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Composition and Pasting Properties of Breadfruit (*Artocarpus communis Forst*) from South-West States of Nigeria

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ABSTRACT

Breadfruit (BF) is an underutilised crop in Nigeria. Information on its composition and the behaviour of its flour during cooking are important requirements for enhancing the utilisation of BF. Flours of BF obtained from three towns in South-West Nigeria were analysed for their chemical and pasting properties. Starch, crude fibre, ash, fat, protein and pasting properties were evaluated. Starch was the predominant carbohydrate, representing about 60.4 to 65.8% in the pulp and 47.5 to 57.5% in the peel. Crude fibre values varied from 6.31 to 9.04%. There was no significant difference between the crude fibre contents of the pulp and peels. Ash content ranged from 2.77 to 4.78% with the peels having significantly higher values than the pulp. Fat content ranged from 0.43 to 0.65%. The pulps had significantly higher protein content than the peels. Peak viscosity varied significantly across locations with the peels having significantly lower viscosity than the pulps. The peels were significantly hot stable with breakdown viscosity values of 6.92 to 7.95 RVU compared to the pulps (72.33 to 210.77RVU). Final viscosity of the pulp was higher than that of the peels. Higher setback viscosity values were observed in the pulps than the peels and the former cooked in significantly shorter time (3.67 to 3.77 min) than the peels (8.93 to 8.99 min). The study revealed considerable differences in the composition of breadfruit grown in different locations in Nigeria.

Keywords: Breadfruit, flour, composition, pasting properties.

Introduction

Breadfruit (*Artocarpus comminus Frost)* is a carbohydrate rich food and staple diet in some developing countries of the world. The tree fruits primarily between May and August producing 50 to 200 fruits in a year. The mature fruit is round or ovoid, 15 – 20 cm in diameter and weighing 2 – 10 kg on average (Graham *et al*., 1981).

The fruit is produced mainly in Malaysia, the South Pacific Island, the Caribbeans and West Africa (Morton, 1987; Loos *et al*., 1981).

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Total yearly production in Nigerian is about 10 million metric tonnes with potential to exceed 100 million metric tonnes with improved agricultural practice (Adewusi *et al*., 1995). The economic utilisation of breadfruit has been limited by its poor storage properties (about 3 – 4 days). However, it has been suggested (Morton, 1987; Thomsonet *et al*., 1974) that conversion to flour would provide a more stable storage form as well as enhance the versatility of the fruit. Current usage of bread-fruit is attaining greater industrial importance particularly in food application such as bakery products, flour confectionaries and related products (Olatunji and Akinrele, 1978) while its starch is of potential value as adhesives in packaging and also in textile and pharmaceutical industries (Whistler *et al*., 1984). Breadfruit is an underutilised crop in Nigeria, and adequate information on its composition, nutritional importance and the behaviour of its flour during cooking are important requirements for enhancing its utilisation. The aim of this study is therefore to contribute to the limited information available on the composition and pasting properties of breadfruit produced in Nigeria.

Materials and Methods

Mature fruits of the seedless variety of breadfruit *(Artocarpus communis Frost)* used for the study were obtained from three locations (Ifewara, Mamu and Noforija) in the south-western states of Nigeria. Peeling was done conventionally, as done by women (involving the removal of the pericarp with some of the mesocarp).

Flour preparation

Breadfruit sample was processed as described by Wootton and Tumaalii (1984). Mature breadfruit – Peel Colour Index-PCI 3 (Peel Colour Index-PCI 3) (Ajayi, 1997) were hand peeled, cored, washed, thinly (0.2 to 0.5 cm) sliced and soaked in 5% sodium metabisuplhite solution for 30 min to prevent enzymic browning. Samples were dried on steel trays in a forced air convection oven (chirana Hs201A, England) at 80°C for 2 h and then at 35°C for 12 h. The dried chips were milled to flour in a Disc mill and sieved through a 250 μm mesh sieve.

Analysis of flour

Moisture and ash contents were determined according to AOAC (1997) method. Fat content was determined by the soxhlet extraction (AOAC, 1997). Protein content of the sample was determined as described by Hach (1990). Free sugar and starch in flour samples were determined by the spectrophotometer method of Dubois *et al.* (1970) and Macready (1970). Crude fibre content of flour was determined by trichloroacetic acid method as described by Entwistle and Hunter (1949) while calcium content of the sample was determined by a combination of acid digestion using the procedure of Novozamsky *et al.* (1983) and subsequent reading of calcium concentration using atomic absorption spectrophotometer at 422 nm (Bulk scientific model 200 A, USA).

Determination of pasting characteristics of flour

The pasting characteristics of flour were studied using the Rapid Visco Analyser (RVA) series 4 (New Port Scientific P.T.V. LTD, Australia) with the aid of Thermocline for windows (version 1.1. software, 1996). It has the advantages of small sample size, ability to measure the viscographic properties of the paste as it is being cooled and a computerized attachment for interpreting the pasting curve. The 12 min profile was used, and the time-temperature regime used was an idle temperature 50°C for 1 min. Samples were heated from 50°C to 95°C in 3 min 45 sec, held at 95°C for 2 min, 10sec, then cooled to 50°C over a 3 min 45 sec period followed by a period of 2 min when the temperature was held at 50°C (Newport Scientific 1996).

Statistical analysis

All experiments and analyses were conducted in triplicates. Data obtained from different parameters of the study were subjected to analysis of variance ($P < 0.05$). Mean scores of some of the results were reported. Data were subjected to analysis of variances, and Duncan multiple range test was used to separate the means (Duncan, 1955). Statistical analysis package software SPSS 13 for Windows was used for all the analyses.

Result and Discussion

Proximate composition of breadfruit varieties

The proximate composition of flours prepared from the pulp and peels (skin) from the "mature" fruits obtained from the three locations is shown in Table 1. Except for the Ifewara peels, there was no significant difference in the moisture content of the flour samples. This may be due to the uniformity of the procedure used in converting the fruit (pulp and peels) to flour.

Protein content varied considerably between the pulp and the peels, and within the pulp varieties. Contrary to values reported by Graham and De-Bravo (I981), the pulp had significantly higher protein content than the peels. This may be connected with the precaution that was taken to reduce the filth load in the flour and also because the heart (core) of the fruit was milled with the pulp to prevent unnecessary loss of protein in the resulting flour. Adewusi *et al*. (I995) had reported high crude protein content inthe core of the fruit. However, there was no significant difference in the protein content of the peels from the three locations. Noforija pulps had significantly higher protein content than the other two, while the Ifewara varieties had the lowest value.

Although present in low levels, fat content ranged from 0.43 to 0.65% with the Noforija variety having the highest and Mamu's the lowest. The knowledge of its fatty acid composition may be important to minimize possibility of rancidity and the associated storage stability and acceptability problems. Wootton and Tumaalii (1984) had reportedly identified between 41 and 64% unsaturated acids as total percentage of the total fatty acids in breadfruit. Ash content varied significantly with respect to the part of the fruit as well as with variety. The peels had significantly higher ash content than the pulp, suggesting that the peel is richer in minerals than other parts.

High concentrations of carbohydrates were found in both the pulp and peels. Starch is the predominant carbohydrate representing close to 60% in the pulp and about 50% in the peel. Ifewara and Mamu pulps had the highest and the lowest concentration respectively. The relatively high level of starch observed in the peel may be due to the thin exocarp nature of the peel (skin) that made it inevitable for an appreciable amount of the pulp to adhere to it during manual peeling. The amount of soluble sugars in the pulp was not significantly different from that in the peel. High soluble sugars observed in the pulp and peel may be the remnants of those not yet used for the accumulation of starch in the fruit. The soluble sugars comprise some reducing sugars which may be partly responsible for browning during deterioration and softening of fruit; this occurs as a result of Maillard reaction between reducing sugar and protein contents of the fruit.

There was an observed variation in the mineral contents of the analyzed varieties of the fruit pulp. Noforija variety had a significant high level of calcium than the other two. However, the composition of calcium (49.4 – 65.2 mg/100 g) in both varieties is relatively lower than the 235 – 390 mg calcium per 100 g flour required by the UK Bread and Flour Regulation (Ranken *et al*., 1997). Crude fibre values varied widely within the sample. There was no significant difference in the fibre contents of the pulp and peels. The high fibre content has both nutritional and processing significance for the flours. Dietary fibre has implications in the prevention of arteriosclerosis (Trowell, 1972), diverticulosis which are pouches in the large intestine (Painter and Burkitt, 1971), colonic cancer, appendicitis (Walker *et al*., 1973) and haemorrhoid symptomized by pronounced swelling of a large vein in the anal region.

Viscosity characteristics

The viscosity is a measure of both the effect of alpha-amylase activity and other contributory factors including the inherent susceptibility of the starch to enzyme (typified by starch damaged) and the starch gel strength (Watson, 1984). Pasting temperature is the temperature where viscosities first increase by at least 2RVU over a 20 sec period. It gives an indication of temperature required to cook the flour beyond its gelatinization point (OIkku and Rha, 1978; Appelqvist and Debet, 1997). These ranged from 64.25 to 64.37 (Table 2). There was no significant difference in pasting temperature of the pulp and peels of breadfruit from the three locations.

Peak viscosity

Peak viscosity is the maximum viscosity developed during or soon after the heating portion of the test. Maximum viscosity of starch suspensions heated in excess water occurs after granule swelling has ceased and the increase in viscosity is due mainly to exudates released from the granules (Miller *et al*., 1973). Peak viscosity of breadfruit pulp varied significantly across locations with 'Noforija' having the highest (385.78 RVU) and Ifewara's the

Table 1: Composition of breadfruit *(Artocarpus communis Forst)*

Flour source	Moisture (%)	Crude protein	Starch (%)	Sugars (%)	Fat (%)	Crude fibre	Ash %	Calcium mg/100g)
Noforija (Pulp)	9.35 ± 56[a]	5.66 ± .74[d]	60.4 ± .25[d]	2.45 ± 1.0[a]	0.65 ± .15[b]	9.04 ± 1.2[c]	3.74 ± 0.2[b]	5.2 ± 3.0[b]
Mamu (Pulp)	9.68 ± 30[ba]	4.27 ± 41[c]	64.5 ± 2.0[e]	4.65 ± .95[a]	0.43 ± 10[a]	8.02 ± 1.5[b]	4.35 ± .23[c]	54.1 ± 3.2[a]
Ifewara (Pulp)	9.63 ± .02[ba]	3.12 ± .10[b]	65.8 ± .85[e]	4.15 ± 2.0[a]	0.47 ± .10[a]	6.32 ± 0.5[b]	2.77 ± .0.2[a]	49.4 ± 4.5[a]
Noforija (Peel)	9.99 ± 0.2[ba]	1.68 ± .03[a]	57.5 ± .35[c]	2.38 ± .13[a]	0.46 ± .12[a]	9.01 ± 1.8[c]	4.68 ± .02[d]	
Mamu (Peel)	10.0 ± 0.1[ba]	1.72 ± 05[a]	47.8 ± 1.2[a]	2.52 ± .99[a]	0.45 ± .10[a]	8.01 ± .49[b]	4.73 ± .04[d]	
Ifewara (Peel)	10.0 ± 1.5[b]	1.92 ± .01[a]	47.5 ± .71[a]	2.43 ± .02[a]	0.45 ± .01[a]	6.31 ± 1.2[a]	4.78 ± .15[d]	

a-* Mean in the same column with the same subscripts are not significantly different P < 0.05

Table 2: Pasting characteristics of breadfruit *(Artocarpus communis Forst)*

Flours	Peak viscosity (RVU)	Holding strength (RVU)	Breakdown viscosity (RVU)	Final viscosity (RVU)	Setback viscosity (RVU)	Peak time (Min)	Pasting tempera-ture (^{O}C)
Noforija (Pulp)	385.78[d]	152.95[d]	210.77[d]	211.89[c]	58.94[b]	3.70[a]	64.37[a]
Mamu (Pulp)	238.36[c]	120.31[bc]	112.14[c]	249.39[d]	129.08[d]	3.67[a]	64.32[a]
Ifewara (Pulp)	219.64[c]	143.17[cd]	72.33 B	234.39[cd]	91.58[c]	3.77[a]	64.25[a]
Noforija (Peel)	76.97[a]	74.09[a]	7.95[a]	102.80[a]	28.70[a]	8.97[b]	64.35[a]
Mamu (Peel)	125.61[b]	103.75[b]	7.44[a]	161.97[b]	57.44[b]	8.97[b]	64.35[a]
Ifewara (Peel)	127.83[b]	105.00[b]	6.92[a]	162.00[b]	57.00[b]	8.93[b]	64.35[a]
Standard Error	24.91	6.94	18.22	12.8	8.15	0.636	0.44

a-* Mean in the same column with the same subscripts are not significantly different (P < 0.05) lowest (219.64 RVU). The viscosity of peels was significantly lower than that of the pulps (Figures 1 – 3).

Holding strength

Holding strength is the minimum viscosity after the peak, normally occurring around the commencement of sample cooling. It is the ability of the granules to remain undisrupted when the flour paste is subjected to a hold period of constant high temperature (95°C for 2 min 30 sec) and mechanical shear stress. The holding strength of sample from Mamu pulp and peels were higher than those from the other locations.

Breakdown viscosity

The holding period is often accompanied by a breakdown in viscosity; it can also be called shear-thinning, hot paste viscosity, paste stability or trough. It is regarded as a measure of the degree of disintegration of the granules or of "paste stability" (Olkku and Rha, 1978; Dengate, 1984). Breakdown viscosity gives an indication of hot paste stability, the smaller the breakdown viscosity, the higher the paste stability (Hugo *et al.*, 2000). Samples obtained from pulps of Ifewara were significantly stable (72.33 RVU) compared to those of Noforija (210.77 RVU) and Mamu (112.14 RVU). Final viscosity is the viscosity at the end of the test. As gelatinisation dispersion of starch is cooled, a loose paste or gel is formed depending on the starch concentration. At concentrations above the critical concentration, a three-dimensional network is established, where the swollen granules become embodied into a continuous matrix of entangled amylose molecules (Ring, 1985). Such a complex polymer matrix set as a viscoelastic gel in which the molecular associations involving hydrogen bonding between chains are mainly physical rather than covalent cross links (Appelqvist and Debet, 1997). The formation of such gel is indicated by increased viscosity and is known as the final viscosity in the pasting curve. The pulps had significantly higher final viscosity than the peels, with Mamu's having the highest (249.39 RVU) and Noforija's the lowest (211.89). Setbackviscosity is measured as the difference between the final viscosity and the

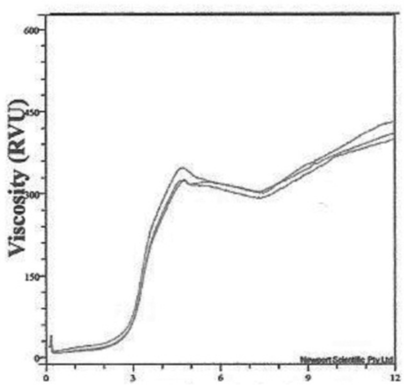

Fig. 1: Pasting properties of breadfruit samples from Noforija, Lagos State

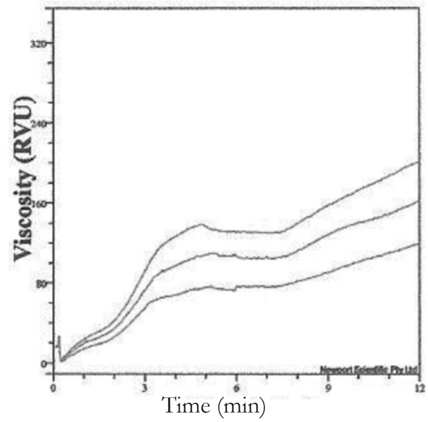

Fig. 2: Pasting properties of breadfruit samples from Mamu, Ogun State

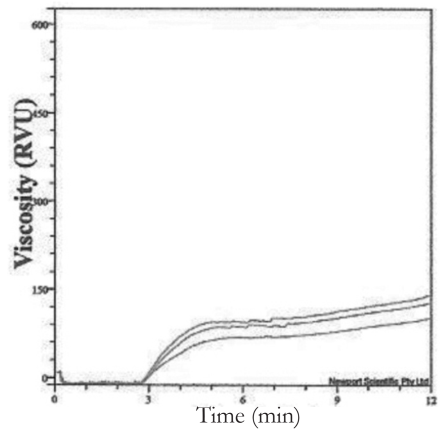

Fig. 3: Pasting characteristics of breadfruit peels

trough. It is the phase of the pasting curve after cooling the starches to 50ºC.This stage involves re-association, retrogradation or re-ordering of starch molecules. It shows the tendency of the starch to associate and retrograde. The setback of flours has been correlated with texture of various products (Adeyemi and Idowu, 1990; Mikhiyo *et al.*, 2004). Highest and lowest setback viscosity values were observed in Mamu and Noforija's samples respectively with the peels having considerably lower setback viscosity. However, there was no significant difference between pulp and peel from Mamu and Ifewara peels. Peak time is the time at which the peak viscosity occurred in minutes, indicating that the pulps cooked in shorter (3.67 to 3.77 min) times than the peels (8.93 to 8.99 min).

Conclusion

Information on composition and pasting behaviour of breadfruit is important for the selection of the right varieties for specific processing characteristics and need. The study revealed that considerable differences exist in the composition and pasting properties of breadfruit irrespective of the locations in Nigeria The flour can compete favourably with other native starches for pastries and confectionary.

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