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Full Length Research Paper

Effect of Parboiling temperatures, Drying methods on Dehulling efficiency, Quality and Storageability of Breadfruit (*Treculia africana*) Seeds

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Abstract
African breadfruit seeds (5Kg) were sorted, cleaned and parboiled at different temperatures (60, 70, 80, 90, 100)°C. The seeds were dehulled and the dehulling efficiency determined. The Proximate and functional analyses were carried out on the dehulled seeds. The samples were dried using sun drying and oven drying methods respectively, then packaged in a high density polyethylene film and stored in a cool dry place for two months. The samples were used to prepare African bread fruit dishes and subjected to sensory evaluation. Results showed that parboiling the seeds at 90°c for 2mins 5secs gave the highest dehulling rate (86.06%), while the least dehulling rate (64.17%) was obtained from parboiled samples at 60°c for 4mins 7secs.There was increase in protein with increase in parboiling time. Also, drying the dehulled seeds increased their protein content. The sample (E) parboiled at 100°c and oven dried, gave the best proximate quality attributes such as protein content (17.73%) and carbohydrate (62.07%). The functional properties result of the seeds parboiled at 100°C and oven dried sample showed higher water absorption capacity (2.6ml/g after storage), than the sun dried samples. Sensory evaluation results showed that sample parboiled at 100°c and oven dried (E) was highly acceptable in terms of taste and colour, while its sun dried counterpart (E¹) was rated higher in softness and aroma.

Keywords: *African breadfruit, parboiling, dehulling efficiency, oven drying, sun drying*

Introduction

African breadfruit (*Treculia Africana)* is a tropical crop among the large number of trees growing naturally in the high forest and savanna areas of Nigeria. African breadfruit is known as "Ukwa" by Igbo speaking region of Nigeria. Ukwa is probably one of the oldest wild tree species under cultivation and or protection in Nigeria. It belongs to the family of *Moracea* and the genus *Treculia* and has a height of about 24m to 36m. African breadfruit seeds are consumed by humans, mainly by the rural dwellers due to its high nutritional status. The seeds of African breadfruit are currently a potential source of nutrient because of their immense contributions to the diet of the people of Nigeria (Iwe and Ngoddy, 2001). The crop sustains the consumers during planting seasons when major staples such as yam, cocoyam and corn are under cultivation (Nwabueze, 2006). African breadfruit like the legumes is hard to cook. This may be attributed to certain factors such as the variety of the breadfruit, geographical region of growth, genetics, the chemical constituents which include: phytates, phenolic compounds, divalent cations (ca^{2+}, Mg^{2+}), their interaction with pectic substance, protein, starch, lipid and tannins and as well as storage conditions (Shehata, 1992).

A major constraint in the utilization of African breadfruit is the difficulty encountered during dehulling of the seeds. Traditionally, the dehulling involves manual removal of the hulls from the parboiled seeds. This method is quite labourious, time-consuming and does not favour large scale production. The raw African breadfruit seeds do not store for very long periods due to infection by certain fungi. Also the dehulled seeds keep for less than 12 hours at ambient temperature. Drying the dehulled seeds before storage to reduce the moisture content that aids food spoilage will go a long way to increase the storage-ability of the seeds. Hence the objectives of this study which include determining the ease of dehulling, effect of drying methods and storage-ability of dehulled dried African breadfruit seeds.

Materials and Method

Source of raw material.

African breadfruit seeds (*Treculia Africana* var *intermediate*) were bought from a local market in Owerri, Nigeria.

Equipment and chemicals used

All the equipments and chemical used were obtained from Laboratory unit of Food Science and Technology Department, Federal University of Technology, Owerri. Imo-State Nigeria.

Sample Preparation

Five kilogram (5 Kg) of raw African breadfruit seeds were washed thoroughly with clean water several times until traces of slimy, jelly-like substances covering the seeds, dirts and spoilt seeds were removed. The seeds were divided into five portions of 960g each.

The different portions were heated at different temperatures of 60^{o}C, 70^{o}C , 80^{o}C, 90^{o}C, 100^{o}C and different times (1min,2min, 3min, 4min, and 5min). After parboiling, the seeds were drained and spread separately on clean smooth trays until the moisture at their surfaces dried. The seeds were then labeled accordingly, namely:

Sample A = Seeds parboiled at 60^{o}c
Sample B = Seeds parboiled at 70^{o}c
Sample C = Seeds parboiled at 80^{o}c
Sample D = Seeds parboiled at 90^{o}c
Sample E = Seeds parboiled at 100^{o}c

Dehulling operation

The parboiled dry seeds were dehulled using manual disc attrition mill which was adjusted to avoid crushing the seeds. The efficiency of dehulling was determined by random sampling of the number of dehulled and undehulled seeds from each group (A – E). The percentage of broken and unbroken seeds present in each sample group was also determined. The dehulled seeds were manually winnowed to remove the hulls and other dirts present. Each sample of the dehulled seeds was divided into two. One portion of each was sun dried for 4 days while the other portion was oven dried at 60^{o}C for 6 hours.

Dried samples were packaged in transparent air-tight high density polyethylene bags, and sealed with an electric sealing machine. The samples were put in a plastic bucket and stored at room temperature (28^{0}c – 30^{0}c) for 2 months (fig.1).

Raw seeds of African breadfruit
↓
Washing and Sorting
↓
Parboiling(at different temperatures)
↓
Draining
↓
Dehulling (using manual disc attriction mill)
↓
Winnowing and Cleaning (sorting)
↓
Drying (Oven/sundrying)
↓
Packaging (in airtight high density polyethylene film)
↓
Storing (at ambient temperature)
↓
Dehulled, Clean, dried African Breadfruit seeds

Figure 1. Flow chart for the production of dehulled, clean, dried African Breadfruit seeds.

Proximate analysis

The procedure for the proximate analyses of the dried samples were carried out using standard methods as described by AOAC (1990) for fat, ash, crude protein, moisture, crude fibre and carbohydrate.

Determination of Colour and water absorption of samples

The colour of the samples was determined by visual perception. The method described by Onwuka, (2005) was used for the water absorption capacity of the samples. One gram of ground sample was weighed into a centrifuge tube and mixed with 10ml distilled water for 1 minute by manual shaking. The mixture was allowed to stand at ambient temperature for 30 minutes, and then centrifuged for 30 minutes at 3,000rpm. After which the supernatant was poured in 10ml graduated cylinder and the volume recorded as "ml of water absorbed per gram of sample". These analyses were carried on both fresh and dried samples.

Sensory Evaluation of Cooked samples

The dried samples stored for two months and freshly dehulled samples were used to prepare African breadfruit dishes using the same recipe. Sensory evaluation was carried out on the cooked samples using 20 semi-trained panelists; the sensory attributes of the dishes scored were softness, color, aroma and taste. A 9-point Hedonic scale was used to score, which included like extremely (9)", like very much (8)", like moderately (7)", like slightly (6)", neither like nor dislike (5), dislike slightly (4), dislike moderately (3), dislike very much (2) and dislike extremely (1).

Statistical Analysis

All the data obtained from the proximate composition and sensory evaluation was analyzed statistically using the mean and analysis of variance (ANOVA) at $P \leq 0.05$. The separation of means was carried out using Fisher's least significant difference (LSD) and the significant differences and similarities of the samples were determined.

Results and Discussion

Effect of Parboiling Temperature and Time on Dehulling Efficiency and Colour of Dehulled African bread fruit Seeds

It was observed that the higher the parboiling temperature, the shorter the parboiling time and the higher the dehulling efficiency (Table 1). Sample D (seeds parboiled at 90^{o}c for 2 minutes and 5 seconds) had the highest dehulling efficiency (86.06%) and the seeds color were rated very good, though the dehulling efficiency decreased by 2.83% from the sample D. This decrease in efficiency could be due to the fact that sample E was softer and had broken seeds. It was observed that the higher the parboiling temperature, the better the color of dehulled seeds. This observation could be due to activities of enzymes which are usually destroyed at higher temperature (Macrae et al, 1993). Sample A (seeds parboiled at 60^{o}c for 4 minutes 7 seconds) had poor color which could be associated with enzymic browning, which according to Lee (1975) and macrae et al (1993) was due to the action of enzyme on phenols in cell in the presence of oxygen. The poor color observed in the samples was also due to bran adherent of the seeds, as lower parboiling temperature could not eliminate all the bran.

Table 1. Dehulling efficiency and colour of breadfruits seeds

Sample	Temperature (^{o}C)	Time (min/sec)	Dehulling Efficiency (%)	Color of dehulled seeds
A	60	4min 7sec	64.17	Poor
B	70	3min 40sec	71.25	Slightly good
C	80	2min 15sec	74.93	Moderately good
D	90	2min 5sec	86.06	Good
E	100	1min 30sec	83.24	Very good

Proximate composition of freshly dehulled African bread fruit seeds.

The proximate compositions of dehulled African bread fruit seeds obtained from different parboiling temperatures and time are shown in Table 2. The moisture content of the samples increased with increase in boiling temperature. Sample A (parboiled at 60^{o}c for 4 minutes. 7sec.) had the lowest moisture content (42.11%). There were significant difference ($p > 0.05$) between samples A and D (parboiled at 90^{o}c for 2 minutes 5 seconds). The high moisture contents showed that uptake of water and total water absorbed increases with increase in temperature.

The original aim of parboiling was to loosen the hull and facilitate dehulling, in addition, it increased the nutrient value of the seeds (Bassir and Lawal, 1985; Ihekoronye and Ngoddy, 1985). It was observed from the data that protein content increased with increase in parboiling temperature. This according to Bassir and Lawal (1985) was due to leaching of the soluble proteins from the hulls (seed coats) into the seed. Nwosu et al (2012), reported that heat processing improved the ash and protein content of *L.chinensis* seeds. No significant difference ($p < 0.05$) was observed in the protein contents of samples C, D and E; also in B and E, which could be due to the higher parboiling temperatures used for the samples, which could have dissolved more soluble protein from the hulls and translocated into the endosperm.

There were significant increase in crude fiber content of the various samples as the parboiling temperature increased. Samples A and B were significantly the same while the rest of the samples were significantly different. Also there were no significant difference ($p > 0.05$) in the ash content of the samples, which showed that the ash was not affected by the different parboiling temperatures.

Fat contents of the samples decreased (8.00 to 6.2%) with increase in parboiling temperatures. This observation was in agreement with the report of Pomeraz and Meloan (1994), that at elevated temperatures, undesirable reactions occurs which include some lipids being attached to protein and carbohydrate and thus render them in extractable. It was also observed that no significant difference existed in samples A, B, and C while the rest of the samples were significantly different. There were also variations in the carbohydrate contents of the samples as parboiling temperature was varied. The Significant differences was attributed to variation in other parameters which must have resulted to change in the carbohydrate content of the samples since it was calculated by difference.

Table 2.Proximate composition of freshly dehulled African breadfruit seeds obtained from different parboiling temperatures and time.

Parameter (%)	A(60c)	B(70^{o}c)	C(80^{o}c)	D(90^{o}c)	E(100^{o}c)
Moisture	42.11±0.24^c	43.57±0.79^{bc}	43.73±0.55^{bc}	44.39±0.77^{ab}	45.84±1.38^a
Protein	8.42±0.33^c	8.98±0.44^{bc}	9.51±0.20^{ab}	10.26±0.65^a	10.37±0.60^a
Fibre	2.45±0.05^d	2.52±0.05^d	3.05±0.07^c	3.42±0.06^b	4.80±0.04^a
Fat	8.00±0.09^a	8.15±0.04^a	7.90±0.71^a	7.05±0.05^b	6.20±0.01^c
Ash	1.00±0.09^a	0.90±0.01^a	0.90±0.04^a	0.80±0.05^a	0.60±0.008^a
CHO	38.42±0.09^a	35.98±0.82^b	34.91±0.37^c	33.98±0.50^c	31.79±0.24^d

Mean values within same row with different superscripts are significantly different ($P \leq 0.05$)

Effects of Oven and Sun Drying Methods on Proximate Composition of Dehulled African breadfruit Seeds

The moisture and fiber contents of all the oven dried samples showed no significant differences (Table 3). The protein contents of samples C, D and E were not significantly different ($p < 0.05$) from the other, but were significantly different ($p > 0.05$) from samples A and B. Decrease in fat and ash contents of the samples were observed with increased parboiling temperature. Also carbohydrate contents increased with increased parboiling temperature. The carbohydrate contents of samples were significantly different with the exception of samples D and E.

In sun dried African breadfruit seeds, there were decrease in composition with increase in parboiling temperatures for moisture, protein, ash and carbohydrate while increase in composition was observed for fat and fiber (Table 3). For fiber and ash, no significant differences ($P < 0.05$) were observed irrespective of parboiling temperature used. For moisture, there were no significant difference in sample A and B, and in samples D and E, but there were significant difference between these samples and sample C.

The wet samples before drying had 43.91% moisture which was significantly different from both oven dried sample (8.06%) and sun dried sample (10.21%) which could be attributed to the drying efficiency of the methods.

Table 3. Proximate composition of sundried dehulled African breadfruit seeds

Parameter (%)	A(60^{o}c)	B(70^{o}c)	C(80^{o}c)	D(90^{o}c)	E(100^{o}c)
Moisture	12.00 ± 0.48^a	11.56 ± 0.23^a	10.17 ± 0.20^b	8.99 ± 0.34^c	8.35 0.25^c
C Protein	16.28 ± 0.13^a	16.20 ± 0.18^a	16.00 ± 0.24^a	14.38 ± 0.06^b	14.00 ± 0.15^c
Fibre	2.80 ± 0.14^a	2.85 ± 0.13^a	2.90 ± 0.40^a	3.00 ± 0.41^a	3.20 ± 0.19^a
Fat	10.26 ± 0.34^c	10.80 ± 0.29^{bc}	10.65 ± 0.38^{bc}	11.40 ± 0.50^{ab}	11.69 ± 0.07^a
Ash	2.30 ± 0.59^a	2.20 ± 0.35^a	1.90 ± 0.17^a	1.70 ± 0.20^a	1.60 ± 0.20^a
CHO	60.01 ± 0.38^a	58.96 ± 0.23^b	58.38 ± 0.58^{bc}	57.96 ± 0.28^{bc}	57.51 ± 0.70^c

Mean values within the same row with different superscripts are significantly different at P (0.05).

Table 4. Proximate composition of Oven dried African breadfruit seed

Parameter (%)	A(60^{o}c)	B(70^{o}c)	C(80^{o}c)	D(90^{o}c)	E(100^{o}c)
Moisture	7.80$\pm$0.58^a	7.85$\pm$0.34^a	7.90$\pm$0.47^a	7.95$\pm$0.15^a	8.80$\pm$0.72^a
C Protein	17.25$\pm$0.03^c	17.48$\pm$0.06^b	17.63$\pm$0.02^a	17.70$\pm$0.06^a	17.73$\pm$0.06^a
Fibre	2.90$\pm$0.14^a	2.90$\pm$0.08^a	2.90$\pm$0.21^a	2.80$\pm$0.16^a	2.70$\pm$0.02^a
Fat	8.95$\pm$0.29^a	8.00$\pm$0.35^b	7.75$\pm$0.39^{bc}	7.50$\pm$0.06^{bc}	7.10$\pm$0.34^c
Ash	3.70$\pm$0.58^a	2.90$\pm$0.32^b	2.30$\pm$0.07^{bc}	2.00$\pm$0.16^c	1.70$\pm$0.13^c
CHO	59.40$\pm$0.04^d	60.87$\pm$0.06^c	61.52$\pm$0.02^b	62.05$\pm$0.07^a	62.07$\pm$0.04^a

Mean values within the same row with different superscripts are significantly different ($P \leq 0.05$)

Result of Sensory Evaluation of African Breadfruit Dishes prepared from Dried Seeds Stored for Two Months

Oven dried African breadfruit dishes

Color: There were no significant difference ($p>0.05$) between Sample D (parboiled at 70^{0}c) and sample E (parboiled at 100^{0}c), also there were no significant difference between sample A,B, and C. But there were significant difference between the samples and the control (Table 5a). The result may be attributed to the difference in their parboiling temperatures. Increase in the temperature yielded better color according to the rating of the panelist.

Aroma: There were no significant difference ($p>0.05$) observed in the aroma of all the oven dried African breadfruit dishes and the control sample.

Taste: No significant difference ($p>0.05$) was also observed in the taste of all the samples including the control though some mean scores were higher.

Softness: There were significant difference ($p<0.05$) between the samples. The control sample was the softest, followed by sample E, the result revealed that the temperature of parboiling affected the softness of the oven dried seeds. Increase in the temperature of parboiling led to increase in the rate of cooking of the seeds.

Sundried African breadfruit dishes

Colour: Significant differences ($p<0.05$) were observed between colour of the control samples and the sundried samples (Table 5b). The dishes prepared from samples parboiled from temperature 80^{0}c and above were significantly similar in color. The results obtained for other parameters taste and softness were similar to those obtained from oven dried dishes with little variations in figures. The aroma of the dishes were significantly different ($p<0.05$) from each other while there was no significant difference in the aroma of the oven dried samples. The difference in the results may be attributed to the method of drying. Oven drying took shorter time than sundrying, which must have affected the aroma of the dishes since aroma has to do with volatile substances. The results also showed that parboiling temperature affected the organoleptic properties of the dishes.

Table 5: Mean values of the organoleptic characteristics of African breadfruit dishes prepared from oven and sun dried samples after 2 months of storage.

(5a) Oven dried African breadfruit Samples

Variables	A(60^{o}c)	B(70^{o}c)	C(80^{o}c)	D(90^{o}c)	E(100^{o}c)	F(Control)
Color	5.7^c	6.1^c	6.3^c	7.2^b	7.3^b	8.8^a
Aroma	5.1^a	5.7^a	6.1^a	6.5^a	5.9^a	8.6^a
Taste	5.0^a	5.5^a	6.0^a	6.6^a	6.6^a	8.9^a
Softness	3.7^e	4.2^{de}	4.5^d	5.9^c	6.8^b	8.9^a

(5b) Sundried African breadfruit Samples

Variables	A^{l}(60°c)	B^{l}(70°c)	C^{l}(80°c)	D^{l}(90°c)	E^{l}(100°c)	F(control)
Color	5.2^{c}	5.5^{c}	5.7^{bc}	6.5^{b}	7.2^{b}	8.8^{a}
Aroma	6.2^{c}	7.0^{b}	7.2^{b}	7.1^{b}	6.8^{b}	8.6^{a}
Taste	5.3^{a}	4.7^{a}	4.9^{a}	5.4^{a}	6.3^{a}	8.9^{a}
Softness	5.5^{d}	6.0^{d}	6.7^{c}	7.5^{b}	7.9^{b}	8.9^{a}

Key: Mean values with different superscripts are significantly different at ($P \leq 0.05$).
F is control, from freshly dehulled African breadfruit seeds.

Effect of Drying method and Storage moisture content on water absorption capacity of dehulled dried African breadfruit seeds.

The moisture content of all the dried samples were below 12%. The results signify that the sample were supposed to have longer shelf-life than dehulled African breadfruit seeds that were not dried. There was general slight decrease in moisture of all the samples while their water absorption capacity increased after 2 months storage, though samples A and E from the sun dried samples recorded constant water absorption capacity (Table 6).

There was a slight increase in the water absorption capacity for samples processed at higher parboiling temperatures than at lower temperature. The water absorption capacity of samples (E and E^1) parboiled at 100°c were relatively higher than those of samples parboiled at lower temperature. This could be due to starch gelatinization and protein dissociation in samples parboiled at 100°c, which according to Tagodoe and Nip (1992) improved the water absorption capacity. Rampersad *et al.* (2003) reported an improved WAC with increase in protein and carbohydrate content of particular flour blends. Nibia *et al.* (2001) also stated that water absorption capacity is important in bulking and consistency of products as well as baking applications. After storage the water absorption capacity for samples parboiled at 100°c and oven dried (E: 2.60 ml/g) and sundried (E^1: 2.60ml/g) were said to be comparable. This functional property is good attribute in dough formulation and soup thickening. The slight increase in water absorption capacity in almost all the samples and the samples after storage showed that the packaging material used was not inert and there was moisture loss to the environment. The differences in water absorption capacity before and after storage showed that the change was more in oven dried samples. This suggested that oven dried samples had higher water absorption capacity than the sun dried samples. Water absorption capacity could be a functional indicator of degree of cooking (Nwabueze, 2006).

Table 6: Mean values of moisture content (%) and water absorption capacity (ml/g) before storage and after two months of storage of dehulled dried African bread fruit seeds.

Oven dried Samples

Samples	Before Storage		After Storage		% Different
	MC (%)	WAC(ml/g)	MC (%)	WAC(ml/g)	WAC
A	7.80	2.00	7.60	2.20	10
B	7.85	2.00	7.65	2.40	20
C	7.90	2.10	7.71	2.40	14.30
D	7.95	2.10	7.73	2.50	19.10
E	8.80	2.20	8.64	2.60	18.20

Sundried Samples

Samples	Before Storage		After Storage		%
	MC (%)	WAC(ml/g)	MC (%)	WAC(ml/g)	WAC
A[l]	8.95	2.20	8.72	2.20	0.00
B[l]	8.99	2.20	8.76	2.30	4.60
C[l]	9.90	2.20	9.78	2.50	13.60
D[l]	10.56	2.40	10.34	2.50	4.20
E[l]	11.00	2.60	10.97	2.60	0.00

Mean values in the same row with different subscripts are significantly different ($P \leq 0.05$)

Conclusion

African breadfruit seeds parboiled at 90^o for 2mins and 5 secs had the highest dehulling efficiency rate (86.06%) and the dehulled seed color was 'good', followed by samples parboiled at 100^{0}C for 1 min and 30secs (83.24%), the colour was rated 'very good'. Protein, carbohydrate contents and moisture contents were higher in samples parboiled for 90^{0}C and 100^{0}C which implied that the higher the parboiling temperature the higher the protein, carbohydrate and moisture contents of the samples. There were no significant difference($p<0.05$) in terms of aroma of the dishes prepared from the oven dried samples but there were significant difference in the aroma of the dishes prepared from sun dried samples, which could be due to the longer period of drying that may have affected the samples composition. After 2 months of storage. Oven dried samples had higher water absorption capacity that the sun dried samples. Water absorption capacity of the sun dried samples increased with increase in storage time. Shelf-life of African breadfruit was prolonged by dehulling and drying the seeds.

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