Quality Evaluation of Fleshy Mesocarp and Stored Chips of African Bush Mango (*Irvingia spp.*)

Mudashir K. Abdulbaki[1], Mulikat K. Elemasho[2], Mandu E. Inana[2], Emmanuel Nwebor[2], Dare S. Daramola[2], Chikaodili O. Ogodo[2], Nneka M. Emelieze[2], Ekene E. Ugama[2], Juliet E. Nnaji[2], Chisom E. Ekeocha,[2] and Idorenyin U. Nwaehujor[3]

[1]Nigerian Stored Products Research Institute (NSPRI), Ibadan, Oyo State, Nigeria
[2]Nigerian Stored Products Research Institute (NSPRI), Port-Harcourt, Rivers State, Nigeria
[3]Nigerian Stored Products Research Institute (NSPRI), Ilorin, Kwara State, Nigeria

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CORRESPONDING AUTHOR
Mudashir K. Abdulbaki,
Nigerian Stored Products Research Institute (NSPRI), Ibadan, Oyo State Nigeria.
kijanstar1@gmail.com,
+2348066079736

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Abstract

African bush mango has fleshy mesocarp (pulp) rich in vitamins, essential minerals, and phytochemicals. This essential part is usually wasted due to a lack of knowledge of the processing and storage methods. This study aimed to determine the quality evaluation (proximate compositions, microbial loads, and sensory evaluation) of fleshy mesocarp and stored chips of African bush mango. African bush mango fruits were obtained from a farmer in Effraya, Etung Local Government Area, Cross River State. The fruits were sorted, and the hard ones were washed and used for this experiment. The exocarp of the fruits was slightly peeled, and the fleshy pulps were then sliced thinly. The sliced pulps were dried using a multi-crop dryer (at an average temperature of 56.61±1.577 °C). The proximate composition and the sensory evaluation of the fresh pulp and chips (dried pulp) were evaluated. Then, the chips were stored for 6 weeks, and the proximate and microbial analyses were conducted using standard laboratory methods (at 3-week intervals). Except the moisture content, all other proximate contents —ash, fat, fibre, protein, and carbohydrate—showed higher values in the chips (dried pulp) compared to the fresh pulp, with respective values of 3.20%, 1.10%, 10.50%, 5.20%, and 72.10% in the chips, as opposed to 0.89%, 0.65%, 1.65%, 2.43%, and 13.83% in the fresh pulp. The values of sensory scores obtained for both samples were more than 6. Furthermore, the retention of proximate nutrients and observing low microbial loads in the chips during storage suggest that the product remains safe and suitable for consumption during the off-season. Therefore, the chips could be maximally utilised to reduce wastage.

Keywords:
African bush mango, Chips, Microbial count, Multi-crop dryer, Proximate composition

Introduction

African bush mango (*Irvingia spp.*) is one of the wild fruits, and they are in abundance in the Southern parts of Nigeria. The fruit is 4-7 cm long, it has an oval mango-shape with drupe, and a pericarp comprising the exocarp (outer skin- peel) and fleshy mesocarp (pulp); and endocarp, which is a hard stone surrounding the kernel (Etebu & Tungbulu, 2015; Etebu, 2013). Recent studies have shifted attention to this crop's pulp and other parts. In contrast, previous research has predominantly concentrated on the kernel, which is rich in fats, oils, and protein (Etebu & Oku, 2017). The fruits of African bush mango serve as food, the seeds are used for making soup, and the bark extracts and leaves have anti-diabetic properties (Okpala, 2016). There are different varieties of bush mango trees. Still, only two varieties of *I. gabonensis* were identified in Nigeria in 1974, and they are *gabonensis* (with sweet edible fruits) and excels (with bitter fruit) (Mgbemena et al., 2019; Anil, 2007). The poor processing method and inadequate storage structure have subjected it to post-harvest losses.

The fleshy mesocarp of this fruit constitutes more than 80% of the whole fruit; however, it is usually considered as waste (Etebu & Bawo, 2012). Off-Olua & Ehwunife (2015) reported that wild fruits are underutilised because of a dearth of information about their

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processing and chemical composition. The juice obtained from the African bush mango pulp is rich in vitamins, proximate compositions, essential minerals, and phytochemicals (Akubor, 2017; Etebu et al., 2016; Tungbulu et al., 2016). Ezenatein et al. (2021) emphasised that any effort to improve the mesocarp of African bush mango must ensure adequate shelf life, optimal nutritional content, and acceptable microbial quality.

Post-harvest food loss has threatened food security in developing countries such as Nigeria. According to Iheanyi & Nwosu (2012), food security is defined as the capacity of a nation, area, or household to ensure that its citizens or individuals have readily available access to sustainable and very nutritious food supply. Despite the benefits of the African bush mango tree, the post-harvest loss of the fruit has been attributed to the local processing of the fruits aimed to remove the seeds, in which the edible yellowish and nutritious flesh of the fruits, which is rich in vitamin C, is allowed to ferment, and deliberate action of breaking the whole fruit into two to remove the seeds only and other parts become a waste (Akubor 2017; Etebu & Oku, 2017; Etebu & Bawo, 2012; Manach et al., 2004). The post-harvest losses of the fruit need to be prevented through exploitation of the potential values as an important crop (Elemasho et al., 2022).

Previous studies have shown that the fleshy mesocarp of this fruit (*I. gabonensis*) contains important phytochemicals (which include tannins, alkaloids, glucosides, saponins, and alkaloids); however, it was considered waste by the native people (Etebu & Bawo, 2012). Banso & Adeyemo (2007) have proven that phytochemicals are critically essential for human health and the management of diseases. *I. gabonensis* fruits are prone to spoilage shortly after harvest, with a shelf life of two to three days if collected ripe and less than ten days if harvested during the mature greenish stage (Etebu & Bawo, 2012). Hence, processing them into dried chips is necessary to extend their shelf life and explore their nutritional benefits. Therefore, this study was set to determine the proximate compositions, microbial loads, and sensory evaluation of stored chips (dried pulps) of African bush mango.

Materials and Methods

Study location-This research was conducted in the premises (processing unit and laboratories) of the Port Harcourt Zonal Office of the Nigerian Stored Products Research Institute, Rivers State, South-South Nigeria.

Source of African bush mango- African bush mango used was obtained from a farmer in Effraya village, Etung Local Government Area, Cross River State, and transported to NSPRI Port-Harcourt office.

Bioassay- The African bush mangoes were sorted, and the hard ones were washed and used for this experiment. The exocarp (peel) of the fruits was slightly peeled, and the fleshy mesocarp (pulp) was manually sliced thinly. The sliced pulps were dried using the NSPRI multi-crop dryer (similar to the one used by Babarinsa & Omodara, 2011, with slight modification, due to the source of energy used, which is gas instead of kerosene). The drying period and temperature were monitored and recorded using temperature and humidity measuring devices (Anymetre JR900A with a resolution of 0.1 °C & 1% and accuracy of ±1 ºC & 5%). The fleshy pulps of the African bush mango were dried into chips within 12 hours at an average temperature of 56.61±1.577 °C (Mean±SEM). The proximate analysis and sensory evaluation of the fresh and chips (dried pulps) were determined. The chips were packaged inside a Ziploc bag and stored inside a NSPRI hermetic steel drum for 6 weeks. The chips' proximate composition and microbial analysis during storage were obtained at 3-week intervals.

Proximate analysis- Moisture, ash, fat, fibre, and protein contents of the pulps and the chips were quantified by analysis methods of the AOAC (2019), while difference was used to calculate carbohydrate content (CHO).

Sensory evaluation- Taste, appearance, odour, and acceptability of the fresh pulp and chips were done by twenty semi-trained panelists using the 9-Point Hedonic Scale.

Microbial analysis- The microbial counts (bacteria and fungi) were tested according to procedures used by Oriakpono et al. (2022).

Data analysis- Statistical analyses were performed on the data collected using Statistical Package for the Social Sciences (SPSS version 20). Analysis of Variance (ANOVA) was used to calculate the mean, and Duncan's test was used to calculate separation at a 95% significance level.

Results and Discussion

Table 1 shows the percentage proximate composition of the peeled fruit, pulp, and chips. The moisture content results obtained in this study for peeled fruit, pulp, and chips were 80.55, 81.43, and 7.91% respectively. Analysis of variance in the values was statistically significant ($p<0.05$). The moisture content (less than 10%) recorded for the chips in this study is the same as that obtained for mango chips in previous research work (Ayustaningwarno et al., 2020). Angelovič et al (2018) stated that stability of agricultural products during storage can be achieved when the moisture content is <10%. The crude ash content recorded ranged from 0.50 to 3.20%. The pulp had the lowest value (0.5%), while the chips had the highest value (3.20%), and the values obtained were significantly different ($p<0.05$). The ash content of peeled fruit (0.89%) in this study falls within the range of values reported by Mgbemena et al. (2019).

The crude fat varied between 0.30±0.049 and 1.10±0.032%, the chips had the highest crude fat (1.10) among the samples, and the differences in the fat contents among the samples were statistically significant ($p<0.05$). The increase in fat content after drying of pulp to chips (dried pulp) is similar to reports of Ayustaningwarno et al. (2020) and Dueik & Bouchon (2011), during frying of mango and apple chips, respectively.

The results of crude fibre obtained in this study ranged from 1.65 to 10.51% and were significantly different ($p<0.05$). Previous research findings reported similar results for pulp's crude fibre (Mgbemena et al., 2019; Akubor, 2017). The high crude fibre content can serve as a source of roughage, aid in water absorption, and enhance the functioning of the gastrointestinal tract (Akubor, 2017).

The result obtained from crude protein ranged from 2.43 to 5.20% and the differences were significant ($p<0.05$). The percentage of crude protein in the chips (dried pulp) was higher than in the pulp. The values 7.7 and 6.5% for protein content reported in previous research (Mgbemena et al., 2019) for peeled fruit and pulp are higher than 2.43 and 3.33% recorded in this current study, respectively.

The total carbohydrate content observed for peeled fruit, pulps, and chips in this study was 13.83, 11.29, and 72.10% respectively. The differences in the figures were significant ($p<0.05$). The carbohydrate content obtained for the chips is similar to the value reported by Akubor (2017). However, the 64.3% reported by Ezenatein et al. (2021) is less than the value recorded in this study.

Table 2 shows the average sensory scores for the pulp and chips of African bush mango. The values in the results obtained for both samples were more than 6 and less than 7.5, showing higher preferences for the products (pulp and chips). The results are similar to the findings of Akubor (2017). Ogbonnal et al. (2013) reported that aroma (flavour) and taste determine the acceptability of fruit and fruit products. Table 3 reveals the proximate composition of the African bush mango chips at the initial and during storage. The result obtained for moisture content ranged from 7.91±0.020% to 10.48±0.129% and the differences were significant among the values statistically ($p<0.05$). The percentage moisture content of the African bush mango chips increased as the storage period increased, and this is contrary to the findings of previous works by Ezenatein et al. (2021) and Oppong et al. (2019) that indicated a decrease in moisture content during the storage of African bush mango juice and mango chips, respectively. Vera Zambrano et al. (2019) stated that the moisture content of dried products increased because of moisture absorption from the surrounding, reducing the product's shelf-life. The total ash content observed in this study ranged between 3.20±0.013 and 3.72±0.055%, with significant differences in the values ($p<0.05$). The figures of total ash content obtained by Ezenatein et al. (2021) are lower than the values recorded in the present research.

The crude fat varied between 0.62±0.054 and 1.10±0.018%, and the difference was significant ($p<0.05$). The figures of crude fat (0.62 to 1.10) recorded in this study are significantly lower than the values (21.1 to 23.41%) reported by Ezenatein et al. (2021), and this could be associated with the heating that the chips passed through. There was a significant drop in the fat content values as the storage period increased in this current research, which conforms to the findings of Ezenatein et al. (2021).

The crude fibre recorded ranged between 8.39±0.040 and 10.51±0.035%, and statistically significant differences ($P<0.05$) exist among the values obtained during the storage. The percentage crude fibre of the chips decreased during the storage, and Ezenatein et al. (2021) have also reported a decrease in crude fibre during the storage of African bush mango pulp juice.

The results of crude protein obtained in this study ranged from 3.80±0.032 to 5.20±0.050%, and were significantly different ($p<0.05$). The crude protein values recorded for this study are slightly lower than previous findings (Ezenatein et al., 2021) for storing juice extract from this fruit.

The result of carbohydrate recorded in this study varied between 72.10±0.126 and 74.22±0.052%, and the length of the storage of chips showed a statistically significant ($P < 0.05$) effect on the carbohydrate content. The figures recorded by Ezenatein et al. (2021) are lower than the findings in this current research.

Table 1: Percentage proximate composition for fresh peel, fresh pulp and dried pulp (chips) of African bush mango

Sample	Moisture (%)	Crude Ash (%)	Crude fat (%)	Crude fibre (%)	Crude protein (%)	Carbohydrate (%)
Peeled fruit	80.55±0.058^{c}	0.89±0.031^{b}	0.65±0.071^{b}	1.65±0.053^{a}	2.43±0.073^{a}	13.83±0.021^{b}
Pulp	81.43±0.048^{b}	0.50±0.105^{a}	0.30±0.049^{a}	3.15±0.042^{b}	3.33±0.120^{b}	11.29±0.127^{a}
Chips	7.91±0.058^{a}	3.20±0.013^{c}	1.10±0.032^{c}	10.51±0.035^{c}	5.20±0.050^{c}	72.10±0.047^{c}

Average±SE. Values indicate averages of triplicate samples and standard error of means. Averages in the same column have significant differences ($p<0.05$) when they have different superscripts.

Table 2: Average sensory scores for fresh and chips of African bush mango pulp

Sample	Appearance	Taste	Flavor	General Acceptability
Fresh	6.80±0.247^{a}	6.30±0.291^{a}	6.50±0.320^{a}	7.35±0.232^{a}
Chips	6.60±0.245^{a}	6.10±0.292^{a}	6.40±0.450^{a}	7.10±0.261^{a}

Average±SE. Values indicate average of triplicate samples thereafter standard error of means. Averages in the same column have significant differences ($p<0.05$) when they have different superscripts.

Table 3. Proximate composition of African bush mango chips during the storage

Storage period	Moisture (%)	Crude Ash (%)	Crude fat (%)	Crude fibre (%)	Crude protein (%)	Carbohydrate (%)
0 week	7.91±0.020^{a}	3.20±0.013^{a}	1.10±0.018^{c}	10.51±0.035^{b}	5.20±0.050^{c}	72.10±0.126^{a}
3 weeks	9.23±0.078^{b}	3.72±0.055^{c}	0.62±0.054^{a}	8.42±0.012^{a}	3.80±0.032^{a}	74.22±0.052^{b}
6 weeks	10.48±0.129^{c}	3.57±0.006^{b}	0.69±0.032^{b}	8.39±0.040^{a}	4.57±0.083^{b}	72.23±0.135^{a}

Averages±SE. Values indicate average of triplicate samples thereafter standard error of means. Averages in the same column have significant differences ($p<0.05$) when they have different superscripts.

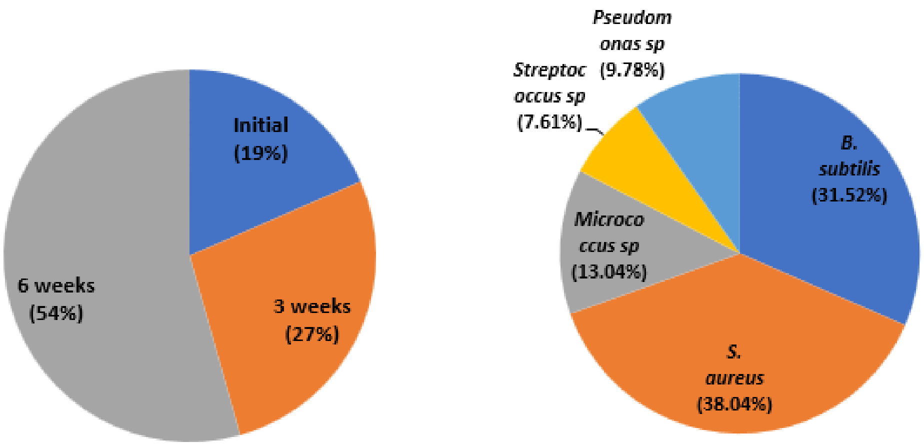
Total heterotrophic bacteria and fungi counts for the African bush mango chips at the initial and during the storage are shown in Table 4. All the samples had bacterial and fungal growths. The range of heterotrophic bacteria before and during the storage was between 8.50±1.500 and 15.30±3.232 cfu/g, while the fungal counts ranged from 0.50±0.500 to 1.50±0.500 sfu/g. The chips at 6 weeks storage had the highest bacteria (15.30±3.232 X 10^6 cfu/g) population, while the 3 weeks sample had the highest fungi (1.50±0.500 X 10^3 sfu/g) population. Some previous findings (Ezenatein et al., 2021; Etebu & Bawo, 2012) have reported that the bacterial population growth is directly proportional to the storage period. An increase in moisture content could be one of the reasons for an increase in bacteria growth during storage because Pérez-Rodríguez et al. (2008) have reported that bacteria-pathogen transmission may be determined by water and physical handling. However, the microbial counts obtained in this study did not exceed the limit value (10^6 cfu/g) recommended for dried food samples by the International Commission for Microbiological Specification for Food.

Figure 1 shows the percentage of bacteria during the storage period and the species of bacteria present. At the initial stage, the population of the bacteria in the chips was 19%, which increased to 27% after 3 weeks and reached 54% after 6 weeks. *Streptococcus sp, Pseudomonas sp, Micrococcus, B. subtilis,* and *S. aureus* are the bacteria identified in this study with the percentage abundance of 7.61%, 9.78%, 13.04% 31.52% and 38.04% respectively. The bacteria identified in this current research are similar to those found in previous findings of Ezenatein et al. (2021) and Leff & Fierer (2013) that characterized African bush mango as a fruit that harbors a high bacterial load, and this may result in foodborne infectious disease and economic loss (Maarten, 2021). Figure 2 shows the percentage of fungi during the storage period and the species of fungi present. At the initial stage, 14.29% of the fungi population increased to 42.86% after 3 weeks, and reached 42.86% after 6 weeks. Fungi identified include *A. flavus* and *A. niger*, with percentage abundance of 42.86% and 57.14% respectively. The fungi identified in this current research are the same as those identified by Ezenatein et al. (2021) and Leff & Fierer (2013).

Table 4. Total Microbial Counts of African bush mango chips during the storage

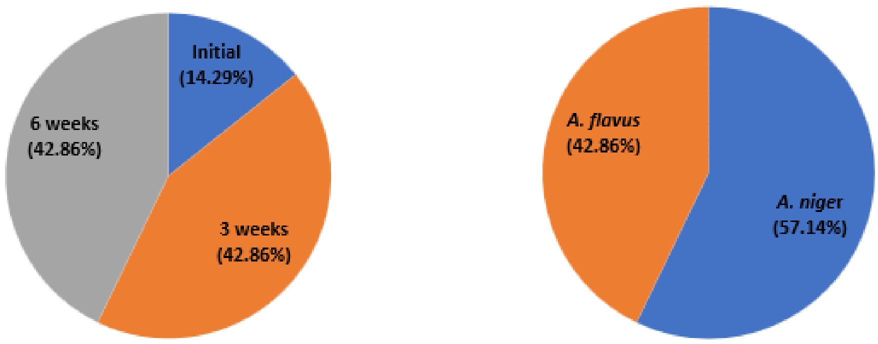
Storage period	Total Bacteria Count (X 10^6cfu/g)	Total Fungi Count (X 10^3 sfu/g)
0 week	8.50 ± 1.500^a	0.50 ± 0.500^a
3 weeks	12.50 ± 1.500^a	1.50 ± 0.500^a
6 weeks	15.30 ± 3.232^b	1.17 ± 0.307^a

Averages±SE. Values indicate average of duplicate samples thereafter standard error of means. Averages in the same column have significant differences ($p<0.05$) when they have different superscripts. cfu/g: colony forming unit per gram; sfu/g: spore forming unit per gram.



(a) Storage legnths (b) Species of bacteria

Figure 1: Percentage abundance and species of bacteria during the storage bush mango chips



(a) Storage lengths (b) Species of fungi

Figure 2: Percentage abundance and species of fungi during the storage of bush mango chips

Conclusion

Apart from a decrease in the moisture content, all other proximate contents (ash, fat, fibre, protein, and carbohydrate) increased in value in the chips (dried pulps) compared to the pulps (fresh). The sensory score observed in this study indicates that the chips were accepted like the pulps. The study also revealed that the moisture content of the chips increased during storage, and there was a slight significant difference in the other nutritional components (ash, fat, fibre, protein, and carbohydrate). There is a need to ensure low moisture content before storing the chips. The bacteria and fungi populations increased during storage, but did not exceed the value recommended by the International Commission for Microbiological Specification for Food (ICMSF). The nutrients (proximate compositions) retained and safe (low microbial loads) observed in chips during the storage indicate they can be available for consumption during the offseason. Therefore, the chips could be maximally utilized to reduce wastage.

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