Pak. J. Sci. Ind. Res. 2004 ***47*** *(1) 60 - 65*

A Study of the oil Content of Nigerian Grown *Monodora Myristica* Seeds for its Nutritional and Industrial Applications

I A Ajayi, K O Adebowale, F O Dawodu and R A Oderinde*

Chemistry Department, University of Ibadan, Ibadan, Nigeria

(Received June 2, 2001; accepted January 6, 2004)

A study of the oil content of *Monodora myristica* for its potential and industrial applications has been undertaken. The study revealed that *M. myristica* seeds have high oil and protein content (21.79 ± 0.51% and 20.57 ± 0.38%, respectively). The carbohydrate content is quite high, (44.29 ± 1.50%) while it has low crude fibre content (4.70 ± 0.15%). The physico - chemical characteristics of the seed oil show that the oil has high acid value, (14.31 ± 0.32%); peroxide value, (15.90 ± 0.50%) and saponification value, (252.11 ± 2.50%). The iodine value of the seed oil which places the oil in the non-drying group is 85.00 ± 0.50%. Eight nutritionally valuable minerals of the seeds were determined and the result indicates the seeds to be richest in potassium 64.96 ± 1.60 ppm followed by magnesium (8.58 ± 1.50 ppm) and iron (8.40 ± 0.91 ppm). Fatty acid composition of the seed oil shows the oil to be rich in linoleic acid (35.52%) and oleic acid (33.15%). It also contains arachidic acid 9.52%. The other fatty acids present in the oil are palmitic acid, stearic acid, gadoleic acid and linoceric acid. Triacylglycerols (OOO, OPO / POO and OOL) accounted for over 57.70% of the total triacylglycerol content of the oil. In addition, high molecular weight triacylglycerols (containing fatty acid moiety > 18 carbons) was also detected in oil The potential domestic and industrial applicatioins of the oil under study are enumerated.

Key words: *Monodora myristica,* Physico - chemical properties, Mineral element, Fatty acid.

Introduction

Fats and oil belong to a class of compound known as lipids, which can be either simple or complex triacylglycerol. The existence of these as fat and oil depends on their state at room temperature, 30 ± 2°C (fats are solid while oils are liquid at room temperature) (Gurr *et al* 1972).

Fats and oil are indispensable food factors (Tooley 1971) and they are also extensively used for nutritional, cosmetic and industrial purposes (Berdick 1972). They are used for delivering fat soluble vitamins as carriers and contributing flavours to food (Masson 1981) and also for supplying essential fatty acids such as linoleic, linolenic and arachidonic acids which are not made by the body but are required by the body (Triebold and Aurand 1963). They are also used for producing drug dispersants in therapeutics (Oyolu 1971 and Ngoddy and Ihekoronye 1984).

Monodora myristica (Gaertn) Dunal also called African nutmeg or false nutmeg is a tree of evergreen and deciduous forest, up to 35m high by 2m in girth. It is of the family Annonaceae (Unwin 1920). The seeds of *M. myristica* which are embedded in a white sweet-smelling pulp are the most important part of the tree economically. The seeds contain 5 - 9.00% colourless essential oil consisting largely of terpenes and with a pleasant taste and smell (Oliver 1960) and about 35.00 - 36.00% of a reddish-brown fixed oil which contains mainly linoleic acid (46.90%) and oleic acid (35.00%) (Busson 1965).

The bark of *M. myristica* is used in Ivory Coast to treat haemorrhoids, stomachache and febrile pains and mixed with that of *M. tenuifolia,* a collyrium is prepared for use in eye troubles (Bouquet 1974). Dusting or application of the pomade is used to disinfect from fleas and lice. The seeds chewed up are applied to the forehead for headache and for migraine in Gabon. The seeds are also applied on sores and are eaten as anti-emetic operative and tonic in Congo (Burkill 1985).

The world production of fats and oils shows the production of vegetable oils to be higher than fats from animal (International Association 1988). Currently, despite the relatively high oil and seed meal production in the United States, the USDA (U.S. Department of Agriculture) continues to investigate non-conventional seeds. The example set forth by the USDA is worth emulating by the developing countries that are more in need of alternative oil sources. According to Balogun *et al* (1986), lack of information on the composition and utilization of the many and varied oil seeds indigenous to the tropics is more of problems than is the real shortage of oils. There exist already abundant data in literature on the proximate

*Authors for correspondence

composition, mineral content and other characteristics of the more conventional oil seeds but this is lacking on the non-conventional oil seed types. In response to these needs and in continuation of our effort to bring into focus the non-conventional seed oils (Oderinde and Ajayi 1998 and 2000), the oil content of *Monodora myristica* seeds have been studied for its domestic and industrial applications.

Experimental

The seeds of *M. myristica* were purchased from a local market (Ojoo market in Ibadan). The chemical used were supplied by British Drug House (BDH)

Sample preparation. The seeds were cracked to remove the brown-coloured kernels. These were ground to powder with the use of a laboratory mortal and pestle. They were then stored in a polythene bag and kept in the fridge until needed for analysis.

Extraction. Extraction of oil of the seed was carried out in a soxhlet apparatus using purified hexane as the solvent. The oil obtained, after distilling off the hexane, was stored in a labelled flask. All analysis was carried out in the Chemistry Department of Ibadan except for crude protein determination which was carried out in Human Nutrition Department of University of Ibadan.

Physical characterization. Physical characterization of the seeds and kernels was carried out according to the method outlined by Femeni *et al* (1995). Weight, length and width of one seed kernel was determined by taking the mean measure of 50 seeds / kernel.

Proximate properties. Pulp and seed moisture was determined gravimetrically by placing 1g of specimen into an oven at 105˚C for 6h to reach constant weight according to Femenia *et al* (1995). Crude protein (N% x 6.25) was determined by the micro Kjedhal method while analysis for ash and crude fibre were according to the methods of AOAC (1980).

Carbohydrate content was determined by difference [100.00% - (protein + crude fat + ash + crude fibre)] (AOAC 1990; Ajayi *et al* 2002).

Physico - chemical characteristics. Procedures for the determination of iodine value (Wij's method), saponification value, peroxide value and acid value were as those recommended by the AOAC (1984). For iodine value, 0.20g of the oil was taken into a glass-stoppered flask and dissolved in 15ml carbon tetrachloride. 25ml of Wij's solution was added, the flask was stoppered and allowed to stand for 2h in the dark at 25˚C, after which 20ml of 10.00% KI solution was added. The mixture was titrated with 0.2N $Na_2S_2O_3$ using starch indicator. A blank determination was carried out. The iodine value was calculated as follows:

$$\text{Iodine value} = 12.69M \frac{V_2 - V_1}{W}$$

Where, M = Molarity of thiosulphate
V_1 = Volume (in ml) of thiosulphate solution used in test
V_2 = Volume (in ml) of thiosulphate solution in blank
W = Weight of sample

The saponification value of the oil was determined by dissolving 1g of it in 12.50ml of ethanolic KOH and refluxing the mixture for 30 minutes after which 1ml of phenolphthalein indicator was added, the hot soap solution was then titrated with 0.50N HCl. A blank determination was carried out under the same condition and the following equation was used to calculate the saponification value of the oil.

$$\text{Saponification value} = 56.1M \frac{(V_2 - V_1)}{W} \quad \text{(AOAC 1984)}$$

Where, M = Molarity of hydrochloric acid used
V_1 = Volume of hydrochloric acid used in test
V_2 = Volume of hydrochloric acid used in blank
W = Weight of oil taken

For the peroxide value, 1g of the oil was weighed into a 200ml conical flask and 25ml of 2:1 v / v glacial acetic acid and chloroform solvent was added. 1ml of potassium iodide solution was then added and the solution was left in the dark for 1 minute after which 30ml of water was added. The mixture was titrated with 0.20 N thiosulphate solution using 5ml starch as indicator. A blank was determined simultaneously. The peroxide value of the oil was then calculated using the equation below:

$$\text{Peroxide value} = 100 \frac{(V_1 - V_2)}{W} M \text{ meg / kg (AOAC, 1990)}$$

Where, W = Weight of sample
V_1 = Volume (ml) of $Na_2S_2O_3$ used in test
V_2 = Volume (ml) of $Na_2S_2O_3$ used in sample
M = Molarity of $Na_2S_2O_3$

The acid value of the oil was determined by dissolving 0.20g of the oil in 2.5ml of 1:1v / v ethanol and diethylether and titrating each with 0.10M NaOH with swirling using phenolphthalein as indicator. The acid value is calculated as follows:

$$\text{Acid value} = 56.1M \frac{(V_2 - V_1)}{W}$$ (Cock and van Rede 1966; AOAC 1990).

Where, M = Molarity of NaOH used
W = Weight of sample
V_1 = Volume (ml) of NaOH used

Refractive index and specific gravity. The refractive index of the oil was determined with an Abbe refractometer while the specific gravity was measured using the specific gravity bottle. Both parameters were determined at room temperature (30˚C ± 2˚C) and following the procedures described by Pearson (1976).

Metal composition. The metal composition of the seeds was determined according to the method used by Idouraine *et al* (1996). 1g of the seed was completely ashed in a muffle furnace at 600˚C. The ash obtained was digested with 3ml concentrated HNO_3. The digest was filtered carefully into a 100ml volumetric flask and made up to mark with distilled water. A blank solution was also prepared. The metal composition was then determined using an Atomic Absorption Spectrophotometer and following the manufacturer's specifications.

Fatty acid analysis. Fatty acid was determined at the Institute of Organic Chemistry, University of Tübingen, Germany according to the method of Lutz *et al* (1998). To 0.10g of the oil was added 5ml of CH_3OH and 1ml of CH_2Cl_2. The mixture was cooled in ice and 0.6ml of CH_3COCl was added.1ml of the solution was withdrawn into the hydrolysis tube and heated for 1 hour at 110˚C. The solution was cooled and discharged into 10ml of 1.00% NaC1 solution in a separating funnel. The organics were extracted with 3 x 4ml hexane and volume was reduced to 0.5ml using a rotary evaporator. This was eluted on silica gel column successively with 5ml hexane and 4ml CH_2C1_2. The CH_2C1_2 fraction was separated on a DB5 30m x 0.25mm capillary installed on a GC Chrompack 9001 equipped with computer software and Mosaic integration. Flame ionisation detector was used. The temperature was programmed as follows: 35˚C for 3 minutes, temperature was then increased at 20˚C per minute up to 230˚C for 5 min. Heptadecanoic acid was used as an internal standard.

Triacylglycerols. Lipids were first separated on silica gel (20 x 20cm) using petroleum ether: diethylether:acetic acid (80:20:1) as the mobile phase. Details of the procedure have been described in earlier publication (Esuoso and Bayer, 1998). The triacyglycerol fraction was identified, scrapped off and eluted with CH_2Cl_2. The samples and standards (0.1µl) were injected into the gas chromatography (CHROMPACK CP9000) using a Chrompack TAP capillary column, 25m x 0.25mm, film thickness, 0.1µ(J & W Scientific, Köln, Germany). The carrier gas was hydrogen maintained between 95 - 96 kpa. The temperature was programmed as follows; 80˚C for 2 min.; temperature increased to 280˚C at 30˚C per min.; temperature increased to 355˚C at 3˚C per min.

All the standards used for the studies were purchased from the SIGMA Chemical Company. They include: Tripalmitin PPP; 1,2 - Dipalmitoyl - 3 - oleoyl - rac - glycerol PPO; 1,3 - Dipalmitoyl - 2 - oleoyl - rac - glycerol POP; 1,2 - Distearoyl -3 -palmotoyl - rac - glycerol SSP; 1 - Stearoyl - 2 - oleoyl -3 -palmitoyl - rac - glycerol SOP; 1,3 - Dioleoyl - 2 - palmitoyl - rac - glycerol OPO; 1 - Palmitoyl - 2,3 - dioleoyl - rac - glycerol SOO, 1,3 - Dioleoyl - 2 - stearoyl - rac - glycerol OSO; 1,3 - Distearoyl - 2 - oleoyl - rac - glycerol SOS; 1,2 - Distearoyl - 3 - oleoyl - rac - glycerol SSO; Triolein OOO; 1,2 - Dimyristoyl - 3 - lauroyl - rac - glycerol MMLa; 1,2 - Dimyristoyl - 3 -palmitoyl - rac - glycerol MMP; 1,3 - Dipalmitoyl - 2 - Linoleoyl - rac - glycerol PLP; Trolinolein LLL; 1,2 - Dilauroyl - 3 - myristoyl - rac - glycerol LaLaM; 1,2 - Dilinoleoyl - 3 - oleoyl - rac - glycerol LLO; 1 - Palmitoyl - 2 - oleoyl - 3 - linoleoyl - rac - glycerol POL; 1,2 - Dioleoyl - 3 - linoleoyl - rac - glycerol OOL, 1,2 - Linoleoyl - 3 - arachidonyl - rac - glycerol LLA ; 1-oleoyl - 2 - Linoleoyl - 3 - arachidonyl - rac - glycerol OLA ; 1 - stearoyl - 2,3 - diarachidonyl - rac -glycerol SAA ; 1 - oleoyl - 2 - stearoyl - 3 - arachidonyl - rac - glycerol OSA ; 1 - Linoleoyl - 2 - stearoyl - 3 - arachidonoyl - rac - glycerol LSA ; 1,2 - dioleoyl - 3 - arachidonoyl - rac - glycerol OOA

Results and Discussion

The result of the proximate composition of *M. myristica* seed is presented in Table 1. The oil yield of the seed is 21.79 ± 0.51% while the protein content is 20.57 ± 0.38%. The oil yield compare favourably with 21.00% of *C. lanatus* (Chinese) (Al - Khalifa 1996) and it is in the same order with the oil content reported for some conventional oil seeds such as soybeans (19.00 ± 2.00%), olive (22.51 ± 2.50%) and cotton seed (19.50 ± 1.00%). The protein content of the seed is also comparable to those of known oil seeds like sunflower (19.50%), castor seed (18.90%) and cashew nut (12.20%) (Fetuga *et al* 1973). The seed has a low quantity of moisture (5.21 ± 9.24%) which is comparable to the value reported in literature for C. *colocynthis* (Al - Khalifa, 1996). The carbohydrate content of the seed is similar to 45.35 ± 1.10% reported for *E. pursaetha* (Oderinde and Ajayi, 1998).

The oil from *M. myristica* seeds which is reddish-brown in colour is consistently liquid at room temperature. The acid value of the oil is 14.31 ± 0.32% (Table 2), it is lower than the value reported in literature for *C. reticulata varsatsuma* (21.71 ± 0.30%) and *C. tuberosus* tuber oil (17.39 ± 0.75%) (Dagne and Johnson, 1997). This value is high but it can be reduced by alkali refining. The saponification value is 252.11 ± 2.50%, this value is closed to that of *A. cohune* 252 - 256 (Oboh and Oderinde 1998). The high saponification value of the oil suggests that the oil contains high molecular weight fatty acids and also that it will be useful for soap production. The high

Table 1
Proximate properties of *M. myristica* seeds

Parameters	Range (%)	Mean ± S.D
Oil yield	21.28 - 22.30	21.79 ± 0.51
Moisture content	4.97 - 5.45	5.21 ± 0.24
Ash content	3.24 - 3.64	3.44 ± 0.20
Crude protein	20.19 - 20.95	20.57 ± 0.38
Crude fibre	4.55 - 4.85	4.70 ± 0.15
Carbodhydrate content	42.79 - 45.79	44.29 ± 1.50

[a]Mean of triplicate analysis

Table 2
Physico-chemical characteristics of *M. myristica* seed oil

Characteristics	Range (%)	Mean ± S.D
Oil content (%)	21.2800 - 22.3000	21.79 ± 0.510
Saponification value	249.6100 - 254.6000	252.11 ± 21.50
Peroxide value	15.4000 - 16.4000	15.900 ± 0.500
Acid value	13.9900 - 14.6300	14.310 ± 0.320
Iodine value	80.0000 - 90.0000	7.2000 ± 0.320
Free fatty acid (as % oleic)	6.8800 - 7.5200	237.800 ± 2.180
Ester value	235.6200 - 239.9800	1.4400 ± 0.015
Refractive index (25°C)	1.4520 - 1.4550	0.9180 ± 0.026
Specific gravity	0.8428 - 0.8668	
Consistency at room temperature	Liquid	
Colour	Reddish - brown	

[a]Mean of triplicate analysis

ester value 237.80 ± 2.18 is an indication of high level of ester is present in the oil. The specific gravity and refractive index of the oil are 0.8428 ± 0.02% and 1.4400 ± 0.015%, respectively.

The role of trace elements in human nutrition and disease cannot be overemphasized. Even though the mineral elements form a small portion of total composition of most plant materials and of total body weight and they do not contribute to energy value of food, and are of great physiological importance particularly in body metabolism (Schwart 1975). The seeds of *Monodora myristica* are richest in potassium (64.96 ± 1.60 ppm) followed by iron (8.40 ± 0.91ppm) and magnesium (8.58 ± 1.50ppm) and poorest in copper (0.33 ± 0.05ppm). From the potassium content of the seed, it can be deduced that the seed of *M. myristica*, if consumed, could be a good source of potassium and to some extent iron.

Presented on Table 4 is the fatty acid composition of *M. myristica* seed oil. The fatty acid composition of the total seed oil reveals that linoleic acid (35.52%) and oleic acid

Table 3
Mineral element composition of *M. myristica* seeds

Element	Range (%)	Mean ± S.D
Calcium	2.08 - 2.48	2.28 ± 0.20
Magnesium	7.08 - 10.08	8.58 ± 1.50
Potassium	63.36 - 66.56	64.96 ± 1.60
Sodium	1.25 - 1.55	1.40 ± 0.15
Manganese	0.92 - 1.08	1.00 ± 0.08
Iron	7.49 - 9.31	8.40 ± 0.91
Copper	0.28 - 0.38	0.33 ± 0.05
Zinc	0.54 - 0.94	0.74 ± 0.20

Table 4
Fatty acid composition of *M. myristic*a seed oil

Fatty acid (%)	*M. myristica* oil[a]	Groundnut oil[b]	Soybean oil[b]
12: 0	-	0.05	trace
14: 0	-	0.05	0.10
16: 0	5.96	11.15	11.20
18: 0	4.44	0.10	0.10
18:1	33.15	-	4.10
18:2	35.52	-	21.70
18:3	-	3.15	53.90
20:0	9.52	51.75	7.50
20:1	2.96	0.05	0.40
20:2	5.43	1.40	0.20
20:3	2.87	1.20	-
22:0	-	3.25	-
22:1	-	0.15	0.50
22:2	-	1.65	0.10
24:0	0.15	0.15	0.20
Saturated	20.07	20.30	16.40
Unsaturated	79.93	78.70	83.50

[a]Present work; [b]Rossell and Pritchard (1991)

(33.15%) are the predominant unsaturated fatty acids. It is well - known that dietary fats rich in linoleic acid prevents disorders such as coronary heart disease, atherosclerosis and high blood pressure and also linoleic acid derivatives serve as structural components of the plasma membrane and as precursors of some metabolic regulatory compounds (Viles and Gottenbos 1989). The other fatty acids found in *M. myristica* seed oil are palmitic acid (5.96%), stearic acid (4.44%), gadoleic acid (2.96%), arachidic acid (9.52%) and linoceric acid (0.15%). The percentage saturated fatty acid in the oil is 20.07% while the percentage of unsaturated fatty acid is 79.93%. This is of great nutritional significance. This suggests that the oil could serve nutritional purposes. It can be used to lower serum cholesterol and prevent coronary heart disease.

Table 5
Physical characterization of *Monodora myristica* seeds

Property	Range	Mean ± SD
Kernel (% of whole seed)	77.13 - 90.54	83.835 ± 0.671
Weight of 100 seeds	98.20 - 100.13	99.165 ± 0.965
Weight of 100 kernels	69.74 - 76.37	73.050 ± 3.315
Seeds length (mm)	0.52 - 0.80	0.660 ± 0.140
Seeds width (mm)	0.32 - 0.47	0.395 ± 0.075
Kernel length (mm)	0.52 - 0.76	0.640 ± 0.120
Kernel width (mm)	0.30 - 0.45	0.375 ± 0.075

Physical properties of *Monodora myristica* seed and kernel regarding weight, length and width in addition to the kernel percentage of whole seed are listed in Table 5. The result showed that the kernel constitute 77.13% of the seeds. This is higher than the value(22-38g / 100g) reported sweet kernel of apricot by Filsoof *et al* (1976); Hallabo *et al* (1975) and Ermakov (1980). The average length and width of the seeds are 0.660 mm ± 0.140 and 0.395 ± 0.075 mm, respectively while those for the kernel are 0.640 ± 0.120 mm and 0.375 ± 0.075 mm, respectively.

The comparison of the cost of production reported in Table 6 revealed that the cost of production of conventional oil such as soybean is slightly lower than and our unconventional oil (*Monodora myristica*) used for the present studies.

The composition of the triacylglycerols in the oil is presented in Fig 1. OOO, OPO / POO and OOL accounted for over 57.70% of the total triacylglycerol in the oil. High molecular weight triacylglycerols (containing fatty acid moiety > 18 carbons) was also detected in oil. SAA, OSA and LLA accounted for about 5.00% of the total triacylglycerol. The search for vegetable oil and fats as alternatives for cocoa butter in chocolate and confectionery products have been a major focus of research for decades now. The terms cocoa butter equivalents (CBEs); cocoa butter substitutes (CBSs) and cocoa butter replacers (CBRs) are strong for technological and economic reasons (Lipp and Anklam 1998). From the composition of the triacylglycols of the oil, it appears our *M. myristica* oil could serve as cocoa butter equivalents (CBEs)

Conclusions

Monodora myristica seeds could be utilized as a source of edible oil and protein for human consumption. In addition, the seeds could be considered as a good source of dietary fibre. The seeds have high content of unsaturated fatty acids and therefore, could serve as substitute for highly unsaturated fatty oils. Finally, the triacylglyreol content of the oil revealed that the oil could serve cocoa butter equivalents.

Table 6
Comparison of the cost of production of the present oil (*Monodora myristica*) with a conventional oils (Soybean and groundnut oils)

Seed	Yield/kg	Residue/kg	Cost of seed/kg ($)	Selling price ($) Oil	Residue	% profit
M.myristica	217.90	782.10	2.00	2.50	0.70	60.00
Groundnut	400.00	600.00	1.50	2.00	0.50	66.70
Soybean	200.00	800.00	20.00	2.80	0.50	65.00

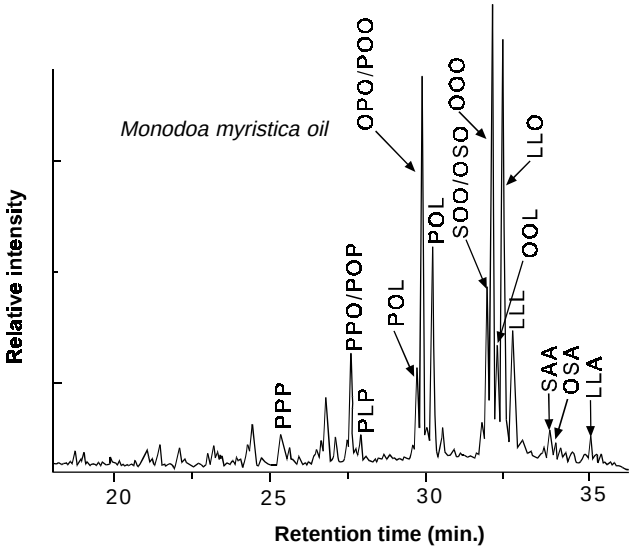

Fig.1 Triacylglycerols of *M. myristica* oil

References

Al - Khalifa A S 1996 Physico - chemical characteristics, fatty acid composition and lipoxygenases activity of crude pumpkin and melon seed oil. *J. Agric Food Chem* **44** (4) 964 - 966.

AOAC 1980 *Official Methods of Analysts*, Association of Official Analytical Chemists, 14th ed. Arlington, USA **67** 503 B 515.

AOAC 1984 *Official Methods of Analysts*, Association of Official Analytical Chemists Washington, DC, USA **63** 2.

AOAC 1990 *Official Methods of Analysts*, Association of Official Analytical Chemists, 14th ed. Washington DC, USA.

Balogun A M, Fetuga B L, Osibanjo O 1990 Nutrient composition of the kernel of *Terminalia catappa* (Tropical almond) *Nig J Sci* **24** 206-209.

Berdick M 1972 The role of fats and oils in cosmetics. *JAOCS* **49** (7) 406 - 407.

Bouquet A, Debray M 1974 *Plantes medicinale de la Cote d'ivoire* Trav. Doc ORST OM 32.

Burkill H M 1985 *Useful Plants of West Africa:* Families A - D Royal Garden Kew, 2nd ed pp 119 - 120.

Busson F 1965 *Plantes alimentaires de l'ouset African, Leconte, Marseilles.*

Dagne K and Johnson A 1997 Oil content and fatty acid composition of seeds of *Cmizzotia cass* (Compositae) *J Sci Food. Agric* ***73*** **(2)** 274 - 278.

Ermakov A I 1980 Composition and comparative fatty acid content in the oils of apricot and peach seeds. *Tri Prikl Bot Genet Sel* **6** 6120 - 6127.

Esuoso, K O and Bayer, E 1998 Chemical composition and potentials of some underutilised tropical biomass II: *Adenopus breviflorus* and *Cucumeropsis edulis. Rivista Italiana Delle Sostanze Grasse*, **75** 191 - 196.

Femina A, Rosells C, Mulet A, Canellas J 1995 Chemical composition of bitter and sweet apricot kernels. *J Agric Food Chem* **43** (2) 356 - 361.

Fetuga B L, Babatunde G M, Oyenuga V A 1973 Composition and nutritive value of cashew nut to rat. *J Agric Food Chem* **22** (4) 67 - 682.

Filsoof M, Mehran M and Farrohi F 1976 Determination and comparison of oil characteristics in Iranian almond, apricot and peach nuts. *Fette, Seifen Anstrichim* **4** 150 - 151.

Gurr M I, James A T 1972 *Lipids Biochemistry, an introduction.* Cornell University Press, Ithaca, New York, USA pp 1.

Hallabo S A S, El - Wakeil F A and Khairy S 1975 Chemical and physical properties of apricot kernel oil and almond kernel oil Egyptian. *J Food Sci* **3** 1 - 5.

Idouraine A, Kohlehepp E A, Webber C W 1996 Nutrient constituents from eight lines of naked seed squash (*Curubita pepo* L*). J Agric Food Chem* **44** (3) 721 - 724.

International Association of seed crushers 1998 *Congress Proceedings* Rome, New Delhi, India, Vancouver.

Lipp M and Anklam E 1998 Review of cocoa butter and alternative fats for use in chocolate - Part A. Composition data. *Food Chemistry* **62** 73 - 97.

Lutz H, Esuoso K Kutubuddin M, Bayer E 1998 Low temperature conversion of sugar cane by - products, *Biomass and Bioenergy* **15** (2) 155 - 162.

Masson L 1981 Relative nutritional values of various dietary fats and oils *JAOCS* **28** (3) 767.

Ngoddy P O, Ihekoronye A I 1964 Integrated food science and technology for the tropics. In: *Baileys Industrial Oil and Fat Produced Swern,* USA 3rd ed. pp. 1103.

Oderinde R A, Ajayi I A 1998 Metal and Oil composition of *Terminalia catappa. La* Riv Ital *Delle Sostanze Grasse* **75** 361 - 362.

Oderinde R A Ajayi I A 1998 Composition of *Entada pursaetha* seed and seed oil grown in Nigeria *La Rivista Ital Sostanze Grasse* **75** 457 - 459.

Oderinde R A, Ajayi I A 2000 Physico - chemical and metal composition of *Calophyllum inophyllum* seed and seed oil *Pak J Sci Ind Res* **43** (6) 357 - 358.

Oboh F O J, Oderinde R A 1998 Development of *Tucum* pulp oil fractions for possible edible and industrial use. *La Riv Delle Sostanze Grasse* **75** 209 - 211.

Oliver B 1960 *Medicinal plants in Nigeria.* Nigerian College of Arts, Science and Technology 231.

Oliver C 1971 A qualitative and quantitative study of seed types in Egusi (*Colocynthis citrulus* L.*) Trop. Sci* **19** (1) 55 - 56.

Pearson D 1976 The Chemical Analysis of Food, Sheck Wah Tong pp 10 - 18.

Rossell, J B and Pritchard J I R 1991 Analysis of oil seeds, fats and fatty foods. Elsevier Science Publishers Ltd.,The Netherlands pp 305 - 308.

Schwart M K 1975 Role of trace elements in cancer *Cancer Research* **35** 3481 - 3484.

Tooley P 1971 The Chemistry in Industry, *Fats, Oils and Waxes.* John Murrey, London, UK pp 16.

Triebold H O, Aurand L W 1963 *Food Composition and Analysis.* D Van Nostrand Co. Inc. Princeton, NJ, USA.

Unwin A H 1920 *West African Forests and Forestry* Unwin, London, U.K.

Viles R O, Gottenbos J J 1989 *Nutritional characteristics and food uses of vegetable oils in:* Oil crops of the World, Robblen G., Downey RK and Ashri A. McGraw Hill, New York, USA, 36 - 86.