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Physicochemical Properties and Fatty Acid Profiles of Crude Oil Extracts from Three Vegetable Seeds

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Abstract: Crude oils extracted from three vegetable seeds namely: soya beans (*Glycine max*), groundnut (*Arachis hypogaea*) and maize (*Zea mays)* purchased from a local market in Sagamu Ilisan, Ogun State were investigated. Extraction of the oils from the seeds was carried out by soxhlet method using petroleum ether as the extractant. The physio-chemical properties of the oils were determined using Gas Chromatography (GC) and other standard methods. The results of physical analysis showed that soy bean oil had the highest percentage of oil yield (14. 51%), followed by groundnut oil (10. 54%) and lastly maize (6. 63%). The refractive indexes of the oils are as follows: Soya bean oil (1.4662), groundnut (1.4622) and maize (1.4632). The chemical analysis showed that the saponification values were 228.19, 227.49 and 211.37 mg KOH/g and free fatty acid values were 6.85, 1.65 and 23.35 mgNaOH/g for soybean, groundnut and maize oils respectively. The acid values were 19.21, 4.63 and 65.50mg KOH/g and iodine values were 73.02, 38.65 and 47.25 for soybean, groundnut and maize oils respectively. Gas Chromatography analysis gave the following fatty acid profiles: oleic (26.2%), linoleic (5.5%), stearic (4.8%), myristic (1.5%) and lauric (1.25%) for groundnut oil; oleic (26.2%), linoleic (8.5%), stearic (5.6%) for soybean oil while corn oil contained stearic (3.8%) and oleic (4.6%). The study revealed that the three vegetable seeds are good sources of edible oils. Soya bean oil is considered to be the most suitable for food formulation as well as drying oil in pharmaceutical, paints, soap and perfume industries because of its higher level of unsaturation in the fatty acid contents.

Key words: Vegetable oils, fatty acid profiles, gas chromatography

INTRODUCTION

A wide variety of vegetable oils of varying quantity are available on the Nigerian markets.

Oils recovered from vegetable seeds or nuts by solvent extraction or mechanical pressing are termed 'crude vegetable oils' and they contains various classes of lipids. They consist primarily of neutral lipids which include tri-, di- and monoacylglycerols, free fatty acids and polar lipids such as phospholipids. They also contain a minor amount of unsaponifiable matter that includes phytosterols, tocopherols and hydrocarbons such as squalene (Gunstone, 2002).

Soybean is the dominant oilseed produced in the world, due to its favourable agronomic characteristics, its high-quality protein and its valuable edible oil. Soyabean yields two products-oil and meal-which represent approximately 18 and 79%, respectively of the dried bean. The production of soybeans and soybean oil is driven by the need for soy protein meal which is used extensively in commercial feeds for poultry, swine and cattle.

For groundnut, only about one half of the crop is crushed for oil and meal and the rest is consumed as nuts. Due to the high content of digestible protein and unsaturated oil in groundnuts and their exceptional roasted nutty flavour, they have substantial value as a nutritious and flavourful food commodity (Sanders, 2002). Seeds such as soyabeans and groundnut are used by animals to repair worn out tissues, build new cells and produce energy (Vickery and Vickery, 1979). Maize (corn) is grown primarily for cereal and the oil is a byproduct. Unlike most other vegetable oils, maize oil is obtained from seeds (kernels) that contain only 3-5% oil and about 60-75% of starch. Because of the low levels of oil in the kernels, corn kernel oil' is costly to produce (Moreau, 2002).

These vegetable seeds are also rich in thiamine, nicotinic acid, riboflavin and minerals (Gill and Vear, 1980). In addition, most vegetable oils find some oleochemical use. Thus oils from plant origins are also exploited commercially in soap manufacture, cosmetics and paints industry. They are also used for the

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production of biodiesel as the methyl esters (Duke, 1981). The demand of these esters as solvents and as biodiesel has increased considerably in recent times.
The aim of this study is to determine the physicochemical properties as well as the fatty acids profiles of crude oils extracted from groundnut, soyabean and maize seeds sold in the open market.

MATERIALS AND METHODS

Samples: Groundnut, soyabean and maize seeds were purchased from the open market in Ilisan-Remo, Ogun State, Nigeria. The seeds were sun dried and stored in polythene bags prior to analysis.

Oil extraction: The vegetable seeds were broken between rollers, deshelled and milled into powder. 100g of the ground seeds was extracted with petroleum ether (b.p. 40-60°C) using Soxhlet's apparatus. The extracts were concentrated on a rotator evaporator at 40°C leaving behind the crude vegetable oils.

Determination of the physicochemical properties of the crude oils
Colour: Colour measurement was done by visual comparison.

Acid value: 25ml of ethanol was added to 1g of each oil extract in a conical flask. This was titrated against 0.1MKOH solution using phenolphthalein as indicator.

Saponification value: 2g of each oil sample was hydrolyzed by adding 25ml of ethanolic solution of KOH and refluxing on a steam bath for 1hour with occasional shaking. While the solution was still hot, 3 drops of phenolphthalein indicator was added and the excess KOH solution was titrated against 0.5M HCl acid.

Percent free fatty acid: The percentage of free fatty acids as oleic acid, the number of milligrams of potassium hydroxide required to neutralize the fatty acids resulting from complete hydrolysis of one gram of oil, was determined by the method of Parquot and Hauffeine (1987).

Refractive index: The refractive indices, η/D^{30} (RI), of the crude oils samples were measured using a refractometer connected to a thermostatically controlled water bath that maintained the temperature of the refractometer at 30±0.1°C.

Iodine Value (IV): A mathematical relationship between refractive index and iodine value (IV) has been described by Perkins (1995) as η/D^{30} (RI) = 1.45765+0.0001164 IV
The reverse relationship was used to calculate the iodine value of crude soybean oil since the RI is known as follows:

$$IV = \frac{RI - 1.45765}{0.0001164}$$

Oil content: The weight of oil extracted was determined by calculating the lipid content. Result was expressed as the percentage of lipids in the dry matter of seed powder.

Preparation of Fatty Acid Methyl Esters (FAME): 1g of each crude oil sample and six fatty acid standards were placed in various test-tubes. 5ml of 0.5M methanolic NaOH solution was then added and allowed to heat on a steam bath for 5 minutes until they globalized into solution. 10ml of BF_3 in methanol was added to each sample in the test tube and the mixture was again boiled for 2 minutes. Each of the mixture containing the Fatty Acid Methyl Esters (FAME) was extracted with 30ml petroleum ether (b.p.40-60°C) and 20ml saturated NaCl solution in a separating funnel. The lower layer of aqueous methanol was allowed to separate, drained off and discarded, while the upper petroleum ether layer was poured into a test tube and made up to 2ml.

Determination of fatty acid profiles: The acid esters present in the crude oils were modified to Fatty Acid Methyl Esters (FAME) by transmethylation as described above and these were determined by Gas Chromatograph with Flame Ionization Detector (GC/FID). The FAME extracted with petroleum ether was concentrated under nitrogen gas before injecting to the GC. The column temperature was 185°C, the flow rate of the carrier nitrogen gas was maintained at 2.8kg/cm and chart speed at 1cm/min. Fatty acids composition of the crude seed oils were obtained by comparison with retention times of the standard mixture FAMEs and were expressed as percentage.

RESULTS AND DISCUSSION

The studied physicochemical properties of the crude seed oils are presented in Table 1.
The colour of the oils ranged from light yellow to golden yellow. All are odourless liquids at room temperature. The oil content is of great significance in the determination of the produce for processing. The percentage oil yield in all the oils ranged between 6.63 and 14.51% which fall below the range 15-20% estimated by Anthony and Offiong (1998). The oil yield was highest for soyabean oil (14.51%), followed by groundnut oil (10.54%) and the lowest was obtained from maize (6.63%). This indicates that soyabean is best suitable for industrial production of vegetable oil.
The Refractive Index (RI) is a parameter that relates to molecular weight, fatty acid chain length, degree of unsaturation and degree of conjugation (Gunstone, 2002). The refractive index of the oils analyzed ranged from 1.4622 for groundnut oil to 1.4662 for soyabean oil. These values fall within the range for many edible oils (Egbekun and Ehieze, 1997; Ilesanmi *et al*., 1990).

Table 1: Physicochemical properties of oils

Seed oil	Colour	Oil yield (%)	RI	AV (mgKOH/g)	FFA (%)	IV[a]	SV (mgKOH/g)
Soyabean	Golden yellow	14.51	1.4662	19.21	9.66	73.02	228.19
Groundnut	Light yellow	10.54	1.4622	4.63	2.33	38.65	227.49
Maize	Turbid yellow	6.63	1.4632	65.50	32.95	47.25	211.37

(IV)[a] Iodine value by calculation as described by Perkins (1995), RI: Refractive index, AV: Acid value, IV: Iodine value, SV: Saponification Value

Saponification value is used in checking adulteration. The saponification values recorded for the oils are shown in Table 1. These ranged from 221.37mg/KOH in corn oil to 228.19mg/KOH in soyabean oil. The relatively high values showed that the three oils have potential for use in the soap industry (Amoo *et al*., 2004).

The acid and Free Fatty Acid (FFA) values are used to indicate the level of rancidity of oils (edibility) and their suitability for use in the paint industry. The acid value ranged from 4.63mg/KOH for groundnut oil to 65.50mg/KOH for corn oil. The percent FFA values for the oils ranged from 2.33% for groundnut oil to 32.95% for corn oil. The allowable limit for FFA for edible oils is 1.0-3.0% (Paul and Mittal, 1997). The lower the FFA level, the better the quality of the oil for human consumption. It then follows that groundnut oil is the most edible oil among the three oils investigated. The high level of FFA obtained for the corn oil may be due to increased growth of microorganisms on the corn seeds which caused hydrolysis to take place in the presence of moisture (Hiditch and Williams, 1975; Bobbio and Bobbio, 2001).

The Iodine Value (IV) is a measure of the relative degree of unsaturation in oils. The greater the iodine value, the more the unsaturation and the higher the susceptibility to oxidation. Our results show that soyabean oil had the highest value for IV (73.02) hence the most unsaturated compared to groundnut oil which had the least value for IV (38.65), thus the most saturated.

The results of the determination of fatty acids composition are shown in Table 2 and Fig. 1. The fatty acid composition which is the relative proportion of different fatty acids in the mixture of triglycerides is a characteristic to each vegetable oil. The physiological effects of vegetable oil are also based on their fatty acid composition. The primary concerns with fatty acid consumption relate to two chronic Diseases-Coronary Heart Disease (CHD) and cancer. Both soyabean and groundnut oils have high content of Monounsaturated Fatty Acid (MUFA) oleic acid, 29.2 and 26.2% respectively. From nutritional viewpoint, the presence of oleic acid in diet is very useful. It has been shown that oleic acid is effective in lowering total cholesterol (10%) and Low-Density Lipoprotein (LDL) cholesterol content in blood (Grundy, 1999; Dennys *et al*., 2006). Unsaturated (especially polyunsaturated) fatty acids are also more prone to oxidation. In contrast, dietary intake of certain unsaturated fatty acids, in particular conjugated linoleic and fat-soluble antioxidants (e.g., α-tocopherol, carotenoids) has been linked to potential

Table 2: Percentage composition of fatty acids in oils

FA (%)	Form	SO	GO	MO
Lauric	C12:0	0.04	1.25	0.25
Myristic	C14:0	-	1.5	-
Palmitic	C16:0	-	0.02	-
Stearic	C18:0	5.6	4.8	3.8
Oleic	C18:1	29.2	26.2	4.6
Linoleic	C18:2	8.5	5.5	-
Total SFA		5.64	7.57	8.65
Total UFA		37.7	31.7	4.6

SFA: Saturated fatty acid, UFA: Unsaturated fatty acid, FA: Fatty acid, SBO: Soyabean oil, GO: Groundnut oil, MO: Maize ooil

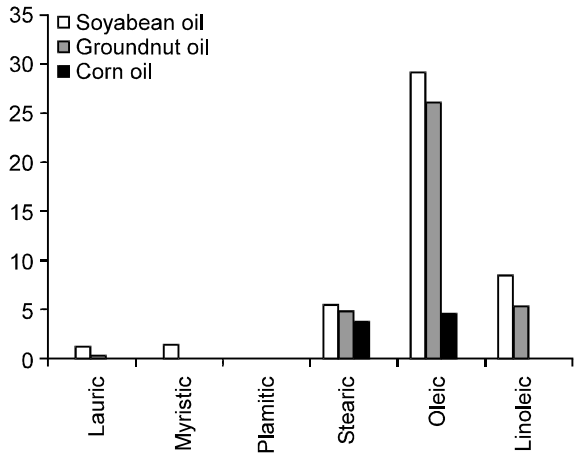

Fig. 1: Fatty acids profile of seed oils

health benefits (Gillian *et al*., 2008). The levels of linoleic acid in the oils studied are low; 8.5% in soyabean and 5.5% in groundnut oil but undetected in corn oil. This result confirm the findings of Hiditch and Williams (1975) and Belitz and Grosch (1987) who reported that Nigerian and West African groundnut have two times more oleic acid than linoleic acid. Thus soyabean and groundnut oils are of a high nutritive value. Groundnut oil contains a high proportion of unsaturated fatty acids, in particular oleic and linoleic). Fatty acid composition values for peanut oil have been reported to vary widely (Worthington *et al*., 1972).

The total Unsaturated Fatty Acid (UFA) is seen to be much higher than the total Saturated Fatty Acids (SFA) in soyabean and groundnut oils. This agrees with the report of Wardlaw (2003) that plant oils contain mostly UFA ranging from 73-94% of total lipids. Saturated fatty acids with 12, 14 and 16 carbon atoms are known to be the primary contributors to elevated blood cholesterol

and so contribute to cardiovascular diseases of these the C14 myristic acid is found to be the main culprit (Warldlaw, 2003; Grundy, 1999). The important properties of corn oil include its pleasing flavour, its high levels of polyunsaturated (essential) fatty acids and its low levels of saturated fatty acids (<15%) and of linolenic acid (Anonymous, 1996).

The appreciably high levels of unsaturated fatty acids in both soyabean and groundnut oils showed that these oils can be classified as non-drying. This non-drying attributes qualifies the oils for use in the paint industry (Dosunmu and Ochu, 1995).

Conclusion: The results of this study have shown that from nutritional viewpoint soyabean and groundnut oils appear to have a beneficial effect on health. Soyabean could be considered to be a good source of oil suitable for food formulation as well as pharmaceutical, paint, soap and perfume industries due to its high level of unsaturation in the fatty acid content compared to the other seed oils.

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REFERENCES

Amoo, I.A., A.F. Eleyinmi, N.A.O. Ifelaboye and S.S. Akaja, 2004. Characteristic of oil extracted from gourd (*Cucurbita maxima*) seed. Fd, Agric. Env., 2: 38-39.

Anonymous, 1996. Corn Oil, Manufacturing, Properties, Uses and Analysis of Corn Oil, Corn Refiners Association, St. Louis, Pages: 24.

Anthony, O.U. and U.E. Offiong, 1998. Nutritional Quality of Plant Foods. Ambile Press, Benin City, pp: 52-65.

Belitz, D. and W. Grosch, 1987. Food Chemistry, Springer Werlag, Berlin, pp: 472-482.

Bobbio, P.A. and F.O. Bobbio, 2001. Quimica do Processamento de Alimentos, 3rd Edn., Varela, Sao Paulo.

Dennys, E.C.C., G.V.C. Andre, C.G.P. Maria do, D.S. Sergio Matta, T.C.S. Marco and M.B.C. Neuza, 2006. Lipid profile of rats fed high-fat diets based on flaxseed, peanut, trout, or chicken skin. Nutrition, 22: 197-205.

Dosunmu, M.I. and C. Ochu, 1995. Physicochemical Properties and Fatty acid Composition of Lipids extracted from Nigerian fruits and seeds. Global J. Pure APPL. Sci., 1: 45-47.

Duke, J.A., 1981. Handbook of Legumes of World Economic Importance. Plenum Press. New York, pp: 18-22.

Egbekun, M.K. and M.U. Ehieze, 1997. Proximate Composition and Functional Properties of full fat and defatted Seeds. Macmillan Publishers. London, 51: 35-41.

Gill, N.T. and K.C. Vear, 1980. Agricultural Biology-Dicotyledonous Crops, 3rd ed. K.C Vear and D.J. Barnard Garden City Press, Great Britain, pp: 190-191.

Gillian, B., H.N. Jacob, S. Tina, S. Chris, D.E. Mick, S. Roy and L. Carlo, 2008. Fatty acid and fat-soluble antioxidant concentrations in milk from high- and low-input conventional and organic systems: seasonal variation. J. Sci. Food Agric., 88: 1431-1441.

Grundy, S.M., 1999. Monounsaturated Fatty acids and Cholesterol Metabolism. Implication for dietary recommendation. J. Nutr., 119: 529-533.

Gunstone, F., 2002. Vegetable Oils in Food Technology: Composition, Properties and Uses. Blackwell Publishing Ltd., CRC Press.

Hiditch, T.P. and P.W. Williams, 1975. J. Am. Oil Chem. Soc., 42: 745-745.

Ilesanmi, J., B.A.O. Okusanya and S. Tanko, 1990. Characterization of oil extracts from Vegetable Seeds. National Conference on Application of Science for National Development. Mubi Press. Niger State, Nigeria, pp: 717-729.

Moreau, R.A., 2002. Corn oil In: Vegetable Oils in Food Technology: Composition, Properties and Uses, Gunstone, F. (Ed.), Blackwell Publishing Ltd. CRC Press, pp: 293-311.

Paquot, C. and A. Hauffeine, 1987. Standard Methods for the Analysis of oils, fats and derivatives. 7th Edn., IUPAC. Blackwell Science Publication, Oxford.

Paul, S. and G.S. Mittal, 1997. Regulating the use of degraded oil/fat in deep fat/oil food frying. Critical Rev. Food Sci. Nutr., 37: 635-662.

Perkins, E.G., 1995 Physical properties of soybeans, in Practical Handbook of Soybean Processing and Utilization Erickson, D.R. (Ed.), AOCS Press, Champaign, IL, pp: 29-38.

Sanders, T.H., 2002. Groundnut (peanut) oil In: Vegetable Oils in Food Technology: Composition, Properties and Uses Gunstone, F. (Ed.), Blackwell Publishing Ltd., CRC Press, pp: 246-258.

Vickery, M. and B. Vickery, 1979. Plant Products of Tropical Africa. Macmillan Press, New York, pp: 1-31.

Wardlaw, G.M., 2003. Contemporary Nutrition. 5th Edn., Mc Graw Hill. Higher Education, New York, pp: 143-159.

Worthington, R.E., R.O. Hammons and J.R. Allison, 1972. Varietal differences and seasonal effects on fatty acid composition and stability of oil from 82 peanut genotypes. J. Agric. Food Chem., 20: 727-730.