How do different types of flour affect the rate of baking a cake?

Abstract:

The main research idea for the experiment that was conducted was finding how different types of flour affected the way a cake bakes. The problem that this topic was trying to solve is how to find quicker and more effective gluten alternatives for people affected by celiac disease and other similar dietary restrictions. Although there was an increased access to gluten alternatives, an issue existed that often there hasn't been adequate and accessible information as to which gluten alternative is the most efficient to bake with. This experiment assisted in solving that problem by finding efficiency in which flour type was the fastest to bake with. From the findings the overwhelming result was that cakes with a higher density before baking would have an overall higher density change, this followed the trend that cakes with initial density of at least 0.7 g/cm^3 had a greater change. The cakes that had a greater change in density correlates with the fact that they had faster temperature increases and were able to bake faster than the rest of the test subjects. As a whole the cake that baked the fastest was the one baked with pumpkin flour, in accordance with the results it also had the largest density change and fastest temperature increase compared to the other subjects. Overall, this experiment impacts people with dietary conditions, allowing them to find the most efficient way to bake and cook food that they can safely eat.

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Question

How do different types of flour affect the rate of how quickly white cake bakes?

Variables

Independent Variable: the different flour types

Dependent Variable:the rate of how quickly the white cake bakes

Background Research

For our research question, our group will be studying to see which type of flour alternative affects the baking time for chocolate chip cookies. This research is important because of how

common celiac disease is, a condition that affects your intestinal system and it is recommended to avoid gluten. Celiac disease can be challenging due to the change of diet, this fact is shared in a study done by Nasim Hasanpoor, “Celiac disease is a digestive autoimmune disorder caused by the digestion of gluten. As of current, the only known treatment for this disease is to get a gluten-free diet,” (Hasanpoor 2018.) Flour contains gluten and finding a flour alternative that has a reduced cooking time allows people with celiac disease to use that time for their personal lives, as opposed to spending time finding by the best food combination for their stomachs. This will overall make the lives of people with celiac disease easier by saving their time, allowing them to know the best possible flour alternatives so they aren’t limited by their condition when it comes to cooking and baking.

An example of other scientists supporting finding food alternatives is the 2024 study by Feriehiwote Weldeyohanis Gebremariam “Undeniably, imparting the enrichment of food quality to accomplish the prime quality product is serious concern for managing the food security and preventing specific chronic diseases and dietary shortcomings as well as promoting communal well-being of various populations,” (Gebremariam 2024.) In sum, our group’s research question will likely have a minor impact on society but could inspire others with better equipment and more experience in the subject to pursue similar topics and have greater impact on society.

Our experiment is one of the many that have tested and researched flour alternatives for numerous reasons, including medical reasons or lack of flour availability in regions. For example, certain studies demonstrate the conservation of materials and try to find uses for other ingredients, as seen here; “However, among aforementioned food ingredients for value added purpose, the pumpkin (Cucurbita pepo) seeds are seem to be one of the underutilized food values,” (Hasanpoor 2018.) Overall researchers seemed to add their own personal

element to their experiments, creating a personal connection to their experiments which showed in the amount of detail that they considered when presenting the data. Some experiments focused on the overall better consistency or taste of the cookies and created tables and visual representations when processing the results, others incorporated direct aspects of their culture into the experiment. An example of this is in a 2022 Ukrainian study where they use traditional recipes to test out the properties of mixed flours, “The most common today in Ukraine is the use of a synthetic group of technological additives used both in flour mills and in bakery, confectionery plants, etc. However, a group of herbal supplements is more promising and natural,” (Khorenghy 2022.) These show how although the experiments vary on the specific elements and research they all incorporate their own elements of the scientists’ personalities and morals, whether it be portrayal of their culture or solutions to medical diseases.

We also saw research on the increased demand for healthier food options on the shelves. Scientists experimented with ingredients like coloured rice and tricholoma matsutake powder for a higher value in nutrition while maintaining the compelling qualities like taste, aroma, and texture. This study demonstrated how to take other ingredients and process them into flour to evaluate their ability to act as a substitute in baked goods. However other research concluded that wheat flour was the best option and that any substitute will not suffice as a replacement from the original product. Scientists in Russia recorded that regular wheat flour is the most popular around all segments of the population and can even have a positive emotional effect on people. As we said earlier, this is going to vary among different locations and populations. Our group’s research question could have different kinds of societal impact, apart from the most prominent impact being the beneficial effects of those who have celiac disease but also inspiring others to find solutions to problems in the world around them. A benefit for those who have celiac disease includes finding a time-effective flour alternative,

since finding a flour alternative may be difficult and time consuming due to the rarity of gluten-free recipes and foods. Additionally, other scientists or individuals could be inspired to find the best flour alternatives for other recipes for not only celiac disease but for others who have dietary restrictions, such as food allergies, lactose-intolerance and diabetes.

Materials List

1. One Ruler: Utensil of measurement used to measure the rise of the cake, to determine height change for data collection.
2. One food thermometer: Utensil of measurement used to measure internal temperature of the cake, to determine when the cake is baked for data collection.
3. One kitchen scale: Utensil of measurement used to determine weight of cake, to determine density and moisture loss for data collection.
4. One 8x8 Cake Pan: 8 inches by 8 inches a deeper square shaped cake pan for when the cakes are being baked.
5. One roll of parchment paper: material that is placed in the cake pan to prevent the cake from sticking to the side of the pan.
6. Set of Measuring Cups: Utensil used to measure ingredients to make cake batter.
7. Set of Measuring Spoons: Utensil used to measure smaller portions of ingredients to make cake batter.
8. Two Spatulas: Utensil used to mix and combine ingredients into batter.
9. Two Mixing bowls: Location where ingredients will be added and combined to make batter.

10. One Oven: Location where cake batter in the 8x8 cake pan will go to be baked and the experiment is conducted.
11. Two Aprons: Apparel used to protect clothes from being dirtied with batter.
12. One bottle of Dish soap: Substance used to clean dirty dishes post-experiment.
13. One Sponge: Utensil used to clean dirty dishes post-experiment.
14. One Sink: Location where dirty dishes will go post-experiment to be sanitized.
15. Two pairs of Gloves: Apparel used to protect hands while cleaning, cooking during various steps throughout the experiment.
16. 1 cup White sugar (per each batch according to recipe): Food item that is used as an ingredient in the cake recipe that helps create the cake batter.
17. ½ Cup Unsalted butter (per each batch according to recipe): Food item that is used as an ingredient in the cake recipe that helps create the cake batter.
18. 2 Eggs (per each batch according to recipe): Food item that is used as an ingredient in the cake recipe that helps create the cake batter.
19. 2 teaspoons Vanilla extract (per each batch according to recipe): Food item that is used as an ingredient in the cake recipe that helps create the cake batter.
20. 1 ¾ teaspoons Baking powder (per each batch according to recipe): Food item that is used as an ingredient in the cake recipe that helps create the cake batter.
21. ¼ teaspoon Salt (per each batch according to recipe): Food item that is used as an ingredient in the cake recipe that helps create the cake batter.
22. ½ cup Whole Milk (per each batch according to recipe): Food item that is used as an ingredient in the cake recipe that helps create the cake batter.

23. 1 ½ cup All purpose Flour (per each batch according to recipe): Ingredient (independent variable) that will affect the cake's bake time.
24. 1 ½ cup Almond Flour (per each batch according to recipe): Ingredient (independent variable) that will affect the cake's bake time.
25. 1 ½ cup Oat flour (per each batch according to recipe): Ingredient (independent variable) that will affect the cake's bake time.
26. 1 ½ cup Whole wheat flour (per each batch according to recipe): Ingredient (independent variable) that will affect the cake's bake time.
27. 1 ½ cup Pumpkin flour (per each batch according to recipe): Ingredient (independent variable) that will affect the cake's bake time.
28. 1 ½ cup 'Gluten free' flour blend (per each batch according to recipe): Ingredient (independent variable) that will affect the cake's bake time.

Experimental Procedure

Each person that was participating washed their hands and put on a pair of gloves and an apron. The oven was preheated to 350 degrees celsius, then materials and ingredients were gathered in the kitchen. 1 cup of white sugar and ½ cup of unsalted butter were added and mixed until combined in the first mixing bowl. Two eggs were added, one at a time, and mixed until combined with the mixture in the mixing bowl. 2 teaspoons of vanilla extract were added and mixed until combined with the mixture in the mixing bowl.

In the second separate bowl with a separate spatula ¼ teaspoon of salt and 1 ¾ teaspoons of baking powder were added, then mixed until combined. 1 ½ cups of whichever type of flour is being used in the recipe is added then was mixed until combined.

Dry ingredients were poured into and mixed until combined with the ingredients from the first bowl. ½ cup of whole milk was added and mixed until combined with the other

ingredients. Cake batter was poured and spread into the 8x8 cake pan that was lined with parchment paper. The cake was placed in the oven once it was completely preheated. The cake was taken out in intervals after 5, 15, 25 and 35 minutes to measure if it was baked using a kitchen thermometer to measure internal temperature. The cake was also measured in centimeters (cm) using a ruler before and after it was baked to see height changed. The cake was also measured in grams using a kitchen scale, before and after it was baked to determine density change and moisture loss. All of the previous was repeated with each individual independent variable of flour for data to be collected. At the end the dish soap and sponge were used in the sink to clean up after the experiment.

Data Analysis

Figure 1: Cake Internal temperature Table

Flour Type:	Cake internal temperature before baking:	Cake internal temperature after 5 minutes	Cake internal temperature after 15 minutes	Cake internal temperature after 25 minutes	Cake internal temperature after 35 minutes
All Purpose flour (control):	63 degrees fahrenheit	86 degrees fahrenheit	114 degrees fahrenheit	138 degrees fahrenheit	162 degrees fahrenheit
Almond Flour:	68 degrees fahrenheit	87 degrees fahrenheit	110 degrees fahrenheit	130 degrees fahrenheit	139 degrees fahrenheit
Oat Flour:	62 degrees fahrenheit	89 degrees fahrenheit	117 degrees fahrenheit	135 degrees fahrenheit	141 degrees fahrenheit
Whole Wheat Flour:	68 degrees fahrenheit	85 degrees fahrenheit	102 degrees fahrenheit	139 degrees fahrenheit	141 degrees fahrenheit
Pumpkin Flour:	85 degrees fahrenheit	99 degrees fahrenheit	116 degrees fahrenheit	126 degrees fahrenheit	139 degrees fahrenheit
‘Gluten	70 degrees	85 degrees	111degrees	137 degrees	143 degrees

Free' Flour Blend:	fahrenheit	fahrenheit	fahrenheit	fahrenheit	fahrenheit

Figure 2: Cake Moisture Loss Table:

Flour type:	Moisture before baking: (initial weight)	Moisture after baking: (final weight)	Total moisture loss:
All Purpose flour (control):	771g	741g	-3.89%
Almond flour:	747g	731g	-2.14%
Oat flour:	746g	712g	-4.56%
Whole wheat flour:	798g	767g	-3.88%
Pumpkin flour:	728g	696g	-0.04%
'Gluten Free' Flour Blend:	809g	783g	-3.21%

Figure 3: Density Change vs. Flour Type Graph

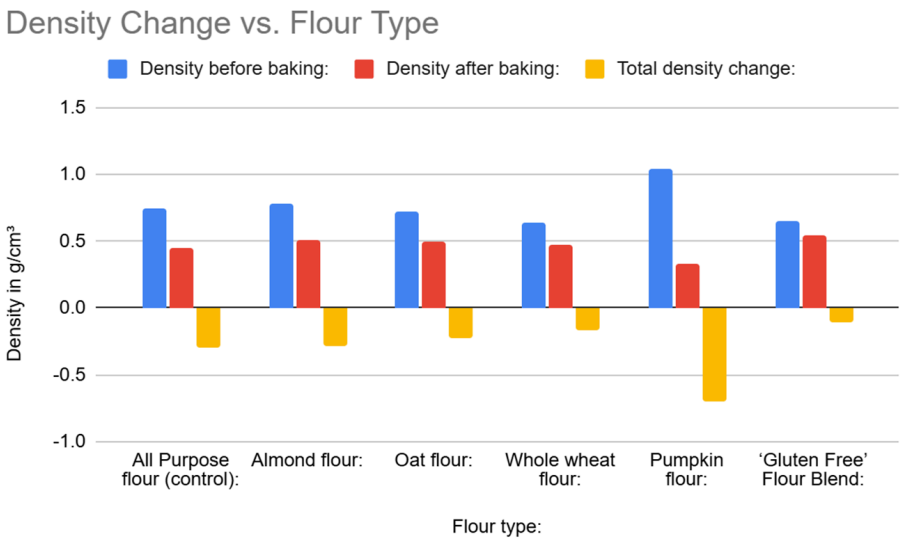


Figure 4: Height Changes vs Flour Type Graph:

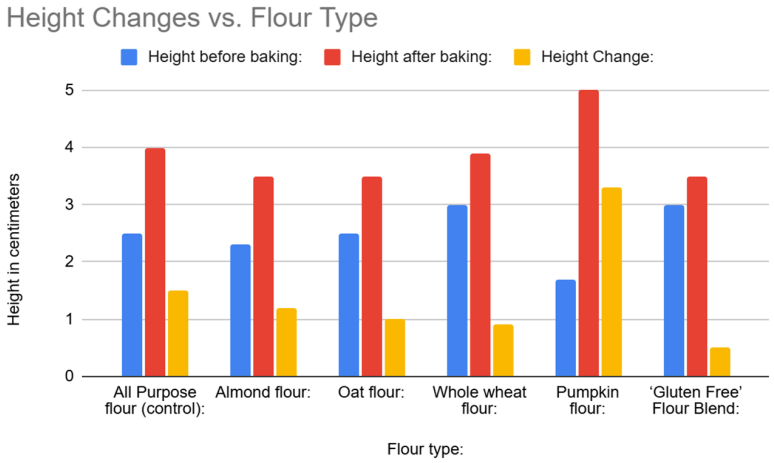


Figure 5: Weight Changes vs. Flour Type Graph:

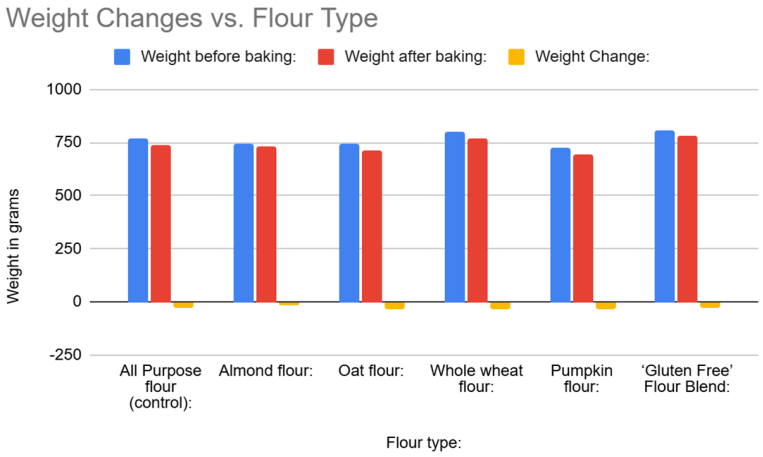
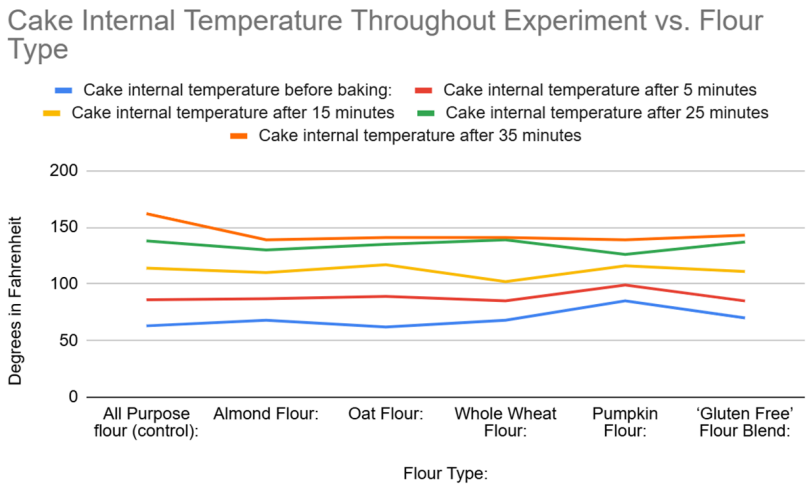


Figure 6: Internal Temperature vs. Flour Type Graph:



Observations:

Throughout the duration of the experiment, there were clear differences between the independent variables, the different types of flour, and the way they combined with the other ingredients creating different consistencies. The different consistencies were likely the reason that the cakes baked unevenly. Cakes that had runnier batter were also the cakes that had lower density, which we can see in Figure 3. The lower-density cakes had the least change because they weren't able to bake as consistently.

Conclusions

Different types of flour do affect the rate and efficiency of how quickly cakes bake. The different types of flour created different consistencies and textures which affected the baking because the density of the cake batter. The removing of the cakes from the oven also affected how consistently they baked. This means that cakes with higher density were able to bake easier rather than those with lower density.

Ideas for Future Research

For future research there are different variations of the same experiment that could change the question being tested. Similarly the experiment could be redone and have some of the minor flaws fixed. On another note there are many other food based experiments that can test food alternatives for other recipes and other dietary restrictions. The experiment that was conducted had aspects in itself that could be redone such as minor adjustments to the procedure or even the variables. For example letting the cake bake through the full time and testing a different quality of the cake to allow consistent baking, which affected the original experiment conducted. Overall these kinds of experiments are very helpful for communities due to the different needs in society with allergies, dietary restrictions (whether they are health based or by personal choice) and the availability of different ingredients in certain places.

Acknowledgements

Initially for this project I was paired up with another student, unfortunately this student transferred schools and was unable to continue the project. During the experiment I recruited my dad to assist with menial tasks in order to have the experiment be able to be conducted more manageably.

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