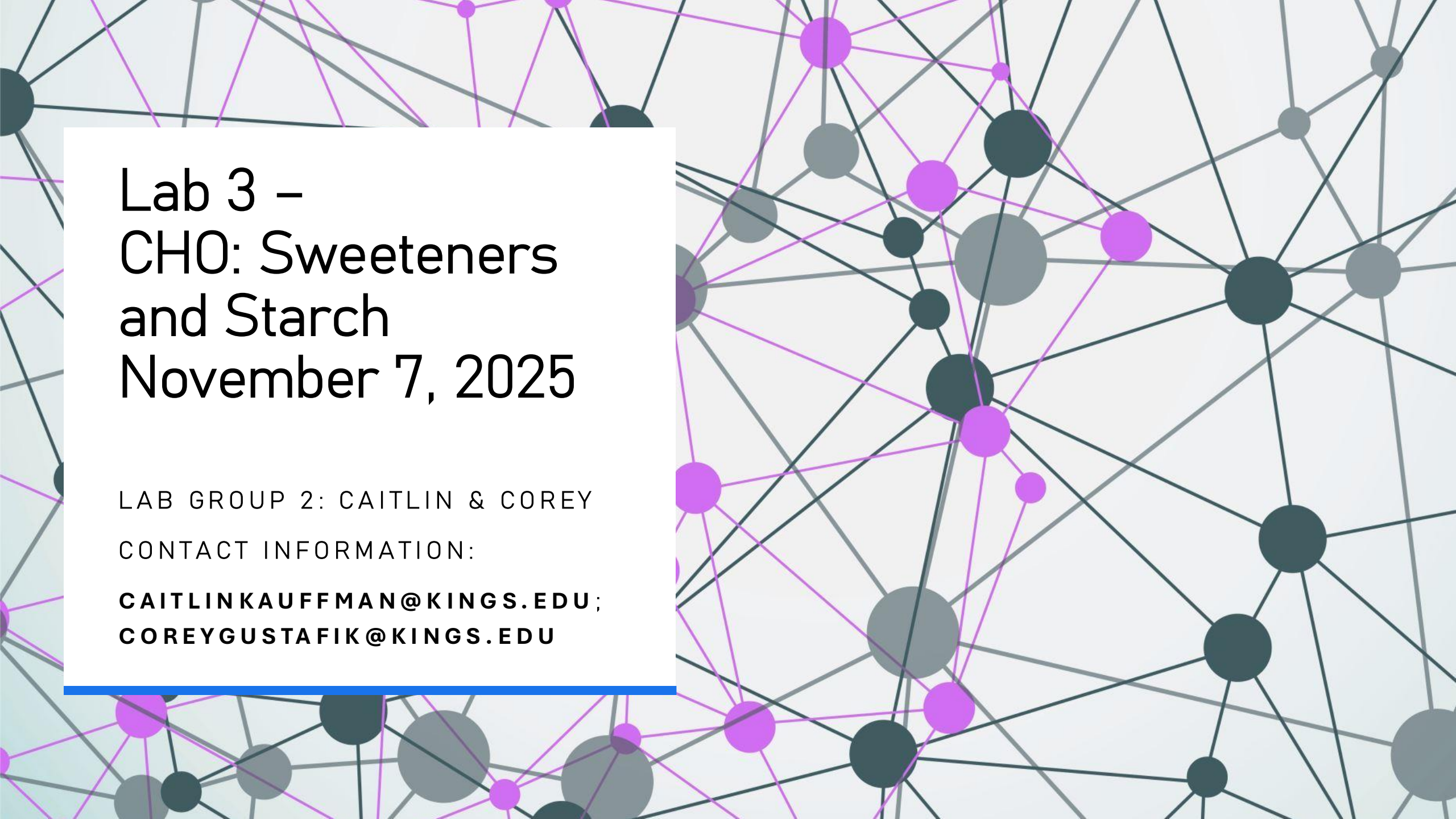




Lab 3 – CH0: Sweeteners and Starch November 7, 2025

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Introduction – Baking Performance of Sweeteners (Cookies)

This lab explored how replacing white sugar with varying alternative sweeteners affected the sensory qualities of the resultant cookies.

Objectives – The purpose of this lab is to:

- Discuss the effects of replacing part of the sugar with Aspartame in cookies.
- Discuss the effects of replacing part of the sugar with Sucralose in cookies.
- Discuss the effects of replacing part of the sugar with Stevia in cookies.

Food Science Principles – Sugars play an important role in determining the texture, moisture, sweetness, appearance, and color (caramelization/browning [Maillard reactions]), among other characteristics, of baked goods.¹

Methods/Procedures

Ingredients:

- 112 g shortening
- 75 g sugar
- 79 g brown sugar
- 2.5 mL vanilla extract
- 47 g beaten egg
- 124 g flour
- 2 g baking soda
- 3 g salt

Procedure: Basic Recipe (Cookies, CONTROL) –

1. Preheat oven to 190°C (375°F).
2. Cream together shortening and sugars for 30 sec on high setting using electric mixer.
3. Add vanilla and egg and beat 1 min on high setting using electric mixer.
4. Stir flour, baking soda, and salt together first before adding to mixing bowl.
5. Using a wooden spoon, stir 30 strokes, or until no dry flour remains.
6. Drop by 1T dough onto a cookie sheet (air bake pan), evenly-spaced.
7. Bake at 190°C (375°F) in a conventional oven for 9 min.
8. Remove from cookie sheet and cool on wire rack.

Variations:

- Control 1- 75 g white sugar (without brown sugar)
- Control 2- 75 g white sugar (with brown sugar)
- Aspartame/Equal- Prepare the basic formula but substitute 12 g Aspartame (Equal) for the white sugar.
- Sucralose/Splenda- Prepare the basic formula but substitute 12 g Sucralose for the white sugar.
- Stevia/Truvia- Prepare the basic formula but substitute 12 g Stevia for the white sugar.



Methods/Procedures (Continued)

Evaluations:

Penetrometer:

1. Place a single cookie (1 of each sample/condition) on the penetrometer platform.
2. Conduct the penetrometer test in triplicate (choosing different areas of the cookie) and calculate the mean and SD for each sample.
3. Record your data in the Table.

Tenderness:

Evaluate tenderness by number of chews from a bite of each sample.

Record your data in the Table.

Subjective:

Evaluate Surface (top and bottom) Appearance, Color, Flavor, Sweetness, Bitterness, Aftertaste.

Record your data in the Table.

Results – Penetrometer

*see PDF of observations/ images	CONTROL: Original Recipe, white sugar	CONTROL: Original Recipe, white sugar+ brown sugar	Aspartame (Equal)	Sucralose (Splenda)	Stevia (Truvia)	Monk fruit Extract	Acesulfame-K (Sweet One)
You complete all that is highlighted from data and observations provided*							
Penetrometer							
Measurement #1	65	170	160	155	173	163	143
Measurement #2	47	170	178	146	145	156	139
Measurement #3	70	175	148	135	150	144	142
Average	60.7	171.7	162	145.3	156	154.3	141.3
Standard Deviation	12.1	2.9	15.1	10	14.9	9.6	2.1

- Control 2 had the highest value, on average; Control 1, the lowest.
 - SDs were in the tens to teens across all cookie types except for Control 2, which had a comparatively low SD of 2.9; Monk Fruit Extract-sweetened cookies, which had an SD just under 10 (9.6); and Acesulfame-K-sweetened cookies, which had the lowest SD of 2.1.

Results – Tenderness (Number of Chews)

*see PDF of observations/images	CONTROL: Original Recipe, white sugar	CONTROL: Original Recipe, white sugar+ brown sugar	Aspartame (Equal)	Sucralose (Splenda)	Stevia (Truvia)	Monk fruit Extract	Acesulfame-K (Sweet One)
Number of chews							
Judge 1	14	15	12	12	9	11	10
Judge 2	20	15	9	13	14	12	9
Judge 3	10	12	20	12	15	16	10
Average	14.7	14	13.7	12.3	12.7	13	9.7
Standard Deviation	5	1.7	5.7	0.6	3.2	2.6	0.6

- Control 1 required the greatest number of chews, on average; Acesulfame-K-sweetened cookies, the fewest.
 - The two highest SDs were from Control 1 and Aspartame-sweetened cookies (5.0 and 5.7, respectively); the two lowest, Sucralose-sweetened cookies and Acesulfame-K-sweetened cookies (0.6 each). All other cookies' SD values fell in between, ranging from 1.7-3.2.

Results – Subjective Data

[*see PDF of observations/images](#)

	CONTROL: Original Recipe, white sugar	CONTROL: Original Recipe, white sugar+ brown sugar	Aspartame (Equal)	Sucralose (Splenda)	Stevia (Truvia)	Monk fruit Extract	Acesulfame- K (Sweet One)
Surface Top	pale with deep, prominent cracks	cracks and craters, sunken-in center	wider cracks and craters, flat, thins out at the edges	wider cracks and craters, flat, thins out at the edges	wrinkled appearance with craters, uniformly thin and flat		
Surface Bottom	light brown center with darker edges	evenly crisp and brown, very dark in color	darker in the center and lighter on the outside, unevenly crisp	evenly crisp, but slightly darker edges than the center	slightly darker center, golden brown		
Color	pale with light brown edges	uniformly light brown	top surface - darker brown on the edges, lighter brown in the center; bottom surface - lighter brown on the edges and darker brown in the center	top surface - light brown with darker edges; bottom surface - medium brown with slightly darker edges	uniformly light brown (top); golden with a slightly darker center (bottom)		
Overall Appearance	thick, lumpy, and pale; less spread	light brown, moderate thickness and expansion (more spread)	light brown with dark edges (on top), oblong circle, slightly lumpy, more spread	light brown with darker edges (on top), ragged edges, slightly lumpy, more spread	uniform thickness, even coloring (top), more spread		

Results – Subjective Data (Continued)

Summary: Left to Right: Control (No Brown sugar); Control (Brown + Granulated); Stevia; Sucralose; Aspartame



- **Control 1 Cookies:** Palest, thickest in the center, lumpiest, and the least spread.
- **Control 2 Cookies:** Uniformly brown and crisp; thick, but sunken in the center (unlike the other cookies); spread the most.
- **Stevia-Sweetened Cookies:** The most uniformly thick; wrinkled top surface; some disparities in coloring on the bottom surface.
- **Sucralose-Sweetened Cookies:** Thin, dark, and ragged edges; slightly lumpy; similar in appearance to the Aspartame-sweetened cookies, but less spread and with less texture on the top surface.
- **Aspartame-Sweetened Cookies:** Uneven in crispness and color, lumpy and oblong shape; second-most spread.

Results – Flavor

*see PDF of observations/images	CONTROL: Original Recipe, white sugar	CONTROL: Original Recipe, white sugar+ brown sugar	Aspartame (Equal)	Sucralose (Splenda)	Stevia (Truvia)	Monk fruit Extract	Acesulfame-K (Sweet One)
Flavor	salty	sweeter	not too sweet	popcorn-sweet taste	not good (no words)		
Sweetness (0-10)	5	7	6	6	5		
Bitterness (0-10)	0	0	1	2	10		
Aftertaste (0-10)	0	0	1	3	10		
Overall rating (1= Best, 5=Worst)	2	3	1	4	5		

- **Control 1 Cookies:** Sweetness – lowest (tied with Stevia); Bitterness – lowest (tied with Control 2); Aftertaste – lowest (tied with Control 2); Overall Rating – 2/5 (second best).
- **Control 2 Cookies:** Sweetness – highest; Bitterness – lowest (tied with Control 1); Aftertaste – lowest (tied with Control 1); Overall Rating – 3/5 (third best).
- **Aspartame-Sweetened Cookies:** Sweetness – middle tier (tied with Sucralose); Bitterness – second lowest; Aftertaste – second lowest; Overall Rating – 1/5 (first best).
- **Sucralose-Sweetened Cookies:** Sweetness – middle tier (tied with Aspartame); Bitterness – third lowest; Aftertaste – third lowest; Overall Rating – 4/5 (fourth best).
- **Stevia-Sweetened Cookies:** Sweetness – lowest (tied with Control 1); Bitterness – highest; Aftertaste – highest; Overall Rating – 5/5 (worst).



Discussion – Analysis of Results

- Conclusions From and Interpretations of the Results:
 - The cookies sweetened with white sugar alone were the toughest/least tender (Penetrometer and Number of Chews data); do not forget the brown sugar when making cookies!
 - The cookies sweetened with both brown sugar and white sugar were the most "tender" according to Penetrometer data but required the second highest number of chews; these cookies may have been soft, but chewy.
 - Uneven browning/caramelization was common across the cookies that were not sweetened with white sugar; this may be due to the differing capacities of these sweeteners to caramelize and promote Maillard reactions compared to white/brown sugar.²
 - The Stevia sweetener produced the most bitter cookies that had the strongest aftertaste; Stevia may not be the best choice of sweetener for cookies.
 - Aspartame came out on top as the best cookie, with an overall acceptable flavor, modest sweetness, and moderate tenderness and chewiness; Aspartame may be a better alternative sweetener for use in baking cookies.

Discussion – Analysis of Results (Continued)

- Why Did We Get These Results?
 - Aspartame- and Sucralose-sweetened cookies have been reported to have more uneven surfaces due to a higher moisture content in the base cookie dough they are incorporated into.³
 - Stevia-sweetened cookies have also been found to create cookie dough with higher water activity, but only at higher percentages of sugar replacement.⁴ This may explain why these cookies appeared less "lumpy" than the aforementioned cookies.
 - Aspartame is destroyed with excessive heat, which may explain the perception of a cookie that is "not too sweet."²
 - Sugar substitutes interfere with sucrose's ability to recrystallize after a cookie has finished baking, leading to softer, less crisp cookies.^{1,3} This might explain, in part, the lower number of chews (on average) for the cookies made with alternative sweeteners, compared to both controls.
 - Brown sugar is slightly acidic and has more moisture than white sugar, which may account for the differences seen between the two control cookies.^{1,5}
- Explanation of Differences/Limitations:
 - Subjective nature of sensory observations; our perceptions having not completed the experiment ourselves



Discussion – Summary of What We Learned

- We learned that:
 - Replacing white sugar with varying alternative sweeteners leads to shifts in sensory qualities like appearance, flavor, texture, moisture, and color.
 - Some sweeteners may be less suitable for baking than others (i.e., Stevia), unless other steps are taken to improve palatability of the final product (e.g., using less of a sweetener or combining different sweeteners, adding other ingredients, etc.).²
 - Personal preference dictates which sweeteners are desired in baked cookies.
 - Sugars contribute more than just sweetness to baked goods; they are also vital to producing a moist, tender, golden brown, and crisp cookie.

Discussion – How We Met the Objectives

- Discuss the effects of replacing part of the sugar with Aspartame, Sucralose, or Stevia in cookies.
 - We discussed how these three sweeteners affected key sensory characteristics of cookies, such as appearance (color, crispness, evenness of cooking, etc.), texture, flavor, and moisture.





Discussion – Conclusion: Take-Home Message

- The role of sugars in baking goes beyond providing sweetness; sugars are critical for creating baked goods (such as cookies) that have a desirable flavor, texture, and appearance.
- Alternative sweeteners can be used to replace some of the sugar when baking cookies, with varying degrees of success.
- Whether or not a sweetener can successfully replace sugar depends on the type and amount of sweetener used, among other factors.

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