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Note

Physical properties of wild mango fruit and nut

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A b s t r a c t. Physical properties of two wild mango varieties were studied at 81.9 and 24.5% moisture (w.b.) for the fruits and nuts, respectively. The shape and size of the fruit are the same while that of nuts differs at $P = 0.05$. The mass, density and bulk density of the fruits are statistically different at $P = 0.05$ but the volume is the same. The shape and size, volume and bulk density of the nuts are statistically the same at $P = 0.05$. The nuts of both varieties are also the same at $P = 0.05$ in terms of mass and density. The packing factor for both fruits and nut of the two varieties are the same at 0.95. The relevant data obtained for the two varieties would be useful for design and development of machines and equipment for processing and handling operations.

K e y w o r d s: physical properties, wild mango, moisture content, postharvest, processing

INTRODUCTION

Wild mango (*Irvingia* Spp.) is grown for its fruits and kernels popularly known as Ugiri and Ogbono (Igbo) respectively in Nigeria. The edible fruit is eaten fresh or used to make juice and the kernel when ground is used to make ogbono soup. The powder of the kernel is also used as ingredient in other sauces like tomatoes and groundnut for a sticky effect and taste. Extracts of ogbono seed can be used to reduce obesity, cholesterol and chances of developing degenerative diseases such as diabetes, cancer, high blood pressure, kidney failure, heart attack and stroke (Leakey *et al*., 2005; Ngodi *et al*., 2005).

Processing wild mango fruit involves four stages: separating the mesocarp from hard endocarp (done manually using knife to peel off the mesocarp or allow it to rot); cracking the stony endocarp with hammer or stone to remove the kernel (splitting fresh fruit into two with sharp knife can also be used to extract the kernel); drying the extracted kernel to storable moisture content and finally, grinding the kernel to powder. The kernel composed about 62.8% lipids, 19.7% carbohydrates, 8.9% protein, 5.3% dietary fibre and 3.2% ash (Ejiofor, 1994).

The knowledge of physical properties of biomaterials are important in providing essential engineering data required for design and development of machines, structures and equipment for handling, processing, transporting and storage of food materials. Shape and size are relevant in designing equipment for grading, sorting, cleaning, dehulling and packaging. Density with specific gravity are used for calculating thermal diffusivity in heat transfer, terminal velocity, Reynolds number for pneumatic and hydraulic handling of products. Mass, bulk density and porosity are employed in storage, transportation and separation system (Oh *et al*., 2001; Ureňa *et al*., 2002).

The aim of this study was to determine physical properties of two varieties of wild mango fruit and nut.

MATERIALS AND METHODS

Two varieties of wild mango, *Irvingia gabonensis* and *wombolu*, used for this study were gathered from the wild mango trees found in the Staff Quarters of Michael Okpara University of Agriculture, Umudike – Umuahia, Abia State, Nigeria (Fig. 1). Abia State is located in the rain forest vegetation zone of SE Nigeria. Abia state lies between $04° 40^1$ and $06° 14^1$ N and $07° 10^1$ and $08°$ E. Fifty fruits of each variety were gathered, washed and labeled for easy identification. The moisture content of the two varieties determined by oven method as described by ASAE (2003) were found to be 81.9% w.b.is for fruit and 24.5% w.b. for nuts.

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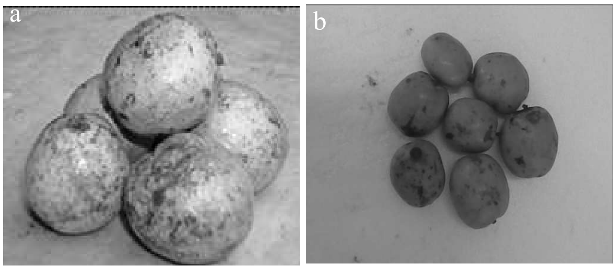

Fig. 1. Samples of *Irvingia gabonensis* (a) and *wombolu* (b) fruits.

The principal axial dimension, major, intermediate, and minor of the fruits and nuts of samples were measured using digital vernier caliper reading to 0.01 mm. The geometric mean diameter (GMD), porosity (packing factor), bulk density, sphericity of the varieties were calculated using the formula given by Mohsenin (1986). The arithmetic mean diameter (AMD), square mean diameter (SMD), and equivalent diameter (EQD) were calculated using expressions given by Asoegwu *et al.* (2006) and Eke *et al*. (2007).

The volume of fruit and nut for the samples were calculated using the expression given by Mohsenin (1986).

The data obtained were analyzed using General Linear Model (GLM) procedure (SAS, 1989). The frequency distributions of the measured and calculated parameters above were given as skewedness and kurtosis.

RESULT AND DISCUSSION

The averages of the tri-axial dimensions major, intermediate and minor diameter of the fruits are given in Table 1. The result gave 66.3 ± 7.0, 63.1 7.4 and 60.5 ± 6.9 mm for *I. gabonensis*, and 61.3 ± 4.8, 55.1 ± 3.9 and 48.9 ± 4.1 mm for *I. wombolu,* respectively. There was no significant difference between major and intermediate diameters at $P = 0.05$ while a significant difference was observed between minor diameter of the two varieties as shown in Table 5. The mean value of minor diameter of *I. gabonensis* was 19.2% larger than that of *I. wombolu*. This confirms the tempered nature of minor diameter of *I. wombolu* physically observed during measurement.

The mean value of GMD, SMD, AMD and EQD of both varieties were statistically the same at $P = 0.05$. The same trend was also observed by Eke *et al*. (2007) and Simonyan *et al*. (2007) for Jackbean and Samaru sorghum, respectively. Table 3 showed that all the dimensions of *I. gabonensis* had leptokurtic distribution with major diameter having the highest value of 21.7 while *I. wombolu* had the major diameter as platykurtic of -0.388. The major diameter of *I. gabonensis* and minor diameter of *I. wombolu* are negatively skewed while the rest were positively skewed. All these observations showed that both varieties of *Irvingia spp.* have the same shape and size. The fruit and nut is prolate and oblate spheroid in shape, respectively.

T a b l e 1. Measured and calculated physical parameters of *Irvingia* fruits

Parameter	*Irvingia gabonensis*		*Irvingia wombolu*	
	Mean	(SD)	Mean	(SD)
Major (mm)	66.3	(7.0)	61.3	(4.8)
Intermediate (mm)	66.1	(7.4)	55.1	(3.9)
Minor (mm)	60.5	(6.9)	48.9	(4.1)
GMD	63.2	(6.9)	55.0	(4.8)
SMD	63.3	(7.0)	55.0	(3.7)
AMD	63.3	(6.9)	55.1	(3.6)
EQD	63.3	(6.9)	55.1	(3.7)
Sphericity	0.95	(0.99)	0.90	(0.04)
Aspect ratio	0.91	(0.99)	0.90	(0.05)
Mass (g)	171.5	(37.7)	97.8	(13.9)
Volume (cm^3)	1.2	(0.4)	0.9	(0.1)
Density (g cm^{-3})	154.5	(33.4)	107.6	(3.7)
Bulk density (g cm^{-3})	6.6	(-)	5.9	(-)
Packing factor	0.96	(-)	0.95	(-)

T a b l e 2. Measured and calculated physical parameters of the nuts

Parameter	*Irvingia gabonensis*		*Irvingia wombolu*	
	Mean	(SD)	Mean	(SD)
Major (mm)	46.3	(3.0)	44.0	(4.2)
Intermediate (mm)	38.2	(2.5)	33.7	(2.5)
Minor (mm)	26.8	(3.1)	20.7	(2.0)
GMD	36.0	(2.5)	31.4	(2.4)
SMD	36.7	(2.5)	32.1	(2.2)
AMD	36.0	(5.4)	32.8	(2.4)
EQD	36.7	(2.5)	32.3	(2.5)
Sphericity	0.78	(0.03)	0.7	(0.04)
Aspect ratio	0.83	(0.04)	0.8	(0.06)
Mass (g)	11.5	(3.5)	14.4	(2.8)
Volume (cm^3)	0.1	(0.1)	0.1	(2.8)
Density (g cm^{-3})	103.1	(3.2)	103.8	(4.8)
Bulk density (g cm^{-3})	4.2	(-)	3.7	(-)
Packing factor	0.96	(-)	0.97	(-)

The seeds of *I. gabonensis* are bigger than that of *I. wombolu* by 4.9, 11.9, and 22.8% for major, intermediate and minor diameters respectively (Table 2). There was highly significant difference between all the dimensions measured

T a b l e 3. Coefficient and frequency distribution of the *Irvingia* fruits

Parameter	*Irvingia gabonensis*					*Irvingia wombolu*				
	m*	C	R^2	K	s	m	C	R^2	K	s
Major (mm)	-0.384	72.31	0.223	21.64	-4.321	-0.004	61.52	0	-0.388	0.147
Intermediate (mm)	-0.427	69.73	0.252	0.376	0.646	-0.006	55.45	0.002	0.360	0.436
Minor (mm)	-0.326	65.51	0.169	1.085	0.877	-0.002	49.06	0	2.962	-0.860
GMD	-0.378	69.10	0.222	0.07	0.454	-0.003	55.14	0	-0.049	-0.091
SMD	-0.379	69.14	0.223	-0.193	0.361	-0.002	55.16	0	-0.256	-0.177
AMD	-0.377	69.15	0.222	-0.089	0.432	-0.002	55.22	0	-0.307	-0.193
EQD	-0.377	69.10	0.221	-0.192	0.375	-0.002	55.23	0	-0.061	-0.111
Sphericity	0	0.958	0.009	-0.253	0.097	$5\ 10^{-5}$	0.893	0.001	-0.824	-0.338
Aspect ratio	-58.48	1.325	0.084	0.401	0.158	$3\ 10^{-5}$	0.897	0	-0.135	-0.589
Mass (g)	-1.297	191.6	0.088	0.46	1.028	-0.366	103.6	0.148	-0.378	0.485
Volume (cm^3)	-0.631	1.493	0.247	0.493	0.73	-0.318	96.05	0.126	-0.319	0.454
Density (g cm^{-3})	1.954	24.20	0.259	0.306	1.046	-0.033	108	0.017	0.175	0.624

*m – slope (gradient), C – intercept, R^2 – coefficient of determination, K – kurtosis, s – skewness.

T a b l e 4. Coefficient and frequency distribution of the *Irvingia* nuts

Parameter	*Irvingia gabonensis*					*Irvingia wombolu*				
	m	C	R^2	K	s	m	C	R^2	K	s
Major (mm)	-0.008	46.35	0.008	0.215	-0.829	-0.023	45.23	0.027	-0.447	0.552
Intermediate (mm)	-0.088	39.58	0.092	0.646	-0.376	0.009	34.11	0.010	0.815	0.363
Minor (mm)	-0.118	28.64	0.113	0.401	1.085	0.005	20.41	0.006	4.117	1.565
GMD	-0.108	37.71	0.141	0.526	0.070	0.001	31.35	0	1.880	1.014
SMD	-0.121	38.51	0.171	0.422	-0.193	0.002	31.9	0.001	0.675	0.461
AMD	-0.105	38.63	0.138	0.526	-0.089	0.009	33.25	0.012	-0.379	0.431
EQD	-0.113	38.29	0.154	0.487	-0.019	-0.001	32.14	0	-0.415	0.501
Sphericity	0	0.785	0.015	0.645	-0.253	0	0.699	0.027	1.452	0.002
Aspect ratio	0	0.823	0.001	0.158	0.282	0	0.757	0.011	0.569	-0.103
Mass (g)	-0.154	13.83	0.149	1.028	0.460	-0.013	14.63	0.001	-0.608	0.662
Volume (cm^3)	-0.002	0.318	0.111	0.730	-0.149	-0.025	14.31	0.006	-0.350	0.774
Density (g cm^{-3})	-0.187	42.23	0.083	1.046	0.306	0.120	101.9	0.048	8.689	2.300

Explanations as in Table 3.

(Table 5). All the dimensions of *I. gabonensis* had leptokurtic distribution and only the major diameter of *I. wombolu* had platykurtic distribution (Table 4) with the major and intermediate diameters were negatively skewed having -0.829 and -0.376, respectively while *I. wombolu* had the entire dimension were positively skewed. These observations showed that the shape of nuts of both varieties is not the same. This information will encourage the design of the same machine and conveyor for cleaning, sorting, grading and handling of the fruits while machine for processing and handling the nuts should be designed differently.

The average values of mass, volume and density of *gabonensis* and *wombolu* fruits are 171.5 ± 37.7 g, 1.2 ± 0.4 cm^3 and 154.2 g cm^{-3} and 97.8 ± 13.9 g, 0.9 ± 0.1 cm^3 and 107.6 g cm^{-3}, respectively (Table 1). Mass of the fruits of the two varieties showed highly significant difference at $P = 0.05$ while the volume and density are significant at the same level as shown in Table 5. For frequency distribution in Table 3, the mass, volume and density of *I. gabonensis* and density of *I. wombolu* fruits had leptokurtic distribution at 0.460, 0.493, 1.046 and 0.175, respectively. The frequency distribution of both varieties skewed is positively skewed.

T a b l e 5. Comparison of measured and calculated physical parameters of *Irvingia* fruits and nuts

Parameters	Fruits	Nuts
Major diameter	NS	**
Intermediate diameter	NS	**
Minor diameter	*	**
Mass	**	NS
Volume	NS	**
Density	*	NS
Bulk density	*	*
Sphericity	NS	NS
Aspect ratio	NS	NS

*Significant, **highly significant, NS – not significant.

The values of mean mass, volume and density of nuts shown in Table 2 for *I. gabonensis* and *wombolu* are 11.5 ± 3.5 g, 0.3 ± 0.1 cm^3 and 39.4 ± 5.6 g cm^{-3}, and 14.4 ± 2.8 g, 0.1 cm^3 and 103.8 ± 4.8 g cm^{-3}, respectively. There was no significant difference between the mass of the seeds while volume and density are highly significant at 5% level of significance (Table 5).

The frequency distribution of mass, volume and density of *I. gabonensis* and density of *I. wombolu* nuts had leptokurtic distribution (Table 4). The mass, volume and density of *I. wombolu* and the mass and density of *I. gabonensis* nuts is positively skewed while only the volume of *I. gabonensis* skewed is negatively skewed. This information also will aid in developing machines and conveyors for processing and handling of wild mango fruits and nuts.

The bulk density of *I. gabonensis* and *wombolu* fruits shown in Table 1 were 6.6 and 5.9 g cm^{-3}, respectively. There was a significant difference between the bulk densities of the two varieties of wild mango. It was also observed that the fruit of *I. gabonensis* is 11.2% more bulky than *I. wombolu*. For the nuts, in Table 2, the bulk density of *I. gabonensis* and *wombolu* are statistically different at 5%, with *I. gabonensis* 12.0% bulkier than *I. wombolu*. The packing factor of both fruits and nuts of the two varieties are the same at 0.95.

CONCLUSIONS

1. The average values of the calculated arithmetic mean diameter, geometric mean diameter, square mean diameter and equivalent diameter for fruits and nuts were found to be statistically different at $P = 0.05$.

2. The particle and bulk density of fruits are not the same at $P = 0.05$.

3. The nuts particle and bulk density of the two varieties are the same at $P = 0.05$.

4. The aspect ratio and sphericity of both varieties fruits and nuts are spherical and are more likely to roll than slide.

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