

The background features a light gray grid with several wavy, overlapping lines in a darker gray color that create a sense of movement and depth. The text is centered within this design.

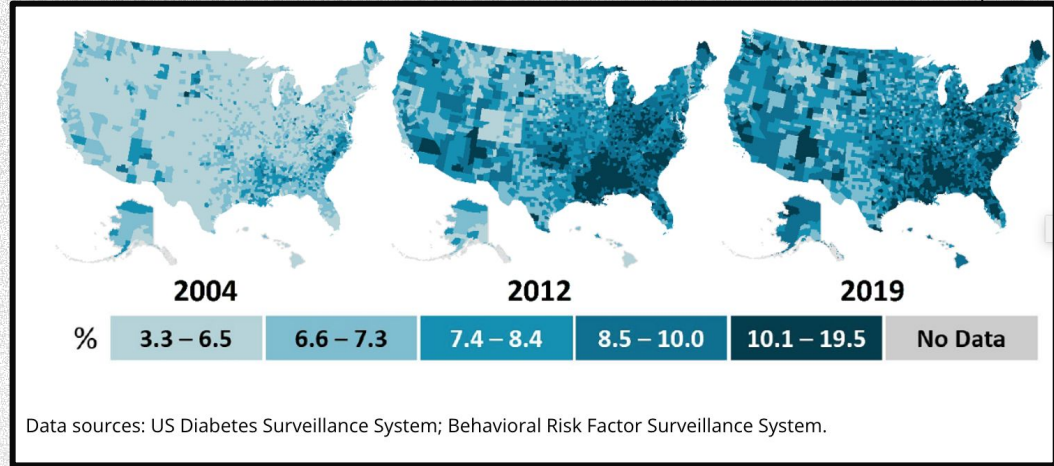
# **Effects of Sugar Substitutes on the Flavor Profile and Overall Acceptability of Brownies**

Jennifer Fleck  
Experimental Foods- Fall 2022  
Section 1  
Station 3



# Clinical Condition: Diabetes

- Risks of Diabetes: The body is unable to produce enough insulin or use the insulin properly. When there is a lack of insulin response there becomes an excess amount of blood sugar present within the bloodstream.
  - Overtime diabetes can cause great health issues including heart disease, kidney disease, and vision loss.



- There is no cure for diabetes but those with the disease are often encouraged to lose weight, eat healthy, and be active.
- 37.3 million people have diabetes (11.3% of the US population).
  - 96 million people aged 18 or older are considered to be prediabetic (38.0% of the US adult population).



# Diabetes (cont.)



- When one consumes a high amount of sugar, the pancreas is overworked as it must pump out lots of insulin in order to transport the excess blood sugar into the cells.
- As more and more sugar is consumed, the body of diabetes patients become resistant to insulin, and eventually, blood sugar levels continue to rise to unhealthy levels.
- This increase in blood sugar levels can be a major cause of type 2 diabetes.



# Food Product: Brownies

- Brownies are a sweet treat, however, they contain a high level of sugar which poses a great threat for diabetic patients.
- Brownies are baked confections within minimal ingredients: flour, sugar, butter, flour, chocolate, and eggs.
- In this lab, sugar was replaced with other sweetener alternatives including:
  - ✓  **Stevia**
  - ✓  **Splenda**
  - ✓  **Monk Fruit Sweetener**
- These alternatives allow for a sweet taste while reducing the sugar intake of a brownie.





# Sugar Alternatives

STEVIA IN THE RAW® IS A PRODUCT OF CUMBERLAND PACKING CORP. 2 CUMBERLAND ST, BROOKLYN, NY 11205 USA

## Nutrition Facts

100 servings  
**Serv size 1 packet (1g)**

Amount per serving	
<b>Calories</b>	<b>0</b>
	<b>% Daily Value</b>
<b>Total Fat</b> 0g	<b>0%</b>
<b>Sodium</b> 0mg	<b>0%</b>
<b>Total Carb.</b> Less than 1g	<b>0%</b>
Total Sugars Less than 1g	
Incl. < 1g Added Sugars	<b>0%</b>
<b>Protein</b> 0g	

Not a significant source of saturated fat, trans fat, cholesterol, fiber, Vitamin D, calcium, iron, and potassium.

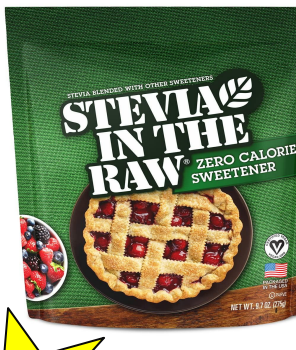
**INGREDIENTS:** Dextrose, Stevia Leaf Extract

Stevia is naturally sweeter than sugar. So, like many zero-calorie sweeteners, it is blended with dextrose. This helps create the perfect balance of sweetness, making it easier to both pour and measure.

**SUITABLE FOR PEOPLE WITH DIABETES.**

Each packet contains less than 4 calories per serving which the FDA considers dietetically zero.

Stevia



## Nutrition Facts

400 servings per container  
**Serving size 1 packet (1g)**

Amount per serving	
<b>Calories</b>	<b>0</b>
	<b>% DV*</b>
<b>Total Fat</b> 0g	<b>0%</b>
<b>Sodium</b> 0mg	<b>0%</b>
<b>Total Carb.</b> <1g	<b>0%</b>
Total Sugars <1g	
Includes <1g Added Sugars	<b>2%</b>
<b>Protein</b> 0g	

Not a significant source of sat. fat, trans fat, cholesterol, dietary fiber, vitamin D, calcium, iron, and potassium

\*%DV = %Daily Value

**INGREDIENTS:** DEXTROSE, MALTODEXTRIN, SPLENDA® SUCRALOSE.

**U** PARVE **GF** GLUTEN FREE

**M** HALAL

**SUITABLE FOR PEOPLE WITH DIABETES.**

**STORE IN A COOL, DRY PLACE.**

\*Among healthcare professionals clinically treating patients.

Distributed by  
 TC Heartland, LLC  
 Carmel, IN 46032

Splenda



Monk Fruit



## Nutrition Facts

About 59 servings per container  
**Serving size 1 tsp (4g)**

Amount Per Serving	
<b>Calories</b>	<b>0</b>
	<b>% Daily Value*</b>
<b>Total Fat</b> 0g	<b>0%</b>
<b>Sodium</b> 0mg	<b>0%</b>
<b>Total Carbohydrate</b> 4g	<b>1%</b>
Sugar Alcohol 4g	
<b>Protein</b> 0g	<b>0%</b>

Not a significant source of saturated fat, trans fat, cholesterol, dietary fiber, sugars, vitamin D, calcium, iron, and potassium

\*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

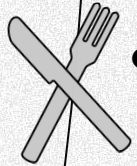
**INGREDIENTS:** Erythritol, Monk Fruit Extract

**Net Carbs:** Substitutes For Sugar





# Hypotheses



- **Nutritional Value:** If sugar is substituted with splenda, stevia, or monkfruit sweetener, the brownie will become more nutritionally valuable as these alternative ingredients will reduce the sugar content within the baked good.



- **Objective Measures General Hypothesis:** The height, number of chews, and total time to bake will be larger for the sugar brownie than the brownies with alternative sweeteners.




- **Sensory Properties General Hypothesis:** The sugar brownie will have a higher overall liking than any of the brownies with alternative sweeteners.

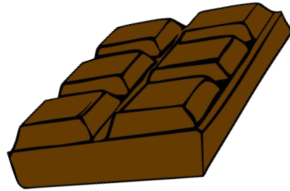


# Methods: Recipe



## Ingredients

- ½ cup butter
- 1 cup white sugar
- 2 eggs
- 1 teaspoon vanilla extract
- ⅓ cup unsweetened cocoa powder
- ½ cup all-purpose flour 
- ¼ teaspoon salt
- ¼ teaspoon baking powder



## Directions

### Step 1

Preheat the oven to 350 degrees F (175 degrees C). Grease and flour an 8-inch square pan.

### Step 2

Melt ½ cup butter in a large saucepan. Remove from heat, and stir in sugar, eggs, and 1 teaspoon vanilla. Beat in ⅓ cup cocoa, flour, salt, and baking powder. Spread batter into prepared pan.

### Step 3

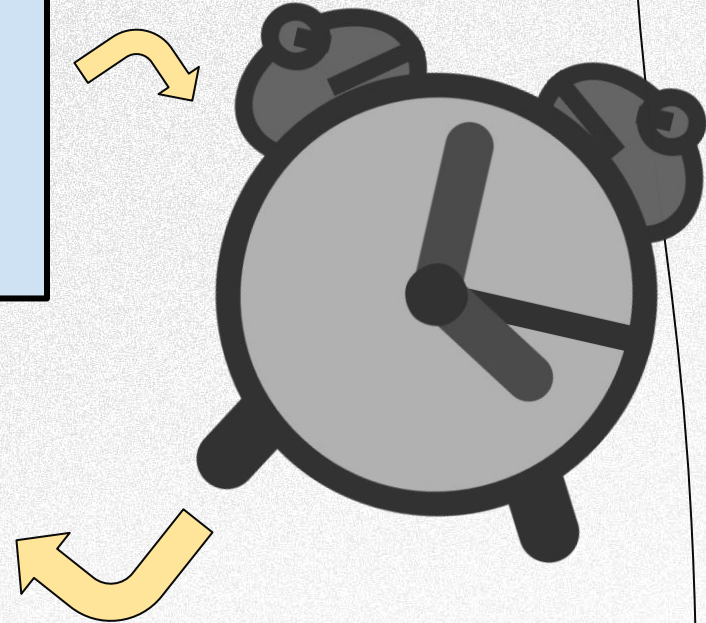
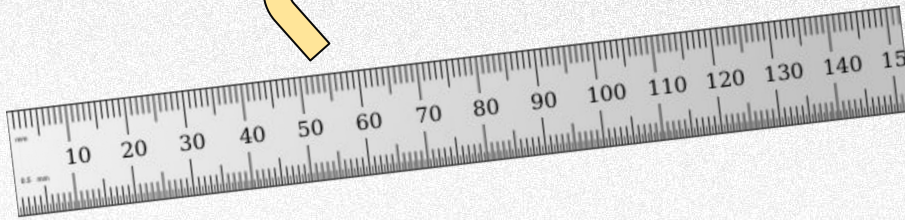
Bake in the preheated oven until top is dry and edges have started to pull away from the sides of the pan, about 25 to 30 minutes. Let cool briefly before frosting.

### Step 4

To make the frosting: Combine softened butter, confectioners' sugar, 3 tablespoons cocoa, honey, and 1 teaspoon vanilla extract in a bowl. Stir until smooth. Frost brownies while they are still warm.

# Methods: Objective Evaluation

- ❖ Average **Heights** of Baked Brownies (millimeters)
- ❖ Total **Time** to Bake (minutes)
- ❖ Number of **Chews**



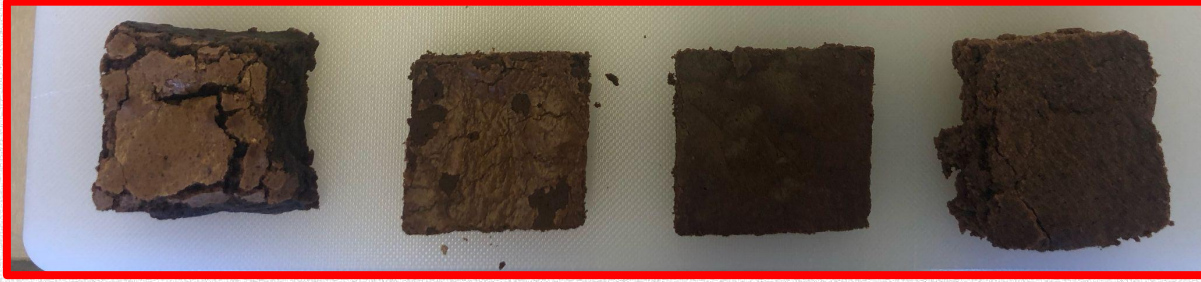


# Methods: Sensory Evaluation

		Rate the samples from 1 (LEAST) to 7 (MOST)			
		Sample ID			
Category	Rated For	317	499	103	749
Appearance (Exterior)	Glossy	(1) (2) (3) (4) (5) (6) (7)	(1) (2) (3) (4) (5) (6) (7)	(1) (2) (3) (4) (5) (6) (7)	(1) (2) (3) (4) (5) (6) (7)
Appearance (Interior)	Dense	(1) (2) (3) (4) (5) (6) (7)	(1) (2) (3) (4) (5) (6) (7)	(1) (2) (3) (4) (5) (6) (7)	(1) (2) (3) (4) (5) (6) (7)
# Chews					
Texture	Smooth	(1) (2) (3) (4) (5) (6) (7)	(1) (2) (3) (4) (5) (6) (7)	(1) (2) (3) (4) (5) (6) (7)	(1) (2) (3) (4) (5) (6) (7)
Aroma	Chocolate	(1) (2) (3) (4) (5) (6) (7)	(1) (2) (3) (4) (5) (6) (7)	(1) (2) (3) (4) (5) (6) (7)	(1) (2) (3) (4) (5) (6) (7)
Taste	Sweet	(1) (2) (3) (4) (5) (6) (7)	(1) (2) (3) (4) (5) (6) (7)	(1) (2) (3) (4) (5) (6) (7)	(1) (2) (3) (4) (5) (6) (7)
Flavor	Chocolate	(1) (2) (3) (4) (5) (6) (7)	(1) (2) (3) (4) (5) (6) (7)	(1) (2) (3) (4) (5) (6) (7)	(1) (2) (3) (4) (5) (6) (7)
Presence of after taste?	Yes/No Describe				
	Overall Liking	(1) (2) (3) (4) (5) (6) (7)	(1) (2) (3) (4) (5) (6) (7)	(1) (2) (3) (4) (5) (6) (7)	(1) (2) (3) (4) (5) (6) (7)
Comments					



# Results: Photos



SUGAR

SPLENDA

STEVIA

MONKFRUIT



SUGAR

SPLENDA

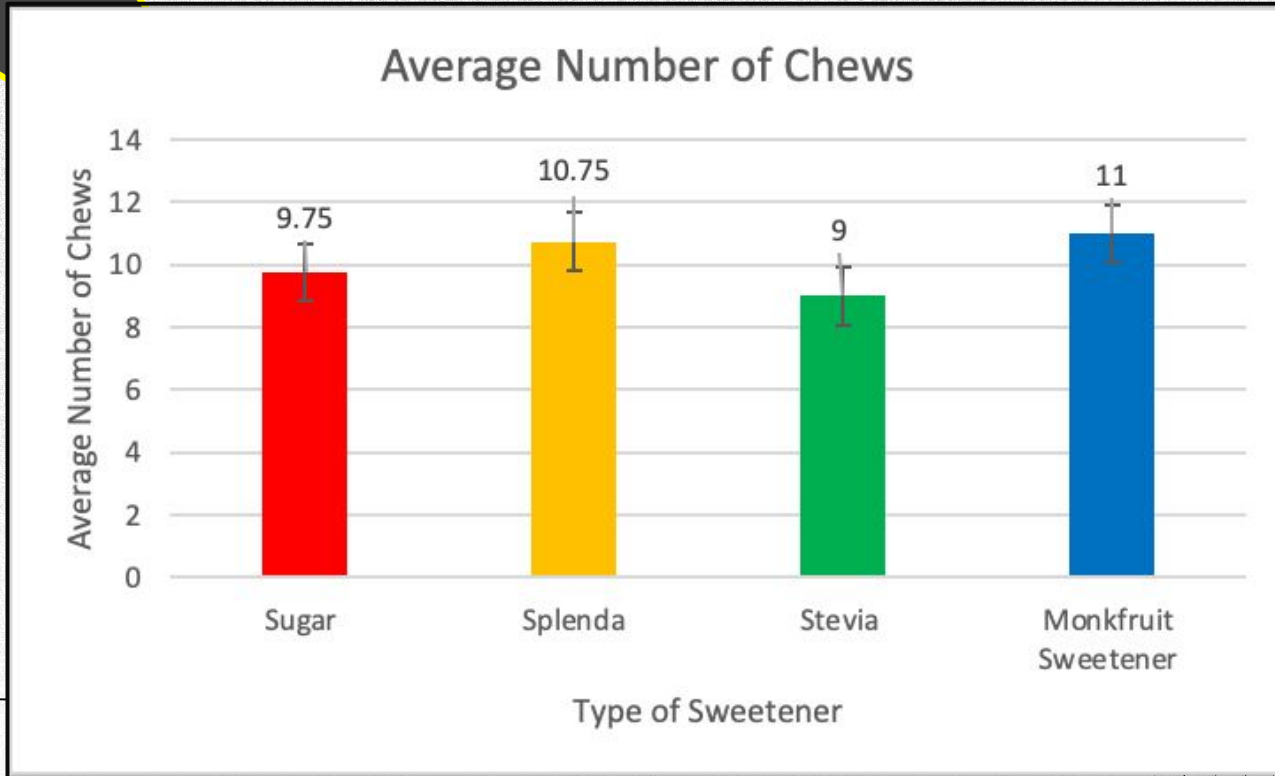
STEVIA

MONKFRUIT



# Results: Objective Evaluations

NUMBER OF CHEWS

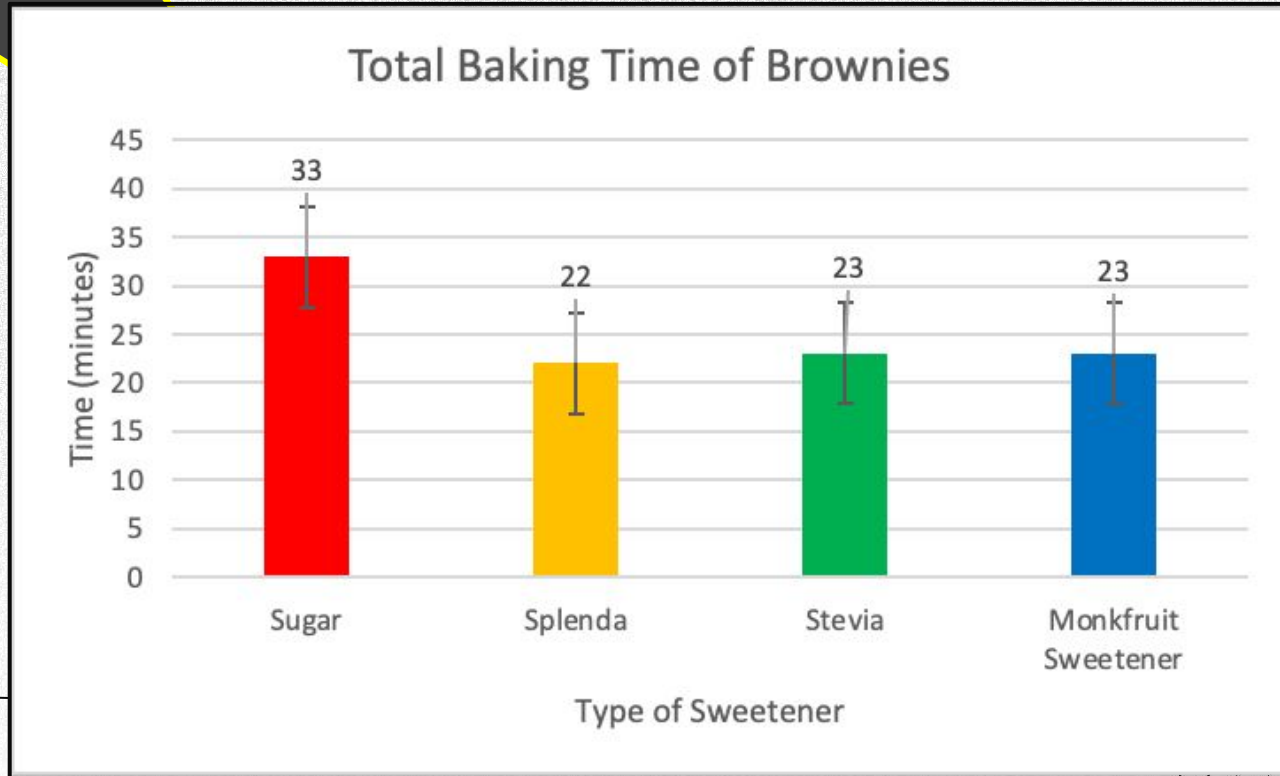


No statistical significant difference between the four samples.



# Results: Objective Evaluations

TOTAL TIME TO BAKE

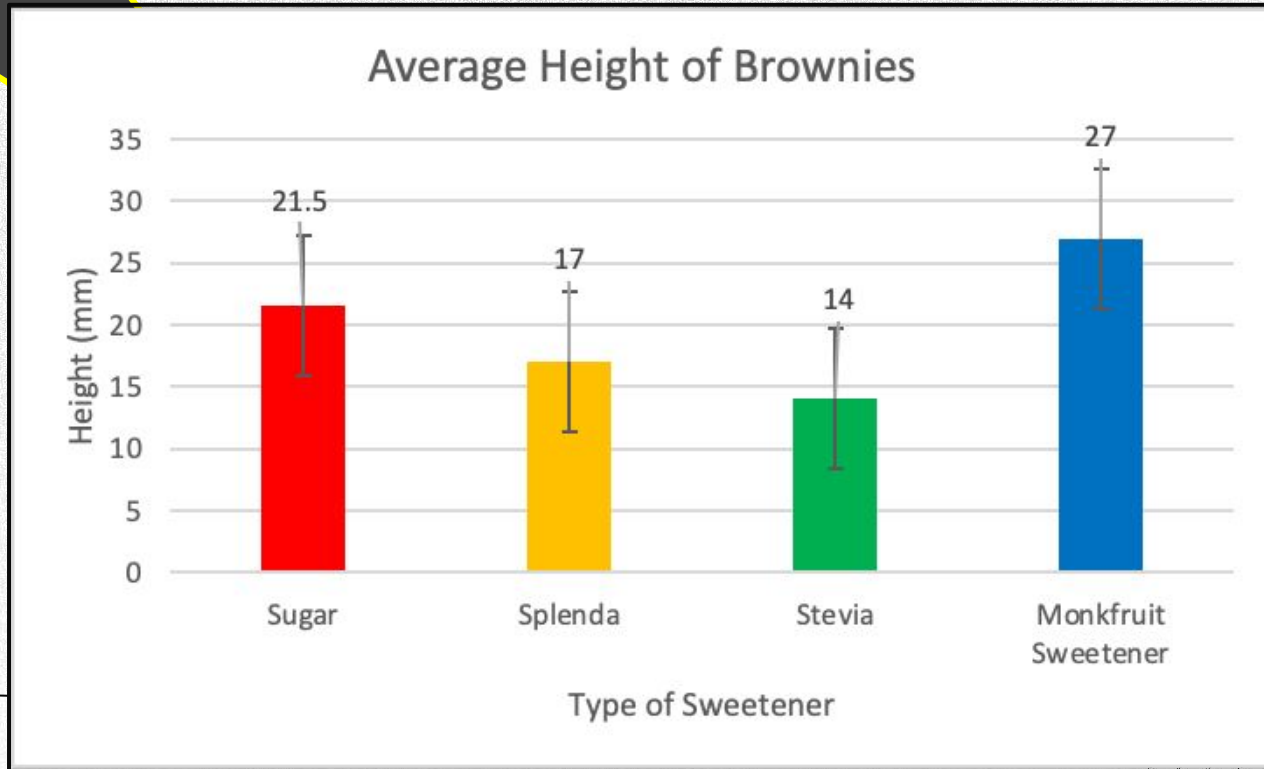


Sugar brownie took much longer to bake.



# Results: Objective Evaluations

AVERAGE HEIGHT

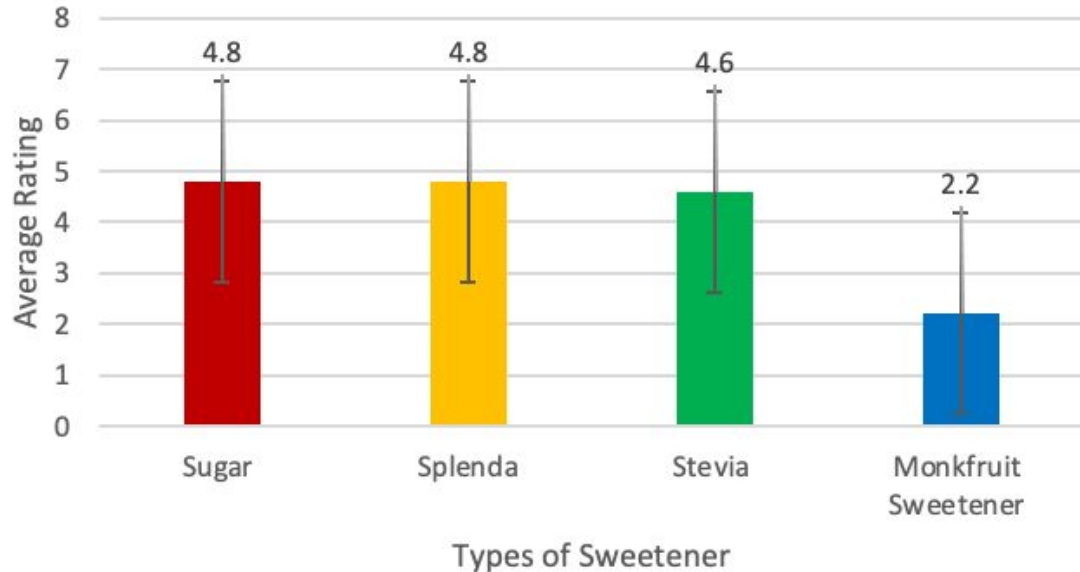




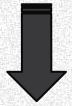
# Results: Sensory Evaluations

**GLOSSINESS**

Average Rating for Exterior Appearance Based on Glossiness



Statistical significance between Splenda and Monkfruit Sweetener.



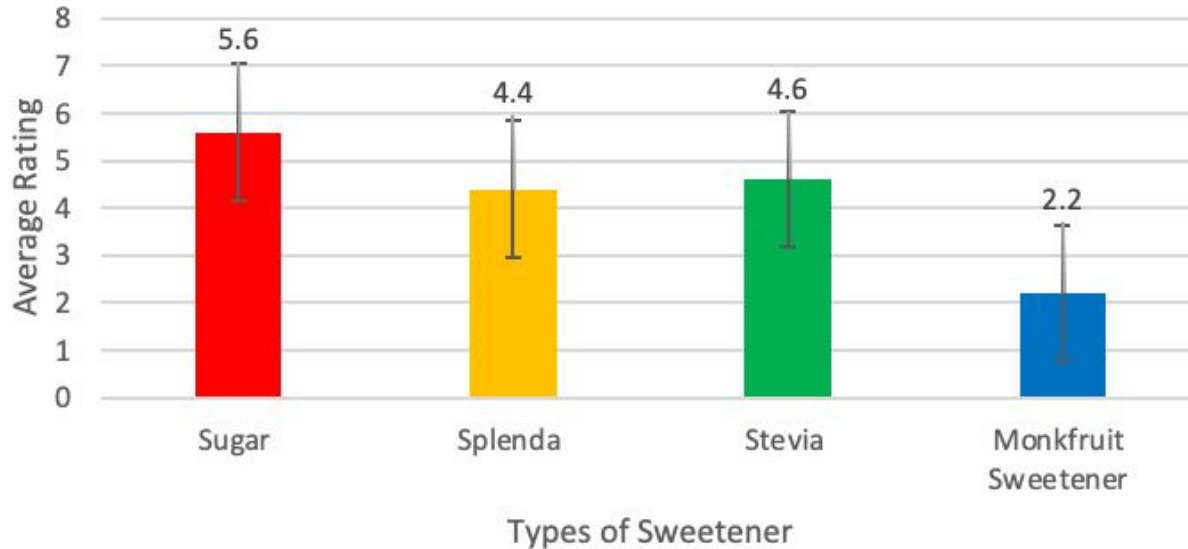
$p = 0.0034$



# Results: Sensory Evaluations

DENSE

Average Rating for Interior Appearance Based on Density



Statistical significance between Splenda and Monkfruit Sweetener.

$p = 0.0373$

Statistical significance between Sugar and Monkfruit Sweetener.

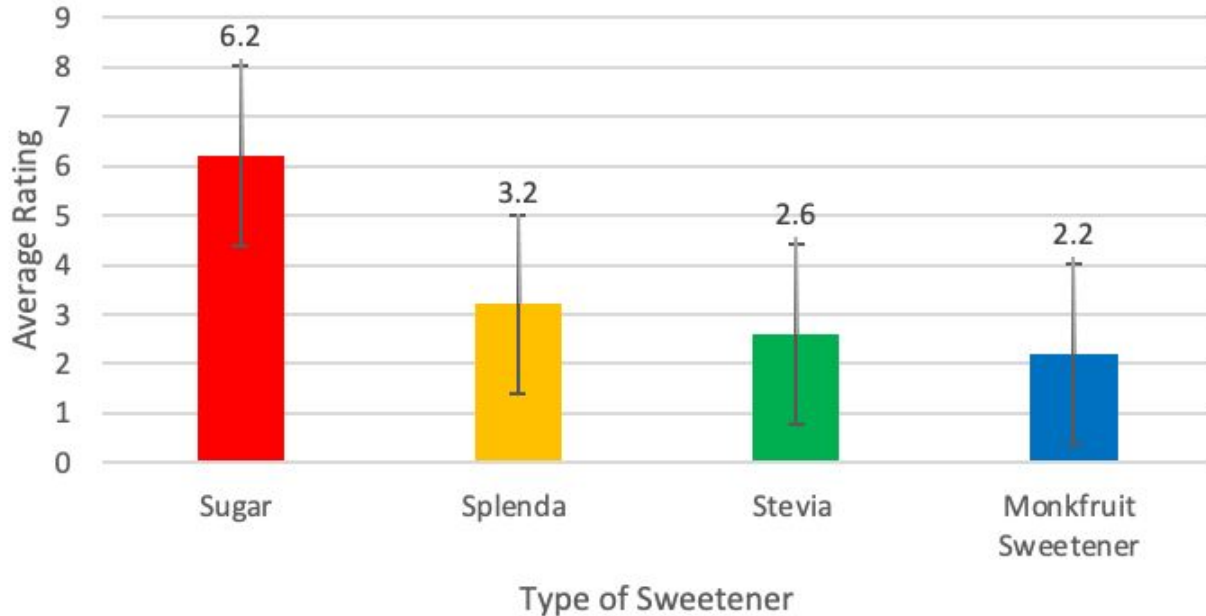
$p = 0.0219$



# Results: Sensory Evaluations

**SMOOTHNESS**

Average Rating for Texture Based on Smoothness



Statistical significance between Sugar and Monkfruit Sweetener

$p = 0.0046$

Statistical significance between Sugar and Splenda

$p = 0.0292$

Statistical significance between Sugar and Stevia

$p = 0.0072$

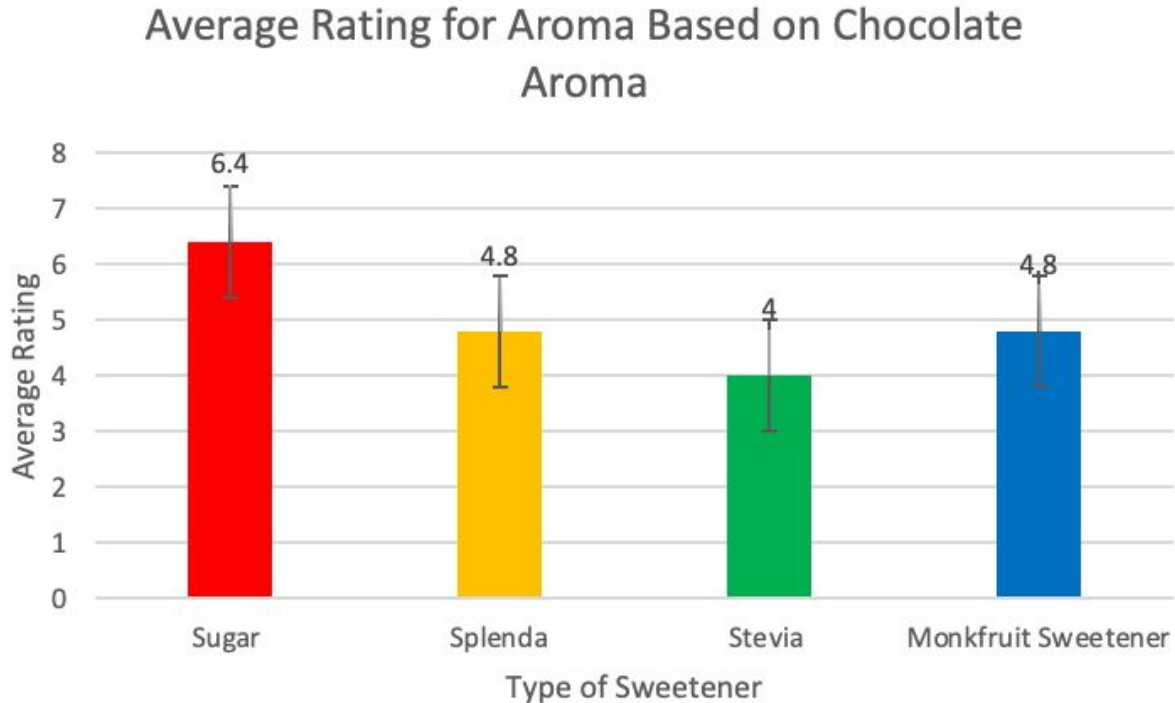


# Results: Sensory Evaluations

CHOCOLATE AROMA

Statistical significance between Sugar and Monkfruit Sweetener

$p = 0.0092$



Statistical significance between Sugar and Splenda

$p = 0.0092$

Statistical significance between Sugar and Stevia

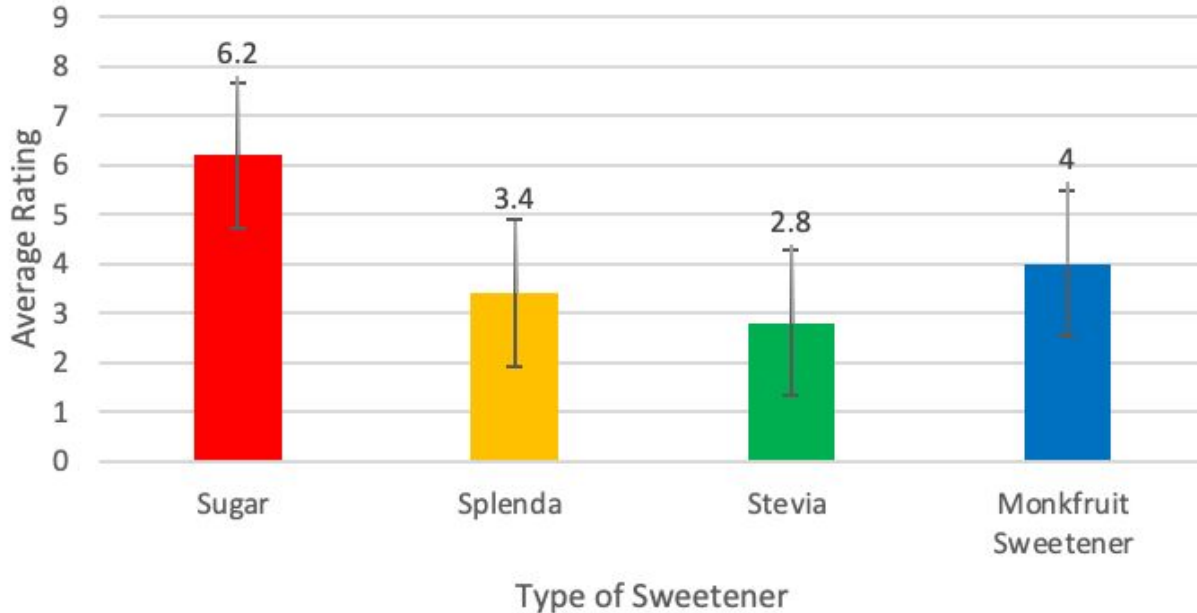
$p = 0.0157$



# Results: Sensory Evaluations

SWEETNESS

Average Rating of Taste Based on Sweetness



Statistical significance between Sugar and Stevia

$p = 0.0033$

Statistical significance between Sugar and Splenda

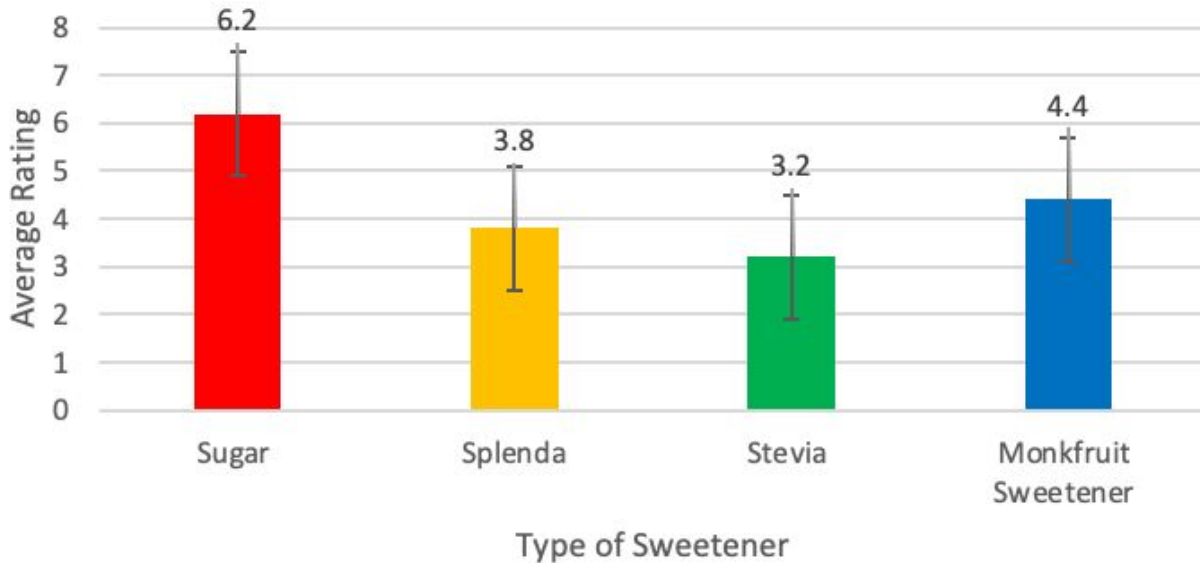
$p = 0.0101$



# Results: Sensory Evaluations

CHOCOLATE FLAVOR

Average Rating of Flavor Based on Chocolate Flavor



Statistical significance between Sugar and Stevia

$p = 0.0020$

Statistical significance between Sugar and Splenda

$p = 0.0394$

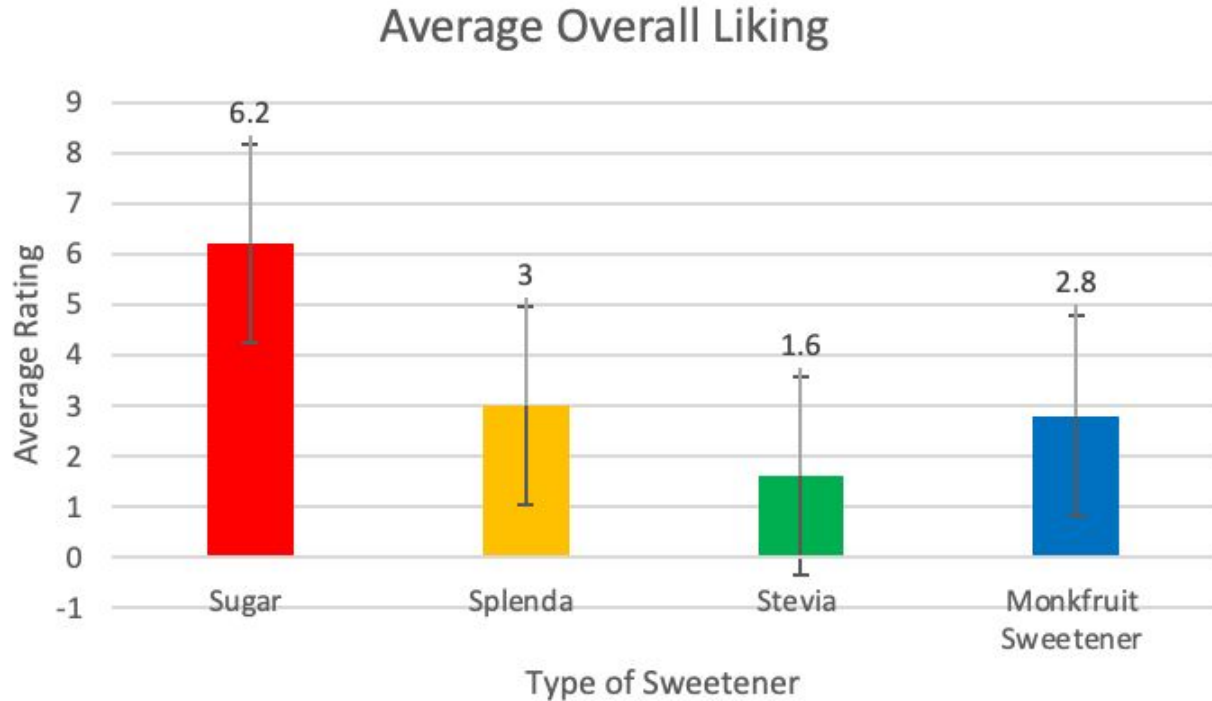


# Results: Sensory Evaluations

OVERALL LIKING

Statistical significance between Sugar and Monkfruit Sweetener

$p = 0.0141$



Statistical significance between Sugar and Splenda

$p = 0.0129$

Statistical significance between Sugar and Stevia

$p = 0.0022$



# Nutrition Facts Label

Sugar Brownie

## Nutrition Facts

Serving Size 1 Serving

Amount Per Serving

Calories 128

		% Daily Value*
<b>Total Fat</b>	6.7 g	9 %
Saturated Fat	3.9 g	20 %
Trans Fat	0.2 g	
<b>Cholesterol</b>	38.6 mg	13 %
<b>Sodium</b>	53.6 mg	2 %
<b>Total Carbohydrate</b>	16.6 g	6 %
Dietary Fiber	0.8 g	3 %
Total Sugars	12.6 g	
Added Sugars	12.5 g	25 %
<b>Protein</b>	1.6 g	
<b>Vitamin D</b>	0.2 mcg	1 %
<b>Calcium</b>	12.1 mg	1 %
<b>Iron</b>	0.5 mg	3 %
<b>Potassium</b>	41.7 mg	1 %

\* The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Full Info at [cronometer.com](https://cronometer.com)

</>

Splenda Brownie

## Nutrition Facts

Serving Size 1 Serving

Amount Per Serving

Calories 82.3

		% Daily Value*
<b>Total Fat</b>	6.7 g	9 %
Saturated Fat	3.9 g	20 %
Trans Fat	0.2 g	
<b>Cholesterol</b>	38.6 mg	13 %
<b>Sodium</b>	25.8 mg	1 %
<b>Total Carbohydrate</b>	4.8 g	2 %
Dietary Fiber	0.8 g	3 %
Total Sugars	0.7 g	
Added Sugars	0.6 g	1 %
<b>Protein</b>	1.6 g	
<b>Vitamin D</b>	0.2 mcg	1 %
<b>Calcium</b>	12 mg	1 %
<b>Iron</b>	0.5 mg	3 %
<b>Potassium</b>	41.5 mg	1 %

\* The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Full Info at [cronometer.com](https://cronometer.com)

</>

Stevia Brownie

## Nutrition Facts

Serving Size 1 Serving

Amount Per Serving

Calories 91.5

		% Daily Value*
<b>Total Fat</b>	6.7 g	9 %
Saturated Fat	3.9 g	20 %
Trans Fat	0.2 g	
<b>Cholesterol</b>	38.6 mg	13 %
<b>Sodium</b>	53.5 mg	2 %
<b>Total Carbohydrate</b>	7 g	3 %
Dietary Fiber	0.8 g	3 %
Total Sugars	0.3 g	
Added Sugars	0 g	0 %
<b>Protein</b>	1.6 g	
<b>Vitamin D</b>	0.2 mcg	1 %
<b>Calcium</b>	12 mg	1 %
<b>Iron</b>	0.5 mg	3 %
<b>Potassium</b>	41.5 mg	1 %

\* The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Full Info at [cronometer.com](https://cronometer.com)

</>

Monkfruit Sweetener Brownie

## Nutrition Facts

Serving Size 1 Serving

Amount Per Serving

Calories 82.2

		% Daily Value*
<b>Total Fat</b>	6.6 g	9 %
Saturated Fat	3.9 g	20 %
Trans Fat	0.2 g	
<b>Cholesterol</b>	38.6 mg	13 %
<b>Sodium</b>	53.4 mg	2 %
<b>Total Carbohydrate</b>	15.6 g	6 %
Dietary Fiber	0.6 g	2 %
Total Sugars	0.1 g	
Added Sugars	0 g	0 %
<b>Protein</b>	1.5 g	
<b>Vitamin D</b>	0.2 mcg	1 %
<b>Calcium</b>	11.4 mg	1 %
<b>Iron</b>	0.5 mg	3 %
<b>Potassium</b>	34.7 mg	1 %

\* The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Full Info at [cronometer.com](https://cronometer.com)

</>

# Discussion: Hypotheses

- **Nutritional Hypothesis: Supported**



- There is less sugar present in the alternative sweeteners as compared to the sugar brownie.

- **Objective Measures Hypothesis: Rejected & Supported**



- The Sugar brownie took significantly longer to bake than the alternative brownies.



- The Monkfruit brownie had the largest height.



- There was no statistical significant difference in number of chews between each of the four brownies.

- **Sensory Evaluation Hypothesis: Supported**



- The Sugar Brownie had a significantly higher overall liking rating.

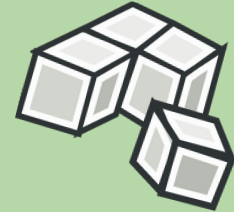


# Discussion: Functional Properties



## FUNCTIONAL PROPERTIES OF SUGAR:

- Sweetness
- Promotes the browning process of baked goods
- Hygroscopic- Retains moisture of baked goods



## IMPORTANT NOTES:

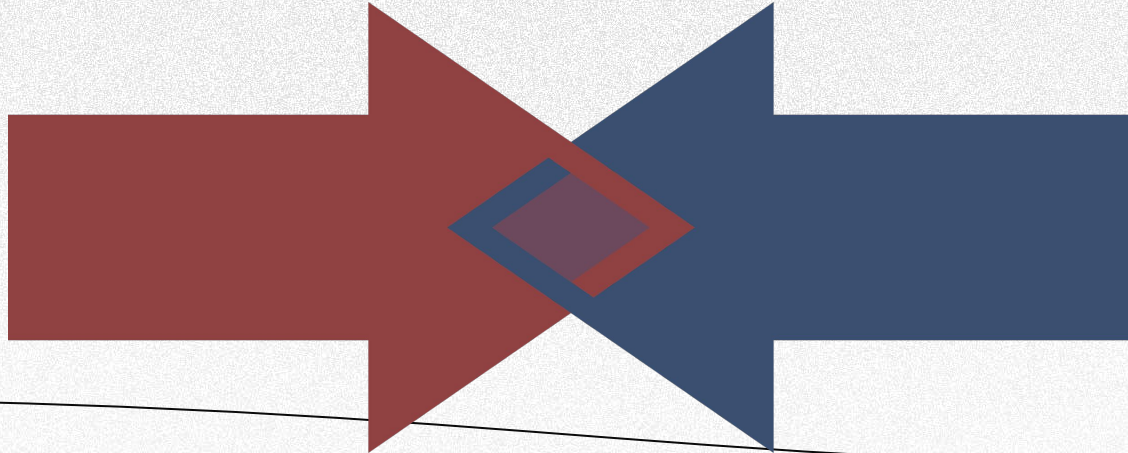
- In brownies, the browning process is not as important (as it would be in a golden brown cookie, for example) so sugar alternatives are useful in this sense, even though they do not have browning capabilities like sugar.
- Alternative sugars are more dry because they are not hygroscopic in nature.
- ➔ - “103 [Monkfruit sweetener] **Dry**. It **lacked moisture**” – Panelist
- ➔ - “499 [Stevia] **Dry**.” – Panelist
- ➔ - “317 [Splenda] **Dry**.” – Panelist
- ➔ - “749 [Sugar] **Perfect balance between sweet, moisture, very tender.**” – Panelist

## In the Future...



Recommendation: Make a **home blend** with half regular sugar, half alternative sweetener.

- This way there are still functional properties of sugar incorporated without having all of the excess sugar.





# References

- ❖ Centers for Disease Control and Prevention. (2022, July 7). *What is diabetes?* Centers for Disease Control and Prevention. Retrieved from <https://www.cdc.gov/diabetes/basics/diabetes.html#:~:text=With%20diabetes%2C%20your%20body%20doesn't,vision%20loss%2C%20and%20kidney%20disease.https://www.cdc.gov/diabetes/data/statistics-report/index.html>
- ❖ Rao, D. (n.d.). In *Carbohydrates- Simple Sugars* (Vol. PPT 9B). essay.
- ❖ Emdin, C. A., Anderson, S. G., Woodward, M., & Rahimi, K. (2015). Usual Blood Pressure and Risk of New-Onset Diabetes: Evidence From 4.1 Million Adults and a Meta-Analysis of Prospective Studies. *Journal of the American College of Cardiology*, 66(14), 1552–1562. <https://doi.org/10.1016/j.jacc.2015.07.059>
- ❖ Malik, V. S., Popkin, B. M., Bray, G. A., Després, J.-P., Willett, W. C., & Hu, F. B. (2010). Sugar-sweetened beverages and risk of metabolic syndrome and type 2 diabetes: a meta-analysis. *Diabetes Care*, 33(11), 2477–2483. <https://doi.org/10.2337/dc10-1079>
- ❖ Kanter, J. E., & Bornfeldt, K. E. (2016). Impact of Diabetes Mellitus. *Arteriosclerosis, Thrombosis, and Vascular Biology*, 36(6), 1049–1053. <https://doi.org/10.1161/atvbaha.116.307302>
- ❖ Meng, Y., Li, S., Khan, J., Dai, Z., Li, C., Hu, X., Shen, Q., & Xue, Y. (2021). Sugar- and Artificially Sweetened Beverages Consumption Linked to Type 2 Diabetes, Cardiovascular Diseases, and All-Cause Mortality: A Systematic Review and Dose-Response Meta-Analysis of Prospective Cohort Studies. *Nutrients*, 13(8), 2636. <https://doi.org/10.3390/nu13082636> (meta analysis)
- ❖ Wilcox, G. (2005). Insulin and Insulin Resistance. *The Clinical Biochemist. Reviews*, 26(2), 19–39. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1204764/>
- ❖ CDC. (2019, August 12). *The Insulin Resistance–Diabetes Connection*. Centers for Disease Control and Prevention. <https://www.cdc.gov/diabetes/basics/insulin-resistance.html#:~:text=The%20pancreas%20pumps%20out%20more>