Characterization of Fruit, Seed and Oil of Vegetable Tallow (*Allanblackia floribunda*) Found in Rivers State, Nigeria

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Abstract
Unpopular and underutilized fruits, seeds and oil of vegetable tallow (Allanblackia floribunda) found in forest of some communities in Rivers State, Nigeria were characterized. Mature A. floribunda fruits were sourced from 7 communities in Rivers State: Okehi, Igbodo, Rumuewhor, Ubimin, Elibrada, Oyigbo and Ndoki and analyzed for fruit weight; length, circumference and pulp weight by means of a calibrated flexible tape and digital weighing scale. The seeds were extracted manually after two weeks of natural disintegration of the pulp. Number of seeds per fruit was noted and the seed weight, density, thickness, length, shells and seed oil content was measured. Length of fruit, fruit circumference, fruit weight and pulp weight ranged respectively, from 35.66 - 43.00 cm, 13.36 – 15.70 cm, 2021.47- 4133.37 g and 400 and 712 g. Number of seeds per fruit ranged from 42.66-50.66 pieces. Average seed thickness, seed shell, mass of 100 seeds and seed length varied significantly ($p<0.05$) from 0.42 - 0.83 mm, 12.06-25%, 185.66- 355.67 g, 1.26 - 4.33 mm respectively. Oil extraction yield using hot water floatation ranged from 42.21-51.40%. Oil extraction efficiency and extraction loss varied significantly ($p<0.05$) from 63.48-77.80% and 2.50-5.30% respectively. Fruit and seed characteristics of samples collected from Ndoki was considered the best with significantly ($p<0.05$) the highest fruit length, circumference, fruit and pulp weight; and maximum oil content with minimum extraction loss. This study has provided a baseline data for the commercialization of underutilized A. floribunda fruits which will be of great economic benefit.

Key words: *Allanblackia floribunda, fruit, seed, physical characteristics, oil yield*

1. Introduction

The tallow tree *Allanblackia floribunda* Oliv is one of the nine spices in the Allanblackia genus belonging to the Clusiaceae family. It is found in lowland West, East, and Central African rainforest regions including Nigeria, Ghana and Cameron. Others members of the Allanblackia genus are *A. kimbiliensis A. gabonensis, A. stanerana, A. marienii Staner, A. ulugurensis* Engl., *A. parviflora A. Chevalier, A. kisonghi Vermoesen, and A. stuhlmannii* Engl (Van Rompaey, 2003). *A. floribunda* is an unpopular and underutilized fruit tree which has over the years provided an alternative source of income through household sale of seed oil in some parts of Africa (Atangana *et al*., 2010**)**, however, it has received no attention in Nigeria and Rivers state in particular. When matured, an individual tree can grow up to a height of up to 40 m with a width of 80 cm; and can produce up to 250 - 300 brown berry-like fruit that contains 40-50 seeds per fruit enclosed in a

reddish pink gelatinous pulp. The tree starts flowering from September to February and develops into fruits slowly. The fruit attains its peak period by March to August and sometimes in October before harvest (Mpanda *et al.,* 2009). Rivers state has one season of harvest while Cross Rivers State has two seasons. The tree is appreciated for fruit and seed yield as well as its high oil content (58-67%). The fruit is an ovoid (berry-like drupe) 9-20 cm long and 7-14 cm in diameter while the seeds are brittle-shelled, 2-5 cm long by 1.5-3.2 cm in diameter (Adubofuor *et al.,* 2013).
In Nigeria, *A. floribunda* local name varies from community to community, according to Anegbeh *et al.,* (2007); it is called "Egba" in Ibo language, "Ediang" in Efik, "Uzoka" in Edo, "Orogbo-erin" in Yoruba and "Obobio-obo" in Ijaw**.** Here in Rivers state, it is known as "Njahabinah" in Eleme, "Ucham" in Obio/Akpor/Emohua, "Ichaa" in Oyigbo, and "Ureni" in Ogba/Egbema/Ndoni Local Government Areas (Ofori, *et al*. 2015).
Characterization of *A. floribunda* fruit, seed and oil has become important for identification since their physical characteristics vary from communities to communities. Classification has also become important for best individuals with superior desirable features as one of the critical factors in the selection of tree species for domestication (Nyabera *et al*., 2021). Evaluation of variability and morphological characteristics of fruits and seeds is one of the most significant steps determining the superior planting stocks for domestication (Leakey & Asaah, 2013). Other characters are environmental factors, such as climate and soil type, coupled with genetic heredity, may also have a significant influence on fruit size, seed weight, and number of seeds per fruit, fruit weight, fruit length, and fruit circumference (Leakey, 2012). Extracted seeds from Allanblackia fruits are traded by local communities; this market value would potentially increase livelihood opportunities for farmers and ensure the retention of trees on farms for environmental conservation (Nyabera *et al*., 2021). However, it has been argued that seed extraction from fruits collected from wild stands alone is not enough to meet the increasing market demand for Allanblackia seed oil (Shrestha & Akangaamkum, 2008). A practical approach is to seek trees for planting that have desired character combinations such as larger fruits seeds, high oil content or seed with low shell. Despite the above information, evidence of classification of Allanblackia trees is missing; hence, this study was to characterize fruit, seed and oil of *A. floribunda* found in forest of some communities in Rivers State, Nigeria.

2. Materials and methods

2.1 *Source of Plant Material*

Mature fruits of *A. floribunda* (Plate 1) were sourced from wild forest of some communities: Okehi, Igbodo, Rumuewhor, Ubimin, Elibrada, Oyigbo and Ndoki. These communities are in Ikwere, Emuoha, Etche and Oyigbo Local Government Area of Rivers State. Fruits were collected between the months of March-July 2022. Only mature fruits were collected and these were fruits that had dropped from the tree on their own. The fruits collected from each community were kept separately in labeled sacks. They were identified and classified by a Plant Biologist in Rivers State Sustainable Development Agency (RSSDA) Port Harcourt, Rivers State, Nigeria.

2.2 Chemical Reagents

All chemical reagents for the experiment were of analytical grade, obtained from Joechem Chemicals Choba, Port Harcourt, Rivers State, Nigeria.

2.3 Determination of the Physical Characteristics of *A. floribunda* Fruit

A total of twenty fruits were randomly sampled within the study area. Fruit length and circumference were measured using calibrated flexible tape. A digital weighing scale was used to determine the weight of each fruit and its pulp weight. The fruit weight, length and circumference were recorded.

2.4 Determination of the *Physical Characteristics of A. floribunda Seed*

Fruits were stored in covered bags for two weeks to allow fruit pulp fermentation and disintegration. Thereafter, the seeds were manually removed (Plate 2) and sun dried.

2.5 Number of Seeds per Fruit/Seed thickness and Seed length

The dried seeds were rubbed clean of any pulp particles and the number of seeds per fruit was counted manually and recorded. Seed thickness and Seed length was measured using venire caliper

2.6 Determination of 100 Seed Weight

A set number of seeds (at least 100 seeds) were weighed and the seed weight calculated as:

$$100 \text{ seed weight} = \frac{1000}{\text{seeds per kg}} \times 100 \quad \text{----------Eq (1)}$$

***2.7* Determination of Seed density**

Three hundred (300) seeds were weighed with a digital scale and transferred into a 1L measuring cylinder to obtain the volume. Seed density was calculated as:

$$\textit{Seed density (g/ml)} = {}^{Mass}/_{Volume} \quad \text{----------Eq (2)}$$

2.8 Determination of seed shell weight

Five hundred grams (500 g) of dried seeds were weighed and cracked open to separate the shells from clean kernels. The shell and any other impurity attached to the kernel was carefully removed. The separated shells and the kernels were weighed separately and the percentage of seed shell and kernel was calculated as:

$$\text{Seed shell (\%)} = \frac{weight\ of\ shell}{weight\ of\ sample} \times 100 \quad \text{----------Eq (3)}$$

$$\text{Seed kernel (\%)} = \frac{weight\ of\ kernel}{weight\ of\ sample} \times 100 \quad \text{----------Eq (4)}$$

2.9 Kernel preparation for oil extraction

Kernels were cleaned, washed and oven dried at 60℃ for 12 h in (model QUB 305010G, Gallenkamp, UK). Dried kernels were pulverized in a mortar and blended in a Panasonic mixer (model MXAC2105, Japan) to obtain a much finer powder (Plate 3). The resultant powder was stored in an air tight high density polyethylene (HDPE) bag and kept until further analysis.

2.10 Extraction of oil from *A. floribunda* kernels

The Hot water flotation method described by Rosenthal *et al.,* (1996) and Okwechime *et al.,* (2017) was followed with slight adjustment. Three kilogram (3 kg) of pulverized *A. floribunda* was conditioned in a mortar by adding equal volumes (250 mL each) of warm and cold water concurrently with continuous stirring until a paste was formed (Plate 4). The paste was then released into boiling water (100℃) and heated with periodic stirring for 5 h and the extracted oil was separated from the oil-water mixture. The separation was achieved by allowing the mixture to stand for 24 h at room temperature for the oil to solidified and removed by scoping from the mixture. Images of the oil separation and crystallization are shown in Plates 5 and 6 respectively. The separated solid fat (Plate 7) was heated up to 40 ℃ and filtered with clean handkerchief before drying in an oven to remove any traces of moisture (Plate 8). Recovered oil was cooled (Plate 9) and stored in an air tight stainless steel container.

2.11 Determination of oil Extraction Yield, Efficiency and Loss

Oil yield, oil extraction efficiency and extraction loss were determined mathematically as defined by Olaniyan, (2011). Oil yield was the ratio of the weight of oil recovered to the weight of crushed seed sample before extraction:

$$Ey\ (\%) = \frac{wor}{wcss}\ x\ 100 \quad \text{---------- Eq (5)}$$

Where:
Ey = Extraction yield (%)
Wor = weight of oil recovered
Wcss = weight of the crushed seed sample

Oil extraction efficiency was computed as the ratio of the weight of oil recovered to the product of the seed oil content and weight of crushed seed sample before extraction.

$$Ee\ (\%) = \frac{wor}{soc \times wcss} \times 100 \quad \text{----------Eq (6)}$$

Where:
Ee = Extraction efficiency (%)
Wor = weight of oil recovered
Soc = seed oil content (72% or 0.72).
Wcss = weight of crushed seed sample

Extraction loss was calculated as the difference between the weight of the crushed seed sample before extraction and the sum total weights of oil recovered and residual cake after extraction divided by the weight of the crushed seed sample before extraction.

$$El\ (\%) = wcss - \frac{wor+wrc}{wcss} \times 100 \quad \text{---------- Eq (7)}$$

Where:
El =Extraction loss (%);
Wcss= weight of crushed seed sample before extraction (g)
Wor = weight of oil recovered after extraction (g)
Wrc = weight of residual cake after extraction (g)

Plate 1. *A. floribunda* fruits

Plate 2. *A. floribunda* seeds

Plate 3. *A. floribunda* seed flour

Plate 4. *A. floribunda* flour conditioning

Plate 5. *A. floribunda* oil separation

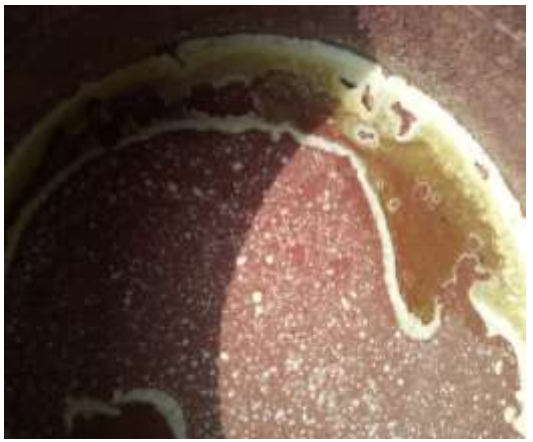

Plate 6. *A. floribunda* oil crystallization

Plate 7. *A. floribunda* fat

Plate 8. *A. floribunda* oil at 40^{O}C

Plate 9. *A. floribunda* oil at 28^{O}C

2.12 Statistical analysis

Obtained data were analyzed using Minitab (Release 18.1) Statistical Software English (Minitab Ltd. Conventry, UK). Analysis of variance (ANOVA) was performed and the significant differences between treatments were determined using Turkey's multiple comparison range tests, and significance accepted at P<0.05 level).

3. Results and Discussion

3.1 Physical characteristics of *A. floribunda fruits from different* communities *in Rivers State*

The results of the physical characteristics of *A. floribunda* fruit is shown in Table 1.

Table 1. Physical characteristics of *A. floribunda* fruits from different communities in Rivers State

Location	Fruit Characteristics			Pulp weight (g)
	Length (cm)	Circumference (mm)	Weight (g)	
Okehi	35.66^{b}±0.57	14.40^{b} ±0.10	2141.42^{d}±8.1	402.00^{c}±1.00
Igbodo	36.00^{b}±1.00	13.36^{c}±0.15	2331.67^{c}±0.47	399.667^{c}±1.52
Oyigbo	41.00^{a}±1.00	15.53^{a}±0.15	3551.63^{b}±0.76	513.00^{b}±1.00
Ndoki	43.00^{a}±1.00	15.70^{a}±0.10	4133.37^{a}±0.15	712.00^{a}±1.00
Omalelu	32.00^{c}±1.00	14.20^{b}±0.10	2021.47^{e}±0.59	400.00^{c}±2.00

Values are means ± standard deviation of duplicate samples
Means that do not share a letter are significantly (p<0.05) different.

There were significant (P<0.05) differences in all measured characteristics. Mean fruit length ranged from 32.0 - 43.0 cm with samples collected from Ndoki having significantly (p<0.05) the highest length and sample from Omalelu recording the least value. Average fruit circumference, was maximum in sample found in Ndoki (15.70 mm) followed by Oyigbo (15.53 mm), Okehi (14.40 mm), Omalelu (14.20 mm) and Igbodo (13.36 mm) was the smallest. Fruit weight was significantly (p<0.05) heaviest in sample from Ndoki (4133.3 g) and lowest in sample from Omalelu (2021.47 g). Pulp weight was significantly (p<0.05) highest in sample obtained from Ndoki (712.00 g) and lowest in fruits collected from Igbodo (399.66 g). Comparing the mean fruit length and circumference, Oyigbo measured 41 ×15.53 cm, Ndoki 43 × 15.70 cm, Okehi 35.66 × 14.40 cm, Igbodo 36 × 13.36 cm and Omalelu 32 × 14.20 cm. Peprah, *et al.*, (2009) reported 10 – 50 cm × 15 cm in *A. parviflora A. Chev* and stated that fruit size can be determined by fruit length, circumference, diameter, and weight. They posited that fruit size is an important quality parameter determining fruit prices. There were also significant (p<0.05) differences in the weight of the fruit and the pulp in samples collected from Oyigbo and Ndoki and the other communities. The amount of the pulp in the fruit is an important characteristic for evaluating the fruit weight. It was observed that the heavier the fruit weight the more the pulp content. Peprah *et al*., (2009), characterized *A. parviflora* for the selection of elite morphotypes for domestication across three provenances. They considered parameters such as fruit size, seed weight, number of seeds per fruit, fruit weight, fruit length, and fruit diameter and found significant variations among the selected individual trees and not among different provenances. This suggests that a closer examination of the individual trees

in each location might show significant variation but in the present study, variations were observed per location of the trees not as per individual trees in each location. *A. floribunda* genotypes can be selected based on high heritability index on fruit size (length, circumference, and weight). However, in order to avoid wrong conclusions, no single trait (fruit length, diameter, circumference or weight) can be perfect to be used for selection. This is because fruit shape varied with some being elongated but with small diameter and vice versa Peprah *et al*., (2009).

3.2 Physical characteristics of *A. floribunda* seeds from different communities in Rivers State

Seed is a vital input in crop production, the quality of seeds is considered as an important factor for increasing nutrient and oil yield for commercial production (Freitas *et al.*, 2015). The result of the number of seeds in a fruit, the seed thickness, percentage seed shell and kernel, seed weight, and seed length is presented in Table 2.

Table 2. Physical characteristics of *A. floribunda* seeds from different communities in Rivers State

Characteristics	Location				
	Okehi	Igbodo	Oyigbo	Ndoki	Omalelu
Number of seeds	$43.00^{c}\pm1.00$	$44.00^{c}\pm1.00$	$48.66^{b}\pm1.15$	$50.66^{a}\pm0.57$	$42.66^{c}\pm1.5$
Seed thickness (mm)	$0.42^{d}\pm0.00$	$0.46^{c}\pm0.010$	$0.82^{a}\pm0.010$	$0.83^{a}\pm0.010$	$0.52^{b}\pm0.02$
Seed shell (%)	$25.00^{a}\pm0.10$	$18.40^{b}\pm0.10$	$13.26^{d}\pm0.15$	$12.06^{e}\pm0.15$	$15.46^{c}\pm0.15$
Seed kernels (%)	$75.00^{e}\pm0.01$	$81.60^{d}\pm0.11$	$86.74^{b}\pm0.07$	$87.94^{a}\pm0.04$	$84.54^{c}\pm0.10$
100 Seed weight (g)	$185.66^{e}\pm1.52$	$265.33^{d}\pm1.52$	$343.66^{b}\pm1.52$	$355.67^{a}\pm2.52$	$281.00^{c}\pm1.00$
Seed length (mm)	$1.26^{d}\pm0.10$	$2.53^{c}\pm0.05$	$4.10^{b}\pm0.10$	$4.33^{a}\pm0.05$	$1.26^{d}\pm0.05$

Values are means ± standard deviation of duplicate samples
Means that do not share a letter are significantly ($p<0.05$) different

A. floribunda obtained from Ndoki had significantly ($p<0.05$) the largest number of seeds (50.66) followed by that of Oyigbo (48.66), Igbodo (44.00), Okehi (43.00) while the smallest was found in sample collected from Omalelu (42.66). Peprah *et al*., (2009) reported the number of seeds per fruit of *A. parviflora* in the range of 18 – 48 seeds. This shows that *A. floribunda* has more seed yielding ability than *A. parviflora*. Values obtained for seed thickness ranged from 0.42 - 0.83 mm with sample from Ndoki having significantly ($p<0.05$) the highest thickness whilst Okehi had the least. The seed shell and kernel content (%) ranged from 12.06 - 25.0 and 75.00 – 87.94 respectively. Ndoki seed samples had significantly ($p<0.05$) the lowest shell content and the highest kernel content when compared with seeds collected from other communities, the reverse was the case for samples from Okehi. Seed weight was significantly ($p<0.05$) maximum in *A. floribunda* from Ndoki (355.67 g) and minimum in seeds from Okehi (185.66 g). Similar trend was seen in the length of the seed. The seeds were ovoid in shape and varied in length from 1.26 - 4.33 cm. The highest mean length was obtained from Ndoki while the least was found from Okehi and Omalelu. This is in line with the report by Orwa & Oyen, (2007) for *A. parviflora* with seed

length of 1.5 – 3.0 cm. The variations in the characteristics of the seed from the different locations could be attributed to many factors from the soil type, variety and age of the tree, pollination and other environmental factors.

Table 3. Oil extraction parameters of *A. floribunda* from different communities in Rivers State

Location	WCSS	WOR	WRC	Ee	EL	SOC	Ey
Okehi	$501.00^{a}\pm1.41$	$223.20^{d}\pm0.70$	$366.0^{a}\pm1.41$	$69.95^{b}\pm0.03$	$3.55^{b}\pm0.02$	$0.665^{a}\pm0.00$	$44.55^{d}\pm0.01$
Igbodo	$501.50^{a}\pm2.12$	$211.50^{e}\pm0.70$	$265.50^{c}\pm0.70$	$63.48^{d}\pm0.14$	$5.30^{a}\pm0.14$	$0.665^{a}\pm0.00$	$42.21^{e}\pm0.14$
Oyigbo	$501.50^{a}\pm0.70$	$240.50^{b}\pm0.70$	$337.50^{b}\pm1.41$	$72.66^{a}\pm0.02$	$3.25^{b}\pm0.03$	$0.660^{a}\pm0.01$	$48.00^{b}\pm0.02$
Ndoki	$500.50^{b}\pm0.70$	$257.00^{a}\pm1.41$	$228.00^{e}\pm1.41$	$77.80^{a}\pm0.01$	$2.50^{c}\pm0.14$	$0.660^{a}\pm0.01$	$51.40^{a}\pm0.21$
Omalelu	$501.50^{a}\pm2.12$	$231.50^{c}\pm0.70$	$241.00^{d}\pm1.41$	$68.38^{c}\pm0.02$	$5.45^{a}\pm0.21$	$0.675^{a}\pm0.00$	$46.16^{c}\pm0.21$

Values are means ± standard deviation of duplicate samples
Means that do not share a letter are significantly ($p<0.05$) different.

WCSS =Weight of seed crushed (g)
WOR = Weight of oil recovered (g)
WRC = weight of residual cake (g)
Ee = Extraction efficiency (%)
EL = Extraction loss at 10.2 % Moisture content
SOC = Seed oil content (0.67 = 67%)
Ey = Oil extraction Yield (%)

3.3 Oil extraction yield of *A. floribunda* from different communities in Rivers State

Table 3, presents the oil content of *A. floribunda* seeds collected from the different communities The weight of the seeds crushed for oil extraction ranged from 500.50 – 501.50 g for samples from Ndoki and Igbodo respectively.

There was no significant ($p<0.05$) differences in crushed seed weight except for samples from Ndoki with the least. Weight of oil recovered was significantly ($p<0.05$) higher in samples from Ndoki (257.00g) and least in Igbodo (211.50 g). The weight of residual cake varied significantly ($p<0.05$) from 228.00 – 366.00 g for Ndoki and Okehi respectively. There was significant ($p<0.05$) variations in the oil extraction efficiency which ranged from 63.48 – 77.80%. Samples from Ndoki had the highest extraction efficiency and Igbodo had the least value. Extraction loss at 10.2% moisture content was significantly ($p<0.05$) least in samples from Ndoki (2.50%) and highest in Omalelu (5.45%). There was no significant ($p<0.05$) difference in the seed oil content which ranged from 66.0 – 67.5% but the oil yield was significantly ($p<0.05$) highest in samples from Ndoki and least in Igbodo samples. The lower extraction loss, the better the oil recovery, this implies that seeds from Ndoki with highest extraction efficiency and lowest extraction loss yielded more oil and would be more economical in terms of resources input. The result of oil yield and extraction efficiency in this present study (44.55 – 51.40 and 63.48 – 77.80%) were higher than the oil yield (42.2%) and extraction efficiency (58.6%) report for *A. floribunda in Ghana* using the traditional hot water floatation (HWF) method by Alenyorege *et al.,* (2015), while the extraction loss was lower except for samples from Omalelu that was comparable with the extraction loss (5.4%) of Ghanaian *A. floribunda.* The oil yields however, exceeded the minimum oil yield (30 %) for commercial, domestic and industrial consideration (Alenyorege *et al.,* 2015). Siaw, *et al.,* (2003) also reported that Allanblackia seed oil is superior to other alternative oils such as palm oil due to its moderately high melting point and fatty acid composition. The concentration of oil in the fruit seed is tending to 60% of the fruit weight which is the promising characteristics of the fruit. Though, this depends on the variety, growing climatic condition, harvesting time of the fruit, topography where the fruit are grown (Dixon *et al.,* 2004). *A. floribunda* from different parts of Rivers State will not only meet commercial production but will present a good alternative for various uses including the multiplication of best individual trees based on the revealed desirable traits. Identification of best individuals with superior desirable features has been underlined as one of the thoughtful factors in the selection of tree species for domestication (Leakey & Asaah, 2013).

4. Conclusion

The study showed that the Allanblackia fruit sample collected from Ndoki and Oyigbo had the best physical characteristics; fruit and seeds from these communities are considered to be best when compared with sample found in other communities. Their seeds were high in oil content, a consideration for economic and commercial values. Though, there are no commercial scales productions of Allanblackia fruit, seeds or oil in Rivers State. The knowledge from this study can serve as a baseline study for the commercialization of this underutilized fruits and seed which will be of great benefit to the farmers in terms of income generation. Use of modern molecular markers for genetic diversity assessment, are recommended for selection of superior mother tree populations with superior desirable traits.

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