shown below.

Sensory Scorecard

Please test each sample. Mark the statement that describes your preference.

Hedonic Rating

___ Excellent flavor, rich golden brown color, extremely smooth texture, thick and chewy consistency.
___ Very desirable flavor, golden brown color, very smooth texture, thick and less chewy consistency.

___ Moderately desirable flavor, brown color, smooth texture, somewhat thick consistency

___ Somewhat desirable flavor, light brown color, slightly grainy texture, somewhat thin consistency

___ Indecisive flavor, pale brown color, somewhat grainy texture, thin consistency

___ Mildly dislike flavor, slightly undesirable color, mildly grainy texture, thin and stringy consistency

___ Moderately dislike flavor, moderately undesirable color, moderately grainy texture, very thin consistency

___ Dislike flavor very much, very undesirable color, very grainy texture, very thin consistency

___ Dislike flavor extremely, very undesirable color, extremely grainy extremely thin consistency

**Results:**

Figure 1: Average L, a, b Values for Sugar and Sugar Substitute Variables Using Hunter Colorimeter

<table>
<thead>
<tr>
<th>Variables</th>
<th>L</th>
<th>a</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>34.87</td>
<td>10.27</td>
<td>13.87</td>
</tr>
<tr>
<td>Stevia</td>
<td>30.63</td>
<td>9.16</td>
<td>13.69</td>
</tr>
<tr>
<td>Sugar +Stevia</td>
<td>30.88</td>
<td>9.73</td>
<td>12.67</td>
</tr>
</tbody>
</table>
Figure 2: Average Hunter Colorimeter L, a, b Values for 3 Trials of Each Sugar and Sugar Substitute Variable

Figure 3: Average Penetration Force and Standard Deviation for Each Sugar and Sugar Substitute Variable

<table>
<thead>
<tr>
<th>Variables</th>
<th>Average Penetration Force (g)</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>78.6</td>
<td>0.818535277</td>
</tr>
<tr>
<td>Stevia</td>
<td>10.33</td>
<td>0.305505046</td>
</tr>
<tr>
<td>Sugar + Stevia</td>
<td>48.63</td>
<td>3.879862541</td>
</tr>
</tbody>
</table>
Figure 4: Average Penetration Force and Standard Deviation for Each Sugar and Sugar Substitute Variable

Figure 5: Average Hedonic Scale Rating for Each Sugar and Sugar Substitute Variable

9=Excellent  
8=Very Desirable  
7=Moderately Desirable  
6=Somewhat Desirable  
5=Indecisive  
4=Mildly Dislike  
3=Moderately Dislike  
2=Dislike  
1=Dislike Extremely

Discussion

Color Analyses
Color seems to be very important when acquiring taste of the caramels. People use color to determine taste of the food and how appetizing it will be. Having a consistent color for each of our caramels was important because it can change the outcome of desirability based on the Hedonic Scale alone. Caramel colors can range anywhere from golden brown to a mahogany brown.

To determine color, the Hunter Colorimeter was used. The Hunter Colorimeter is used to measure color in many ways. In this experiment, we used the L, a, b parameters. The “L” value represents the lightness and darkness of a product, where 100 is light and 0 is black. The “a” value can be positive or negative, where positive is red and negative is green. The “b” value can be positive or negative as well, where positive indicates yellow and negative indicates blue (Buck and others 1987).

In **Figure 1**, the table shows the different L, a, b values for the different caramel variations. The control, which is the sugar only caramel, had the highest “L” value. This indicates it was the lightest in color, having an approximate 4 point difference from the other 2 variations. The stevia variation and the stevia/sugar variation both had consistent “L” values. The “a” and “b” values were consistent for all of the variables. There was little variation for the “a” value, with the control being approximately 1 point higher than the other 2 variables. The “b” value for sugar/stevia was approximately 1 point lower than the other 2 variables. Overall, **Figure 2** shows the consistency between each value for each variable.

Three different variables could have affected the results we obtained from the Hunter Colorimeter. Some of the variables could have been cooked longer, reaching a temperature that could have brought the caramels to a different heating stage for candies. This could cause more
Maillard browning to occur, which could make the caramels darker. The caramels could have also been slightly scorched if heated at a higher stove setting. This would also cause a darker color. One other variable that could have occurred is that more sugar and sugar substitute could have been added than intended, especially for the stevia/sugar combination. This could also have increased the Maillard reaction causing more browning.

Texture Analyses

The texture of the caramels was evaluated using the Texture Analyzer. The Texture Analyzer is used to analyze the texture of many different food products by cutting, penetrating, and compressing it. The Texture Analyzer works by measuring the penetration force of the product (Weaver and Daniel 2003). In this experiment, the cone probe was used since caramels have a soft structure.

In Figure 4, the average penetration force can be seen for the control, stevia, and stevia/sugar caramel variations. These results seemed to vary completely. The penetration force of the control is much higher than the stevia variable and the stevia/sugar variable, with an average force being 78.6 g. The stevia/sugar variable was at 48.63 g and stevia was the lowest at 10.33 g.

Sources of error that could have affected these tests are that stevia does not have the same consistency as sugar. Stevia has a powder consistency so more liquid should be added to make the product because it does not liquefy like sugar does. This could lead to a denser product with a drier consistency (Hulett 2002).
Sensory Panel

The Hedonic Scale was used in this study to evaluate over desirability of this product. In this method of evaluating a food product, a sensory panel is used to taste the food and rate it on a 9-point scale. The scale ranges from 0-9 where 0 is disliked extremely and 9 is extremely desirable. This method can be used on a wide range of individuals who are not trained in depth on taste testing. This method is also used widely for statistical reasoning (Peryam and Pilgrim 1957).

All of the caramel variables in this study ended up receiving a considerably high ranking on the Hedonic Scale. The control received a ranking of 8.13, which is considered to be very desirable. The stevia variable received a ranking of 7.04, which is slightly lower than the control. The stevia/sugar variable was the lowest at a ranking of 6.45.

Desirability of this product could have been affected by cooking the caramels too long and scorching the product. Cooking the caramels longer and at a higher temperature could have scorched the overall product, causing an undesirable taste. This could be the issue with the stevia/sugar variable. The amount of sugar added could have also affected the desirability of the product. Too much sugar or sugar substitute added could have led to a decreased or increased desirability of the product. In the stevia and stevia/sugar variable, more liquid was not added to compensate for the consistency of the product, which could affect the overall desirability of the product. The same could have been affected by using less sugar or sugar substitute in the caramel product.

Overall Results
After analyzing the data, there seems to be little effect using stevia as a sugar substitute. The color and texture seem to vary greatly compared to the other variables. However, using stevia and sugar combined in making caramels seems to affect the desirability and the overall color of the product. When looking at the overall data, the control variable is much higher for color and texture, while the stevia variable is much lower. When looking at the stevia/sugar variable, there is an evening-out effect occurring. The results for this variable seem to be correlated directly to the proportions of the sugar versus the stevia substitute that the caramel product is comprised of.

From analyzing the results, stevia clearly shows to be a desirable product that could actually compete with sugar to be a functional product. It has multiple studies supporting its benefits, of which include hypertension and type 2 diabetes. Stevia has been proved to lower systolic and diastolic blood pressure levels over a 3 month period for hypertensive subjects, which can conclude that stevia could potentially be used as a treatment therapy for a hypertensive patient (Chan and others 2000). Stevia has been shown to decrease blood glucose levels in type 2 diabetics, which could benefit glucose metabolism in these patients (Gregersen and others 2004). Rebaudioside A, which is an extraction of the stevia plant, has been shown to stimulate insulin secretion (Abudula and others 2004). This could ultimately act as a treatment for type 2 diabetics.

Future research could be done on this project by adding more variations of the caramels. The caramels could be composed of different proportions of stevia and sugar, rather than one half-and-half variable. This could actually compare the interactions of the two variables on a deeper level to see if stevia actually acts as sugar or if they compensate each other. It would then
be more valid to say if stevia and sugar did act equally when used to make food products or if a difference between the two variables actually can be distinguished through taste and objective parameters. This could ultimately lead to a better acceptance of the new sweetener stevia as well as benefits to type 2 diabetics and hypertensive patients everywhere.

References


Peryam D, Pilgrim F. Hedonic scale method of measuring food preferences. Food Technology 11:9-14


Web References
Cavities/Tooth Decay. 2009. Retrieved from


http://www.recipenet.org/health/articles/stevia_equivalents2.htm