Shelf-Life Assessment of Three Sun Dried Bread Fruits Varieties Found in Rivers State, Nigeria

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Abstract
Research on the nutrient quality and phyto-chemical properties of three species of sundried bread fruits was conducted in the Plant Pathology and Food Science and Technology Laboratories in the Rivers State University. Varying concentrations of moisture, ash, lipid, fibre, protein and carbohydrate were found in the three species of bread fruits stored for six months. Highest concentration of moisture (14.53±0.06), fibre (3.1±0.00), protein (21.2±0.00) and carbohydrate (6.1±0.00) were recorded for A. heterophyllus while T. africana had highest values of 11±0.00 for lipid. Ash content was highest (3.8±0.00) in A. camansi. Phyto-chemical screening further revealed the availability of several plant chemicals in the tested breadfruits stored for six months. Highest concentrations of phytate (1.08±0.00), saponin (3.9±0.00), tannin (3.8±0.00), carotenoid (31.4±0.00) and polyphenol (31.2±0.1) were recorded for A. heterophyllus than the other species. However, T. Africana had highest values for flavonoid (6.11±0.00) and lignan (6.8±0.00). In general, A. heterophyllus had highest nutrient quality and phytochemical contents during the storage period.

Keywords: *Breadfruits, nutrient quality, phytochemical and shelf life*

INTRODUCTION

Shelf life is the length of time that a commodity may be stored without becoming unfit for use, consumption, or sale. In other words, it might refer to whether a commodity should no longer be on a pantry shelf (unfit for use), or just no longer on a supermarket shelf (unfit for sale, but not yet unfit for use). It applies to cosmetics, foods and beverages, beverages, medical devices, medicines, explosives, pharmaceutical drugs, chemicals, tyres, batteries and many other perishable items (Charles *et al.*, 2005). In some regions, an advisory best before, mandatory use by or freshness date is required on packaged perishable foods. The concept of expiration date is relative but legally distinct in some jurisdictions.

Chuku and Chuku, (2014) reported the storage duration of three garden varieties. It was observed that the green garden egg rotted faster than all other varieties. Rottening of the green garden egg set in after four days with profuse ripening of the fruits in the laboratory. The local garden egg stored for twenty one days followed by shrinkage of the fruits. The yellow garden egg stored only for ten days and ripening set in accompanied by shrinkage and eventual rot of the fruits. In general, the local garden egg variety stored better than the yellow and green varieties. Some fruits were still intact after three weeks of storage when all the other varieties have rotted.

There are two basic phenomena involved in drying operations, namely: evaporation of moisture from the surface and migration of moisture from the interior of a particle to the surface. The rate of evaporation is proportional to the difference between the saturated vapour pressure of water at the surface temperature, and the partial vapour pressure of the water in the adjacent air. The vapour pressure increases with increase in air temperature at constant humidity whereas the partial vapour pressure of the adjacent air increases with humidity at any fixed temperature (Akanbi *et al.,* 2009). In practical terms the warmer the air the greater the difference between saturated vapour pressure (Ps) - actual vapour pressure (Pa) and hence the greater the rate of evaporation; the more humid the air the smaller the Ps-Pa and hence a lower rate of evaporation (Brenndorfer *et al*., 1985). Drying can be done by various means including the use of solar and oven dryers.

Composite flours have become important mainly due to the rising demand and cost of importing wheat flour to countries where the climate is not suitable for growing wheat. Attempts have been made to replace wheat flours with flour from vegetable sources for food product development. Although vegetable flour has been successfully used for food products, the substitutes have usually been in combination with wheat in order to produce products of desirable characteristics. Different types of flours are sometimes blended together to enhance specific quality attributes (Dendy, 1993). For instance Liener (1981) indicated that the relatively high protein content of soybean along with its relatively high lysine, trytophan and minerals grant soybeans the potential for use to supplement maize and other flours.

MATERIALS AND METHODS

Sample Collection and Preparation

Breadfruits *Artocarpus spp* and *Treculia africana* were harvested within the State. *Artocarpus altilis* were obtained from Igwuruta while *Artocarpus camansi* were obtained from Ozuaha all in Ikwerre Local Government Area of Rivers State. *Artocarpus heterophyllus* were obtained from Tere Ama in Phalga Local Government Area and *Treculia africana* were obtained from Bori in Khana Local Government Area respectively.

Freshly harvested matured unripe fruits were washed with clean water and transported immediately to the laboratory for proximate, mineral, vitamin and phyto-chemical content analysis.

Preservation of Chips Flours

Extracted breadfruit seeds were boiled, dehusked and blended. The blended sample was sundried. The sundried flours were preserved in air tight containers and stored for six months. Samples were taken monthly to assess the proximate and phytochemical compositions.

Fermentation of fruits for 5 days
↓
Seed extract from 20 ripe fruits
↓
Washing of seed (2kg)
↓
Sun drying for 24hrs
↓
Dehusking
↓
Milling (blender milling)
↓
Sun-drying
↓
Packaging in plastic plates

Figure I: *A. camansi*, *T. africana* and *A. heterophyllus* flour production

Nutrient Determination

Mineral and proximate contents of *A. altilis, A. camansi, A. heterophyllus* and *Treculia africana* were determined by atomic absorption spectrometry, flame photometry and spectro-photometry according to the methods of AOAC (2010).

Data Analysis

All procedures were carried out in triplicates and data obtained were subjected to one way analysis of variance (ANOVA). The means were tested for significance at 5% level using Duncan's multiple range (DMR) test.

RESULTS AND DISCUSSION

Table I: Effects of the Proximate Composition of Sundried Flours of Three Species of Breadfruit Stored for Six Months

Sun Dried Flour Samples of Bread Fruit	Months	Proximate Composition					
		Moisture %	Ash %	Lipids %	Fibre %	CHO %	Protein %
A. camansi	Month 1	12.5±0.1^{b}	3.8±0.1^{a}	8.5±0.1^{b}	1±0^{d}	59.97±0^{b}	14.5±0^{c}
	Month 2	3.6±0^{b}	3.8±0^{a}	8.5±0.1^{b}	1.2±0^{c}	57.2±0.1^{c}	14.5±0.1^{c}
	Month 3	14.3±0^{a}	3.8±0.1^{a}	8.5±0.1^{b}	1.4±0^{c}	57.5±0.1^{c}	14.5±0.1^{c}
	Month 4	10.2±0	3.7±0^{a}	8.5±0.1^{b}	2.0±0^{b}	59.5±0.1^{b}	16.5±0.1^{b}
	Month 5	7.5±0.1	3.5±0.^{b}	8.6±0.1^{a}	2.2±0.1^{b}	60.5±0.1^{a}	18.5±0.1^{a}
	Month 6	6.5±0.1^{c}	3.5±0.1^{b}	8.6±0.1^{a}	2.4±0.1^{a}	60.6±0.1^{a}	18.6±0.1^{a}
A. heterophyllus	Month 1	14.4±0^{a}	2.65±0.01^{a}	2.4±0.1^{c}	2.6±0.1^{b}	59.45±0^{b}	18.5±0.1^{c}
	Month 2	14.5±0^{a}	2.65±0.1^{a}	2.4±0.1^{c}	2.5±0.1^{b}	58.5±0.1^{b}	19.5±0^{b}
	Month 3	14.53±0.06^{a}	2.64±0.01^{a}	2.4±0.1^{c}	2.5±0.44^{b}	58.5±0.1^{b}	19.7±0.1^{b}
	Month 4	12.5±0.1^{b}	2.65±0.1^{a}	2.3±0.1^{c}	2.6±0.1^{b}	58.8±0.1^{b}	19.8±0.1^{b}
	Month 5	10.0±0.1^{c}	2.6±0.1^{a}	3.5±0^{b}	3.0±0^{a}	60.5±0^{a}	20.5±0.1^{a}
	Month 6	8±0^{d}	2.6±0.1^{a}	4±0^{a}	3.1±0^{a}	61.1±0^{a}	21.2±0^{a}
T. africana	Month 1	11.5±0^{b}	3.13±0.0^{a} 6	10.17±0.06^{b}	2.03±0.06^{b}	54.9±0^{c}	18.27±0.06^{b}
	Month 2	12.5±0^{a}	3.1±0.1^{a}	10.2±0.1^{b}	2.05±0^{b}	55.5±0^{b}	16.7±0.1^{c}
	Month 3	13.2±0.1^{a}	3.1±0.1^{a}	10.3±0.1^{b}	2±0^{b}	55.4±0.1^{b}	16.5±0.1^{c}
	Month 4	10.5±0.1^{b}	3.1±0.1^{a}	10.5±0^{b}	2.2±0.1^{b}	56.1±0^{a}	18.2±0.1^{b}
	Month 5	7.2±0.1^{c}	3±0^{a}	10.5±0^{b}	2.5±0^{a}	56.3±0^{a}	18.5±0.1^{b}
	Month 6	7.6±0.1^{c}	3±0^{a}	11±0^{a}	2.6±0.1^{a}	56.3±0^{a}	19.5±0^{a}

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

Table II: Effects of the Phytochemical Composition of Sun-dried Flours of Three Species of Breadfruit Stored for Six Months

Sun-Dried Flour Samples of Bread Fruit	Months	Phytochemicals (%)						
		Phytates	Saponins	Tannins	Carotenoids	Polyphenols	Flavonoids	Lignants
A. camansi	Month 1	0.01 ± 0^{c}	3.5 ± 0^{a}	3.02 ± 0^{a}	21.5 ± 0^{a}	6.5 ± 0^{a}	2.1 ± 0^{b}	1.9 ± 0^{b}
	Month 2	0.01 ± 0^{c}	3.5 ± 0^{a}	3 ± 0^{a}	20.5 ± 0^{a}	6.5 ± 0^{a}	2 ± 0^{b}	1.9 ± 0^{b}
	Month 3	0.12 ± 0^{b}	0.31 ± 0^{b}	0.15 ± 0^{c}	0.19 ± 0^{c}	2.01 ± 0^{b}	1.5 ± 0^{c}	2.12 ± 0^{a}
	Month 4	0.13 ± 0^{b}	0.3 ± 0^{b}	0.16 ± 0^{c}	0.19 ± 0^{c}	2.0 ± 0^{b}	1.5 ± 0^{c}	2.1 ± 0^{a}
	Month 5	0.15 ± 0^{a}	0.2 ± 0^{c}	1.8 ± 0^{b}	4.2 ± 0^{b}	1.6 ± 0^{c}	3.0 ± 0^{a}	1.45 ± 0^{c}
	Month 6	0.15 ± 0^{a}	0.2 ± 0^{c}	1.9 ± 0^{b}	4.4 ± 0^{b}	1.8 ± 0^{c}	3.1 ± 0^{a}	1.47 ± 0^{c}
A. heterophyllus	Month 1	0.08 ± 0.01^{c}	3.8 ± 0.01^{b}	3.01 ± 0^{c}	31.1 ± 0^{a}	6.2 ± 0^{c}	2 ± 0^{b}	1.97 ± 0.03^{b}
	Month 2	0.05 ± 0.01^{c}	3.7 ± 0.01^{b}	3.0 ± 0^{c}	31 ± 0^{a}	16.3 ± 0^{b}	2.1 ± 0^{b}	$.96\pm0.02^{b}$
	Month 3	1.08 ± 0^{a}	0.04 ± 0^{c}	3.8 ± 0^{a}	3.02 ± 0^{b}	31.2 ± 0.1^{a}	6.2 ± 0^{a}	2.1 ± 0^{a}
	Month 4	1.04 ± 0^{a}	0.05 ± 0^{c}	3.7 ± 0^{a}	6.2 ± 0^{b}	31 ± 0^{a}	6.3 ± 0^{b}	2.0 ± 0^{a}
	Month 5	0.92 ± 0^{c}	3.9 ± 0^{a}	3.1 ± 0.01^{b}	31.1 ± 0^{a}	9 ± 0^{c}	4 ± 0^{a}	1.74 ± 0.01^{c}
	Month 6	0.81 ± 0^{c}	3.9 ± 0^{a}	3.12 ± 0.01^{b}	31.4 ± 0^{a}	8 ± 0^{b}	4.05 ± 0^{a}	1.76 ± 0.01^{c}
T. africana	Month 1	0.07 ± 0^{b}	3.2 ± 0^{b}	3.05 ± 0^{c}	20.1 ± 0^{b}	6.1 ± 0^{b}	2.5 ± 0^{c}	6.8 ± 0^{a}
	Month 2	0.07 ± 0^{b}	3.1 ± 0^{b}	3.02 ± 0^{b}	20 ± 0^{b}	6.1 ± 0^{b}	2.6 ± 0^{c}	6.3 ± 0^{a}
	Month 3	0.07 ± 0^{b}	0.04 ± 0^{c}	3.3 ± 0^{a}	3.08 ± 0^{c}	20.1 ± 0^{a}	6.11 ± 0^{a}	2.52 ± 0^{b}
	Month 4	0.7 ± 0^{a}	0.04 ± 0^{c}	3.2 ± 0^{a}	3.04 ± 0^{c}	20 ± 0^{a}	6.01 ± 0^{a}	2.42 ± 0^{b}
	Month 5	0.8 ± 0^{a}	3.2 ± 0^{a}	3.12 ± 0.01^{b}	27.1 ± 0.1^{a}	6.05 ± 0^{b}	2.71 ± 0^{b}	1.6 ± 0^{c}
	Month 6	0.8 ± 0^{a}	3.4 ± 0.1^{a}	3.12 ± 0.01^{b}	27.2 ± 0.1^{a}	6.15 ± 0^{b}	2.81 ± 0^{b}	1.61 ± 0^{c}

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

The moisture contents of *A. camansi* recorded 12.5±0.1 for month 1, 14.3±0 for month 3 and 6.5±0.1 for month 6 respectively. *A. heterophyllus* for months 1, 3 and 6 were 14.4±0 14.53±0.06 and 8±0 respectively. While *T. africana* for months 1, 3 and 6 were 11.5±0, 13.2±0.1 and 7.6±0.1 respectively. Moisture content is an indicator of shelf stability; increase in moisture content enhances microbial contamination and reduces food quality and stability (Akanbi *et al.* 2009). Therefore, the lower the moisture content of a sample, the more its storability and proficiency for industrial processing. Values obtained for moisture content in this study are lower than the ones reported for cocoyam flour samples in a study by Obadina *et al.* (2016). He evaluated the proximate composition of cocoyam flour as influenced by storage periods, processing methods and storage temperatures and revealed that they had significant ($P \leq 0.05$) effects on the parameters except for the fat content of the cocoyam flour.
The ash contents of *A. camansi* for months 1 and 3 were 3.8±0.1 while month 6 was 3.5±0.1. *A. heterophyllus* recorded 2.65±0.01 for month 1, 2.64±0.01 for month 3 and 2.6±0 for month 6.There was no variation in the ash contents. *T. africana* for months 1, 3 and 6 were 3.13±0.06, 3.1±0.1, and 3±0 respectively. Ash content in this study was higher than cassava flour cultivars (bitter and sweet) reported by Charles *et al.* (2005) and Uchechukwu-Agua *et al.* (2015). High ash content could influence the brightness and quality appearance of the final product such as white bread. However, for products like brown bread and whole wheat snack, high ash content is recommended. According to Park and Henneberry (2010), the knowledge of the ash content in flour is essential because it allows the milling industries to estimate the expected flour yield as well as identify the milling functionality of flour. Ash content gives a quantitative estimation of the minerals available in a given food product (Eleazu *et al.*, 2012).

The lipid content of *A. camansi* for months 1 and 3 were 8.5±0.1 while month 6 recorded 8.6±0.1. *A. heterophyllus* months 1 and 3 recorded 2.4±0.1 while month 6 was 4±0. *T. africana* recorded 10.17±0.06, 10.3±0.1 and 11±0 for months 1, 3 and 6 respectively. The lipid content of the sundried breadfruit flours were higher than cocoyam flours (2-3%) reported by Obadina *et al.* (2016) and cereals-legumes blended flours reported by Rehaman *et al.* (2017).
The fibre content of *A. camansi* was 1±0 for month 1 (control), 1.4±0 for month 3 and 2.4±0.1 for month 6. *A. heterophyllus* was 2.6±0.1, 2.5±0.44 and 3.1±0 respectively. *T. africana* for months 1, 3 and 6 recorded 2.03±0.06, 2±0 and 2.6±0.1 respectively. The result from this study was within the range of cocoyam flour 2.4% reported by Obadina *et al.* 2016, cereals- legumes blended flours reported by Rehaman *et al.*, 2017.

For *A. camansi*, the carbohydrate content for months 1, 3 and 6 were 59.97±0, 57.5±0.1 and 60.6±0.1. *A. heterophyllus* was 59.4±0, 58.5±0.1 and 61.1±0 for months 1, 3 and 6 respectively. *T. a fricana* was 54.9±0, 55.4±0.1 and 56.3±0 for month 1, 3 and 6 respectively. The increase in carbohydrate content is in line with *A. gangetica* reported by Chuku *et al.* (2018). More so, Agbagwa *et al.*, (2020a) also reported high carbohydrate content in sundried cassava peels.
The protein content at sundried *A. camansi* at month 1 (control) and month 3 were 14.5±0 while month 6 was 18.6±0.1. That of *A. heterophyllus* for month 1 (control) was 18.5±0.1, 19.7±0.1 for month 3 and 21.2±0 for month 6. That of *T. africana* was 18.27±0.06 for month 1, 16.5±0.1 for month 3 and 19.5±0 for month 6. However Rehaman *et al* (2017 and Funami *et al* (2005) revealed that storage had a significant effect on protein content in various composite flours. This study showed that instead of reduction, the protein content increased at month 6. Generally, the protein content of flour gives an indication of the nutrient quality of the flour. Flours are usually fortified with high protein flours to provide needed nutrition (Zhao *et al.*, 2004). Proteins are increasingly been utilized to perform functional roles in food

formulations. Therefore the protein content of the flours in this study suggest that they may be useful in food systems where protein functionality is needed, and also contribute to the daily intake of proteins for adults (34-56g/day) and children (13-19g/day) (FNB, 2002).
Excluding moisture, the shelf life study of sundried flour revealed that most of the nutrients as shown on the proximate composition became more concentrated and increased in values. The protein content, ash, lipid, fibre and carbohydrate increased, an indication of quality stability meaning that drying gave rise to increased nutrient quality accompanied by reduction in moisture content. This finding is in line with the report of Chuku and Agbagwa, (2018).

The phytate content of *A. camansi* for months 1, 3 and 6 were 0.01±0, 0.12±0 and 0.15±0 respectively while *A. heterophyllus* for months 1, 3 and 6 were 0.08±00.01, 1.08±0 and 0.81±0 respectively. The phytate content of *T. africana* for months 1 and 3 recorded 0.07±0 while month 6 was 0.8±0. This study revealed that the phytate content of sundried flour of breadfruit increased when compared with the seeds as seen in Table 2.
The saponin content of *A. camansi* for months 1, 3 and 6 were 3.5±0, 0.31±0 and 0.2±0. The saponin content of *A. heterophyllus* recorded 3.8±0.01 for month 1, 0.04±0 for month 3 and 3.9±0 for month 6. *T. africana* recorded 3.2±0 for month 1, 0.04±0 for month 3 and 3.4±0.1 for 6 month. However, the saponin content of sundried breadfruit flour increased after month 1 except for *A. camansi* that had reduction from 3.5±0 in month 1 to 0.2±0 in month 6.
Tannin content of sundried *A. camansi* flour for months 1, 3 and 6 were 3.02±0, 0.15±0 and 1.9±0 respectively. *A. heterophyllus* for months 1, 3 and 6 were 3.01±0, 3.8±0 and 3.12±0.01 respectively. *T. africana* for months 1, 3 and 6 were 3.05±0, 3.3±0 and 3.12±0.01. The tannin content of the sundried flour also increased as compared to the seeds in Table 2.
The carotenoid content of sundried *A. camansi* for months 1, 3 and 6 were 21.5±0, 0.19±0 and 4.4±0 respectively. *A. heterophyllus* for months 1, 3 and 6 were 31.1±0, 3.02±0 and 31.4±0 respectively. *T. africana* for months 1, 3 and 6 were 20.1±0, 3.08±0 and 27.2±0.1 respectively. The carotenoid content also increased for example *T. africana's* seed carotenoid content was 1.7±0 while that of month 6 was 27.2±0.1. Therefore it recorded 16 times increase as compared to the seed.

The polyphenol content of sundried flour of *A. camansi* for month 1, 3 and 6 were 6.5±0, 2.01±0 and 1.8±0 respectively. *A. heterophyllus* for months 1, 3 and 6 were 6.2±0, 31.2±0.1 and 8±0 respectively. *T. africana* for months 1, 3 and 6 were 6.1±0, 20.1±0 and 6.16±0 respectively. This result showed that month 3 had more polyphenol content than month 1 and 6. Moreover, the polyphenol content of the sundried flour was higher than the seeds.
The flavonoid content of sundried *A. camansi* flour for months 1, 3 and 6 were 2.1±0, 1.5±0 and 3.1±0 respectively. *A. heterophyllus* for months 1, 3 and 6 were 2±0, 6.2±0 and 4.05±0 respectively. *T. africana* was 2.5±0 for month 1, 6.11±0 for month 3 and 2.81±0 for month 6.
The lignant content of sundried *A. camansi* flour for months 1, 3 and 6 were 1.9±0, 2.12±0 and 1.47±0. *A. heterophyllus* for months 1, 3 and 6 were 1.97±0.03, 2.1±0 and 1.76±0.01. *T. africana* for months 1, 3 and 6 were 6.8±0, 2.52±0 and 1.61±0. This result showed that the lignant content of sundried flour of breadfruit reduced at month 6 and values of the seeds became higher than the flours.

Literature has shown the occurrence these assessed pytochemicals in several plants (Agbagwa *et al* 2020b). These phytochemicals play vital role in the human health and have the potentials to fight against invading microorganisms (Fratianni *et al*., 2007). Campos-Vega *et al*., (2010) also reported the anticarcinogenic activities of phytochemicals. Chronic degenerative diseases have been shown to be prevented by dietary carotenoid, which also serve as vitamin A precussor (Gupta *et al*., 2015). The carotenoid data resented in this study disagrees with the findings of Rodriguez-Amaya *et al* (2011) as they reported high percentage loss of carotenoid in sun dried sweet potato, cassava and maize when compared to other drying methods. Generally, phytochemicals such as oxalate, tannins, saponins and carotenoids increased considerably in dried samples than the records from the fresh ones reported by early researchers (Chuku *et al.* 2019).

CONCLUSION

The present study has shown that the three sundried breadfruit species contain high nutrient quality as indicated by the proximate compositions and other essential phytochemicals after being stored for six months. However higher nutrient values were recorded in *A. heterophyllus*. Breadfruit should be added to diets as it can offer nutritional support.

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