THE PROXIMATE COMPOSITION OF AFRICAN BUSH MANGO KERNELS (*IRVINGIA GABONENSIS*) AND CHARACTERISTICS OF ITS OIL

***Ogunsina, B.S.[1], Bhatnagar, A.S.[2], Indira, T.N.[3] and Radha, C.[3]**
[1]Department of Agricultural and Environmental Engineering, Obafemi Awolowo University, Ile-Ife, Nigeria.
[2]Department of Lipids Science &Traditional Foods, and [3]Department of Protein Chemistry &Technology, Central Food Technological Research Institute (CSIR), Mysore, India, 570 020

*Author for correspondence: babsina@oauife.edu.ng
(Received: 4th June, 2012; Accepted: 25 June, 2012)

ABSTRACT

The proximate analysis (moisture, crude protein, crude fat, mineral ash and total carbohydrates) in the kernels and flour of African Bush Mango (*Irvingia gabonensis*) were investigated. The results revealed that the kernels contained moisture (2.5 g/100 g), crude protein (8.9 g/100 g), crude fat (68.4 g/100 g), mineral ash (2.3 g/100 g) and total carbohydrates (18.7 g/100 g). The defatted flour was also found to contain moisture (6.4 g/100 g), crude protein (25.2 g/100 g), mineral ash (6.2 g/100 g) and total carbohydrates (62.2 g/100 g). The physico-chemical characteristics of its oil revealed that its oil has colour intensity of 3.4 Lovibond units, free fatty acids (2.72 g/100 g), peroxide value (0.5 meq O_2/Kg), iodine value (8.2 g I_2/100 g) and saponification value (256.5 mg KOH/g). The fatty acid composition of the fat showed that it is rich in myristic acid (61.7%) and contains substantial amount of medium chain lauric acid (27.6%).

Key words: *Irvingia gabonensis, Ooro Ibadan*, Kernels, Proximate Composition, Physico-chemical Characteristics, Fatty Acid Composition

INTRODUCTION

The exploitation of several underutilized legumes and oilseeds as sources of vegetable protein to augment supplies from the inadequate animal sources has been well reported (Kinsella, 1976; Sosulski, et al., 1976; Kinsella, 1979; Booma and Prakash, 1990). One of these lesser known seeds is *Irvingia gabonensis* which hitherto was mainly grown for mitigating deforestation and environmental degradation due to the size and height of its tree in the sub-sahara African region from where it originates (Leakey *et al*., *2003, 2005)*. In the *Irvingiaceae* family of plants, *I. gabonensis* and *I. wombolu* kernels are well known. However, *I. gabonensis* is known for its edible fleshy fruits by which it has other common names like dika fruit, African bush mango, wild mango, sweet bush mango; whereas the fruit of *I. wombolu* is bitter and not eaten but their kernels are used in local food preparations (Leakey *et al*., *2005;* Ainge and Brown, 2001; Okolo, 2000). Natural geographical distribution of both species span through the humid forest zones of West and Central Africa, including Angola, Cameroon, Central African Republic, Congo, Côte d'Ivoire, Democratic Republic of Congo, Equatorial Guinea, Gabon, Ghana, Guinea-Bissau, Liberia, Nigeria, Senegal and Sierra Leone, Sudan, Uganda, Sao Tome and Principe (Kengni *et al*., 2011).

Irvingia gabonensis fruit is a broadly ellipsoid drupe; yellowish and having very juicy fibrous pulp when ripe. Its stony nut encases an oil rich dicotyledonous kernel wrapped inside a brown seed-coat (Ogunsina *et al.,* 2008a, b). The average length, width and thickness of the nut are 43.3×30.62×22.11 mm respectively (Ogunsina *et al.,* 2008a). In Nigeria, Ghana and Gabon, the powdered full fat kernels of either *I. gabonensis* or *I. wombolu* or a mixture of both is cooked with leafy vegetables (Eka, 1980; Ekpe *et al.,* 2007), chili powder, smoked fish, crayfish, meat, spices and other additives into a thick, gelatinized, slimy and assorted draw soup called o*gbono. Ogbono* is usually eaten as a delicacy with solid foods such as *eba* or *foofo* in the South Western part of Nigeria. Ainge and Brown (2001) reported that the defatted flour of *I. gabonensis* is potentially useful as raw material in food products development. Based on its nutritional properties, the kernel oil and meal have been reported as potential base materials for confectioneries, edible fats, soaps and cosmetics (Agbor, 1994; Joseph, 1995 and Ayuk *et al*., 1999). For instance, dika bread is a popular local food snack in Gabon. With about 100,000 metric tons valued at $300,000 traded in 1997 *I. gabonensis* kernels promise high revenue for producers, who are majorly rural dwellers (Ainge and Brown, 2001; Ndoye *et al*., 1998; Ladipo and Boland, 1994).

The widespread utilization of *I. gabonensis* kernels as a local sub-sahara African traditional food necessitates a good understanding of the properties that could further promote its exploitation (Ejiofor, 1994; Leakey and Newton, 1994; Vivien and Faure, 1996; Ladipo *et al.,* 1996). Previous studies by other researchers on the compositional, nutritional and biochemical aspects of *I. gabonensis* kernels and its kernel fat constitute the currently existing literatures. Onimawo *et al.* (2003) reported the proximate composition of *I. gabonensis* kernel as including moisture, crude protein, crude fat, mineral ash, crude fiber and carbohydrates. Leakey *et al.* (2005) reported the fat content of 151 dika nut kernels from 24 dika nut trees of Cameroon and Nigeria ranged from 37.5 75.5% while their fatty acid composition showed lauric acid (33.5-42.1%) and myristic acid (48.7-55.5%) as the major fatty acids. Ngondi *et al.* (2005) studied the effect of *I. gabonensis* seed kernel oil on blood and liver lipid levels of lean and overweight rats. Womeni *et al.* (2008) performed aqueous enzymatic oil extraction from *I. gabonensis* seed kernels belonging to Ebolowa, Southern Cameroon. Matos *et al.* (2009) reported the chemical composition and thermal property of *I. gabonensis* kernel oil belonging to two Congo Brazzaville localities of Ouesso and Sibiti. Olawale (2010) reported the total fat content and neutral lipids of *I. gabonensis* kernel oil obtained from Ogbomoso area in Nigeria. Nangue *et al.* (2011) reported that the increasing amount of dika nut fat significantly alter cholesterol and triglyceride at high dose diet, but also increase HDL-cholesterol in young wistar rats. Bello *et al.* (2011) showed the possibility of *I. gabonensis* kernel oil as a biofuel to be used as alternative fuel for diesel engines. However, studies on *Ooro Ibadan* cultivar of *Irvingia gabonensis* has not been documented hitherto. Given the local popularity of *Ooro Ibadan* fruits among the Oyo people of South Western Nigeria and increasing acceptance of the soup prepared from its powdered kernels (*Ogbono* soup) in West African coasts, this study focused on the evaluation of proximate compositions of *Ooro Ibadan* kernels (OIK) and the characteristics of its oil as a step to extending its exploitation in human food systems.

MATERIALS AND METHODS

Clean and dried African bush mango kernels (*Ooro Ibadan* cultivar) botanically identified as *I. gabonesis* were obtained from farms in Iware village, Ibadan, Nigeria in December, 2008.

Proximate Composition of Full Fat Oik and Defatted Oik Flour

The moisture content of ground OIK was determined by oven drying the sample at 105°C for 4 h and expressed as g/100g seeds, according to AOCS Method No: Ai 2-75 (Firestone, 1998). The fat content of ground OIK was determined by Soxhlet's extraction method. Approximately 10 g of ground OIK was packed in cellulose extraction thimbles (Whatman). The thimble was placed in the extractor and hot solvent (35-40°C) was percolated continuously for 8 h and the miscella was desolventized by flash evaporation and oil content was determined gravimetrically and expressed as g/100g seeds. Percent nitrogen content of samples was determined by Kjeldahl method and multiplied by a factor of 6.25 to obtain crude protein and expressed as g/100g kernels (AOAC, 2000). The mineral ash content was determined by incineration and ashing in a muffle furnace at 550°C for 6 h. The weight difference was calculated and expressed as g/100g kernels (AOAC, 2000). Total carbohydrates was calculated by the difference in total dry matter.

Evaluation of Physicochemical Characteristics of OIK fat

The color of the melted fat (oil) was determined by transmission measurement in a 1 inch cell using a Lovibond tintometer (Model - F, The Tintometer Ltd., Salisbury, U.K.) and calculated as 5 × Red units + 1 × Yellow units (5R + Y value) and expressed as Lovibond units. Free fatty acids value (FFA) of the fat was determined by AOCS Method No: Ca 5a-40 (1997) and expressed as g/100g oil. Peroxide value (PV) of fat was determined by AOCS Method No: Cd 8-53 (1997) and expressed as meq O_2 / kg oil. Iodine value (IV) of the fat was determined by AOCS Method No: Cd 1-25 (1997) and expressed as g I_2 / g oil. Saponification value (SV) of the fat was determined by AOCS Method No: Cd 3c-91 (1997) and expressed as mg KOH/g oil (Firestone, 1998).

Determination of Fatty Acid Composition of Oik Fat

Fatty acid methyl ester (FAME) of OIK fat was prepared by transesterification using methanolic KOH according to the AOCS method Ce 2-66

(1997) in Firestone (1998). The FAMEs were separated in a gas chromatograph (Model GC-15A, Shimadzu corporation, Japan) equipped with a hydrogen flame detector (FID) using a S.S. column coated with 15% DEGS on chromosob w/HP 80-100 mesh as the stationary phase. The column oven temperature was 180°C. Injector and detector temperatures were 220 and 230°C respectively and the carrier gas, nitrogen was maintained at a flow rate of 40 ml/min. The fatty acids in the sample were identified by comparing retention times of FAMEs with those of standard FAME mix C8 - C24 (Supelco, Belle, USA). The fatty acids were expressed as relative area percent.

Reagents used for all investigation were of analytical grade and all the experiments were performed using glass-triple-distilled water.

Statistical Analysis

All the analyses were done in triplicate and the mean values ± standard deviation are provided.

RESULTS AND DISCUSSION

The summary of the proximate compositions of full fat OIK and its defatted flour is provided in Table 1. It was found that OIK had moisture (2.5g/100g), crude protein (8.9g/100g), crude fat (68.4g/100g), mineral ash (2.3g/100g) and total carbohydrates (18.7g/100g). The proximate composition of OIK suggested that it is a rich source of edible fat (68.4g/100g). Onimawo *et al.* (2003) reported that the proximate composition of *I. gabonensis* seed had moisture, crude protein, crude fat, mineral ash, crude fiber and carbohydrates to the extent of 3.36%, 7.70%, 65.46%, 2.26%, 10.23% and 10.93% respectively. The proximate composition determined in the present study agreed very well with earlier reported values (Onimawo *et al.*, 2003 and Gliami *et al.,* 1994). The proximate composition of OIK revealed that it is essentially a rich source of edible crude fat with about 68% edible fat. Previous reports on the crude fat content of *I. gabonensis* kernels were 54-67% (Oke and Umoh, 1978) and 72% (Ejiofor, 1994). Leakey *et al.* (2005) reported the fat content of 151 dika nut kernels from 24 dika nut trees of Cameroon and Nigeria which ranged from 37.5 - 75.5%. Some oil bearing products with such high percentage of crude oil are coconut, almond, pistachio, sunflower, walnut, and water melon seeds which contained 62.3, 58.9, 53.5, 52.1, 64.5 and 52.6 % respectively (Gopalan *et al.,* 2007). The defatted OIK flour had a composition of moisture (6.4g/100g), crude protein (25.2g/100g), mineral ash (6.2g/100g) and total carbohydrates (62.2g/100g).

The physico-chemical characteristics of OIK fat are shown in Table 2. It showed that the oil has color intensity of 3.4 Lovibond units, free fatty acids (2.72g/100g), peroxide value (0.5meq O_2/kg fat), iodine value (8.2g I_2/100g fat) and saponification value (256.5mg KOH/g). Information regarding previous studies on these physico-chemical characteristics of *I. gabonensis* kernel fat was scanty hence direct comparison was not possible. The fatty acid composition of OIK fat revealed a high amount of myristic acid (61.7%), lauric acid (27.6%); other fatty acids

Table 1. Proximate Composition of *Ooro Ibadan* Kernels (*Irvingia gabonensis*)

Full fat kernel	g / 100 g
Moisture content	2.55 ± 0.02
Crude Fat	68.37 ± 2.44
Crude Protein	8.90 ± 0.6
Mineral Ash	2.32 ± 0.12
Total Carbohydrates	18.67 ± 1.47
Defatted flour	
Moisture content	6.41 ± 0.51
Crude Protein	25.19 ± 0.36
Mineral Ash	6.20 ± 0.05
Total Carbohydrates	62.19 ± 0.45

Each value represented mean ±SD of n=3

Table 2. Physico-chemical Characteristics of *Ooro Ibadan* Kernels (*Irvingia gabonensis*) fat

Parameters	OIK fat
Appearance	White solid at room temperature and clear liquid after melting
Color (1' cell, 5R + Y, Lovibond units	3.4 (2.4Y + 0.2R + 0W + 0B)
Free fatty acid content (g/100g fat)	2.72 ± 0.12
Peroxide value (meq O_2 /Kg fat)	0.5 ± 0.04
Iodine value (g I_2 / 100g fat)	8.2 ± 0.4
Saponification value (mg KOH / g fat)	256.5 ± 0.8
Fatty acid composition (relative area %)	
Lauric acid (C 12:0)	27.63 ± 0.35
Myristic acid (C 14:0)	61.68 ± 0.67
Palmitic acid (C 16:0)	7.49 ± 0.24
Stearic acid (C 18:0)	0.81 ± 0.11
Oleic acid (C 18:1)	2.12 ± 0.21
Linoleic acid (C 18:2)	0.27 ± 0.05
% Saturated fatty acids (S)	97.61
% Monounsaturated fatty acids (M)	2.12
% Polyunsaturated fatty acids (P)	0.27

present included palmitic (7.5%), stearic (0.8%), oleic (2.1%) and linoleic (0.3%) acids. Moreover, OIK fat contained 97.6% of saturated fatty acids which consisted of 27.6% of medium size chain fatty acid (lauric acid), 2.1% of monounsaturated fatty acid (oleic acid) and 0.3% of polyunsaturated fatty acid (linoleic acid). Leakey *et al.* (2005) reported the fatty acid composition of 151 dika nut kernels from 24 dika nut trees of Cameroon and Nigeria which contained lauric acid (33.5-42.1%), and myristic acid (48.7-55.5%) as the major fatty acids. The richness of OIK fat in myristic acid makes it a potential source of myristic acid with additional benefits of medium chain lauric acid (27.6%). Okolo (2000) reported that *I. gabonensis* kernel fat from Sierra Leone contained 33.5% and 58.6% of myristic and lauric acids respectively. Slight variations may exist normally in the composition of agricultural products from one place to another depending on the varietal differences, soil types and agro-climatic changes (Leakey *et al.*, 2005).

The fatty acid profile of *I. gabonensis* kernel fat was observed to be similar to that of coconut and palm kernel oils (O'Brien, 2005). The clear and slightly pale appearance of the oil and its greasy white colour at room temperature conditions might probably be due to its high myristic acid content. Myristic acid exists at room temperature as white or yellowish glossy crystals with a faint, waxy-oily odor. O'Brien (2005) reported that the melting point of myristic acid is about 54.4^{o} C which explains why the oil solidifies at room temperature. This behaviour may be attributed to its high myristic acid and lauric acid contents. Burdock and Carabin (2007) reported that myristic acid has several applications in food systems; it is a multi-purpose food additive, flavor ingredient, defoaming agent and useful for coating fresh citrus fruits in the food industry. It is also a key ingredient in the manufacture of alkali salts, synthesis of perfume esters and cutting agent in various flower absolutes and essential oils. Nangue *et al.* (2011) observed that myristic acid showed a low order of acute oral toxicity in rats; however, excessive intake of saturated fats (with myristic acid as the major fat) may increase blood triglyceride and cholesterol levels. Kiyasu *et al.*, (1952) reported that *I. gabonensis* kernel fat increases the amount of HDL-cholesterol (good cholesterol) in blood and liver lipids; this may be credited to the presence of lauric acid and myristic acid which metabolized faster through portal absorption. This has been earlier validated by Rioux *et al.* (2000) who reported that myristic acid is more rapidly metabolized in cultured hepatocytes than palmitic acid. With 79% myristic acid in its fatty acid profile, nutmeg is the richest known source of myristic acid (Piras *et al*., 2012); however, the high myristic acid content (about 62%) of *I. gabonensis* kernels suggested that it might also be exploited as a substitute for nutmeg as a condiment in food preparations.

CONCLUSIONS

1) The proximate composition of African bush mango kernels (*Irvingia gabonensis*) has been investigated and found as: moisture (2.5 g/100g), crude protein (8.9 g/100g), crude fat (68.4 g/100g), mineral ash (2.3 g/100g) and total carbohydrates (18.7 g/100g).
2) The defatted flour of OIK contained moisture (6.4 g/100g), crude protein (25.2 g/100g), mineral ash (6.2 g/100g) and total carbohydrates (62.2 g/100g).
3) *Ooro Ibadan* kernels is a rich source of edible fat with about 68.4 g/100g. The fatty acid composition shows a rich presence of myristic acid (a 14-carbon, straight-chain saturated fatty acid) and substantial amount of lauric acid.
4) The physico-chemical properties of OIK fat are: color, 3.4 Lovibond units; free fatty acids (2.72 g/100g), peroxide value (0.5 meq O_2/kg), iodine value (8.2 gI_2/100g) and saponification value (256.5 mg KOH/g).
5) Beyond the local consumption of OIK within the sub-sahara African coast, the rich presence of myristic acid in its fat could be exploited to promote it as a potential source of myristic acid with additional benefit of a medium chain lauric acid. This may expand the land area under *Ooro Ibadan* cultivation and consequently improve the revenue obtainable by farmers in the core-rural sub-saharan Africa where it is sparsely grown.

ACKNOWLEDGEMENTS

The authors express deep appreciation to the Heads of Department of Protein Chemistry and Technology; Lipids Science and Traditional Foods; and Central Instruments Service of Central Food Technological Research Institute (CSIR laboratories) where this investigation was carried out for the facilities. Dr B.S. Ogunsina expresses gratitude to the United Nations University, Tokyo, Japan for granting him Fellowship.

REFERENCES

Agbor, L.O.N. 1994. Marketing trends and potentials for *Irvingia gabonensis* products in Nigeria. Proceedings of ICRAF-IITA Conference on *Irvingia gabonensis*. Ibadan, Nigeria. Pp 3-5

Ainge, L and Brown, N. 2001. *Irvingia gabonensis* and *Irvingia wombolu*. A State of Knowledge Report undertaken for The Central African Regional Program for the Environment by Oxford Forestry Institute Department of Plant Sciences University of Oxford, UK.

AOAC Methods. 2000. Official Methods of Association of Official Analytical Chemists. In P. Cunnif (Ed.), Vol. II, 17th Ed. Arlington, VA, USA. Pp137.

Ayuk, E.T., Duguna, B., Kengue, J., Mollet, M., Tiki-Manga, T and Zenkeng, P. 1999. Uses, management and economic potential of *Irvingia gabonensis* in the humid lowlands of Cameroon. *Forest Ecology Managmt.,* 113(1): 1-9.

Bello, E.I., Fade-Aluko, A.O., Anjorin, S.A and Mogaji, T.S. 2011. Characterization and evaluation of African bush mango (dika nut) (*Irvingia gabonensis*) oil biodiesel as alternative fuel for diesel engines. *J. Petroleum Technol. and Alternative Fuels*, 2(9): 176-180.

Booma, K and Prakash, V. 1990. Functional properties of the flour and the major protein fraction from sesame seed, sunflower seed and safflower seed. *Acta Aliment.,* 19:163176.

Burdock, G.A and Carabin, I.G. 2007. Safety assessment of myristic acid as food ingredient. *Food and Chem. Toxicol.,* 45: 517-529.

Ejiofor, M.A.N. 1994. Nutritional values of *Ogbono (Irvingia gabonensis* var. excelsa). ICRAF-IITA Conference on *Irvingia gabonensis,* Ibadan, Nigeria.

Eka, O.U. 1980. Proximate Composition of seeds of bush mango tree and some properties of dika fat. *Nigerian J. Nutri. Sci.,* 1: 33 36.

Ekpe, O.O; Umoh, I.B and Eka, O.U. 2007. Effect of a typical rural processing method on the proximate composition and amino acid profile of bush mango seeds (*Irvingia gabonensis*) *African J. Food, Agric. Nutri. and Dev.,* 7(1)

Firestone, D. 1998. Official methods and recommended practices of the American Oil Chemists Society, AOCS method no. Ai 2-75, AOCS method no. Ca 5a-40, AOCS method no. Cd 8-53, AOCS method no. Cd 3c-91, AOCS method no. Cd 1-25, AOCS method no. Ce 1-62. 5th Ed. AOCS Press, 1608, Broadmoore Drive Champaign, Illinois - 61826 USA.

Gliami, S.Y., Okonkwo, V.L and Akusu, M.O. 1994. Chemical composition and functional properties of raw, heat-treated and partially proteolysed wild mango (*Irvingia gabonensis*) seed flour. *Food Chem.*, 49: 237243.

Gopalan, C., Rama Sari, B.V and Balasubramanian, S.C. 2007. *Nutritive Value of Indian Foods*. National Institute of Nutrition, Indian Council of Medical Research. Pp 52.

Joseph, J.K. 1995. Physico-chemical attributes of wild mango (*Irvingia gabonensis*) seeds. *Biores. Technol.*, 53: 179181.

Kengni, E., Kengue, J., Ebenezer, E.B.K and Tabuna, H. 2011. *Irvingia gabonensis*, *Irvingia wombolu*, bush mango. Conservation and Sustainable Use of Genetic Resources of Priority Food Tree Species in sub-Saharan Africa. *Biodiversity Int'l.*, pp 7.

Kinsella, J.E. 1979. Functional properties of soy proteins. *J. Am. Oil Chem. Soc.,* 56:242258.

Kinsella, J.E. 1976. Functional properties of proteins in foods: A Survey. *Critical Reviews in Food Sci. and Nutr.*, 7, 219280.

Kiyasu, J.Y., Bloom, B and Chaikoff, I.L. 1952. The portal transport of absorbed fatty acids. *J. Bio. Chem.,* 199: 415419.

Ladipo, D.O and Boland, D.J. 1994. Trade in *Irvingia* kernels. In D.O. Ladipo and Boland, D. Proceedings of the International Workshop on *Irvingia* in West Africa. International Centre for Research in Agroforestry (ICRAF) Nairobi, Kenya.

Ladipo, D.O., Fondoun, J.M and Ganga, N. 1996. Domestication of the bush mango *(Irvingia spp)*:Some exploitable intraspecific variations in West and Central Africa. Proceedings of the FAO/ICRAF International Conference on the Domestication and Commercialization of Non-Timber Forest Products in Agroforestry Systems, pp 193-206.

Leakey, R.R.B., Greenwell, P., Hall, M.N., Atangana, A.R., Usoro, C., Anegbeh, P.O., Fondoun, J.M and Tchoundjeu, Z. 2005. Domestication of *Irvingia gabonensis*: 4. Tree-to-tree variation in food-thickening properties and in fat and protein contents of *dika* nut. *Food Chem.,* 90, 365-378.

Leakey, R.R.B. and Newton, A.C. 1994. Domestication of `Cinderella' species as the start of a woody-plant revolution. 3-6. In: *Tropical trees*: The potential for domestication and rebuilding of forest resources. Ed. R.R.B. Leakey and A.C. Newton. HMSO, London

Leakey, R.R.B., Schreckenberg, H and Tchoundjeu, Z. 2003. The participatory domestication of West African Fruits. *Int'l. Forestry Rev.,* 5(4): 338-347

Matos, L., Nzikou, J.M., Matouba, E., Pandzou-Yembe, V.N. 2009. Studies of *Irvingia gabonensis* seed kernels: Oil technological applications. *Pakistan J. Nutri.,* 8(2): 151-157.

Nangue, T.J., Womeni, H.M., Mbiapo, F.T., Fanni, J. and Michel, L. 2011. *Irvingia gabonensis* fat: nutritional properties and effect of increasing amounts on the growth and lipid metabolism of young rats wistar sp. *Lipids in Health and Disease*. 10:43. doi: 10.1186/1476-511X-10-43

Ndoye, O., Ruiz Perez, M and Eyebe, A. 1998. The markets of non-timber forest products in the humid forest zone of Cameroon. Rural Development Forestry Network Paper 22c, ODI, London,UK.

Ngondi, J.L., Hermann, M.D., Etame S, Julius O. 2005. Effect of *Irvingia gabonensis* kernel oil on blood and liver lipids on lean and overweight rats. *J. Food Technol.*, 3(4): 592-594.

O'Brien, R.D. 2005. *Fats and Oils*. Formulating and processing for applications. 12-42. CRC Press

Olawale O. 2010. Evaluation of lipids extracted from mango and melon seeds. *The Pacific J. Sci. and Technol.,* 11(2): 508-510.

Ogunsina, B.S., Koya, O.A. and Adeosun, O.O. 2008a. Deformation and fracture of *dika* nut (*Irvingia gabonensis*) under uni-axial compressive loading. *Int'l. Agrophy.*, 22(3), 249-253

Ogunsina, B.S., Koya, O.A and Adeosun, O.O. 2008b. A table mounted device for cracking *dika* nut (*Irvingia gabonensis) Agric. Eng. Int'l., The CIGR Ejournal.* Manuscript PM 08 011.Vol.X. Aug., 2008.

Oke, O.L and Umoh, I.B. 1978. Lesser known oilseeds. Chemical composition. *Nutr. Reports Int'l,* 17, 293297

Okolo, H.C. 2000. Industrial potential of various *Irvingia gabonensis* products, such as oil, *ogbono* and juice. In D. Boland and D. O. Ladipo (Eds.), Irvingia: Uses, potential and domestication. Nairobi, Kenya: ICRAF.

Onimawo, I.A., Oteno, F., Orokpo, G., Akubor, P.I. 2003. Physicochemical and nutrient evaluation of African bush mango (*Irvingia gabonensis*) seeds and pulp. *Plant Foods for Human Nutr.,* 58: 1-6.

Piras, A., Rosa, A., Marongiu, B., Atzeri, A., Assunta, M., Falconieri, D and Porcedda, S. 2012. Extraction and Separation of Volatile and Fixed Oils from Seeds of *Myristica fragrans* by Supercritical CO_2: Chemical Composition and Cytotoxic Activity on Caco-2 Cancer Cells, *J. Food Sci.* 77(4) doi: 10.1111/j.1750-3841.2012.02618.x.

Rioux, V., Lemarchal, P and Legrand, P. 2000. Myristic acid, unlike palmitic acid, is rapidly metabolized in cultured rat hepatocytes, *J. Nutr. Biochem.*, 11: 198207

Sosulski, F.W., Garratt, M.O and Slinkard, E.A. 1976. Functional properties of ten legume flours. *Canadian Inst. Food Sci. Technol. J.* 9: 6669.

Vivien, J. and Faure, J.J. 1996. Fruitiers Sauvages d'Afrique. Espèces du Cameroun Ministère Français de la Coopération. Centre Technique de Coopération Agricole et Rurale (CTA).

Womeni, H.M., Ndjouenkeu, R., Kapseu, C., Mbiapo, F.T., Parmentier, M., Fanni, J. 2008. Aqueous enzymatic oil extraction from *Irvingia gabonensis* seed kernels. *European J. Lipid Sci.and Technol.,* 110: 232-238.