EXTRACTION AND PHYSICOCHEMICAL CHARACTERIZATION OF BAOBAB *ADANSONIA DIGITATA)* SEED OIL

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Abstract

Baobab seed oil was extracted from powder sample of baobab (Adansonia digitata) seeds using Soxhlet extraction method with n–hexane as solvent. The powder seeds gave 27 % oil yield with density of 0.86 g/cm^3. The oil was yellowish–orange in colour with a fried smell. The chemical analysis of the oil revealed saponification value of 153.82 ± 0.41 mgKOH/g, acid value of 0.5 ± 0.00 mgKOH/g and iodine value of 24.36 ± 0.71 gI/100 g. The GC–MS analysis of the oil indicated nine different compounds of which comprises of ether, ketone, amide, methyl ester fatty acids, fatty acid and steroids. The oil was used to produce soap with a milky colour which is slightly soluble in water with a soft texture. The solution of the soap has pH value of 13.00 and foam height of 10.10 cm. Soap pH can be easily adjusted and made fit for usage. The oil when properly processed may serve as source of vital drugs and be very useful in both cosmetics and pharmaceutical industrials.

Keywords: *Adansonia digitata*, baobab, oil, GC–MS, soap, physicochemical

INTRODUCTION

The African baobab (*Adansonia digitata*) species belong to the family of *Bombacaceae* and the genus *Adansonia*. The tribe, which is pan tropical, includes *Bombax* and *Ceiba* with species producing fruit fiber used as *kapok*. The family includes about 30 genera, six tribes and about 250 species (Baum, 1995). A number of these species are used locally and various parts of the plant used are the leaves, wood, fruits, seeds or gum. The African baobab (*Adansonia digitata*) occurs naturally in most countries of the Sahara, as a scattered tree in the savannah, the site at which it mostly occurs naturally is the dry area of African, mainly in the Sahelian, Soudano–Sahelian and Soudanian zones; the whole of the baobab tree itself belong to the family of malvarcea. Its distribution extends through the woodlands, savannas and grasslands of sub–Saharan Africa to about 25°S (Alverson, 1999).

African baobab is a long–lived tree that has many uses. It is thought that some of the tree is over 1000 years old. They are characterized by its massive size, have a rounded crown and show a stiff branching habit. The trunk is swollen and stout, up to 10 m in diameter, usually tapering or cylindrical and abruptly bottle–shaped. Giant individuals can reach a girth of up to 28 m (Igboeli *et al.,* 1997). The plant is known to be bat–pollinated; the branches are large and irregularly distributed. The fruits develop 5–6 months after flowering and tend to fall from the late rainy season onwards. Seeds are uniform and embedded in the pulp, dark brown to reddish black with a smooth testa; kernels are obtained after seed decortications. Leaves are 2–3 foliate at the start of the season and are early deciduous, more mature ones are 5–7(9) foliate. Leaves are alternate at the end of branches or occur on short spurs on the trunk. Leaves of young trees are often simple (Asogbadjo *et al.,* 2008).

From literature the seeds were revealed to contain 22.2 % oil (Ezeagu *et al.,* 1998) with 21.4 g/100g dw crude protein, carbohydrate content is 31.7g/100 g dw (Arnold *et al.,* 1985) and 49.7 g/100 g dw fiber (Lockett *et al.,* 2000). For the mineral content, it has high magnesium, calcium, potassium and phosphorus contents (Lockett *et al.,* 2000). The seeds also contain amino acids which have high glutamic acid content and limiting methionine content (Glew *et al.,* 1997). From the study by Glew *et al.* (1997), it was revealed that the fatty acid content of the whole seeds shows the presence of a relatively high quantity of oleic acid (Glew *et al.,* 1997). The African baobab (*Adansonia digitata*) is a promising plant which almost all the plant parts are used nutritionally or medicinally or even industrially (the seeds are used as coagulant). The seeds are rich source of minerals, amino acids and fatty acid; oleic acid. Quiet number of research has been done on the nutritional aspect of the seeds, but not much on the oil. For this reason physicochemical characteristic and soap production from the oil is a worthwhile research.

MATERIALS AND METHODS

Baobab seed was collected from Aliero market, Kebbi State Nigeria, and it was authenticated by the Botanical Department, Kebbi State University of Science and Technology, Aliero. The epicarp was

removed and dried under the sun for three days. The dried seeds were pound with mortar and pestle into powder and stored in polyethylene bag for further use. All reagents were of analytical grade unless otherwise stated. Distilled water was used in the preparation of solutions and dilution unless otherwise stated. The physicochemical analyses were carried out in triplicates unless otherwise stated.

Oil Extraction

Extraction of oils from seeds was carried out using Soxhlet extraction apparatus. 60 g of the powdered seed sample was put into a porous thimble and placed in a Soxhlet extraction, using 140 cm^3 of n–hexane (with boiling point of 40 – 60^oC) as extracting solvent for 6 h. The oil was obtained after the solvent was removed under reduced temperature and pressure and refluxing at 70^oC to remove excess solvent from the extracted oil. The oil was then stored in a refrigerator at – 2^oC for subsequent physicochemical analyses (Warra *et al.*, 2011)

Determination of Percentage Yield

The oil gotten after the extraction was transferred into a measuring cylinder which was placed over water bath for 30 min at 70^oC so as to ensure complete evaporation of solvent. The volume of the oil was recorded and expressed as oil content (%) (Warra *et al.*, 2011);

$$\text{Oil content (\%)} = \frac{weight\ of\ oil}{weight\ of\ sample} x\,100\ \% \quad .....(1)$$

Determination of Specific Density of the Oil

The oil (10 cm^3) was measured in a pre – weighed measuring cylinder. The weight of the cylinder and oil were measured, the weight of the oil was then obtained by subtracting the weight of the cylinder from the weight of the oil and cylinder. The specific density of oil was obtained using equations below (John, 2003).

$$\text{Density of oil} = \frac{W_1 - W_0}{V_0} \quad .....(2)$$

Where

W_1 = weight of empty measuring cylinder + oil
W_0 = weight of measuring cylinder
V_0 = volume of oil used

Determination of Saponification Value

The oil sample (2 g) was added to a flask with 30 cm^3 of ethanolic KOH and the flask was then attached to a condenser for 30 min to ensure the sample was fully dissolved. After sample had cooled, 1 cm^3 of phenolphthalein was added and titrated with 0.2 M HCl until a pink endpoint has reached. The same analysis was performed using blank. Blank was also prepared using the same reagents as the sample without the oil in it (AOAC, 1998).

Saponification value was calculated from the equation below;

$$SV = \frac{S - B\ x\ M\ x\ 56.1}{sample\ weight\ (g)} \quad .....(3)$$

Where

S = sample titre value
B = blank titre value
M = molarity of the HCl
56.1 = molecular weight of KOH

Determination of Acid Value

Neutral ethyl alcohol (100 cm^3) was heated with 10 g of oil sample in a 250 cm^3 beaker until the mixture began to boil. The heat was removed and was titrated with 0.1 M KOH solution, using two drops of phenolphthalein as indicator with consistent shaking for which a permanent pink colour was obtained at the end point (Warra *et al.*, 2012; Bassir, 1978).

The acid value was calculated using the expression;

$$A.V = \frac{M\ x\ C\ x\ TV}{W} \quad .....(4)$$

Where

M = molar mass of KOH (56.1)
C = concentration of KOH (0.1)
TV = Titre value
W = weight of oil sample (10 g)

Determination of Iodine Value

The oil (0.50 g) was dissolved in 15 ml carbon tetrachloride in 100 ml conical flask. 5 ml of iodine solution was added to the flask and allowed to stand for 2 h in the dark at 25^oC. 5 ml of potassium iodide (KI) solution was added and the mixture titrated with 0.1 M sodium thiosulphate using starch indicator. A blank determination was carried out and the iodine value was calculated using the formula below (Warra *et al.*, 2010).

$$\text{Iodine value} = \frac{12.69\ x\ C(V_1 - V_2}{W} \quad .....(5)$$

Where

C = Concentration of Sodium thiosulphate
V_1= Volume (ml) of Sodium thiosulphate solution used in blank
V_2 = Volume (in ml) of thiosulphate solution used in the determination
W = Weight of the sample (0.50 g).

GC–MS Analysis of the Oil

For the analysis of the fatty acids in the oil sample a Shimadzu QP2010 plus series gas chromatography coupled with mass spectroscopy detector (GC–MS) was used. The temperature program was set up from 70^oC to 280^oC. Helium gas was used as carrier gas. The injection volume was 2 µL with injection temperature of 250^oC and a column flow of 1.80 ml/min for the GC. For the mass spectroscopy ACQ mode scanner with scan range of 30 – 700 amu at the

speed of 1478 was used. The mass spectra were compared with the NIST 05 mass spectral library (NIST, 2012).

Saponification Procedure

For each soap formulation 70 cm^3 of 170 g/dm^3 alkali solution were poured directly into the beaker containing the oil in the ratio 1:1(v/v). The oil was warmed gently and poured into the beaker followed by the alkali solution to form an intimate mix and then stirred frequently for 10 – 15 mins using stirring rod. The saponification mixture was then poured into moulds, allowed to dry and get hardened to formed soap bars (Warra *et al.,* 2012).

pH Determination

The pH was determined using pH meter (827 PH Metron Model). 10 g of the soap shaving was weighed and dissolved in distilled water in a 100 ml volumetric flask. The electrode of the pH meter was inserted into the solution of the soap and the pH reading was recorded (Warra *et al.,* 2012).

Foam Ability Test

The soap shaving (2 g) was added to a 500 cm^3 measuring cylinder containing 100 cm^3 of distilled water. The mixture was shaken vigorously so as to generate foams. After shaking for 2 min, the cylinder was allowed to stand for 10 min. The height of the foam in the solution was measured and recorded (Warra *et al.,* 2012).

RESULTS AND DISCUSSION

The results on the physicochemical characteristics of Baobab (*Adansonia Digitata*) are presented in the tables and charts below:

Table 1: Physicochemical characteristics of Baobab (*Adansonia Digitata*) seed oil

Parameter	Value
Saponification mgKOH/g	153.82± 0.41
Iodine value Ig/100 g	24.36± 0.71
Acid value mgKOH/g	0.51± 0.00
Oil yield (%)	27.00± 0.00
Density g/cm^3	0.86± 0.00

Values are expressed as Mean ± Standard deviation

Table 2: Physical characteristics of soap produced from Baobab (*Adansonia Digitata*) seed oil

Parameter	Value/Observation
pH	13.00
Foam height (cm)	10.10
Colour of soap	Milky
Solubility in water	Slightly soluble
Texture	Soft

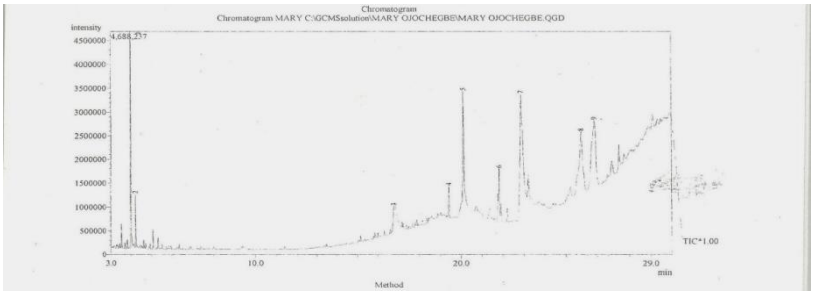

Fig. 1: GC–MS Chromotogram of Baobab *Adansonia digitata* seed oil

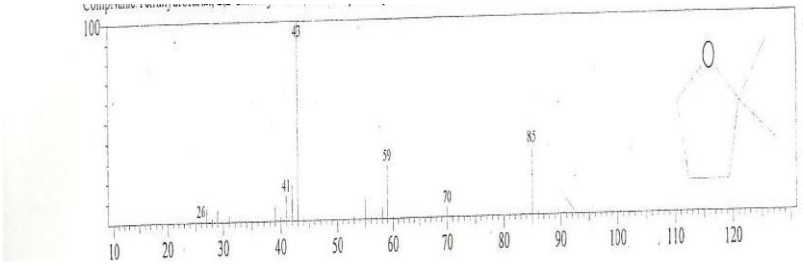

Fig. 2: Chart for peak 1 of the Chromotogram of Baobab *Adansonia digitata* seed oil.

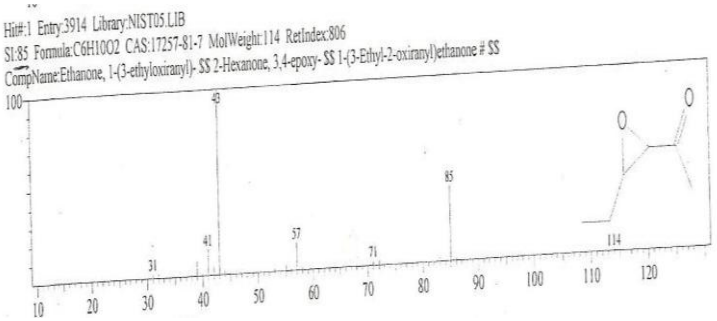

Fig. 3: Chart for peak 2 of the Chromotogram of Baobab *Adansonia digitata* seed oil.

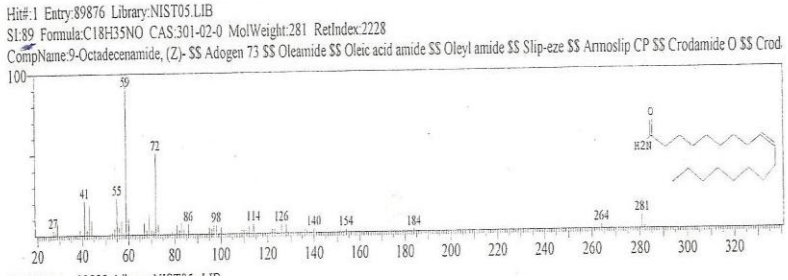

Fig. 4: Chart for peak 3 of the Chromotogram of Baobab *Adansonia digitata* seed oil.

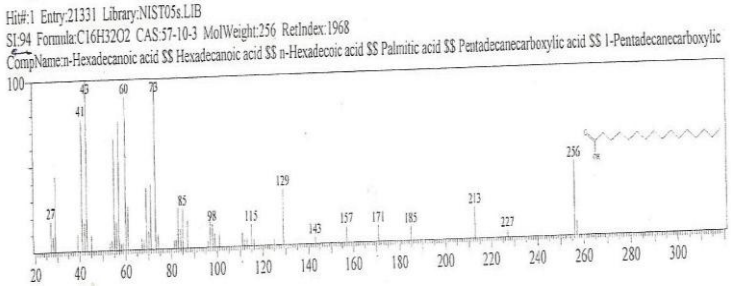

Fig. 5: Chart for peak 4 of the Chromotogram of Baobab *Adansonia digitata* seed oil.

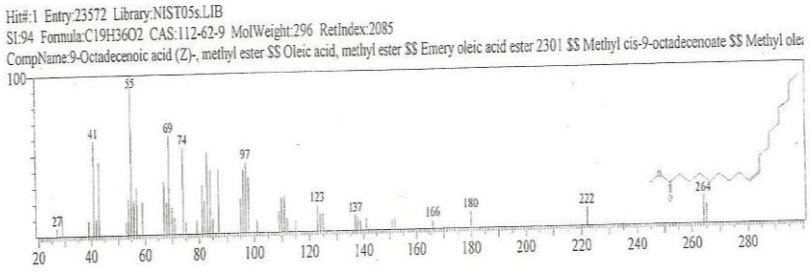

Fig. 6: Chart for peak 5 of the Chromotogram of Baobab *Adansonia digitata* seed oil.

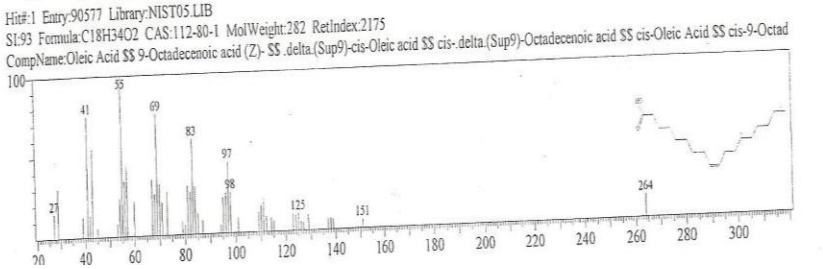

Fig. 7: Chart for peak 6 of the Chromotogram of Baobab *Adansonia digitata* seed oil.

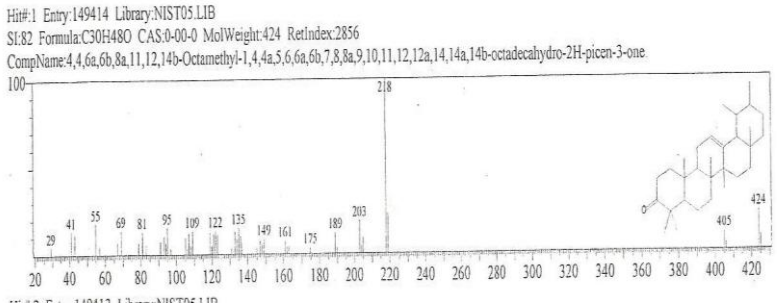

Fig. 8: Chart for peak 7 of the Chromotogram of Baobab *Adansonia digitata* seed oil.

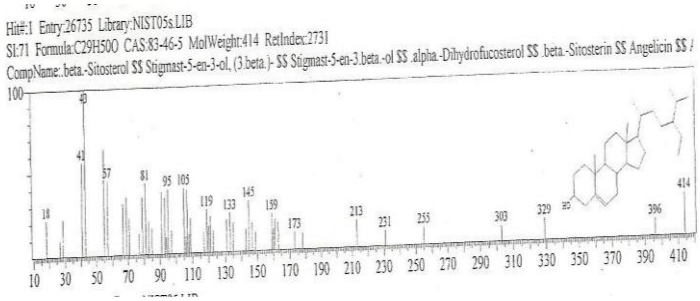

Fig. 9: Chart for peak 8 of the Chromotogram of Baobab *Adansonia digitata* seed oil.

Fig. 10: Chart for peak 9 of the Chromotogram of Baobab *Adansonia digitata* seed oil.

Table 3: Summary of the GC–MS Peaks interpretation of Baobab (*Adansonia Digitata*) seed oil

Peak No.	Name of compounds	Formula	M.Wt.	S.I% to the T.C.
peak 1	2,2–dimethyl–tetrahydrofuran	$C_6H_{12}O$	100	86 %
peak 2	2,3–epoxy–2– hexanone	$C_6H_{10}O_2$	114	85 %
peak 3	9–octadecenamide	$C_{18}H_{35}NO$	281	89 %
peak 4	Methyl ester palmitic acid	$C_{17}H_{34}O_2$	270	95 %
peak 5	Palmitic acid	$C_{16}H_{32}O_2$	256	94 %
peak 6	Methyl ester oleic acid	$C_{19}H_{36}O_2$	296	94 %
peak 7	cis – Oleic Acid	$C_{18}H_{34}O_2$	282	93 %
peak 8	4,4,6a,6b,8a,11,12,14b,–Octamethyl–1,4,4a,5,6,6a,6b,7,8,8a,9,10,11,12,12a, 14,14a,14b–octadecahydro–2H–picen–3–one (A Steroid)	$C_{30}H_{48}O$	424	82 %
peak 9	beta–Sitosterol	$C_{29}H_{50}O$	414	71 %

SI% = Similarity index; **M.W =** Molecular weight; **T.C =** Target compound

The percentage of oil yield 27 % is lower when compared with 48 % of *J. curcas* seed oil (Warra *et al.,* 2012), but higher than 22.5 % of garlic (*Allium sativum L.*) oil as reported by Gafar *et al.* (2012) (Table 1). The specific density of the oil 0.86 g/cm^3 is also lower when compared with 0.90 g/cm^3 of garlic (*Allium sativum L.*) oil (Gafar *et al.,* 2012). If oil has low density, it indicates that it contain low molecular weight fatty acids as well as high saponification value. This is suitable for soap production (Afolabi, 2008). The iodine value 24.36 ± 0.71 gI/100 g is higher than 12.69 ± 0.05 gI/100g of garlic (Gafar *et al.,* 2012) but lower when compared to 119.7±0.81 gI/100 g of cotton seed oil (Warra *et al.,* 2011). Any oil which has iodine value less than 100 gI/100 g is termed as non – drying oils which are suitable in the manufacture of soaps (Kochhar, 1998). The acid value 0.51 ± 0.00 mgKOH/g is lower when compared with 1.20 ± 0.065 mgKOH/g of *J. curcas* seed oil (Warra *et al.,* 2012) and 4.18 ± 0.01 mgKOH/g of garlic (*Allium sativum L.*) oil (Gafar *et al.,* 2012). This signifies a maximum purity and suitable for soap production (Oyedele, 2002). The saponification value from 153.82 ± 0.41 mgKOH/g is lower than 192 ± 1.00 mgKOH/g of garlic (*Allium sativum L.*) oil (Gafar *et al.,* 2012), but lies within the range of 140.3 mgKOH/g, 183.9 mgKOH/g and 187.7 mgKOH/g of tallow oil (animal fat), shea–nut oil and ground nut oil, respectively, which are used for soap production . This indicates that the oil could be used for soap production since higher saponification values justify the usage of the oil for soap production (Warra *et al.,* 2010).

Table 2 shows the pH of the soap produced from the oil as 13.0 which is higher than the pH range of 9 – 11 that has been considered to be the high level for any soap by National Agency for Food and Drug Administration and Control (NAFDAC) (Warra *et al.,* 2011). This soap can be harsh or toxic to skin (Warra *et al.,* 2011). The high pH may be due to incomplete alkali hydrolysis during the saponification process. The pH can be adjusted by adding more oil or any other super fatting agent (Warra *et al.,* 2011). The foam height of 10.10 cm is higher than 4.50 cm and 5.40 cm for soaps produced from cotton seed oil (Warra *et al.,* 2011) and *Jatropha curcas* seed oil (Warra *et al.,* 2012), respectively. Although foam generation has little to do with cleaning ability, but consumer choice made it a parameter in evaluating soaps and detergents (Mainkar & Jolly, 2000).

The GC–MS run result showed that baobab (*Adansonia Digitata*) seed oil indicate the presence of nine different compounds which are 2,2–dimethyl tetrahydrofuran, 2,3– epoxy–2–hexanone, 9 – octadecenamide, methyl ester palmitic acid, palmitic acid, methyl ester oleic acid, cis – oleic acid, octamethyl – octadecahydro – 2H – picen – 3 – one (steroid) and beta –sitosterol (Table 3). The oil contained two fatty acids and two methyl ester fatty acids which were nutritionally important to the human body. Another group of important compounds in the oil are the steroid, which when properly processed can serve as a source of some vital drugs. The other classes of compounds; ether, ketone and amide can also be of medicinal importance since these classes of compounds can also possess some physiological effects on the human system (Glew *et al.,* 1997).

CONCLUSION

From the highlights of this analysis, it is evidence that Africa baobab (*Adansonia Digitata*) seed oil has a good storage capacity and can be used in soap production due to its low acid and iodine values with high saponification value. The GC–MS result shows presence of nine compounds which ranges from fatty acids, methyl ester fatty acids, ethers, ketone to amides. These compounds when properly processed could serve as important sources for vital drugs formulations.

REFERENCES

Afolabi, S. I. (2008). Chemical qualities of oils from fresh and market vegetable crops within Kwara State Nigeria. Nigerian Society of Experimental Biology, 20(2): 71 – 75.

Alverson, W. S. (1999). Phylogeny of the core Malvales: Evidence from sequence data. American Journal of Botany, 86(10): 1474–1486.

AOAC (1998). Official Methods of analysis of the Association of Official Analytical Chemists, 16th edition, Gaithersburg, USA.

Arnold, T. H., Wells, M. J. & Wehmeyer, A. S. (1985). Khoisan food plants: taxa with potential for future economic exploitation, JR Wickens, Goodin and DV Field. (Ed), In Plants for arid lands. Allen and Unwin, London, pp. 69–86.

Asogbadjo, A. E., Kyndt, T., Sinsin, B., Gheysen, & Van Damme, P. (2008). Patterns of genetic and morphometric diversity in baobab (Adansonia digitata) populations across different climatic zones of Benin (West Africa). Annals of Botany, 97: 819–830.

Bassir, O. (1978). Handbook of Practical Biochemistry, Ibadan University Press, Ibadan, Nigeria.

Baum, D. A. (1995). A systematic revision of Adansonia (*Bombacaceae*). Annals of the Missouri Botanical Garden, 82(3): 440–471.

Ezeagu, I. E., Petzke K. J., Lange E. & Metges C. C. (1998). Fat content and fatty acid composition of

oils extracted from selected wild–gathered tropical plant seeds from Nigeria. Journal of the American Oil Chemists Society, 75(8): 1031–1035.

Gafar, M. K., Itodo, A. U., Warra, A. A. & Abdullahi, L. (2012). Extraction and Physicochemical characteristics of garlic (*Allium sativum L.)* oil. Int. J. Food and Nutr. Sci., 1(2): 4–7.

Glew, R. H., Vanderjagt, D. J., Lockett, C., Grivetti, L. E., Smith, G. C., Pastuszyn, A. & Millson, M. (1997). Amino acid, fatty acid, and mineral composition of 24 indigenous plants of Burkina Faso. Journal of Food Composition and Analysis, 10(3): 205–217.

Igboeli, L. C., Addy, E. O. H. & Salami, L. I. (1997). Effects of some processing techniques on the antinutrient contents of baobab seeds (*Adansonia digitata*). Bioresource Technology, 59(1): 29–31.

John, K. (2003). Analytical Chemistry for Technicians, 3rd Edition, Lewis Publishers, Kalyani Publisher, New Delhi, India, pp. 347–349.

Kochhar, S. L. (1998). Economic Botany in the tropics, 2nd edition, Macmillian India Ltd, Delhi, India.

Lockett, C. T., Calvert, C. C. & Grivetti, L. E. (2000). Energy and micronutrient composition of dietary and medicinal wild plants consumed during drought. Study of rural Fulani, Northeastern Nigeria. International Journal of Food Sciences and Nutrition, 51(3): 195–208.

Mainkar, A. R. & Jolly, C. I. (2000). Evaluation of commercial Herbal Shampoos. Int. J. Cosmet. Sci, 22: 385–391.

NIST (2012). GCMS NIST Library Information Manual.

Oyedele, A. O. (2002). The skin tolerance of shea fat employed as excipient in tropical preparations Nigeria Journal of Natural Products and Medicine, 66: 26–29.

Warra, A. A., Hassan, L. G., Gunu, S. Y. & Jega, S. A. (2010). Cold–process synthesis and properties of soaps prepared from different triacylglycerol sources. Nig. Jour. of Basic and App Sci., 18(2): 315–321.

Warra, A. A., Wawata, I. G., Gunu, S. Y. & Atiku, F. A. (2011). Soap preparation from Soxhlet extracted Nigerian cotton seed oil. Pelagia Research Library, 2(5): 617–623.

Warra, A. A., Wawata, I. G., Umar R. A. & Gunu S. Y. (2012). Soxhlet Extraction, Physicochemical analysis and Cold Process Saponification of Nigerian Jatropha Curcas L. Seed Oil. Canadian Journal of Pure and Applied Sciences, 6(1): 1803–1807.