Chemical, Functional and Organoleptic Evaluation of African Breadfruit (*Treculia africana* Decne) Kernel Flour for Making Cookies

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Abstract

African breadfruit (Treculia africana Decne) seeds were parboiled and their kernels dried and milled into flour. The flour was packed in two different materials and stored under ambient (30 $\pm$ 2°C) conditions for 5 months. Chemical, functional and organoleptic properties of the flour before and during storage were evaluated. Cookies were made with the flour in addition to wheat flour. Results showed that parboiling for 15 min did not adversely affect the vitamin C and total carotenoids contents of the kernel. Other nutritional components – protein, oil, ash and fibre of the kernels were not deleteriously affected by parboiling. Within 2 months of storage, 20 – 28% vitamin C and 13-17% and total carotenoids were lost whereas after 5 months, 48-50% and 36-44% of vitamin C and carotenoids were lost, respectively. There was significant difference (P< 0.05) between the rate of depletion of vitamin C and carotenoids. During storage of the flour, apart from its bulk density and swelling index other functional properties (foam stability, emulation activity, nitrogen solubility) changed irrespective of the packaging material. However, the flour could store for 2 months under ambient (30$\pm$2°C) conditions without adverse changes in quality. Cookies made from composite of the breadfruit and wheat flours were acceptable to consumers. The bread fruit has food potentials.

Key words: African breadfruit seeds, parboiling, kernel flour, storave, vitamin C, total carotenoids, function properties, cookie

Introduction

African breadfruit (*Treculia africana* Decne) belong to the moraceae family. Because it is native to Africa coupled with large fruits and edible kernels, this common forest tree is often called the African breadfruit. It fruits between February and March and the fruits are yellow, spongy in texture containing numerous individual fruits like orange pips, embedded at various depths in the fleshy elongated bracts. The tree is widely distributed in Senegal, Sudan and Angola. In Nigeria, it is commonly found in the southern states such as Imo, Enugu, Anambra, Delta, Edo, Cross-River and Rivers. They are found growing wild in the forest and in home gardens. The fruits fall from the tree when mature. They are cut into halves, stacked in a heap and allowed to ferment (Solid state fermentation) from 5 to 6 days. Therefore, the fermented mass in macerated and the seeds mashed in water until the adhering slimy, jelly-like sustances are removed. The seeds are then sun dried. The seeds are eaten in various forms such as boiled and roasted forms. "Mili ukwa" is a non-alcoholic beverage from cooked African breadfruit kernels and is popular among the Ibo ethnic group of Nigeria. A pudding known as "ukwa" is another traditional product of African breadfruit kernel. It is prepared by milling the kernels with a small amount of water to form slurry. Ingredients such as pepper, fish or meat and salt are added to taste, mixed and this is followed by

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wrapping in flamed plantain leaves (*Musa paradisiaca* L). This is then cooked in boiling water. Another paste form of the product is obtained by cooking the seed and dehulling to get the kernel. The cooked kernel is mashed and moulded manually and wrapped in flamed plantain leaves. In this form, it could be added into, palm oil for eating yam.

Studies on antinutritional factors (Nwokolo, 1985) and nutritional components (Nwokolo, 1985; Edet *et al.*, 1985; Ekpenyoung, 1985) have been reported. Parboiling is one of the unit operations in processing African breadfruit seeds. Therefore, quality changes that occur during this operation should be important to both processors and consumers. Further, information on the functional properties of flour obtained from the breadfruit kernel would help in diversifying its food uses.

The purposes of this investigation, therefore, were to determine the changes in some chemical components of the breadfruit seeds during parboiling; to assess the changes in functional properties of the kernel flour before and after a specific period of storage and to evaluate organoleptic qualities of the cookies prepared from the flour in combination with or without wheat flour.

Materials and methods

Source of Raw Materials and Preparation of Flour

Fresh African breadfruit (*T. africana* Decne) seeds were purchased from a local market in Nsukka township of Nigeria. The seeds were washed with water and parboiled (97 ± 2^0C) at varied times (0-60min) in a stainless aluminium pot with a lid. The boiled seeds were drained in a basket for 12-15 min and allowed to cool at ambient temperature ($30 \pm 2°C$). Thereafter, the seeds were dehulled manually and the kernels sun-dried to a fairly constant weight of about 9-11% moisture. The dried kernels were milled (No 1A Premier mill, R.L.A 201-80014, England) and screened through a 40 – mesh (British Standard) sieve. The flour was put in screw capped bottles and stored in a deep freezer ($-19o^C$) from where samples were taken for subsquent use.

Chemical components

Moisture, ash, protein (N%x6.25). ascorbic acid (vitamin C), fibre, oil and peroxide value were determined as described in AOAC (1984). Total carotenoids were determined according to the procedure of Reddy and Sistrunk (1980).

Functional properties

Water and oil absorption capacities (Sosulski *et al.*, 1976), nitrogen solubility (Giami and bekebain, 1992), foaming properties (Coffmann and Garcia, 1977), emulsion properties (Yasumatsu *at al.*, 1972) and swelling index (Fleming *et al.*, 1974) were determined. Packed bulk density was determined as described by Okaka and Potter (1977).

Storage

Flour obtained from the seeds parboiled for 15 min was used for storage study. The flour was divided into two portions. One portion was packaged in 20 bags made of low density polyethlene sheet in 200g per bag. The other portion was packaged in 20 lacquered tin cans in 200g flour per tin can. They were all stored under ambient ($30 + 2°C$) conditions simulating the local market conditions. Samples were taken from them at monthly intervals for analysis for a period of five months. Chemical, functional and sensory indices were used to evaluate changes during storage. The stability of vitamin C and carotenoids in the flour was predicted using the data obtained on regreaaion analysis (Spiegel, 1972).

Preparation of Cookie

The African breadfruit kernel flour was used in preparing cookie at varied levels of substitution. The method of cookie making described by Nishibori and Kawashiki (1990) was employed. Levels of the flour used to replace wheat flour were 5,10,15,25 and 30%. The ingredients used were 49.5% wheat flour, 20% margarine, 10% homogenised whole egg, 20% sugar and 0.5% baking powder. They were thoroughly mixed and kneaded.

The dough was cut into about 14g portions and put in greased (with margarine) pans. The pans with the dough was charged into oven set at 160°C and baked for 15 min. The cookies were removed after the baking time and allowed to cool at ambient conditions (30+2°C) for about an hour, and packed in polythylene bags. Cookie samples with only wheat flour plus other ingredients as mentioned were used as control.

Sensory Evaluation of the flour and Cookie

Coded samples of both the flour and cookie including control were evaluated in a sensory laboratory under white light. An untrained 10-member taste panel comprising students and staff who were familiar with the product was presented with the samples. For the African breadfruit kernel flour the colour and overall acceptability attributes were evaluated whereas texture in addition was evaluated for the cookies. The judges were instructed to score the attributes of the samples and their overall acceptability using a 5-point hedonic scale where 5 = liked extremely and 1 = dislike extremely. In addition, clean water was provided for the judges to rinse their mouth in between samples. Two panel sessions for each sample were conducted and the average data obtained were subjected to the analysis of variance and least significant difference (Snedecor and Cochran, 1980).

Results and discussion

Parboiling and Chemical Components

Figure 1 shows the effect of parboiling of the African breadfruit seeds on vitamin C and total carotenoids of their kernels. There was a significant ($p<0.05$) decrease of content of these micronutrients with prolonged parboiling time. The vitamin C was more affected than the total carotenoids. Parboiling for 60 min reduced the ascorbic acid and the carotenoids contents by 73 and 41%, respectively. Leaching and oxidation of ascorbic acid and carotenoids might have occurred during parboiling of the seed. Vitamin C is water soluble and this, perhaps, explains its high percentage reduction due to leaching. The importance of carotenoids in foods goes beyond their role as natural pigments. Biological functions and actions have been increasingly attributed to these compounds. The provitamin A activity of carotenoids has been known for a long time. On a worldwide basis, about 60% of vitamin A is estimated to come from provitamins A (Simpson, 1983). Carotenoids have also been linked with enhancement of the immune system and decreased risk of degenerative diseases such as cancer, cardiovascular disease, age-related macular degeneration, and cataract formation (Mathew-Roth, 1991; Ziegler, 1991; Gerster, 1991; Byers and Perry, 1992; Bendich, 1994; Krinsky, 1990; 1994).

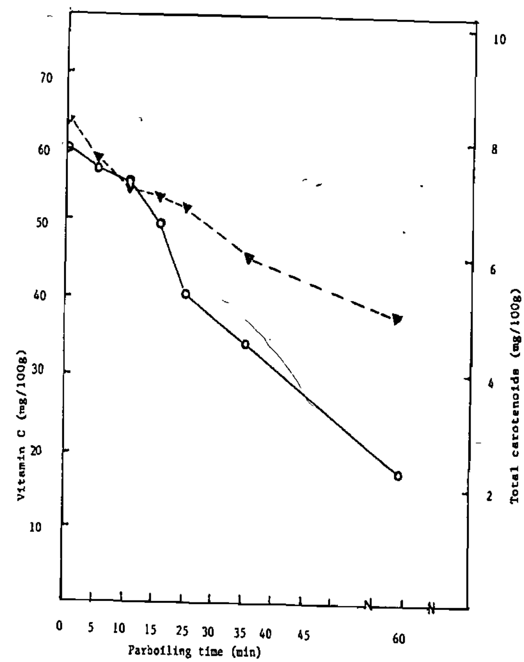

Figure 1: Effect of parboiling of African breadfruit seeds on vitamin C(0), and total carotenoids (V), contents of their kernels

There was no appreciable change in protein (16.8-17.1%); oil (11.0-11.7%, ash (3.5-4.2%) and fibre (2.5-2.5%) contents of the kernel resulting from parboiling of the seed even at varied parboiling time. These nutritional components were not deleteriosly affected by parboiling. Parboiling of the seeds for 15 min was adequate and most appropriate to avoid adverse changes in nutritional components of the kernel.

Parboiling and Functional Properties

The effect of parboiling of African breadfruit seed on some functional properties of its kernel flour is presented in Table 1. The water and oil absorption capacities of the flour increased significantly ($p < 0.05$) with parboiling time of the seed. Prior to parboiling, oil absorption capacity was 99% for the raw flour samples. This increased to 134% at 60 min of seed parboiling. There was slight increase in bulk density, which was not significant ($p > 0.05$). Parboiling of the seed significantly ($p < 0.05$) decreased foaming capacity, foam stability and emulsion activity of the flour.

The increase in water absorption capacity of the parboiled African breadfruit seeds agreed with reports on legume flours from earlier investigators. Heat treatment increased water absorption capacity of soy-flour (Wu and Inglett, 1977), mungbean flour (del Resario & Flores, 1981), winged bean flour (Narayana and Narasinga Rad, 1982) and cowpea flour (Giami, 1993). Increase in oil absorption of cowpea flour had been reported (Abbey & Ibeh, 1988; Giami, 1993). This increase could be due to both protein dissociation and denaturation on heating which unmasked the non-polar residue from the interior of the protein molecule (Kinsella, 1976). Heat had been reported (Yasumatsu *et al.*, 1972) to decrease the nitrogen solubility of protein by denaturation and also reduced foaming capacity. Foaming and emulsion properties are known to be dependent on solubilized proteins (Kensella, 1976). Mcwaters and Holmes (1979) reported a reduction in emulsion activity of heated soybean and peanut flours. Prolonged parboiling of African breadfruit seed may not be desirable for its flour intended for use in spread formulation because of the high emulsion requirements of the product.

Table 1: Effect of parboiling of African breadfruit seed on some functional properties of its kernel flour

Parboiling time (min)	Water absorption capacity %	Oil absorption capacity (%)	Foaming capacity (%)	Foam stability (%)	Emulsion activity (%)	Bulk density (g/cm^3)
0	$120.0+0.10^{f}$	$99.0+0.30^{e}$	$22.0+0.08^{a}$	$90.0+0.12^{a}$	$29.0+0.0^{d}$	$0.51+0.9^{c}$
5	$142.0+0.30^{e}$	$106.0+0.40^{d}$	$22.0+0.34^{a}$	$88.0+0.15^{a}$	$27.3+0.20^{d}$	$0.59+0.01^{c}$
10	$158.0+0.20^{d}$	$109.0+0.25^{cd}$	$21.0+0.20^{a}$	$35.0+0.20^{a}$	$25.2+0.41^{a}$	$0.53+0.04^{c}$
15	$179.0+0.10^{c}$	$114.0+0.15^{b}$	$20.0+0.19^{ab}$	$80.0+0.02^{ab}$	$24.0+0.3^{a}$	$0.54+0.5b^{c}$
20	$183.0+0.34^{c}$	18.0+0.03c	$16.0+0.04^{c}$	$60.0+0.37^{c}$	$16.3+0.9^{ab}$	$0.58+0.08^{b}$
30	$190.0+0.02^{b}$	$124.0+0.9^{bb}$	$10.0+0.03^{a}$	$30.0+0.0.20^{d}$	$10.1+0.21^{b}$	$0.59+0.04^{a}$
60	$210.0+0.25^{a}$	$134.0+0.01^{e}$	$6.0+0.07^{a}$	$5.0+0.04^{a}$	$3.4+0.08^{c}$	$0.63+0.01^{a}$
r	0.90	0.90	-0.98	-0.96	-0.95	0.81
lsd	7.17	6.69	3.54	8.36	10.95	0.04

Means $\pm$ sd of 3 determinations. R = coefficient of correlation. Lsd = least significant difference, Zero min = unparboiled seed (control) Means with the same superscript within a column were not significantly different ($p>0.05$)

The protein, fat, ash and fibre obtained in this study compared well with values reported by Edet et al. (1985) and Ekpenyoung (1985) for African breadfruits. The protein content compared well with 16-18% reported (Eke and Akobundu, 1993) for yam bean. The reasonable protein content of the African breadfruit kernel suggests that it is a good source of protein for humans.

Chemical Constituents and Storage

The effects of storage of material with time on some chemical constituents of the African breadfruit kernel flour are presented in Table 2. Changes in peroxide value of flour packaged in low density polyethylene bag were higher than those packaged in tin can. A peroxide value of 4.4 meq/kg was obtained on the 5-month storage in polyethylene bag whereas 3.0 was recorded for those in tin in the same storage period.

Though there was an increase in peroxide values with storage, the degree of peroxidation in the flour was not too much to cause any deleterious effect in the flour. The rate of

Table 2: Changes in chemical properties of African breadfruit kernel flour during storage in polyethylene bag (PB) and tin can (TC) at ambient (30 + 2°C) conditions

Component	Packaging Material	Storage time (month) 0	1	2	3	4	5
Protein(Nx6.25%	PB	17.1±0.03	17.1+0.08	17.0±0.10	17.0±0.01	16.90±0.06	16.8±0.01
	TC	17.1±0.03	17.1+0.01	17.1±0.10	17.4±0.1	17.0±0.01	16.9±0.04
Fats%	PB	11.0±0.02	11.0+0.41	10.5±0.20	10.0±0.01	9.8±0.04	9.7±0.02
	TC	11.0±0.02	11.0+0.02	10.8±0.30	10.5±0.02	10.2±0.01	10.1±0.04
Moisture, %	PB	8.2±0.04	9.5+0.01	10.0±0.02	9.0±0.02	10.5±0.10	9.0±0.02
	TC	8.2±0.04	8.2+0.02	8.2±0.01	8.2±0.03	8.02±0.01	8.2±0.10
Vitamin C	PB	50.2±0.06	40.0+0.00	36.0±0.04	30.0±0.05	26.0±0.01	20.0±0.02
	TC	50.2±0.06	45.0+0.01	40.0±0.05	36.0±0.01	30.0±0.04	26.0±0.08
Total carotenoids, mg/100g	PB	7.0±0.01	6.0+0.05	5.8±0.30	5.0±0.09	4.1±0.04	3.9±0.20
	TC	7.0±0.01	6.5+0.09	6.1±0.04	5.4±0.01	5.0±0.03	4.5±0.02
Peroxide value, meg/kg	PB	1.1±0.01	1.5+0.01	2.2±0.00	3.5±0.02	4.00±.01	4.4±0.02
	TC	1.1±0.00	1.2+0.01	1.9±0.01	2.0±0.01	2.5±0.00	3.0±0.01

Means + sd of 3 determinations. Zero month = fresh flour (control)

peroxidation was more in flour packaged in polyethylene bag than that in tin can. Sosulski et al. (1987) reported similar observation for wheat and cowpea flours stored in polyethylene bags. There were no appreciable changes in moisture, protein and fat with storage in either polyethylene bag or tin can. However, about 48-60% vitamin C, and 36-44% carotenoids were lost after the 5-month period. After 2-month storage, only 20-28% and 13-17% losses were observed in vitamin C and carotenoids, respectively.

The slight fluctuation in moisture in the polyethylene-packed flour was due to the permeability of the polyethylene bag to moisture. The decrease in vitamin C and carotenoids during storage was due probably to oxidation, which was also promoted by, perhaps, the increase in oxygen available in the flour. The tin can was impermeable to oxygen, therefore, vitamin C reduction was due to oxidation caused by, perhaps, the residual oxygen in headspaced followed by anaerobic oxidation (Kefford et al., 1959). The tin can was not sealed under vacuum or with an inert gas.

Functional Properties and Storage

Table 3 shows the changes in functional properties of the African breadfruit kernel flour packed in low density polyethylene bag and lacquered tin can and stored under ambient (30+2°C) conditions for a period of 5 months. Fluctuating values for water and oil absorption capacities were observed. This could be related to the changing relative humidity of the storage environment (ambient). Sosulk et al. (1987) reported that water absorption capacity of dehulled cowpea flour increased on storage in polyethylene bag at 64% relative humidity (RH) but decreased at 79% RH. After the 5-month storage, there was only about 11 and 6% loss in the ability of the floor to absorb water and oil, respectively. This implies that these qualities were not deleteriously affected during storage.

The bulk density and swelling index of the flour did not change during the period of storage irrespective of the packing material. There was a progressive decline in foaming capacity (FC), foam stability (FS), emulsion activity (EA), and nitrogen solubility (NS) of the flour with storage. After the 5-month storage about 50-75% FC, 50-88% FS, 58-67% EA, and 15-18% NS were lost. The loss in NS was not much. The observed losses were reduced by limiting the storage period of 1-2 months.

Sosulski et al. (1987) reported that storage of cowpea flour in polyethylene bag decreased its foaming and emulsion properties. The decrease in foaming and emulsion properties of

Table 3 :Changes in functional properties of African breadfruit kernel flour during storage in polyethylene bag (PB) and tin can (TC)

Properties	Packaging Material	Storage time (month) 0	1	2	3	4	5	SE	Lsd
Water absorption capacity,%	PB	179.0^{a}	150.0^{a}	167.0^{c}	164.0^{c}	168.0^{c}	160.0^{d}	1.20	5.71
	TC	179.0^{a}	168.0^{b}	174.0^{a}	165.0^{c}	178.0^{a}	168.0^{a}	1.46	6.93
Oil absorption capacity, %	PB	$114.o^{c}$	105.0^{d}	115.0^{c}	106.0^{d}	124.0^{b}	130.0^{a}	0.88	4.19
	TC	114.0^{d}	108.0^{e}	121.0^{c}	111.0^{d}	129.0^{b}	136.0^{a}	0.62	2.96
Bulk density, g/cm^3	PB	0.54^{b}	0.58^{a}	0.60^{a}	0.52^{a}	0.54^{b}	0.52^{bc}	0.01	0.05
	TC	0.54^{b}	0.58^{a}	0.54^{b}	0.49^{c}	$0.51b^{c}$	0.51^{bc}	0.01	0.04
Foaming capacity, %	PB	20.0^{a}	13.5^{b}	12.0^{c}	11.0^{b}	10.0^{bc}	5.0^{d}	0.59	2.80
	TC	20.0^{a}	13.2^{b}	13.0^{b}	12.0^{c}	11.0^{c}	10.0^{d}	0.42	1.97
Foaming stability, %	PB	80.0^{a}	66.0^{b}	50.0^{d}	40.0^{d}	20.0^{e}	10.0^{f}	0.88	4.19
	TC	80.0^{a}	70.0^{b}	67.0^{b}	60.0^{c}	50.0^{d}	40.0^{e}	0.97	4.61
Emulsion activity, %	PB	24.0^{a}	16.7^{b}	13.5^{c}	11.4^{d}	8.3^{e}	8.0^{f}	0.28	1.32
	TC	24.0^{a}	23.1^{b}	20.6^{c}	17.0^{d}	12.5^{e}	$10.o^{f}$	0.29	1.35
Emulsion stability, %	PB	23.0^{a}	18.0^{c}	13.0^{c}	12.0^{c}	9.0^{d}	8.0^{d}	0.42	2.02
	TC	23.0^{a}	22.0^{a}	20.0^{a}	18.0^{b}	13.0^{c}	11.5^{c}	0.71	3.40
Swelling index %	PB	150.0	150.0	150.0	150.0	150.0	150.0	0.01	NS
	TC	150.0	150.0	150.0	150.0	150.0	150.0	0.01	NS
Nitrogen solubility in H_20,%	PB	36.94^{a}	35.0^{ab}	33.0^{ab}	32.0^{c}	31.0^{c}	30.4^{c}	0.62	2.97
	TC	36.99^{a}	36.0^{a}	35.0^{a}	33.0^{a}	32.0^{b}	31.6^{b}	0.94	4.47

Values are means of 3 determinations. Zero month = freshflour (control). SE=standard error, LSD= least significant difference. Means within a row with the same superscript were not significantly different (P<0.05). NS=not significant.

the stored African breadfruit kernel flour may be related to the relative decrease in the solubility of the flour protein, as these properties are known to be dependent on nitrogen solubility.

Stability of vitamin C and Carotenoids

The likely shelf life of vitamin C and carotenoids components of the flour as predicted from regression equation is shown in Table 4. The rate of depletion of ascorbic acid under the storage was more than in carotenoids. After a 5-month storage of the flour under the ambient conditions (30+2°C), about 34 mg/100g and 29mg/100g vitamin C would be expected in the flour packaged in tin can and polyethylene bag, respectively. From regression equation, it was predicted that the flour had to store for about 5

Table 4: Rates of depletion of vitamin C and total carotenoids contents and probable shelf life (months) of African breadfruit flour

Component	Packaging material	Correlation coefficient	Linear regression equation	Depletion rate per month (slope)	Period (months) taken to attain zero component	Mean component score over 5
Vitamin C,mg/100g)	TC	-1.21	Y=37.14-0.58x	4.67	64.03	34.24+0.01
	PB	-0.99	Y=31.90-0.50x	5.00	63.80	29.40+0.04
Total carotenoids,mg/100g)	TC	-0.99	Y=7.03-0.51x	0.53	13.78	4.48+0.02
	PB	-0.98	Y=6.73-0.59x	0.83	11.40	3.78+0.01

Means + Sd of 3 determinations, TC=tin can, PB=Polyethylene bag, Y-component, X= time (month) years under the same condition before its vitamin C content could be completely depleted.

The rate of depletion of carotenoids was expectedly slower than for vitamin C. After 5 months storage, about 4.5 mg/100g and 3.8mg/100g of carotenoids remained in flour packaged in tin can and plyethylene bag, respectively.

Sensory evaluation

Table 5 shows the organoleptic changes in terms of colour and flavour of the African breadfruit kernel flour during storage up to a period of 5 months under ambient conditions (30+2°C) and different packaging materials (polyethylene bag and tine can). There was no significant difference (P>0.5) in the attributes during and after the storage period, irrespective of the packaging material. This implies that flour may be stored outside a refrigerator of coldstore for 5 months without losing its colour and flavour qualities. This is an advantage to individuals or communities that have neither electricity power supply nor storage facilities.

The suitability of the flour for food product fermentations was tested by using it solely and in combination with wheat flour to make cookies. The sensory qualities of colour, texture and general acceptability of the cookies were evaluated. The addition of 5,10,15,20,25 and 30% African breadfruit kernel flour before and after storage to wheat flour did not adversely affect colour, texture, flavour and genral acceptability of the cookies prepared from them. However, some panelists were able to detect slight difference in texture and flavour among cookies from the blends. Preference decreased with the increase in the levels of African breadfruit kernel flour. High levels of wheat substitution increased textural quality of cookies supplemented with safflower (Ordorical-falomi and Parades-Lopez, 1991)

Table 5: Changes in sensory properties of African breadfruit kernel flour in tin can (TC) and polyethylene bag PB) stored for 5 months under ambient conditions (30 + 2°C)

Sensory Attribute	Packaging Material	Storage time (month) 0	1	2	3	4	5
Colour	TC	4.8ᵃ	4.7ᵃ	4.7ᵃ	4.5ᵃ	4.3ᵃ	4.2ᵃ
	PB	4.8ᵃ	4.7ᵃ	4.7ᵃ	4.3ᵃ	4.1ᵃ	4.0ᵃ
Flavor	TC	4.7ᵃ	4.5ᵃ	4.4ᵃ	4.4ᵃ	4.2ᵃ	4.1ᵃ
	PB	4.7ᵃ	4.5ᵃ	4.4ᵃ	4.2ᵃ	4.0ᵃ	4.0ᵃ

Means within a row with the same superscript were not significantly different (P>0.05), Sensory scale: 1=very poor, 5= excellent

Conclusion

The most appropriate parboiling time for the African breadfruit seeds was established. This reduced the adverse effect of parboiling on some nutritional components of the kernel. The kernel flour could be stored for about 1-3 months without deleterious changes in food quality. The flour, in addition to wheat flour produced acceptable cookies. The food potentials of African breadfruit kernel could be of commercial interest.

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