The differences of using white sugar, light brown sugar, or dark brown sugar when baking a chocolate chip cookie recipe

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Abstract:

Sugar is an essential ingredient when baking that not only changes the flavour of a baked good, but also affects the overall texture, color, volume, and tenderness. The difference between white sugar, light brown sugar, and dark brown sugar is often overlooked and many people will interchange the three without realizing just how drastically it can affect the results. The objective of this experiment is to investigate the impact of using the three types of sugar in a simple chocolate chip cookie recipe on the final size (diameter, height) and observed color and texture. I predicted that the white sugar cookies would be the thinnest and largest in diameter, while the dark brown sugar cookies would be fluffiest and smallest in diameter, and the light brown sugar would be in between the two. Two one-way ANOVA tests were run on Microsoft Excel to statistically analyze the data to see if differences existed between the mean height and mean diameter of each type of cookie. P-values of 0.00001 were determined for both the mean height and mean diameter across the three types of cookies, and since this value is less than the significance level of 0.05, the null hypothesis was rejected stating that there is no difference between the sugar types and cookie sizes. It was found that white sugar cookies were smallest in height and largest in diameter, dark brown cookies were largest in height and smallest in diameter, and light brown sugar was in between which aligns with the initial predictions.

Introduction:

White sugar and brown sugar both come from sugar cane and sugar beets, and the difference between them comes down to how they are processed. After raw sugar is crushed and mixed with water, it is boiled down and purified to produce a sugar pulp that is further refined by undergoing further purification and crystallization (Brekhman, and Nesterenko). At this point, the products end are about 85% white sugar and 15% unrefined products that can either be turned into white sugar by further refinement or as brown sugar by adding molasses back into the unrefined product (Brekhman, and Nesterenko). For light brown sugar, about 3.5% of the product is molasses while dark brown sugar has nearly double the amount of molasses with about 6.5%, the main difference being the deeper flavor profile and color that comes with the additional molasses (Kumer). Molasses in baking makes for a richer flavour and a moist product, and this

moisture is key for getting sugar to melt without burning and that is why white sugar tends to burn faster than brown sugar (Moore). The molasses in brown sugar also helps with leavening as it is an acid that reacts with baking soda to make for a fluffier baked good (Selasky).

When baking, different recipes maybe use either white sugar, brown sugar, or a combination of the two in order to get the desired product. People will often interchange the two if they do not have both sugars in hand or if they prefer one sugar over another, and in many cases, they do not understand what a difference it will make when baking. In fact, most people tend to think that sugar only acts as a sweetener, but when baking, sugar has a role in the volume, tenderness, color, texture, and shelf life of the product ("Sugars - Joyofbaking.com"). This experiment aims to test the difference between white sugar, light brown sugar, and dark brown sugar when baking a simple chocolate chip cookie recipe. The significance behind this research is to identify the role of the three types of sugars in baking, and in order to do so, the baked cookies will be measured for height, diameter, and observed for their colors and textures.

The null hypothesis of this investigation is that the cookies made with each of the sugar types will all produce cookies of equal diameter and height, and the alternative hypothesis states that the cookies from the three types of sugar will not be equal and size and will differ in diameter and height. I predicted that the cookies made with white sugar would be crispier, thinner, and larger in diameter while the cookies made with brown sugar would be more compact, taller, and chewier. This is because the molasses in brown sugar would add moisture to the cookies, and the acidity would react with the protein in the cookie dough making for firmer cookies while white sugar melts faster and would spread the cookies thin (Selasky).

Methods:

For this experiment, I followed a simple chocolate chip cookie recipe that was found highly rate online and adjusted it accordingly to fit the experimental procedure ("Best Chocolate Chip Cookies"). Since I needed to make three different cookie doughs, with the only difference between them being the sugars, I decided to combine all of the dry ingredients together first (flour, salt, baking soda) and then split it into three equal parts using a kitchen scale. I then proceeded to make three different wet mixtures using butter, egg, vanilla extract and the sugar of choice. To make sure that all the cookie doughs were exactly the same except for the sugar, I measured all the ingredients by weight (grams) using a kitchen scale. When I had three dry mixtures and three different sugar mixtures, I proceeded to combine each dry mix with one of the sugar mixes to make a total of three cookie doughs. The dough made with white sugar should be a very light cream color, the light brown sugar dough should be a lighter tan color, and the dark brown sugar dough should be a darker tan color. Since the recipe uses melted butter, I then proceeded to chill all of the doughs in the refrigerator for 24 hours (minimum 1 hour).

Once the dough was chilled, I preheated the oven and made 5 cookie dough balls per recipe by using the kitchen scale once again to ensure that they were equal in size. Once measured, I rolled each ball into a sphere using my hands, placed it onto a pre-greased cookie sheet, and baked for 12 minutes. Since I baked my cookies using a toaster oven, I ended up having to bake each type of dough separately. After the cookies were baked and cooled, they were observed for the color, texture, height, and diameter. To measure the diameter, I took a measuring tape (in cm) and measured the bottom of each cookie as the flat bottom allowed for more accurate measures. To measure the height of the cookie, I broke each cookie in half and measured the middle dough part (not any chocolate chips) from top to bottom. Any observations

were written in my lab notebook and data was analyzed using Microsoft Excel. One-way ANOVA tests were used to statistically analyze the data to see if differences existed between the mean height and mean diameter of each cookie for each of the three doughs using different sugars. A QQ plot was made to check for normal distribution, and when the graph indicated normal distribution, the ANOVA tests were performed, and the P-value was found and recorded. The mean for each recipe and measure (diameter, height) was calculated and made into a bar graph with error bars for standard error to help visualize the data.

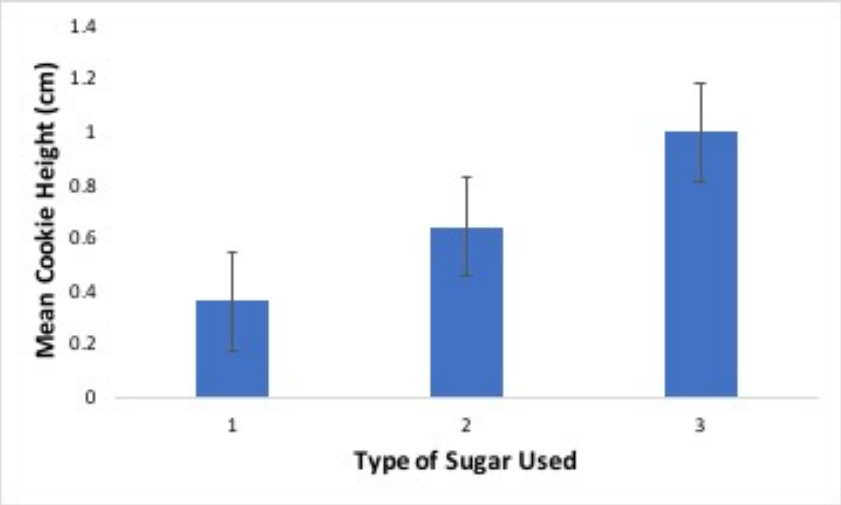
Results:

The mean cookie diameter and height was calculated for each cookie recipe (Figures 1 and 2), the white sugar cookies were found to have a mean diameter of 12.4 cm and mean height of 0.4 cm, light brown sugar cookies had a mean diameter of 11.4 cm and mean height of 0.6 cm, and dark brown sugar cookies had a mean diameter of 10.4 cm and a mean height of 1 cm. The results indicate statistically significant size differences amongst the treatment groups, and the results from the one-way ANOVA tests both indicate a P-value of 0.00001 which is less than the alpha value of 0.05, and thus the null hypothesis can be rejected.

Figure 1 describes the mean cookie height for the three recipes. Recipe 1 used white sugar and had the smallest mean cookie height of 0.36 cm, recipe 2 used light brown sugar and had a mean cookie height of 0.64 cm, and recipe 3 used dark brown sugar which had the highest mean cookie height of 1 cm. Figure 2 describes the mean cookie diameter for three types of sugars used. Recipe 1 with white sugar had the largest mean diameter with 12.44 cm, recipe 2 using light brown sugar had the second largest mean cookie diameter with 11.38 cm, and recipe 3 using dark brown sugar had the smallest mean cookie diameter with 10.44 cm overall. This aligns with the predicted outcome of white sugar cookies being the thinnest and the dark brown

sugar cookies being the smallest in diameter but tallest in height. Error bars in Figures 1 and 2 represent standard error, which describes the deviation between the sampling estimate for the means and the true mean. Smaller error bars mean that the sampling error is predicted to be low.

Figure 1. A bar graph for the mean cookie diameter (cm) for each recipe using different types of sugars. Recipe 1 (n=5) used only white sugar to make the cookie, recipe 2 (n=5) used only light brown sugar, and recipe 3 (n=5) used only dark brown sugar. Error bars represent standard error.



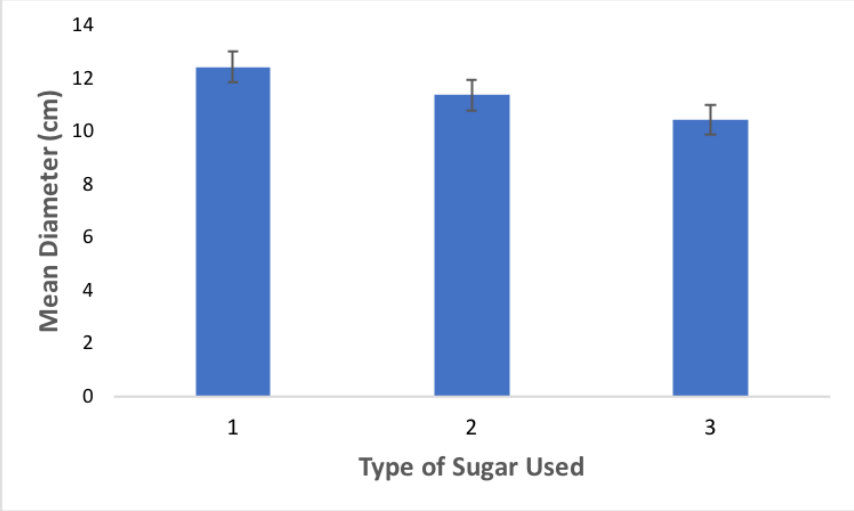


Figure 2. A bar graph for the mean cookie height (cm) for each recipe using different types of sugars. Recipe 1 (n=5) used only white sugar to make the cookie, recipe 2 (n=5) used only light brown sugar, and recipe 3 (n=5) used only dark brown sugar. Error bars represent standard error.

The color and texture of the cookies also varied between each type of sugar used. The white sugar cookies were observed to be a light golden-brown colour, very flat, oily, dense, with the chocolate chips being visible. The light brown sugar cookies were a nice golden brown with crispy edges, fluffier in height, some air pockets and chocolate chips were not as visible. The dark brown sugar cookies were dark all over, fluffiest overall, little to no visible chocolate chips, with a layer of air pockets.

Figure 3. Final baked cookies, top are the white sugar cookies, bottom left are the light brown sugar cookies, and bottom right are the dark brown sugar cookies.

Figure 4. Cross-section of each cookie recipe. Top is the white sugar cookies with no air bubbles, middle is the light brown sugar cookies with small air bubbles throughout, and bottom is the dark brown sugar cookies with a layer of air bubbles.

Discussion:

The results from this experiment indicates that the type of sugar used when baking does drastically affect the final outcome of a baked good. For this instance, the cookies varied in both diameter and height for the three treatment groups- white sugar, light brown sugar, and dark brown sugar. The one-way ANOVA tests determined P-values of 0.00001 when testing between the mean height and mean diameter amongst the three treatment groups. This P-value is greater than the significance level of 0.05, and as a result I rejected the null hypothesis stating that there is no significance difference between the three recipes and sugar types. My initial prediction stating that the white sugar cookies would be thin and largest in diameter while the dark brown sugar cookies would be thicker yet smaller in diameter was supported by this data. The analytical results align with the data presented in the bar graphs in Figure 1 and 2, which shows that the mean cookie height and mean diameters varied between all three treatment groups. For each cookie recipe, the mean height and diameter seem to oppose each other, the larger the diameter, the smaller the height is and vice versa. This corresponds to the literature stating that the chemical reaction with molasses in the brown sugar and baking soda creates a fluffier cookie while just using white sugar creates a thinner cookie (Selasky). The science behind this reaction is because the slight acidity of the molasses reacts with baking soda to create air bubbles in the dough which lifts the cookie in height and creates a chewier texture (Moore). These air bubbles were observed in the final product where the dark brown sugar cookies had a layer of air bubbles in the cookie layers, whereas the light brown sugar cookies had some air bubbles but not as much as the dark brown cookies, and the light brown cookies had no air bubbles.

Though most of the possible measurement and instrumental variation was controlled by using exact measurements on a kitchen scale, there are still possible sources of error that could

have affected my results. One of the sources being the small number of replicates in this experiment, having a larger number of replicates and even having more than one trial provides more accurate mean values and a smaller margin of error in the data.

Conclusion:

After investigating the effects of using different types of sugars in the same cookie recipe, I found that there is a significant difference in the outcome of the size (diameter, height) of each cookie produced. This indicates that white sugar and brown sugar affects more than just the sweetness of a baked good, and the amount molasses incorporated in brown sugars also affects the final product of the cookies. Analysis of the data led me to reject the null hypothesis which states that there is no difference between each sugar type and the size of the cookies. This confirms the initial prediction that white sugar and brown sugar has great affects in the final outcome of a baked good and to be aware of these differences when interchanging the types of sugar in a recipe.

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Appendix:

Table 1: Measured cookie diameters (cm) for each of the three sugar types used. Each cookie dough type (white sugar, light brown sugar, dark brown sugar) made a total of 5 cookies for a total of 15 cookies baked and measured. Diameter was measured from the bottom of each whole cookie.

Cookie Diameters (cm)		
White sugar	**Light brown sugar**	**Dark brown sugar**
12	11.6	10.8
12.2	11	10.7
12.6	11.5	10.4
13	11.1	10.3
12.4	11.7	10

Table 2: Measured cookie heights (cm) for each of the three sugar types used. Each cookie dough type (white sugar, light brown sugar, dark brown sugar) made a total of 5 cookies for a total of 15 cookies baked and measured. Height was measured from the middle of each cookie broken in half.

Cookie Height (cm)		
White sugar	**Light brown sugar**	**Dark brown sugar**
0.4	0.5	1.2
0.3	0.6	0.9
0.4	0.7	0.8
0.4	0.7	1
0.3	0.7	1.1