ACETYLATION AND CHARACTERIZATION OF THREE CULTIVARS OF UNRIPE PLANTAIN *(Musa species)* STARCH

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Abstract: *Three cultivars of mature unripe plantain (giant horn, agbagba, French horn), consumed in Nigeria had their native starches extracted, and chemically modified by acetylation. Acetylated and native starches were evaluated for physicochemical and pasting and functional properties. Moisture content (MC), ash content (AC), amylose content (AMC) and blue value (BV) of native starches ranged between (10.6 and 12.8%), (0.02 and 0.04%), (17.23 and 22.38%), (0.21 and 0.29nm) respectively. For native plantain starches Functional property values obtained ranged as follows solubility (1.50 and 2.50%), swelling power (SP) (5.58 and 8.15g/g), bulk density (BD) (0.79 and 0.82g/ml), water absorption capacity (WAC) (60.45 and 68.50%). Acetylation treatment was observed to cause a significant difference (P<0.05) between the mean scores, for physicochemical and functional properties of plantain starches. Acetyl and degree of substitution of acetylated starches ranged between (2.05 and 7.20%), (0.08 and 0.28) respectively. Acetylated starches functional properties such as solubility, SP, BD and WAC of acetylated starches ranged between (2.50 and 4.50%), (8.23 and 9.29g/g), (0.73 and 0.78g/ml), (81.50 and 86.50%) respectively. Acetylation significantly (P<0.05) reduced the peak, trough, breakdown, final, setback viscosity and pasting temperature of the three cultivars of plantain starches in this study, but increased the peak time.*

Keywords: Plantain, cultivars, starches, Acetylation, acetylated, unacetylated.

INTRODUCTION

Plantain is an important dietary staple food widely grown in coastal areas of Nigeria and many West African countries. It belongs to the genus *Musa* in the family of *Musaceae* and it is consumed at various stages of ripeness after maturity. It is widely cultivated in several tropical and subtropical countries of the world. Consumption and utilization of plantain ranks third position after that of yam and cassava for sustainability in Nigeria (Akomolafe & Aborisade, 2007). A significant percentage of the Nigerian population consumes plantain as a dietary staple, to satisfy their carbohydrate/starchy food energy requirements. Plantain is usually eaten raw when mature and ripe. It could also be boiled, roasted, fried, or processed into flour. Traditionally the flour is prepared from unripe plantain after cutting into thin slabs and drying, followed by milling to obtain flour. Flour is as an intermediate product which is more shelf stable. The flour can be made into a gruel/ dough, by mixing the flour with appropriate quantity of boiling water and stirring vigorously to

gelatinize it to form thick dough (Mepba *et al.,* 2007) and eaten with stew. Adeniji *et al.,* (2006) reported, mature plantain pulp to be rich in nutrients such as iron, potassium and vitamin A, but low in protein and fat. Consumers relish eating the dough with assorted soup or stew based on their preferences. Mature unripe plantain is particularly consumed as a functional food by diabetic patients because of its low glycemic index to reduce postprandial glucose level. Most ripe plantain foods are however eaten boiled, fried or roasted. Increased consumption of carbohydrate-rich diets with high glycemic index has been reported to predispose individuals to diabetes and obesity (Oboh & Erema, 2010). Starch a major dietary component of plant carbohydrate foods, in all human populations is as a biopolymer that constitutes an excellent raw material to modify food texture and consistency (Bello-perez *et al.,* 2000; Biliaderis, 1991) and functional properties. In Nigeria and many other countries of the world striving to achieve food and Nutrition security, the main purpose of starch utilization in foods is nutritional rather than aesthetic. Native starches have been used as functional ingredients in different food products to promote certain desirable effects such as thickening, gelling, and to prevent retrogradation. Advancement in the frontiers of science has made modification of starches possible to obtain more precise and diverse desired effects for various food and industrial purposes. Modification of starches from their native form is a treatment usually applied to alter the natural characteristics of the starches to produce value added starches to meet specific demands and needs of the industry. There are many ways to achieve modification of starches depending on the intended objectives. Some could be physical while others could be chemical or hybrid methods.

Acetylation is a chemical modification treatment applied to starches for esterification, in which the hydroxyl groups are replaced with acetyl groups, that offers resultant starches major stability, thus changing the physicochemical and functional properties of resultant starches. Adeoya (2015) reported that it is important to study acetylation of food and industrial starch matrixes for possible substitution / replacement of expensive commercially available starches presently used in the food industries especially from potatoes. Extensive literature surveys have revealed limited information on the effects of using acetic anhydride to modify starches of plantain cultivars and the properties of modified starches obtained thereof.

The aim of this study is to extract and chemically modify native plantain starches from selected plantain cultivars grown in Nigeria using acetic anhydride, and then investigate changes in the functional, pasting and physicochemical properties of resultant modified starches due to acetylation and compare them with the native starch samples. This is to determine its potential to obtain sustainable alternative sources of modified starches in food systems and reduction in postharvest losses and to enhance the applicability of plantain germplasm.

2. MATERIALS AND METHODS

Source of Materials

Three cultivars of mature unripe plantain (giant horn, agbagba, French horn), commonly consumed in Nigeri*a* were purchased from International Institute of

Tropical Agriculture in Oyo Ibadan Nigeria. Analytical grade reagents such as Acetic Anhydride was purchased in a chemical market in Ojota, Lagos, Nigeria.

Starch Extraction

To achieve starch extraction, mature unripe plantain fingers of respective cultivars (giant horn, agbagba, French horn), were peeled, cut and washed manually with the aid of a stainless steel kitchen knife. The pulp was cut into thin slabs of uniform slices; wet milled using an attrition mill, sieved with the aid of a muslin cloth. The muslin cloth permeates (starch matrix) was allowed to settle. Water was decanted from the sediment slurry, to obtain starch. Drying followed in a laboratory scale air draught oven at 60 $\pm$ 2^0C for 48hours.

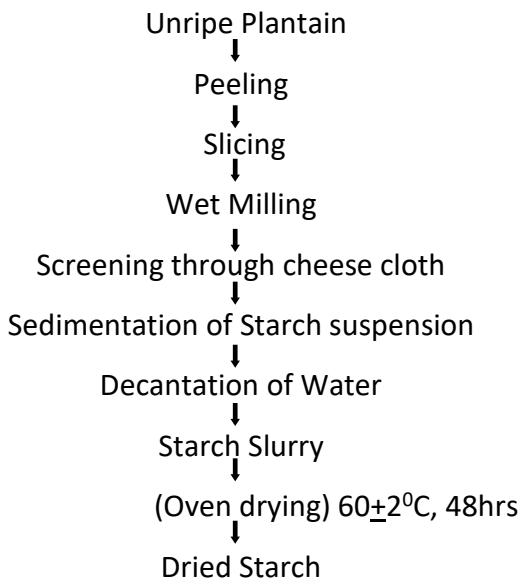

Figure 1: Process flow chart showing procedure for extraction of starch from mature unripe plantain

Starch Acetylation

Starch was acetylated using the method described by Huang et al., (2005) to chemically modify plantain starch. The starch was dispersed in distilled water (45mL) and stirred vigorously for an hour to make slurry. Analar grade 3% Sodium hydroxide (NaOH) solution was added in drops to adjust the pH to 8.0. Analar grade. Acetic Anhydride (AA) (11.6mL) was added in drops to the mixture, while the pH kept at pH 8.0-8.3 with 3%. NaOH solution, and kept for 10min for proper reaction. The mixture was adjusted to pH 4.5 with Analar grade 0.5M Hydrochloric Acid (HCl), and washed twice using distilled water. It was dried in an electric oven for 24hrs at 60^0C.

Moisture Content:

The moisture content was determined using the AOAC (2005) method. 2g of starch (native and acetylated respectively) was accurately weighed into a previously dried and weighed crucible. This was placed in a controlled drying oven at 105^0C for 3h. The crucible was removed, cooled in a desiccator and weighed. The moisture content was determined in triplicates.

$$\% \text{ moisture} = \frac{\text{weight moisture in sample}}{\text{Weight of sample before drying}}$$

Ash content determination: This was determined by the standard procedure described by (AOAC, 2005). 5g of the sample was weighed into an empty crucible of a known weight. The sample was then transferred into the muffle furnace set at 600^0C for about 6 hours for it to ash. The crucible and the content were then allowed to cool at about 100^0C in the air, and room temperature in the desiccator.

$$\% \text{ Ash} = \frac{\text{weigh ash in sample}}{\text{Weight of sample}}$$

Acetyl Percentage and Degree of Substitution

The percentage of acetylation (% acetyl) and degree of substitution were determined titrimetrically according to the procedure described by (Bello-Perez, 2002; Sodhi and Singh, 2005). 1gram of Acetylated starch was placed in a 250ml flask and 50ml of 75ml/100mL ethanol in distilled water were added. The loosely stoppered flask was agitated, warmed to 50^0C for 30mins, cooled and 40ml of 0.5mol/L KOH was added. The excess alkali was then back titrated with 0.5mol/L HCL using phenolphthalein as an indicator. A blank using the original unmodified starch was used.

Acetyl (%)

$$\frac{(\text{Blank (ml)} - \text{Sample (ml)}) \times \text{Molarity of HCL} \times 0.043 \times 100}{\text{Weight of sample}}$$

Degree of substitution (DS) is defined as the average numbers of sites per glucose unit that possess a substituent group.

$$\textbf{DS} = \frac{(162 \times \text{Acetyl \%})}{(4300 - \{42 \times \text{Acetyl}\})}$$

Amylose Content

Amylose content was determined according to the method described by Sobukola and Aboderin (2012). 0.1g of starch was weighed into a 100ml volumetric flask. 1ml of 99.7% - 100 (v/v) ethanol and 9ml of 1N NaOH was carefully added and the mouth of the flask was covered with a foil and the content mixed properly. The sample was heated for 10min in a boiling water bath to gelatinize the starch (timing started when boiling began). The sample was then removed from the water bath and allowed to cool very well. It was then topped to mark with distilled water. Absorbance value (A) was determined from the reading of the spectrophotometer (CamSpec 106 model, USA) at 620nm wavelength. The blank contained 1ml of ethanol, 9ml of 1M NaOH, then boiled and topped up to the mark with distilled water. 5ml was then pipetted into a 100ml volumetric flask. 1ml of 1N acetic and 2ml of iodine solution was added to top up the mark.This was used to standardize the spectrophotometer at 620nm. It was then calculated as shown below: Calculation: Amylose content (%) = (3.06) (A) (20); where A = absorbance value

Blue Value

The method described by Nwokocha and Ogunmola (2014) was used to determine blue value in this study. 1g dry starch sample was weighed into a boiling test tube. 1ml ethanol (95%) was added, followed by 9ml of 1M NaOH solution and heated in boiling water to solubilize the starch. The starch solution was cooled and quantitatively transferred into a 100ml standard volumetric flask and the volume made up to 100ml mark with distilled water. 2.5ml of starch solution was put into 50ml standard flask. 0.5ml of 1M acetic acid was added followed by 1ml stock iodine (0.2g I_2/2.0g KI/100ml) and the solution made up to 50ml mark with distilled water. The resulting colour was left for 20min to allow for full development of colour, before reading the absorbance value at 620nm on a Spectrophotometer (CamSpec 106model, USA). Iodine solution of same concentrationas above but without strarch sample was used in the reference cell. Starch Iodine solution complex was monitored visually. The blue value was calculated according to the method of

Gilbert and Spragg (1964) using the formula.

Blue Value = $\frac{\text{Absorbance 620nm X 4}}{\text{Concentration (mg/dl)}}$

Swelling power and solubility determination:

This was carried out with a slight modification on the method described by Oladele and Aina (2007). 1g of unripe plantain starch was mixed with 10ml of distilled water in a centrifuge tube and was heated at 80^0C in a thermostatically controlled water bath for 30min with constant stirring. The tube was then removed, wiped dry on the outside and cooled to room temperature. It was centrifuged for 15min at 2200rpm. The solubility was determined by evaporating to dryness the supernatant and weighing the residue. The sediment paste was weighed and the percentage solubility and swelling power calculated.

Swelling power – $\frac{\text{weight of swollen sediment x 100}}{\text{Weight of dry starch}}$

Solubility = $\frac{\text{weight of dry supernatant x 100}}{\text{Weight of starch sample}}$

Determination of water absorption capacity

Water absorption capacity of starch from plantain was determined according by the method of Beuchart's (1977). 1g of sample was mixed with 10ml of distilled water for 30secs. The sample was allowed into stand at ambient temperature for 30secs and centrifuged at 300rpm for 30minutes. The supernatant was decanted and the weight of the tube taken.
The water absorption capacity was then calculated as
WAC = final weight of sample after centrifuge with sample – weight of tube before with sample

Bulk Density:

The method described by (Oladele and Aina, 2007) was used for the determination of bulk density. 50g of plantain starch was put into 100ml measuring cylinder. The measuring cylinder was then tapped continuously on a laboratory table until a constant volume was obtained.

Determination of Pasting Properties

The pasting property of the plantain starch samples was determined by using Rapid ViscoAnalyser (RVA TEST MASTER, Newport scientific, Australia). Starch (4g, 14% b) was weighed directly in the aluminum RVA sample canister, and distilled water was added to a total weight of 28g. The samples were held at 50^0C for 1min heated to 95^0C in 3.7min, held at 95^0C for 2.5min and holding at 50^0C for 2min, viscosity profile indices were recorded. The pasting temperature (P. temp); peak viscosity (PV); Hot paste viscosity (HPV); Cool Paste Viscosity (CPV); Breakdown (BD), Setback (SB). HPV = minimum viscosity at 95^0C, CPV = final viscosity at 95^0C, CPV = final viscosity at 50^0C, BD = PV-HPV and SB = CPV-HPV

RESULT AND DISCUSSION

Moisture Content

The moisture content of starch as shown in table 1 shows the amount of moisture present in the starch. The moisture content of the three varieties of plantain studied in their native form was within the recommended value of below 14% (Austin, 1984). Native French horn variety of plantain had the lowest values of moisture content (10.6%), while Native giant horn had the highest moisture content of 12.8%. These results are similar to that earlier reported by (Daramola and Osanyinlusi, 2006) in the study of preliminary quality evaluation of selected plantain flour *(Musa spp)* sold in Port Harcourt Market, Nigeria. Moisture content values in acetylated starches were higher than those obtained in native starches. Moisture content values of acetylated French horn variety of plantain had the lowest values for moisture content when compared to acetylated agbagba and acetylated giant horn varieties of plantain. By implication acetylated French horn should have better keeping qualities compared to other acetylated Agbagba and acetylated false horn. The moisture content of any food is an index of its storage stability. The higher the moisture content, the more the food is predisposed to spoilage. A low level of moisture ensures good shelf life.

Ash Content: Ash content of a sample is the non-volatile inorganic matter of a compound which remains after subjecting it to a high decomposition temperature. During heating, the organic compounds are decomposed or released leaving behind the residue which consists mainly of other organic matter. The ash content can be considered an indication of clean processing and is also used as an index to determine adulteration. Modification of plantain starches by acetylation decreased the ash content of the three varieties with acetylated French horn having the least ash content. This indicates modification by acetylation produces better starches. Ash content in acetylated starch ranged between (0.01 and 0.02%) while that of the native starch ranged between (0.02 and 0.04%). This result is similar to the earlier result obtained in a study by Bello Perez *et al.,* (2000).

Acetylation Percentage and Degree of Substitution: Acetyl percentage and Degree of substitution (DS) is defined as average number of sites per glucose unit that possess a substituent group Whistler and Daniel (1995). Acetyl percentage and degree of substitution in table 1 ranged from (2.05 to 7.20%) and (0.08 to 0.28) respectively. Acetyl percentage and degree of substitution are usually classified as low (<0.1) and medium (0.1-1.0), the results obtained from this this study is higher than the one earlier reported by Bello-Perez *et al*., (2000). Acetylated starches with low DS are usually find application in food industries as agents of texture, consistency and stability in foods. They are currently being studied for their suitability in the development of novel biodegradable packaging and pharmaceutical application.

Amylose Content: Amylose is a helical polymer made of α-D-glucose units, bound to each other through α, 1 - 4 glycosidic bond. Modified starches contained higher amount of Amylose than their native starches as shown in table 1. Amylose content value ranged from (18.72 to 24.32) % for acetylated plantain starches and (17.23 to 22.38) % for the native starches. Amylose and Amylopectin are considered as most important factors that influence the functional properties of starch. Starch with high amylose content will show high volume expansion and a high degree of flakiness. On the other hand starch foods prepared with less amylose content, becomes moist, sticky and hard to chew as reported by Kamakar *et al.*, (2014).

Blue Value: Higher blue values were obtained for acetylated starches, it ranged from (0.22 to 0.36mm) than their native starches ranged from (0.21 to 0.29mm). This result is similar to the findings observed in the study of Bello-Perez *et al*., (2000). Acetylated French horn cultivar of plantain had the highest blue value amongst the cultivars in this study. This indicates higher value of apparent Amylose content in the modified starches. Whistler and Daniel (1995) reported that, the presence of some acetyl group interferes with the regrouping of amylose and amylopectin during the cooling of the starch. These results in the generation of linear segments which ease the absorption of higher amount of iodine, reflected in the Amylose content determined.

Pasting Properties

Table 2 shows the result of the pasting properties of both modified and native plantain starches. Pasting properties describe the behavior of starch and starch-based products during heat processing in the presence of water. From results obtained in this study, acetylation as a treatment reduced the paste viscosities and pasting temperature of plantain starches compared to their native starches except for peak time. The structural differences in native and acetylated samples explain the rheological characteristics in both native and acetylated starches (Sanchez-Rivera,2013). Significant difference ($P<0.05$) was observed for viscosity parameters (peak, breakdown, final viscosity and setback). Native starches had the higher paste viscosities compared to their acetylated starches. This trend was however different for peak time where there were similarities in mean score for peak time among the samples in this study. The Peak, trough, breakdown, final and setback viscosities for acetylated starches had the following range of values (233.4 - 261.5) RVU, (215.8 - 247.4) RVU, (14.1 - 85.0) RVU, (356.4 - 392.3) RVU and (140.5-150.4) RVU respectively. For the native starches, the mean scores for Peak, trough, breakdown, final and setback viscosities ranged between (245.6 - 378.8) RVU, (256.3- 329.3) RVU, (16.4 - 122.4) RVU, (451.8 to 579.0) RVU and (195.6 to 249.8) RVU respectively. The reduced value of

paste viscosities for acetylated plantain starches compared to its native starches is similar to the findings of Olatunde *et al.* (2017). The pasting temperature gives an indication of the temperature at which starches would be cooked, to ascertain the stability of its gel (Sannie *et al.,* 2005). Pasting temperature for acetylated varieties were within the range (80.8 to 81.6^{o}C) and the native starches pasting temperatures were within the range (81.6 to 82.8^{o}C). The results in this study are however is lower than values obtained by Abioye *et al.,* (2011) in their study. The peak time which is the time required for starch granules to reach the highest paste viscosity during heating had values ranging from (5.87 - 7.00) min and (4.74 - 5.73) min for acetylated and native plantain starches respectively.

Bulk Density: Bulk density values for acetylated starches ranged between (0.73 and 0.77g/ml), while that for native starches ranged between (0.78 and 0.82g/ml) as shown in table 3. These values are comparable to that obtained for sweet potato powder (0.745g/ml), used as thickener or base in yoghurt (USDA 2009). Acetylated agbagba was observed to give the lowest values for bulk density. Low density starches are particularly desirable in preparation of infant and weaning food. Stoiceska *et al.,* (2009) reported that bulk density is an important parameter in powdered foods and is highly correlated to the moisture content of products during extrusion. Bulk density is a functional property, measures the heaviness of starch (Oladele & Aina, 2007). It is an important parameter that determines the packaging requirements of a product. Increase in bulk density is desirable in that it offer a greater packaging advantage as greater quantity may be packed within constant volume (Molina *et al.,* 1983). Bulk density determines flow and compaction behavior of products and dry mixes. It varies with the fineness of the particles. Acetylation as a treatment was observed to reduce the bulk density of native starches in the three cultivars of plantain starch in this study.

Water Absorption Capacity (WAC): WAC was found to be significantly different ($P \leq 0.05$) among all cultivars studied. The values for acetylated and native starches obtained in this study were within the following ranges (81.50 - 86.50) % and (60.45 - 68.50) % respectively. Water absorption capacity values obtained for acetylated starches were higher compared to their native starches in this study as shown in Table 3. Water absorption capacity is important in the food system in terms of water interaction with proteins and enhancing flavor, texture of the food and baking properties. This is important in determining the quality and texture of some food products because it stabilized them against effects such as syneresis which occur during

retorting and freezing (Wooten and Bamnuaruchi, 1978).

Solubility and Swelling Power: Table 3 shows the result for solubility of starches: acetylated plantain starch (2.50 to 4.50) %, native starches (1.50 to 2.50) % respectively. Swelling power values for acetylated (8.23 to 9.29g/g) and for native starches (5.58 to 8.15g/g) respectively. Solubility and swelling power were observed to be higher in value for acetylated starches compared to their native starches. Swelling power values obtained in this study among different cultivars of plantain samples is similar to that reported by Akpa and Dagde (2012), in their study on modification of cassava starch for industrial uses. Solubility is the ability of starch to dissolve into a solvent e.g. water. When an aqueous suspension of starch is heated as the temperature increases and exceeds gelatinization temperature, the starch granules become weakened and intermolecular bonds of the starch molecule become weakened and the intermolecular bonds of the starch molecule become distorted. Distortion allows water molecule to become more attached to the starch molecules thus causing swelling of the starch granules. The starch continues to swell as they absorb more water. (Gunaranntne and Corke, 2007). The observed increase in solubility infers better dispersion of the starch in aqueous systems, because acetyl group obstruct chain association. The modification by acetylation also increased its swelling power which may be explained by introduction of hydrophilic substituting groups allowing the retention of water molecules because of the ability to form hydrogen bond.

Table 1. Physicochemical Properties of Acetylated and Native starches from three cultivars of unripe plantain.

Samples	Moisture Content (%)	Ash Content (%)	Amylose Content (%)	Blue Value (nm)	Acetyl (%)	Degree of substitution
PA	15.40±0.10^{f}	0.02±0.00^{a}	24.32±0.01^{f}	0.27±0.01^{c}	7.20±0.01^{d}	0.28±0.01^{d}
PAC	11.10±0.10^{b}	0.03±0.00^{b}	22.38±0.01^{e}	0.24±0.01^{b}	ND	ND
PB	11.50±0.10^{c}	0.01±0.01^{a}	20.42±0.01^{d}	0.36±0.01^{e}	2.05±0.01^{b}	0.08±0.01^{b}
PBC	10.60±0.10^{a}	0.02±0.00^{a}	17.23±0.01^{a}	0.29±0.01^{d}	ND	ND
PC	14.50±0.10^{e}	0.02±0.00^{b}	18.72±0.01^{c}	0.22±0.01^{a}	4.50±0.01^{c}	0.21±0.01^{c}

PCC	12.80±0.10^{d}	0.04±0.00^{c}	17.51±0.01^{b}	0.21±0.01^{a}	ND	ND

Values are means of duplicate samples ± SD, Means of samples with different superscripts are significantly different (P<0.05). PA = Acetylated Agbagba, PAC = Native Agbagba, PB = Acetylated French horn, PBC = Native French Horn, PC = Acetylated giant Horn, PCC = Native gaint Horn, ND = Not detected

Table 2. Pasting properties of Acetylated and Native starches from three cultivars of unripe plantain.

Test	Peak 1 (RVU)	Trough 1 (RVU)	Breakdown (RVU)	Final Viscosity (RVU)	Setback (RVU)	Peak Time (min)	Pasting Temp (^{0}C)
PA	237.7±0.71^{b}	215.8±0.71^{a}	21.9±0.71^{d}	356.4±0.71^{a}	140.5±0.71^{a}	5.87±0.01^{cd}	80.8±0.07^{a}
PAC	356.0±0.71^{e}	281.8±0.71^{e}	77.8±0.71^{e}	512.5±0.71^{e}	230.8±0.71^{e}	5.07±0.01^{ab}	83.2±0.07^{c}
PB	261.5±0.71^{d}	247.4±0.71^{c}	14.1±0.71^{b}	392.3±0.71^{c}	145.0±0.71^{b}	6.50±0.71^{de}	81.6±0.07^{b}
PBC	245.6±0.71^{c}	329.3±0.71^{f}	16.4±0.71^{c}	579.0±0.71^{f}	249.8±0.71^{f}	5.73±0.01^{bc}	82.8±0.64^{c}
PC	233.4±0.71^{a}	225.1±0.71^{b}	85.0±0.71^{a}	375.5±0.71^{b}	150.4±0.71^{c}	7.00±0.07^{e}	81.6±0.07^{b}
PCC	378.8±0.71^{f}	256.3±0.71^{d}	122.4±0.71^{f}	451.8±0.71^{d}	195.6±0.71^{d}	4.74±0.01^{a}	81.6±0.07^{b}

Values are means of duplicate samples ± SD, means of samples with different superscripts are significantly different (P<0.05). PA = Acetylated Agbagba, PAC = Native Agbagba, PB = Acetylated French horn, PBC = Native French Horn, PC = Acetylated giant Horn, PCC = Native gaint Horn

Table 3. Functional Properties of Acetylated and Native Starches from three cultivars of unripe plantain.

Samples	Bulk Density (g/ml)	Swelling Power (g/g)	Solubility (%)	WAC (%)
PA	0.73±0.01^{a}	9.29±0.01^{e}	2.50±0.71^{ab}	84.55±0.07^{e}
PAC	0.82±0.01^{e}	8.15±0.01^{c}	1.50±0.71^{a}	66.50±0.71^{b}
PB	0.78±0.01^{c}	8.23±0.01^{c}	3.45±0.07^{bc}	81.50±0.71^{d}
PBC	0.79±0.01^{cd}	5.58±0.01^{a}	2.50±0.71^{ab}	68.50±0.71^{c}
PC	0.75±0.01^{b}	9.16±0.01^{d}	4.50±0.71^{c}	86.50±0.71^{f}

PCC	0.80±0.01[d]	6.05±0.07[b]	1.50±0.71[a]	60.45±0.07[a]

Values are means of duplicate samples ± SD, Means of samples with different superscripts are significantly different (P<0.05). PA = Acetylated Agbagba, PAC = Native Agbagba, PB = Acetylated French horn, PBC = Native French Horn, PC = Acetylated giant Horn, PCC = Native gaint Horn, WAC = Water absorption capacity

CONCLUSION AND RECOMMENDATION

Conclusion

The modification of plantain starches (Agbagba, Giant horn and French horn) cultivars through acetylation significantly ($P \leq 0.05$) increased their water absorption capacities (stability against the effects such as syneresis), solubility (enhance digestibility), moisture content (though limit the application of the starch storage for a long time), amylose content (shows gelling properties), acetyl percentage and degree of substitution but significantly ($P \leq 0.05$) reduced. Native plantain starches of cultivars used in this study were characterized by relatively lower moisture, amylose, water absorption capacity, swelling power and solubility. Higher paste viscosities of native starches suggest good behavior of such native starches and their products during heat processing. Considering these properties, acetylated plantain starches has potentials of good application in canned foods, infants and weaning foods, manufacturing of thermoplastic foods. Acetylation of plantains starches is important for modifying starches industrially to create a variety of reliable raw material for sustainable development.

Recommendation

Further studies should be conducted to determine the effect of varying the concentration of alkaline solution (NaOH) on the acceptability of acetylated products especially if the acetylated starch would be used in food formulations for children. Evaluation should be carried out on the three cultivars of acetylated plantain starches and to ascertain how amenable they are to different food and industrial applications and consumer acceptance of such products.

Competing Interest statement

The authors declare that there are no competing interests.

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