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Effects of Mucilage on the Pasting, Thermal and Retrogradative Properties of Native and Modified Starches Obtained from Ipomoea Batatas

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Abstract
This study investigates the effect of mucilage on the pasting, thermal and retrogradative properties of native, pregelatinized and acid modified starches obtained from *ipomoea batatas*. Dispersions of mucilage with each starch was carried out in a ratio 1:20, 1:10, 1:5, 3:10 and 2:5 respectively. Native starch (SPS) had a higher peak viscosity, trough, breakdown, final viscosity and enthalpy (ΔH) as compared to pregelatinized starch (PPS) and acid modified starch (APS) in the order SPS > PPS > APS. Parameters such as pasting temperature, syneresis, onset, peak and conclusion temperature were in the order APS > PPS > SPS. Pregelatinized starch had a higher set back and peak time as compared to other starches in the order PPS > SPS > APS. Generally, dispersions of SPS, PPS and APS in mucilage followed similar trends as described above with increase in peak time, pasting temperature and ΔH as the mucilage concentrations increased and a decrease in peak viscosity, trough, breakdown, final viscosity, set back, syneresis (except SPS), onset, peak and conclusion (except APS) temperature as the mucilage concentration increases.
Keywords: *Ipomoea batatas* starch, pregelatinized, acid modified, dispersion, mucilage

INTRODUCTION

Tropical roots and tubers generally contain different levels of mucilage. These mucilage's exhibit unique rheological properties with considerable potential as food thickener and stabilizer (Fedeniuk & Biliaderis, 1994). The beneficial effects of mucilage in pasting properties of tuber crops products has been recognized and applied commercially for starchy foods, such as mash taro, mash yam, taro paste or poi (Hawaiian staple food), and sweet potato paste. Sweet potato *(Ipomoea batatas*) is a crop plant with large, starch, and sweet tasting roots which belongs to the family *Covolvulaceae*. It contains a viscous polysaccharide polymer called mucilage. This substance is mainly composed of water-soluble glycoprotein's containing a number of different sugars. The major components of carbohydrate in purified mucilage of sweet potato are galactose and arabinose. Moreover, the remaining carbohydrate compositions are glucose, rhamnose, and xylose (Chien-Chun *et al*., 2010). The term 'hydrocolloids' refers to a range of polysaccharides and proteins that are widely used in a variety of industrial sectors to perform a number of functions. Increasing attention has been paid to incorporating hydrocolloids into starch-based products due to their unique functional properties (Christianson, 1982., Tester and Morrison, 1990., Liu *et al*., 2006., Fasihuddin and Williams, 1999).

One of the most useful attributes of starch is the ability to modify it to suite a particular application. For many years acid hydrolysis has been used to modify the structure of starch granules to produce "soluble starch". Also, physical modification such as annealing and pregelatinization provides a cold-soluble substance that gives a high cold paste viscosity rather than a gelatinization peak. Other substance such as sugars, lipids, emulsifiers, gums, salts and ph modifiers can affect the pasting and thermal properties of starch. Blending of starches with other biopolymers is a well-known technique to modify texture or maintain desirable texture during a long storage period (Lee *et al.,* 2002; Tester and Sommerville, 2003). When a starch/hydrocolloid mixture is used as a texture modifier, understanding of its pasting and thermal properties is important. Thus, various studies on pasting and thermal properties of mixtures between starches and hydrocolloids have been reported (Shi and Bemiller, 2002; Sudhakar *et al.,* 1995). The extent of starch granule swelling or melting of crystalline parts during gelatinization is influenced by the presence of hydrocolloids and synergistic interactions between hydrocolloids and starch may be anticipated (Closs *et al*., 1999).

Retrogradation of the starch can be altered depending on the type and concentration of individual components in the mixed systems during storage. Sugars are one of the most common ingredients presented in

food systems. Non-ionic solutes, such as saccharides have been found to increase the gelatinization temperature of starch depending on the sugar concentration (D'Appolonia, 1972; Lelievre, 1976; Maaurf, 2001). The addition of saccharides into starch generally increases the gelatinization temperature due to the retardation of the swelling of starch granules and changes in the structure of water phase. However, the effect of sugars on starch showing different behaviors depends on types of starch and saccharide, concentration and preparation methods. The proposed mechanisms of gelatinization in sugar systems are based on the ability of sugars to compete for water against starch, reduction of water activity, boiling point elevation, free and bound water, sugar-starch interactions, increase in free volume resulting in less plasticizing effect of sugar-water solvent, "antiplasticization" by sugar-water co-solvent, rate of penetration of sugar molecules into the interior of the starch granules, molecular weight issue, change in conformation of the starch polymer, and reduction in water polarization. A well-known technique to modify viscosity/texture or maintain desirable viscosity/texture during storage is to blend starches with other hydrocolloids or biopolymers (Lee *et al.*, 2002; Tester and Sommerville, 2003; Yoshimura *et al.*, 1996).Combinations of polysaccharides are often used to increase the solution viscosity, and control the texture and structure of food systems (Williams and Phillips, 1995). Many reports show that the using of small amount of hydrocolloid can modify the starch properties and affects the gelatinization and retrogradation of the starch (Baek *et al.*, 2004; Chinachoti *et al.*, 1990; Eliasson, 1992; Gonera and Cornillon, 2002; Lee *et al.*, 1998; Ikeda *et al.*, 2001; Kohyama and Nishinari, 1991; Kruger *et al.*, 2003; Maaurf *et al.*, 2001; Spies and Hoseney, 1982, Yousaria and William, 1994; Yoshimura *et al*., 1996). The objective of this study is to investigate the effect of increased mucilage concentrations on the pasting and thermal properties of native, pregelatinized and acid modified starch obtained from *Ipomoea batatas*.

MATERIALS AND METHOD

Materials

Ipomoea batatas (white skin, cream flesh variety) was obtained from central market in Sokoto State, Nigeria. All other chemicals and reagents used were of analytical grade.

Methods

Flour extraction

Flour extraction was conducted as established by (Alves *et al,* 2002). The tubers were peeled, washed, cut into 1-2 cm cubes, and sliced into thick chips (-5mm). This chip was then soaked in sodium metabisulphite solution (0.075 %) for -5 min and oven dried at 30^0 C for 40 hours until it reaches 13 % moisture. Subsequently, the dried chips were milled into flour and sifted through a 500-um sieve, and stored under dry conditions at room temperature.

Mucilage separation

The mucilage concentrate was prepared following the method as described by Jiang and Ramsden (1999) with the little modification as follows, flour sample (100 g) was dispersed in 300 ml of sodium metabisulphite (0.075 %) solution and stored at 4^0 C overnight. This dispersion was centrifuged at 14,000 x g for 20 min and the supernatant (mucilage) then collected. This was followed by pellet dissolution in metabisulphite solution and centrifuged under conditions as described above. The resulting supernatant was filtered using a filter paper (110 mm diameter) and purified as followed; 150 ml of the supernatant was treated with 0.5 % saturated solution of calcium chloride and left overnight. Subsequently, the supernatant was carefully collected and further treated by heating at 95^o C for 30 min and allowed to cool to room temperature. The resulting supernatant was precipitated using three times its volume of ethanol (96 %) and then dried in an oven 40^0 C.

Starch isolation

The pellets obtained from the centrifugation step during the mucilage separation was re-suspended in a large amount of sodium metabisulphite (0.075 %) solution and then this homogenate was passed through a 150 m sieve. The residue was washed with sodium metabisulphite (0.075 %). The resulting slurry was left to stand overnight at 4^0 C and then centrifuged (14,000 x g; 20 min). After this, the supernatant was discarded and the colored layer manually scraped off of the starch. This centrifugation step was repeated until the supernatant layer becomes almost colorless. After the last centrifugation, the supernatant was decanted and sodium hydroxide solution (0.1 M) added to the remaining sediment (starch). This would be followed by addition of deionized water to wash the pellets until its pH becomes neural. The recovered starch was dried using an air oven at 40^oC for 30 hrs, ground, and sieved using a 500 µm sieve. The yield of starch based on the weight of its respective flour (100 g) was determined. The resulting starch was stored in an air tight container under dry conditions (Alves *et al*., 2002**).**

Modified starches:-

Acid modified starch

In the production of acid modified starch, four hundred and fifty grams of an aqueous suspension of starch (36 % w/w wt starch) was poured into a stainless steel vessel. To this suspension, 28 ml, 6N HCI was added drop wise with stirring and subsequently, the reaction was conducted for 6 hours at 54^0 C. After cooling, the acid modified starch was separated from the reaction medium by filtration. On the filtrate, the separated starch was washed 1:1 with water, then the starch suspended again in 250ml water and adjusted to pH 7 with sodium hydroxide. The starch product was separated by means of filtration with water and dried in an oven at 40^0 C to a moisture content of <10 %, Then ground into a powder and passed through a 500 µm sieve.

Pregelatinized starch

In the production of partially pregelatinized starch, native Starch 39.6 g was added to 70 ml of distilled water and the suspension stirred for 10 min at room temperature. The suspension was heated on a water bath thermostatically maintained at a temperature of 55^0 C (i.e. below the gelatinization temperature) for 15 minutes, the resultant paste was dried in a hot air oven at temperature of 40^0 C to a moisture content of <10 %, then ground into a powder and passed through a 500 µm sieve.

Starch and mucilage dispersions

Production of mucilage/native starch, mucilage/pregelatinized starch and mucilage/ acid hydrolyzed starch dispersions in a ratio 1:20, 1:10, 1:5, 3:10 and 2:5 respectively was carried out as follows:
Ipomoea batatas mucilage was slowly added to distilled water (150 ml) with stirring until dissolution is affected. Starch (native, pregelatinized or acid modified) was then added to the mucilage solutions, and the dispersion stirred for one hour at room temperature. The whole dispersion was then transferred into a glass dish and dried at 45^0 C in an oven to a moisture content of <10 %, ground into a powder and passed through a 500 µm sieve.

Proximate analysis

The proximate analysis for moisture, crude protein, crude lipid, fiber and ash content of the native starch, modified starches and mucilage obtained from *Ipomoea batatas* were carried out according to the method of the AOAC (1990). The conversion factor of total nitrogen to crude protein was 6.25. Percentage total carbohydrate was determined by subtracting the sum total of ash, crude protein, lipid and fiber from 100. Apparent amylose content was determined by the method as described by William *et al*., (1958).

Pasting properties

The pasting properties (ICC standard Method 162) of native starch, modified starches and their dispersions in mucilage were investigated with a Rapid Visco-Analyzer (RVA-4, Newport Scientific, Australia). All sample weight and the water to be added were corrected for sample moisture content (within normal moisture basis of 14 %). All samples were treated with a heating– cooling cycle. The starch suspensions were equilibrated at 50^oC for 1 min, heated from 50 ^oC to 95^o C at heating rate of 12^o C/min, then held at 95^o C for 3 min. Afterwards the paste was cooled to 50^oC at 12^o C/min and kept at 50^o C for 2 min. Paddle speed was set at 960 rpm for the first 10 s, then 160 rpm for the remainder of the experiment. The viscoamylogram described the various characteristics of the starch including peak temperature, peak viscosity, time to peak, and final viscosity at the end of a 50^o C holding period. Other parameters, including setback and breakdown, were calculated from the above viscoamylogram characteristics. The unit of pasting properties of the various starch samples was expressed as RVU, where RVU is the unit of viscosity from the Rapid Visco-Analyzer. Three replicates of each sample were analyzed.

Thermal properties

The thermal properties of the mixed flour were measured using a differential scanning calorimeter (Pyris 6 DSC, Perkin Elmer USA). Native and modified starches with their dispersions in mucilage (3 mg) and distilled water (12 mg) were loaded into an aluminum pan and hermetically sealed. The sample pans were allowed to stand for 2 h at room temperature in order to attain an even distribution of water before heating the calorimeter. An empty aluminum pan was used as reference and the calorimeter was calibrated with indium. The scanning temperature range was 20^oC – 120^o C at a heating rate of 10^o C/min. The onset (To), peak (Tp), and conclusion (Tc) temperatures, as well as the enthalpy (ΔH) of gelatinization of the dry starch and mucilage were calculated automatically.

Syneresis

Starch retrogradation measured by syneresis was carried out according to the method described by kuar *et al*, (2002) with little modification. 2% w/v starch suspension was heated at 85^o C for 30 min in a temperature

controlled water bath and then cooled to room temperature in an ice water bath. The starch samples were stored for 1, 2, 4 and 7 days at 4^{o}C. Syneresis was measured as the amount of water (%) released after centrifugation at 3000 xg for 15 min.

Statistical analysis

The mean values and standard deviations of each analysis were reported. Analysis of variance (ANOVA) was performed as part of the data analyses. When F-values were significant ($p < 0.05$)

Keys to abbreviations

SPS (sweet potato starch), PPS (pregelatinized sweet potato starch), APS (acid modified sweet potato starch). 5-MSPS, 10-MSPS, 20-MSPS, 30-MSPS and 40-MSPS (represents 5,10,20,30 and 40 grams of mucilage incorporated into 100 grams of sweet potato starch respectively). 5-MPPS, 10-MPPS, 20-MPPS, 30-MPPS and 40-MPPS (represents 5,10,20,30 and 40 grams of mucilage incorporated into 100 grams of pregelatinized sweet potato starch respectively). 5-MAPS, 10-MAPS, 20-MAPS, 30-MAPS and 40-MAPS (represents 5,10,20,30 and 40 grams of mucilage incorporated into 100 grams of acid modified sweet potato starch respectively)

RESULT AND DISCUSSION

Table 1.0: proximate analysis of native starch, modified starches and mucilage obtained from ipomoea batatas

parameters	Moisture content (%)	Ash value (%)	Lipid (%)	Fiber (%)	Crude Protein (%)	Total carbohydrate (%)	Amylose (%)	Amylopectin (%)
SPS	12.0	0.51	0.30	0.50	0.35	98.34	34.9	65.1
PPS	5.0	0.58	0.20	0.50	0.38	98.34	37.6	62.4
APS	7.5	0.53	0.25	0.50	0.39	98.33	35.4	64.6
Ipomoea batatas mucilage	6.5	0.68	0.10	0.35	3.33	85.54	nd	nd

As seen in Table 1.0 above, the moisture content and ash values for native and modified starches were within the specification of the British pharmacopoeia (2012). There were no significant differences between the crude fiber, crude protein and total carbohydrate for the native and modified starches. There was an increased crude protein content in the mucilage as compared to the native and modified starches. This could be attributed to the glycoprotein complex which is a major component in the mucilage. From Table 1.0, it can also be seen that the amylose content were in the order PPS > APS > SPS. Increase in amylose content as seen in PPS and APS could be attributed to amylose leaching and early disintegration of the amorphous inter-micellar regions of the Amylopectin molecule respectively. The difference in amylose and amylopectin contents contributes to significant differences in the starch properties and functionality (*Thomas and Alweell, 1999)*. The higher the amylose content, the less expansion potential and lower the gel strength for the same starch concentration.

Table 2.0: Pasting properties of native starch and dispersions of starch and mucilage obtained from *ipomoea batatas*

Parameters	SPS	5-MSPS	10-MSPS	20-MSPS	30-MSPS	40-MSPS
Trough 1	204.33^{a}	137.17^{b}	119.5^{c}	97.5^{d}	85.33^{e}	70.17^{f}
Breakdown	103.5^{a}	39.58^{b}	33.58^{c}	20.00^{d}	8.67^{e}	4.83^{f}
Final viscosity	277.33^{a}	175.33^{b}	142.5^{c}	119.5^{d}	104.0^{e}	82.08^{f}
Setback	73.0^{a}	38.17^{b}	23.0^{c}	22.0^{c}	18.67^{d}	11.92^{e}
Peak time	4.72^{a}	5.18^{b}	5.38^{b}	5.52^{b}	5.78^{b}	6.12^{c}
Pasting temperature	78.95^{a}	84.75^{b}	85.55^{b}	85.80^{b}	86.35^{b}	89.55^{c}

*value is mean, number of replicate = 3, a–f Means with different letters within the same row differed significantly ($p < 0.05$)

Table 3.0: Pasting properties of pregelatinized starch and dispersions of pregelatinized starch and mucilage obtained from *ipomoea batatas*

Parameters	PPS	5-MPPS	10-MPPS	20-MPPS	30-MPPS	40-MPPS
Trough 1	185.08[a]	133.75[b]	110.42[c]	86.92[d]	64.25[e]	49.58[f]
Breakdown	43.42[a]	16.75[b]	13.92[c]	9.08[d]	2.5[e]	1.92[f]
Final viscosity	276.5[a]	171.08[b]	140.25[c]	104.83[d]	75.67[e]	60.0[f]
Setback	91.42[a]	37.33[b]	29.83[c]	17.92[d]	11.42[e]	10.42[f]
Peak time	5.25[a]	5.58[a]	5.72[b]	5.92[b]	6.32[c]	6.92[c]
Pasting temperature	82.30[a]	84.00[b]	84.75[b]	84.80[b]	84.80[b]	87.95[c]

*value is mean, number of replicate = 3, a–f Means with different letters within the same row differed significantly ($p < 0.05$)

Table 4.0: Pasting properties of acid modified starch and dispersions of acid modified starch and mucilage obtained from *ipomoea batatas*

Parameters	APS	5-MAPS	10-MAPS	20-MAPS	30-MAPS	40-MAPS
Trough 1	8.67[a]	8.67[a]	7.42[b]	6.17[c]	5.83[d]	5.08[d]
Breakdown	10.83[a]	9.92[b]	9.42[b]	7.67[c]	5.08[d]	3.58[e]
Final viscosity	111.58[a]	12.08[b]	10.25[c]	8.75[d]	7.17[e]	7.33[e]
Setback	2.92[a]	3.42[b]	2.83[a]	2.58[a]	1.33[c]	2.25[a]
Peak time	4.45[a]	4.58[a]	4.52[a]	4.58[a]	4.45[a]	4.38[a]
Pasting temperature	87.15[a]	87.95[a]	88.80[a]	88.05[a]	88.00[a]	88.00[a]

*value is mean, number of replicate = 3, a–f Means with different letters within the same row differed significantly ($p < 0.05$)

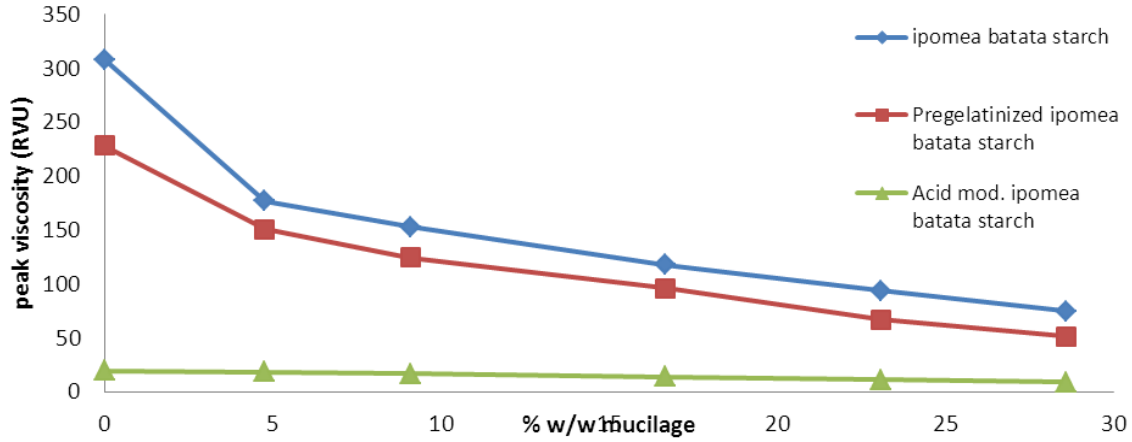

Fig.1.0: Effect of mucilage concentrations on the peak viscosity of native and modified starches obtained from *ipomoea batatas*

Starch suspensions swell markedly and the viscosity increase dramatically when heated in sufficient water. The RVA results as seen in Table 2-4 and Fig. 1.0 shows that SPS have a higher peak viscosity, trough, breakdown and final viscosity as compared to pregelatinized and acid modified starch in the order SPS > PPS > APS. This is as a result of depolymerization of starch chains by acid and heat. This trend was also seen with the various dispersions in mucilage with a decrease in peak viscosity, trough, breakdown and final viscosity as the mucilage concentration increase. An increase in peak viscosity of starch paste in the presence of a hydrocolloid has been previously reported (Liu *et al*., 2003, Sasaki *et al*., 2000). The reason for an increase in peak viscosity could be accounted for by a thickening gum that enhances the forces being exerted on the starch granules in the shear field. Yoshimura *et al*., (1996) indicates that an addition of hydrocolloid increase the effective starch concentration by immobilizing water molecules. The mucilage could also form a strong entanglement with the Amylose released from starch granules (Liu *et al*., 2003). The effect of mucilage on gelatinization and pasting properties are dependent upon the source of starch and the concentration of mucilage (Huag *et al*., 2010). The set back and peak time were in the order pregelatinized starch > native starch > acid modified starch, and also with their dispersions which decreased with increase in mucilage concentration and increased with increased mucilage concentration respectively in the same order. The secondary increase in viscosity (set back) during the cooling phase is associated with the retrogradation phenomenon and relates to the amylose content (Mishra and Rai, 2006). The pasting temperature was higher with acid modification as compared with native and pregelatinized

starch in the order acid modified > pregelatinized starch > native starch. Similar trends were seen with their various dispersions which increased with increase in mucilage concentration. This increase could be due to the interaction of mucilage with a small amount of amylose released by the limited swelling of starch granules (Liu *et al*., 2006)

The thermal properties as seen in Table 5.0 shows that the addition of mucilage caused marked increase in the onset temperature for the tested starches. This may be as a result of either interaction between mucilage and starch or competition of starch with water in the early stages of heat gelatinization. Several studies indicate that sugars or polyhydroxy compounds increase the gelatinization temperature of starch (kim and walker, 1992, liu *et al*., 2006). The onset of temperature, peak temperature, conclusion temperature and temperature range were in the order APS > PPS > SPS. For both native and pregelatinized starches, there was an initial increase in the onset temperature, peak temperature and conclusion temperature at lower concentrations of mucilage followed by a reduction at higher concentrations as compared to acid modification which showed a decrease in the onset temperature with increase mucilage concentrations. Increase in gelatinization can also be due to the presence of other components such as protein and lipids that would obstruct the swelling of granules and thus increase the amount of heat required to reach the final swelling.

Table 5.0: Effect of mucilage on the thermal properties of starch and modified starches obtained from *Ipomoea batatas*

Parameters	To	Tp	Tc	Tc - To	ΔH (J/g)
SPS	67.81 (1.23)	77.37 (0.67)	83.45 (1.22)	15.64	6.79 (0.68)
5-MSPS	70.16 (0.46)	78.51 (0.34)	85.65 (0.82)	15.49	6.81 (1.01)
10-MSPS	72.90 (0.86)	84.65 (1.06)	88.40 (0.56)	15.50	6.86 (0.86)
20-MSPS	71.02 (0.45)	81.66 (0.86)	86.55 (0.76)	15.53	8.10 (0.14)
30-MSPS	63.06 (1.08)	78.91 (0.24)	77.67 (0.54)	14.61	9.31 (0.88)
40-MSPS	55.82 (0.66)	66.45 (1.68)	69.36 (1.06)	13.54	9.35 (2.06)
PPS	75.45 (0.56)	80.49 (1.08)	84.15 (0.67)	8.70	5.53 (0.45)
5-MPPS	77.67 (2.07)	82.62 (2.08)	86.07 (0.88)	8.40	6.78 (0.33)
10-MPPS	77.20 (1.86)	82.21 (1.88)	85.25 (0.82)	8.05	6.81 (1.08)
20-MPPS	76.25 (0.64)	81.94 (0.82)	85.99 (1.52)	9.74	6.93 (1.55)
30-MPPS	74.36 (0.66)	77.25 (2.98)	80.52 (0.16)	6.16	6.84 (0.42)
40-MPPS	71.94 (0.89)	71.74 (0.46)	74.76 (1.22)	2.82	9.01 (0.81)
APS	80.83 (0.92)	81.63 (2.02)	84.43 (0.65)	3.60	5.21 (0.22)
5-MAPS	78.97 (0.45)	85.29 (1.08)	89.15 (0.82)	10.18	6.55 (0.67)
10-MAPS	78.89 (1.08)	85.81 (2.74)	91.89 (0.92)	13.00	6.73 (0.92)
20-MAPS	77.68 (1.22)	82.38 (1.22)	84.82 (1.86)	7.14	8.39 (1.86)
30-MAPS	77.46 (1.69)	84.53 (0.12)	85.45 (2.28)	7.99	8.42 (0.74)
40-MAPS	81.18 (0.92)	85.99 (1.66)	88.53 (0.18)	7.35	8.92 (1.36)

To, Tp, Tc, and DH are onset temperature, peak temperature, and conclusion temperature, and enthalpy change, respectively. *value is mean and standard deviation is in parenthesis, number of replicate = 2

The enthalpy change for native and modified starches were in the order SPS > PPS > APS. This trend also was seen with their dispersion in mucilage as seen in Table 5.0 with a increase in ΔH as the mucilage concentration increases. Enthalpy change is an indicator of a loss of molecular order within the granules, which increases with a decline of the degree of starch crystallinity (Tester and Morrison, 1990). Fasihuddin and Williams (1999) studied the effect of sugars on the thermal and rheological properties of sago starch. They found that sugars increased the gelatinization temperature and the gelatinization enthalpy. They discussed the effects in terms of the anti-plasticizing effect of sugars compared with water, the influence of sugar–starch interactions, and also the effect of sugars on water structure. Ahmad and Williams (1999) explained the influence of the sugars on the structure of the dispersions in terms of inhibition of chain organization.

The syneresis of gels prepared from starches was measured as amount of water released from gels during storage (up to 7 days) at 40^{o}C. The result as seen in Fig 2,3 and 4 shows that syneresis for native and modified starches were in the order APS > PPS > SPS. Singh *et al* (2004) reported that the low amylose content might have caused less syneresis of the starch during the gel formation and resulted in weaker gel structure. In all starch samples, there was an increase in syneresis with increase in mucilage concentration. Miles *et al* (1985) attributed the initial gel firmness during gelation to the formation of amylose matrix gel and the subsequent slow increase in gel firmness to Amylopectin recrystallization.

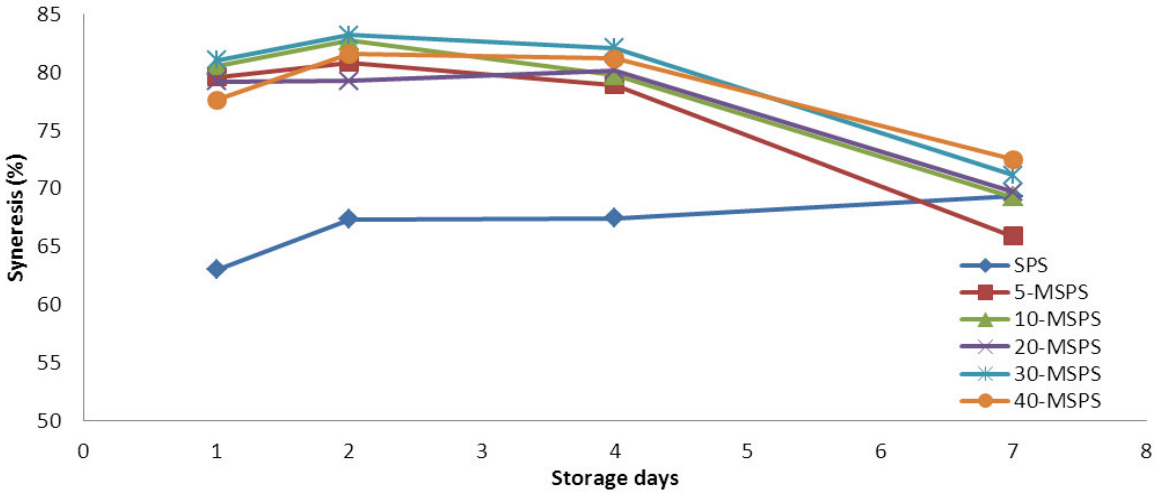

Fig. 2.0: Effect of mucilage on the retrogradative property of starch obtained from *ipomoea batatas*

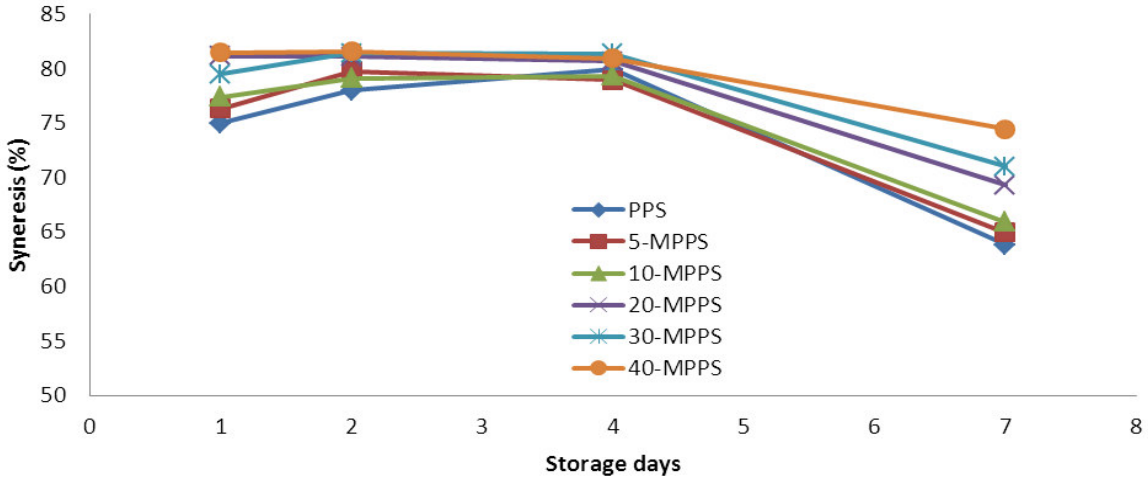

Fig. 3.0: Effect of mucilage on the retrogradative property of pregelatinized starch obtained from *ipomoea batatas*

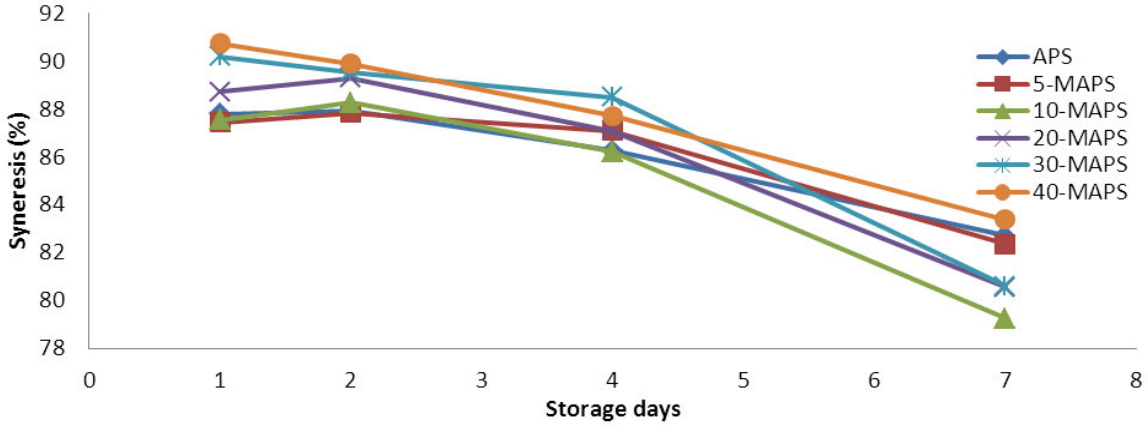

Fig. 4.0: Effect of mucilage on the retrogradative property of acid modified starch obtained from *ipomoea batatas*

However, studies on the effect of sugars on starch recrystallization have been conflicting and inconclusive. Various studies reported that certain sugars could retard (I'Anson *et al*., 1990; Katsuta *et al*., 1992a, Slade & Levine, 1987) or accelerate starch recrystallization (Chang & Liu, 1991; Germani *et al*., 1983; Hoover & Senanayake, 1996; Prokopowich & Biliaderis, 1995; Ward *et al*., 1994). This could imply that sugars can behave differently, possibly depending on the host system and storage conditions. In fact, many of the above studies emphasized that sugars may be used either as plasticizers, like water, affecting the thermal transitions of

starch, or as water immobilizers that reduce the mobility of water in the host system Generally, native starch showed an increase in syneresis with time while both modified starches and all dispersions showed a decrease in syneresis.

Conclusion

Modification of native starch obtained from *ipomoea batatas* into pregelatinized and acid modified forms showed an increase in parameters such as pasting temperature, gelatinization temperature and syneresis in the order APS > PPS > SPS and a decrease in peak viscosity and enthalpy of gelatinization in the order SPS > PPS > APS. Subsequent dispersions in mucilage showed a similar trend as described above with increased in pasting, gelatinization and syneresis and decrease in peak viscosity and enthalpy as the mucilage concentration increases. The influence of mucilage and modification on the thermal and pasting properties may be useful for modifying *ipomoea batatas* starch based food products in terms of product texture and process development.

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