

Does the use of sucralose and/or sugar alcohols in baked goods change the rheological and sensorial properties

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When we think of baked goods we want them to taste great, have amazing mouth feel, good texture and many other things depending on what kind of baked good it could be. When baking we use many different ingredients to make our end product. Sugar is one of those ingredients we use a lot of in baking which can add a lot of calories to those baked items. There are so many different types of alternative sweeteners we can use in place of sucrose or table sugar as it is known to most consumers. With replacing these alternative sweeteners for sucrose will the product end up looking and tasting the same as it would if sucrose was used only having fewer calories. Does the use of sucralose and / or sugar alcohols in baked goods change the rheological and sensorial properties?

Introduction

Sucralose is a disaccharide which also known as Splenda to the consumers. The manufacture of sucralose is done by removing three hydroxyl groups from sucrose and replacing the hydroxyl groups with chlorine molecules which gives this molecule structure and stability. Sucralose is intensely sweet since it is made from sucrose compared to other sweeteners made from other monosaccharaides or disaccharides.¹ Sucralose has been available on the consumer market since the late 1990's when it was approved by the FDA. Sucralose is highly water soluble and can be used in baking. Since sucralose is a low calorie sweetener we see a lot more baked items using this sweetener and others to lower the calories of the baked items.

Sugar alcohols are also referred to as polys. There are many different types of polys that are used in baked goods. Many polys are found in nature but they are manufactured from

monosaccharides and/ or polysaccharides to be used in different consumer food items. One of the main reasons for using sugar alcohols is that they do not raise the blood glucose levels like sucrose does.² Some items that are marked sugar-free usually have some kind of sugar alcohol or multiple sugar alcohols cooked into them to allow companies to place this message on their packages. We have seen a lot of these food items that contain sucralose and sugar alcohols marketed towards those who have diabetes, overweight or obese to allow them to still enjoy certain food items that would normally be packed with lots of calories for sucrose.

Rheological and mechanical properties of the dough and/ or batters

With replacing sucrose for sucralose or sugar alcohols in baking goods it could change the rheological and mechanical properties of the dough or batter. In this study they kept all the ingredients the same except the sweetener to see what affect it has on the dough. They followed a croissant-type formulation for making the dough. Using these ingredients for each dough recipe were distilled water, margarine, salt, wheat flour, and egg yolk with the only varying ingredient being the sweeteners per dough recipe. The sweeteners that were used were sucrose, fructose, and sucralose. When figuring out how much of the sweeteners to use they had to take in to account the sweetness levels. For instance fructose is 1.5 times sweeter than sucrose and sucralose is 600 times sweeter than sucrose.³ Since this study was looking at the mechanical and rheological properties of the dough there was no yeast used in the croissant type dough.

All of the dry ingredients were added to a bowl and mixed for 1 minute, then the liquids were added including the yolk they stopped the mixer for a minute to collect the particles on

the side of the bowl to make sure that everything is incorporated and continued mixing for another 20 minutes. The dough's were then divided into 12 balls that each weighed 10 grams. The dough was then put into containers and placed in a stable temperature of 25 degree Celsius to rest for 15 minutes before the study went any further.³

The first test that was done was a compression test done on a flat plate which compressed the dough until it reached 40% of its initial start height. When pulling the probe off of the dough they tested the forces of removal and recorded this for the dough's stickiness. The compression test recorded for stiffness, hardness, and compression energy. The Kieffer extensibility mold test was done with 12 strips after they rested for 40 minutes. This test was for resistance to extension, extensibility, and energy to break. The last test that was done to see how much moisture was in the dough.³

The results from this study was that sucralose had the highest resistance in the compression test as well it was the hardest and had the most compression of energy which had similar mechanics to the dough without sugar.³ In the Kieffer test the sucralose had the highest numbers compared to the other sugars for breaking force. Sucralose ranked the lowest on the extensibility, and for the energy break it ranked in the middle of the other sweeteners. The moisture of the dough for sucralose was 33.2% where sucrose was 33.9%.

The rheological properties were greatly affected by the sweeteners used in this croissant-type dough. The dough that was made with the sucralose was more solid, elastic, and had a higher resistance to the tensile forces, where the dough with sucrose was softer and had

more viscous texture. This is why there are other additives added to sugar free baked goods to compensate for sucrose functionalities in the dough and end product.³

There was an earlier study done on biscuit dough studying the rheological properties of the dough using different polys in the dough. The mixing method they used was not the traditional biscuit method. They added the sugar and fat to the water first to create a creamy mass then added the flour quickly and mixed vigorously to have minimal gluten formation in the dough so that it obtained the proper strength.⁴ The dough had a resting period similar time frame to the croissant type dough before any of the test were performed. They test the elasticity and rigidity of the dough. The dough that was made with the sugar alcohols had higher rigidity and elasticity since the dough had less bulk because there is less sugar alcohols need vs. sucrose.

What effects can different polys have on the rheological properties of a cake batter? With sucrose having such a major impact on the cake batter by allowing air to be added to the batter which then affects the cake during baking by allowing bubbles to form which add the volume to the cake. The starch gelatinization is very important in cake making for this will give the cake the texture. With replacing the different polys equal for sucrose in the batter the ability to see the full reaction of how the poly will incorporate all of the rheological properties.⁵

They tested the batter for viscosity with shears behavior and consistency by specific gravity. Mannitol had the highest consistency of the polys and the specific gravity for this sugar alcohol was not as low as expected. The two other polys that were part of this study were lactitol and maltitol which had rheological proprieties close to that of sucrose when it came to

the batter. They were able to incorporate the air so the bubbles would form correctly to give the cake proper volume and the starch gelatinization was similar to sucrose which gave the cake the right texture.⁵

Physical and Sensory properties of baked goods

More individuals want their baked goods to be lower calories, but still want that same taste and texture of sucrose. In this study that takes out sucrose complete from a sponge cake recipe and replaces it with different sugar alcohols to see if it will taste and have the same physical properties as a regular sponge cake made with sucrose. There were cakes made from xylitol, sucralose, and there was a control cake made with sucrose. After all the cakes were baked off and cooled for 3 hours first and were cut in half. The top half for the cake was testing the crust and the bottom half was used to analyze the crumbs. There was also a sensory evaluation on the cakes which asked a trained panel group about sweetness, mouth feel, texture, after taste, uniformity and color of the crusts and crumbs.⁶

The results for the color of the cake were that the crumbs of the control and most of the sugar alcohols that were a part of this study had similar darker color. All of the sugar alcohols had a much darker crust than the cake made with sucrose. Since the crust of the cakes gets exposed to the high temperatures of the oven there is a Maillard reaction that occurs and which also for the changes in color of the crust. For the firmness part of the evaluation it was done over a four day period. Mannitol had the highest firmness on the day they were baked with the control falling behind, and the other sugar alcohols were lower than the control for firmness. The firmness increases with each day however xylitol end up having the lowest

firmness for all of the days. For the aftertaste sensory after the control was xylitol then mannitol for the most pleasing sweeteners. However mannitol did not do well on the other sensory of mouth feel and uniformity. The sugar alcohol xylitol scored the highest for the sensory evaluation. Out of all the sugar alcohols that were a part of this study xylitol was the best substitute for sucrose for this study.⁷

Muffins are a good baked item to use for replacing sucrose for there is a lot of physical and sensory properties that can be analyzed. Since muffins have a delicate mixing method the replacement sugars will stand out from flour. This study used 3 different sugar alcohols sorbitol, erythritol, and maltitol. They analyzed the color, texture, flavor, sweetness, and their overall acceptances from a group of analysis. Erythritol was the less liked and had the most negative sensory feedback with the muffin being too hard, very chewy, low height, and less springiness. Whereas the other two sugar alcohols had similar results to that of sucrose, their height was closer to sucrose, slightly less hardness than sucrose and less chewy. When it comes to replacing sucrose for a sugar alcohol maltitol and sorbitol are the better choices in this study.⁸

When eating cookies we want them to have good mouth feel, great texture, and have a good balance of sweetness. When substituting sugar alcohols in for sucrose the cookies may have an unpleasant taste, be brittle or hard. The lactitol and sorbitol were softer than the control cookie made with sucrose. The cookies made with maltitol were the hardest ones. Sucrose and maltitol had a higher brittleness compared to lactitol and sorbitol. However maltitol did have the most brittleness cookies. When it comes to the sensory analysis maltitol was the one most liked compared to the other two sugar alcohols in this study.⁹

Health Benefits and Concerns

With obesity and diabetes numbers on the rise these patients want to be able to enjoy some sweet that will not have all the calories as regular table sugar and will keep their blood glucose levels from raising. A lot of these patients have made the switch to sucralose or sugar free items that have different types of sugar alcohols but how are these alternative sweeteners benefiting these patients. One of the facts we know about these alternative sweeteners is they are lower in calories and are very popular among these demographics. We have seen a raise in children consuming products containing these alternative sugars since childhood obesity has been rising every year. What affect do these alternative sweeteners have on our system and is there a link to any major health concerns like some of the other alternative sweetener? ¹⁰

Sucralose has been studied in over 110 studies looking to see if there are any health concerns or health benefits in consuming sucralose. When looking at sucralose we know that it is a disaccharide that is made from a sucrose molecule which makes this a fairly small molecule. This molecule is also polyhydroxylated which makes it highly water soluble. One of the health concern had to do with metabolism and if this molecule was bioaccumulative. Sucralose doesn't accumulate in our system. It passes through our system without even being absorbed. Close to 80%-85 % is excreted out through our feces. The other 10%- 15% that does get absorbed through our oral cavity only 2%-3% is metabolized of the sucralose that does get absorbed it is excreted through the urine.¹¹

Since our bodies only absorb sucralose from our oral cavity there was a study done to see if this affects the amount of GLP-1 or PYY hormones secreted in the gastrointestinal tract.

There was a single blind study done with eight volunteer who were nonsmokers and at a healthy weight. This study was done over 4 randomized days where the volunteers drank a solution containing sucralose or water. After drinking they had to stay for blood to be drawn at different time frames after the solution was ingested. On the four day after drinking the normal amount of the solution they had to use a straw to ingest a different solution to swish around their mouth then spilt it out until all 200 mL we gone. After this they had more blood work done. In the results of this study there was there was no change in the GLP-1 or PYY hormones after those who had ingested the sucralose solution.¹² This shows that there needs to be more studies down with a larger group. However, according to this study consumption of sucralose doesn't affect GLP-1 or PYY hormones.

Sugar alcohols as I mentioned earlier in the paper do exist in nature in fruits and vegetables because sugar alcohols are not sugars or alcohols but a hydrogenated carbohydrate. There are some health benefits to consuming some of these sugar alcohols. They are non-cariogenic, low glycemic, low-energy, low-insulinaemic, and low digestible. With sugar alcohols being marketed as a low glycemic index sweetener they market these sugar alcohols to those who have diabetes for they are able to enjoy some sweets without spiking there glucose or they market them as a low calorie sweet for those who are on a lower calorie intake.¹³

Conclusion

After looking at all the different research on sucralose and sugar alcohols, and the effects they have on the rheological and mechanical properties of the dough and/ or batters that create the end baked products, makes you want to think twice about what product you are

consuming. With sucralose being 600 times sweeter than sucrose there is less need to make a baked item sweet which allows items made with this to have fewer calories. Sucralose does change the rheological properties of the dough compared to sucrose. The dough made with sucralose was much harder and resembled dough without any sweetener. After being baked the sucralose does have a similar mouth feel to sucrose and texture which is one of the reason why since the late 1990's sucralose has been used in beverages and other consumer products that want their items to have fewer calories than items with sucrose but have the same properties as sucrose.¹⁴

Sugar alcohols have been used for a long time in baked goods labeled sugar free since they are considered a hydrogenated carbohydrate that is either made from a ketone or aldehyde with an alcohol group attached at the end of the chain making it a sugar alcohol. With most of these being made from either a monosaccharide or a polysaccharide they have different characteristics in taste, reactions, and sweetness. With the research that has been on the different sugar alcohol to find one that compared to sucrose in mouth feel, taste, and has similar rheological properties for the dough to create an item similar to one made with sucrose. The sugar alcohols that had the best results from the studies I researched were xylitol, sorbitol, and maltitol.¹⁵

Application to practice

With the use of these sugar alcohols and sucralose in baked goods that are on the consumer market which are labeled to those who are on lower glycemic index diets like someone who has diabetes.¹⁶ These baked goods with these alternative sweeteners allows

those who need to watch their glucose levels enjoy a sweet treat. All though these sweeteners do help lower the calories of these items and not raise the glucose levels consumers still need to make sure they don't over consume these items. If they do end up over consuming they will be adding all the calories of a full baked item made with sucrose.

With these alternative sweeteners they account for few calories and our body process them differently than sucrose does for their molecular structure does not get absorbed into our systems or they are partially metabolized. We should only be taking in sweets a few times a week not a few times a day. Even if these treats are made with alternative sweeteners they can still add extra calories to one's diet which could lead to weight gain or other health problems that are linked to sweeteners.

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