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Effect of *Sida acuta* and *Corchorus olitorius* Mucilages on the Physicochemical Properties of Maize and Sorghum Starches

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ABSTRACT

The aim of this study is to isolate gum from *Corchorus olitorius* and *Sida acuta* leaves and characterize it. The interaction of the isolated gums with maize and sorghum starches was also determined. Gum was isolated from the leaves of *Corchorus olitorius* and *Sida acuta* with excess isopropanol. Proximate analysis and physicochemical characteristics of the gums with maize and sorghum starches were determined. The yields of the gums were 8.234±0.82% and 27.149±0.44 for *Sida acuta* and *Corchorus olitorius*, respectively. Three different concentrations of the gum were used to study the effect of the gums on paste characteristics of maize and sorghum starches using Rapid Visco Analyzer (RVA). In the paste viscosity analysis, the final viscosities of the two starches were higher at the lowest concentration (0.1%) of the gums while setback and viscosity breakdown was lowered at the three concentrations. Concentration of the starches was varied for the determination of paste clarity at a constant gum concentration (0.2%) by measuring the percentage light transmitted at a wavelength of 660 nm. The gums decreased the clarity of the starches at all the concentrations. Addition of *Sida acuta* and *Corchorus olitorius* gums also increased the percentage syneresis of the starches. Emulsification stability analysis performed at different time intervals showed that there was almost a complete miscibility of the starches with the oil when gum was added.

Key words: Proximate analysis, syneresis, paste clarity, emulsification stability, viscosities

INTRODUCTION

Natural gums are natural polymers which mainly consist of carbohydrates sometimes with small amounts of proteins and minerals. They are made from different parts of plants seaweeds or bacteriology activity (GEA Niro, 2008). Hydrocolloids, often called gums, are hydrophilic polymers, of vegetable, animal, microbial or synthetic origin that generally contain many hydroxyl groups and may be polyelectrolyte. They are naturally present or added to control the functional properties of aqueous foodstuffs (Phillips and Williams, 2000). Most important among these properties are viscosity (including thickening and gelling) and water binding but also significant are many others including emulsion stabilization, prevention of ice recrystallization and organoleptic properties. (Ferry *et al.*, 2006). Mucilage has been found to be used as stabilizer in production of yoghurt to give better properties (Khalifa *et al.*, 2010). As hydrocolloids can dramatically affect the flow behavior of many times their own weight of water, most hydrocolloids (gums) are used to increase viscosity which is used to stabilize foodstuffs by preventing settling, phase separation, foam collapse and crystallization. Viscosity generally changes with concentration, temperature and shear strain rate in complex manner dependent on the hydrocolloid and other materials present; mixture of hydrocolloid act synergically to increase viscosity or antagonistically to reduce it (Marcotte *et al.*, 2001). Starch is the major carbohydrate reserve in plant tubers and seed endosperm where it is found as granules, each typically containing several millions amylopectic molecules accompanied by much larger of smaller amylose molecules (Vorwerg *et al.*, 2002). By far the largest source of starch is corn (maize) with other commonly used sources being wheat, potato, tapioca and rice. Amylopectin (without amylose) can be isolated from waxy maize starch whereas amylose (without amylopectin) is best isolated after specifically hydrolyzing the amylopectin with pullulanase (Jobling, 2004). Genetic modification of starch crops has recently led to the development of starches with improved and targeted functionality (Thomas *et al.*, 1999). The amylose/amylopectin ratios of starches can be genetically manipulated and offer a significant opportunity for the researcher with certain crops. Viscosity, shear resistance, gelatinization, textures, solubility, tackiness, gel stability, cold swelling and retrogradation are all functions of their amylose/amylopectin ratio (Satin, 2000). Certain starches are good film formers can be used in coatings or as film barriers for protection of the food from oil absorption during frying (Frazier *et al.*, 1997).

The combination of starch and non-starch hydrocolloids is often employed by food formulators to modify and control the characteristics and properties of food systems (Stephen, 2008). The starch-hydrocolloid products are also useful emulsifiers, particularly for vegetable oil and water emulsion. For example, an equal dispersion of wheat starch-guar product at 10% solids is capable of emulsifying levels of corn oil up to about 35%. The resulting emulsion is smooth and spreadable and has many of the characteristics of margarine (Christianson and Fanta, 1994). Mixing maize starch and flaxseed gum, a lesser used hydrocolloid with properties similar to guar gum, may offer food formulators a new way of control texture and improving stability, suggests fundamental research from China and Turkey (Christianson and Fanta, 1994).

Sida acuta burm f. (Malvaceae) is an erect, branched, small perennial herb or small shrub which grows abundantly on cultivated fields, waste areas, roadsides and open clearing in Nigeria (Akobundu and Agyakwa, 1998). The plant has a variety of traditional uses. The hot water extract of the dried entire plant is administered orally in India as a febrifuge, an abortifacient and a diuretic (Kholkute *et al.*, 1978). In Papua New Guinea; the fresh root is chewed for the treatment of dysentery (Holdsworth, 1974). The leaf juice is also used in India to stop vomiting and gastric disorders (Ramachandran and Nair, 1981). In Nicaragua, the decoction of the entire plant is taken orally for asthma, fever, aches and pains, ulcers and as an anti-worm medication; while a decoction of the dried entire plant is taken orally for venereal diseases (Barrett, 1994). Chemomicroscopical tests on the powder showed the presence of lignin, starch, calcium oxalate and mucilage (Oboh and Onwukaeme, 2007).

Tossa jute (*Corchorus olitorius*) is an Afro-Arabian variety of plant with genus name Corchorus and family Tiliaceae. It is quite popular for its leaves that are used as an ingredient in an okra slimy Arabian potherb called molokhiya. The book of Job in the Hebrew Bible mentions this vegetable potherb as Jews mallow. Tossa jute fibre is softer, silkier and stronger than white jute. This variety astonishingly showed good sustainability in the climate of the Ganges Delta. Along with white jute, tossa jute has also been cultivated in the soil of Bengal from the start of the 19th century. Currently, the Bengal region (West Bengal, India and Bangladesh) is the largest global producer of the tossa jute variety. Jute leaves are consumed in various parts of the world. It is a popular vegetable in West Africa (Doraiswamy *et al.*, 1998). *Corchorus olitorius* has been found to have higher magnessium content than cabbage and spinach (Ndlovu and Afolayan, 2008). *Corchorus olitorius* also possesses antibacterial activity that is comparable to some of the standard antibiotics (Zakaria *et al.*, 2006). The Yoruba of Nigeria call it ewedu and the Songhay of Mali calls it fakohoy. It is made into a common mucilaginous (somewhat slimy) soup or sauce in some West African cooking traditions, as well as in Egypt, where it is called mulukhiyya and is often considered the national dish. It is also a popular dish in the northern provinces of the Philippines, also known as saluyot. Jute leaves are also consumed among the Luyhia people of Western Kenya, where it is commonly known as mrenda or murere. It is eaten with ugali which is also a staple for most communities in Kenya (GFTCL, 2007). One of the major constraints of getting plant regeneration from the explant of *Corchorus olitorius* was the production of health seedlings *in vitro* (Asma *et al.*, 2003).

In this work, mucilage from *Corchorus olitorius* and *Sida acuta* were isolated and their effects on physicochemical properties of maize and sorghum starches were investigated.

MATERIALS AND METHODS

Materials: *Sida acuta* plant was collected from Ibadan, Oyo State, Nigeria while; *Corchorus olitorius* plant was bought from a farm land at Ijokodo area of Ibadan, Oyo State, Nigeria around October, 2008. Maize and Sorghum starches were gotten commercially. The protein, fat moisture, ash, fibre and amylose content for the maize starch is; 8.2, 1.2, 10.25, 1.86, 1.96 and 18.75 while that of sorghum starch is; 9.0, 2.1, 9.77, 2.15, 1.77 and 19.05.

Gum isolation and purification: The fresh leaves of the plants were collected and air dried. The dried leaves were milled to fine particle size using a local grinding machine. The powder was defatted with hexane in a soxhlet extractor for 6 h. The defatted sample was air dried to vaporize the hexane. Then the defatted powder extracted with ethanol to remove colored components of the sample. The decolorized sample was then air dried to vaporize the ethanol.

Ten gram of the sample was dispersed in 250 mL of distilled water and the slimy water separated from the residue by passing through muslin cloth. The residue was re-constituted with distilled water and sieved again. The gum solution was poured into centrifuge tubes and centrifuged at 3.500 rpm for 30 min. The supernatant was poured into a large beaker. The residue was reconstituted repeatedly with fresh distilled water, stirred and then centrifuged. The supernatant was pooled together and treated with isopropanol to spool out the gum. The clear liquor was decanted while the trapped solvent was removed by filtering under suction in a Buchner funnel. The gum was purified by dissolving in distilled water. This was then centrifuged and gum spooled out with isopropanol. The purified gum sample was dried in a convention oven at 50°C overnight and cooled in a desiccator. The dried gum was pulverized in a mortar and stored in sealed container. Determination of the yield of the gum was carried out in triplicate.

Proximate analysis: Moisture and ash contents were determined according to AOAC procedure (AOAC, 1990). Nitrogen content was determined using Hach method (HACH, 1990) and protein content calculated as Nitrogen×6.25. Fat and crude fibre contents were obtained from hexane extraction according to the method of Entwistle and Hunter (1994). Carbohydrate content was estimated as 100%-(moisture+fat+protein+fibre+ash). Amylose content was determined using the method of Juliano (1971).

PHYSICOCHEMICAL ANALYSIS

Paste viscosity: Pasting characteristics were determined with a Rapid Visco Analyzer (RVA), (model RVA 3D$^+$, Network Scientific, Australia). The 2.5 g of the flour sample were weighed into a dried empty canister; 25 mL of distilled water was dispensed into the canister containing the sample. The solution was thoroughly mixed and the canister was well fitted into the RVA, as recommended. The slurry was heated from 50 to 95°C with a holding time of 2 min followed by cooling to 50°C with 2 min holding time. The rate of heating and cooling were at a constant rate of 11.25°C min^{-1}. Peak viscosity, trough, breakdown, final viscosity, set back, peak time and pasting temperature were read from the pasting profile with the aid of Thermocline for Windows Software connected to a computer (Newport Scientific, 1998).

Paste clarity: Paste clarity was determined according to the method of Ahamed *et al.* (1996). The 0.05, 0.1, 0.2 and 0.3 g of the different starches were weighed in different test tubes. Ten milliliter of distilled water was added into each of the test tubes. The solution was stirred well with a glass rod to give dispersion. The tubes were clapped, immersed in a boiling water bath for 30 min (making sure the starch is continuously stirred throughout the heating period to prevent starch settling). At the end of 30 min, the tubes were removed and allowed to cool for about 10 min and then the percentage light transmitted at a wavelength of 660 nm was measured using water in the reference cell.

The 0.2% gum solution was prepared by dissolving 0.3 g of the gum in 150 mL of distilled water. The solution was attached to a shaker for complete solubilization. Then 0.05, 0.1, 0.2 and 0.3 g of the different starches were weighed in different test tubes. Ten milliliters of the gum solution was measured into each test tube of starch. The mixture was stirred to disperse the starch in the gum solution. This was pasted in boiling water bath for 30 min as described earlier after which they were cooled for 10 min. The percentage light transmitted at 660 nm was measured using distilled water in the reference cell. Light transmittance of the 0.2% gum was also measured. The percentage light transmitted was then plotted against starch concentrations.

Freeze-thaw stability: The method used was that of Schoch and Maywald (1968). Five grams of each of the starch was weighed into a conical flask and 50 mL of distilled water added. The starch was dispersed properly in the water and then pasted in boiling water bath for 30 min making sure the starch did not settle during heating. The stirring was continued after it was brought down from heating to prevent formation of skin during cooling. Ten milliters of the starch paste was transferred into three preweighed centrifuge tubes, the weight of the tube and the paste was obtained as well as the weight of the paste. The tube with the paste was put in a freezer and freezed for 18 h. It was then left to thaw at room temperature for three h. It was then centrifuged for 15 min at 10.000 rpm. The separated water was carefully decanted. The tube and the paste were weighed after which the weight of the water separated out was obtained. The freeze-thaw was obtained as:

$$\text{Stability} = \frac{\text{Weight of water separated}}{\text{Weight of the paste}} \times 100$$

The results were obtained in triplicate.

Table 1: The proximate composition of *Sida acuta* and *Corchorus olitorius* gum

Gum	Protein content	Fat content	Ash content	Fiber content	Moisture content	Total carbohydrate	Phosphorus content
	(%)						(mg/100 g)
Corchorus olitorius	10.28	1.02	2.47	2.99	9.88	73.36	398.75
Sida acuta	9.88	1.16	2.28	2.44	8.96	75.28	466.33

Five gram of starch was weighed into a conical flask and 50 mL of 0.2 g of gum solution was pasted as above and finally freeze-thaw stability was calculated.

Emulsion stability: This property was evaluated using an adaptation of the original method of Dagorn-Scaviner *et al.* (1987). One percent of starch paste was prepared by heating 0.1 g of starch in 10 mL of distilled water in a boiling tube immersed in boiling water for 20 min with stirring properly throughout the heating period. Ten milliliter of soya bean oil was added and solution pH was adjusted to 5.5 with 0.1N NaOH. This suspension was homogenized in a mixer at high speed for 30 sec and the emulsion poured into a 10 mL graduated test tube. Time of emulsion stability (which was observed as the upper creamy opaque phase) was recorded from the moment the test tube was filled (t = 0) and at 30s, 5, 30 and 120 min. The process kinetics was quantified as volume (Vl in mL) of the watery phase at the time intervals 0, 30s, 5, 30 and 120 min.

One percent of starch paste was prepared in gum solution by heating 0.1 g starch in 10 mL of 0.1% gum solution in a boiling tube immersed in boiling water for 20 min with stirring properly throughout the heating period. The steps as above were then carried out.

RESULTS AND DISCUSSION

Yield and composition of *Sida acuta* and *Corchorus olitorius* gum: The percentage yield of gum from *Sida acuta* was 8.234±0.82 while that of *Corchorus olitorius* was 27.149±0.44. These values show a quite high percentage of hydrocolliods in the two leaves compared to the yield reported for some plants like *Opuntia ficus indica* (0.07%, okra yield-16 g kg^{-1} okra (1.6%), baobab-18 g kg^{-1} (1.8%) (Cardenas *et al.*, 1997), M. neglecta (26.14%) and A. angulata (15.18%) (Pakravan*et al.*, 2007). Table 1 shows the chemical compositions of the gum from both leaves.

PHYSICOCHEMICAL CHARACTERISTICS

Paste viscosity: Figure 1 shows the pasting profile of sorghum starch with different concentrations of *Corchorus olitorius*. Figure 2 shows the pasting profile of maize starch with different concentrations of *Corchorus olitorius*. Figure 3 shows the pasting profile of maize starch with different concentrations of *Sida acuta*. Figure 4 shows the pasting profile of sorghum starch with different concentrations of *Sida acuta*. Figure 5 shows the pasting profile of maize starch only and Figure 6 shows the pasting profile of sorghum starch only. It was noted that viscosity breakdown which is the measure of fragility of the starches (125.67 for maize, 130.84 for sorghum) were lowered on addition of the *Sida acuta* gum mainly at high concentration while it was lowered at all concentrations of gum for the *Corchorus olitorius* gum. This means that addition of *Sida acuta* gum to the two starches helps in making them stronger.

The setback value (165.92 for maize, 97.34 for sorghum), an index of retrogradation tendency in the starch paste was generally lowered (Table 2) on addition of both gums to the two starches at all the concentrations used. It was also lowered with increase in gum concentrations. This

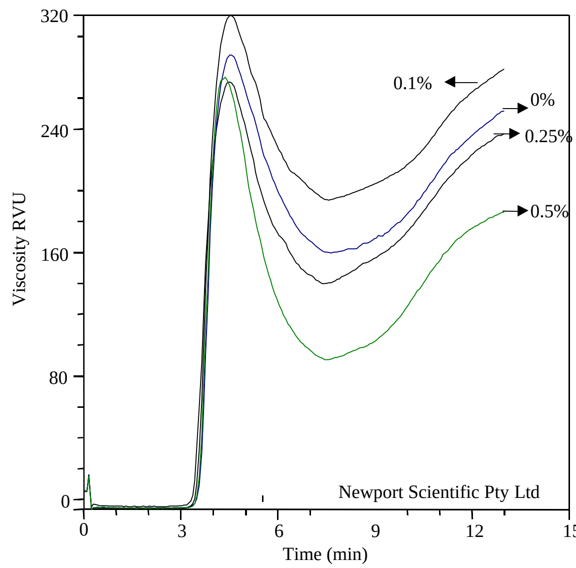

Fig. 1: Pasting profile of sorghum starch in different concentrations of *Corchorus olitorius* gum

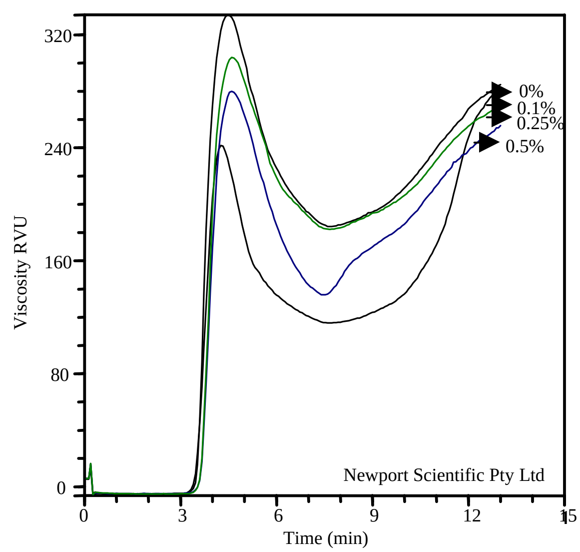

Fig. 2: Pasting profile of maize starch in different concentrations of *Corchorus olitorius* gum

indicates a low retrogradation tendency in the starch paste when these gums were added. The final viscosity of the starch-gum mixture, decreased with increase in concentrations of the gums. Incorporation of the two gums into the maize and sorghum starches helped to increase the peak viscosity of the starches. This can be related to the research performed on gum arabic in which there was an increase in viscosity thereby stabilizing creams and lotions (Nussinovitch, 1996).

Paste clarity: Figure 7 shows the plot of percentage light transmittance against different concentrations of maize and sorghum starches with 0.2% *Corchorus olitorius* gum and Fig. 8 is the plot of percentage light transmittance against different concentrations of maize and sorghum

Table 2: Pasting viscosity composition of the gums in maize and sorghum starches

Sample	Peak 1	Trough 1	Breakdown	Final viscosity	Set back	Peak time	Peak temp
Sorghum starch+ 0.1% *C. olitorius*	313.58	194.25	119.33	278.92	95.67	4.53	80.80
0.25	288.00	160.00	128.00	252.08	92.08	4.60	81.55
0.5	273.67	90.83	128.83	186.50	84.67	4.40	81.50
Maize starch+ 0.1% *C. olitorius*	240.00	115.50	124.50	280.75	165.25	4.33	80.90
0.25	297.67	155.00	124.67	256.92	144.75	4.47	80.00
0.5	243.33	100.92	124.42	245.67	101.92	4.20	79.90
Sorghum starch+ 0.1% Sida acuta	304.67	164.92	139.75	253.33	97.17	4.53	80.95
0.25	322.08	134.83	107.25	232.00	89.58	4.27	80.00
0.5	213.83	107.08	106.75	196.67	88.42	4.53	81.55
Maize starch+ 0.1% Sida acuta	242.50	115.25	128.33	282.25	167.00	4.33	80.80
0.25	249.58	121.25	127.25	279.83	158.58	4.40	81.50
0.5	166.75	83.67	83.08	204.50	120.83	4.47	83.90

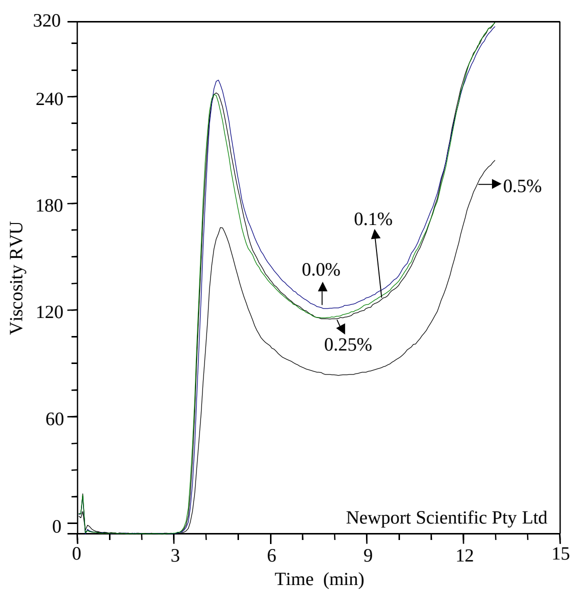

Fig. 3: Pasting profile of maize starch in different concentrations of *Sida acuta* gum

starches with 0.2% *Sida acuta* gum. The results show that addition of 10 mL of 0.2% gum to the two starches reduced the percentage transmittance of the starches. It was also noted that there was a general decrease in percentage transmittance with increase in concentration. This result shows that addition of gum and increase in its concentration lowers the clarity of the starches due to high refraction of light by swollen granular remnants but little reflection of light by collapsed or associated starch molecules.

Freeze thaw stability result: The result of freeze thaw stability shown in Table 3 shows that there was increase in water loss by the starches when the gum was added. The gums showed poor

Table 3: Percentage syneresis of maize and sorghum starches with and without gum

Sample	Syneresis (%)
Maize starch only	87.26±0.22
Maize starch with *Sida acuta* gum	89.11±0.84
Maize starch with *Corchorus olitorius* gum	87.90±0.01
Sorghum starch only	84.97±0.03
Sorghum starch with *Sida acuta* gum	85.47±0.68
Sorghum starch with *Corchorus olitorius* gum	90.47±0.17

Table 4: Emulsion stability of maize and sorghum starches with and without gum

	Volume (oil-mL mL^{-1} of sample)				
Sample	0 sec	30 sec	5 min	30 min	120 min
Maize starch only	0.1	0.3	3.6	3.8	3.8
Maize with *Sida acuta* gum	0.0	0.0	0.0	1.0	1.8
Maize with *Corchorus olitorius* gum	0.0	0.0	0.0	0.0	0.0
Sorghum starch only	0.1	0.3	3.8	4.0	4.0
Sorghum with *Sida acuta* gum	0.0	0.0	0.0	0.2	0.9
Sorghum with *Corchorus olitorius* gum	0.0	0.0	0.2	1.0	1.0

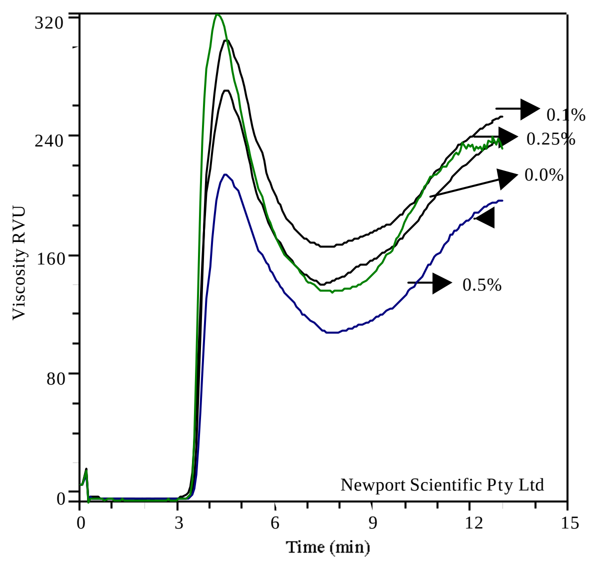

Fig. 4: Pasting profile of sorghum starch in different concentrations of *Sida acuta* gum

freeze thaw stability with the starches. This can be due to factors such as their origin and molecular structure, various environmental factors like pH (Lee *et al*., 2002).

Emulsion stability result: There was a greater separation of the oil from the mixture when it was only starch (Table 4). This shows that the starches alone have higher emulsion capacity than when gums were added. The gums introduced hydrophilic chain into the starch molecules and thereby making them more surface active by increasing the viscosity (Wurzburg, 1995). This gives the gum good emulsion stability for cosmetics industry.

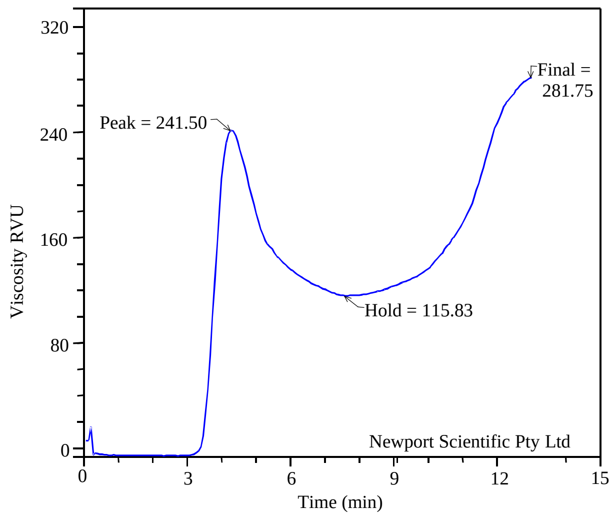

Fig. 5: Pasting profile of maize starch

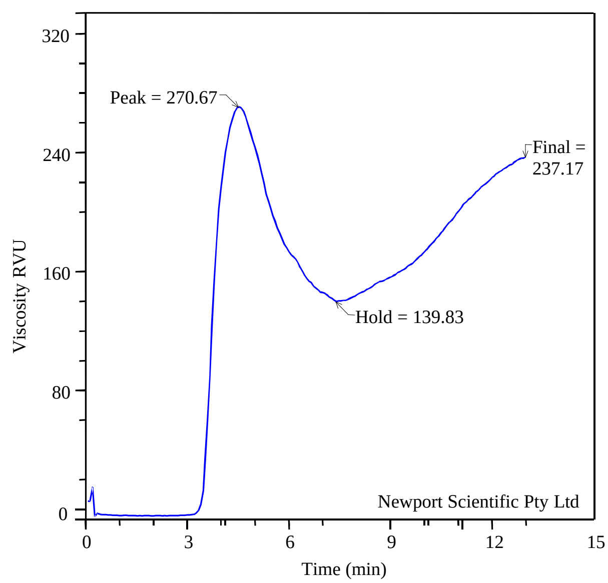

Fig. 6: Pasting profile of sorghum starch

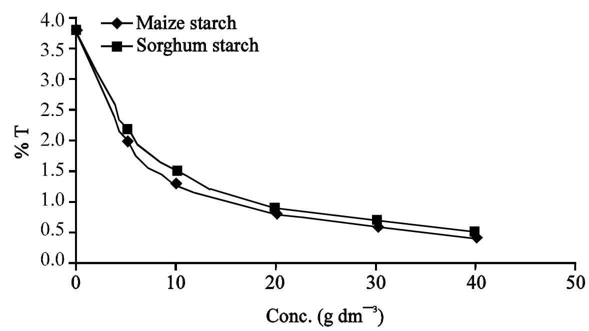

Fig. 7: Paste clarity of 0.2% *Corchorus olitorius* on addition of different concentrations of the starches

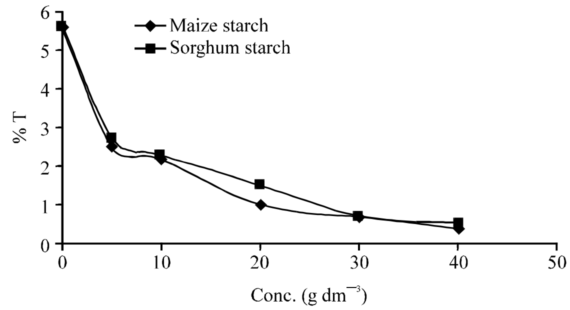

Fig. 8: Paste clarity of 0.2% *Sida acuta* on addition of different concentrations of the starches

CONCLUSION

Going by the results obtained from the experiment that the alcohol precipitation method used for the extraction gave good yields of gum. Experiment results from the percentage yield, proximate composition and physiochemical analysis of *Sida acuta* and *Corchorus olitorius* gum has a lot of beneficial parameters to be exploited by food, cosmetics and pharmaceutical industries. The low percentages of crude fibre make the gums useful in fibre controlled diet.

Incorporation of the gums into maize and sorghum starches helped to lower the setback value and viscosity breakdown of the two starches thereby making them stronger. Meanwhile, addition of the gums and increase in their concentrations lowers the clarity of the starches as shown in the paste clarity result. Addition of Sida *acuta* and *Corchorus olitorius* gums to the starches will be of great advantages for the cosmetics industries because the gums increased the starches viscosities and made it more surface active.

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