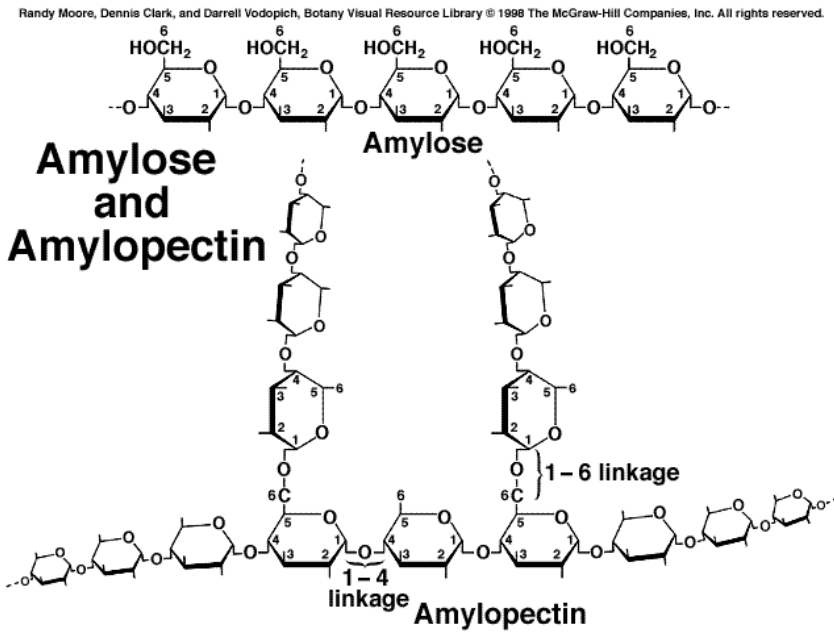
The Power of Starch

Background information

Definition of starch: A starch is an odorless white substance occurring widely in plant tissue and is obtained chiefly from cereals such as corn, wheat, rice and potatoes.

A starch is a type of carbohydrate meaning it is made up of sugar molecules. Starch is a complex carbohydrate meaning that it is made of simple sugars joined together like a chain that is then stored in your body and burnt off as energy slower than simple carbohydrates. Starch can be broken into two fractions, amylose and amylopectin. The amylose makes a colloidal dispersion when mixed with hot water whereas the amylopectin is insoluble. The amylopectin makes up a large percentage of the structure compared to the amylose. The amylopectin make up approximately 80-90% of the structure whereas the amylose makes up only 10-20%.



(http://biochemable.wordpress.com/tag/amylose/)

Source	Amylose (%)	Amylopectin (%)
Potato	21	79
Maize	28	72
Wheat	26	74
Tapioca	17	83
Waxy maize*	-	100
Long grain rice flour	22	78
Medium grain rice flour	18	82

Ratio of amylose and amylopectin in some starches
(http://www.food-info.net/uk/carbs/starch.htm, http://www.sagevfoods.com/MainPages/Products/RiceFlour.htm)

Starch works by absorbing water. It absorbs the water or other liquid into its individual starch grains. The amount of liquid a particular type of starch is able to absorb is how concentrated its starch grains are. If you just add water to a starch and stir it, you won't get the result you were looking for. Without a catalyst, the starch grains will just sink to the bottom without absorbing the most amount of liquid it can. The catalyst for starch is heat. This works because when you heat a liquid, its molecules start moving around really fast causing them to bump into the grains of starch. This bump is just enough to disrupt the grains structure causing the small grain of starch to take in water.

It is hard to measure how thick a sauce is so by doing some research it was found that one way to do this was to measure how far it would run down a plate/tray.

The starches selected for this experiment are corn flour, plain white wheat flour, white rice flour and semolina. Semolina can come from maize or wheat. The semolina from wheat was used for this experiment.

Statistical analysis of results

Average: The average when looking at statistics is the arithmetic mean. To calculate the average, add all the scores up and then divide the answer by the number of scores.

Variance: The average of the squared differences from the mean.

Standard Deviation: Standard Deviation shows how diverse a set of data is. The standard deviation is the square root of the variance. The standard deviation is a more reliable measure of variation and is less susceptible to outliers. After calculating the standard deviation, the lower the number is, the more consistent the set of data was.

Range: The range is the difference between the highest and lowest values. To find the range, the minimum and maximum scores are found and then the minimum score is subtracted from the maximum score.

Aim

To discover which starch has the most concentrated starch grain and thus thicken water the most.

Hypothesis

The amylose is what makes a starch thicken a liquid when heated so by looking at the amylose content (in table above) in the starches selected, the corn flour should make the liquid the thickest. The plain flour and semolina should be similar and the rice flour will be last regardless of whether it is long or medium grain rice. (Not sure what size grain rice flour was used)

Equipment

- Stove
- Small tray – 19.5 X 31.5cm
- Large tray – 27.5 X 40.0cm
- Ruler
- Tape
- Stack of books, 8.5cm – to make angle
- Small saucepan
- Stirring spoon
- Tablespoon measure
- Half tablespoon measure
- ¾ cup measure
- 16 ½ tablespoons of selected starches:
    - Corn flour
    - Semolina
    - Plain flour
    - Rice flour
- 8.5 Liters of water

Risk Assessment

The safety hazard in this experiment is that there is heat from the stove that is in use at all times. To overcome this safety hazard you must be aware of hot saucepans after they have been on the stove and also make sure you turn the stove off after use. Because the sauce has been heated until boiling point, the sauce itself is very hot and retains its heat for a few minutes after removed from the saucepan. The only way to overcome this safety hazard is to be aware of what is going on at all times.

Some simple things to follow for safety are:

- Only touch saucepan on the handle
- Do not put fingers in the sauce
- Turn flame off before removing saucepan
- Use a plastic stirring spoon
- Place saucepan on a cooling rack whilst hot

Variables

The dependent variable in this experiment is how thick each starch makes the water. The independent variables are the different types of starches which are; corn flour, plain flour, rice flour and semolina. The controlled variables are the amount of water and the amount of starch that is used, the heat, how long it is over the heat and resting, the tray size and the angle that the tray is placed on.

Method

1. Place tray on a stack of books to make tray 8.5cm from bench/table

2. Measure 4.5cm down from the top of the tray and place a strip of tape on this mark

3. Measure 1 ½ tablespoons of the starch to be tested and place in small saucepan
4. Measure ¾ cup of water and add to small saucepan with starch
5. Place saucepan on medium heat and stir continuously

6. Start timer and time for 2 ½ minutes
7. Take off heat and rest in saucepan for another 2 minutes

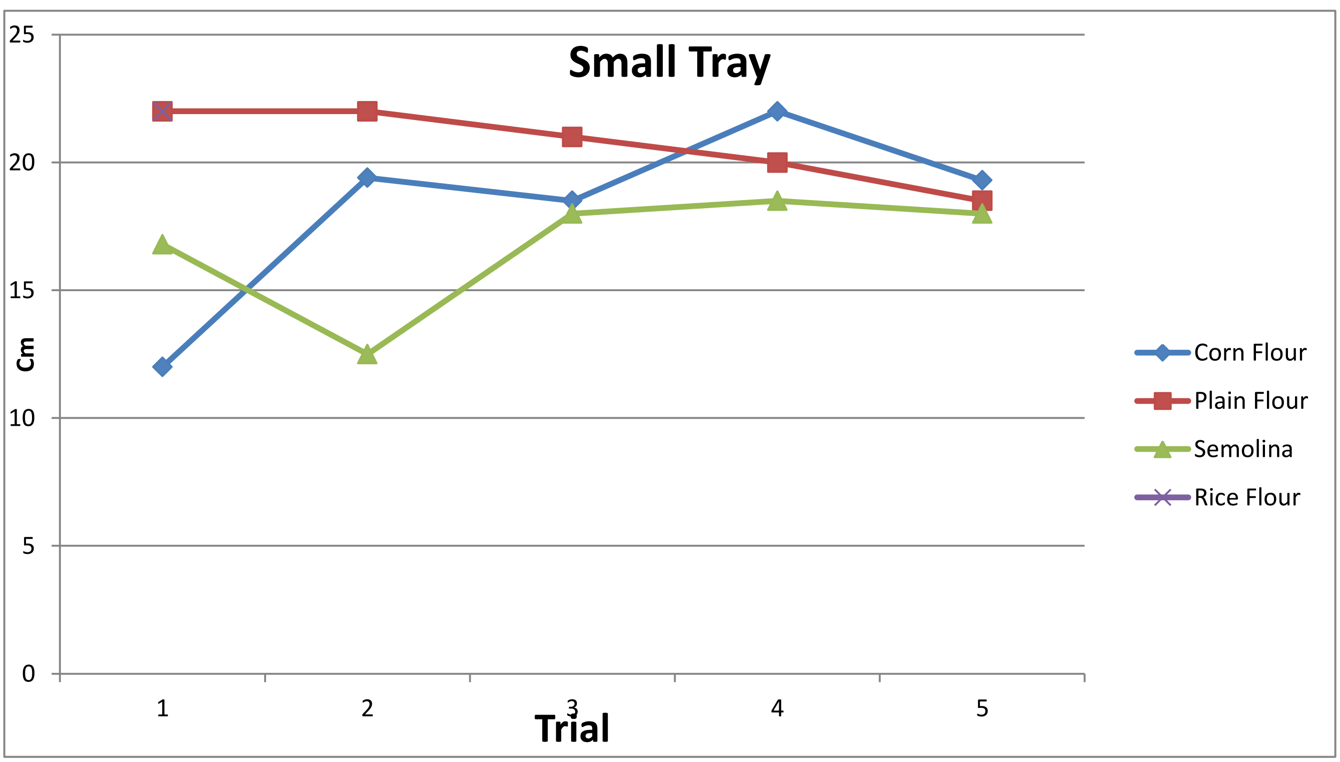
8. Pour all of mixture above tape on the tray that is on an angle
9. Let mixture run until it stops

10. Place another piece of tape where mixture stopped running
11. Use a ruler to measure from the top of the first piece of tape to the top of the second piece of tape

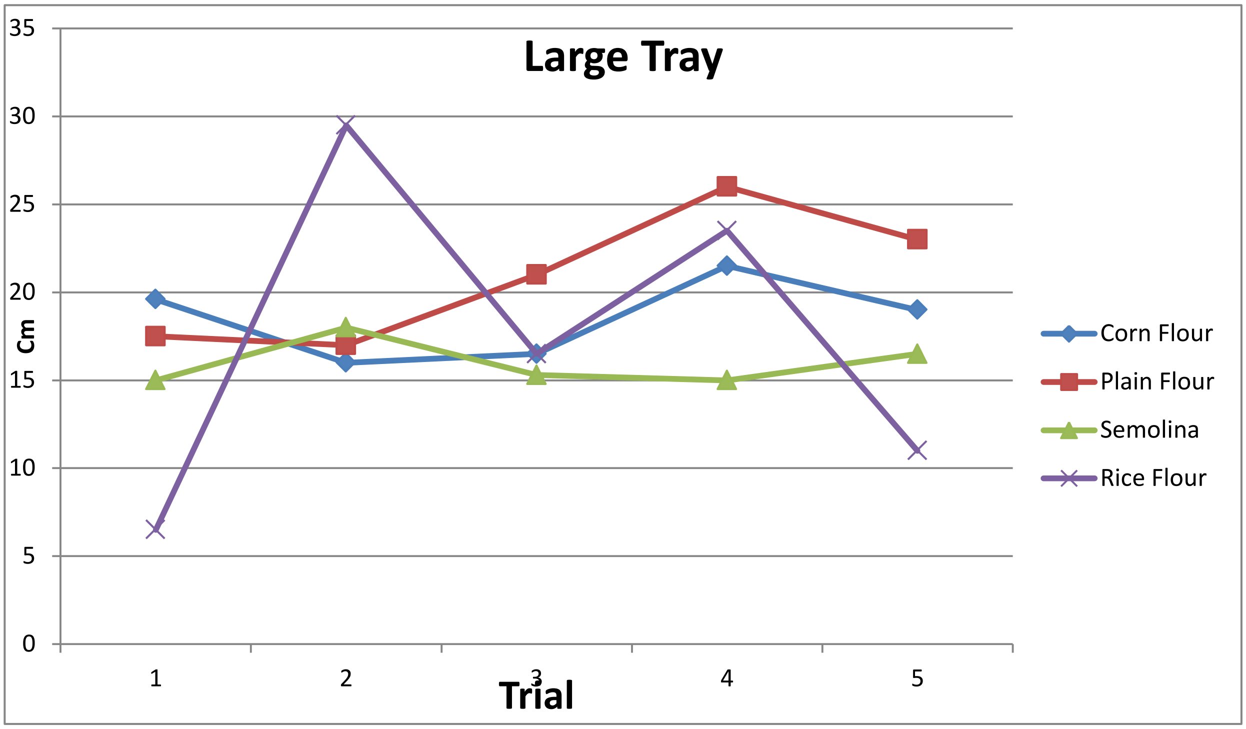
12. Record results
13. Wash and dry utensils
14. Repeat steps 1 to 13 five times for each starch
15. Repeat steps 2 to 12, this time as a control, keep the tray flat on the bench/table

Results

SMALL TRAY				
Number	**Corn Flour (cm)**	**Plain Flour (cm)**	**Semolina (cm)**	**Rice Flour (cm)**
1	12.0	22.0	16.8	22.0
2	19.4	22.0	12.5	-
3	18.5	21.0	18.0	-
4	22.0	20.0	18.5	-
5	19.3	18.5	18.0	-
Average	18.24	20.7	16.76	22
Red = Outliers				



LARGE TRAY				
Number	**Corn Flour (cm)**	**Plain Flour (cm)**	**Semolina (cm)**	**Rice Flour (cm)**
1	19.6	17.5	15.0	6.5
2	16.0	17.0	18.0	29.5
3	16.5	21.0	15.3	16.5
4	21.5	26.0	15.0	23.5
5	19.0	23.0	16.5	11.0
Control – Flat Tray	7.5	8.0	6.0	5.7
Average	18.52	20.9	15.96	17.4
Standard Deviation	2.28	3.78	1.30	9.28
Ranking	3	4	1	2
Average without outliers	17.8	19.6cm	15.5cm	14.4cm
Ranking	3	4	2	1
Standard Deviation without outliers	1.79	2.87	0.71	7.33
Minimum	16.0	17.0	15.0	6.5
Maximum	21.5	26.0	18.0	29.5
Range	5.5	9.0	3.0	23.0
Red = Outliers				



Discussion

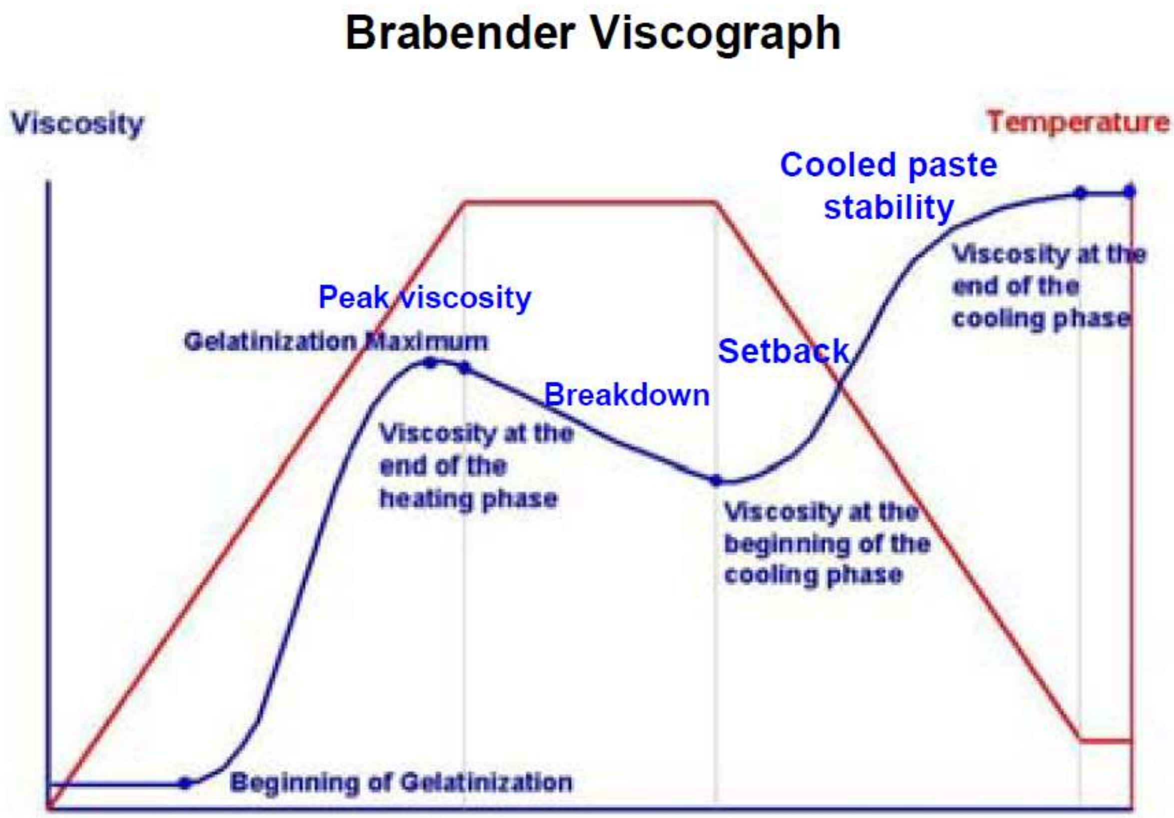
From the experiment, it is difficult to determine which starch thickened water the most. All the starches when heated thickened the water but it is difficult to clearly draw conclusions due to the difficulties that occurred during the experiment. The results, difficulties and suggested improvements will be discussed here.

Originally, the experiment was performed using a small tray to pour the thickened sauce on but after noticing that some were reaching the bottom of the tray at 22cm, it was realized that the experiment would need to be improved to get valid results. Because most of these sauces reached 22cm, it makes the results from the small tray invalid. The whole experiment was then repeated using a large tray to obtain valid results. Because the results from the small tray are invalid and the experiment was repeated, they will not be discussed further.

After completing the experiment using the large tray and recording the results, the average and standard deviation were taken for each set of data/starch. The corn flour has an average of 18.52cm and a standard deviation of 2.28cm. The plain flour has an average of 20.9cm and a standard deviation of 3.78cm. The semolina has an average of 15.96cm and a standard deviation of 1.30cm and finally the rice flour has an average of 17.4cm and a standard deviation of 9.28cm. After calculating the average and standard deviation of the sets of data/starch, they were ranked in order of the lowest to highest average showing which was the thickest, ranked as 1, and the runniest, ranked as 4. The rankings were; semolina, rice flour, corn flour and plain flour. Although these results seem as though they could be the final rankings, they are not due to the difference in the standard deviation. The corn flour, plain flour and semolina's standard deviation are all under 4 but the rice flours is 9.28, more than twice the standard deviation of the others. This shows that the rice flours results are extremely inconsistent compared to the other starches. To try and make the results more reliable, the outliers were then removed.

When removing the outliers, there was an obvious score to remove in the corn flour, plain flour and semolina, but when it came to the rice flour, the data was so inconsistent there was no obvious outlier. To decide which score was best to be removed, out of 6.5cm and 29.5cm, the difference from the mean was calculated for each value (12.1cm for the 29.5cm measurement and 10.9cm for the 6.5cm measurement). It was then decided that the 29.5cm would be the outlier because it has the largest difference from the mean. The average was then calculated again without these outliers to see if it would change the results. The rankings of the starches from the average without the outliers were; rice flour, semolina, corn flour and plain flour. Comparing these two sets of rankings, it can be seen that from before the outliers were removed and after the outliers have been removed the semolina and rice flour ranking positions have been swapped. It is clear that before the outliers were removed, the rice flour was ranked last because it had such high outliers. But even after the outliers were removed and the standard deviation was calculated for the second time, it shows that the rice flour results were very inconsistent. The standard deviation of the rice flour without outliers is still 7.33 compared to the corn flour with 1.79cm, the plain flour with 2.87cm and the semolina with 0.71cm. Because the rice flour results are so inconsistent, it is hard to tell if it should be ranked before or after the semolina or even where it would rank. The rice flour results may not be valid and would need to be repeated more times to get a better idea of whether it could be consistent.

There were inconsistencies throughout the experiment and after completing the experiment, some possible reasons for the inconsistencies were identified. First and foremost is the heat. Although this was meant to be controlled by timing how long it was on the heat for and setting it to medium heat on the stove it was extremely hard because it was a gas stove. This may have resulted in inconsistent results. If this experiment were to be repeated, some ways to improve it are to measure the heat. This could be done by placing a thermometer in the sauce whilst it is over the heat and heating it to a certain temperature before starting the timer. This would make sure that each starch gets the same amount of time at the same temperature if some happen to heat faster than others. Another way to improve using heat is to measure the temperature of it as it cools down. This can be done by placing a thermometer in the sauce once it is removed from the heat and cooling it to a certain temperature before pouring it instead of timing how long it gets to cool for. Another factor possibly affecting the results was how much sauce was poured on the tray. To show that the distance the starch travelled was related to the thickness, a control test was performed by placing the tray flat on the bench/table and still pouring the sauce above the tape. These results were a lot less than any of the test results. This shows that it was actually the thickness and angle that made it run and not



(http://www.cfs.purdue.edu/class/f%&n630)

just the quantity that was being used. All the sauce made was poured onto the tray and this may have been too much to get a good measure. To overcome this if repeating the experiment, a ¼ cup measure could be used to create a smaller amount to see if this would be a better way to measure the thickness. Another factor that may result in an inconsistency is how thick the starch is whilst thickening and cooling. The Barbender Viscograph is a machine that measures the viscosity of a starch at the beginning of gelatinization, gelatinization maximum, and gelatinization temperature, viscosity during holding and viscosity at end of cooling. As shown in the diagram above, the viscosity varies as it heated and cooled. This shows that not all starches are at their thickest at the same time and the viscosity changes during gelatinization. To improve this, a lot more research would be needed to find the best time to measure the viscosity of each starch.

By watching the starches thicken on the stove during the experiment, there were a few observations that were made about how each starch thickened. The corn flour would stay the same consistency as water until 1 minute and 30 seconds and then it would instantly go thick and stay this way until it was removed from the heat. The plain and rice flour both acted the same way in the thickening process. They would slowly thicken and then around 1 minute 30 seconds they would get white splotches in them and then start to thicken a lot faster. The semolina also was very slow at thickening at first but when it started to boil, it went really thick. Another observation I made about the semolina was that it is naturally grainy. When mixed with water, the corn flour, rice flour and plain flour all went into a smooth paste but the semolina was grainy. This could be a disadvantage for using semolina in cooking if you wanted a very smooth sauce/liquid.

One other factor that could affect the conclusions to be made about this experiment is the weight of the starches. In the experiment, 1 ½ tablespoons of the starch was used and while the volume was kept the same, the weight of each starch may differ. To see if this is the case 1 ½ tablespoons of each starch was weighed (Semolina = 16g, Rice Flour = 14g, Plain Flour = 15g, Corn Flour = 15g). This was overlooked at the start of the experiment and if this experiment were to be repeated again it would be best to weigh the starches rather than measuring them. Because the semolina weighs more than the other starches, it is possible that more of this starch was used and similarly less of the rice flour may have been used as it weighed less.

Conclusion

The rice flour results were so inconsistent that no valid conclusions can be made. Not including the rice flour, the semolina thickened the water the best, then the corn flour followed by the plain flour. This does not support the hypothesis that the corn flour would thicken the water the best, then the plain flour and semolina followed lastly by the rice flour. This could have been because the starches were measured rather than weighed. To make valid conclusions this experiment would need to be re-designed and repeated again using the suggested improvements.

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