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Effect of maturation and pretreatment on the physicochemical properties of plantain flour

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ABSTRACT

Plantain (*Musa spp*.) is an important dietary source of carbohydrate in the humid tropical zones of Africa, Asia and South. Although there are reports on the physical, chemical and microbiological properties of plantain flour, little or no information is available on the effects of maturity time and pretreatment on the physicochemical properties of the flours. Thus, to promote and enhance the use of plantain flour, it is necessary to determine the physicochemical properties of the flour. Green Horn cultivar of fresh plantains was harvested at different periods of maturity from week 9 to 13 at Federal University of Technology Owerri university farm. The different batches were washed, peeled and cut into slices of 1cm thickness. Each batch of the sliced plantain was blanched, treated with citric acid, sodium metabisulphite, and milled into flour. The untreated plantain flour sample was used as control. Results showed no significant differences in the oil absorption capacity gelling point and bulk density of the flour samples, irrespective of the maturity time and pretreatment. However, there were significant differences in the water absorption ($p<0.05$) with the blanched sodium metabisulphite-treated sample, having the highest value of 2.74 g/g. Also, in the swelling index ($p<0.05$), the 13th week blanched sample had the highest value of 3.76 mL/mL. Irrespective of time of maturity, higher pH values were recorded for flours treated with sodium metabisulphite and blanched with values ranging from 6.87 - 7.54. Maturity time and different preheat treatments could be exploited for the development of multipurpose plantain flour.

KEYWORDS

Plantain;
Pretreatment;
Maturity;
Physicochemical.

INTRODUCTION

Plantain (*Musa spp*.) is an important dietary source of carbohydrate in the humid tropical zones of Africa, Asia and South America[15]. Plantain is rich in vitamins A, C and B group as well as minerals such as calcium and iron[15]. Plantain provides between 9% and 35% of the total calories in the diets of more than 14 million people in sub-Sahara Africa[15]. Usually, harvested at a mature but unripe stage, plantain ripens within 2–7 days, making it highly perishable crop particularly in the over-ripe stage. FAO data sources put the world production of plantains at about 60 million tons[8]. In West Africa, plantain production increased at an average annual rate of between 2.3% and 2.6%[8]. Despite the huge tonnages of plantains harvested worldwide, there are certain problems that limit the availability of plantain. Robinson[15] showed that fresh plantain could be preserved by the use of chemical preservatives, controlled or modified atmosphere. However, these technologies are not utilised, because agricultural production of plantain is mainly by small-holder farmers that may find the technologies not economically feasible. Plantain may be processed into many products at different stages of physiological maturity; unripe, ripe, overripe or in a number of ways such as frying, grilling, boiling and drying. According to Demirel and Turhan[5], drying adds value to banana in addition to preservation. Moisture removal from plantain seems to be an appropriate and economical means of preserving Musa spp, resulting in shelf stable and convenience products. Currently, unripe plantain flour is being processed into a thick paste product known as 'amala', which is medically recommended for diabetic patient[2]. Ripe banana powder is used in bakery and confectionery industries, in infant diets and the treatment of intestinal disorders[2]. Sun and oven-drying methods have been used for drying of plantain and banana[4,5] with some success. Although some reports exist on the physical, chemical and microbiological properties of plantain flour, there's little or no information on the effects of pretreatment and drying time on the physicochemical properties of plantain flours. Thus, to promote and enhance the use of plantain flour, it is necessary to characterise the physico-chemical properties of the flour. The objectives of the study were to determine the effects of maturity time and pretreatment on the physicochemical properties of plantain flours.

MATERIALS AND METHODS

Cultivars of fresh mature plantains were obtained from the FUTO Farms Limited. Harvesting was done at different periods of anthesis ranging from week 9 to 13. The different batches were washed, peeled and cut into slices of 1cm thickness. Each batch of the sliced plantain was given the following pretreatment as presented in TABLE 1.

TABLE 1 : Pre-treatments and procedure

Pre-treatment	ID code	Pre-treatment solution
Control	CN	-
Blanched	BL	3 min in boiling H_2O3 min in boiling H_2O
Citric acid	CA	3 min in CA
Na metabisulphite	KM	5% $Na_2S_2O_5$ (5 min)
Blanched + Na metabisulphite	BLKM	BL +5% $Na_2S_2O_5$ (5 min)
Blanched + Citric acid	BLCA	BL + CA

Production of unripe plantain flour

Unripe plantains at different stages of maturity (stages 9th,10th, 11th,12th and 13th week) were cleaned, peeled and sliced to 1cm thickness using a slicer. The slices were dried using a solar dryer and sun drying. The dried samples were milled into flour and screened through a 100μm sieve and packaged in hermetic glass containers and stored at room temperature for further use.

ANALYSIS OF PLANTAIN FLOUR

Determination of bulk density

The bulk density of a powder is the weight of the powder divided by the volume it occupies as determined by Falade & Omojola (2008), normally expressed as kg/ m^3.

Water and oil absorption capacity determination

Water and oil absorption capacity was determined according to the method of Beuchat (1977).

Swelling index determination

Swelling power and solubility of the plantain flours were determined according to the method of Svarovsky[17] 1 g of dried and milled sample was weighed into 100 mL conical flask. Subsequently 15 ml of distilled water was added and it was shaken for 5

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min at low speed using a vortex mixer. The sample was transferred into water bath and heated for 40 min at 80– 85^{0}C with a constant stirring. The sample was then transferred into pre-weighed centrifuge tube and 7.5 ml of distilled water was added. It was centrifuged at 220rev/min for 20 min. The supernatant was carefully decanted into a pre-weighed can and dried at 100 _C to constant weight. The difference in weight of the evaporating dish was used to calculate starch solubility. The precipitate was weighed with the centrifuge tube. To calculate the swelling power, the weight of residue was divided by the original weight after solubility subtraction. Analysis was conducted in triplicate.

Determination of wettability of plantain flour

Wettability describes the capacity of the particles to absorb water on their surface, thus initializing reconstitution. About 3 g of dried plantain was placed around a pestle inside a funnel so that the pestle blocks the funnel opening. Then, the pestle was lifted to allow the power to flow through the stem into a beaker of water. As soon as all the powder has flowed into the beaker of water, a stop watch was started and the time(s) it took a sample of plantain powder to be completely wetted by water was determined.

Determination of pH

30g of plantain pulp juice was weighed which was obtained by blending 30 g of plantain with 90 ml of distilled water. The pH electrode was washed with distilled water. The electrode was placed in the filtrate. The electrode was allowed to stabilize for few moments. The pH value of the filtrate was taken after then[1].

Determination of gelling point

5g of the sample was dispersed in different chemicals in 250ml and made up to 500ml flour suspension. A thermometer was clamped on a retort stand with its bulb submerged in the system heated with a mantle. The heating and stirring is continued until the suspension begins to gel and the corresponding temperature was recorded.

Impact of maturity and pretreatment on physico-chemical properties of plantain flour

Oil absorption

The Oil absorption capacities of the pretreated samples were all higher than the control, for all the week of maturity (TABLE 2). However, there were no significant differences ($p<0.05$). Based of this, water absorption can be enhanced by harvesting at the 9th week of maturity and blanching, after treatment with Sodium metabisulphite which a value of 3.297ml/g ; According to Fagbemi[7], good oil absorption capacity of flour samples suggest that they may be useful in food preparations that involve oil mixing like in bakery products, where oil is an important ingredient. The water/fat binding capacity of proteins is an index of its ability to absorb and retain oil, which in turn influences the texture and mouth feel of food products like ground meat formulations, doughnuts, pancakes, baked goods and soups.

TABLE 2 : Mean values of the oil absorption (mL/g) of plantain flours as affected by maturity time and pretreatment

PRE-TREATMENT	MATURITY TIME				
	9th	10th	11th	12th	13th
CONTROL	2.5868^a	3.1841^a	3.1065^a	2.9305^a	3.2837^a
CA	2.8852^a	3.0041^a	2.82^a	2.8646^a	3.1817^a
BL	2.8438^a	2.8930^a	2.8156^a	2.9875^a	3.1135^a
CABL	2.9481^a	2.9918^a	2.8056^a	2.6952^a	2.6304^a
NaM	2.91325^a	3.4292^a	3.0582^a	3.0172^a	3.0241^a
NaMBL	3.29785^a	3.1763^a	2.9379^a	2.8401^a	2.8826^a

Values with the same superscript in a column are not significantly different ($p<0.05$)

Swelling index

The effect of maturity and pretreatment on the swelling power of flour produced from the plantain flours are presented in TABLE 3. Bainbridge *et al.* (1996) stated that good quality starch with high starch content and paste viscosity will have a low solubility and high swelling volume and power. A similar observation was made that the swelling powers were appreciably low. The swelling power may be attributed to the low levels of fat by the plantain. This is because high levels of fat leads to the formation of amylose-lipid complexes that restrict swelling. It might also be due to a more highly ordered internal arrangement of the starch granules as found in yam with a swelling capacity of 9%[16]. The swelling capacity ranged from 1.37% (9th week control) to 3.76% (BL at 13th week) This indicated that BLA pretreatment was effective in increasing the swelling power of the plantain flour.. These values were comparable those reported for soybean fortified yam flour (6.8 - 9.6%) by Jimoh and Olatidoye (2009). Generally the plantain samples showed a better swelling capacity than cassava and this could be because of the small particle size of plantain starch and its highly digestible nature[13]. The variant swelling power could be due to amylose/amylopectin ratio and by the characteristics of amylose and amylopectin in 100 101 terms of molecular weight distribution, degree of branching, length of branches and conformation of the molecules[10].

TABLE 3 : Mean values of the swelling index (mL/mL) of plantain flours as affected by maturity time and pretreatment

PRE-TREATMENT	MATURITY TIME				
	9th	10th	11th	12th	13th
CONTROL	1.37^a	1.43^a	1.625^a	1.73^c	1.805^b
CA	1.655^a	1.50^a	1.57^a	1.83^c	1.785^b
BL	1.855^a	1.855^a	2.915^a	2.155^b	3.76^a
CABL	2.445^a	1.975^a	2.895^b	2.155^b	2.46^b
NaM	1.415^a	2.00^a	1.535^b	1.595^c	1.885^b
NaMBL	1.855^a	2.23^a	2.70^b	2.77^a	2.465^b

Values with the same superscript in a column are not significantly different (p<0.05)

The general observation was that pretreatment and temperature had a significant effect ($p<0.05$) on the bulk density of the three plantain varieties as indicated in TABLE 4. It was also observed that plantain varieties dried at lower temperature had a higher swelling power compared to those dried at higher temperatures except for MBS pretreatment for French Horn; BLA, MBS and CIT pretreatment for False Horn. This general observation can be attributed to the deteriorative effect of high temperature on the molecular conformation of the starch present. This is in agreement with observations made by Muyonga *et al.* (2000).

BULK DENSITY

According to Bhattacharya and Prakash[3], bulk density of foods increases with increase in starch content. Okezie and Bello[14] stresses that high bulk density of food material is important in relation to its packaging. However, according to the results listed in TABLE 4, there were no significant effect ($p>0.05$) of maturity time and pre treatment on the bulk density of the plantain flours. Although there were no significant difference ($p>0.05$) between bulk densities of the plantain flours, the highest bulk density was recorded for CABL at 11th week of maturity. The generally low bulk density of the flours could be an advantage in the formulation of baby foods where high nutrient density to low bulk density is desired.

TABLE 4 : Mean values of the bulk density (g/mL) of plantain flours as affected by maturity time and pretreatment

PRE-TREATMENT	MATURITY TIME				
	9th	10th	11th	12th	13th
CONTROL	0.7126^a	0.756^a	0.7328^a	0.7177^a	0.7504^a
CA	0.6669^a	0.7359^a	0.7424^a	0.7231^a	0.7638^a
BL	0.6988^a	0.7334^a	0.6595^a	0.7482^a	0.6936^a
CABL	0.7115^a	0.7565^a	0.7417^a	0.7329^a	0.6071^a
NaM	0.6757^a	0.6631^a	0.7335^a	0.682^a	0.6375^a
NaMBL	0.7519^a	0.7334^a	0.7265^a	0.6936^a	0.6628^a

Values with the same superscript in a column are not significantly different (p<0.05)

Gelling point

Results in TABLE 5 indicate no significant differences in the gelling point of the flour samples, when compares with the control, for all the week of maturity. Flours made from plantain harvested in the 11th week and treated with citric acid gave the least value of gelling point of 61, while treatment with sodium metabisulphite gave the highest value of 76.

TABLE 5 : Mean values of the gelling point (°C) of plantain flours as affected by maturity time and pretreatment

PRE-TREATMENT	MATURITY TIME				
	9th	10th	11th	12th	13th
CONTROL	68^a	62^a	66.5^a	64^a	60^a
CA	68^a	69^a	61^a	64^a	70^a
BL	59^a	68^a	60^a	67^a	69^a
CABL	64^a	66^a	69^a	65^a	61^a
NaM	68^a	76^a	72^a	56^a	64^a
NaMBL	65^a	68^a	60^a	68^a	60^a

Values with the same superscript in a column are not significantly different (p<0.05)

Water absorption capacity

Water absorption capacity is an indication that particular flour would be useful in food system such as bakery products which require hydration to improve handling characteristics. Giami and Alu[9] assert that water binding capacity of 1.25 g/g and above is an indication of good bakery material. The effect of maturity time and pretreatment on the water binding capacity of flour produced from the plantain is presented in TABLE 6. The water absorption capacity ranged from 0.7635 mL/g (CABL at 11th week) to 2.7744 ml/g (NaM at 10th week).

TABLE 6 : Mean values of the water absorption capacity (mL/g) of plantain flours as affected by maturity time and pretreatment

PRE-TREATMENT	MATURITY TIME				
	9th	10th	11th	12th	13th
CONTROL	2.4548^{a}	2.2434^{a}	2.241^{a}	2.2541^{b}	2.2019^{a}
CA	2.2044^{a}	2.3511^{a}	2.369^{a}	2.7769^{a}	2.6526^{a}
BL	1.0282^{b}	1.0709^{b}	1.0058^{b}	1.4700^{c}	1.13325^{b}
CABL	0.9595^{b}	1.3151^{b}	0.7635^{b}	0.905^{d}	0.7941^{b}
NaM	2.6289^{a}	2.7744^{a}	2.4475^{a}	2.7357^{a}	2.2231a
NaMBL	1.2526^{b}	1.2645^{b}	0.7898^{b}	0.8337^{d}	0.7985^{b}

Values with the same superscript in a column are not significantly different ($p<0.05$)

Lower values could be associated with lower carbohydrate content in these plantain flours whose complex molecule will demand less water during hydrolysis[12]. Higher water binding capacities can also be attributed to loose association of starch polymers in the granules[16] which might not be the case for these plantain flours. High water absorption and swelling capacities have both economic and culinary advantage. It is evident that NaM pretreatment provided the highest water absorption capacity irrespective of maturity time a. The increase in water absorption capacity as a result of NaM pretreatment could suggest possible increase in the level of their incorporation into food formulation like dough in other to improve its handling characteristics and also to maintain freshness of the product.

pH

Assessment of pH in plantain is used primarily to estimate consumption quality and hidden attributes. Acids make an important contribution to the post-harvest quality of the fruit, as taste is mainly a balance between the sugar and acid contents, hence post-harvest assessment of acidity is important in the evaluation of the taste of the flours.

Analysis of variance for pH of the flours produced from different varieties indicated that pH of the flours was significantly affected ($p<0.05$) in 9th and 13th week of maturity but not significant in the other weeks (TABLE 7); this was affected by the time of maturity and the treatments undertaken. The pH values recorded ranged from 5.28 (CABL at 10th week) to 7.625 (NaMBL at 11th week). Emperatríz *et al.*[6] reported values in the range of 4.6 - 6.1 when plantain flours were produced from different dehydration procedures. Dadzie (1998) reported values within the range of 6.0 – 6.5. Deviations from reported values could be attributed to variations in maturity time and pretreatment as well as differences in the morphology of the plantain varieties.

TABLE 7 : Mean values of the pH of plantain flours as affected by maturity time and pretreatment

PRE-TREATMENT	MATURITY TIME				
	9th	10th	11th	12th	13th
CONTROL	6.3^{bc}	6.35^{a}	6.585^{a}	6.075^{a}	5.765^{c}
CA	6.895^{ab}	5.945^{a}	6.855^{a}	6.74^{a}	6.78^{a}
BL	5.645^{bc}	5.6^{a}	6.26^{a}	6.11^{a}	6.875^{a}
CABL	5.425^{bc}	5.28^{a}	5.79^{a}	6.1^{a}	6.5^{b}
NaM	6.785^{ab}	6.985^{a}	6.73^{a}	7.115^{a}	7.01^{a}
NaMBL	7.545^{a}	6.87^{a}	7.625^{a}	7.24^{a}	7.45^{a}

Values with the same superscript in a column are not significantly different ($p<0.05$)

One common observation in all the flours irrespective of time of maturity is that higher pH values were recorded for flours treated with sodium metabisulphite and blanched indicating the significant role the pre-treatments on plantain flours.

CONCLUSION

This study has shown that higher maturity time and treatment with Sodium metabisulphite increase the oil absorption capacity and pH of plantain flours while treatment with Citric acid increases the water absorption capacity as the weeks of maturity increases. Swelling index increases with increasing maturity time. Blanching also increases the swelling index of plantain flours. Low density plantain flour could be obtained by citric acid treatment before blanching, for a 13th week mature plantain. The usefulness of plantain flour could be enhanced by monitoring the maturity time of the plantain and applying the best pretreatment as required.

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