

FLUFFY FLOUR?

***DOES THE TYPE OF FLOUR CHANGE THE
DENSITY OF A MUFFIN?***

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GRADE 7

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ABSTRACT:

Fluffy Flour?

Does the Type of Flour Change the Density of a Muffin?

The purpose of this experiment was to see if wheat flour was denser than other types of flour that are gluten-free. Three types of flour were used in the same recipe to determine if the type of flour would change the density of the muffins. The types of flour used were wheat flour, rice flour, and buckwheat flour. The recipe used to cook the muffins was a simple vanilla muffin recipe. There were no added ingredients to alter the density of the batter. The hypothesis is if the type of flour is changed from wheat flour with gluten to other types of non-gluten flour (rice and buckwheat) then, the density of the muffin will increase. The same recipe was used for all of the flour types as well as the same type of mixing bowls, mini-muffin trays, oven, temperature, rack position, and amount of batter.

Ten trials were completed. There were five muffins in each trial, for a total of 50 of each type of muffin. In total, 150 muffins were baked. The muffins were cut into cubes so that it was easier to calculate the density of them. To calculate the volume the length, width and height was measured using a ruler. These dimensions were multiplied to get the volume. The mass was measured using a triple beam balance. The density was calculated by dividing the mass by the volume.

The mean density of the muffins was 0.66 g/cm^3 for the rice flour, 0.45 g/cm^3 for the buckwheat flour and 0.45 g/cm^3 for the wheat flour. The hypothesis was partially refuted as I thought that the gluten-free flour would be denser than the wheat flour.

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Question:

Does the type of flour effect the density of a muffin?

Purpose:

The purpose of this experiment is to find out if wheat flour are less dense than buckwheat and rice flour and muffins.

Hypothesis:

If the type of flour is changed from wheat flour with gluten to other types of non-gluten flour (rice and buckwheat) then, the density of the muffin will increase.

Independent Variable: Type of Flour

Dependent Variable: Density

Controlled Variables:

- Same recipe
- Mix ingredients for the same amount of time
- Same bowls
- Same oven
- Same temperature
- Same oven rack position
- Same position on the oven rack
- Same muffin tins
- Same amount of batter in muffin tins
- Same cooking time
- Same ruler
- Same scale

Background Research:

Flour is a substance that is eaten daily. It is in many items that we eat each day. There are many types of flour. The most common type of flour is made from wheat, but it can be made from other grains and substances such as rice, buckwheat, potato or almond. How is flour made? The first step is to take the raw material and put through a cleaning machine to get out any objects other than wheat. Then the wheat is brushed to get off any things that are stuck to it. The wheat is shaken in a large motorized drum to soften the grain and put in water and stored in a silo to get the humidity levels to a normal level for processing. Finally the grain is grinded in stages. The grains first go through break rolls where it is separates the bran and endosperm chunks. It finally goes through a whole bunch of machines to separate the chunks from the bran. That is how whole grain flour made. Other type of flours are made with similar methods.

Muffins are a delicious treat, but when did people start eating them. Well the first "American" muffin was estimated to be made around the end of the 18th century when pear lash was discovered. Pearlash Was a type of baking powder made from potash and it put carbon dioxide in the dough. Pear lash was used in lots of recipes and as featured in the first American cookbook "The American Cookery". Baking powder allow "breads" to rise quickly. It doesn't need to sit as long as yeast does, to add air to the dough.

In this experiment I will be measuring the muffin's density. Density is an objects mass divided by volume. Mass is the amount of matter in an object. Volume is the amount of space an object takes up. You find the mass by weighing an object by a scale. Volume is measured directly from the length, width and height of an object. Since there are three measurements with volume with

the units measured in are centimeter cubed. Mass is measured in grams. Density is mass divided volume so the units are grams per centimeter cubed.

Materials:

Recipe:

- 2 cups of flour
- 3 teaspoons of baking powder
- $\frac{1}{2}$ teaspoons of salt
- $\frac{3}{4}$ cup of white sugar
- 1 egg
- 1 cup of milk
- $\frac{1}{4}$ cup of vegetable oil
- $\frac{1}{2}$ teaspoon of vanilla

Ingredients

- 2 cups of wheat flour
- 2 cups of rice flour
- 2 cups of buckwheat flour
- 9 teaspoons of baking powder
- 1.5 teaspoons of salt
- $2\frac{3}{4}$ of white sugar
- 3 eggs
- 3 cups of milk
- $\frac{3}{4}$ of vegetable oil

- 1.5 teaspoons of vanilla
- 3 small muffin tins
- 3 medium plastic bowls
- Measuring cups and spoons
- Oven
- Mix master

Other Materials:

- Knife
- Cutting board
- Ruler
- Triple beam balance

Procedures:

1. put oven rack to the middle
2. pre-heat oven to 350⁰F
3. put the wheat flour in a bowl
4. put the rice flour in a separate bowl
5. put the buckwheat flour in last bowl
6. add the rest of the dry ingredients in the bowls
7. sift the dry ingredients for 10 rotations on high with the electric mixer
8. beat the eggs for 30s in a small bowl
9. make a well in dry ingredients
10. add egg to each well

11. put the vanilla, vegetable oil, and milk also in the well
12. mix all the ingredients for 60s
13. add 1 table to each muffin tin
14. place 1 muffin tray in the middle of the oven rack
15. bake for 25 minutes
16. remove from oven
17. repeat steps 14-16 in till all batter has been baked
18. once muffins cooled cut into cubes
19. measure the length, width and height of each cube
20. multiply the length, width and height to find out volume
21. find out the mass of each cube by using a triple beam balance
22. determine the density by dividing the mass by the volume

Data:

Qualitative Data:

The dry ingredients were placed in the bowls and sifted for 10 rotations on high with the electric mixer. The eggs were beat for 30 seconds on high with the electric mixer. The vanilla and avocado oil and the other liquid ingredients were added to the egg mixture. The liquid mixture was added to a well in the dry mixture.

Each batter was beat for 1 minute on high using the electric mixer. The rice and whole wheat mixture were a nice smooth liquid, but the coconut flour mixture was lumpy. The coconut flour

was substituted with buckwheat flour because of this and because the coconut flour muffins were too crumbly. They broke apart when I tried to remove them from the muffin tin. The mixture with the buckwheat flour was a nice smooth liquid as well, although it seemed stickier than the wheat and rice flour mixtures.

The batter was placed in the mini-muffin trays using a 1 tablespoon scoop. They were baked for 25 minutes. Was removed from the oven the muffins sat for 10 minutes before they were removed from the muffin tins.

Figures 1-4: Types of flour (in order: wheat, rice, coconut, buckwheat)



Figures 5 - 10: Dry ingredients



Figures 11 - 16: Dry ingredients with liquid ingredients (wheat, rice, and coconut flour)



Figures 17 - 21: batter (Wheat, rice, rice, coconut, buckwheat)

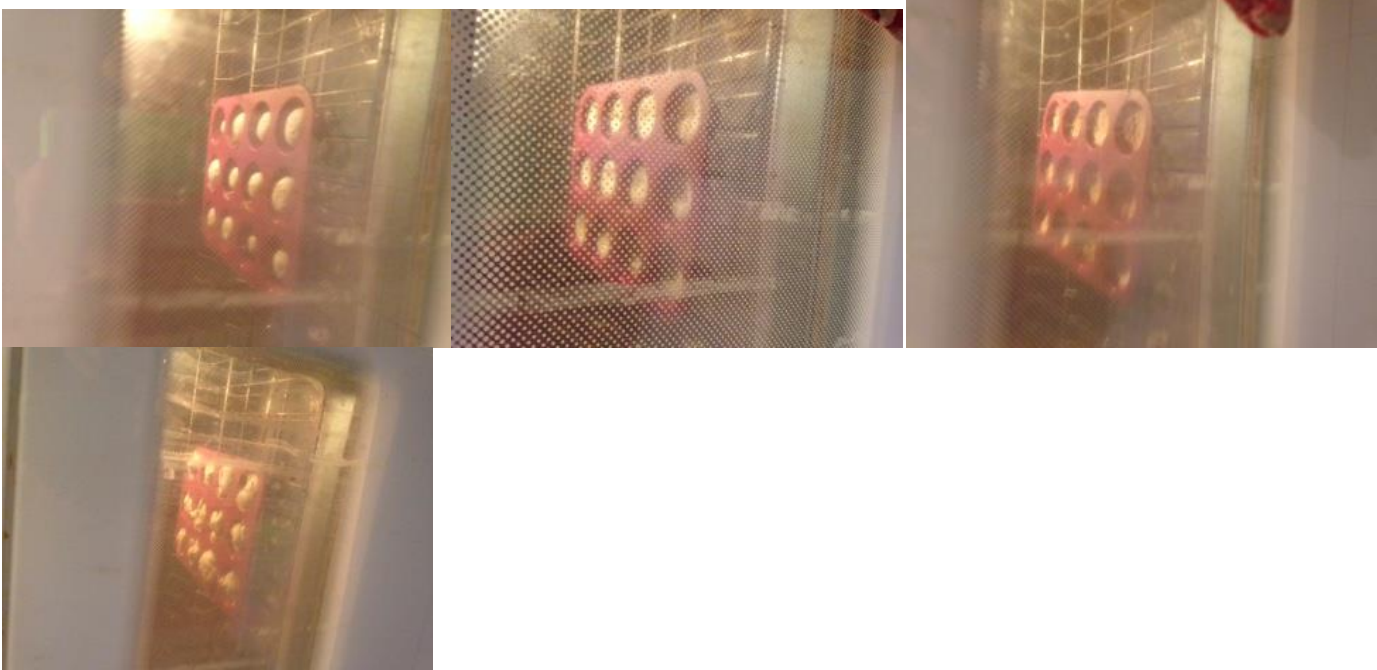




Figures 22 – 26: Batter in tins (wheat, rice, wheat and rice, coconut, wheat, rice and coconut)



Figures 27 - 30: Muffins cooking (wheat, rice, coconut, buckwheat)



Figures 31 - 34: Cooked Muffins



Figures 35 - 37: Cubing it



Figures 38 - 45: Weighing It



Quantitative Data:

Table 1: Raw Data for Buckwheat Flour

Type of Flour	Mass	Volume	Density
Buckwheat	2.8	7.2	0.388889
	4.1	10.4	0.394231
	3.1	7.6	0.407895
	6.1	12.3	0.495935
	6.9	11.01	0.626703
	4.8	9.4	0.510638
	6.2	12.5	0.496
	7.4	16.9	0.43787
	8.6	19.6	0.438776
	3.9	6.8	0.573529
	6.9	15.3	0.45098
	7.2	17.9	0.402235
	2.9	3.8	0.763158
	1.3	4.6	0.282609
	7.1	16.7	0.42515
	7.5	11.5	0.652174
	3.6	7.3	0.493151
	2.3	6.4	0.359375
	1.7	6.3	0.269841
	2.5	6.3	0.396825
	6.9	14.9	0.463087
	Mass	Volume	Density
	4.3	9.2	0.467391
	6.9	16.7	0.413174
	8.2	19.5	0.420513

	6.4	15	0.426667
	5.7	14.7	0.387755
	5.6	11.6	0.482759
	6.7	18	0.372222
	5.3	10.5	0.504762
	5.1	10.1	0.50495
	5.6	13	0.430769
	5.9	11.7	0.504274
	3.9	8.8	0.443182
	5.9	13.9	0.42446
	5	12.2	0.409836
	5.9	12.5	0.472
	6.3	12.7	0.496063
	4.5	8.1	0.555556
	6.3	20.4	0.308824
	5.4	12.5	0.432
	4.7	8.6	0.546512
	3.3	7.2	0.458333
	7.1	19.6	0.362245
	6.9	20.3	0.339901
	6.2	18.4	0.336957
	6	15.6	0.384615
	5.3	11	0.481818
	4.7	9.4	0.5
	4.9	10.5	0.466667
	2.7	5.8	0.465517

Table 2: Raw Data for Rice Flour

Type of Flour	Mass	Volume	Density
Rice	10.7	10.8	0.990741
	7.8	10.9	0.715596
	2.9	14.5	0.2
	7.2	11.3	0.637168
	9.4	13.8	0.681159
	6.5	4.4	1.477273
	3.1	11.3	0.274336
	8.6	15	0.573333
	6.9	17.4	0.396552
	5	10	0.5
	10.1	18	0.561111
	7	11.5	0.608696
	8.5	8	1.0625
	5.5	10.5	0.52381
	7.1	6.4	1.109375
	6.6	15.6	0.423077
	8	14.5	0.551724
	5.6	9.4	0.595745
	6	15.7	0.382166
	9.1	18	0.505556
	5.5	6	0.916667
	7	9	0.777778
	6.8	11.9	0.571429
	5.7	11.5	0.495652

	Mass	Volume	Density
	6.7	14.9	0.449664
	7.1	11.6	0.612069
	4.3	8.4	0.511905
	7.7	11.3	0.681416
	8.3	10.9	0.761468
	7.7	10.1	0.762376
	7.4	11.8	0.627119
	8.5	7	1.214286
	10.8	11.7	0.923077
	9.6	6.3	1.52381
	5.3	12.5	0.424
	9.5	11.3	0.840708
	7.5	7.5	1
	7.9	12.4	0.637097
	6.5	6	1.083333
	6.6	12.9	0.511628
	9.1	18.1	0.502762
	11	21.2	0.518868
	8.8	15.5	0.567742
	8.8	21.6	0.407407
	9.7	20.2	0.480198
	9.2	19.1	0.481675
	8.6	18.8	0.457447
	9.5	20.3	0.46798
	8.4	23.3	0.360515
	9.1	17	0.535294

Table 3: Raw Data for Wheat Flour

Type of Flour	Mass	Volume	Density
Wheat	9.6	20.3	0.472906
	8	19	0.421053
	6.3	13.7	0.459854
	7.5	19.5	0.384615
	6.2	9.5	0.652632
	8.1	10.1	0.80198
	9.2	25.2	0.365079
	5.4	8.6	0.627907
	4.1	10.6	0.386792
	7	11.4	0.614035
	8.3	21	0.395238
	6.9	7.8	0.884615
	8	18.2	0.43956
	8.9	18.9	0.470899
	5.8	16.9	0.343195
	5.1	18.1	0.281768
	4	9.6	0.416667
	11	22.7	0.484581
	4.7	13.8	0.34058
	10.7	19.7	0.543147
	5.2	15.3	0.339869
	6.2	12.2	0.508197
	7	11	0.636364
	8.7	16.3	0.533742

	6.5	11.5	0.565217
	Mass	Volume	Density
	5.6	18.2	0.307692
	8.9	16.7	0.532934
	7.2	12.5	0.576
	6.7	24.2	0.27686
	8.3	28.5	0.291228
	9.2	23.5	0.391489
	3.7	10.6	0.349057
	9.7	21.6	0.449074
	7.2	16.5	0.436364
	8	16.1	0.496894
	5.8	18	0.322222
	8.2	13.5	0.607407
	3.7	15	0.246667
	5.9	15	0.393333
	5.4	14.1	0.382979
	7.5	21.1	0.35545
	8	17.3	0.462428
	6.2	19.6	0.316327
	10	25	0.4
	8.4	16.6	0.506024
	8.1	21	0.385714
	5.2	16.5	0.315152
	8.3	12.2	0.680328
	11.2	26.6	0.421053
	6	21.8	0.275229

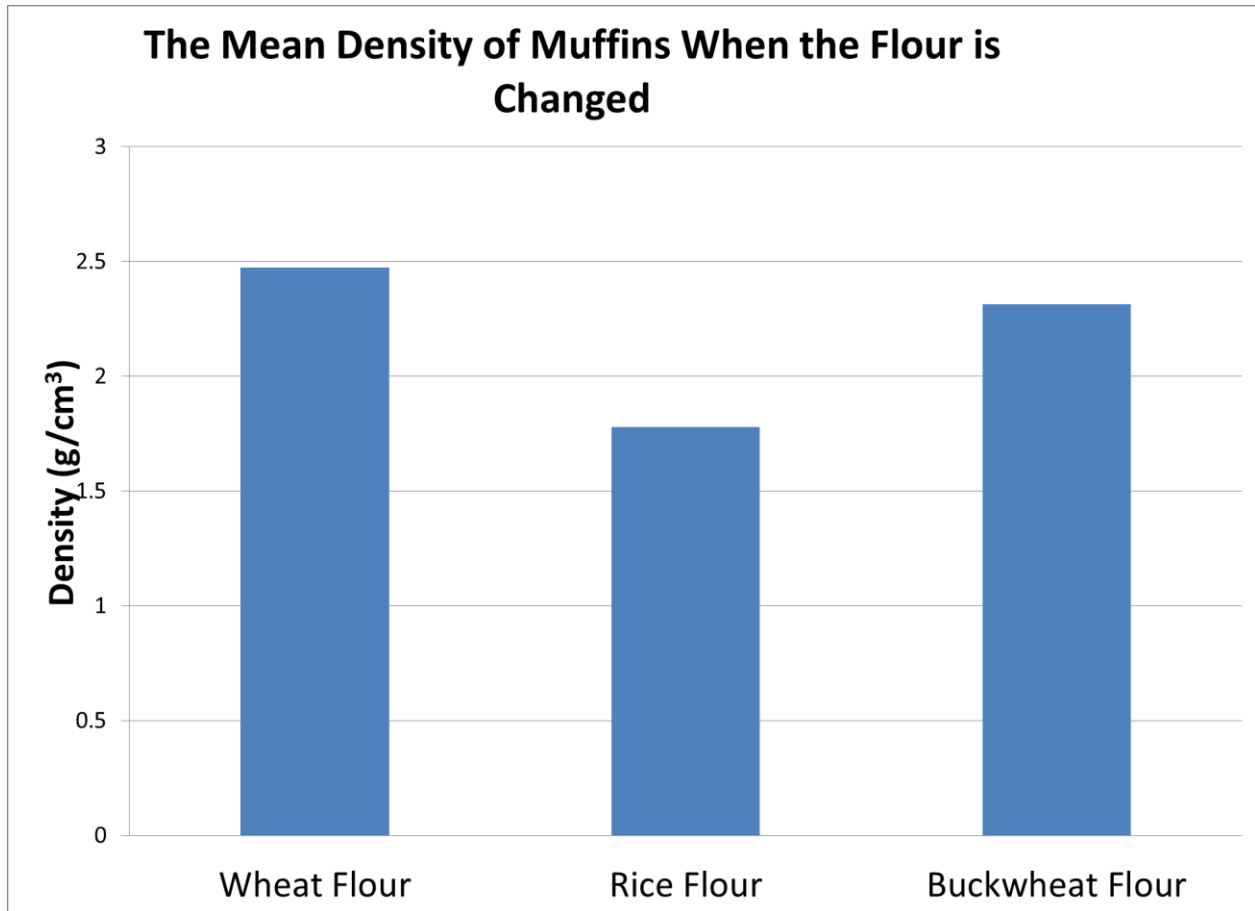
Table 4: Comparison of the densities of muffin with different flours (using data from log book)

	Rice Flour	Wheat Flour	Buckwheat Flour
Mean Density (g/cm ³)	1.778	2.472	2.312
Median Density (g/cm ³)	1.375	1.571	1.043

Table 5: Percent Increased Mean Density Compared to Rice Flour (using data from log book)

	Percentage Denser than Rice Flour
Buckwheat	30%
Wheat Flour	39%

Figure 46: Central Tendency graph using data from log book



Data Analysis:

Table 6: Central Tendency (mean) and Standard Deviation of Muffin Density

Buckwheat		Rice		Wheat	
Average (Mean) Density (g/cm ³)	0.450575	Average	0.657506	Average	0.450968
Standard Deviation	0.089061	Standard Deviation	0.282474	Standard Deviation	0.136257

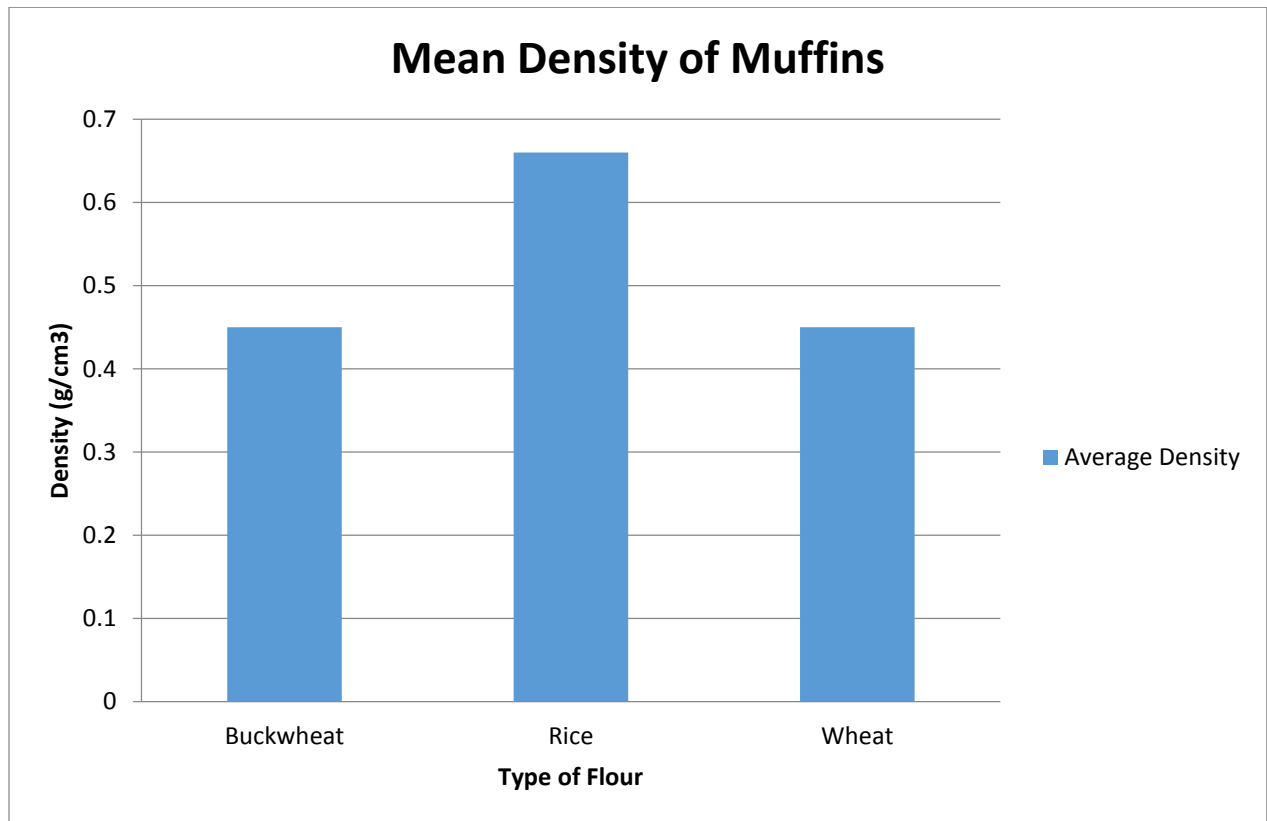
Table 7: Central Tendency (mean) and Standard Deviation of Muffin Density using correct number of significant digits

Buckwheat		Rice		Wheat	
Average (Mean) Density (g/cm ³)	0.45	Average	0.66	Average	0.45
Standard Deviation	0.09	Standard Deviation	0.28	Standard Deviation	0.14

Table 8: Percentage Density of Rice Flour

	Percentage Density of Rice Flour (Rice flour is 100%)
Buckwheat	68 %
Wheat	68%

Figure 47: Graph showing Central Tendency (mean) Density of Muffins



ANOVA: Results

The results of an ANOVA statistical test performed at 19:48 on 9-DEC-2014

Source of Variation	Sum of Squares	d.f.	Mean Squares	F
between	1.425	2	0.7123	20.11
error	5.208	147	3.5430E-02	
total	6.633	149		

The probability of this result, assuming the null hypothesis, is less than .0001

Group A: Number of items= 50

0.270 0.283 0.309 0.337 0.340 0.359 0.362 0.372 0.385 0.388 0.389 0.394 0.397 0.402 0.408 0.410 0.413
 0.421 0.424 0.425 0.427 0.431 0.432 0.438 0.439 0.443 0.451 0.458 0.463 0.466 0.467 0.467 0.472 0.482
 0.483 0.493 0.496 0.496 0.496 0.500 0.504 0.505 0.505 0.511 0.547 0.556 0.574 0.627 0.652 0.763

Mean = 0.45058

95% confidence interval for Mean: 0.3980 thru 0.5032

Standard Deviation = 8.906E-02

High = 0.7632 Low = 0.2698

Median = 0.4410

Average Absolute Deviation from Median = 6.443E-02

Group B: Number of items= 50

0.200 0.274 0.361 0.382 0.397 0.407 0.423 0.424 0.450 0.457 0.468 0.480 0.482 0.496 0.500 0.503 0.506
0.512 0.512 0.519 0.524 0.535 0.552 0.561 0.568 0.571 0.573 0.596 0.609 0.612 0.627 0.637 0.637 0.681
0.681 0.716 0.761 0.762 0.778 0.841 0.917 0.923 0.991 1.00 1.06 1.08 1.11 1.21 1.48 1.52

Mean = 0.65751

95% confidence interval for Mean: 0.6049 thru 0.7101

Standard Deviation = 0.282

High = 1.524 Low = 0.2000

Median = 0.5696

Average Absolute Deviation from Median = 0.198

Group C: Number of items= 50

0.247 0.275 0.277 0.282 0.291 0.308 0.315 0.316 0.322 0.340 0.341 0.343 0.349 0.355 0.365 0.383 0.385
0.386 0.387 0.391 0.393 0.395 0.400 0.417 0.421 0.421 0.436 0.440 0.449 0.460 0.462 0.471 0.473 0.485
0.497 0.506 0.508 0.533 0.534 0.543 0.565 0.576 0.607 0.614 0.628 0.636 0.653 0.680 0.802 0.885

Mean = 0.45097

95% confidence interval for Mean: 0.3984 thru 0.5036

Standard Deviation = 0.136

High = 0.8846 Low = 0.2467

Median = 0.4211

Average Absolute Deviation from Median = 0.104

Data Reference: 7F23

The average (mean) density of the muffins was: buckwheat 0.45 g/cm³, rice 0.66 g/cm³, and wheat 0.45 g/cm³. The standard deviation was 0.09 g/cm³ for the buckwheat muffins, this means that 50% of the data fit in the data range of 0.36 – 0.54 g/cm³. The standard deviation was 0.28 g/cm³ for the rice muffins, this means that 50% of the data fit in the data range of 0.37 – 0.94 g/cm³. The standard deviation was 0.14 g/cm³ for the wheat muffins, this means that 50% of the data fit in the data range of 0.31 – 0.59 g/cm³. The rice muffins had the greatest variation in the density. An ANOVA test was performed because I was comparing more than two types of flour. The ANOVA test result was 0.001; this is less than 0.05, so it means that I **can** compare these numbers.

Conclusion

The results state that rice muffins are denser than buckwheat flour and wheat flour. The rice flour was more dense than the buckwheat flour and wheat flour. The hypothesis says that "if the type of flour is changed from wheat flour with gluten to other types of non-gluten flour (rice flour and buckwheat flour) then the density will increase." The hypothesis is partially correct; I thought the non-gluten muffins would be denser because I thought the gluten would make it less dense. The wheat muffin is less dense than the rice muffin, but so is the buckwheat muffin.

My experiment could not be 100% accurate because I could have mixed up the muffins when I was weighing them and the muffins could be cooked at a different position because the muffins could have been placed a little to the left or right. I had difficulty at the beginning because I was going to use coconut flour but the flour fell apart so I used buckwheat flour instead.

Future Directions:

This experiment could impact people because if you are baking and don't want your muffins to be dense this would be helpful to figure out what flour to use. The results also show that buckwheat flour has the same density as wheat flour, so if you want a gluten-free muffin that is similar to a wheat flour muffin, then buckwheat flour should replace the wheat flour. Gluten-free recipes normally have more eggs to compensate for the fact that the flour produces a denser product. Next year I could use a gluten-free recipe, rather than a wheat flour recipe. I could use different gluten-free flours and compare their densities. People could further this experiment by having more flours and making more muffins for each flour.

Acknowledgements:

A thank you to my mom for buying my supplies and helping me bake.

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