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Section A07, Thu 9-11:50 am

Partner: Sh. G

Lab 7 (looking at polysaccharides functional properties)

PURPOSE/OBJECTIVE:

The purpose of this lab is to look at different characteristics and functionality of polysaccharides by evaluation of functional properties using rheological measurement. Measurement of elastic, plastic, viscous characteristic of solutions and gels of functional polysaccharides helps define each one's unique characteristics as well as how different variables affect these characteristics. For example measurements could be made to determine how different cations affect pectin gel strength and plasticity, or how solution viscosity changes with increased concentration.

Introduction:

Polysaccharides are polymeric carbohydrate molecules composed of long chains of monosaccharide units bound together by glycosidic bonds. They range in structure from linear to highly branched. They have different functions; there are storage polysaccharides such as starch and glycogen, and structural polysaccharides such as cellulose and chitin. They have great diversity of structural features, because of their differences in the monosaccharide composition, linkage types and patterns, chain shapes. These differences make their physical properties including solubility, gelling potential, surface and interfacial properties. The structural diversity also gives them their unique functional properties shown by each polysaccharide. Polysaccharides, which are available for use in food industries work as stabilizers, thickening and gelling agents, crystallization inhibitors.

Functional properties of polysaccharides are the physical and chemical properties that determine the usefulness of polysaccharides in food systems during processing, storage, preparation and consumption. They play roles in emulsification and flavor and color binding, but more importantly they affect the texture of food. Functional uses of polysaccharides usually involve modification of the rheological properties of the aqueous phase of food system. Measurement of elastic, plastic, viscous characteristic of solutions and gels of functional polysaccharides helps define each one's unique characteristics as well as how different variables affect these characteristics. For example we can measure to determine how different cations affect pectin gel strength and plasticity, or how solution viscosity changes with increased concentration.

Functional properties of polysaccharides are mostly because of their interactions with water and their intermolecular interactions which are related to their structure. They all have many hydroxyl groups that if available to their aqueous surroundings can make hydrogen bond with water. Insoluble polysaccharides like cellulose do not dissolve in water because portions of their unbranched linear structure pack tightly together in a crystalline arrangement. Soluble polysaccharides tend to have more irregular or branched structures with many of their hydroxyl groups or other polar functional group in contact with water. In general the larger or less branched a polysaccharide is the more viscous the solution. Food technologists use polysaccharides as thickeners stabilizers and gel formers.

Procedure:

The procedure followed for the experiment is found in "Principles of Food Composition Laboratory Manual" (2013) Experiment 7polysaccharieds: functional properties and Rheology, pages 70-86.

Data/result:

Table 1. viscoumetry data(for ketchup)

Temperature degree of Celsius	spindle number	speed (RPM)	Average (cp)	standard deviation (cp)
21.5 C	LV04 (64)	0.30	671,500	42,600
21.5 C	LV04 (64)	0.60	395,500	27,600
21.5 C	LV04 (64)	1.2	242,100	8,938
21.5 C	LV04 (64)	2.4	141,800	3,506
21.5 C	LV04 (64)	4.8	74,160	2,246
21.5 C	LV04 (64)	9.6	32,940	920.1
21.5 C	LV04 (64)	19.2	16,280	222.4

Table 2: viscoumetry data (Xantham gum)

Temperature degree of Celsius	spindle number	speed (RPM)	Average(cp)	standard deviation (cp)
21.3C	LV04 (64)	1.5	128,600	6,114
21.3 C	LV04 (64)	3.0	81,350	661.5
21.3 C	LV04 (64)	6.0	49,950	99.49
21.3 C	LV04 (64)	12.0	30,080	118.7
21.3 C	LV04 (64)	18.0	22,270	144.4
21.3 C	LV04 (64)	24.0	17,840	126.7
21.3 C	LV04 (64)	36.0	13,150	142.2

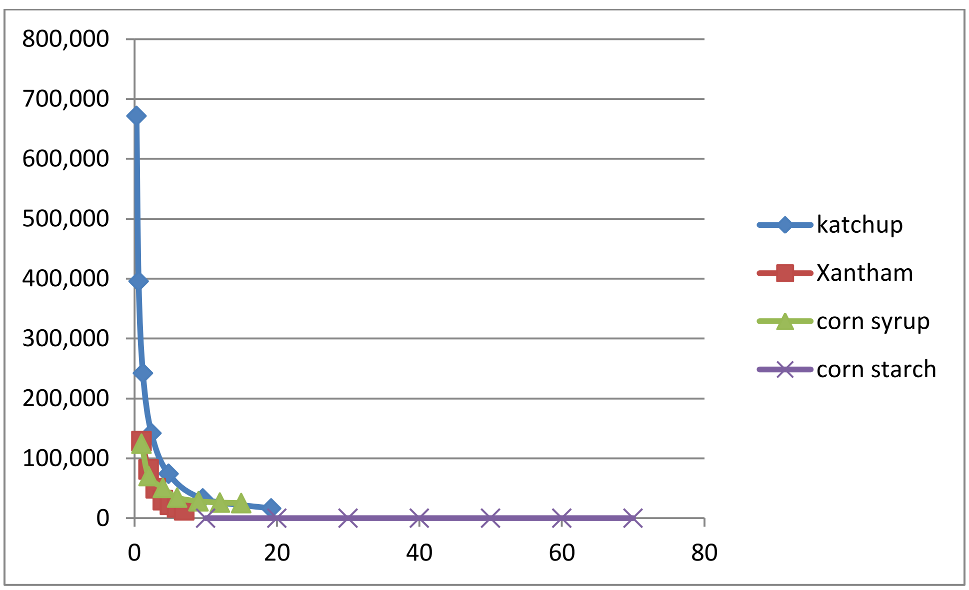
Table 3: viscoumetry data (corn syrup)

Temperature degree of Celsius	spindle number	speed (RPM)	Average(cp)	standard deviation (cp)
21.8 C	LV04 (64)	1.0	124,400	15,810
21.8 C	LV04 (64)	2.0	70,430	3,476
21.8 C	LV04 (64)	4.0	50,590	4,824
21.8 C	LV04 (64)	6.0	34,380	434.7
21.8 C	LV04 (64)	9.0	28,300	3394.3
21.8 C	LV04 (64)	12.0	26,110	232.0
21.8 C	LV04 (64)	15.0	25,200	65.32

Table 4: viscoumetry data (corn starch)

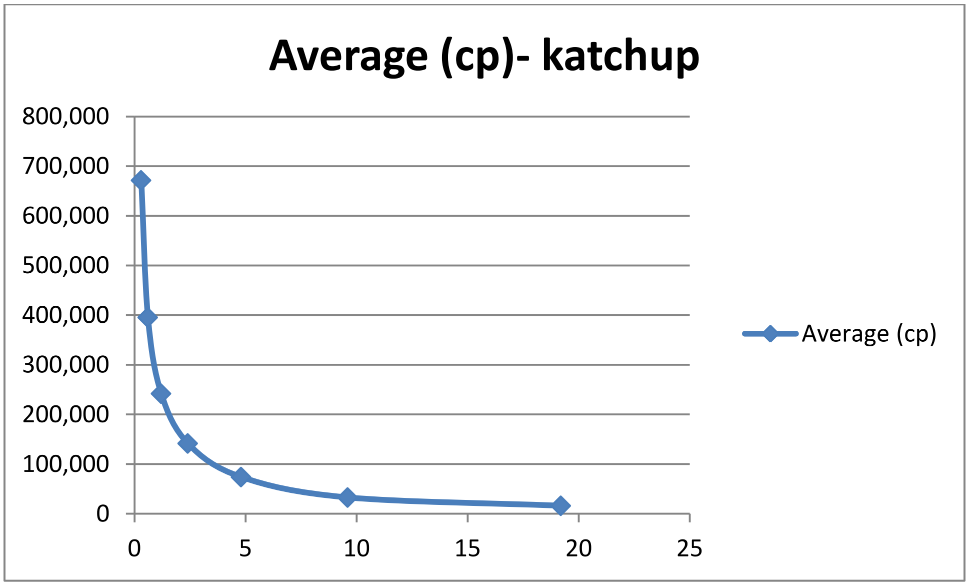
Temperature degree of Celsius	spindle number	speed (RPM)	Average (cp)	standard deviation (cp)
21.1 C	LV03 (63)	10.00	14.23	0.47
21.1 C	LV03 (63)	20.00	17.00	1.05
21.1 C	LV03 (63)	30.00	18.93	0.92
21.1 C	LV03 (63)	40.00	21.24	1.1
21.1 C	LV03 (63)	50.00	27.72	8.94
21.1 C	LV03 (63)	60.00	29.89	7.37
21.1 C	LV03 (63)	70.00	47.47	10.2

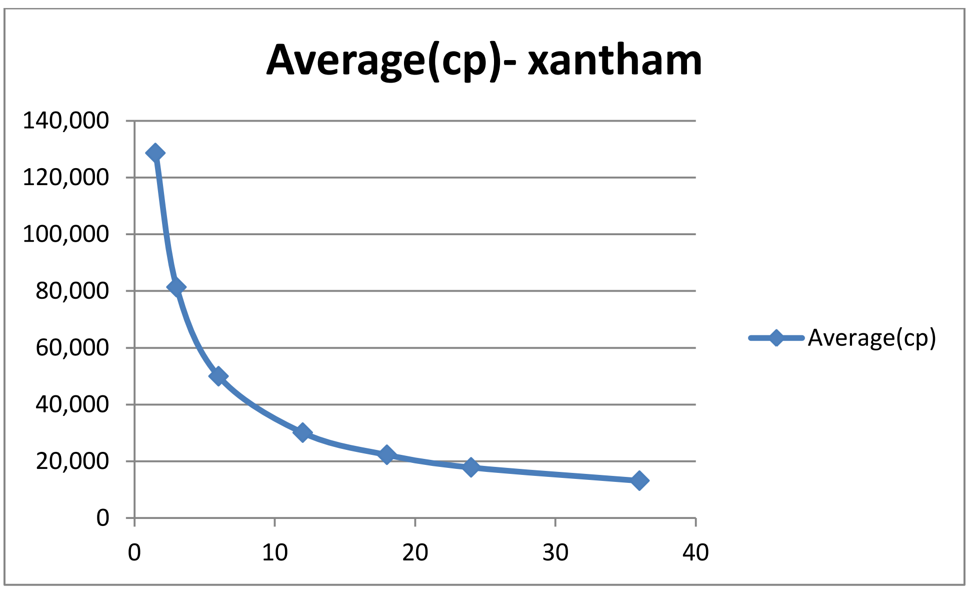
Graph 1: Brookfield viscometer versus RPM for each in same graph

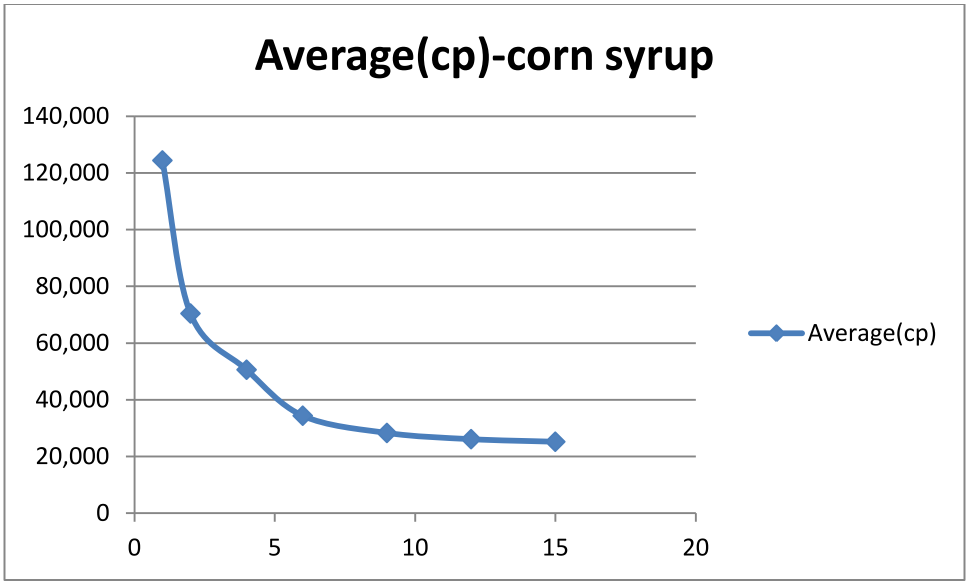


Graph 2: each viscosity versus RPM

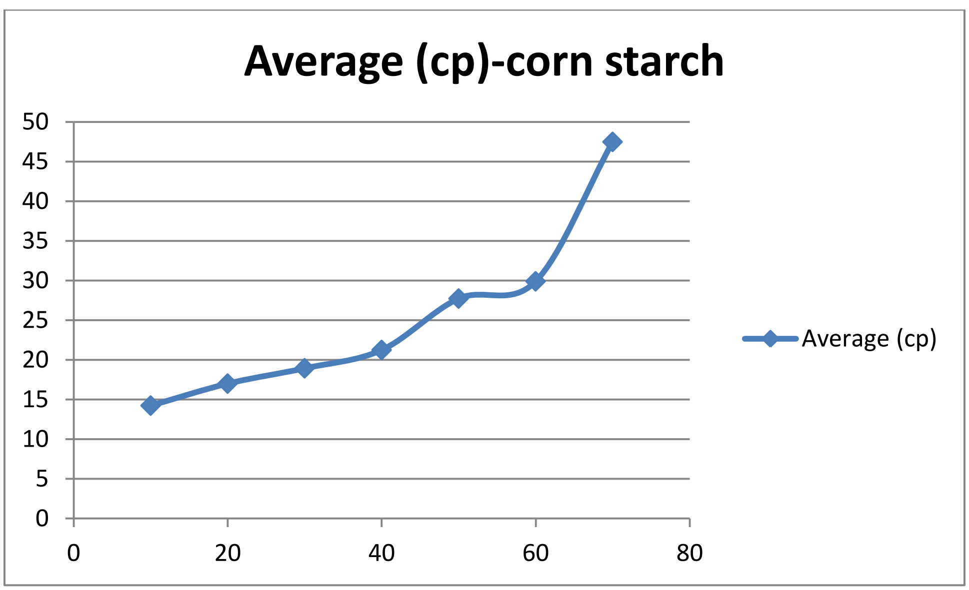
Ketchup:







Average(cp)-corn syrup
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
0
5
10
15
20
Average(cp)



Average (cp)-corn starch
50
45
40
35
30
25
20
15
10
5
0
0
20
40
60
80
Average (cp)

Graph 3: log of viscosity versus RPM:

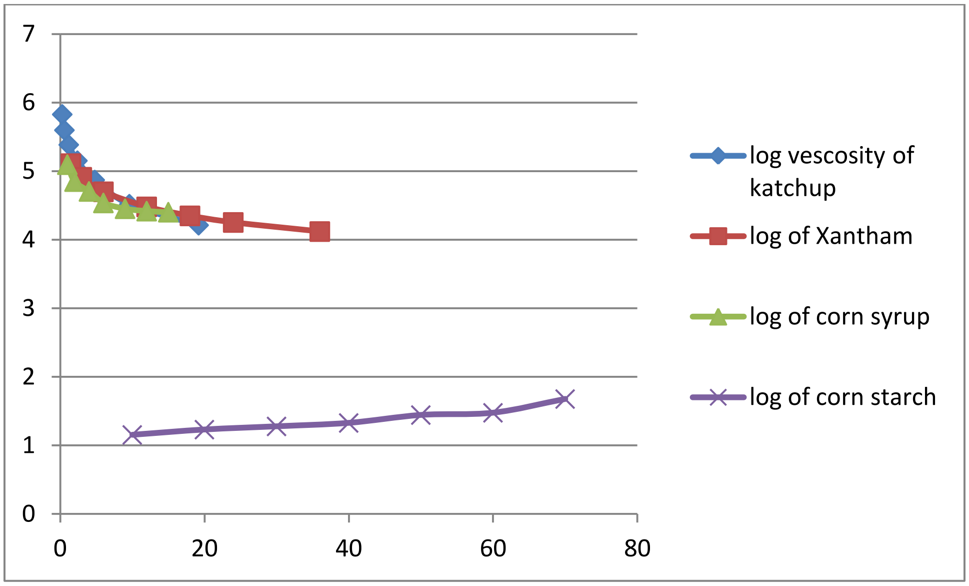


Table 5 (Observations of HMP and LMP):

LMP (1%HMP and 30% sugar):

AlCl3	+3	Gel
CaCl2	+2	Gel and liquid
NaCl	+1	Not gel

HMP (1%HMP and 65% sugar):

Gel 1	pH 3.3	Gel
Gel 2	No adjustment for pH	Gel and liquid

Discussion:

In Newtonian fluids viscosity is a constant. In a pseudoplastic fluid, the the viscosity decreases as sheer rate and sheer stress increases and in a Dilatant system viscosity increases as the stress and rate of strain increases. If a pseudoplastic fluid is stirred at an increasing rate the product appear to be decreasing in thickness. If a Dilatant fluid is stirred faster the product appear to be increasing in thickness. Ketchup, xanthan gum are pseudoplastic fluid and corn starch is Dilatant. Corn syrup is plastic since it needs some sheer forces before it moves. When we stirred them they showed the same characteristics. In HMP the lower pH < 3.5 is good. In HMP acid is added to protonate some of carboxyl groups which reduce the repulsion between the negatively charged chains. This way they can bond together. In LMP the pH can be higher >3.5. Our data showed similar behavior. This lab showed how important the structure and functional properties of materials are in food industry. For example polysaccharides such as starch, pectin, gum because of their structure and bonds can show different functional properties and give different texture to food. Texture in food is very important since for example a consumer who is buying bread doesn't like to get liquid bread or someone who buys jam expects it to be jelly texture not too liquid or too solid. In this lab the different measurement the viscosity of different solutions were measured. In this lab one group test the high methoxyl pectin and other low methoxyl pectin. The different amount of sugar and different procedure for those two groups gave the different data for viscosity. The lower the pH the more protons are present so it form more gels. The other group compared 3 solutions; $AlCl_3$, $CaCl_2$ and NaCl. Their result was that $AlCl_3$ had the most gel formed, the $CaCl_2$ was combination of gel and liquid and the NaCl was just liquid. Based on what was told in the class we expected to see that $CaCl_2$ forms the more gels.

Conclusion:

We learned that polysaccharides are a polymer of hexoses or pentoses that posses many structural variation. They have different functions based on their structure. The most important role they play in food technology is that they help the texture of food. They can be used as thickener, stabilizer or gel form. Their functional properties are based on their interactions with water and their intermolecular interactions. Rheology is dealing with deformation and flow of materials. There are three mechanical properties that govern the rheological behavior of any system; they are elasticity, plasticity and viscosity. Knowing the structure and functional properties of polysaccharides such as starch, gum, and pectin are very important for food technologist. The method for this lab was easy to follow. The result seems to be correct for our group, but as it was said in the class $CaCl_2$ should have the most gel but our neighbor group got different results. The cations reduces the negative charge repulsion between chains and electrostatically interact with the anionic chains to form a cross linked network that results in a gel. The more the cation the more it forms gels. The one with +3 cation formed more gel according to our neighbor group.

Questions:

1- In HMP the lower pH < 3.5 is good. In HMP acid is added to protonate some of carboxyl groups which reduce the repulsion between the negatively charged chains. This way they can bond together. In LMP the pH can be higher >3.5.
2- The cations reduces the negative charge repulsion between chains and electrostatically interact with the anionic chains to form a cross linked network that results in a gel. The more the cation the more it forms gels. The one with +3 cation formed more gel according to the group next to us.
3- Ketchup, xanthan gum are pseudoplastic fluid and corn starch is Dilatant. Corn syrup is plastic since it needs some sheer forces before it moves.
4- In Newtonian fluids viscosity is a constant. In a pseudoplastic fluid, the the viscosity decreases as sheer rate and sheer stress increases and in a Dilatant system viscosity increases as the stress and rate of strain increases. If a pseudoplastic fluid is stirred at an increasing rate the product appear to be decreasing in thickness. If a Dilatant fluid is stirred faster the product appear to be increasing in thickness. Our observations agree.
5- Xanthan gum is a polysaccharide secreted by the bacterium *Xanthomonas campestris*, used as a food additive and rheology modifier, commonly used as a food thickening agent for example in salad dressings.The viscosity of xanthan gum solutions decreases with higher shear rates; because it is a pseudoplasticity fluid. This means that a product subjected to shear, whether from mixing, shaking and it will thin out, but once the shear forces are removed, the food will thicken back up. A practical use would be in salad dressing. The xanthan gum makes it thick enough at rest in the bottle to keep the mixture fairly homogeneous, but the shear forces generated by shaking or hitting at the bottom of the bottle thins it, so it can be easily poured. When it exits the bottle, the shear forces are removed and it thickens back up, so it clings to the salad. The viscosity of corn syrup is higher than xanthan gum.