Science Research Project

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Year 10

What is the relative difference in gluten content between different types of flour?

Abstract: The aim of this experiment was to determine the relative differences in gluten content between different types of flour, so people who needed to monitor their gluten intake could be aware of which flours were best for them. To test this, a method was developed based on several reliable sources and research conducted on this topic. Each variety of flour being tested was used to create a ball of dough, which was then rinsed under cold tap water until only the gluten remained, which was then weighed. This procedure was repeated 2 times (after the original test). The results gathered were concordant with the hypothesis, in that (out of the flours tested); wheat had the most gluten, then rye, then barley. Buckwheat and rice flour, as predicted, were both gluten free.

Introduction: How much gluten is in the different varieties of flour available for purchase? Do flours that claim to be gluten-free or low in gluten really fulfil these claims? These are the key questions behind this science research project, and why discovering the relative difference in gluten content between various flours was chosen as the topic. Most types of flour have gluten, and varying amounts of it. As well as this, there is a wide variety of gluten-free flours, all which can be used for different purposes. These factors can make it difficult for a consumer to decide which flour they want to purchase. This is especially true for those who have gluten sensitivity or Celiac Disease, an autoimmune disorder of the small intestine that causes pain in the digestive tract and is triggered by gluten, and have to watch their gluten intake as outlined by a study from the University of Maryland.[1] This experiment was designed to help make it easier to understand how much gluten various types of flour contain. A method was developed, as outlined in the research section, where a ball of dough was placed under running water until only the gluten remained and could be weighed. This method was verified with several reliable sources that outlined a similar process.

Research was also conducted in order to obtain a more detailed understanding on the topic, determine the controlled variables and allow for a more comprehensive interpretation of the results. The research is displayed on the following page.

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[1] Robinson, K. 2011. *University of Maryland School of Medicine researchers identify key pathogenic differences between Celiac Disease and Gluten Sensitivity*. [ONLINE] Available at:http://somvweb.som.umaryland.edu/absolutenm/templates/?a=1474. [Accessed 25 March 2013].

Research:

Gluten is a formless, ergastic protein found in cereal grains. This protein is a composite of gliaden and glutenin, taking the form of chains of amino acids. Information obtained from Science Daily[2] states that gluten is found with starch in the endosperm of grain. It makes up 80% of grain's total protein and is found in a large variety of food including bread, pasta, pastries and pies. Gluten forms a different type of protein in each individual type of grain. In wheat, gluten forms gliaden, in rye the protein is secalin and in barley, it is hordein. Gluten is what gives dough its plasticity and elasticity, enables it to rise when baking, maintains its shape and gives it a chewy consistency when baked.

In A.D. 100, an ailment known as Celiac Disease was discovered by the Greek Doctor Aretaeus, which is caused by the consumption of gluten. According to the Scientific American's website[3] , this is disease is autoimmune, so it triggers an inflammation of the gut and causes the body's immune system to damage the villi, which are found in the small intestine and help absorb nutrients. People diagnosed with Celiac Disease adopt a gluten-free diet, as it is the only known cure.

More recently, studies have been conducted which show that some people may have what is known as "gluten sensitivity" or "gluten intolerance". New studies from the BMC Medicine Journal[4] and the University of Maryland Centre for Celiac Research[5] have discovered that it is possible for gluten to trigger an immune response in some people who don't have Celiac Disease. This response can be much milder than the disease, and so in many cases, can be treated by removing some gluten from the diet, rather than all of it.

For people with Celiac Disease, or gluten sensitivity, it is essential to be able to monitor the amount of gluten in the foods they are consuming and have a successful treatment. This monitoring of gluten is also important for people who are aware that gluten is mainly found in heavily processed foods and want to avoid making it a staple in their diet for health reasons.

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[2] Science Daily. 1995. *Gluten*. [ONLINE] Available at: http://www.sciencedaily.com/articles/g/gluten.htm. [Accessed 04 February 13].

[3] Scientific American. 2011. When, and why, did everyone stop eating Gluten?. [ONLINE] Available at: http://blogs.scientificamerican.com/guest-blog/2011/05/10/when-and-why-did-everyone-stop-eating-gluten/. [Accessed 04 February 13].

[4] WSJ Health Journal. 2011. Study sheds light on Gluten Sensitivity. [ONLINE] Available at:http://online.wsj.com/article/SB10001424052748704893604576200393522456636.html. [Accessed 04 February 13].

[5] University of Maryland. 2011. *University of Maryland School of Medicine researchers identify key pathogenic differences between Celiac Disease and Gluten Sensitivity*. [ONLINE] Available at:http://somvweb.som.umaryland.edu/absolutenm/templates/?a=1474. [Accessed 04 February 13].

A technique has been developed to test for gluten in flour, as written about in the book, On Food and Science: The Science and Lore of the Kitchen6. If a ball of dough (consisting of flour and cold water) is kneaded, the starch present in the dough will progressively fall away and dissolve in the water. Once this occurs, a ball of insoluble gluten is left behind. This can be used in cooking and produces a chewy texture similar to meat. It is this researched and tested process that will be used in this project.

Aim: To determine the relative differences in gluten content between different types of flour.

Hypothesis: Out of the flours tested, the wheat flour has the most gluten, the rye and barley have less and the buckwheat and rice flour have the least.

Risk assessment:

Activity Description: An experiment to determine the relative differences in gluten content between different types of flour.

Step 1: Identify the hazard	CSIS User code (for chemicals only)	**Step 2: Strategies to minimise the hazard**	**Step 3: Assessment of risk** (see table below)	**Step 4: What if something goes wrong?**	**Step 5: Packing up**
Ceramic bowls can break and cause cuts	na	Place bowls away from edges of benches and keep outside dry to minimise slipperiness	1+2=3=MODERATE	In case of breakage consult an adult. Avoid touching the broken pieces of ceramics. Wipe up any spills. If cuts occur, seek first aid.	Clean, dry and pack away carefully
Flour can enter the eye and cause irritation	na	Keep the flour away from the eyes and wash hands after handling the flour.	1+1=2=LOW RISK	In case of flour entering the eye consult an adult. Wash the irritated area with cold water. If irritation continues, seek first aid.	Seal and pack away the flour. Wash hands.

Mandatory precautions: Covered shoes, safety glasses, hair exceeding shoulder length tied back.

Date: ..... **Student Signature: .....**

How do you assess the risk? For each hazard identified in Step 1, answer A then answer B. Then add A and B together to determine Risk and Action required

A What is the potential impact or consequence of the hazard?	B What is the likelihood of the event happening?	Add the numbers in columns A and B together	How to assess the risk	Action
1 = MINOR First Aid required with little or no lost time	1 = LOW It could happen but only rarely		1 – 2 = LOW RISK	Proceed with caution
2 = MODERATE Medical treatment required, some lost time	2 = MODERATE It could occasionally happen		3 – 4 = MODERATE	Consult with adult
3 = SERIOUS Medical treatment required, extended lost time	3 = HIGH It could frequently happen		5 – 6 = HIGH	Reassess the need to perform practical/ consult with adult

6 McGee, H, 2004. *On Food and Cooking: The Science and Lore of the Kitchen*. 1st ed. New York: Scribner.

Equipment:

- 750g x SF Health Foods Brand Rye flour
- 750g x Lotus Organic Brand Barley flour
- 750g x Coles Brand Buckwheat Flour
- 750g x Coles Brand Brown Rice flour
- 750g x Coles Brand Plain White Wheat flour
- 1 x Ceramic bowl
- 1 x 500mL measuring cup
- 1 x Wire mesh strainer with a 1mm grid mesh
- 1 x Metal Fork
- 1 x Kitchen scale
- 1 x Measuring bowl, 500mL size that comes with kitchen scale
- 1875 mL x Cold tap water
- 1 x Stopwatch
- 1 x Tea Towel

Method:

1) 250 grams of wheat flour was measured out with the 500mL measuring bowl on the scale. (Refer to figure 1.) NB: The measuring bowl weighed 40 grams, so 250 grams of flour was measured when the scale actually indicated 290 grams. This was then put in a ceramic bowl.
2) 125 grams of cold tap water (measured with the 500mL measuring cup) was added to the bowl of wheat flour, while being stirred with the fork. (Refer to figure 2.) Once this was done, a ball of dough had formed. (Refer to figure 3).
3) The ball of dough was placed on a work surface and kneaded (the process of pressing down on the ball with the palms, pulling it back up and repeating) for 5 minutes, which was timed using the stopwatch. (Refer to figures 4 and 5).
4) The ball of dough was put back in its bowl and allowed to rest for 10 minutes.
5) The strainer was placed in the sink and the ball of wheat dough held over the strainer while cold water from the tap ran over it. The ball of dough was gently pulled apart until the water-soluble components (in the form of milky liquid) had dissolved and stopped coming out from the dough. (Refer to figures 6-8.) A smaller, solid ball of only gluten was left behind and it is when the ball had reached this point that the rinsing was stopped.
6) The ball was wrapped in a tea towel and squeezed at a consistent pressure for 10 seconds, to dry it. (Refer to figure 9.)
7) The ball of gluten was weighed on the kitchen scale and its weight recorded. (Refer to figure 10).
8) The strainer, ceramic bowl, fork and measuring bowl were washed and dried. (Refer to figure 11.)
9) Steps 1-8 were repeated with the 4 other variations of flour. (Refer to figure 12.)
10) Steps 1-9 were repeated twice more. (Refer to figure 13.)

NB – Refer to Appendix 1 at the end of the report for photos.

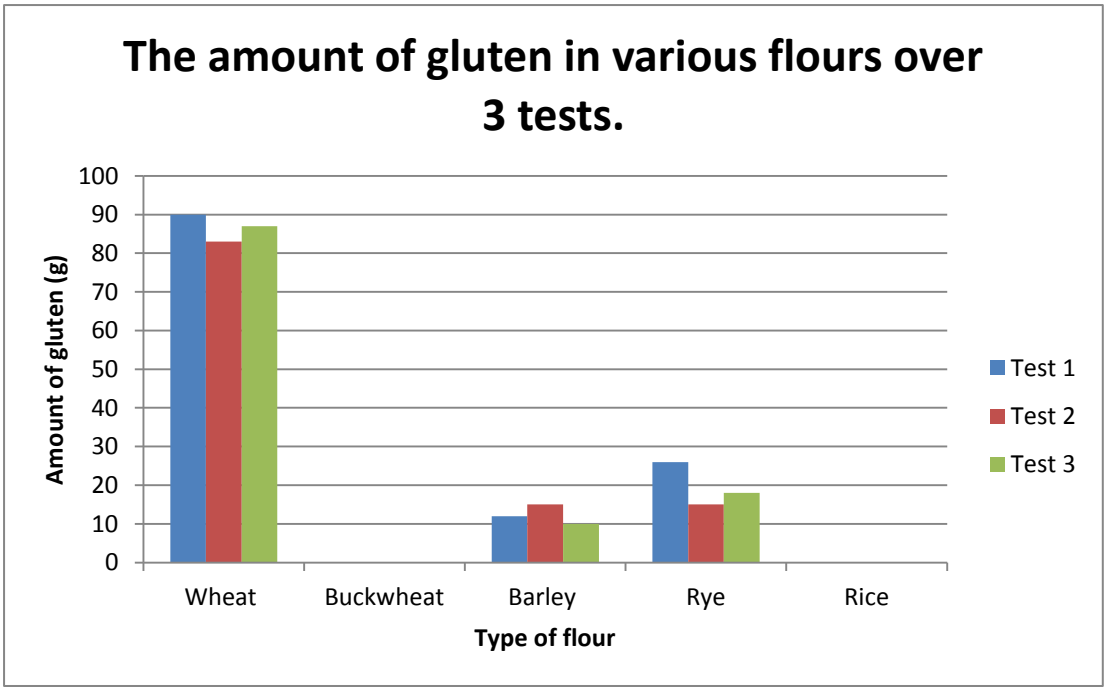
Results:

Raw data:

Table 1 – The relative differences in gluten content in various flours for each test.

	Mass of gluten in 250g wheat flour (g):	Mass of gluten in 250g buckwheat flour (g):	Mass of gluten in 250g barley flour (g):	Mass of gluten in 250g rye flour (g):	Mass of gluten in 250g rice flour (g):
Test 1:	90	0	12	26	0
Test 2:	83	0	15	15	0
Test 3:	87	0	10	18	0

Graph 1 -



Processed data:

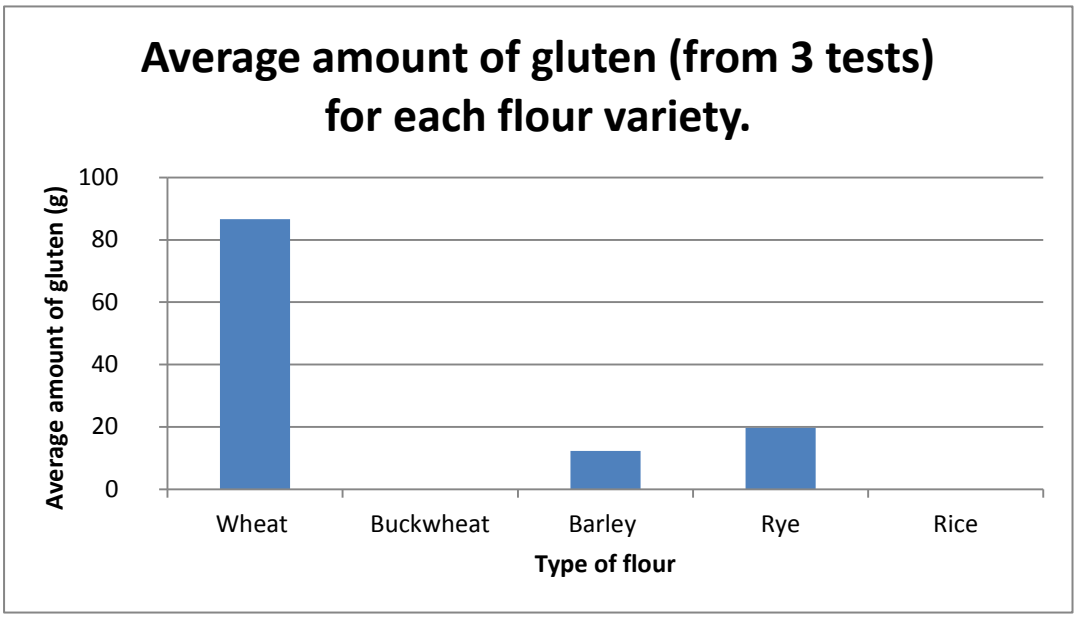
Table 2 – Average amount of gluten (from 3 tests) for each flour variety.

	Wheat flour:	Buckwheat flour:	Barley flour:	Rye flour:	Rice flour:
Average amount of gluten (g):	86.7	0	12.3	19.7	0

Table 3 – The range of the amount of gluten (from 3 tests) for each flour variety.

	Wheat flour:	Buckwheat flour:	Barley flour:	Rye flour:	Rice flour:
The range of the amount of gluten:	7	0	5	11	0

Graph 2 –



Discussion: The data gathered in this experiment strongly support the hypothesis. The hypothesis stated that, “Out of the flours tested, the wheat flour will have the most gluten, the rye and barley will have less and the buckwheat and rice flour will have the least.” The results were concordant with this, as, in every test, the wheat flour had the most gluten, followed by rye flour, then barley flour, then buckwheat flour and rice flour. This is also shown in the averages, where wheat had 86.7 grams of gluten per 250 grams of flour, barley had 12.3 grams, rye had 19.7 grams and buckwheat and rice had 0 grams.

These results are also concordant with secondary sources and research on the topic. According to medical journalist and expert on celiac disease, Jane Anderson, “Wheat flour... definitely contains gluten, since gluten is a protein found in the grains wheat, barley and rye” however, “flours made from a starch other than wheat, barley

or rye are usually gluten-free."[7] This research matches up accordingly with the data obtained from the experiment.

A number of observations and conclusions could be obtained from the results of the experiment. As shown in Table 1, and its corresponding graph, Graph 1, wheat flour had the highest amount of gluten content for every trial, and this was higher than the other amounts by a significant minimum of 57 grams. The reason for this is that the protein of wheat flour is made up of 80% gluten, and so this flour should have had the most gluten, as it did. Rye and barley had similar trends in that they had some amount of gluten content, but not as much as wheat. The reason for this trend, according to Jane Anderson, is that rye and barley are also grains, but don't contain as much of the protein that makes up gluten as wheat does. Also, both rice and buckwheat flour came up with 0 for all tests. This trend was predicted because, as indicated in the research, there are many flours that are made gluten-free and these two flours where chosen because they were made this way.

This experiment, and the data collected from it, was, overall, reliable. The reason for this is that the experiment was conducted 3 times in total, and this repetition gave results that were similar across all tests (within an acceptable margin of error). Because the results were like this, it can be said that the experiment was reliable. As well as this, many variables, excluding the experimental ones, were carefully controlled. These controlled variables included the same amount of flour being used in each test, the same equipment (scales, sieve, etc) being used in each test, each ball of dough was kneaded for the same amount of time and the same brand for each type of flour was used consistently across all 3 trials of the experiment. There were however, some variables that weren't completely controlled, such as controlling the amount of pressure used to dry the gluten so it was the same for every test and preventing any dough from getting stuck on the work surface (which would've meant not all balls of dough weighed the same as they should've).

The results obtained from this experiment were also valid. This occurred because the results were reliable, as detailed in the previous paragraph. The results were also valid because the method had validity. To ensure the method was valid, the measurements gathered were the ones intended to be measured. This was done by separating the gluten from the other components of the flour, which was necessary in order to be able to compare the gluten from each type of flour without other ingredients in the flour being present. The method then provided a way to precisely differentiate between the various amounts of gluten, by using suitable equipment (a kitchen scale) to weigh each ball of gluten and determine the amount present.

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[7] Anderson, J. 2012. *Celiac Disease and Gluten Sensitivity*. [ONLINE] Available at: http://celiacdisease.about.com/od/glutenfreegrains/f/Is-Flour-Gluten-Free.htm. [Accessed 25 March 13].

Finally, the results were valid because the data obtained was accurate. They were accurate because they were close to the true value of the quantity being measured, as explained previously in the discussion. Also, suitable equipment, controlled variables and appropriate measuring procedures were all put in place to ensure the data was accurate.

In further investigations, a number of different strategies could be employed to gather more data and, in turn, enable further conclusions to be drawn. One of these methods is to test a wider variety of flours. This would be beneficial as it would generate a more thorough answer to the question of how much gluten different types of flour contain. This is especially important for people who can't consume gluten and need to be aware of which flours they can be eating. Another strategy that could be employed in future investigations is to do the experiment a greater number of times. Since the experiment was not a lengthy one and didn't require huge amounts of equipment, this is a strategy that would be easy to implement, and would be useful as it would further determine the reliability of the results and conclusions drawn.

Conclusion: The data reflected that the wheat flour had the most gluten, then the rye and barley flours, and that the buckwheat and rice flour had the least, as stated in the hypothesis.

Bibliography:

Books:

McGee, H, 2004. On Food and Cooking: The Science and Lore of the Kitchen. 1st ed. New York: Scribner.

Websites:

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Robinson, K. 2011. *University of Maryland School of Medicine researchers identify key pathogenic differences between Celiac Disease and Gluten Sensitivity*.

[ONLINE] Available at:http://somvweb.som.umaryland.edu/absolutenm/templates/?a=1474. [Accessed 25 March 2013].

Author unknown. 1995. *Gluten*. [ONLINE] Available at: http://www.sciencedaily.com/articles/g/gluten.htm. [Accessed 25 March 13].

Appendix 1 – Photographs for method:

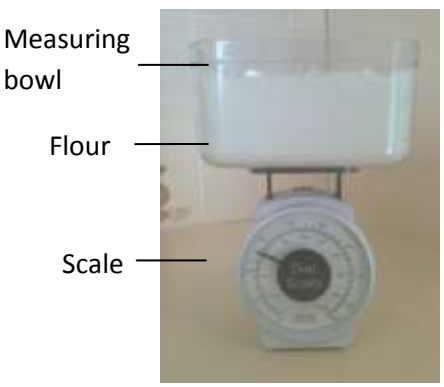

Figure 1 – Measuring out the flour

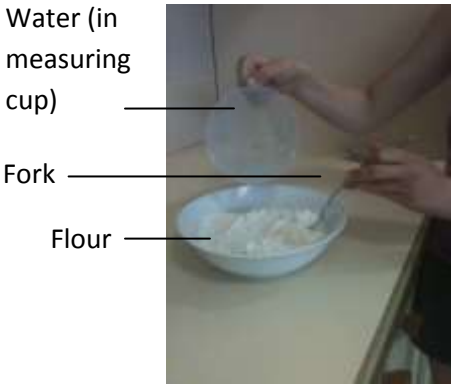

Figure 2 – Mixing water with flour

Figure 3 – Ball of dough formed from Figure 2

Figure 4 – Kneading (pushing dough down)

Figure 5 - Kneading (pulling dough up)

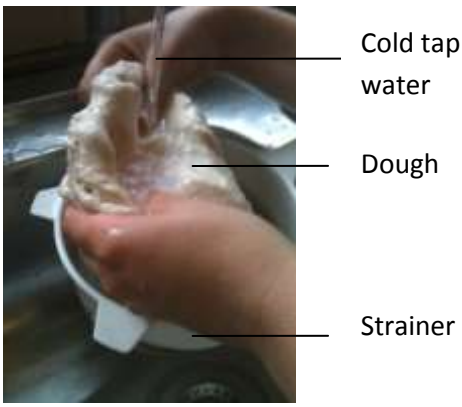

Figure 6 – Stretching the dough out under cold tap water to get rid of water-soluble parts

Figure 7 – Demonstrates that there is still water-soluble parts in the dough because a milky-coloured solution comes from the dough when squeezed.

Figure 8 – Demonstrates that only the gluten is left because no milky-coloured solution comes from the dough when squeezed.

Figure 9 – The gluten ball left behind after the dough has been rinsed.