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Extraction, Characterization and Fatty Acids Profiles of *Nymphaea Lotus* and *Nymphaea Pubescens* Seed Oils

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Fats and oils are part of food constituents, and may play a vital role in cosmetics and pharmaceuticals industries. There are several underutilized plants which their seeds have not been fully studied in terms of oil extraction and characterization. In this work two underutilized plants seeds *Nymphaea lotus* and *Nymphaea pubescens* were studied. Oils from these two seeds were extracted using soxhlet extraction with n-hexane. Gas chromatographic coupled mass spectrometry analysis of the *N. lotus* seed oil showed that linoleic (13.01%), palmitoleic (4.46%), arachidic (9.01%) and stearic (12.45%) acids were the major fatty acids whereas oleic (37.85%), palmitic (23.57%) and stearic (5.71%) were the major fatty acids detected in *N. pubescens* seed oil. In addition, oil extracted from *N. pubescens* seed was found to have better quality than *N. lotus* seeds. The fatty acids composition of *N. pubescens* seed oil is similar to palm and groundnut oil. Extracted oil from of *N. pubescens* seed is unsaturated which type is classified in the oleic – linoleic acid group. This work has shown that *N. pubescens* seed oils have great nutritional and industrial potentials.

Keywords: *Nymphaea lotus, Nymphaea pubescens,* seed oils, Fatty acids, Nutritional qualities.

Oils extracted from plant seed are of nutritional importance, and some may have omega -3 fatty acids. Some plant oils play essential role in curbing disease conditions (Wang, 2004). Besides, some characterized seed oils have been proven to have fatty acids of nutritional as well as nutraceutical importance (Muibat *et al*., 2011). It is worth to note that more interest is growing in the area of seed oil, this may be associated to their bioactive components. Several bioactive components identified in seed oil are showing different health benefits. In addition fats and oils can extensively be used in food and other needs. Some of these oils have antioxidant properties, a factor strongly considered for therapeutic usage. Antioxidants tends to reduce fat oxidation by scavenging the free radicals generated. Two herbaceous aquatic plants (*Nymphaea lotus* and

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Nymphaea pubescens) were studied in this work, these plants are commonly known as white and red lily respectively. These two herbaceous plants are known as hydrophytes, they usually float in water with white or yellow flowers (Wasagu *et al.*, 2015). This work is aimed at extracting characterizing and evaluating fatty acids compositions of *Nymphaea lotus* and *Nymphaea pubescens* seed oils and to compare their nutritional qualities with commonly consumed vegetable oils to ascertain their suitability or otherwise for human consumption and industrial applications.

MATERIAL AND METHODS

Sample Identification

Plant samples *(Nymphaea lotus* and *Nymphaea pubescens* seeds) were obtained from Guzu- Guzu Dam in Kabo Local Government Area, Kano state of Nigeria. The samples were authenticated by the Department of Plant Biology, Bayero University Kano with accession number BUKHAN 0356 and BUKHAN 0357 for *Nymphaea lotus* and *Nymphaea pubescens* seeds respectively.

Preparation of Samples

The samples were washed, drained and dried thoroughly. This was followed by grinding into powder with subsequent drying of the powdered samples at 25^{0}C. The samples were placed in clean plastics before analysis and labelled appropriately.

Extraction of oil using Soxhlet apparatus

n-Hexane (300 ml) was poured into a flask, with subsequent addition of 50 grams of the powdered sample. The mixture was heated at 60^{0}C and at boiling point, the vapour rises and condenses at the top of the Soxhlet apparatus. The condensed liquid drips down to the filter containing the oil to be extracted. The extract flows through the thimble thereby filling the tube and subsequently flows back to the flask. The set-up continued for 30 minutes, then removed removed, dried, cooled and weighed again to estimate the amount of extracted oil. The experiment was replicated with determination of the weight of extracted oil determined at intervals of 30 minutes. Resulting mixture containing the oil was distilled off using simple distillation to recover the solvent. Extracted oil was properly stored in labelled container prior to analysis (AOAC, 2006)

Percentage oil Yield Determination

The percentage oil yield was calculated by using following relation (AOAC, 2000).

$$\% \text{ Oil yield} = \frac{\text{weight of oil}}{\text{weight of sample on dry matter basis}} \times 100$$

Determination of physicochemical properties of *Nymphaea lotus* seed oil, *Nymphaea pubescens* seed oil, Palm oil and Groundnut oil

Determination of Acid value

The oil sample (0.25g) was placed in flask with addition of 50 ml ethanol (95%). Three drops of 1% phenolphthalein indicator was added and the mixtures was allowed to boil. Titration was done using 0.1N NaOH. Resultant solution was shaked properly as titration proceeds. Appearance of red colour within the first ten seconds was taken as an end point, while the volume of alkali used was noted (Onwuka, 2005).

$$\text{Acid value} = \frac{56.1 \times N \times A}{W}$$

A=Volume of Alkali
N=Normality of NaOH
W= Weight of sample (g)

Determination of Saponification value

The sample (0.26g) was poured in a flask and 25 ml of KOH was added. The mixture was boiled for an hour using a reflux condenser, while the mixture is swirled regularly at different intervals. Excess alkali was determined by titrating with 0.5 N HCl, 3 drops of phenolphthalein was used as as indicator. Blank was determined using KOH under same experimental procedure (AOAC, 2005).

$$\text{Saponification Value} = \frac{56.1 \times N \times (A-B)}{W}$$

N= Normality of KOH
A= Volume of HCL (ml) for the sample
B= Volume of HCL used (ml) for blank titration
W= Weight of sample taken (g)
Equivalent weight = molecular weight of KOH = 56.1

Determination of Iodine value

The sample (0.26g) was placed in a flask and 10 ml of CCL_4 together with 20 ml of Wij's solution were mixed and shaked properly. The resulting mixture was kept safely in dark for thirty minutes at 37^{0}C. Potassium iodide (10 percent; 15

ml) and distilled water (100 ml) were later added to the flask. Resulting mixture was titrated against 0.1 M $Na_2S_2O_3$. Starch was used as an indicator in this titration, the appearance of a colorless solution from a blue black coloration marks the end point. Blank titration was done using with 10 ml CCL_4. Iodine value was calculated using the below formula (AOCS, 1998; Kyriakidis and Katsiloulis, 2000; Knothe, 2002; AOAC, 2005).

$$\text{Iodine Value} = \frac{12.69 \times N \times (B - S)}{\text{Weight of sample}}$$

B = 0.1 N $Na_2S_2O_3$ needed (ml) by blank
S = 0.1 N $Na_2S_2O_3$ needed (ml) by sample
N = Normality of $Na_2S_2O_3$

Peroxide value Determination

The sample (0.26g) was placed in a flask with addition of 7.5 ml of acetic acid and 5 ml chloroform, the mixture was swirled properly until the sample was fully dissolved. Subsequent addition of saturated potassium iodide (0.25 ml) was done with vigorous shaking for a minute. This was followed with addition of 15 ml of distilled water. The reaction mixture was titrated with 0.05 N $Na_2S_2O_3$ solution, until the appearance of a pale yellow color from the original brownish color Furthermore; Five ml of starch was then added with continuous shaking, the appearance of blue color is an indication of the end point (Onwuka, 2005).

$$\text{Peroxide Value} = \frac{2.6 \times \text{strength of soduim thiosulphate} \times 1000}{\text{Weight of sample in g}}$$

Determination of pH

The sample (2g) was placed in a dry clean beaker containing 13 ml distilled water (hot), it was stirred gently and allowed to cool at 25^0C. pH meter was inserted to the mixture and the reading was taken (Garba *et al*., 2015).

Determination of Density

The weight of an empty dried beaker was taken and exactly 50 cm^3 of each of the oil sample were measured and pour into the beaker and weighed. The weights of the 50cm^3 of the samples were recorded (Garba *et al.,* 2015). The density was calculated thus;

$$\text{Density of oil sample} = \frac{\text{Weight of oil sample}}{\text{Volume of the oil sample}}$$

GC-MS Analysis of *Nymphaea lotus* seed oil, *Nymphaea pubescens* seed oil, Palm oil and Groundnut oil

Procedure

Fatty acid methyl esters (FAMEs)

Oils extracted from the samples were subjected to heat in presence of NaOH, with subsequent addition of BF3 methanol for esterification. n-Heptane (5 ml) was poured to the reaction mixtures in order obtain methyl esters in organic phase. Further addition of NaCl was done while both the aqueous and organic layers were then separated. The upper part contains n-heptane which was pipetted out and stored (-4^0C) for GC-MS analysis. (AOAC, 1997). The preparation was done at the National Research Institute of Chemical Technology (NARICT), Zaria, Nigeria.

Fatty Acid Methyl Ester (FAME) Analysis (GC-MS)

The analysis was done using Shimadzu QP2010 quadrupole (GC-MS). The instrument has a capillary in which one microliter of sample was injected into it. The carrier gas used was helium, while the temperatures (injector and detector) were maintained at 280°C. While for the column the temperature was initially 50°C for a minute and left to increase steadily at 5°C per minute till it reached 280°C. Split mode (1:30) was allowed during injection. Separation of the esters were done at a constant pressure (100kPa). Mass spectra of identified peaks as well as their retention time were compared that of a database.

Statistical Analysis

One way analysis of variance (ANOVA) of the SPSS statistical package was used in determining significance difference between the results obtained. The mean ± standard deviation of the triplicates were presented in the results.

RESULTS AND DISCUSSION

Physicochemical properties (pH, Density, Peroxide value, Iodine value, free fatty acid, saponification number and peroxide value) of *Nymphaea lotus* and *Nymphaea pubescens* seed oils were presented in Table 1. The results were compared with commonly consumed oils.

Table 2 showed the fatty acids detected in *Nymphaea lotus* and *Nymphaea pubescens* seed oils

using GC-MS analysis. Saturated and unsaturated fatty acids were present in varied proportions

Table 3 showed the fatty acids detected in Palm oil and Groundnut oil by GC-MS analysis. Saturated and unsaturated fatty acids were present in varied proportions

Table 4 shows the comparison of the relative abundance of common fatty acids detected by GC-MS analysis in *Nymphaea lotus* seed oil, *Nymphaea pubescens* seed oil, palm oil and groundnut oil. Saturated and unsaturated fatty acids were present in varied proportions

Table 5 presents saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) as well as polyunsaturated to saturated fatty acids ratios (P/S index) of *Nymphaea lotus* seed oil, *Nymphaea pubescens* seed oil, palm oil and groundnut oil

The results for *Nymphaea lotus* seed oil, *Nymphaea pubescens* seed oil, palm and groundnut oils were presented. The *Nymphaea lotus* seed oil was pale red and *Nymphaea pubescens* seed oil was red in colour. The oil contents of *Nymphaea lotus* and *Nymphaea pubescens* seeds were 13.23% and

Table 1. Physicochemical properties of *Nymphaea lotus* seed oil, *Nymphaea pubescens* seed oil, Palm oil and Groundnut Oil

Parameters	*N. lotus* Seed Oil	*N. pubescens* Seed Oil	Palm Oil	Groundnut Oil
% Oil yield	13.23	9.28	-	-
pH	5.90	6.20	6.18	5.73
Density (g/cm^3)	0.73	0.82	0.98	0.77
Colour	Pale red	Red	Red	Light yellow
Odour	Pleasant	Pleasant	Pleasant	Pleasant
Iodine Value (gI_2/100g)	38.85±0.44^a	133.14±0.93^a	128.28±1.16^a	110.82±1.16^a
Acid Value (mgKOH/g)	3.19±0.02^{ab}	2.54±0.08^a	3.00±0.14	2.40±0.36^b
Free fatty acid Value (%)	1.59±0.01	1.27±0.04	1.51±0.07	1.11±0.04
Saponification Value (mgKOH/g)	138.98±1.77	186.81±161	198.68±0.40	141.61±0.96
Peroxide Value ($mEqO_2$/kg)	3.18±0.22^a	5.11±0.40	4.62±0.29	7.89±0.23^a

Values are expressed as mean ± standard deviation. Same superscripts in a single row indicates statistical significance ($p<0.05$). Different superscripts indicates no statistical significance ($p>0.05$).

Table 2. GC-MS detected fatty acids in extracted oils of *Nymphaea lotus* and *Nymphaea pubescens* seeds

RT	Fatty acid	Trivial name	Formula	Mol. Weight	Area%
		Nymphaea lotus seed oil			
15.492	Pentadecanoic acid	-	$C_{15}H_{32}O_2$	270	6.42
17.167	9,12-Octadecadienoic acid	Linoleic acid	$C_{18}H_{34}O_2$	294	13.01
17.342	11-Octadecenoic acid	Vaccenic acid	$C_{18}H_{36}O_2$	296	2.42
17.442	Octadecanoic acid	Stearic acid	$C_{18}H_{38}O_2$	298	12.45
19.150	9-Hexadecenoic acid	Palmitoleic acid	$C_{16}H_{30}O_2$	254	4.46
19.217	Eicosanoic acid	Arachidic acid	$C_{20}H_{42}O_2$	326	9.01
20.842	Docosanoic acid	Behenic acid	$C_{22}H_{46}O_2$	354	1.10
		Nymphaea pubescens seed oil			
13.983	Tetradecanoic acid	Myristic acid	$C_{14}H_{28}O_2$	228	0.65
16.158	Hexadecanoic acid	Palmitic acid	$C_{16}H_{32}O_2$	256	23.57
17.908	9-Octadecenoic acid	Oleic acid	$C_{18}H_{34}O_2$	282	37.85
18.025	Octadecanoic acid	Stearic acid	$C_{18}H_{36}O_2$	284	5.71
19.442	9,12-Octadecadienoic acid	Linoleic acid	$C_{18}H_{34}O_2$	294	0.78
19.650	Eicosanoic acid	Arachidic acid	$C_{20}H_{42}O_2$	312	1.02

9.28% respectively. The value of oil yield obtained for *Nymphaea lotus* seed was greater than the literature value reported by Musa *et al.,* (2012) and Wasagu *et al*., (2015) respectively. Variation in the percentage oil yield might be due to intra species variations, extraction procedures and climatic or soil condition (Raja *et al.,* 201; Mahale and Goswami-Giri, 2012).

Table 3. GC-MS detected fatty acids in Palm oil and Groundnut oil

RT	Fatty acid	Trivial name	Formular	Mol. Weight	Area%
		Palm oil			
10.950	Octanoic acid	Caprylic acid	$C_8H_{16}O_2$	144.21	0.01
16.640	Dodecanoic acid	Lauric acid	$C_{12}H_{24}O_2$	200.32	0.04
19.190	Tetradecanoic acid	Myristic acid	$C_{14}H_{28}O_2$	228	1.35
21.750	Hexadecanoic acid	Palmitic acid	$C_{16}H_{32}O_2$	256	31.05
23.634	9-Octadecenoic acid	Oleic acid	$C_{18}H_{34}O_2$	282	33.79
23.650	9,12- Octadecadienoic acid	Linoleic acid	$C_{18}H_{34}O_2$	294	10.15
24.069	6-Octadecenoic acid	Petroselinic acid	$C_{18}H_{34}O_2$	282.47	11.19
25.265	11-Octadecenoic acid	Vaccenic acid	$C_{18}H_{36}O_2$	296	0.22
25.375	Cis-13-Octadecenoic acid	-	$C_{18}H_{34}O_2$	282.46	0.19
		Groundnut oil			
17.966	Tetradecanoic acid	Myristic acid	$C_{14}H_{28}O_2$	228	0.03
18.025	Octadecanoic acid	Stearic acid	$C_{18}H_{36}O_2$	284	3.38
19.150	9-Hexadecenoic acid	Palmitoleic acid	$C_{16}H_{30}O_2$	254	0.11
19.217	Eicosanoic acid	Arachidic acid	$C_{20}H_{42}O_2$	326	20.00
19.650	Cis-13-Eicosanoic acid	Paulinnic acid	$C_{20}H_{42}O_2$	312	0.09
21.562	Hexadecanoic acid	Palmitic acid	$C_{16}H_{32}O_2$	256	1.04
23.724	9-Octadecenoic acid	Oleic acid	$C_{18}H_{34}O_2$	282	19.43
23.154	9,12-Octadecadienoic acid	Linoleic acid	$C_{18}H_{34}O_2$	294	37.54
24.532	9,12,15-Octadecatrienoic acid	Linolenic acid	$C_{18}H_{32}O_2$	312	0.34

Table 4. Comparison of the Fatty acids Profiles of the *Nymphaea* seed oils extracts with Palm and Groundnut oils

Fatty Acid	*N. lotus* Seed oil	*N. pubescens* Seed oil	Palm oil	Groundnut oil
Caprylic acid	ND	ND	0.01	ND
Lauric acid	ND	ND	0.04	ND
Myristic acid	ND	0.65	1.35	0.03
Palmitic acid	4.46	23.57	31.05	1.04
Stearic acid	12.45	5.71	ND	3.38
Arachidic acid	9.01	1.02	ND	20
Palmitoleic acid	ND	ND	ND	0.11
Oleic acid	ND	37.85	33.79	19.43
Linoleic acid	13.01	0.78	10.15	37.54
Linolenic acid	ND	ND	ND	0.34
Vaccenic acid	2.42	ND	0.22	ND
Behenic acid	1.1	ND	ND	ND
Pentadecanoic acid	6.42	ND	ND	ND
Paulinnic acid	ND	ND	ND	0.09
Petroselinic acid	ND	ND	11.19	ND
Cis-13-Eicosenoic acid	ND	ND	0.19	ND

ND: means not detected

Table 5. SFA, MUFA, PUFA and P/S Index values of the extracted oils, Palm oil and Groundnut oil values are presented

Parameters	*N. lotus* seed oil	*N. pubescens* seed oil	Palm oil	Groundnut oil
Total SFA (%)	28.98	30.95	32.45	24.54
Total MUFA (%)	6.88	37.85	45.20	19.54
Total PUFA (%)	13.01	0.78	10.15	37.88
P/S Index (%)	0.45	0.03	0.31	1.54
P+M/S (%)	0.67	1.24	1.69	2.33

Comparing the oil yield of *Nymphaea lotus* seed oil and *Nymphaea pubescens* seed oil with known vegetable oil of plant origin such as groundnut (46%) (Adebayo *et al*., 2012), soybean seed (18%) (Akbar *et al*., 2009), Shea butter (34%) (Kyari, 2008). Besides the result of the oil yield is similar with other underutilized plant seed, this includes *Detarium microcarpum* (Nzikou *et al*., 2009) and *Pearsea americana* (Sam *et al*., 2008). Furthermore, the density at 30°C for *Nymphaea lotus* seed oil, *Nymphaea pubescens* seed oil and the commercial samples (palm oil and groundnut oil) were presented in table 1. Lower difference were seen when the densities of commercial oil were compared with that of the extracted oils from the samples used. Even though, the high relative densities might suggest an increase molecular weight as well as unsaturation (Onyeka *et al*., 2005)

The acidity or alkalinity of the samples were done by determining the pH, from the results as presented in Table 1, the samples were slightly acidic, a good indication that free fatty acids (small amount) are present, thus, making them fit for consumption. In situation were the free fatty acids are in higher quantity, might rendered the oil non edible, due to reduction in its shelf life and palatability. In terms of iodine value which is a degree of unsaturation as reported by Hamilton, (1999). *Nymphaea pubescens* oil contains the highest iodine value (Table 1), as such it is the most unsaturated when compared to the common oils used in this work. *Nymphaea lotus* oil which had the least iodine value (Table 1) is the most saturated oil, a clear evidence could be seen when the oil is at ambient temperature. Iodine value is directly proportional to the number of saturated bonds (Aremu *et al*, 2006). Furthermore, the lesser the iodine value the lesser susceptible it is to rancidity (oxidative).

Liquid oils are oils that cannot dry, and are usually not suitable for paint and ink production, although they can be applied in soap production. (Kochhar, 1998). Drying oils needs an iodine value of 130gI_2/100g or higher. *Nymphaea pubescens* seed oil has saponification number similar to palm oil. The saponification number of *Nymphaea lotus* seed oil can be compared with the values obtained for groundnut oil. Oils needed in production of shampoos and ice-cream require higher saponification value.

Acid value of *Nymphaea lotus* oil, *Nymphaea pubescens* oil, and common oils are presented in Table 1. The measurement of the extent of which triacylglycerides are decomposed by lipase is known as the acid value (Inekwe *et al*., 2012). Most often in indicates edibility of an oil, in this work low acid values were obtained in *Nymphaea lotus* and *Nymphaea pubescens* seed oils. The result is comparable to palm oil and groundnut oil. It is worthy to note that oil with low level of acidity can serve as quality indicator of oil (Yousefi *et al*., 2013). According to FAO/WHO (1991), edible oils should exceed 4 mgKOH/g in terms of acid value. It is striking to note that the samples studied in this work had there acid values within the recommended range for edible oils

Peroxide values of *Nymphaea lotus* seed oil, *Nymphaea pubescens* seed oil, palm and groundnut oils are presented in table 1.

A measurement of deterioration levels of lipids due to oxidation is considered as peroxide value (Inekwe *et al*., 2012). It is a good indicator in determining the usability of oils, when the peroxide value is low, then the stability and quality

of oil tends to be high (Yousefi et al., 2013). A low peroxide value of *Nymphaea lotus* and *Nymphaea pubescens* seed oils as compared to palm oil shows that the seed oils are stable to relative oxidation. The FAO/WHO (1994) gave a maximum permissible limit for peroxide level which should not exceed 10 milliequivalent of oxygen/kg of the oils. Here we reported the samples used were within the specification recommended by FAO and are suitable for consumption.

The Gas-chromatography coupled with mass spectrometry analysis of free fatty acids in the extracted oil of *Nymphaea lotus* and *Nymphaea pubescens* as well as palm oil and groundnut oil were recorded in table 2 and 3 respectively. Table 4 presents comparison of the relative abundance of common fatty acids of *Nymphaea lotus* seed oil, *Nymphaea pubescens* seed oil and commonly used vegetable oils. Palmitic acid is predominant saturated acid in *Nymphaea pubescens* seed oil and palm oil, while arachidic acid was the predominant saturated fatty acid identified in *Nymphaea lotus* seed oil and groundnut oil. Palmitic acid is an antioxidant, with nematicidal activity commonly used in soap making. Myristic acid was absent in *Nymphaea lotus* seed oil but present in a lower amount in *Nymphaea pubescens* seed oil, palm and groundnut oils. There is appreciable high amount of myristic and palmitic acids which rise blood cholesterol (Zock *et al*., 1994). In addition saturated fatty acids (C12:0-C16:0) have atherogenic effects while stearic acid as neutral effects (Aro *et al*., 1997; Hu *et al*., 1999). In *Nymphaea lotus* seed oil, there was an unusual detection of pentadecanoic acid as well as vaccenic acid. These acids are rarely seen in common vegetable oils, eventhough they are can be seen in animal fats. (Shoji *et al*., 2005).

Nymphaea pubescens seed oil has high amount of oleic acid (37.85) and trace amount of linoleic acid (0.78%). Studies have shown that the presence of good amount of oleic in diet might serve to decrease the development of atherosclerosis. In addition it may also lower the level of cholesterol in serum, as well as promoting antioxidant defense. Even though oleic acid have been associated to an increase in the permeability of alveolar cells to solutes, as a result of an increase in intracellular calcium levels. The overall effect leads to change in membrane fluidity (Wang *et al*., 1994; Davidson *et al*., 2000; Vadaz, 2005).

Linoleic acid was the predominant fatty acids in the extracted oils samples. In *Nymphaea lotus* seed oil it was 13.01%, this was higher than palm oil (10.15%). Although, groundnut oil was reported to have higher (37.54) linoleic acid. Linoleic acid is important in production of some hormonal substance which may exert different functions including blood clotting and lipid levels. Most beauty products use linoleic acid as part of their ingredients (Shanks and Heise, 1993; Egmond *et al*., 1996). Linolenic acid was absent in the extracted oils but present in trace amount in groundnut oil

Total unsaturated fatty acid was observed to be higher when compared to the total saturated fatty acids in the samples except in *Nymphaea lotus* seed oil (table 4). The result conforms to the report that plant oils contains predominantly unsaturated fatty acids ranging between 73.94% of total lipid content (Wardlaw, 2003). Presence of high amount of unsaturated fatty acid than saturated acids could be of nutritional advantage.

The relationship between polyunsaturated fatty acid and saturated fatty acid is presented in Table 4. The relationship is represented as P/S and it is a very good indicator in understanding quality and nutritional value of some oils. Most often oils with P/S value greater than 1 might be of nutritional advantage. On the other hand oils with higher P/S value is an indication that lower lipids are deposited in the body (Lawton *et al.*, 2000). The recommended mean ratio of PUFA/SFA is 0.45 (Da Silva *et al*., 2002). It is worth to note that the P/S index of *Nymphaea lotus* seed oil and *Nymphaea pubescens* seed oil were found to be lower than in palm oil and groundnut oil.

CONCLUSION

Nymphaea lotus and *Nymphaea pubescens* seeds are good sources of oils. *Nymphaea pubescens* seed oil is similar to the common oils used for cooking whereas *Nymphaea lotus* seed oil is not suitable for human consumption due to its saturated nature. But it could be used in industries as raw material for cosmetics, candles and shoe polish due to its low iodine and saponification values.

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