Croatian Journal of Food Science and Technology

Physicochemical properties of some *Magnifera indica* (L.) seeds in South South Nigeria

Rachel Ogheneovo Ogboru[1], Kingsley Nwaokobia[2], Emmanuel Eimiomodebheki Odion[3*], Teslimah Olatoke Gbolagbade[1], Efemena Martha Olorode[4]

[1]*Research Coordinating Unit, Forestry Research Institute of Nigeria, Jericho Hills, Ibadan, Oyo State, Nigeria*
[2]*Department of Agricultural and Bio-Environmental Engineering Technology, Federal Polytechnic, Auchi. Edo State, Nigeria*
[3]*Department of Pharmaceutical Chemistry, Faculty of Pharmacy, University of Benin, Nigeria*
[4]*Bioscience Department, Forestry Research Institute of Nigeria, Jericho Hills, Ibadan, Oyo State, Nigeria*

A B S T R A C T

This study aims to investigate the physicochemical composition of selected mango seed samples from four markets in South South Nigeria. Saigon cultivars of ripe mango were randomly collected from four markets in South South Nigeria, then identified and authenticated. The seeds were de-pulped using a sharp knife and then analyzed for physical, proximate, mineral and main organic elements such as carbon, hydrogen, oxygen, sulphur and nitrogen. The width, length, thickness, sphericity, roundness and true density, were observed to be high in Igbudu market (15.01± 0.01) mm, Igbudu market (42.27 ± 0.15) mm, Kaima market (0.56 ± 0.03) mm, Igbudu market (7.23 ± 0.03) %, Kaima market (38.27 ± 0.03) %, Oba market (78.89 ± 025) g/cm³. High ash content, fat content, moisture content, crude fibre and crude protein were obtained from Oba market (0.86 ± 0.10) %, (4.86 ± 0.24) %, (20.74±0.10) %, Igbudu market (2.03 ± 0.04) and Kaima market (7.03 ± 0.15) %. High level of minerals and ultimate parameters were reported mainly in Oba market. Alphonso cultivars of *Mangifera indica* L. seeds have varying levels of physicochemical parameters. Some of these are taken into consideration during packaging and sorting, while others could determine how long it takes before the seed deteriorates or germinates and also shows that the seed can be a source of minerals.

Introduction

Mango (*Mangifera indica* L.*)* family Anacardiaceae is a stone fruit that provides a good source of nutrients and fibres, which is a major perquisite in post-harvest processed fruit industry (Nixwell et al., 2013). It is a widespread fruit found virtually in all parts of the tropics and several other countries in Asia. India is the largest producer of mangoes with 18.43 million tons produced each year, followed by China and Thailand with 4.67 and 3.59 million tons respectively (Ganesans and Nair, 2017). Mango is commonly found in various markets in both rural and urban parts within all the ecological zones (Iloh and Olorode, 1990; Aguoru et al., 2016) yearly in its crest season (March-July) in Nigeria. Mango fruit is

popular and economically vital due to its fantastic eating quality and nourishment gain in a well-balanced diet with fibre. The fruits are oval-shaped with smooth, leathery skin; the colour ranges from yellow or yellowish-green when ripe (Fahimdanesh and Bahrami, 2013). The seed coat is about 1-2 mm thick with a thin lining of about 4-7 cm long covering a single embryo of 3- 4 cm width. The seed is about 9-23% of the fruit weight depending on the particular cultivar (Kittiphoom, 2012). The kernel content of the seed ranges from 45.7- 72.8%.

Saigon, Rosigold, Heidi, Springfels and Kent mangoes are some of the varieties of mangoes in Nigeria (Butterfly, 2014) and over one hundred and fifty across the globe. The pulp of the fruit is widely consumed fresh as a dessert or is processed into juices,

*Corresponding author E-mail: emmanuel.odion@uniben.edu

jams and other fruit products, while the seeds are mostly discarded as waste. Nevertheless, the seeds can be used in animal feed (Kittiphoom, 2012), while its peels also contain essential nutrients, minerals and phytochemicals like triterpenes and flavonoids, which maintain blood sugar levels and resist early aging (Wauthoz et al., 2007). Oil from the seed is excellent in preventing nappy rash in babies, and acts as a substitute for cocoa butter (Nwaokobia et al., 2017; Bhagat, 2019).

Nigeria happens to be one of the largest producers of mangoes in Africa and various mango species can be found in different states of Nigeria, and the most species are abundant in South South of Nigeria (FAO, 2004). Nevertheless, data that describe the physical and dietary efficacy among the provenances of mango, as well as chemical compositions of mangoes, are lacking in this region of Nigeria. Therefore, the aim of this study was to investigate the physicochemical composition of some mango seeds collected from four markets in South South, Nigeria.

Materials and methods

Collection and preparation of plant materials

Ripe mangoes of the same cultivars (*Mangifera indica* L. via Saigon) were purchased from four markets in South South region in Nigeria. Oba market in Edo state (OE), Igbudu Market in Delta State (ID), Kiama Market in Bayelsa State (KB) and Igwuruta Market in Rivers State (IR). The samples were identified and authenticated by Adeyemo A. of Forestry Research Institute of Nigeria Herbarium Department, and specimen number FHI-112897 was assigned. The fruits were carefully washed with distilled water and cleaned with a dry cotton cloth, cut with a knife to separate the pulp from the seed (de-pulped). The seeds were air-dried for 30 days and reduced to powder using a milling machine, these powdered seeds were then kept at room temperature in an air-tight container until analyzed.

Physical properties

Length, width, thickness, sphericity, roundness, mass, true and bulk densities were the physical properties determined in this study. Vernier caliper reading to 0.01 mm was used to measure the length, width and thickness of each seed. United State Environmental Protection Agency 528 Water displacement method was used to obtain true density. The size distribution of the samples was used to classify the seeds. Bulk density was determined using the AOAC (2000) recommended method while sphericity was calculated by using the data on a geometric mean diameter and the length of the seed.

$$\varnothing = \frac{(lW)^{1/3}}{L} \tag{1}$$

Where, L = maximum length
L = maximum width
W = maximum thickness

$$\text{Roundness} = \blacksquare \tag{2}$$

Where, A_P = Largest projected area of object in natural rest position,
A_C = Area of smallest circumscribing circle.

Proximate analysis

Proximate analysis was conducted based on the methods described in AOAC (2005) and the following analysis were evaluated: moisture content (Method 967.19 E-G), crude protein (Method 955.04), crude fat (Method 945.16), crude fibre (Method 991.43) and ash content (Method 900.02 A).

Ultimate analysis

This shows the range of major organic elementary constituents of coal, such as carbon (C), hydrogen (H), oxygen (O), sulphur (S) and nitrogen (N) and it is important to determine the amount of air required for combustion, the volume and composition of the combustion gases. Carbon and hydrogen were estimated by using the Liebig's method. Sulphur was determined by the Eschka method which was originally described by Mott and Wilkson (1953). MicroKjeldahl method was used to determine the nitrogen content as described in AOAC (2005) and the percentage of oxygen was deduced indirectly as follows:

Percentage (%) of oxygen in mango seed = 100 – (% of C + H + N + S + ash) (3)

Determination of mineral composition

AOAC (2005) was used in the determination of mineral content. Flame emission photometer PFP7 was used for sodium (Na) and potassium (K) determination. Atomic absorption spectrophotometer 210VGP model was used to determine aluminum (Al), calcium (Ca), copper (Cu), iron (Fe), magnesium (Mg), silicon (Si) and zinc (Zn) (Dalton and Malanoski method), while Phosphorus (P) was determined calorimetrically using the vanadomolybdate procedure (Hesse, 1972).

Presentation of the results and statistical analysis

Theresults are presented as mean ± standard deviation (SD) and statistical analysis was done using Instat GraphPad 3.06 version using one-way analysis of variance (post-test). Level of significance was set at $P \leq 0.001$.

Results

The widest mango seeds were observed in Igbudu market (15.01± 0.01 mm) while mango seeds of the lowest width came from Kaima market (12.02 ±0.01) mm, and the average width was 13.67 mm. The longest mango seeds came from Igbudu market (42.27 ± 0.15) mm, and the shortest from Igrwuta market (39.47 ± 0.05) mm, the average length was 41.15 mm. The mango seeds with the highest thickness were observed in Kaima market (0.56

± 0.03) mm, while the mango seeds with the lowest thickness were observed in Igbudu market (0.49 ± 0.04) mm, average thickness was 0.52 mm. The highest sphericity of the mangoes was observed in Igbudu market (7.23 ± 0.03) %, while the lowest sphericity was observed in Igrwuta market (5. 71± 0.05) %, the average sphericity was 6.40%. The highest roundness of mangoes was observed in Kaima market (38.27 ± 0.03) %, while the lowest roundness was observed in Oba market (32.44 ± 0.37) % and average roundness of 35.35%. The highest true density of mango seeds was observed in Oba market (78.89 ± 025) g/cm^3 while the lowest true density was observed in Igbudu market (68.24 ± 0.26) g/cm^3 and the average true density was 73.67 g/cm^3. The mango seeds that showed the highest bulk density were observed in Igbudu market (62.04 ± 0.02) g/cm^3, the lowest bulk density was observed from Igrwuta market (51.47 ± 0.02) g/cm^3, while the average bulk density was 55.59 g/cm^3.

Table 1. Physical properties of *Mangifera indica* L. seed from four selected markets in South South Nigeria

S/N	Parameters	OE	ID	KB	IR
1	Width (mm)	14.46±0.18	15.01±0.01	12.02±0.01	13.21±0.12
2	Length (mm)	41.75±0.41	42.27±0.15	41.14±0.24	39.47±0.05
3	Thickness (mm)	0.54±0.31	0.49±0.04	0.56±0.03	0.51±0.32
4	Sphericity (%)	6.75±0.13	7.23±0.03	5.93±0.13	5.71±0.45
5	Roundness (%)	32.44±0.37	37.12±0.02	38.27±0.03	33.58±0.10
6	True density (g/cm³)	78.89±0.25	68.24±0.26	77.29±0.10	70.27±0.24

OE= Oba market, Edo state. ID= Igbudu market, Delta State. KB= Kaima market, Bayelsa State. IR= Igrwuta market, Rivers State. Each value represented mean S±D of n=3

Table 2. Result of Proximate analysis of *Mangifera indica* L. seed from four selected markets in South South Nigeria

S/N	Parameters	OE	ID	KB	IR
1	Ash content (%)	0.86±0.10	0.71±0.01	0.73±0.02	0.69±0.03
2	Fibre (%)	1.01±0.10	2.03±0.04	0.99±0.08	1.58±0.16
3	Fat (%)	4.86±0.24	3.53±0.01	2.91±0.56	4.06±0.45
4	Moisture content (%) DW	20.74±0.10	15.23±0.10	14.91±0.03	10.76±0.02
5	Crude protein (%)	5.19±0.02	6.35±0.03	7.03±0.15	4.72±0.12

OE= Oba market, Edo state. ID= Igbudu market, Delta State. KB= Kaima market, Bayelsa State. IR= Igrwuta market, Rivers State. Each value represented mean ±SD of n=3, DW=dry weight

Table 3. Mineral analysis of *Mangifera indica* L. seed in four different markets in SouthSouth Nigeria

S/N	Parameters	OE	ID	KB	IR
1	Potassium (mg/100 g)	187.63±0.54	172±0.03	165.12±0.02	173.62±0.03
2	Sodium (mg/100 g)	139.03±0.75	127±0.34	117.03±0.01	132.76±0.02
3	Magnesium (mg/100 g)	98.37±0.28	83.81±0.09	72.04±0.01	91.84±0.12
4	Phosphorus (mg/100 g)	33.53±0.04	26.21±0.02	22.54±0.02	16.38±0.25
5	Calcium (mg/100 g)	26.91±0.71	11.21±0.15	13.27±0.02	22.03±0.02
6	Copper (mg/100 g)	0.11±0.01	0.09±0.01	0.09±0.02	0.13±0.02
7	Iron (mg/100 g)	ND	ND	ND	ND
8	Silicon (mg/100 g)	ND	ND	ND	ND
9	Aluminum (mg/100 g)	ND	ND	ND	ND
10	Zinc (mg/100 g)	3.92±0.31	1.76±1.01	0.92±0.32	2.78±0.01

OE= Oba market, Edo state. ID= Igbudu market, Delta State. KB= Kaima market, Bayelsa State. IR= Igrwuta market, Rivers State, Each value represented mean ±SD of n=3 ND= Not Detected

Table 4. Ultimate analysis of *Mangifera indica* L. seed in four markets in South South Nigeria.

S.N	Parameters	OE	ID	KB	IR
1	Total carbon	45.40±0.25	41.87±0.01	38.26±0.05	35.82±0.15
2	Hydrogen	0.35±0.01	0.45±0.04	0.29±0.03	0.34±0.04
3	Oxygen	24.70±0.03	16.95±0.06	10.74±0.07	6.49±0.02
4	Sulphur	0.03±0.05	0.01±0.05	0.01±0.10	0.07±0.06

OE= Oba market, Edo state. ID= Igbudu market, Delta State. KB= Kaima market, Bayelsa State. IR= Igrwuta market, Rivers State. Each value represented mean ±SD of n=3

The highest ash content was obtained from mango seeds from Oba market (0.86 ± 0.10) % while the lowest ash content was obtained from Igrwuta market (0.69 ± 0.03) %. Volatile matter was highest in mango seeds from Oba market (3.54 ± 0.14) %, and the lowest from Igrwuta market (2.52 ± 0.04) %. Fixed carbon was highest in mango seeds from Oba market (55.16 ± 0.17) % and the lowest from Kaima market (23.67 ± 0.04) %. Crude fibre was highest in mango seeds from Igbudu market (2.03 ± 0.04) % and the lowest from mango seeds from Kaima market (0.99 ± 0.08) %. The highest fat content in mango seeds was obtained from Oba market (4.86 ± 0.24) %, and the lowest from Kaima market (2.91 ± 0.56) %. The highest moisture content was obtained from mango seeds from Oba market (20.74±0.10) % dry weight, while the lowest was obtained from Igrwuta market (10.76 ± 0.02) % dry weight. Crude protein was the highest in mango seeds obtained from Kaima market (7.03 ± 0.15) % and the lowest in mango seeds obtained from Igrwuta markets (4.72 ± 0.12) %.

The level of potassium in the seeds of mangoes collected from Oba market was the highest, while the level in Kaima market was the lowest (165.12 ± 0.02) mg/100 g. Sodium level in mango seeds collected from Oba market (139.03 ± 0.75) mg/100 g was the highest while Kaima market (117.03± 0.01) mg/100 g showed the lowest sodium level. The highest magnesium level was obtained in Oba market (98.37 ± 0.28) mg/100 g and mango seeds obtained from Kaima market (72.04 ± 0.01) mg/100 g had the lowest magnesium level. Oba market (33.53 ± 0.04) mg/100 g showed the highest level of phosphorus obtained from mango seeds, while mango seeds from Igrwuta market (16.38 ± 0.25) mg/100 g had the lowest level of phosphorus. The highest level of calcium in the collected mango seeds was obtained in Oba market (26.91 ± 0.71) mg/100 g, while the lowest was observed in Igbudu market (11.21 ± 0.15) mg/100 g. The highest level of copper was observed in Igrwuta market (0.13 ± 0.02) mg/100 g, while the lowest was observed in Igbudu market (0.09 ± 0.01) mg/100 g. The highest level of zinc was observed in mango seeds obtained from Oba market (3.92 ± 0.31) mg/100 g, while the lowest was obtained from Kaima market (0.92 ± 0.32) mg/100 g.

Silicon, iron and aluminum was not detected in the seeds of the mangoes collected from these regions.

The highest total carbon was observed in mango seeds from Oba market (45.40 ± 0.25), while the lowest total carbon was obtained from Igrwuta market (35.82 ± 0.15) %. The highest hydrogen was observed from mango seeds from Igbudu market (0.45 ± 0.04) %, while the lowest hydrogen was obtained from Kaima market (0.29 ± 0.03) %. Level of oxygen was the highest in mango seeds obtained from Oba market (24.70 ± 0.03) %, while Igrwuta market showed the lowest level of oxygen in mango seeds. Sulphur was the highest in mango seeds obtained from Igrwuta market (0.07 ± 0.06) % and the lowest in mango collected from Igbudu market (0.01 ± 0.05) %.

Discussion

Some physical properties of *Mangifera indica* L. seed from markets in Edo, Delta, Bayelsa and Rivers states were evaluated. The study showed no significant physical variation in these parameters. These discrepancies in the physical characteristics of the mango seeds are utilized as an important engineering data for the design and development of technologies, structures and machines for handling, processing, transporting and storage of the fruits. Shape and size are relevant in designing equipment for grading, sorting, cleaning, dehulling and packaging. These can enhance handling and transportation. Density with specific gravity is utilized for calculating thermal diffusivity in heat transfer, terminal velocity, Reynolds number for pneumatic and hydraulic handling of products. Mass and bulk density are used in storage, transportation and separation system (Ehiem and Simonyan, 2012). Colour of the seeds ranged from grayish-yellow to yellow which can be used for its identification and sorting following the de-pulping of the fruits.

Evaluation of the proximate analysis of the seed sample was done to show the nutritional value with regard to fats, moisture, ash, crude protein, fibres, and volatile matter using already established method. The ash content of mango seeds was observed to vary between (0.69±0.03) % to

(0.86±0.10) % in all the markets, but was relatively high in Oba market, implying that the mineral level will be higher in the seeds collected there (Ilodibia et al., 2014) and could be used to maintain acid-base balance (Hawkin, 1979) and reduce the level of sugar in the blood (Gokani et al., 1992). Fibres are known to lower the absorption of carbohydrate and plasma cholesterol (Khan et al., 2013); the level of fibres was observed to be low in seeds collected from the markets. Seeds from Igbudu market had the highest level of fibres, thus indicating that the seeds from Igbudu market could be used to aid digestion better than those from other markets. Fat and protein are important sources of energy and amino acids which are needed for daily survival of humans and animals. Fat serves as a store of excess carbohydrate in the body while protein acts as the building block for the body. The seeds collected from Oba market was high in fat and low in protein while the seeds collected from Kaima market was high in protein and low in fat, indicating that the seeds from Oba markets are likely to have more of the fat-soluble vitamins, while seeds from the Kaima markets are more likely to enhance cellular growth. The essence of evaluating the moisture content of a food item is to measure its stability and susceptibility to microbial degradation (Uyoh et al., 2013). High moisture content in the mango seeds makes them prone to microbial contamination and thus degradation (Nwofia et al., 2012) and reduces the storage and shelf-life (Aruah et al., 2012). The level of the moisture content in mango seeds from this study will likely encourage the proliferation of microbes in the mango seeds and cause spoilage.

Ultimate analysis provides the mass concentration of carbon, hydrogen, oxygen and sulphur. The relative high level of carbon and oxygen content in mango seeds provides high level of energy giving compounds in the mango seeds, whereas low level of sulphur content showed reduced rate of deterioration in the mango seeds. In terms of fuel quality of mango seeds, proximate analysis is the fastest and unassuming way of evaluating fuel quality of the powdered samples. High moisture content of mango seeds affects the transformation efficiency and heating value of the mango seeds and has the prospect to depreciate its energy quality throughout storage due to decomposition. This ability to decrease the energy value can be further seen with low volatile matter content and ash content. High volatile content observed with mangoes from Oba market indicated that the material is more volatile than solid fuels, whereas the fixed carbon content after pyrolysis was high

(Pradhan and Singh, 2013), thus mango may not be a good source of energy.

It is observed that Fe, Si and Al were absent while Na, K, Mg, Ca, P, Cu and Zn were present in the seed assayed. Deficiency or excess minerals in the human body could cause serious metabolic disorders, alter immunity and result in complications, ill health and in some cases death. Thus, these minerals are needed by living cells for proper functioning and some possess the ability to help fight against infections and chronic ailments like cancer. The functions of some of these minerals are sometimes interdependent (Maron et al., 2012). Inadequate K, Na and Zn have been associated with electrolyte imbalance of body fluids and distorted activities of enzymes. High levels of Zn have been associated with increased immunity, while the presence of Ca has been linked to proper bone and teeth formation, especially in children and maintain other physiological balance within the cell signal system. K helps in retaining proper body pH and is useful in carbohydrate and protein metabolism. Seeds from Oba market showed the highest level of K. An increase of K intake has been shown to reduce blood pressure to approximately 3.2 mmHg (Iloh and Olorode, 1990).

Conclusions

The evaluation of the proximate and physicochemical properties of *Mangifera indica* L. seed has shown that mango seeds have varying width, length, thickness, sphericity, roundness, true density, minerals, ash content, fibres, fats, moisture content and protein content in different states, which have affected seeds from market to market. This could be attributed to different agricultural practice or mode of cultivation, soil conditions affected by the application of manure and marketing conditions Also, the maturation state of the plant, gene variation and environmental changes could have affected the observed differences.

References

Aguoru, C.U., Okoli, B.E., Olisan, J.O. (2016): Taxonomic investigation of four cultivars of *Mangifera indica* with micro-anatomical features. *Inter. Res. J. Nat. Sci.* 3 (5), 21-32.

Aruah, B.C., Uguru, M. I., Oyiga, B.C. (2012): Genetic variability and inter-relationship among some Nigerian pumpkin accessions (*Cucurbita* spp). *Inter. J. Plant Breeding* 6, 34–41.

AOAC (2000): Official Methods of Analysis of International, 17th edition. AOAC international. Gaithersburg, M.D, USA.

AOAC (2005): Official Methods of Analysis of International 18th Edition, AOAC International Gaithersburg, M.D, USA. Official Method of Analysis.

Bhagat, J. (2019): 12 amazing benefits of Mango seed for skin, hair, and health. http://www.stylecraze.com/articulesaccesed. Accessed August 28, 2020.

Butterfly, K. (2014): Mango fruits in Nigeria. Online publication www.google mango fruits. Accessed on August 27, 2020.

Ehiem, J.C., Simonyan, K.J. (2012): Physical properties of wild mango fruit and nut. *Int. Agrophy*. 26, 95-98. https://doi.org/10.2478/v10247-012-0014-x.

Fahimdanesh, M., Bahrami, M.E. (2013): Evaluation of Physicochemical Properties of Iranian Tomatoes Seed Oil. *J. Nutri. Food Sci*. 3, 1-4. https://doi.org/10.4172/2155.9600.1000206.

Ganesans, S., Nair, A. (2017): Food and beverage news (FNB) http://www.fnbnews.com/Topnews of 24th May, 2017. Accessed August 27, 2020.

Iloh, H. C., Olorode, O. (1990): Numerical taxonomy studies of *Mangifera Indica* cultivars in Nigeria. *Euphy*. 51, 197-205. https://doi.org/10.1007/BF00039719

Ilodibia, C.V., Ugwu R.U., Okeke C.U., Ezeabara, C.A. Okeke, F.A., Akachukwu, E.E., Aziagba B.O. (2014): Determination of the proximate composition of various parts of Dracaena species. *Int. J. Bot*. 10 (1), 37-41. http://dx.doi.org/10.3923/ijb.2014.37.41

Gokani, A., Ibrahim, G., Shah, H. (1992): Alkaline-ash foods in the dietary management of Diabetes mellitus. *Int. J. Diab. Dev. Count*. 12, 85-89.

Hesse, P.R. (1972): A textbook of soil chemical analysis. In: Experimental Agriculture, Volume 8, Issue 2, Cambridge University Press, pp. 184. https://doi.org/10.1017/S0014479700005202

Khan, N., Ruqia, B., Hussain, J., Jamila, N., Rahman, N.U., Hussain, S.T. (2013): Nutritional Assessment and Proximate Analysis of Selected Vegetables from Parachinar Kurram Agency. *Amer. J. Res. Com*. 1 (8), 184-198.

Kittiphoom, S. (2012): Utilization of Mango seed. *Inter. Food Res. J*. 19 (4), 1325-1335.

Mott, R. A., Wilkinson, H. C. (1953): The use of the Eschka methods for the determination of high Sulphur contents. *J. Appl. Chem*. 3.5: 218-223. https://doi.org/doi.org/10.1002/jctb.5010030506

Maron, M., Hobbs, R.J., Moilanen, A., Matthews, J.W., Christie K., Gardner T.A., Keith, D.A., Lindenmeyer, D.B., McAlpine, C.A. (2012): Faustian bargains? Restoration realities in the context of biodiversity offset policies. *Biol Conserv*. 155, 141–148. https://doi.org/10.1016/j.biocon.2012.06.003

Nixwell, F.M., Johanna, M.P., Ngezimana, W. (2013): Proximate, chemical compositions and sulphur concentrations on quality of selected dried mango (*Mangifera indica* L.). *Afr. J. Biotech*. 12 (19), 2678-2684.

Nwofia, G.E., Nwogu, N.V., Nwofia, B.K. (2012): Nutritional variation in fruits and seeds of pumpkins (*Cucurbita* Spp) accessions from Nigeria. *Pak. J. Nutr*. 11, 946–956.

Nwaokobia, K., Ogboru R.O., Idugboe O.D. (2017): Some Engineering Properties of Irvingia gabonesis (Aubry-Lecomte ex (Rorke) Bail (Dika nut Seed and Shell). *J. Sust. Environ. Man*. 9, 84-95.

Pradhan, D., Singh, R.K. (2013): Bio-oil From Biomass: Thermal Pyrolysis of Mahua Seed. https://doi.org/10.1109/Iceets.2013.6533433.

Uyoh, E.A., Ita, E.E., Nwofia, G.E. (2013): Evaluation of the Chemical Composition of Tetrapleur tetrapter (Schum and Thonn) Tuap. Accessions from Cross River State, Nigeria. *Int. J. Med. Arom. Plants*, 3 (3), 386-394.

Wauthoz, N., Balde, A.M., Duez, P., Saldou Baide, E. (2007): Ethopharmacology of *Mangifera indica* L. bark and Pharmacological studies of its C-Glucosylxanthione, Mangiferin. *Int. J. Biomed. Pharm. Sci*. 1 (2), 112-119.