Lab Report 2: Starch

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Introduction

Starch is a white, gritty, granulated powder that is insoluble in water, and found within all plants. It is a polysaccharide that is composed of glucose molecules that can be arranged either as a linear polymer known as amylose, or as a branched polymer known as amylopectin (The Editors of Encyclopædia Britannica 2009). Amylose is the simpler version of the two, containing more than 200 glucose molecules that form 1,4-α-glucosidic linkages. Amylopectin also only contains glucose molecules, but consists of two different types of links, the 1,4-α-glucosidic linkages as well as 1,6-α-glucosidic linkages. The two different types of links allows for amylopectin to be branched, or dendritic (McWilliams 2012). Cornstarch, which was used in this experiment, normally consists of 24 - 28 percent amylose (McWilliams 2012), while waxy starch, the other starch used in this experiment, only contains amylopectin (BeMiller and Whistler 2009).

Starch is commonly used as a thickener in foods such as puddings, sauces, soups, and salad dressings. For starch to produce the thickening consistency, it must first be gelatinized by being heated with the addition of water. The addition of heat causes the hydrogen bonds within the starch granules to break, causing the particles to burst, allowing water into the structure, and amylose out into the surrounding water (McWilliams 2012). The absorbed water within the starch particle will become trapped, and become bound water. This bound water results in the starch particles expanding. The thickening action is then produced by having less free water available, and the swelling of the starch particles (McWilliams 2006). If the starch mixture continues to be heated after gelatinization, and pasting, or the implosion of the starch granule, will occur. As the mixture cools, gelation will occur. As heat is loss, the amylose molecules slow, and begin to reform hydrogen bonds. As an ongoing chain is formed, it confines the swollen granules, creating a gel (McWilliams 2012).

The objective of this experiment was to observe the changes in the starch during gelatinization, pasting, and gelation. The differences between regular starch and waxy starch were observed as well as the effect that acid had on gelatinization and gelation.

Texture and viscosity was measured using a universal texture analyzer, and a Bostwick consistometer while the cellular structure was observed through the microscope before and after heating.

Materials & Methods

This experiment was conducted in two parts, gelatinization observation of starch and preparation of starch pudding. All four groups conducted the gelatinization experiment by mixing thirty-six grams of starch with cold water in two cook pans. In one of these samples sixteen grams of citric acid was added. KI (potassium Iodide) solution was added to a small sample of the starch without acid until it turned blue. It was then observed under the microscope. Next, both solutions were heated until boiling, then covered and left on low heat for ten minutes while stirring occasionally. A small sample of the hot starch sample was mixed with KI solution and observed under the microscope as well. The starch was left to cool until it reached 70°C and five mL samples were collected at 15°C intervals. The consistency of the sample that did not contain acid, starting with the 70°C sample, was measured and recorded using a Bostwick consistometer by measuring the distance flowed in one minute. Clarity of the suspension was also recorded.

For the starch pudding experiment, kitchen one prepared a cornstarch pudding while another group prepared a waxy cornstarch pudding. The recipe for a cornstarch pudding included twenty-four grams of regular corn starch, sixty-five grams sucrose, 472 ml milk, five mL vanilla, and five grams butter. The recipes were the same, with the type of starch being the only variation. After mixing and heating, the pudding was poured into plastic cups, covered with plastic wrap, and placed in the refrigerator. The following week, the firmness was measured using TA.XT.>plus Texture Analyzer. Other equipment that was used during the experiment were slides and cover slips to observe samples under the microscope, and a thermometer to monitor the temperature of the starch samples.

Results and Discussion

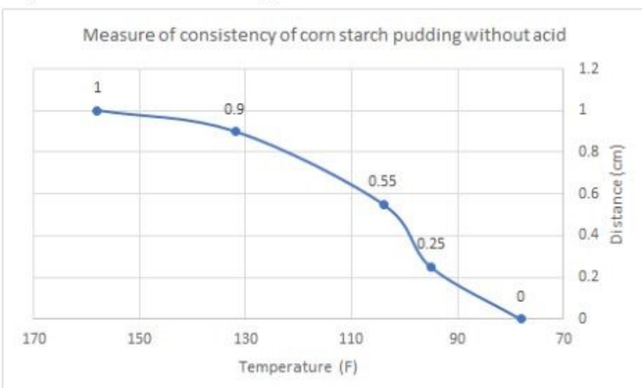
Table 1. Consistency of Starch Pudding using Bostwick Consistometer

Temperature (F)	Distanced traveled of Corn Starch Pudding without Acid (cm)	Distance Traveled of Corn Starch Pudding with Acid (cm)
158	1.0	No record
132	0.9	No record
104	0.55	No record
95	0.25	No record
78	0.0	13.5

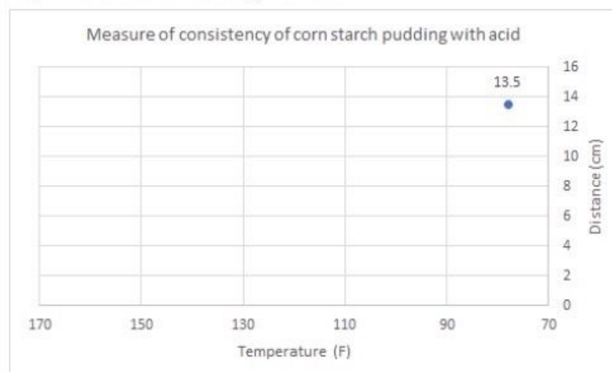
Table 2. Firmness of the starch using a texture analyzer

Sample	Kg / sec
1	0.136
2	0.152
3	0.161
4	0.142

Graph 1. Cornstarch Pudding without Acid



Graph 2. Cornstarch Pudding with Acid



*only one data point due to group error

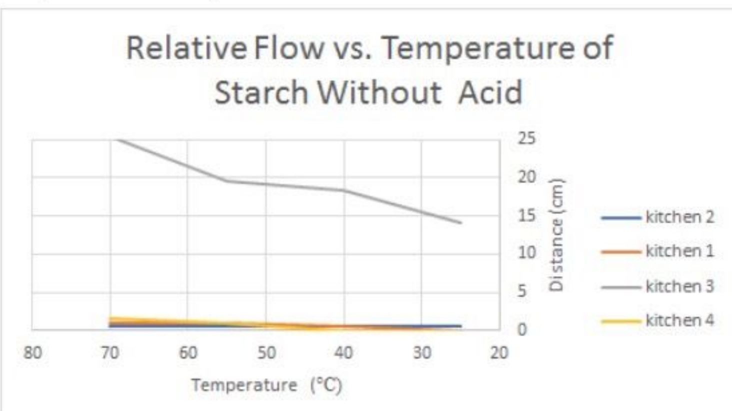
Slide 1. Boiled Starch

Slide 2. Cold starch

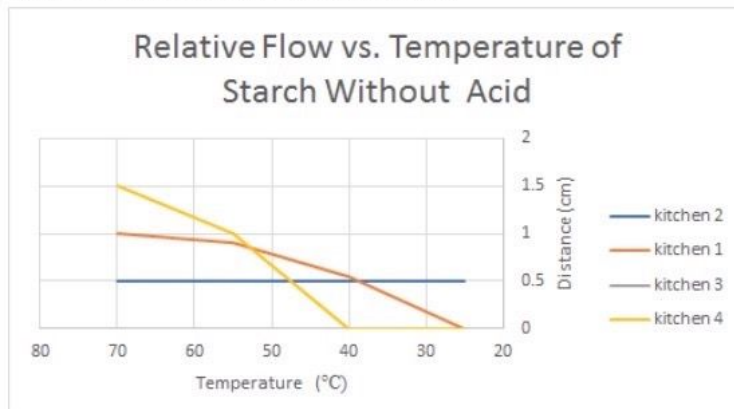
Table 3. Firmness of regular corn starch pudding

Samples	Kitchen 1	Kitchen 2	Kitchen 3	Kitchen 4
1	0.09	0.136	0.108	0.477
2	0.091	0.152	0.105	0.452
3	0.085	0.161	0.123	0.437
4	0.8	0.142	0.096	0.464
mean	0.2665	0.14775	0.108	0.458
SD	0.15689			
firmness	0.2665±0.15689	0.14775±0.15689	0.108±0.15689	0.458±0.15689

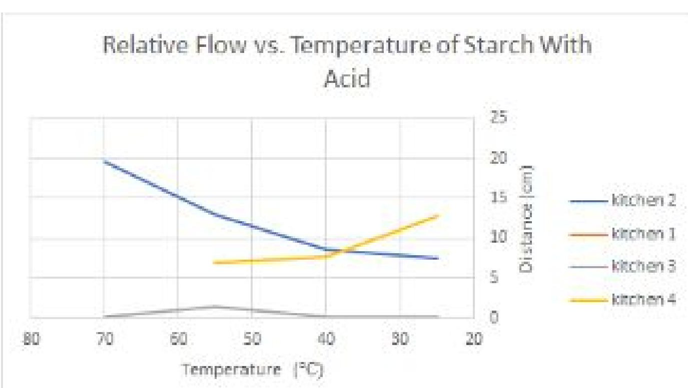
Graph 3. Flow vs. Temp without Acid



Graph 4. Zoom in of Graph 3, Kitchen 3 removed



Graph 5. Flow vs. Temp with Acid



Discussion

While observing the starch suspensions there is a noticeable difference between cold and hot starch mixtures on both microscopic and macroscopic levels. Before boiling, the cold starch looked like a coarse suspension in the cook pan because the grains were not dissolved in water, and they stick together creating lumps. Under the microscope the starch granules or lumps can be seen as small dots as you can see in slide 2. However, as seen in Slide 1, there are less granules because the grains were dissolved by boiling water. When the starch granules absorbed the water they swelled which made the starch look more homogenous and transparent on the slide and in the cook pan.

According to the data collected by kitchens one, three, and four, the relative flow of the starch without acid decreased with the reduction in the temperature, as seen on Graph 3. The data collected by kitchen two did not show any difference with reduction of temperature, as seen in Graph 4. At the higher temperatures, the starch granules absorb water, which increased flow resistance, and thus decreased viscosity. Gelatinization occurred as the temperatures decreased during cooling, which decreased the flow of the gel. This occurs due to the swollen starch granules becoming confined by the reforming hydrogen bonds of the amylose molecules. Data for the flow of the starch mixture once acid was added varied wildly from kitchen to kitchen, as seen in Graph 5.

The addition of acid should have increased the flow of the starch, as acid hydrolysis creates shorter molecular chains, allowing for more movement. This could be seen when the data sets of kitchens one, two, and four were compared. Although it cannot be certain, by comparing all of the graphs, it would appear that kitchen three inputted the data incorrectly, by putting the without acid numbers in the with acid results. Because of this we made a comparison between only kitchen one, two and four as shown in graph number four. Kitchen one only provided one data point for the with acid results as the instructions were misunderstood within the group that both samples were supposed to be measured by the Bostwick consistometer.

Table three shows the results of the firmness test for regular and waxy cornstarch pudding. Kitchen one and two performed the test on regular cornstarch while kitchen 3 and four tested the firmness of waxy cornstarch. The results of the firmness test were not consistent between the groups. Kitchen one and two both tested a regular cornstarch pudding but did not receive similar results. For waxy cornstarch, kitchen three and four also did not receive similar results. Because of this, it is not possible to compare regular to waxy cornstarch firmness and we are unable to decide which one is more firm and why. However, the regular cornstarch was a good source for making pudding, as it created a gelation that created structure, but was still smooth and velvety. Butter was added to the starch mixture after boiling due to the fact that fats and milk proteins reduce the required temperature that is ideal for the best gelatinization and viscosity results (McWilliams 2012). The waxy starch would be a better used in a salad dressing, especially if the dressing contains an acid, as it still had a thicker texture, but was looser and creamier. Acid hydrolysis allows for the starch to have more movement (McWilliams 2012). This would allow for better spreadability and incorporation in a salad.

Conclusion

The starch lab provided an interesting experience as we were able to identify the changes starch makes during gelatinization, pasting, and gelation. These processes were exemplified during the “starch gelatinization” portion of this lab. The gelatinized starch exhibited a higher viscosity when temperatures were gradually decreased starting around 70° C and ending around 20° C; thus, as temperature decreased, viscosity increased. In addition to identifying changes during gelatinization, we were able to differentiate between a starch and a waxy starch while making vanilla pudding. Based on our results, the cornstarch pudding without acid produced a semi-firm pudding when measured by the texture analyzer; however, we do not have results on the firmness of the cornstarch pudding with acid to compare. We were able to understand the effect acid has on gelatinization and gelation of starch through the process of making this pudding. Lastly, when viewed under a microscope, we were able to identify the changes between the two starches at differing temperatures. Based on our results, the cold starch was more heterogeneous because the granules were not completely dissolved in the water, whereas in the boiled starch they were.

References

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