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A Comparative Assessment of the Fatty Acid and Phospholipid Composition of Irvingia Gabonensis (African Wild Mango) and Citrullus Lanatus (Water Melon) Seed Oils

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Abstract

The fatty acid composition of **Irvingia gabonensis** (African wild mango) and **Citrullus lanatus** (water melon) seed oils were determined using gas chromatographic technique with flame ionization detector (GC-FID). The results indicated eight fatty acids in **Citrullus lanatus** and eleven in **Irvingia gabonensis** seed oils. Comparatively, fatty acids common to both seed oils are linoleic acid (61.07%, 22.98%), oleic acid (13.48%, 21.87%), palmitic acid (15.40%, 16.69%), palmitoleic acid (0.53%, 6.32%), linolenic acid (0.52% , 17.55%) and erucic acid (0.54%,0.88%). Lauric acid, arachidic acid, myristic acid and behenic acid though found in **Irvingia gabonensis** were not traceable in **citrullus lanatus** while arachidonic acid was present in **citrullus lanatus** but not in **irvingia gabonensis**. Margaric acid and lignoceric acid were not found in both seed oils. Irvingia gabonensis seed oil presented potential for making hard soaps. The seed oils generally presented potential for industrial use. Phospholipid levels in **Citrullus Lanatus** and **Irvingia gabonensis** seed oils on the other hand was also determined using gas chromatographic technique with pulse flame photometric detector (GC-PFPD). The result showed six phospholipids in each seed oil namely phosphatidylcholine, phosphatidylinositol, phosphatidylethanolamine, phosphatidylserine, lysophosphatidylcholine and phosphatidic acid. The total phospholipid levels in **Citrullus lanatus** seed oil is higher (935.65 mg/100g) than that in **Irvingia gabonensis** (239.89 mg/100g) seed oils. Phosphatidylcholine was the most abundant in both seed oils while phosphatidylserine was the least concentrated. **Citrullus lanatus** seed oils present a higher potential for health benefits based on their phospholipid levels than **Irvingia gabonensis**. The study indicates that Irvingia gabonensis and citrullus lanatus would be useful in soap making industries and for improved health benefits respectively.

Keywords: African wild mango, Citrullus lanatus, Chromatography, fatty acids, Irvingia gabonensis, industrial potential, Phospholipids, Phosphatidic acid, seed oils

Introduction

Nigeria is a country endowed with a lot of mineral and natural resources. One of such endowments is the kind of fruit trees that are grown across the states in Nigeria. Two prominent fruits that are consumed in the country are the water melon (*citrullus lanatus*) and African wild mango (*irvingia gabonensis*). The African wild mango kernel commonly referred to as Apon (Yoruba), Ogbono (igbo), Ogbolor (Edo) among others have been found to grow freely in forest areas especially in zones ascribed as rain forest zones [1]. The trees have been found to be predominantly distributed in forest zones in Africa notably Senegal, Sudan and Angola [2, 3]. In Nigeria it has been reported to be consumed in most states but predominantly in the southwest and south eastern parts. Furthermore, *Irvingia gabonesis* is specie that produces economically and viable non timber forest products from the rain forest zones of West Africa, preferring sites that are well drained [4].

Research have been conducted on kernel of *Irvingia gabonensis* especially those on the nutritional properties which presents them as potential base materials for confectionaries, edible fats, soaps among other needs [5]. A study on the seed flour investigated functional properties such as least gelation concentration, oil absorption capacity, viscosity and other parameters like free fatty acids, peroxide values among others for a period of four weeks [2]. Also a similar study carried out considered proximate, mineral, functional properties, anti nutrients and amino acid composition of the seeds. The result showed that ash, protein, fat, fibre and carbohydrates were present in varying concentrations while magnesium was present as a mineral with water absorption, oil absorption and emulsion capacities found to be relatively high [3].

Citrullus lanatus (water melon) on the other hand is a juicy fruit, considered as a substitute for water in most areas that are dry [6] and a good source of carotenoid and lycopene [7]. Studies have also been carried out on water melon seed. A study on the proximate and mineral composition of the water melon seed indicated the presence of fats/lipids, crude protein, ash, carbohydrates and minerals like sodium, calcium, zinc, iron, copper, manganese and magnesium [8].Chromium was however not detected in this study. Another study carried out on soya bean milk and water melon seed milk in preparing ice creams based on their incorporation in different ratios with guava pulp indicated that water melon seed milk produced good ice creams. [9]. Water melon seeds have also been studied and identified to be a possible alternative of feed ingredients of poultry diets [10].

Lipids are a group of naturally occurring molecules which include fats, waxes, sterols, diglycerides, phospholipids among others [11]. Lipids have been found to improve the body system by storing energy, serving as signaling agents and as structural components of the cell membranes.

Phospholipids which are a form of lipids make up lipid bilayer of cells, involved in metabolism and cell signaling. Phospholipids contain diglyceride, a phosphate group and an organic molecule like choline [12]. The main phospholipids determined in plants include phosphatidylcholine, phosphatidylethanolamine, phospatidylglycerol, phosphatidylinositol, phosphatidylserine and cardiolipins [13]. Phospholipids like phosphatidylserine have impacted positively on the cognitive function, mode and capacity of an individual to cope with stress. Phospholipids have also been used as base components of drugs, cosmetics and emulsifiers [14].

Further studies have also been done on seeds with particular interest in assessing for fatty acids in their oils for industrial potentials [15]. This study thus aims at determining the fatty acid composition of *Irvingia gabonensis* and *citrullus lanatus* seed oils and comparing them for their industrial potential. It further attempts to assess the level of phospholipid in the seed oils of *Citrullus lanatus* and *Irvingia gabonensis*.

2.0 Materials and Method

2.1 Sample collection

The seeds of Irvingia gabonesis were collected from the fruit obtained from its tree located at Orokam in Ogbadibo local government of Benue state, North central Nigeria while the seeds of citrullus lanatus were obtained from the fruits which were purchased from the old market in Wukari, Taraba state, North eastern Nigeria.

2.2 Sample preparation

40g of each sample were oven dried at a temperature of 4^0C for a period of about six hours. This was necessary to maintain the composition of the fatty acids since at a higher temperature they could be converted to other products. The watermelon seeds were then de-hulled and the samples were then ground with a ken wood blender before packaging them for analysis.

2.3 Extraction of oils

Dried samples were extracted in a soxhlet extractor using redistilled n-hexane of analar grade (BDH-British drug houses, London) for the recovery of the undiluted oil. The crude oil extract was separated from water by filtering it through anhydrous sodium sulphate salt. The hexane was removed from the oil-hexane mixture using a rotary evaporator.

2.4 Fatty acid analysis

50mg of the extracted fat content of the sample was saponified (esterified) for five minutes at 95^oC with 3.4 mL of 0.5M KOH in dry methanol. The mixture was then neutralized by using 0.7M HCl. 3 mL of 14% BF_3 in methanol was added. The mixture was heated for five minutes at a temperature of 90^oC to achieve complete methylation. The fatty acid methyl esters were extracted thrice from the mixture with redistilled n-hexane. The content was concentrated to 1mL for gas chromatographic analysis and 1μL was then injected into the injection port of the HP6890 chemstation Rev. A09.01 (1206) software fitted with flame ionization detector and a computing integrator.

2.5 Phospholipid analysis

A modified method of Raheja *et al* (1973) [16] was used for the analysis of the extracted oil phospholipids content determination. 0.01g of the extracted fat was added to the test tubes. To ensure complete dryness of the oil for phospholipids analysis, the solvent was completely removed by passing the stream of the nitrogen gas on the oil. 0.40 mL of chloroform was added to the content of the tube and it was followed by the addition of 0.10 mL of the chromogenic solution. The content of the tube was heated at the temperature of 100^oC in a water bath for about 1 minute 20 seconds. The contents were allowed to cool to the laboratory temperature and 5 mL of the hexane was added and the tube with its content shaken gently several times. The solvent and the aqueous layers were recovered and allowed to be separated. The hexane layer was recovered and allowed to be concentrated to 1 mL for gas chromatographic analysis with pulse flame photometric detector. The analysis was done using GC model HP6890 powered with HP chemstation Rev.A.09.01 (1206).

3.0 Results and discussion

The result of fatty acids contained in *Citrullus lanatus* seed oil is presented in table 1. The result shows that linoleic acid is the most predominant fatty acid in the seed oil (61.07%). The order of composition is linoleic>palmitic>Oleic>Stearic>Erucic>Palmitoleic>Linolenic>Arachidonic acids. The study indicated that there were no traces of Caprylic acid, Capric acid, Lauric acid, Myristic acid, Margaric acid, Arachidic acid, Behenic acid and Lignoceric acid.

The results of fatty acid composition in *Irvingia gabonensis* seed oil is also presented in table 1. The result from this seed oil shows linoleic acid to be the most predominant fatty acid in the seed oil (22.98%). The order in which the fatty acid were composed in the seed oil based on their magnitude is Linoleic >Oleic>Linolenic>Palmitic>Behenic>Lauric>Erucic>Arachidic acids.

The study has established that some fatty acids common to both seed oils include Linoleic acid, Oleic acid, Palmitic acid, Palmitoleic acid, Stearic acid, Linolenic acid and Erucic acids. It was also discovered that Margaric acid and Behenic acid were not detected in both seed oils. However the study indicated that while lauric, Arachidic, Myristic and Behenic acids were present in *Irvingia gabonensis* seed oil they were absent in *Citrullus lanatus* seed oil. In the same vain, Arachidic acid found in *Citrullus lanatus* was not detected in *Irvingia gabonensis* seed oil.

Similar studies of fatty acids done on 25 pomegranate varieties presented Linoleic acid, Linolenic, Oleic, Stearic and Palmitic acids just like those in *citrullus lanatus* and *irvingia gabonensis* seed oils. In this case however the most predominant fatty acid was Linolenic acid (31.8-86.6%) [17]. A study carried on fatty acid composition of rock melon oil and langkawi oils also showed Linoleic, Oleic, Palmitic and Stearic acid being present with Linoleic acid being the most predominant [18] and another study on the fatty acid composition of egusi melon oil indicated the presence of Lauric acid, Myristic acid, Palmitic acid, Stearic acid, Oleic acid, Linoleic acid and Linolenic acid with Linoleic acid being the most predominant [19]. These results corroborates with the composition of fatty acids in water melon seed oil suggesting that species of the melon family have linoleic acid as the predominant fatty acid. It had being further asserted that Egusi is of the water melon family [20]. A study on another common seed in Nigeria, Jatropha curcus (Phisic nut) also indicated linoleic acid as the most predominant fatty acid (34.6%) [21] Which had a concentration lower than that for water melon though higher than for African wild mango seed oils just like Harm seed oils (47.95-50.91%) [22]. Tiger nuts (*Cyperrus esculentus*) which are also predominant with Linoleic acid have a value which is even lower than both seed oils studied (11.8%) [23]

The results show that of all the fatty acids studied, *Irvingia gabonensis* seed oils had a greater % composition of the fatty acids than *Citrullus lanatus* except for linoleic and arachidonic acids which was higher in *Citrullus lanatus* than in *Irvingia gabonensis*. The implication therefore is that for most of the saturated and unsaturated fatty acids studied in both seed oils, *Irvingia gabonensis* generally presented greater quantity of the fatty acids compared to *Citrullus lanatus* seed oils.

The result of the % composition of saturated, unsaturated, monounsaturated and poly unsaturated fatty acids presented in table 2 show that *Citrullus lanatus* seed oils contains 23.57% of saturated fatty acids while *Irvingia gabonensis* contains 30.41%. This value for *Citrullus lanatus* is lower than the concentration of SFA in cashew nuts (*Anarcadium Occidentales*) (28.3%) [24] Which had slightly lower SFA than for *Irvingia gabonensis*. Also the TSFA concentration of Harm seed (17.06%) was lower than concentrations of TSFA in *Citrullus lanatus* and *Irvingia gabonesis*. The TUFA concentration was lower in *Irvingia gabonesis* seed oil (69.60%) than *citrullus lanatus* seed oil (76.44%). Irvingia gabonensis and Citrullus lanatus seed oils expressed inverse relationship values in MUFA and PUFA (29.07%, 14.55%; 40.53%, 61.89%). The presence of higher concentrations of PUFA than MUFA in both seed oils enhances their potential for industrial use. The more the content of a particular unsaturated fatty acids, the higher their potential as industrial feed stock. Consequently efforts have been made to improve Linolenic acid in flax and Erucic acid in rapeseed for this purpose [25]. The presence of unsaturated fatty acids in *Irvingia gabonensis* and *Citrullus lanatus* makes them potential sources for industrial feedstock.

In the soap making industry, studies have shown that Lauric, Myristic and Palmitic acid present in oils harden the soap promoting a fluffy lather and cleaning very well [26] thus *Irvingia gabonensis* which has Lauric acid (1.27%) , Myristic acid (2.46%) and a higher amount of Palmitic acid (16.69%) would be better for producing hard soaps than citrullus lanatus which contains only palmitic acid (15.4%). The success of these fatty acids in hardening soaps is attributed to their saturated nature [27]. Furthermore, Linoleic acid, Linolenic acid and Oleic acid provide conditioning and moisturizing properties in soaps [26]. Both *irvingia gabonensis* and *citrullus lanatus* seed oils contain these fatty acids hence their use as sources of making shampoos will be very good. This corroborates with the characterization of fatty acids in soaps in Nigeria which was found to include Capric acid, Caprylic acid, Lauric acid, Myristic acid, Myristoleic acid, Palmitic acid, Stearic acid, Oleic acid and Linoleic acid [27].

In the polymer industry, unsaturated fatty acids are converted to epoxides, polyols which are precursors in making plastics. Also esters that are based on fatty acids have been used as alternatives to mineral oils in making lubricants for engines [28]. The seed oils from *irvingia gabonensis* and *citrullus lanatus* have unsaturated fatty acids in quantities that can enable their use in these industries.

The phospholipids in *Citrullus lanatus* and *Irvingia gabonesis* seed oils are presented in table 3. Six phospholipids were identified in the seed oils with their order of magnitude being phosphatidylcholine

(513.74264 mg/100g, 148.15834 mg/100g)> phosphatidylinositol (214.52794 mg/100g, 64.95550 mg/100g)> phosphatidylethanolamine (110.58456 mg/100g , 15.05366 mg/100g) > phosphatidic acid (94.06157 mg/100g, 83.45318 mg/100g)> Lysophosphatidylcholine (2.34550 mg/100g, 1.01673 mg/100g) > Phosphatidylserine (0.389339 mg/100g, 0.104561 mg/100g) . The high concentration of phosphatidylcholine in *Citrullus lanatus* seed oil agrees with Adeyeye *et al.*, 2012[29] who reported Phosphatidylcholine as the most abundant phospholipid in animals and plants being the main building blocks of membrane bilayers. The value of phosphatidylcholine in *Citrullus lanatus* is however higher than raw and processed Brachystegia eurycoma seed (4.30-6.01mg/100g) [22]. This value could be as a result of processing such as boiling, fermenting and roasting. The fact that some levels of Phosphatidylcholine have been injected into individuals to reduce subcutaneous fats (Palmer et al., 2006) [31] suggests that consumption or application of *Citrullus lanatus* seed oils could help to improve skin texture in man. Phosphatidylserine is the least concentrated in the seed oil. It is a major acidic phospholipid in the brain [32].

The phospholipid levels in *Irvingia gabonensis* seed oils followed the same pattern as *Citrullus lanatus* seed oils in terms of the order in magnitude. However lysophosphatidylcholine concentration based on the total phospholipids in *Irvingia gabonensis* seed oil was higher than the concentration in *Citrullus lanatus* based on the total phospholipid.

Generally, the total Phospholipid level was higher in *Citrullus lanatus* than in *Irvingia gabonensis*. The phospholipid levels were higher for each of the phospholipids in *Citrullus lanatus* than in *Irvingia gabonensis* .This presents *Citrullus lanatus* seed oils as having a better potential in improving health conditions than *Irvingia gabonensis* .

The US food and drug Administration (USFDA) has shown that when phosphatidylserine is consumed, it could reduce the extent of dementia condition and cognitive dysfunction in the elderly people [33]. Supplements of Phosphatidylserine in the body have been found to promote hormonal balance in athletes and also reduce physiological breakdown that are associated with overtraining and/or overstretching [34]. The Phosphatidylserine values in both seed oils were found to be very low hence they would not be good sources of Phosphatidylserine supplements.

Phosphatidic acid tends to mediate cellular functions by actions like membrane tethering, modulation of enzymatic activities and structural effects on cell membrane [31]. Phosphatidic acid was detected in reasonable concentrations in both seed oils hence consumption of the seed oils of both *Citrullus lanatus* and *Irvingia gabonensis* could help in bringing about these functions in body cells.

Conclusion

The work compared *citrullus lanatus* (Watermelon) and *Irvingia gabonensis* (African wild Mango) seed oils . *Citrullus lanatus* seed oil had 8 fatty acids while *irvingia gabonensis* had 11 fatty acids. Fatty acids common to both include linoleic acid (C18:2), Oleic acid (C18:1), Palmitic acid (C16:0), Palmitoleic acid (C16:1), Stearic acid (C18:0), Linolenic acid (C18:3) and Erucic acid (C22:1). It established that Lauric acid, Arachidic acid, Myristic acid and Behenic acid though present in *irvingia gabonensis* were absent in *citrullus lanatus*. In like manner, Arachidonic acid present in *citrullus lanatus* was absent in *irvingia gabonesis*. Margaric acid and Lignoceric acid were totally absent in both seed oils. A greater quantity of each fatty acid was found in *irvingia gabonensis* than *citrullus lanatus* except for Linoleic acid and arachidonic acid.

Both seed oils portended potential for industrial application as biodiesels, lubricants, plastic and soaps due to the presence of unsaturated and some saturated fatty acids. *Irvingia gabonensis* however indicated better potential for making hard soaps than *citrullus lanatus*. However both seed oils will be useful for making hair shampoos. It is therefore recommended that further research into the use of these seed oils for some industrial processes be embarked upon.

The assessment of phospholipid levels of *Citrullus lanatus* and *Irvingia gabonensis* seed oils was also carried out producing six phospholipids namely phosphatidylcholine, phosphatidylserine, phosphatidylethanolamine, phosphatidylinositol, lysophosphatidylcholine and phosphatidic acid. The phospholipid levels in *Citrullus Lanatus* was found to be more than that in *Irvingia gabonensis* especially phosphatidylcholine which is known to reduce body fats. No data on phospholipid levels in *Citrullus lanatus* and *Irvingia gabonensis* had earlier been documented to the best of the researchers' knowledge. This study thus presents baseline information on this.

Table 1: Fatty acid composition of Citrullus lanatus and Irvingia gabonensis

Lipid number	Fatty acid	% composition[a]	% composition[b]
C8:0	Caprylic acid	ND*	ND*
C10:0	Capric acid	ND*	ND*
C12:0	Lauric acid	ND*	1.27
C14:0	Myristic acid	ND*	2.46
C16:0	Palmitic acid	15.4	16.69
C16:1	Palmitoleic acid	0.53	6.32
C17:0	Margaric acid	ND*	ND*
C18:0	Stearic acid	8.17	8.38
C18:1	Oleic acid	13.48	21.87
C18:2	Linoleic acid	61.07	22.98
C18:3	Linolenic acid	0.52	17.55
C20:0	Arachidic acid	ND*	0.09
C20:4	Arachidonic acid	0.30	ND*
C22:0	Behenic acid	ND	1.52
C22:1	Erucic acid	0.54	0.88
C24:0	Lignoceric acid	ND*	ND*

a- % composition of citrullus lanatus
b- % composition of Irvingia gabonensis
ND*-Not detected

Table 2 : % of saturated and unsaturated fatty acids in citrulus lanatus and Irvingia gabonensis seed oils

Seed oils	%TSFA	%TUFA	%MUFA	%PUFA
I.gabonensis	30.41	69.60	29.07	40.53
C.Lanatus	23.57	76.44	14.55	61.89

Table 3 : Phospholipid levels of *Citrullus lanatus* and *Irvingia gabonensis* seed oil

S/No	Name of phospholipids	Amount (mg/100g)[a]	Amount (mg/100g)[b]
1	Phosphatidylethanolamine	110.58456 (11.82)**	15.05366(6.27)**
2.	Phospahtidylcholine	513.74264(54.91)**	148.15834(61.76)**
3.	Phosphatidylserine	0.389339 (0.042)**	0.104561(0.044)**
4.	Lysophosphatidyl choline	2.34550 (0.2507)**	1.01673(0.424)**
5.	Phosphatidylinositol	214.52794(22.93)**	64.95550(27.08)**
6.	Phosphatidic acid	94.06157(10.05)**	10.60839(4.42)**
	Total phospholipids	935.65155	239.89718

a- Levels of *Citrullus lanatus* seed oils
b- Levels of *Irvingia gabonensis* seed oils
**- Percentages are in parentheses

References

[1] Joseph,K and Aworh,O.C. (1991) Composition of sensory quality and respiration during ripening and storage of edible wild mango (Irvingia gabonensis).*International Journal of Food, Science Technology*.26:337-342

[2] Akusu,O.M and Kiin-Kabiri,D.B. (2013) Effect of storage period on selected functional chemical stability and sensory properties of bush mango (Irvingia gabonensis) seed flour. *African Journal of Food, Science and Technology*.4(6):136-140.

[3] Ogungbele,H.N. (2014) Chemical and amino acid composition of raw and defatted African mango(Irvingia gabonensis)Kernel. *British Biotechnology Journal*. 4(3):244-253.

[4] Okunomo,K and Egho,E.O. (2010) Economic importance of some under exploited tree specie in Nigeria: Urgent need for separate research centres. *Continental Journal of Biological Sciences*.3:16-32

[5] Ogunsina,B.S., Bhatnagar,A.S., Indira,T.N and Radha,C (2012) The proximate composition of African Bush mango kernels (Irvingia gabonensis) and characteristics of its oil. *Ife journal of Science*. 14(1):177-183.

[6] Beshir,A.A and Babiker,A.S. (2009) The effect of substitution of groundnut cake by water melon seed cake (citrullus lanatus) in ration for lamb fattening in Sudan. *Research Journal of Agriculture and Biological Sciences*.5(6):1130-1142.

[7] Oyeleke,G.O., Olagunju,E.O and Ojo,A. (2012) Functional and physicochemical properties of water melon (citrullus lanatus) seed and seed oil. *IOSR journal of Applied Chemistry*. 2 (2):29-31.

[8] Penuel,B.L.,Khan,E.M and Maitera,M.O .(2013) Properties of proximate composition and elemental analysis

of citrullus Vulgaris(Guna) seed. *Bulletin of Environment, Pharmacology and Life Sciences*. 39-46.
[9]Bisla,G., Archana ,Verma,P and Sharma,S.(2011) Development of ice creams from soya bean milk and evaluation of their acceptability and nourishing potential. *Research Journal of Dairy Sciences*. 5 (1):4-8
[10] Hafeni,S., Mpofu,I.D.T and Petrus,P. (2013) The potential of pearl millet and water melon seeds as cheap alternative ingredients in Namibian poultry feeds. *Agricultural Science Research Journal*. 3(5):140-143.
[11] Lipid-Wikipedia, The free encyclopedia www.en.wikipedia.org/wiki/lipid.retrieved on 3rd May, 2014
[12] Phospholipid-Wikipedia, the free encyclopedia. www.en.wikipedia.org/wiki/phospholipids retrieved on 3rd may, 2014.
[13] Hildebrand,D. (2010) Plant lipid biochemistry-production of unusual fatty acids in plants. http://www.lipidlibrary.aocs.org/plantbio/unusualfa/index.htm
[14] Raharjo,T.J.,Nurliana,L & Mastjeh,S. (2011)Phospholipids from pumpkin (Curcurbita Moschata (Duch) Poir) seed kernel Oil and their fatty acid composition. *Indo.J.Chem*. 11(1):48-52.
[15] Aremu, M.O and Amos, V.A. (2010) Fatty acids and physicochemical properties of sponge luffa (Luffa cylindrical) Kernal oils. *International Journal of Chemical Sciences*. 3(2):162-171.
[16] Raheja,R.K., Kaur, C.,Singh,A., & Bhatia,I.S. (1973) New colorimetric method for the quantitative estimation of phospholipids without acid digestion. *Journal of lipid Research*.14:695-697.
[17] Parashar, A., Sinha,N and Singh,P.(2010) Lipid contents and fatty acid composition of seed oil from twenty five pomegranates varieties grown in India. *Advance Journal of Food Science and Technology*. 2 (1):12-15
[18] Ismail,M.,Mariod,A.,Bagalkotkar,G and Ling,H.S.(2010) Fatty acid composition and antioxidant activity of oils from two cultivars of cantaloupe extracted by supercritical fluid extraction. *Grasas Y aceites*.61(1):37-44.
[19] Oluba,O.,Adeyemi,O., Ojieh,G and Isiosio,I.(2007) Fatty acid composition of citrullus lanatus (egusi melon) oil and its effect on serum lipids and some serum enzymes.*The internet Journal of Cardiovascular Research* .5(2).
[20] www.allnigerianrecipes.com/food-ingredients/egusimelon-seeds.html retrieved on 7th March, 2014.
[21] Olaofe, O., Falaye, F.J and Abey, J.A.. (2010) Amino acid, fatty acid and physicochemical analyses of jatropha Curcus (Physic Nut) seed flour and Oil. *Bangladesh Journal of Scientific and Industrial Research*. 45 (4):345-350.
[22] Ajayi, F.A., Aremu, M.O., Mohammed, Y., Madu, P.C., Atolaiye,B.O., Audu,S.S and Opaluwa, O.D. (2014) Effect of processing on fatty acid and phospholipid compositions of Harms (Brachystegia eurycoma) seed grown in Nigeria. *Chemical and Process Engineering Research*.22:18-24
[23] Muhammed, N.O., Bamishaiye, E.I., Bamishaiye, O.M., Usman, L.A., Salawu, M.O., Nafiu, M.O and Oloyede, O.B (2011)Physicochemical properties and fatty acid composition of cyperus esculentus (Tiger Nut) tuber oil. *Bioresearch bulletin*.5:51-54.
[24] Aremu,M.O., Ogunlade,I and Olonisakin, A (2007) Fatty acid and Amino acid composition of protein concentrate from Cashew Nut (Anarcadium Occidentale) Grown in Nassarawa State, Nigeria. *Pakistan Journal of Nutrition*.6 (5):419-423.
[25] Smith, M.A (2007) Engineering oil seeds for industry. Issues in new crops and new uses.J.janick and A.Whipkey(eds).ASHS press Alexandria,VA.
[26] www.soap-making-resource.com/fattyacids-soap-making.html
[27] Oghome, P., Eke, M.U and Kamalu, C.I.O. (2012) Characterization of fatty acids used in soap manufacturing in Nigeria: laundry, toilet, medicated and antiseptic soap. *International Journal of Modern Engineering research*. 2 (4):2930-2934.
[28] Hill,K (2000) Fats and oils as Oleochemical raw materials. *Pure Appl.Chem.*72 (7):1255-1264.
[29] Adeyeye,E.I., Adesina, A.J., Ginika,M.C & Aiyo, H.E. (2012) Great Barracuda: Its skin and Muscle fatty acids, phospholipids and Zoosterol composition. *International Journal of Chemistry*.5(1):18-28.
[30] Palmer, M., Curan, J & Bowler, P (2006) Clinical experience and safety using phosphatidylcholine injections for the localized reduction of subcutaneous fat: a multicentre retrospective UK study. *Journal of Cosmetic Dermatology*. 5:218- 226
[31] No authors listed (2008) Phosphatidylserine. *Alternative Medicine Review*. 13(3):245-247.
[32] Alter, T. (2006) More than you wanted to know about fats and oils. Sundance National food online retrieved on 31st August, 2006.
[33] Starks, M.A., Starks, S.L., Kingsley, M., Purpura, M & Jager, R. (2008) The effects of phosphatidylserine endocrine response to moderate intensity exercise. *Journal of International Society of Sports Nutrition*. 5:11-16.