

Functional and pasting properties of a tropical breadfruit (*Artocarpus altilis*) starch from Ile-Ife, Osun State, Nigeria

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Abstract: This study was carried out to determine the proximate, functional and pasting properties of breadfruit starch. Breadfruit starch was isolated from matured breadfruit (*Artocarpus altilis*) and was analyzed for its functional, proximate and pasting properties. The starch contains 10.83%, 0.53%, 0.39%, 22.52%, 77.48% and 1.77% moisture, crude protein, fat, amylose, amylopectin and ash contents respectively. The average particle size, pH, bulk density and dispersibility of the breadfruit starch were 18 µm, 6.5, 0.673 g/mls, and 40.67% respectively. The swelling power of the breadfruit starch increases with increase in temperature, but there was a rapid increase in the swelling power from 70 to 80°C. The pasting temperature of the starch paste was 84.05 °C, setback and breakdown values were 40.08 and 7.92 RVU respectively. The peak viscosity value was 121.25 RVU while final viscosity value was 153.42 RVU. This study concluded that breadfruit starch has an array of functional, pasting and proximate properties that can facilitate its use in so many areas where the properties of other starches are acceptable.

Keywords: Breadfruit starch, yield, proximate properties, pasting, functional properties

Introduction

Basically, breadfruit (*Artocarpus altilis*) being a multipurpose tree crop in Tropical Nigeria is found in Ile-Ife, Osun state as the crop could nearly be seen in the compound of most dwellers of the ancient city. Although, many people have heard about breadfruit in Nigeria, few have eaten it, this may be due to the insignificant use of the crop by many. Breadfruit is found in many parts of the world, especially in the Caribbeans, also in the tropics such as Malaysia and Nigeria. Some varieties have been studied and are appreciated for their nutritional properties because they are rich in carbohydrates, lipids and proteins (Rincon *et al.*, 2004).

Breadfruit is a tropical fruit and the tree produces fruit twice in a year, from March to June and from July to September with some fruiting throughout the year (Omobuwajo, 2003). Breadfruit has been processed into many forms for utilization in the food industry.

It has also been processed into starches (Loos *et al.*, 1981) and into flour (Olatunji and Akerele, 1978; Graham and De Bravo, 1981).

Studies on the modification of breadfruit starch involving heat-moisture-treatment and annealing, as forms of physical modification collectively referred to as hydrothermal treatment which entail modification of temperature and moisture content have been carried out and reported by Adebowale *et al.* (2004). Chemical modifications of some edible starches (breadfruit starch inclusive) through specific oxidizing agents such as sodium hypochlorite and hydrogen peroxide have also been reported (Forsell *et al.*, 1999; Konoo *et al.*, 1996). Although, the Nigerian weather condition is good to cultivate breadfruit, but its utilization has been overlooked, despite so many reported works on it. The objective of this study is to isolate breadfruit starch and investigate the proximate, functional and pasting properties of the starch

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Materials and Methods

Seven freshly harvested of matured unripe fruits of breadfruit, were collected in Ile-Ife. All analyses were performed with analytical grade reagents at International Institute of Tropical Agriculture (IITA), and results expressed as mean \pm standard deviation (SD) of $n = 3$.

Physical attributes of breadfruit

The morphology of each of the breadfruit was checked to determine the smoothness, shape and presence or absence of dents. The size was measured using measuring tape and the weight was measured using a very precise and sensitive weighing balance and the actual weight was determined by subtracting the value of weight of the peel from that of the breadfruit before peeling.

Breadfruit starch isolation

Breadfruit starch was isolated using the method described by Agboola *et al.* (1990) with some modifications in sifting and drying time. Peeled fruits were washed and grated. The grated pulp was suspended in 5 litres of distilled water for 24 hours to allow the starch to come out of the pulp. The suspended pulp was sieved using a muslin cloth with retained fibre. The fibre was rewashed to remove adhering starch. The extracted starch was allowed to sediment for 4 hours, the supernatant was decanted off and the starch washed with 5 litres of distilled water twice to remove proteins and fibre and finally sedimented for another 4 hours. The supernatant was then decanted. The resulting wet starch was spread in the chamber of a solar drier and dried for about 2 days. The obtained dry starch was milled to powder with 10 mm sieve hammer mill, packaged in glass jars and stored for analysis.

Breadfruit starch yield

Starch yield was derived using the calculation below.

$$\text{Starch yield (\%)} = \frac{\text{Weight of starch (g)}}{\text{Weight of edible portion}} \times 100$$

Proximate composition of breadfruit starch

Moisture, Ash and Fat contents were determined by the AOAC (1990) official methods and crude protein content by (Kjeldahl method). Meanwhile, Amylose content was determined using the methods of Williams *et al.* (1958) involving preparation of iodine solution and reagent. The Amylose content

was then calculated based on the Absorbance value obtained using a spectrophotometer. The total titratable acidity was determined using the method described by Ibok and Brain (1999).

Functional properties

Water binding capacity

This was carried out using the Medcaf and Gillies (1965) method. 37.5 ml of distilled water was added into 2.5 g of the breadfruit starch and was centrifuged for 10 minutes at 3000 rpm. Then the weight of the centrifuge tube and content was determined after decanting the water and allowed to drain for another 10 minutes. The bound water was determined by the change in weight. It was calculated by the formula.

Water binding capacity(WBC)

$$= \frac{\text{Bound water (g)}}{\text{Weight of sample (g)}} \times 100$$

Swelling power and solubility index

It was determined by Takashi and Sieb (1988) method. It involved weighing 1g of sample into 50ml centrifuge tube. 50 ml of distilled water was added and mixed gently. The slurry was heated in a water bath at 60, 70, 80, 90, 100 °C, respectively for 15 minutes. During heating, the slurry was stirred gently to prevent clumping of the starch. On completion of 15 minutes, the tubes containing the paste were centrifuged at 3000 rpm for 10 minutes using SPECTRA U.K. (Merlin 503) centrifuge. The supernatant was decanted immediately after centrifuging. The weight of the sediment was taken and recorded. The moisture content of the gel was thereafter determined to get the dry matter content of the gel.

$$\text{Swelling power} = \frac{\text{Weight of wet mass of sediment}}{\text{Weight of dry matter in the gel}}$$

Water Absorption index

This was carried out using the modified method of Ruales *et al.*, (1993). 2.5 g of the breadfruit starch was suspended in 30 ml of distilled water at 30 °C in a centrifuge tube, stirred for 30 minutes intermittently and then centrifuged at 3000 rpm for 10 minutes. The supernatant was decanted and the weight of the gel formed was recorded. The water Absorption index (WAI) was then calculated as gel weight per gram dry sample

$$\text{Water Absorption Index (WAI)} = \frac{\text{Gram Bound water}}{\text{Weight of sample}}$$

Bulk density

This was determined by the method of Wang and Kinsella (1976). A known amount of sample was weighed into 50 ml graduated measuring cylinder. The sample was packed by gently tapping the cylinder on the bench top from a height of 5 cm. The volume of the sample was recorded.

$$\text{Bulk density} = \frac{\text{Weight of sample}}{\text{Volume of sample after tapping}} \text{ (g/ml or g/cm}^3\text{)}$$

Dispersibility

This was determined by the method described by Kulkarni (1991). 10g of flour was suspended in 100ml measuring cylinder and distilled water was added to reach a volume of 100ml. The set up was stirred vigorously and allowed to settle for 3 hours. The volume of settled particles was recorded and subtracted from 100. The difference was reported as percentage dispersibility

Particle size determination

Particle size determination was carried out using the method described by Sefa-Dedeh (1989). Here 100 g of the powdered starch samples were shaken through 0.063 mm, (230 mesh), 0.125 mm (120 mesh) and 0.17 mm (80 mesh) screen on an electromagnetic sieve shaker and the percentage weight of the remaining product on each sieve was found. The ease of passage of the starch particles in each of the mesh is an indication of the particle size.

Pasting properties of breadfruit starch

This was determined using a Rapid Visco Analyser (Newport Scientific Australia). 3.5g of the sample were weighed into the text canister. 2.5g of breadfruit starch sample were weighed into a dried empty canister; 25ml of distilled water was dispensed into the canister containing the sample. The solution was thoroughly mixed and the canister was well fitted into the RVA, as recommended. The slurry was heated from 50 to 95 °C with a holding time of 2 minutes followed by cooling to 50 °C with 2 minutes holding time. The rate of heating and cooling were at constant rate of 11.25 °C/min. Peak viscosity, trough, breakdown, final viscosity, set back, peak time and pasting temperature were read from the pasting profile with the aid of ThermoLine for Windows Software connected to a computer.

Statistical analysis

Experimental data were analysed statistically using Microsoft Excel and SPSS v. 12.0.

Results and Discussion

Physical attributes of breadfruit

Results are presented in Table 1. The breadfruits used were round and oblong with smooth fairly smooth surfaces, having length and width ranging between 49 to 57 cm and 44 to 50 cm respectively. Their weight ranged from 410g to 505g.

Breadfruit starch yield

The percentage starch yield obtained from the breadfruits was 14.26%, which is less than 18.05%

Table 1. Physical Attributes of breadfruits

Attributes	Coded Breadfruit Samples						
	A	B	C	D	E	F	G
Shape	Oblong	Round	Round	Round	Round	Round	Oblong
Length	52cm	50cm	53cm	49cm	57cm	52cm	51cm
Width	46cm	46cm	48cm	47cm	50cm	49cm	47cm
Weight before peeling	500g	410g	480g	470g	505g	430g	420g
Weight of edible portion	410g	360g	420g	430g	465g	370g	350g

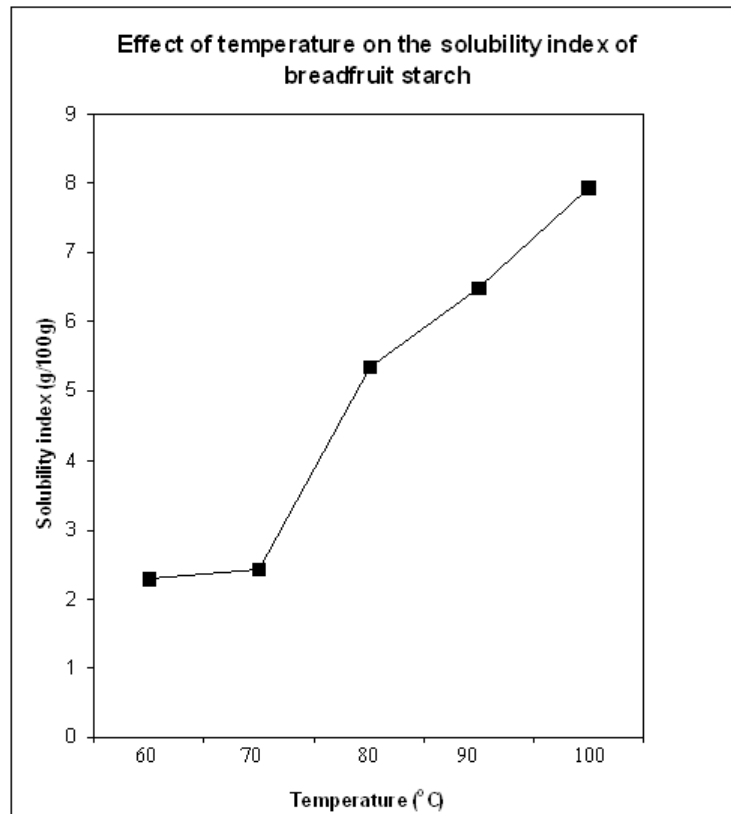


Figure 1. Effect of temperature on the solubility index of breadfruit starch

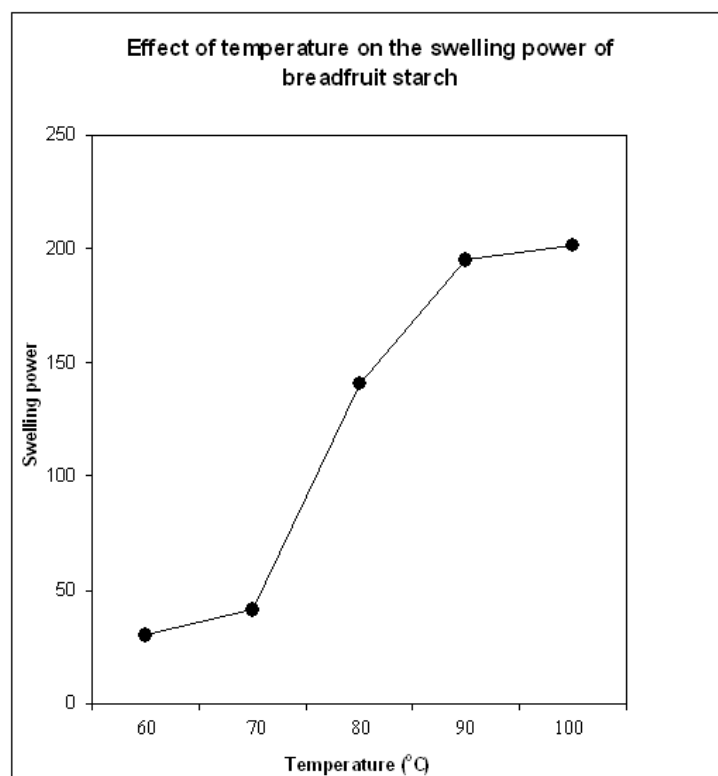


Figure 2. Effect of temperature on the swelling power of breadfruit starch

reported by Rincon *et al.* (2004) and very close to 15.4% reported by Owueme (1978); Omobuwajo and Wilcox (1989). However, the slight yield reduction compared to others that have been reported might have occurred during the extraction and purification processes involved.

Proximate composition of breadfruit starch

The proximate composition of breadfruit starch is shown in Table 2. Mean protein content of the starch was 0.53%, which is higher than 0.31% reported by Wootton *et al.* (1984). The difference in the protein content can be attributed to the climatic conditions and extraction methods involved. The breadfruit starch has amylose content of 22.52% which is closer to those reported by Wootton *et al.* (1984) on two different varieties of breadfruit (seedless and seeded) which are 19.4 % and 18.2 % respectively.

The moderately high breadfruit starch yield of 14.26% from this study is of significant importance in domestic and industrial food utilization and is similar to the one reported by Sing *et al.*, (1989). There can however be variation in the starch content of breadfruit depending on the maturity stage, variety and different climatic and agronomic conditions (Rahman *et al.*, 1999).

Moisture content of 10.83% was obtained from the breadfruit starch, which is lower compared to 13% reported by Rincon *et al.* (2004). Low moisture indicates higher shelf life on dried products. The lower the initial moisture content of a product to be stored, the better the storage stability of the product (Akubo, 1997). The moisture content of the starch is within the 10% stipulated standard of the revised regulation of the Standard Organization of Nigeria (SON 1988).

The ash content of breadfruit starch is 1.77% which is slightly higher than the value reported by Rincon *et al.* (2004) who reported an ash content of 1.1%. The fat content was 0.39% which is lower than 0.8% reported by Iwaoka *et al.* (1994) which may suggest that the breadfruit starch and other products made from it are not susceptible to quick rancidity due to its low fat content.

Functional properties of breadfruit starch

The functional properties of breadfruit starch are shown in Table 3. pH value obtained was 6.5, which is slightly different from 5.51 reported by Rincon *et al.* (2004). This variation might be traced to the different agronomic conditions of cultivation.

The average particle size was 18 μ m for the starch. The breadfruit starch has a high swelling power and this has been reported to be due to its lower degree of intermolecular association (Tian *et al.*, 1991).

Table 2. Proximate composition of breadfruit starch

Parameters	Values (%)
Crude protein	0.53 \pm 0.01
Moisture content	10.83 \pm 0.01
Ash content	1.77 \pm 0.01
Fat content	0.39 \pm 0.01
Amylose content	22.52 \pm 0.00
Amylopectin content	77.48 \pm 0.00

Table 3. Functional properties of breadfruit starch

Parameters	Values
pH	6.513 \pm 0.0058
Bulk density (g/mls)	0.673 \pm 0.0230
Water binding capacity (%)	8.267 \pm 0.2309
Total titratable acidity (cm ³)	0.012 \pm 0.0000
Dispersibility (%)	40.667 \pm 0.5774
Particle size (μ m)	18.000 \pm 0.0000
Water Absorption Index (%)	104.933 \pm 0.2309

This may also probably explain the higher water Absorption index exhibited by the starch. Similar results have been reported by Singh *et al.* (1990) and Loss *et al.* (1981). The starch has bulk density of 0.63 g/mls and dispersibility of 40.6%. Dispersibility is a measure of reconstitution of flour or flour blends in water, the higher the dispersibility the better the flour reconstitutes in water (Kulkarni *et al.*, 1991). However, the starch has a Total Titratable Acidity (TTA) value of 0.012 cm³. The TTA when related with the pH value of 6.51 shows that the starch has low acid content.

Table 4 shows the swelling power and solubility at different temperatures of breadfruit starch. The swelling power of breadfruit starch increases with increase in temperature of the starch, but there was a rapid increase in the swelling power from 70 to 80 °C. This is similar to the findings of Rincon *et al.* (2004). The swelling power has been related to the associative binding within the starch granules and apparently, the strength and character of the micellar network is related to the amylose content of the starch, low amylose content, produces high swelling power, Wootton, *et al.* (1984). As a result of swelling, there is an increment in the solubility, showing the highest value at 90°C. These results are also similar to the ones reported for African Breadfruit by Akubo (1997).

Table 4. Swelling power and solubility index of breadfruit starch

Temperature (°C)	Swelling power	Solubility (g/100g)
60	30.23±0.11	2.30±0.17
70	41.43±0.35	2.43±0.26
80	140.51±0.12	5.35±0.24
90	195.10±2.17	6.49±2.80
100	201.51±2.20	7.94±2.90

Table 5. Pasting properties of Breadfruit Starch

Parameters	RVU
Pasting Temperature (PT)	84.05°C
Peak Viscosity (PV)	121.25
Final Viscosity (FV)	153.42
Breakdown (BD)	7.92
Setback (SB)	40.08

RVU = Rapid Visco Unit

Pasting properties

Table 5 shows the Pasting temperature (PT), Peak viscosity (PV), breakdown (BD), final viscosity (FV) and setback (SB) values. The ability of starch to imbibe water and swell is primarily dependent on the pasting temperature. The higher the pasting temperature, the faster the tendency for paste to be formed (Dreher and Berry, 1983). Hence in the presence of water and heat, starch granules swell and form paste by imbibing water (Rincon *et al.*, 2004). The pasting temperature was found to be 84.05°C and this value is almost the same with the 83.3°C reported by Palansigui *et al.* (1991) and higher than the 73.3°C reported by Rincon *et al.* (2004). The pasting temperature depends on the size of the starch granules; small granules are more resistant to rupture and loss of molecular order, so this might explain the relatively high pasting temperature (Dreher and Berry, 1983).

However, the Peak Viscosity (PV) was 121.25 RVU and higher PV may be attributed to difference in protein content (Sandhu and Singh, 2007). The loosely packed starch granules with lower protein-to-starch ratio in the fine fractions seem to hydrate and swell more rapidly in the presence of heat. The breadfruits starch also has a breakdown value of 7.92 RVU which is higher than that reported by (Rincon *et al.*, 2004). The set back was 40.08 RVU, the higher the setback value, the lower the retrogradation during cooling and the lower the staling rate of the products made from the starch (Adeyemi and Idowu, 1990).

The Final Viscosity (FV) value was 153.42 RVU, this marked increase is due to the alignment of the chains of amylose in the starch (Flores-Farias *et al.*, 2000).

Conclusion

This study concluded that breadfruit starch has an array of functional, pasting and proximate properties that can facilitate its use in so many areas where the properties of other starches are acceptable

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