The Use of Sugar Alcohols in Banana Bread

Abstract

With Americans eating the equivalent of twenty teaspoons of sugar each day, there is a need to find an alternative that will be healthier to consume. Sugar alcohols are an alternative to table sugar, or sucrose. Since they provide fewer calories, they are often used in lower calorie diets, and since they do not raise blood sugar, they are often used in diabetic diets as well. Along with the above two benefits, they prevent dental carries too. This experiment looks to see whether or not baking with sugar alcohols will produce a product that is similar in taste, texture, and appearance, to a product made with table sugar. Four different banana breads were prepared in this experiment. The first was the control bread, or the one made with sucrose. Next, the sugar alcohols, sorbitol, mannitol, and maltitol were all used in the same amount that the sucrose was used in the bread. To test these assumptions, the hedonic nine point taste scale was used to assess the preference in terms of taste. These results indicated that many consumers liked the breads with sugar alcohols as much, if not more, as the bread made with sucrose. Water activity was also a measure that was used in this experiment. Water activity is used to assess texture, appearance, aroma, and taste either directly or indirectly. These results were also very similar to that of the control, indicating that a very similar product can be produced by using sugar alcohols. Last, the texture analyzer was used to assess the moisture and texture of the different breads. The results were also very consistent in that the breads were not very different from that of the control, and often times, the breads required less force than the control to puncture the bread. This could be due to the fact that sugar alcohols are great contributors of moisture and texture to foods. Overall, sugar alcohols are a safe product that can be used in place of table sugar. It is important, however, to make sure that the sugar alcohol is being used as it is recommended for the specific food item. A satisfying product will be the result, as shown by a number of different tests.
Introduction

Sugar alcohols can be used as a low calorie alternative to sugar in the preparation of sweets, such as baked goods like banana bread. This experiment focused on three specific sugar alcohols: sorbitol, mannitol, and maltitol, as well as the use of white sugar (sucrose). Americans are eating the equivalent of twenty teaspoons of sugar each day, so anything that would be cutting back from these excess calories would be good (Henkel 1999). It is important to note that there is a difference between artificial sweeteners and sugar alcohols. Artificial sweeteners include saccharin and aspartame and have zero calories and carbohydrate (Nutrition Advisor). According to information on polyols from the American Dietetic Association, it is known that sugar alcohols occur naturally in foods and come from plant products like fruits and berries. They are known to provide fewer calories (about one-half to one-third less) than regular sugar. The reason being is because they are converted to glucose more slowly, require little or no insulin to be metabolized and do not cause sudden increases in blood sugar, so they are therefore popular amongst diabetics. Sugar alcohols are not considered sugars or alcohols. They are carbohydrates with chemical structures that partially resemble sugar and partially resemble alcohol. Sugar alcohols are incompletely absorbed and metabolized by the body, and consequently contribute fewer calories. Their calorie content ranges from 1.5 to 3 calories per gram compared to 4 calories per gram for sucrose. Most sugar alcohols are half as sweet as sucrose. Maltitol is just about as sweet as sucrose, which was used in this experiment.

This experiment was carried out three different times to see if the results were consistent. Before carrying out this experiment, some assumptions were made. Research and use with sugar alcohols in food products has shown that those baked goods, like the banana bread, made with maltitol as a sugar replacer would give a product that is not as consistent in texture, consistency and cohesiveness as the other breads. In regards to preference, it is likely that the bread made with the sugar alcohols will not have as strong of a preference by consumers as the bread made with sucrose. The purpose of this experiment then is to see if these assumptions are correct. This experiment will look at whether or not banana bread made with sugar alcohols like sorbitol, mannitol, and maltitol will produce a product similar to a bread that is made with sugar in regards to taste, texture, and appearance and water activity. The dependent variable is what will be observed, such as the texture, and preference compared to the control bread, which will be made with regular sugar. The independent variables will be the amount of cooking time of each bread, rate and speed of mixing, cooling, etc. There is a logical relationship between the independent and dependent variables. The whole purpose of this project is to see whether sugar alcohols are as beneficial as they seem in terms of taste, volume and texture compared to the control bread that has more calories, but is otherwise the same and better for individuals to consume. Zoulias, Piknis, and Oreopoulou 2000, found that maltitol and fructose used in the baked goods resulted in dough with high values of hardness and consistency and low adhesiveness and cohesiveness. However, those made with lactitol, sorbitol and xylitol had the opposite effect. These were similar to the sucrose cookies and also had good texture and preference. According to the Sugar Alcohols Fact Sheet 2004, sorbitol and mannitol are both monosaccharide-derived, while
the maltitol is disaccharide-derived. Mannitol may cause some bloating and diarrhea because it lingers in the intestines for a long time. Sorbitol is often found in sugar-free gums and candies and is less likely to cause diarrhea. Maltitol gives a creamy texture to foods and has not been linked to any gastrointestinal distress. These facts are noteworthy before cooking with any sugar alcohols.

Methods

In this experiment, which was carried out three times, four different banana breads were prepared: sorbitol, mannitol, maltitol, and the control bread (sucrose). By performing each experiment three times, the precision and accuracy could be better assessed. The recipe, which is included below, was halved for each bread that was made. First, the dry ingredients were mixed together for each bread for thirty seconds. This included the flour, baking soda, salt, and sugar or sugar alcohol. Then the wet ingredients were also mixed for thirty seconds, which included the butter, eggs, and the mashed bananas. Then the entire mixture was mixed together for two minutes.

Ingredients:
190 g all-purpose flour
5 g baking soda
3 g salt
200 g white sugar
2 eggs, beaten
55 g butter, melted
3 bananas, mashed

Directions:
1. Grease and flour two 7x3 inch loaf pans. Preheat oven to 350 degrees F (175 degrees C).
2. In one bowl, whisk together flour, soda, salt, and sugar. Mix in slightly beaten eggs, melted butter, and mashed bananas. Stir in nuts if desired. Pour into prepared pans.
3. Bake at 350 degrees F (175 degrees C) for 1 hour, or until a wooden toothpick inserted in the center comes out clean.

Each trial was tasted by a different group of people and they used the Hedonic nine point scale to rate their liking for the taste of the different breads. By using different people with each trial, this enhanced the randomization and gave a better idea of which bread was liked most. The people were randomly selected. They were either classmates or roommates. Ten people were used with each trial, so there were a total of thirty different people used in this experiment to test and rate the bread. Overall, testing these results three times helped to see if there was precision in which bread was preferred amongst the consumers. Below is a sample of the scale that people used.
<table>
<thead>
<tr>
<th>SAMPLE 113</th>
<th>SAMPLE 421</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Like extremely</em></td>
<td><em>Like extremely</em></td>
</tr>
<tr>
<td><em>Like very much</em></td>
<td><em>Like very much</em></td>
</tr>
<tr>
<td><em>Like moderately</em></td>
<td><em>Like moderately</em></td>
</tr>
<tr>
<td><em>Like slightly</em></td>
<td><em>Like slightly</em></td>
</tr>
<tr>
<td><em>Neither like nor dislike</em></td>
<td><em>Neither like nor dislike</em></td>
</tr>
<tr>
<td><em>Dislike slightly</em></td>
<td><em>Dislike slightly</em></td>
</tr>
<tr>
<td><em>Dislike moderately</em></td>
<td><em>Dislike moderately</em></td>
</tr>
<tr>
<td><em>Dislike very much</em></td>
<td><em>Dislike very much</em></td>
</tr>
<tr>
<td><em>Dislike extremely</em></td>
<td><em>Dislike extremely</em></td>
</tr>
</tbody>
</table>

Comments:

<table>
<thead>
<tr>
<th>SAMPLE 235</th>
<th>SAMPLE 372</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Like extremely</em></td>
<td><em>Like extremely</em></td>
</tr>
<tr>
<td><em>Like very much</em></td>
<td><em>Like very much</em></td>
</tr>
<tr>
<td><em>Like moderately</em></td>
<td><em>Like moderately</em></td>
</tr>
<tr>
<td><em>Like slightly</em></td>
<td><em>Like slightly</em></td>
</tr>
<tr>
<td><em>Neither like nor dislike</em></td>
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</tr>
<tr>
<td><em>Dislike moderately</em></td>
<td><em>Dislike moderately</em></td>
</tr>
<tr>
<td><em>Dislike very much</em></td>
<td><em>Dislike very much</em></td>
</tr>
<tr>
<td><em>Dislike extremely</em></td>
<td><em>Dislike extremely</em></td>
</tr>
</tbody>
</table>

Comments:
The water activity was measured for each bread using the Water Activity System. Water activity was measured because it is directly or indirectly related to texture, appearance, aroma, taste freeze-thaw stability, and the microbiological, chemical, and many other objective and subjective characteristics of food (Weaver). By knowing the water activity in a food, the compatibility with other foods, formulation and packaging requirements may be better understood. For each sample, the same amount of bread was placed in the water activity system to keep each test consistent, which was a 0.5 inch x 0.5 inch sample. The temperature as well as water activity was recorded three times for each bread.

Another tool used in this experiment was the Stable Micro Systems Texture Analyzer. In this experiment, the cone probe was used and the setting was set on the Cake setting. The way that the texture analyzer works is that it measures the force that is needed to cut, compress or puncture its way through the food item. For each trial, three readings were taken for each bread.

In the original set up of this experiment, seed volume apparatus was one of the measurements that was going to be carried out, however, due to the large volume of the loaf of bread, it could not be done. Therefore, that is why water activity was used in the place of seed volume.

Discussion

Before baking with the sugar alcohols, some basic observations were made on each. Mannitol looked very much like powdered sugar. It was a bit clumpier and required to be stirred up before it was added to the rest of the dry ingredients. The maltitol had more finely grained granules. It had a smoother texture. Sorbitol was the most finely grained of all three sugar alcohols. It had the most similar consistency to table sugar. Mannitol has fifty to seventy percent relative sweetness of sugar, so more must be used to equal the sweetness of table sugar. It is most often used as dusting powder for chewing gum, as an ingredient in chocolate-flavored coating agents for ice cream and confections. With every trial, the bread made with mannitol came out with a different color, almost moldy looking. There was a hard coating that formed on the outside and the consumers consistently rated this bread as the lowest in terms of their liking. This could be an indicator that this sugar alcohol may not be the best to use in baked goods. Maltitol has seventy-five percent the relative sweetness of table sugar. It is very often used in hard candies, chewing gum, chocolate, baked goods, and ice cream. Maltitol was very strongly rated on the hedonic scale as being very well liked. This may be because it was closest in the sweetness to table sugar, so the other breads like mannitol and sorbitol may have been lacking in sweetness, which ultimately affected how they were rated. The high scores that the maltitol bread received is not in agreement with what was hypothesized for this bread. Sorbitol is very often used in sugar-free candies, chewing gums, frozen desserts, and baked goods. It has fifty percent the relative sweetness of table sugar, so twice as much needs to be used in order to achieve the same sweetness. This could very well explain the results in taste preference by consumers.

When measuring water activity, a value of 0.8 or lower is associated with longer shelf life due to inhibition of growth of microbes. The breads made with sorbitol and
mannitol were consistently higher in water activity, usually giving a number higher than 0.8. This effect of water activity would affect food spoilage and food-borne disease hazards. It is most desirable to have a product with lower water activity for these reasons. The bread made with maltitol was closer in similarity to the water activity of the bread made with the control sugar. This was also evident in the ranking by consumers as they rated this bread as being very well liked.

Sugar alcohols as a whole are known to enhance the texture of products and make them more desirable. Overall, all of the forces in grams were relatively similar amongst all of the breads. At times, some would be higher and others lower, but generally they remained in the range of between 20.5 to 41.6 grams. The moistest breads were those that did not need as much force to pierce through the food item. Overall, a sugar alcohol will add to the texture of the product and better retain the moisture of the products, but it is wise to make sure to use the sugar alcohol as it is recommended to be used. As long as future studies continually support that sugar alcohols are safe for consumption, they are a good bet to choose.

Results

Table 1. Trial One: Effects of different sugar alcohols on texture and water activity

<table>
<thead>
<tr>
<th>Bread</th>
<th>Water Activity</th>
<th>Texture Analyzer (grams)</th>
</tr>
</thead>
<tbody>
<tr>
<td>113 (control)</td>
<td>0.742</td>
<td>0.796</td>
</tr>
<tr>
<td>421 (sorbitol)</td>
<td>0.866</td>
<td>0.861</td>
</tr>
<tr>
<td>235 (mannitol)</td>
<td>0.843</td>
<td>0.816</td>
</tr>
<tr>
<td>372 (maltitol)</td>
<td>0.721</td>
<td>0.70</td>
</tr>
</tbody>
</table>
Figure 1. Trial One: Grams of Force vs. Water Activity

Table 2. Trial Two: Effects of different sugar alcohols on texture and water activity

<table>
<thead>
<tr>
<th>Bread</th>
<th>Water Activity</th>
<th>Texture Analyzer (grams)</th>
</tr>
</thead>
<tbody>
<tr>
<td>113 (Control)</td>
<td>0.796</td>
<td>0.824</td>
</tr>
<tr>
<td>421 (Sorbitol)</td>
<td>0.872</td>
<td>0.881</td>
</tr>
<tr>
<td>235 (Mannitol)</td>
<td>0.857</td>
<td>0.862</td>
</tr>
<tr>
<td>372 (Maltitol)</td>
<td>0.746</td>
<td>0.723</td>
</tr>
</tbody>
</table>
Figure 2. Trial Two: Grams of Force vs. Water Activity

Table 3. Trial Three: Effects of different sugar alcohols on texture and water activity

<table>
<thead>
<tr>
<th>Bread</th>
<th>Water Activity</th>
<th>Texture Analyzer (grams)</th>
</tr>
</thead>
<tbody>
<tr>
<td>113 (control)</td>
<td>0.866 0.842 0.845</td>
<td>32.2 37.5 36.4</td>
</tr>
<tr>
<td>421 (sorbitol)</td>
<td>0.737 0.766 0.741</td>
<td>34.9 30.5 31.2</td>
</tr>
<tr>
<td>235 (mannitol)</td>
<td>0.818 0.836 0.842</td>
<td>25.4 32.1 27.1</td>
</tr>
<tr>
<td>372 (maltitol)</td>
<td>0.711 0.70 0.748</td>
<td>22.7 29.0 28.3</td>
</tr>
</tbody>
</table>
Figure 3. Trial Three: Grams of Force vs. Water Activity
Hedonic Scale Results

Trial One

SAMPLE 113 (Control)                      SAMPLE 421 (Sorbitol)
Like extremely-0                          Like extremely-1
Like very much-4                          Like very much-1
Like moderately-1                         Like moderately-7
Like slightly-3                           Like slightly-1
Neither like nor dislike-2               Neither like nor dislike-0
Dislike slightly-0                       Dislike slightly-0
Dislike moderately-0                     Dislike moderately-0
Dislike very much-0                      Dislike very much-0
Dislike extremely-0                      Dislike extremely-0

Comments:
Good texture
Seemed a bit dry

Comments:
Very tasty
My favorite of all four
Most moist

SAMPLE 235 (Mannitol)                     SAMPLE 372 (Maltitol)
Like extremely-0                          Like extremely-0
Like very much-0                          Like very much-4
Like moderately-0                         Like moderately-3
Like slightly-4                           Like slightly-2
Neither like nor dislike-1               Neither like nor dislike-0
Dislike slightly-3                        Dislike slightly-1
Dislike moderately-1                     Dislike moderately-0
Dislike very much-1                      Dislike very much-0
Dislike extremely-0                      Dislike extremely-0

Comments:
Nasty appearance
Too hard on the outside
Looked weird but tasted good inside

Comments:
By far the best
Tasted normal
Trial Two

SAMPLE 113 (Control)
Like extremely-0
Like very much-2
Like moderately-4
Like slightly-3
Neither like nor dislike-0
Dislike slightly-0
Dislike moderately-1
Dislike very much-0
Dislike extremely-0

Comments:
Bland
Good texture
Feels weird
Better than 235
Good but dry
Too dry, bland

SAMPLE 421 (Sorbitol)
Like extremely-0
Like very much-3
Like moderately-1
Like slightly-2
Neither like nor dislike-1
Dislike slightly-2
Dislike moderately-0
Dislike very much-1
Dislike extremely-0

Comments:
Too banana-y
Bland
A little salty
Very moist, sweet

SAMPLE 235 (Mannitol)
Like extremely-0
Like very much-1
Like moderately-1
Like slightly-3
Neither like nor dislike-3
Dislike slightly-0
Dislike moderately-1
Dislike very much-1
Dislike extremely-0

Comments:
Cardboard outside, wet inside
Bland/dry
Kind of dry
Tasted a lot like bananas
Flaky crust, but good flavor

SAMPLE 372 (Maltitol)
Like extremely--6
Like very much-4
Like moderately-0
Like slightly-0
Neither like nor dislike-0
Dislike slightly-0
Dislike moderately-0
Dislike very much-0
Dislike extremely-0

Comments:
Moist, perfect flavor
Soft and yummy
Really flavorful
Very moist
Perfect, great flavor
Trial Three

SAMPLE 113 (Control)
Like extremely-0
Like very much-4
Like moderately-3
Like slightly-3
Neither like nor dislike-0
Dislike slightly-0
Dislike moderately-
Dislike very much-0
Dislike extremely-0

Comments:
Very yummy
My favorite

SAMPLE 421 (Sorbitol)
Like extremely-0
Like very much-2
Like moderately-5
Like slightly-3
Neither like nor dislike-0
Dislike slightly-0
Dislike moderately-
Dislike very much-
Dislike extremely-0

Comments:
Kind of blah

SAMPLE 235 (Mannitol)
Like extremely-0
Like very much-
Like moderately-1
Like slightly-4
Neither like nor dislike-4
Dislike slightly-1
Dislike moderately-0
Dislike very much-0
Dislike extremely-0

Comments:
Not very good
Too hard
Looked gross, but didn’t taste awful

SAMPLE 372 (Maltitol)
Like extremely-2
Like very much-4
Like moderately-4
Like slightly-0
Neither like nor dislike-0
Dislike slightly-0
Dislike moderately-
Dislike very much-
Dislike extremely-0

Comments:
By far the best!
So tasty!
References


Weaver CM, Daniel JR. The Food Chemistry Laboratory. CRC Press LLC. 2003