

## **Effects of Alternative Sweeteners on the Overall Quality and Palatability of Almond Flour Brownies**

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### **Abstract:**

Diabetes Type I and Type II are characterized by the body's inability to regulate blood glucose levels due to impaired insulin secretion, action or both. Brownies are a classic American dessert made with granulated sugar or other sweeteners not suitable for diabetics. Granulated sugar or sucrose is made from simple carbohydrates which have a higher glycemic index. Simple carbohydrates are easily and quickly utilized by the body for energy because of their simple chemical structure, often leading to a faster rise of blood glucose levels (Carbohydrates and Blood Sugar, 2016). The brownies currently available for consumers are also made using a high carbohydrate all-purpose flour with a high glycemic index. Almond flour is an alternative flour, suitable for diabetics, that produces a high quality brownie product. Sensory evaluations of almond flour brownies containing granulated sugar, date paste, xylitol and monk fruit sweeteners were evaluated by a 5 member panel. Objective evaluations were also performed to observe any changes in the quality of the brownies. Density, viscosity and the height of the brownies were measured. The sweetness and chocolate flavor of the xylitol sweetened brownie was most favorable. A t-test showed statistical significance of the xylitol sweetened brownies, which was the most favorable in chocolate color and unfavorable in its chewiness. The date paste sweetened brownies were considered to be the most moist. The sugar sweetened brownies, the control, was considered to be more favorable in chewiness and thickness. The sugar sweetened brownies had a higher overall acceptance, followed by the xylitol sweetened brownies. The monk fruit sweetened brownies were statistically significant in that it had the least overall acceptability, especially in chocolate flavor. In conclusion, almond flour brownies sweetened with xylitol seem to be the most promising alternative sweetener for diabetics, in terms of low glycemic index and overall quality and acceptability.

## **Introduction:**

The global prevalence of diabetes has increased significantly, approximately 425 million adults are living with diabetes today, this number is expected to rise to 629 million by 2045 (Piemonte, 2018). Diabetes is the seventh leading cause of death, nearly 4 million deaths just in 2017, and the number one cause of kidney failure, lower limb amputations and adult-onset blindness (Piemonte, 2018, Diabetes Home, 2017). Today more than 1.1 million children are living with Type I diabetes and more than 21 million births, that is 1 in 7, have been affected by gestational diabetes (Piemonte, 2018). Unfortunately, 1 in 4 people are not aware that they have diabetes and 352 million people are at risk for developing Type II diabetes (Diabetes Home 2017, Piemonte, 2018). Globally, the Western Pacific countries have the highest prevalence of diabetes, 159 million individuals, the United States, 46 million individuals (Piemonte, 2018). Studies show no significant discrepancy in the prevalence of diabetes among males or females, however, there is a notable difference among race and ethnicity. In the U.S., American Indians/Alaskan Natives have the highest prevalence of diabetes (15.1%), followed by non-Hispanic blacks (12.7%) and people of Hispanic ethnicity (12.1%) (National Diabetes Statistics Report, 2017). Additionally, the risk of diabetes increases with age and is more prevalent among males and females between the ages of 45-64 (52.9%) (National Diabetes Statistics Report, 2017).

Diabetes is a chronic metabolic disease that affects your bodies ability to utilize carbohydrates. Most of the food you consume, especially those high in carbohydrates, is broken down into glucose, a sugar, and released in your bloodstream. As blood sugar levels rise, the beta cells of the pancreas begin releasing insulin, a hormone that elicits cells to absorb the glucose in your blood for energy or storage. As cells begin taking in blood sugar, the blood glucose level in the bloodstream begins to decrease. Unfortunately, in individuals with diabetes the pancreas cannot either produce insulin, Type I, or produces insulin but the body is unable to use it effectively, Type II. Type I diabetes is a result of an autoimmune reaction, where the body attacks and destroys the insulin producing beta cells of the pancreas, preventing the body from producing insulin. Thus, Type I is known as, insulin-dependent diabetes and is diagnosed in

children and teens. On the other hand, Type II diabetes is due to insulin resistance, the beta cells of the pancreas are able to produce insulin but the body is ineffective in utilizing the insulin to help lower blood glucose levels. Type II diabetes is also known as, non-insulin dependent, where the bodies resistance to insulin develops over time, which is why it is usually diagnosed in adults. However, with the increase in sugar and overall carbohydrate consumption among children today, more children, teens and young adults are being diagnosed with Type II diabetes. Gestational diabetes is also another type of diabetes that is becoming of increasing concern. It develops among pregnant women, causing an increase in the risk of health complications for the baby. Even though, gestational diabetes goes away after the baby is born, the mother is now more at risk for developing Type II diabetes later on in life and the baby is more likely to become obese and develop Type II diabetes, as well (Diabetes Home, 2017). Diabetes is a dangerous disease, without proper management and treatment it can cause long-term damage of various organs, the eyes, kidneys, nerves, heart and blood vessels and ultimately lead to death. Type I diabetes cannot be prevented but there are many changes to lifestyle behaviors, like, consuming a healthy diet, that can be made to prevent and treat Type I, Type II and gestational diabetes. For these reason, providing alternative sweetener options that do not exacerbate the progression of diabetes is important.

The use of artificial sweeteners as a safe alternative for sugar remains controversial. There is a lack of properly designed randomized controlled studies to assess their efficacy in different populations. However, what can be concluded is pregnant and lactating women, children and diabetics are among the individuals who represent the most susceptible population to the adverse effects of artificially sweetened products and should consume them with caution (Sharma et al., 2016). A Danish study done with 59,334 pregnant women has linked artificial sweeteners with an increased risk of preterm labor (Sharma et al., 2016). Diabetic patients are mainly relying on these sweeteners as an alternative for sugar, unfortunately, recent evidence suggests this may actually be deleterious in the long run (Sharma et al., 2016). In designing this experiment, brownies were chosen to be the ideal product. Notably, brownies are among the most popular American dessert and because of the increasing consumption of chocolate, 23% in 2018, according to the Mintel Global New Product Database. Additionally,

brownies have two components, all-purpose flour and sugar, that are an issue for those with diabetes. Thus, for this experiment we chose to create an almond flour brownie, where the sugar was substituted with three natural and diabetes friendly alternative sweeteners, date paste, xylitol and monk fruit sweetener. All-purpose flour has four times the amount of carbohydrates as almond flour and a glycemic index of 85, whereas, the glycemic index of almond flour is 0 (Almekinder, 2018). The glycemic index values indicate how slowly or how quickly a food will increase blood glucose levels. Carbohydrates with a glycemic index of 55 or less tend to release glucose slowly and at a steady rate, causing a lower and slower rise in blood glucose levels (About Glycemic Index, 2017). In addition to using a flour with low glycemic index, it was important that the sugar alternatives were also low on the glycemic index. The glycemic index of sugar is at 65, date paste at 42, xylitol at 7 and monk fruit sweetener at 0. The negative effects of sugar consumption is well noted, especially in those with diabetes. In addition to a low glycemic index, these natural sugar substitutes also contain various elements that can be beneficial in managing blood glucose levels.

Dates are rich in soluble fiber, protein, minerals and vitamins and they have a low water content, making them a powerhouse natural alternative sweetener. Foods high in soluble fiber are an excellent way to slow down digestion to prevent blood sugar levels from spiking too high. Dates also contain flavonoids, an antioxidant that is also a proposed functional food. Studies have found that flavonoids originated from foods can improve glucose metabolism, lipid profile and regulate hormones like insulin (Ramachandran, Baojun, 2015). Xylitol is a sugar alcohol, which are known to have little to no effect on blood glucose levels. Initially, in the experiment we had planned to use erythritol, also a sugar alcohol, but a complication resulted in substitution for xylitol. Both are natural sweeteners derived from fruits, however, according to [cspi.net](http://cspi.net) xylitol consumption should be limited because it can cause gastrointestinal disturbances. Studies on rats induced with Type II diabetes have shown that not only can xylitol be used as a sugar substitute, it can decrease blood glucose levels and body weight while, increasing serum insulin concentration and glucose tolerance (Islam, Indrajit, 2012). Monk fruit sweetener, also known as, *luo han kuo*, is derived from a fruit native to China. For centuries it has been used in Traditional Chinese Medicine to treat inflammation, cough, sore throat and has been reported to be beneficial for the diabetic population. Monk fruit extract has

only recently been permitted for use in foods in the U.S., since 2009. The sweetening agent and most abundant chemical component in monk fruit is mogroside V, the body recognizes it as an antioxidant and not a sugar so it has no effect on blood sugar levels (Zhou, et al. 2009). In vitro studies have shown mogroside V to stimulate the secretion of insulin in pancreatic beta cells (Zhou, et al., 2009). Utilizing these natural sweeteners as an alternative for sugar in brownies, we did anticipate in there being a difference in the overall taste, texture and appearance, as well as, denseness, viscosity and height. The purpose of this experiment is to determine how the three alternative sweeteners affect the overall quality and palatability of the brownie product. Our prediction is that the control, sugar sweetened brownies, will be overall, the most favorable because that is what majority of people are accustomed to. The point is to determine how significant the brownies made with alternative sweeteners deviates from the control. Supposing that at least one of the variables will come in a close second as far as overall liking, then we will be able to create brownies acceptable and beneficial for those with diabetes.

### **Materials and Methods:**

The four variations of almond flour brownies were measured and prepared as reported in the tables below. The measurements for the base of the control, date paste and xylitol sweetened brownies is the same, however, adjustments had to be made for the monk fruit sweetened brownies, the recipe was cut in half. In order to prepare each variation of the brownie the following equipment was needed, 4- large bowls, measuring spoons ( $\frac{1}{2}$  tsp, 1 tsp, 1 tbsp), measuring cups ( $\frac{1}{2}$  cup,  $\frac{3}{4}$  cup, 1 cup), saucepan, 4- rubber spatulas, 4- wisks, 4- 8" square pans, 1- 200g scale, oven, stovetop, 1-knife, 5-paper plates, marker, gloves, 1- food processor, 1- electric mixer, line-spread board and ring and a ruler.

**Table 1:** Control

Amount	Unit	Ingredients	Ingredient Source (brand, location)
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5	tbsp	Unsalted butter, melted	ShopRite, Keasbey NJ
1 $\frac{3}{4}$	cup	Sugar	Domino, Yonkers NY
$\frac{1}{2}$	tsp	Salt	ShopRite, Elizabeth NJ
1	tsp	Vanilla extract	Simply Organic, Norway IA
$\frac{3}{4}$	cup	Cocoa powder	Baker's, Northfield IL
3	eggs	Eggs	ShopRite, Keasbey NJ
1 $\frac{1}{2}$	cup	Almond flour	Hodgson Mill, Effingham IL
1	tsp	Baking powder	Clabber Girl, Terre Haute IN

**Table 2:** Date Paste

Amount	Unit	Ingredients	Ingredient Source (brand, location)
5	tbsp	Unsalted butter, melted	ShopRite, Keasbey NJ
1 $\frac{1}{4}$	cup	Dates	Mariani, Vacaville CA
$\frac{1}{2}$	tsp	Salt	ShopRite, Elizabeth NJ
1	tsp	Vanilla extract	Simply Organic, Norway IA
$\frac{3}{4}$	cup	Cocoa powder	Baker's, Northfield IL
3	eggs	Eggs	ShopRite, Keasbey NJ
1 $\frac{1}{2}$	cup	Almond flour	Hodgson Mill, Effingham IL
1	tsp	Baking powder	Clabber Girl, Terre Haute IN
1	cup	Hot water	

**Table 3:** Xylitol

Amount	Unit	Ingredients	Ingredient Source (brand, location)
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5	tbsp	Unsalted butter, melted	ShopRite, Keasbey NJ
1 $\frac{2}{3}$	cup	Xylitol	Now, Bloomingdale IL
1/2	tsp	Salt	ShopRite, Elizabeth NJ
1	tsp	Vanilla extract	Simply Organic, Norway IA
3/4	cup	Cocoa powder	Baker's, Northfield IL
3	eggs	Eggs	ShopRite, Keasbey NJ
1 $\frac{1}{2}$	cup	Almond flour	Hodgson Mill, Effingham IL
1	tsp	Baking powder	Clabber Girl, Terre Haute IN

**Table 4:** Monk Fruit Sweetener

Amount	Unit	Ingredients	Ingredient Source (brand, location)
5	tbsp	Unsalted butter, melted	ShopRite, Keasbey NJ
$\frac{2}{3}$	cup	Monk fruit sweetener	Monk Fruit In The Raw, Brooklyn NY
1/2	tsp	Salt	ShopRite, Elizabeth NJ
1	tsp	Vanilla extract	Simply Organic, Norway IA
3/4	cup	Cocoa powder	Baker's, Northfield IL
3	eggs	Eggs	ShopRite, Keasbey NJ
1 $\frac{1}{2}$	cup	Almond flour	Hodgson Mill, Effingham IL
1	tsp	Baking powder	Clabber Girl, Terre Haute IN

**Procedures:**

*Control.* The oven was preheated to 350 F and an 8" square pan was greased with butter. Then the melted butter, salt, vanilla extract, cocoa, eggs and each sweetener (sugar, date paste\*,

xylitol or monk fruit sweetener) were mixed together using an electric mixer. Then the almond flour and baking powder were added. The batter was poured in the pre-greased pan then baked for 33 to 38 minutes or until a toothpick inserted at the center comes out clean. Then each product was cooled for 15 min before cutting.

*\*Date Paste.* To make the date paste blend the depitted dates with the hot water were blended in a food processor.

After each batter was prepared, a line-spread test was performed, where two tablespoons of batter were placed in the ring centered on the line spread board. Once the ring was removed, the measurement of the amount of spread was recorded from all four sides. The four measurements were then averaged out to give the viscosity of each batter.

The height of the final product of each variation was measured. This was done by cutting 3” squares and measuring the height of three pieces stacked on top of each other. This number was then divided by 3 to give the average height the product had risen.

The density of the final product was calculated by measuring the length, width and height of three brownies from each variation, then averaging those numbers. In addition, using a 200 g scale, three brownies from each variation were weighed out and the average taken. The average mass was then divided by the average volume to calculate the density for each variation of the product.

## **Results:**

*Line-spread test.* The viscosity of the batter of all four brownie variations were evaluated by performing a line-spread test, the measurements are reported in Table 5. The least viscous batter was that made with date paste and the most viscous batter was the batter made with sugar. The batters made with xylitol and monk fruit sweetener appeared to be less fluid and alike in strength.

<b>Line-spread test: Measure of Viscosity</b>		
<b>Type of Sweetener</b>	<b>Measurements</b>	<b>Average</b>
Sugar (control)	1, 0.5, 0.5, 1	0.75



Date Paste	5.5, 6, 6.5, 7	6.25
Xylitol	2, 1, 1.5, 2	1.63
Monk Fruit	1, 1.5, 2, 1.5	1.5

**Table 5:** The results from a line-spread test, evaluating the viscosity of all four brownie batters. The second column indicates the amount each batter spread at four points. The third column is the average of these measurements and the level of viscosity of each batter.

*Height.* The height of the final products were measured to evaluate the thickness of each brownie variation and are noted in Table 6. The control had the greatest height and overall thickness whereas, the xylitol sweetened brownies had the shortest height and were the least thick. Both the date paste and monk fruit sweetened were very close in height, 2.67 cm and 2.77 cm, respectively. The height did not vary greatly among the four variations

<b>Height: Measure of Thickness</b>		
<b>Type of Sweetener</b>	<b>Height (3 stacked brownies)</b>	<b>Average</b>
Sugar (control)	9 cm	3 cm
Date Paste	8 cm	2.67 cm
Xylitol	7.7 cm	2.57 cm
Monk Fruit	8.3 cm	2.77 cm

**Table 6:** The height of three 3” brownies was measured and is shown in column 2. Column three indicates the average height of each brownie.

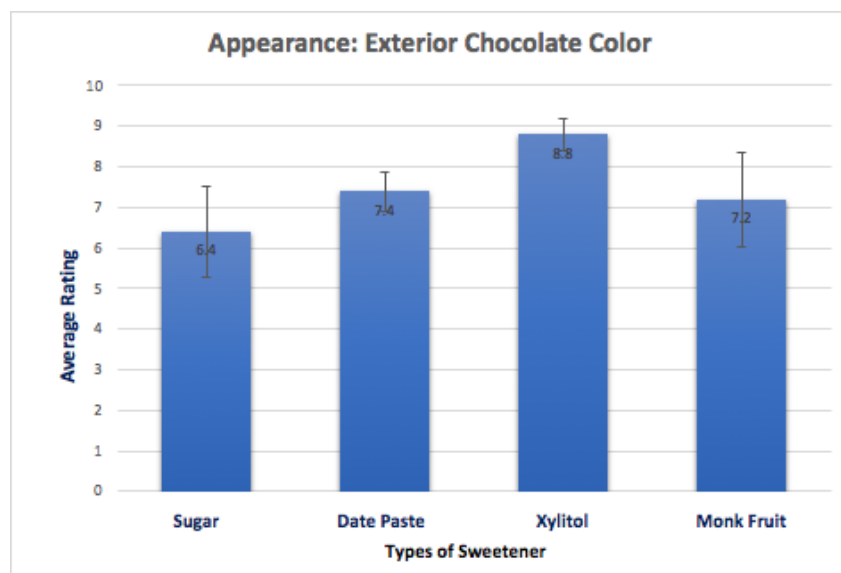
*Density.* The density of the final product was calculated and is reported in Table 7. The date paste brownies had the greatest density, on the other hand, the control was the least dense. The xylitol and monk fruit sweetened brownies were similar in mass to the control but lacked volume.

<b>Density</b>
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Type of Sweetener	Mass (g)	Volume (cm <sup>3</sup> )	Density (g/cm <sup>3</sup> )
Sugar (control)	46, 42, 48	27	1.68
Date Paste	64, 67, 68	24.03	2.76
Xylitol	45, 46, 49	23.13	2.02
Monk Fruit	47, 48, 46	24.93	1.89

**Table 7:** The density of four brownie variations. Column two shows the masses of three 3” brownies which were averaged out and divided by the volume as reported in column three to determine the density of each brownie variation as shown in column 4.

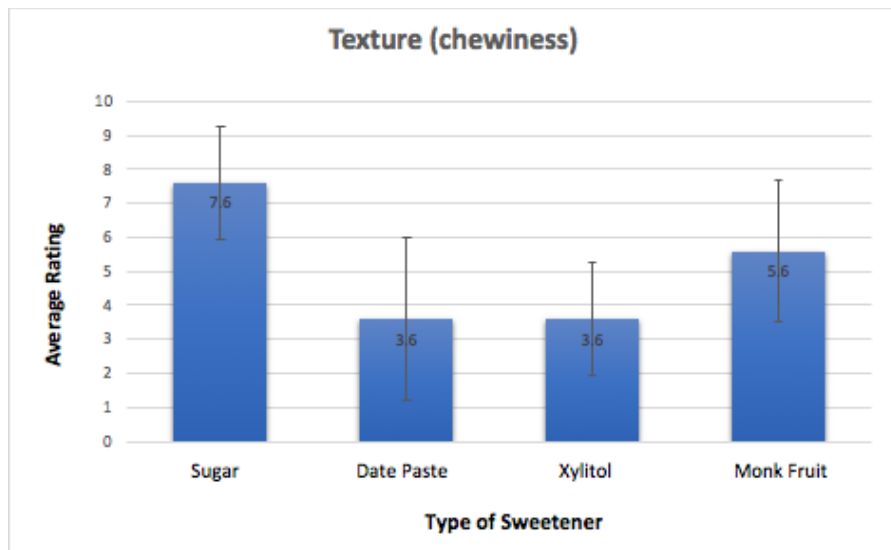
*Appearance (exterior color):* The appearance of the final product was evaluated and is reported in Figure 1. The xylitol sweetened brownies had the greatest chocolate color, on the other hand, the control was the least chocolate color. The date paste and monk fruit sweetened brownies were very similar in color. However, only the results for the xylitol sweetened brownies turned out to be significant ( $p$ -value = 0.004).



P-values: Control 0.14 Xylitol 0.004 Monk Fruit 0.41

**Figure 1:** The exterior color of all four brownie variations were evaluated by panelist. Each bar shows the ratings of how “chocolate color” each brownie variation was on a 1-9 scale, 1 being the least “chocolate color” and 9 being the most “chocolate color”.

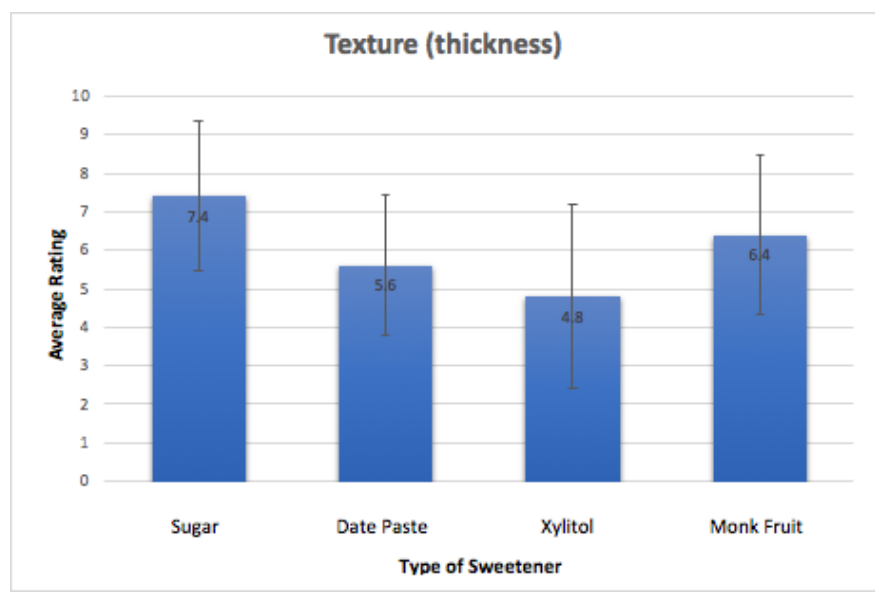
*Texture (Chewiness)*: The chewiness of the final product was evaluated and is reported in Figure 2. The sugar (control) sweetened brownies turned out the most chewy; contrarily, the date paste and xylitol sweetened brownies were the least chewy. The results for the date paste and xylitol sweetened brownies turned out to be significant, while the results for the monk fruit sweetened brownies were insignificant.



P-values: Control      0.01      0.01      0.2

**Figure 2:** The texture (chewiness) of all four brownie variations were evaluated by panelist. Each bar shows the ratings of how chewy each brownie variation was on a 1-9 scale, 1 being the least chewy and 9 being the most chewy.

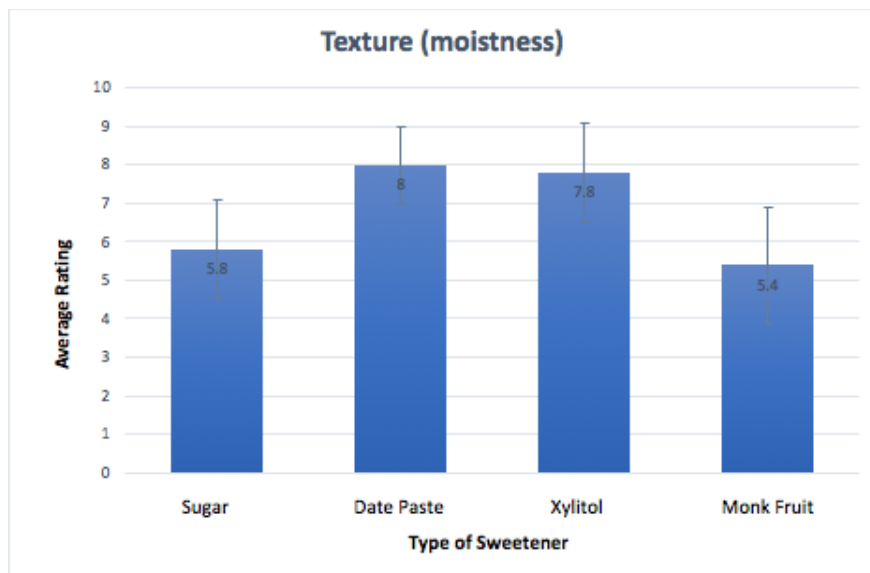
*Texture (thickness):* The thickness of the final product was evaluated and is reported in Figure 3. The sugar (control) sweetened brownies turned out the thickest; however, the xylitol sweetened brownies turned out the least thick. Only the results for the date paste sweetened brownies turned out to be significant, while the results for the xylitol and monk fruit sweetened brownies were insignificant.



P-values: Control      0.05      0.16      0.35

**Figure 3:** The texture (thickness) of all four brownie variations were evaluated by panelist. Each bar shows the ratings of how thick each brownie variation was on a 1-9 scale, 1 being the least thick and 9 being the most thick.

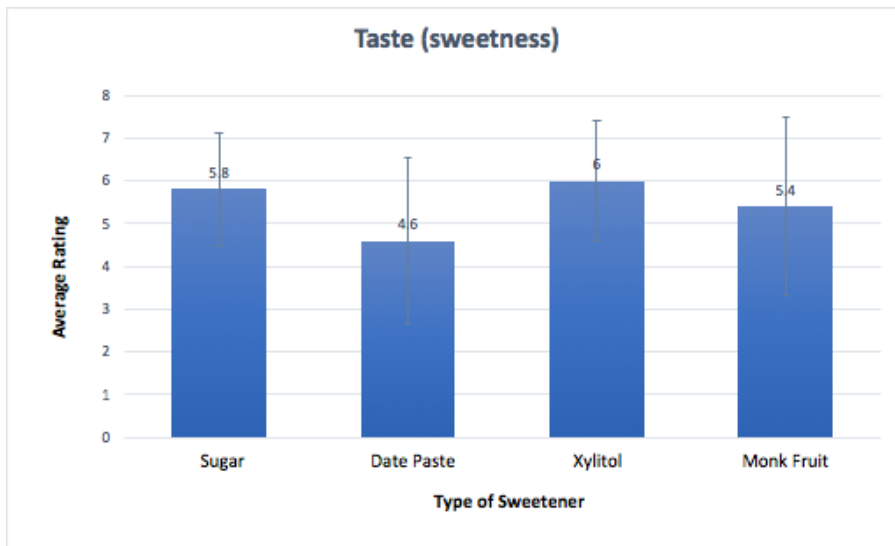
*Texture (moistness)*: The moistness of the final product was evaluated and is reported in Figure 4. The date paste sweetened brownies turned out the most moist; on the other hand, the monk fruit sweetened brownies turned out the least moist. The results for the date paste and xylitol sweetened brownies turned out to be significant, while the results for the monk fruit sweetened brownies were insignificant.



P-values: Control      0.05      0.03      0.59

**Figure 4:** The texture (moistness) of all four brownie variations were evaluated by panelist. Each bar shows the ratings of how moist each brownie variation was on a 1-9 scale, 1 being the least moist and 9 being the most moist.

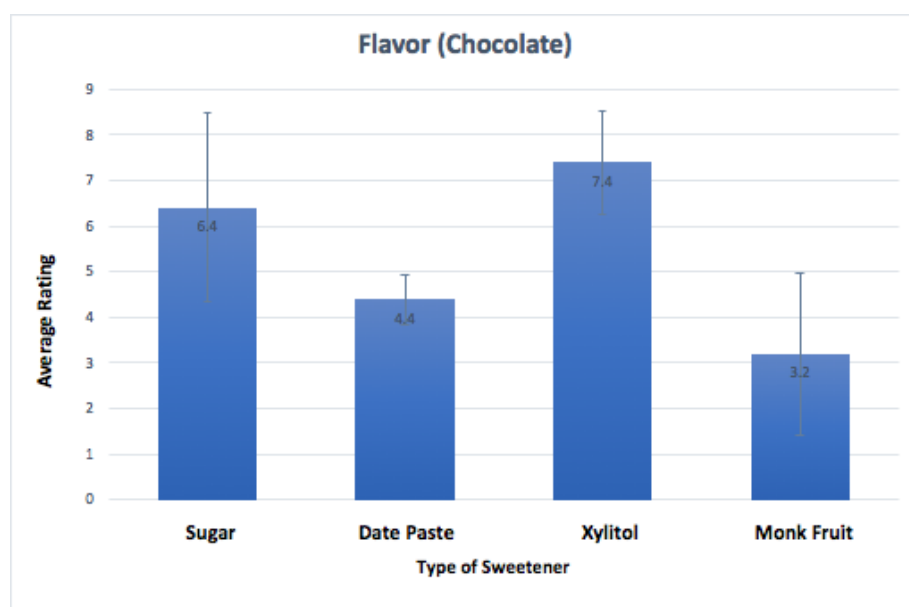
*Taste (sweetness)*: The sweetness of the final product was evaluated and is reported in Figure 5. The xylitol sweetened brownies turned out the most sweet; on the other hand, the date paste sweetened brownies turned out the least sweet. The results for the date paste and xylitol sweetened brownies turned out to be significant, while the results for the monk fruit sweetened brownies were insignificant.



P-values: Control      0.24      0.70      0.69

**Figure 5:** The taste (sweetness) of all four brownie variations were evaluated by panelist. Each bar shows the ratings of how sweet each brownie variation was on a 1-9 scale, 1 being the least sweet and 9 being the most sweet.

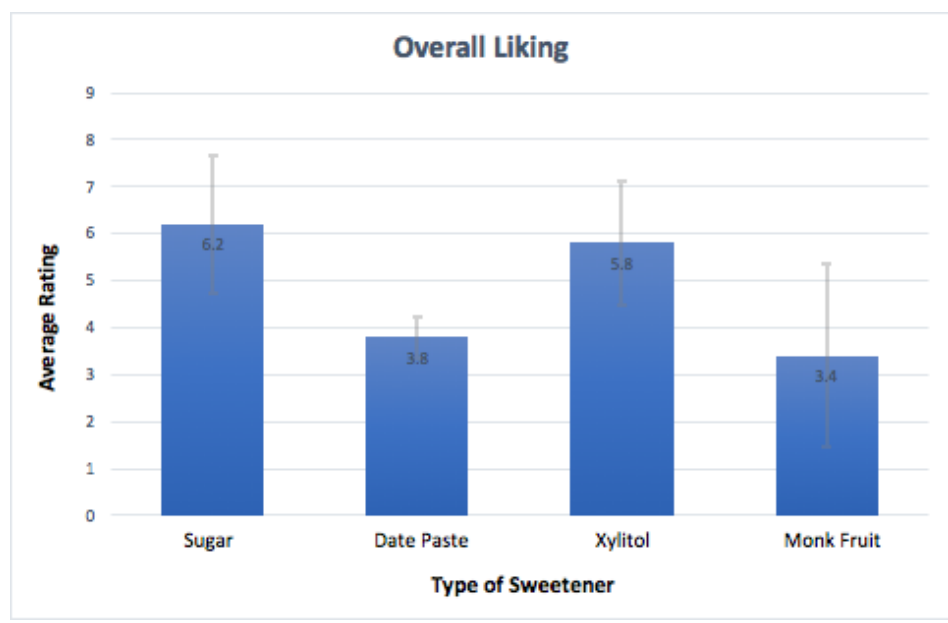
*Flavor (chocolate):* The chocolate flavor of the final product was evaluated and is reported in Figure 6. The xylitol sweetened brownies turned out to have the most chocolaty flavor; on the other hand, the monk fruit sweetened brownies turned out the least chocolaty flavor. The results for the monk fruit sweetened brownies turned out to be significant, while the results for the date paste and xylitol sweetened brownies were insignificant.



P-values: Control      0.15      0.39      0.01

**Figure 6:** The flavor (chocolate) of all four brownie variations were evaluated by panelist. Each bar shows the ratings of how chocolaty each brownie variation was on a 1-9 scale, 1 being the least chocolaty and 9 being the most chocolaty.

*Overall Liking:* The overall liking of the final product was evaluated and is reported in Figure 7. The sugar (control) sweetened brownies turned out to be the most liked and the monk fruit sweetened brownies turned out to be the least liked. The results for the date paste and monk fruit sweetened brownies turned out to be significant, while the results for the xylitol sweetened brownies turned out to be insignificant.



P-values: Control      0.01      0.73      0.04

**Figure 7:** The overall liking of all four brownie variations were evaluated by panelist. Each bar shows the ratings of how liked each brownie variation was on a 1-9 scale, 1 being the least liked and 9 being the most liked.



## Nutrition Labels:

### Almond Flour Brownies (granulated sugar-control)

Nutrition Facts	
Serving Size: 1 piece (38g) Servings Per Container: 1	
Amount Per Serving	
<b>Calories</b> 130	Calories from Fat 60
% Daily Value*	
<b>Total Fat</b> 7g	<b>11%</b>
Saturated Fat 3g	<b>15%</b>
Trans Fat 0g	
<b>Cholesterol</b> 45mg	<b>15%</b>
<b>Sodium</b> 135mg	<b>6%</b>
<b>Total Carbohydrate</b> 19g	<b>6%</b>
Dietary Fiber 2g	<b>8%</b>
Sugars 16g	
Sugar Alcohol 0g	
<b>Protein</b> 3g	
Vitamin A 4%	Vitamin C 0%
Calcium 2%	Iron 6%
* Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:	
	Calories: 2,000 2,500
Total Fat	Less than 65g 80g
Sat Fat	Less than 20g 25g
Cholesterol	Less than 300mg 300mg
Sodium	Less than 2,400mg 2,400mg
Total Carbohydrate	300g 375g
Dietary Fiber	25g 30g

INGREDIENTS: SUGAR, EGG, BUTTER (CREAM, NATURAL FLAVOR), COCOA, ALMOND MEAL, BAKING POWDER (SODIUM ACID PYROPHOSPHATE, SODIUM BICARBONATE, CORNSTARCH, MONOCALCIUM PHOSPHATE), VANILLA EXTRACT (WATER, ALCOHOL (35%), SUGAR, VANILLA BEAN EXTRACTIVES), SALT

CONTAINS: EGG, ALMOND

Figure 8

### Almond Flour Brownies (date paste)

Nutrition Facts	
Serving Size: 1 piece (52g) Servings Per Container: 1	
Amount Per Serving	
<b>Calories</b> 130	Calories from Fat 70
% Daily Value*	
<b>Total Fat</b> 8g	<b>12%</b>
Saturated Fat 3g	<b>15%</b>
Trans Fat 0g	
<b>Cholesterol</b> 45mg	<b>15%</b>
<b>Sodium</b> 135mg	<b>6%</b>
<b>Total Carbohydrate</b> 13g	<b>4%</b>
Dietary Fiber 3g	<b>12%</b>
Sugars 8g	
Sugar Alcohol 0g	
<b>Protein</b> 4g	
Vitamin A 4%	Vitamin C 0%
Calcium 4%	Iron 6%
* Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:	
	Calories: 2,000 2,500
Total Fat	Less than 65g 80g
Sat Fat	Less than 20g 25g
Cholesterol	Less than 300mg 300mg
Sodium	Less than 2,400mg 2,400mg
Total Carbohydrate	300g 375g
Dietary Fiber	25g 30g

INGREDIENTS: WATER, DATES, EGG, ALMOND MEAL, BUTTER (CREAM, NATURAL FLAVOR), COCOA, BAKING POWDER (SODIUM ACID PYROPHOSPHATE, SODIUM BICARBONATE, CORNSTARCH, MONOCALCIUM PHOSPHATE), VANILLA EXTRACT (WATER, ALCOHOL (35%), SUGAR, VANILLA BEAN EXTRACTIVES), SALT

CONTAINS: EGG, ALMOND

Figure 9

### Almond Flour Brownies (xylitol)

Nutrition Facts	
Serving Size: 1 piece (45g) Servings Per Container: 1	
Amount Per Serving	
<b>Calories</b> 140	Calories from Fat 70
% Daily Value*	
<b>Total Fat</b> 8g	<b>12%</b>
Saturated Fat 3g	<b>15%</b>
Trans Fat 0g	
<b>Cholesterol</b> 45mg	<b>15%</b>
<b>Sodium</b> 135mg	<b>6%</b>
<b>Total Carbohydrate</b> 22g	<b>7%</b>
Dietary Fiber 2g	<b>8%</b>
Sugars 0g	
Sugar Alcohol 18g	
<b>Protein</b> 4g	
Vitamin A 4%	Vitamin C 0%
Calcium 4%	Iron 6%
* Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:	
	Calories: 2,000 2,500
Total Fat	Less than 65g 80g
Sat Fat	Less than 20g 25g
Cholesterol	Less than 300mg 300mg
Sodium	Less than 2,400mg 2,400mg
Total Carbohydrate	300g 375g
Dietary Fiber	25g 30g

INGREDIENTS: NOW REAL FOOD XYLITOL, EGG, ALMOND MEAL, BUTTER (CREAM, NATURAL FLAVOR), COCOA, BAKING POWDER (SODIUM ACID PYROPHOSPHATE, SODIUM BICARBONATE, CORNSTARCH, MONOCALCIUM PHOSPHATE), VANILLA EXTRACT (WATER, ALCOHOL (35%), SUGAR, VANILLA BEAN EXTRACTIVES), SALT

CONTAINS: EGG, ALMOND

Figure 10

### Almond Flour Brownies (monk fruit)

Nutrition Facts	
Serving Size: 1 piece (44g) Servings Per Container: 1	
Amount Per Serving	
<b>Calories</b> 90	Calories from Fat 70
% Daily Value*	
<b>Total Fat</b> 8g	<b>12%</b>
Saturated Fat 3g	<b>15%</b>
Trans Fat 0g	
<b>Cholesterol</b> 45mg	<b>15%</b>
<b>Sodium</b> 135mg	<b>6%</b>
<b>Total Carbohydrate</b> 4g	<b>1%</b>
Dietary Fiber 2g	<b>8%</b>
Sugars 0g	
Sugar Alcohol 0g	
<b>Protein</b> 4g	
Vitamin A 4%	Vitamin C 0%
Calcium 4%	Iron 6%
* Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:	
	Calories: 2,000 2,500
Total Fat	Less than 65g 80g
Sat Fat	Less than 20g 25g
Cholesterol	Less than 300mg 300mg
Sodium	Less than 2,400mg 2,400mg
Total Carbohydrate	300g 375g
Dietary Fiber	25g 30g

INGREDIENTS: MONK FRUIT IN THE RAW SWEETENER, EGG, ALMOND MEAL, BUTTER (CREAM, NATURAL FLAVOR), COCOA, BAKING POWDER (SODIUM ACID PYROPHOSPHATE, SODIUM BICARBONATE, CORNSTARCH, MONOCALCIUM PHOSPHATE), VANILLA EXTRACT (WATER, ALCOHOL (35%), SUGAR, VANILLA BEAN EXTRACTIVES), SALT

CONTAINS: EGG, ALMOND

Figure 11

The monk fruit (Figure 11) and xylitol (Figure 10 - nutrition label displays 22 g of carbohydrates, however 18 g are sugar alcohol, therefore the total amount of carbohydrates is actually 4 g) sweetened brownies are significantly lower in carbohydrates than the other three variations. The total amount of sugar in the sugar (control) (Figure 8) sweetened brownies is significantly higher than the other three alternatively sweetened brownies; the date paste (Figure 9) sweetened brownies resulted in a product with the highest amount of sugar (8g) out of the alternatively sweetened brownies.

**Discussion:**

The purpose of this experiment was to evaluate the effects of alternative natural sweeteners on the overall quality and palatability of almond flour brownies, to develop a product that is more diabetes friendly. The control group, sugar sweetened brownies, has a high glycemic index of 65, immediately spiking blood glucose levels making it an unfavorable food item for those with diabetes. Therefore, three alternative natural sweeteners, date paste, xylitol and monk fruit sweetener, were used to create a brownie product low in carbohydrates and in glycemic index. Date paste, xylitol and monk fruit sweetener are not only low in glycemic index, 42, 7 and 0, respectively, but also contain antioxidants and other factors, as mentioned earlier, that may be of benefit to diabetics.

The hypothesis was that the control group would be the most favorable because more people are accustomed to consuming sugar as opposed to any of the three alternative sweeteners. Our sensory evaluations indeed showed that the control was the most preferred, with an average rating of 6.2 out of 9. However, we did not expect the xylitol sweetened brownies to come so close to the control as the second most favorable, with an average rating of 5.8 out of 9. Xylitol like many sugar alcohols, has an unfavorable after taste, that we believed would possibly affect the brownies overall palatability. Of statistical significance were the date paste and monk fruit sweeteners, which were the least favorable with p-values less than 0.05, 0.01 and 0.04, respectively. However, we would not eliminate them as possible alternative sweeteners but rather adjust the recipes. Panelists commented on the bitterness of the date paste brownies, which may have to do with the type of date used to create the paste. Medjool dates are a sweeter and softer date, using this variety could be a better alternative. Monk fruit is 300 times sweeter than sugar and so it is usually combined with a bulking agent to reduce its level of sweetness. The monk fruit sweetener used to produce the brownies contained dextrose, as a bulking agent. We would not recommend any one with diabetes to consume dextrose because it causes dramatic spikes in blood glucose levels and is actually used to treat those with hypoglycemia. In addition, dextrose is known to have a strong, off-putting after taste, as many panelist mentioned in their sensory

ballots. For that reason, using a different brand of monk fruit sweetener like Lakanto, which uses erythritol as a bulking agent may produce a more palatable brownie. Erythritol is known to bake and taste very similar to sugar.

The control brownies had the greatest height and viscosity but were the least dense. This was to be expected, the combination of sugar, butter, salt, baking powder and egg creates a leavening effect when heat is applied. Sugar is hygroscopic, it holds onto liquids and once heat is applied the liquid to gas expansion gives height to the final product. Sugar alcohols, dates and monk fruit do not have the same leavening effect that sugar does, so these products did not rise as high. Similarly, because of the liquid to gas conversion the sugar sweetened brownies had the lowest density. The date paste brownies produced the greatest density and were the least viscous. This could be because of the addition of 1 cup of water that the other three brownie batters did not contain.

After further analyzing the results, we did not expect the xylitol brownies to be more favorable in sweetness, chocolate flavor and color when compared to the control. The appearance of the xylitol brownies was statistically significant, a p-value of 0.004. This could have been due to a different brand of cocoa powder used for the xylitol brownies which resulted in a more favorable chocolate color. The chewiness of the date paste and xylitol brownies resulted in a statistically significant t-test, both with p-values of 0.01. The addition of water to create the date paste produced a fluid batter not ideal for chewy brownies. The xylitol brownies were served straight out of the oven with no time to cool, this certainly can affect the chewiness of the brownie. A warm brownie has a more soft, cake-like texture that crumbles when compared to one that has cooled down, which is more chewy and fudgy. Consequently, this could also be the reason as to why the xylitol brownies were considered to be one of the most moist and had a statistically significant p-value of 0.03. If this study was to be repeated, it is important to let all variations of the brownie to cool for the same amount of time. Furthermore, we would produce the brownie with our original sugar alternative, erythritol, because it is not only safer to consume, according to the FDA's GRAS list, but also has more health benefits. Erythritol, reduces postprandial blood glucose levels, supports maintenance of oral and systemic health and does not contribute to digestive disturbances, unlike xylitol (de Cock, 2018)).

The data on the monk fruit sweetener showed statistical significance, a p-value of 0.01, for its unfavorable chocolate flavor. This could have been a result of the strong off-putting after taste of dextrose, that could have overpowered the chocolate flavor. In addition to using the incorrect brand of monk fruit sweetener, we did not have enough of the sweetener to make the original amount of brownies. A last minute change, where we cut the recipe in half but failed to cut the baking time could have resulted in it being the least moist of all the brownies.

In conclusion, even though the control was overall the most favorable, analysis of the results supports xylitol sweetened brownies as a very close second, in being an alternative to sugar sweetened brownies. Even though xylitol consumption should be limited according to the FDA's GRAS list, it has a glycemic index of 7 and has been shown to decrease blood glucose levels and increase serum insulin concentration, making it a favorable option for diabetics. The significant p-values and errors made during the experiment suggests that this study should be repeated, following the original procedures and ingredients. There is certainly more room for experimentation in finding a diabetes friendly dessert using alternative natural sweeteners.

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**Appendix I**

- A. Project Plan Statement
- B. Original Recipe
- C. Lab Project Procedure
- D. Sensory Ballot
- E. Excel Statistical Data