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Chemical composition of selected Nigerian oil seeds and physicochemical properties of the oil extracts

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Abstract

Proximate composition, energy content and mineral concentrations of oil seeds used in the preparation of Nigerian diets were investigated. The paper also reports the physicochemical characteristics of the oil extracts from the seeds. Moisture content (on dry weight basis) was highest (23.13±0.44%) in coconut seeds (CNS), followed by palm kernel seeds (PKS) (14.26±0.35%) but was lowest (4.12±0.95%) in melon seeds (MS). Ash was highest (3.20±0.40%) in castor seeds (CS) followed by groundnut seeds (GNS) with a value of 2.77±0.65% and was lowest (0.43±0.32%) in CNS. Protein ranged from 6.94±0.10% in PKS to 26.5±0.27% in GNS. Dikanut seed (DNS) had the highest crude fat of 62.80±2.41%, followed by CS (57.33±1.63%), and the lowest value of 40.83±0.50% in GNS. Values for MS, oil bean seeds (OBS) and PKS did not differ significantly. Total carbohydrates were generally low in all the seeds and ranged from 12.5±0.94% in OBS to 26.9±1.01% in CNS. The energy content, in kilocalories, per 100g sample, was highest in DNS (688) followed by MS (643) and was lowest in CNS (516). The oil seeds were found to be good sources of minerals. Copper, potassium, sodium and sulphate were highest in OBS, chloride was highest in PKS; zinc and phosphate were highest in CS while iron ranged from 0.130±0.001 in GNS to 0.489±0.00l mg/100 g in CNS. The physical properties of the oil extracts showed the state to be liquid at room temperature (29±1 °C) and the colour to be pale-yellow or golden-yellow, in general. Melting point was highest in MS oil and lowest in PKS oil while setting point was highest in DNS oil, followed by CNS oil and lowest in MS oil (4.67±0.3 °C). Specific gravity ranged from 0.87 in PKS oil to 0.98 in MS oil. Among chemical properties of the oil extracts, acid value, saponification number, iodine number, percent free fatty acid, peroxide value and unsaponifiable matter were, respectively, highest in CS, MS, PKS, CS, DNS/CNS and GNS oils while the lowest values were, respectively, obtained in OBS, CS, GNS, OBS, PKS and OBS oils. It can be inferred that the oil seeds investigated are good sources of crude fat, crude protein, ash, energy and minerals. The oil extracts exhibited good physicochemical properties and could be useful as edible oils and for industrial applications.

1. Introduction

Oil seeds used in the preparation of diets abound in Nigeria. In Nigeria, castor seeds (CS), coconut seeds (CNS), dikanut seeds (DNS), groundnut seeds (GNS), melon seeds (MS), oil bean seeds (OBS) and palm kernel seeds (PKS) are used in the preparation of diets.

CS (*Ricinus communis*) are not edible in the raw state due to high level of toxic factors such as ricin and haemaglutinins (Jenkins, 1963), and trypsin inhibitors (Uzogara, Udoh, & Eka, 1987). The seeds are fermented and detoxified to obtain a seasoning agent (Uzogara, Agu, & Uzogara, 1990), called ogiri-isi by the Ibos of the southeast zone of Nigeria; they are used as a condiment in soups, salads and stews for rice and yam meals. The condiment has been reported to enhance food flavours, thereby making the food palatable and appetizing (Onyeike & Onwuka, 1999).

The coconut (*Cocos nucifera*) seed is eaten raw and at times smoked and eaten. After grating the edible part, water is added and it is squeezed. This is followed by sieving and the liquid portion is used as such in cooking coconut rice. Dikanut (*Irvin gia gabonensis*) belongs to the Simarubaceae family and is commonly known as African mango (Eka, 1980). The fruit is yellow when ripe and the pulp is edible, but has a turpentine flavour. The seed ranks as an oil seed (Abaelu & Akinrimisi, 1980) and is used as a popular soup thickener in Nigeria (Onyeike, Olungwe, & Uwakwe. 1995).

Groundnut (*Arachis hypogea*) is a leguminous plant grown mainly for its seeds. As reported by Onwueme

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(1979), groundnut seeds are eaten raw, roasted and boiled and can be made into a paste used in soups and stew. Melon (*Citrullus vulgaris*) seeds are ground and used in the preparation of stew for rice and also the popular Nigerian egusi soup, used with garri flour, reconstituted in hot water into a meal/fufu. The egusi soup is also used in a meal of soaked fermented cassava called water fufu or loiloi by the Ibos of the southeast zone. Melon seeds are boiled for about 3 h, dehulled, washed, wrapped tightly in blanched banana leaves, left to ferment for about 5 days at room temperature (29±1 °C), ground into a paste with ash from burnt oil palm shafts, which is added to impart a grey colour to the paste, distributed in small portions into leaves, wrapped up and left near the fire place to develop the characteristic aroma of a food condiment which the Ibo people of Nigeria call ogiri-egusi (Uzogara et al., 1990). The condiment is used as a flavouring agent in stews, soups and sauces.

Nigeria is divided into six geopolitical zones, namely northeast, northwest, northcentral, southeast, southwest and southsouth. The African oil bean seed (*Pentaclethra macrophylla*) is fermented and consumed especially in the southeast, southwest and southsouth zones of Nigeria. It is consumed alone, mixed with other food ingredients or as a condiment in soups and salads (Achinewhu, 1986). The seeds are processed and fermented into a condiment which the Ibo people of the southeast zone of Nigeria call 'ugba'; the latter is consumed either as snacks, salads or as a soup flavour (Uzogara et al., 1990). Unfermented seeds are bitter to taste and contain a toxic alkaloid, paucine, (Mears & Mabry, 1971), and a growth depressant, caffeoyl-putrescine (Mbadiwe, 1979); fermentation renders the seed nutritious and non-toxic (Uzogara et al., 1990).

The palm kernel (*Elaeis guinensis*) is edible and is from the oil palm. It is surrounded by an edible reddish oily pulp. The palm kernel seed is eaten alone or together with garri. It is also eaten with roasted or cooked corn (maize).

There is inadequate information about the nutrient status of these oil seeds, and the physicochemical properties of the oil extracts. The present study therefore reports the proximate composition, energy value and mineral concentrations of these oil seeds, used in the preparation of Nigerian diets, and the physicochemical characteristics of the oils extracted from these seeds.

2. Materials and methods

2.1. Samples

All the seeds (castor, coconut, dikanut, groundnut, melon, oil bean and palm kernel), each lot 800 g, were purchased from Rumuwoji village market, Port Harcourt. The samples were wrapped in black cellophane bags, sealed in air-tight containers and stored in a refrigerator (4 °C) for 2 days prior to processing for analyses.

2.2. Sample preparation

Five hundred grammes of each of the seven samples were ground into a paste using a mains-operated food grinder (Model MX 491 N, National). Each paste was wrapped in a black polyethylene bag and stored in an air-tight sample bottle in a refrigerator (4 °C) for 3 days before analyses.

2.3. Analyses of samples

The recommended methods of the Association of Official Analytical Chemists (AOAC, 1984) were adopted to determine the levels of moisture, ash, crude protein and crude fat. Moisture content was determined by heating 2.0 g of each sample to a constant weight in a crucible placed in an oven (PIus 11 Sanyo, Gallenkamp PLC, UK), maintained at 105 °C for 3.5 h. Ash was determined by the incineration of 1.0-g samples placed in a muffle furnace (LMF4 from Carbolite, Bamford, Sheffield UK), maintained at 550 °C for 5 h. Crude protein (% total nitrogen × 5.30) was determined by the Kjeldahl method (Kjeldahl, 1883), using 1.0-g samples; crude fat was obtained by exhaustively extracting 5.0 g of each sample in a Soxhlet apparatus using petroleum ether (boiling point range 40–60 °C) as the extractant (Onyeike & Onwuka, 1999). Total carbohydrate was obtained by difference; the energy content was calculated by multiplying the mean values of crude protein, crude fat and total carbohydrate by Atwater factors of 4,9 and 4, respectively, taking the sum of the products and expressing the result in kilocalories per 100-g sample as reported by Onyeike et al. (1995). The minerals, lead, iron, copper and zinc, were determined by atomic absorption spectrophotometry, as described by Agte, Gokhale, Paknikar, and Chiplonkar (1995) with a slight modification. One-gramme samples, in triplicate, were dry-ashed in a muffle furnace at 550 °C for 5 h until a white residue of constant weight was obtained. The minerals were extracted from ash by adding 20.0 ml of 2.5% HCI, heated in a steam bath to reduce the volume to about 7.0 ml, and this was transferred quantitatively to a 50 ml volumetric flask. It was diluted to volume (50 ml) with deionised water, stored in clean polyethylene bottles and mineral contents determined using an atomic absorption spectrophotometer (Perkin-Elmer, Model 2380, USA). These bottles and flasks were rinsed in dilute hydrochloric acid (0.10 M HC1) to arrest microbial action which may affect the concentrations of the anions and cations in the samples. The instrument was calibrated with standard solutions containing known amounts of the minerals being determined, using analytical grade reagents; results are expressed in mg/100-g sample. Sodium and potassium were determined using flame photometry (Chapman & Pratt, 1961). The instrument with voltage 230/115 V and power 13 VA, made in the United Kingdom in 1995 by JENWAY Limited, Dunmow Essex, UK, is a low-temperature direct-reading digital single channel emission flame photometer (Model PFP7), designed for routine determination of sodium and potassium with additional filters available for the determination of lithium, calcium and barium. Phosphate (PO_4^{3-}) was determined by the molybdenum blue method using stannous chloride as the reducing agent; the absorbance was measured at 700 nm (Allen, Grimshaw, Parkinson, & Quarmby, 1974). Sulphate (SO_4^{2-}) was measured by the turbidimetric method of Butters and Chenery (1959), involving the precipitation of barium sulphate; the turbidity was measured at 470 nm. The method for the determination of chloride (Cl^-) in the sample was based on Mohr's procedure, as outlined by Bowley (1979). Here, 25 ml of the test solution (sample extract), and a blank for comparison, were each titrated with a standard solution of silver nitrate (0.10 M $AgNO_3$) as reagent to a brick-red end point, a precipitation process in titrimetric analysis known as the Argentimetric method. In this method, potassium chromate solution was used as an indicator and the % chloride was calculated by multiplying the volume (v) of $AgNO_3$ reagent, required for the chloride reaction, by a factor of 0.00568; that is, % $Cl^- = 0.00568v$. Oils from each paste were extracted exhaustively in a Soxhlet apparatus using petroleum ether (b.p. 40–60 °C) as the extractant, and then subjected to physical and chemical characterization. Colour and the state of the oils at room temperature were noted by visual inspection, while melting point, setting point and density were determined by AOAC (1984). The acid and peroxide values were determined by the method of Devine and Williams (1961). The saponification number was determined by the method of Williams (1950) while the iodine value was obtained by the method of Strong and Kock (1974). The percentage of free fatty acids as oleic acid was determined by the method of Devine and Williams (1961). Unsaponifiable matter was obtained by the procedure of AOCS (1973).

2.4. Statistical analyses

Data were analyzed by one way analysis of variance (ANOVA). Means were compared by the Duncan's (1955) multiple range test; significance was accepted at 5% level ($P \leqslant 0.05$).

3. Results and discussion

The proximate compositions of the oil seeds analysed are presented in Table 1. Moisture content was highest (23.13±0.44%) in coconut seeds (CNS), followed by palm kernel seeds (PKS) having a value of 14.26±0.35% and was lowest (4.12±0.95%) in melon seeds (MS), though the value for MS did not differ significantly than those of groundunt seeds (GNS) and dikanut seeds (DNS) at the 5% level. MS, GNS and DNS with low moisture levels could store for a longer time without spoilage than PKS and CNS, since a higher moisture content could lead to food spoilage through increasing microbial action (Onyeike et al., 1995). Ash content was highest (3.20±0.40%) in castor seeds (CS) but the value did not differ significantly from those of oil bean seeds (OBS) and GNS and was lowest (0.43±0.32%) in CNS. Crude protein was highest (26.5±0.27%) in GNS followed by MS (25.4±0.27%) and was lowest in PKS (6.94±0.10%). The concentrations of protein in the seeds analyzed suggest that GNS, MS and OBS can contribute to the daily protein need of 23.6 g for adults, as recommended by the National Research Council (1974). Crude fat ranged from 40.83±0.50% in GNS to 62.80±2.41% in DNS. Values for MS, OBS and PKS were not different at the 5% level; nor were those for GNS and CNS, but each was significantly lower than that of CS *and* DNS. These

Table 1
Proximate composition (%) of selected oil seeds use in the preparation of Nigerian diets[a]

Constituents	Castor seeds	Coconut seeds	Dikanut seeds	Groundnut seeds	Melon seeds	Oil bean seeds	Palm kernal seeds
Moisture	8.83±2.84c,d	23.13±0.44a	5.93±0.32d,e	4.45±0.32e	4.12±0.95e	10.86±0.51c	14.26±0.35b
Dry matter	91.07±2.82b	76.87±0.40d	94.07±0.37a,b	95.55±0.40a	95.88±0.90a	89.14±0.50b,c	85.74±0.36c
Ash	3.20±0.40a	0.43±0.32c	0.63±0.31b,c	2.77±0.65a	1.50±0.62b	2.50±0.36a	1.50±0.53b
Crude protein	14.4±0.44c	7.58±0.26e	8.71±0.07d	26.5±0.27a	25.4±0.27a	22.1±0.30b	6.94±0.10f
Crude fat	57.33±1.63b	42.00±2.21d	62.80±2.41a	40.83±0.50d	53.04±1.62c	52.07±1.45c	54.18±1.88c
Total Carbohydrate	16.2±1.06c	26.9±1.01a	21.93±1.18b	25.4±0.59a	15.9±0.44c	12.5±0.94d	23.1±0.89b
Calorific value (kcal/100 g sample)	639	516	688	575	643	607	608

[a] Values are means±standard deviations of triplicate determinations. Values in the same row sharing the same letters are not significantly different at the 5% level.

values indicate that all the seeds investigated are good oil seeds, especially when compared with soybeans with a value of 19% (Oyenuga, 1968) and African yam bean with a fat content of 2.50% (Edem, Amugo, & Eka, 1990). These seeds are therefore good sources of edible oils that can be used in cooking and in the manufacture of soap as they congeal when exposed to air, probably due to the presence of saturated fatty acids. The oils can also find use in cosmetic industries and in the manufacture of margarine. Total carbohydrate ranged from 12.5±0.94% in OBS to 26.9±1.01% in CNS but was generally low, due to the high levels of crude fat and crude protein. The calorific value (kcal/100-g sample) was highest in DNS (688) followed by MS (643); it was lowest in CNS (516). The energy contents (kcal/100-g sample) of 639, 516, 688, 575, 643, 607 and 608 for CS, CNS, DNS, GNS, MS, OBS and PKS, respctively which generally differed significantly at 5% level showed that 407, 504, 378, 452, 405, 428 and 428 g of these samples would, respectively, provide 2600 kilocalories. This energy value (2600 kcal) falls within the daily energy requirement of 2500–3000 kcal, reported for adults (Bingham, 1978). Due to poor resource management in Nigeria, an inadequate supply of protein and energy-giving foods, a harsh economic situation and the attendant low socioeconomic status, the frequency of consumption of these oil seeds either alone or as condiments in foods is increasing. It can be seen, from these values, that feeding of these samples at only 160 g per day would give energy values (kilocalories) of 1022, 825, 1100, 921, 1000, 971 and 973 for CS, CNS, DNS, GNS, MS, OBS and PKS, respectively. These energy values would meet the Food and Agriculture Organization's (FAO, 1973) recommended value of 800 to 1200 kcal if the samples were consumed at 160 g per day. Individuals requiring oil-free or low oil diets should be mindful of diets prepared using the seeds investigated in this study. However, the speculation that the high lipid levels in all the samples studied may give rise to hyperlipidaemia and the associated coronary heart diseases may not be of concern due to the fact that the amount consumed per day is not high, but adequate to supply the daily energy need of the individual.

Mineral concentrations of the oil seeds are shown in Table 2. Significant variations occurred in mineral concentrations among the samples analyzed. Lead was highest in MS (0.076±0.00 mg/100 g), followed by GNS (0.066±0.00 1 mg/100 g) and was lowest in CNS (0.002±0.001 mg/100 g). Iron ranged from 0.130±0.001 mg/100 g in GNS to 0.489±0.00 1 mg/100 g in CNS. OBS had the highest concentrations of copper, potassium, sodium and sulphate. Zinc and phosphate were

Table 2
Mineral concentrations (mg/100g) of selected oil seeds used in the prepatation of Nigerian diets[a]

Mineral	Concentrations						
	Castor seeds	Coconut seeds	Dikanut seeds	Groundnut seeds	Melon seeds	Oil bean seeds	Palm kernel seeds
Lead	0.004±0.01 3e	0.002±0.001e	0.054±0.001e	0.066±0.001b	0.076±0.00a	0.055±0.001c	0.044±0.001d
Iron	0.293±0.001e	0.489±0.001a	0.315±0.00d	0.130±0.001g	0.352±0.001b	0.328±0.001c	0.132±0.00f
Copper	0.151±0.001e	0.200±0.001b	0.139±0.00f	0.126±0.001g	0.158±0.001d	0.233±0.00a	0.162±0.001c
Zinc	1.20±0.001a	0.223±0.00g	0.285±0.00f	0.574±0.001c	0.474±0.001d	0.728±0.00b	0.320±0.001e
Potassium	15.5±0.066e	15.4±0.001f	15.6±0.011d	16.2±0.01c	16.5±0.00b	16.8±0.00a	13.4±0.001g
Sodium	2.30±0.066c	2.53±0.001b	2.02±0.066d	1.90±0.066e	1.2±0.02b	2.65±0.001a	1.47±0.001f
Phosphate	53.1±0.036a	11.8±0.003g	16.8±0.002f	24.7±0.010d	42.61±0.02b	20.0±0.00e	29.2±0.010c
Sulphate	0.018±0.001c	0.004±0.006d	0.008±0.008d	0.025±0.037b	0.018±0.002c	0.105±0.003a	0.018±0.001c,d
Chloride	80.4±1.02f	272±3.58b	259±1.77c	70.9±1.00g	197±1.77d	88.9±0.51e	284±1.03a

[a] Values are means±standard deviations of triplicate determinations. Values in the same row having the same letters are not significantly different at the 5% level.

Table 3
Physical properties of oil extracts from selected oil seeds used in the preparation of Nigerian diets[a]

Property	Castor seeds	Coconut seeds	Dikanut seeds	Groundnut seeds	Melon seeds	Oil bean seeds	Palm kernel seeds
State at RT	Liquid	Liquid	Semi-liquid	Liquid	Liquid	Liquid	Liquid
Colour	Golden yellow	Pale yellow	Golden yellow	Pale yellow	Golden yellow	Deep brown	Pale yellow
Specific gravity[b]	0.93	0.89	0.89	0.89	0.98	0.94	0.87
Melting point (°C)	62.3±1.2b	59.7±1.5b,c	56.0±2.00c,d	41.7±1.5e	72.0±2.6a	53.0±1.7d	34.0±3.5f
Setting point (°C)	10.0±0.2d	22.7±2.1b	26.3±1.5a	8.67±0.6d	4.67±0.3e	10.0±0.4d	16.0±1.1c

[a] Values are means±standard deviations of triplicate determinations. Means in the same row having the same letters are not significantly different at the 5% level. RT = room temperature (29±1 °C).

[b] Values for specific gravity are means of duplicate determinations.

highest in CS while chloride was highest in PKS (284±1.03 mg/100 g) and lowest in GNS (70.9±1.00 mg/100 g). These oil seeds are, in general, good sources of minerals, especially iron, copper, zinc, potassium, sodium, phosphate and chloride, and are therefore recommended for use in the preparation of diets of individuals with low levels of these cations and anions.

The physical properties of oil extracts from the oil seeds investigated are shown in Table 3. The colour was either golden yellow or pale yellow. The state at room temperature (29.0± 1 °C) was generally liquid. The density of oil relative to that of an equal volume of water (specific gravity) ranged from 0.87 in PKS oil to 0.98 in MS oil. These values are within the range of specific gravities reported for other fats and waxes (Hilditch & Riley, 1964). Melting point was highest in MS oil (72.0±2.6 °C), followed by CS oil (62.3°±1 .2 °C) and was lowest in PKS oil (34.0±3.5 °C). Each of the oil extracts had a melting point that was significantly ($P<0.05$) higher than that of rubber seed oil (2.7 °C) reported by Eka (1977). Oil extracts of MS, CS, CNS and DNS are thought to have higher amounts of saturated fatty acids but lower proportions of unsaturated fatty acids than those of OBS, GNS and PKS, since melting point decreases with increase in the degree of unsaturation. The lower melting point oils may therefore be useful in the manufacture of soft and easy-to-digest margarine and have been shown to be valuable in the manufacture of oil creams (British Standard, 1958). It can be inferred from the report of Peters (1956) that higher melting point oils from MS, CS and CNS, among others, would be valuable in the manufacture of confections. The setting point was highest in DNS oil (26.3±1.5 °C) and lowest in MS oil (4.67±0.3 °C).

The results of some chemical properties of the oil extracts of the oil seeds analyzed are presented in Table 4. The total acidity, expressed as acid value, was highest in DNS oil, followed by PKS oil and was lowest in OBS oil. OBS and GNS oils, which have relatively low acid values compared to MS, CNS, PKS and DNS oils would be most suitable for use in industrial manufacture of soap (Devine & Williams, 1961). GNS oil, which has been shown to have a polyunsaturated: saturated acid ratio of 2:1 and thus widely employed in cooking, has been reported to be useful in industries that manufacture margarine, mayonnaise, salad oils and cosmetics (Weiss, 1983). A previous report by Ekpa and Ekpe (1995) has shown that, unlike free fatty acid content, which is a measure of free fatty acid present in a fat or oil, acid value is a measure of total acidity of the lipid, involving contributions from all the constituent fatty acids that make up the glyceride molecule. It was further shown that better information on the acidity of glycerides should be obtained from the acid value, which takes into account the contribution of all the constituent fatty acids in the oil or fat, and that this parameter is the preferred quality control parameter used by paint manufacturers to monitor the concentrations of acids in resins (Ekpa & Ekpe, 1995). The percentage free fatty acid (% FFA) was highest in CS oil (3.64±0.22%), followed by DNS oil (1.19±0.07%) and was lowest in OBS oil (0.37±0.10%); the latter did not differ significantly from values for GNS MS, PKS and CNS oils. Each of the oils had a free fatty acid concentration below the maximum limit of 5.0% reported for high-grade Nigerian palm oil (NIFOR, 1989). The nutritional value of a fat depends, in some respects, on the amount of free fatty acids (e.g. butyric acid in butter) which develop. In the tropics, where vegetable oils are the most common dietary lipid, it has been shown that it is desirable to ensure that the free fatty acid content of cooking oil lies within limits of 0.0–3.0% (Bassir, 1971). The low levels of % FFA, in all the oils investigated, indicate that the oils are good edible oils that may store for a long time without spoilage via oxidative rancidity. The low free fatty acid values of *Telfaria occidentalis* (1.10±0.2), *Chryosophyllum albidum* (1.81 ±0.1) and *Cola rostrata* (5.0±0.20) seed oils have been reported to support the view that these oils are edible oils and could have long shelf lives (Dosunmu & Ochu, 1995).

The peroxide values of 40.0±4.0 in CNS oil and 40.0±3.0 in DNS oil did not differ but each was significantly higher than all others. No significant difference was obtained in the peroxide values of oils from CS, GNS, MS, OBS and PKS at the 95% confidence

Table 4
Chemical properties of oil extracts from selected oil seeds used in the preparation of Nigerian diets[a]

Parameter	Castor seeds	Coconut seeds	Dikanut seeds	Groundnut seeds	Melon seeds	Oil bean seeds	Palm kernel seeds
Acid value (mg NaOH/g oil)	15±1.12d	12.2±1.16c	24.7±2.97a	2.77±0.71e	11.4±1.41c	2.74±0.12e	16.6±2.53b
Saponification number (mg KOH/g oil)	137±2.80g	338±4.29f	701±2.80d	362±2.78e	979±2.80a	762±4.28b	732±2.80c
Iodine value mg/100 g	20.0±1.54b	17.6±1.86b	21.5±3.46b	11.2±1.73c	19.2±2.60b	18.7±1.51b	33.3±2.48a
% FFA as oleic acid	3.64±0.22a	0.85±0.59b,c	1.19±0.07b	0.44±0.14c	0.52±0.09c	0.37±0.10c	0.57±0.15c
Peroxide value (mg/g oil)	22.7±1.15b	40.0±4.00a	40.0±3.00a	20.0±2.10b	21.3±2.31b	23.3±3.05b	20.0±1.89b
Unsaponifiable matter (%)	4.73±1.22b.c	2.43±0.35d	1.70±0.65d,e	7.80±0.30a	4.63±0.60c	1.00±0.26e	5.80±0.40b

[a] Values are means ± standard deviations of triplicate determinations. Values in the same row having the same letters are not significantly different at the 5% level. % FFA = % free fatty acid.

limit. Fresh oils have been shown to have peroxide values lower than 10 mg/g oil and oils become rancid when the peroxide value ranges from 20.0 to 40.0 mg/g oil (Pearson, 1976). Ojeh (1981) reported that oils with high peroxide values are unstable and easily become rancid (having a disagreeable odour). It can thus be deduced that oils from CS, GNS, MS, OBS and PKS would store for a longer time without deterioration than oils from CNS and DNS. Iodine number was highest in PKS (33.29 ± 2.48) and lowest in GNS oil (11.2 ± 1.73). Values for CS, CNS, DNS, MS and OBS oils did not differ significantly but each was significantly lower than the value for PKS oil and significantly higher than that of GNS oil. All the iodine values of the oils investigated were significantly lower than the value of 52.0 for palm oil (Eka, 1989) and 46.8 ± 0.23 for breadnut seed oil (Nwinuka et al., 2001).

The relatively low iodine numbers in CS, CNS, DNS, MS and OBS oils compared to PKS oil may be indicative of the presence of few unsaturated bonds and hence low susceptibility to oxidative rancidity, as an earlier report has shown (Eka, 1980). It is therefore reasonable to assert that, of the oils investigated, PKS oil with the highest iodine value would undoubtedly contain more unsaturated bonds and can thus be grouped as a drying oil—a feature which, according to Dosunmu and Ochu (1995), could favour the utilization of the oil in the paint industry where unsaturated oils are needed.

Saponification number varied significantly among the oils and was highest in MS oil, followed by OBS oil while the lowest value was in CS oil. All the oils have high saponification values in the order MS > OBS > PKS > DNS > GNS > CNS > CS. Because there is an inverse relationship between saponification number and weight of fatty acids in the oil, it can be inferred as reported by Dosunmu and Ochu (1995) that the oils contain a great number of fatty acids of low molecular weight, and can thus be employed in the soap industry and in the manufacture of lather shaving creams (Eka, 1980; Hilditch, 1949).

4. Conclusion

The seven oil seeds studied are, in general, good sources of crude fat, crude protein, ash and calorie. The mineral concentrations are high, especially those of Fe, Zn, K, Na, PO_4^{3-} and Cl^-. Specific gravities of all the oil extracts are within the range reported for other fats and waxes; melting points of these oils were generally significantly higher than those reported for rubber seed oil and breadnut seed oil. Oil extracts of MS, CS, CNS and DNS contain higher amounts of saturated fatty acids than those of OBS, GNS and PKS and are therefore valuable in the manufacture of confections. Oils from OBS, GNS and PKS with lower melting points and higher degrees of unsaturation, could be useful in the manufacture of easily digestible margarine, creams and salad oils.

Percent free fatty acids in the oils were below the maximum desirable limit of 5.0%; acid and peroxide values were low and these qualify them as good edible oils. Low iodine values in CS, CNS, DNS, MS and OBS oils imply the presence of few unsaturated bonds and low susceptibility to oxidative rancidity; values of saponification number indicate the presence of many fatty acids of low molecular weight, making possible the utilization of these oils in the manufacture of soaps and lather shaving creams. The results may therefore offer a scientific basis for use of the seeds, both in human diet and some commercial products.

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