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Physicochemical Properties of Some Non-Conventional Oilseeds

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Abstract: The fruits and seeds of seven non-conventional oilseeds indigenous to Nigeria were collected from various locations in the western part of Nigeria between August and November, 2002. The flesh of the fruits of two other seeds was collected. A conventional oilseed, *Glycine max* (Soya bean) was used as a control. The samples were analyzed for proximate food values and elemental composition was determined using a combination of Atomic Absorption Spectrophotometer (AAS), Flame Photometer and Total Reflection X-ray Fluorescence Spectrometer (TXRF). The proximate analysis showed that five, (*Dacryodes edulis* seed and flesh, *Pesea americana* flesh, *Irvingia gabonensis* and *Terminalia catappa* seeds) out of nine different samples studied have high oil contents but low protein values. Three of the seeds (*Phaseolus lunatus, Sphenostylis stenocarpa* and *Mucuna* spp.) have low oil values but high protein contents. One other seed (*Persea americana*) is found to have low oil and protein contents and is presumed to have little economic significance. All the seeds showed inverse extracted oils/carbohydrate value relationship. The determined ash and fibre contents are comparable to those obtained for some conventional oilseeds. The high saponification and iodine values confer on the oils the properties required in soap making and cosmetic industry. The low peroxide and acid values recorded for the oils are indicators of their ability to resist lipolytic hydrolysis and oxidative deterioration. The low unsaponifiable matter suggests low cholesterol levels in the oils and thus, they may satisfy the consumption need of antherosclerosis patients.

Key words: Physicochemical, Oil seeds, Non-conventional, Spectrophotometer, Proximate analysis

Introduction

Fixed oils derived from plants are usually obtained from plant seeds generally referred to as oilseeds. Oilseeds are a class of plants in which relatively large amount of lipids are stored in the seed tissue (Lea and Leegood, 1993). The amount of lipid found in oilseeds range from 10-20% in species such as maize and soybeans, to 50% in rapeseed and sunflower. Oilseeds are among the most ancient crops domesticated by mankind (Lea and Leegood, 1993). For example, there is evidence for the cultivation of oil-bearing varieties of linseed in the middle East from over 8,000 years ago. Over the years, there has been a spectacular increase in the World demand for both oils and oil meals with attending up-trend in prices (Milelke, 1988). The significance of oilseeds economically, nutritionally and technologically is enormous. From the earliest times, oilseed products were utilized for a variety of edible and non-edible applications e.g. cooking, body massage, lubrication, grease etc. (Beazley, 1977 and Kern, 1979). In Nigeria, Yoruba women had long used coconut oil as hair dressing pomade and for body massage for babies (Kern, 1979).

During the 20th century, the non-edible uses of oil-seeds products declined substantially due to the availability of relatively inexpensive oil derived from fossil reserves (Lea and Leegood, 1993). There exists already abundant data on the proximate composition, mineral and other properties of the more conventional oil seeds, but not on the non-conventional oilseeds (Oyenuga, 1967). However, continuous exploration and extraction of oils from the non-conventional oilseeds is expected to check the expensive prices of the conventional oils thus making them affordable to people, most especially in the developing countries. In this study, seven non conventional oilseeds: *Dacryodes edulis* (Native pear), *Persea amerincana* (Avocado pear), *Irvingia gabonensis* (Dika nut), *Terminalia catappa* (Almond seed), *Sphenostylis stenocarpa* (Yam bean), *Phaseolus lunatus* (Lima bean) and *Mucuna* spp. (Mucuna bean) were investigated for their proximate composition, mineral values and physico-chemical properties. *Dacryodes edulis* and *Persea americana* flesh were also examined while *Glycine max* (Soya bean) seed was used for quality control.

Materials and Methods

Fruits and their seeds (except *Mucuna* spp.) were collected from various locations in farms around Obafemi Awolowo University, Ile-Ife and Local Markets around, Ile-Ife, Osun State, Nigeria. *Mucuna* spp. was obtained from the Institute of Agricultural Research and Training (IAR andT), Moore Plantation, Ibadan, Oyo State. The fruits were thoroughly washed prior to the separation of the seeds, air-dried for some days, milled and stored in a refrigerator until needed for analysis. The proximate composition and other chemical and physical parameters were determined using the methods of the Association of Official Analytical Chemists (AOAC, 1990). This parameters were determined in triplicates and the standard errors were calculated. Viscosity measurement was performed with the Oswald Kinematic Viscometer immersed in a thermostated water bath. The Viscometer was calibrated using

glycerol as reference sample.The viscometer constant, Ka was 1.1221 × 10^{-3} poise and the viscosity of the oils were determined at 30, 40, 50, 60, 70 and 80°C using the relationship n = Kaρt where ρ and t represent the density and the time of flow of oil. The refractive indices of the oils (at room temperature) were determined using an Abbe refractometer.
The elemental contents of the oilseeds were determined by using Flame photometer for Sodium, Atomic Absorption Spectrometry (AAS) for Mg and Total Reflection XRF spectrometry for all other elements.

Results

The results of the proximate composition of the oilseeds are presented in Table 1. The moisture content of the seeds ranged between 1.50 % in *D. edulis* flesh and 10.78% in *S. stenocarpa* seed. Oil content of the seeds varied between 0.70% in *S. stenocarpa* and 71.41% in *L. garbonensis.* The crude protein values range from 4.21% in *P. americana* to 32.33% in G. max. The crude protein were generally low in most of the samples (between 4.21 and 8.70%) but high in *M.* spp, *T. catappa*, *P. lunatus*, *S. stenocarpa* and *G. max* (between 18.39-32.33%). The ash content, which is a thorough estimation of the minerals, ranged from 2.2% in *L. gabonensis* to 5.7% in *T. catappa*. The crude fibre was highest in *L. garbonensis* (14.40%) while the highest carbohydrate value of 85.4%was obtained for *P. americana* seeds, The result of the analysis showed an inverse relationship between the percentage oil and percentage carbohydrate content of the materials investigated.
The elemental compositions of the species investigated are shown in Table 2 . Potassium and calcium were found to be the dominant elements in all the samples. Their values are in the range of 4330±4.60 µg/g to 13210±7.00 µg/g for potassium and 136±0.80 to 3699± 2.43 µg/g for calcium. Sodium, a complementary element to potassium showed low values (36.00±1.00-263±2.00 µg/g. Concentration of magnesium is also relatively high (157±0.02 to 657.80±0.06 µg/g compared with zinc (12.00-164 µg/g), copper (6.00-118), chromium (4.00-125.00) and iron (8.00-609 µg/g),
The specific gravity and the viscosity of the oils at various temperatures are presented in Tables 3 and 4, respectively. At 30°C, the specific gravity values ranged from 0.882 in *D. edulis* seed oil to 0.906 in *G.max* oil. The viscosity value was highest (24.319 centipoise) in *P. americana* flesh oil. *L. gabonensis* still remain in the solid state at 30°C while *D. edulis* flesh oil is solid even at 40°C.
Other physical and chemical properties of the oils from oilseeds and flesh are presented in Table 5. The refractive indices of oils varied very little, between 1.4531 in *L. gabonensis* seed oil to 1.4567 in *D. edulis* seed oil at room temperature. The values for *D. edulis* seed oil was obtained after subjecting the fat to temperature as high as 70°C to keep the oil in the liquid state. The surface tension of the oils ranged from 0.03056±0.0044 N/m in *L. gabonensis* to 0.03114± 0.00054 N/m in *D. edulis* flesh iols. The saponification values ranged between 169.98±4.25 mg/g in *P. americana* flesh oil and 239.830 ± 1.155 mg/g in *L. gabonensis* seed oil while the unsaponifiable matter varied from 0.837 ± 0.120% in *G. max* oil to 2.615 ±0.055% in *D. edulis* seed oil. The acid values obtained in this work ranged from 1.712±0.120 mg/g in *T. catappa* to 6.726 ± 0.040mg/g in *D. edulis* seed oils while the peroxide values varied between 0.500± 0.100 meq/kg in T. catappa to 5.900±1.410 meq/kg in *D. edulis* flesh oil. The highest iodine value of 136.810 ± 4.715 was obtained for G. max oil while the least value of 4.950 ± 0.610 was obtained for *L. gobonensis.*

Discussion

On the basis of the results of this study, some of the seeds and their flesh are seen as sources of oils, proteins, fibre, carbohydrate and minerals. The relative high moisture content of *S. stenocarpa* compared to *D. edulis* seed may be due to the hard nature of the seed which prevents excessive moisture loss. Low moisture content of the seeds (except *S. stenocarpa*) is an advantage of high shelve-life of the seeds. The high oil content of 71.4% obtained for *L. gabonensis* agreed favourably with 70% reported earlier for the same seed (Okoye and Okonkwo, 1999). The value of 47.8% obtained for *T. catappa* and 50.1% for *P. americana* flesh compared favourably in oil content with 49.49% reported for *Heavea brasiliensis (*Oluyemi *et al.,*1975) 48.5% for Cashew nut (Fetuga *et al.*, 1974), 54.25% reported for melon seed Oyenuga and Fetuga, 1975) and 40% reported for *T. bellirica* kernel (Rukumini and Rao, 1986). In this study, the oil content of *D. edulis* flesh was found to be 58.1% which falls within the range of 49-59% reported earlier (Mbofung *et al* ., 2002) but higher than 30 and 32% reported by other workers for the same seed (Larousille *et al.*, 1994 and Omuti and Okiy, 1987). The difference observed in the values may be due to the differences in the nutrient nature of the soil and some other environmental factors. For example, temperature has been reported to have influence on the level of oils and its composition (Maestri *et al.*, 1998). The high oil value obtained for some of the seeds make them good alternative or supplement to some conventional oil seeds such as; palm oil, groundnut oil, soybean oil etc which values are already reported (Bailey's, 1979). Hence they can be a cheap source of protein and fat for domestic and industrial consumption. Those seeds that are moderate or high in protein compared favourably with legumes and other proteinous plants. For example, *M. spp.*. (21.90%), *P. lunatus* (21.355), *S. stenocarpa* (19.50%) and *T. catappa* (18.39%) agreed with the range

Table 1: Proximate Composition of Oilseeds (in Percentage of Dry Weight)

Name of Oil Seeds Scientific	English name	%Moisture	% Oil	% Crude Protein	% Ash	% Crude Fibre	%Carbohydrate
D. edulis Flesh	Native Pear	1.50±0.15	58.09±1.34	8.12±0.06	2.29±0.05	6.10±0.84	25.43±0.83
D. edulis Seed	Native Pear	3.95±0.09	17.28±0.48	6.68±0.21	2.59±0.04	2.26±0.03	70.84±0.26
Mucuna spp	Mucuna bean	9.43±0.03	5.25±0.41	21.90±0.16	3.10±0.07	6.66±0.11	63.09±0.64
P. americana	Flesh Avocado	1.63±0.10	50.14±0.12	6.33±0.24	3.87±0.27	10.78±0.46	28.80±0.18
P. americana seed	Avocado	5.13±0.10	5.13±0.80	4.21±0.03	2.67±0.16	2.58±0.20	85.41±0.89
L. gabonensis	Wild Mango	4.73±0.29	71.41±2.05	8.70±0.05	2.23±0.06	14.40±0.83	3.36±0.50
T. catappa	Almond	4.22±0.03	47.82±0.17	18.39±0.1	5.69±0.28	2.97±0.03	25.61±0.72
P. lunatus	Lima bean	4.93±0.06	5.76±0.72	21.35±0.03	4.66±0.07	3.39±0.32	64.94±1.13
S. stenocarpa	Yam bean	10.78±0.02	0.70±0.05	19.50±0.08	5.37±0.05	3.60±0.04	70.84±0.10
G. max	Soybean	4.48±0.02	22.35±0.97	32.33±0.01	5.29±0.47	5.97±0.12	34.41±1.72
*G. max**	Soybean	9.67±0.13	18.62±0.14	32.75±0.07	4.75±0.07	8.66±0.07	35.22±0.28

* (Oguntunde and Ajayi, 1994)

Table 2: Elemental Composition of Oil Sources (μg/g)

Name	S	K	Ca	Mg	Na	Zn	Fe	Cu	Cr	Mn	Ni	Ti	Rb
I.gabonensis	412± 0.51	4330± 4.6	1289± 1.83	417.70± 0.09	263.00 ±2.00	128.00 ±0.39	8.00 ± 0.05	83.00± 0.22	ND	40.00 ±0.04	16.00 ±0.02	30.00 ±0.05	15.00 ±0.01
E.guineensis	ND	2330 ±3.70	1339± 1.43	318.30 ±0.01	133.50 ±1.50	144.00 ±0.04	117.00 ±1.54	52.00 ± 0.24	16.00 ±0.47	96.00 ±0.08	23.00 ±0.03	115.00 ±0.15	11.00 ±0.03
P.americana seed	258± 0.63	7430 ±5.0	136± 0.84	157.20 ±0.02	36.00 ±1.00	50.00 ± 0.02	142.00 ±0.42	6.00 ± 0.21	ND	12.00 ±0.03	30.00 ±0.03	77.00 ±0.11	67.00 ±0.03
D. edulis flesh	592± 1.18	8930 ±1.18	2049± 1.33	295.30 ±0.01	159.00 ±1.00	12.00 ±0.04	609.00 ±0.49	99.00 ±0.24	14.00 ±0.47	24.00 ±0.05	29.00 ±0.03	94.00 ±0.14	30.00 ±0.04
D. edulis flesh	415± 1.05	6670 ±4.80	357.0± 0.89	217.10 ±0.02	102.50 ±2.50	361.00 ±0.06	572.00 ±0.47	118.00 ±0.24	10.00 ±0.48	18.00 ±0.05	15.00 ±0.03	140.00 ±0.12	35.00 ±0.03
P.americana flesh	737± 1.20	13210 ±7.00	310± 2.43	297.70 ±0.00	93.00 ±2.00	45.00 ±0.04	302.00 ±0.47	98.00 ±0.32	4.00 ± 0.22	19.00 ±0.05	207.0 ±0.06	99.00 ±0.11	108.00 ±0.04
T. catappa seed	ND	11410 ±6.00	3699 ±2.43	657.8 ±0.06	133.50 ±1.50	164.00 ±0.14	554.00 ±0.72	98.00 ±0.32s	125.0 ±0.66	ND	43.00 ±0.13	ND	106.00 ±0.17
G. max seed	501 ±1.54	11610 ±6.00	2269 ±1.73	486.70 ±0.09	34.50 ±0.50	88.00 ±0.06	230.00 ±0.46	17.00 ±0.25	13.00 ±0.51	33.00 ±0.09	19.00 ±0.05	ND	27.00 ±0.07

ND = Not Detected

Table 3: Specific Gravity Values of oils

Oils	Temperature °C					
	30	40	50	60	70	80
P. americana flesh	0.8905±0.0016	0.8897±0.0011	0.8879±0.0029	0.8859±0.0036	0.8850±0.0043	0.8843±0.0051
L. gabonensis	0.8963±0.0016	0.8960±0.0016	0.8940±0.0032	0.8920±0.0043	0.8900±0.0033	0.8868±0.0061
D. edulis flesh	0.8842±0.0028	0.8830±0.0016	0.8772±0.0021	0.8761±0.0055	0.8730±0.0065	0.8694±0.0081
D. edulis seed	0.8820±0.0026	0.8803±0.0008	0.8783±0.0036	0.8762±0.0044	0.8760±0.0072	0.8735±0.0075
T. catappa	0.8936±0.0002	0.8920±0.0001	0.8901±0.0520	0.8882±0.0049	0.8861±0.0057	0.8845±0.0064
G. max	0.9059±0.0023 (0.919-0.925[a])	0.9053±0.0024	0.9037±0.0019	0.8994±0.0004	0.8961±0.0014	0.8947±0.0003

a = (Nigerian Industrial Standard, 1992)

Table 4: Viscosity Values of oils (Centipoise)

Oils	Temperature (°C)					
	30	40	50	60	70	80
P. americana flesh	24.3193±0.0280	21.5236±0.0345	14.7455±0.0449	10.2459±0.0418	6.6352±0.0611	6.4811±0.2099
D.edulis seed	17.2652±0.0396	14.9087±0.0445	10.1053±0.0311	7.4714±0.0680	5.3670±0.0443	4.4627±0.0344
T.catappa	13.9267±0.0492	11.1332±0.0611	8.2500±0.0340	6.5970±0.0470	4.2297±0.0338	2.4808±0.0412
I. gabonensis	NIL	14.2288±0.0278	9.1189±0.0453	7.5668±0.0451	6.3596±0.0500	4.5127±0.2985
D. edulis flesh	NIL	NIL	12.9262±0.0810	7.3548±0.0525	5.3596±0.0473	4.2778±0.0146
G. max	17.9882±0.0407	13.8345±0.0572	12.2988±0.0431	6.6936±0.0227	5.3353±0.0302	4.6302±0.0904

21-23% reported for legumes (Adewusi and Falade, 1996). Thus, these seeds look promising as sources of dietary protein. However, *P. lunatus*, S. stenocappa, M. spp. and *P. americana* seeds have low oil contents, hence, other chemical characterization were not carried out on their oils.

Most of the seeds are higher in crude fibre than cowpea with crude fibre of 3.6% (Ojimelukwe, Onweluzo and Okechukwu, 1999). Food high in fibre content is considered good for diabetic patients (Anderson, 1986 and Osilesi *et al.*, 1997). Fibre also reduces blood cholesterol (Liu *et al.*, 2000).Thus, these samples could be recommended for incorporation into the diet of diabetic and antherosclerotic patients. The high carbohydrate content is the major sources of readily available energy for human body (Brand and Maggiore, 1992). The ash analyses showed the oi lseeds to be good sources of mineral element (Table 1 and 2).

Table 5: Other Characteristics of the Oilseeds

Characteristics	D.edulis seed	T.catappa	P.americana flesh	D.edulis flesh	I.gabonensis	G.max
Refractive index	1.45766±0.00002	1.45817±0.00051	1.45766±0.00002	1.45667±0.00200 (at 70°C)	1.45314±0.00351	1.45666±0.00003 (1.466[a])
Surface tension (N/M)	0.03060±0.00062	0.03077±0.00071	0.03106±0.00065	0.03114±0.00054	0.03056±0.00047	0.03093±0.00136
Saponification value (mgKOH/g)	193.890±3.320	205.120±3.630	169.980±4.250	204.840±1.560	239.830±1.1155	192.295±5.295 (189-195[a])
Unsaponifible matter (%)	2.615±0.055	1.865±0.136	2.041±0.061	2.505±0.025	1.543 ±0.169	0.837±0.120 (≤1.5[a])
Acid value (mg/g)	5.9620±0.010	1.712±0.120	6.100±0.110	6.726±0.040	2.607±0.179	4.279±0.299
Peroxide value (meq/kg)	5.400±0.800	0.500±0.100	3.000±0.400	5.900±1.410	0.810±0.090	3.500±0.200
Iodine value	130.960±2.540	133.200±2.420	135.192±2.670	100.510±2.540	4.950±0.610	136.810±4.715 (120-143[a])

a = (Nigerian Industrial Standard, 1992)

The abundance of these elements would speed up metabolic process and improve growth and development. For example, the high concentration of Potassium will regulate acid-base balance and normal metabolism. Sodium and Nickel would also play a vital role in this regard. The relatively high concentration of calcium and magnesium would make the oils useful for domestic purposes. This is because calcium and magnesium ions play vital roles in the formation of bones while Mg and Mn act as enzymes activators and for the transmission of various signals such as those that trigger contraction of cardiac muscles causing the heart to beat (Akanni, 2000 and Adewusi, 2002). The concentrations of the transition metals appear normal as they are found in trace quantities in this kind of matrix.

The specific gravity and the viscosity of the oils fall normally with increase in temperature. The drop noticed in the specific gravity of *D. edulis* oil after 40°C suggests the presence of some volatile materials such as sterols and insoluble high molecular weight fatty alcohols in the oils. The specific gravity values of the oils agreed with literature values reported for the conventional oils (De Bussy, 1975). The viscosity of the oils is generally low and the property tends to make them potential materials for use as fuel in diesel engines. This is because oils or fuels with high viscosity would have a low degree of atomization resulting in a longer ignition delay (Ryan, Dodge and Gollahan, 1984). The viscosity values of the oils are in close agreement with those obtained for some non-conventional oilseeds (Omode *et al.,* 1995). *P. americana* flesh oil has exceptionally high viscosity (24.3193 cp) at low temperature and will be a good lubricant for heavy duty machine at a low temperature as the viscosity falls sharply with a rise in temperature. The inability to determine the viscosity of *D. edulis* flesh oil even at 40°C despite its level of unsaturation could be as a result of the presence of saturated fatty acid of longer chain-length than the unsaturated fatty acid. This gives a plausible explanation why Coconut oil with about 90% saturated fatty acids with high proportion of short-chain length fatty acid is a liquid at room temperature whereas lard oil which contains only about 37% saturated fatty acids with longer chain-length is a solid at 26°C (Harry, L. 1995).

The surface tension of the oils are far lower than that of water (0.072575N/M) at room temperatures and consequently, the oils can be used as water surface retardant in desert region where high water loss is the predominant feature of the weather. The refractive indices of the oils are in close range with the values obtained for some conventional oils such as palm kernel oil (1.449-1.451), Soya bean oil (1.466-1.470) etc. (De Bussy, 1975). Since the refractive indices of the oils are greater than that of water (1.330) at room temperature, this property suggests the use of the oils in studies relating to optics.

The saponification values of the oils are quite high and are in good agreement with that of some conventional oils, e.g. groundnut oil (188-195 mg/g) and palm oil (195-205 mg/g) (De Bussy, 1975). The high saponification and iodine values conferred on the oils the properties required in soap making and in cosmetics industry. These properties also make them useful raw materials and as sources of essential fatty acids required in the body. *L.* gabonensis has a low iodine value (4.50). This property makes the oil suitable for cooking and frying. The acid values of the oils are still within the range 3-7 mg/g reported for kernel oil, a conventional oil (I.T.S, 2002). The low acid and peroxide values are indicators of the ability of the oils to resist lipolytic hydrolysis and oxidative deterioration. The unsaponifiable matter showed an inverse relationship to the saponification values of the oils. The values obtained in this work compared well with those of conventional oils such as palm oil (≤ 1%) and maize oil (≤ 1%) (De Bussy, 1975). The unsaponifiable matter represents the non saponifiable materials such as sterols, fatty alcohols, squalene, vitamins etc. which have basic biological functions such as hormone synthesis. The low unsaponifiable matter of the oils is an indicator of low levels of minor constituents such as cholesterol. Hence, can be used as component of drugs and as antioxidant agents.

Conclusion

We hold the view that the negligence of the use of non-conventional oilseeds over the years is a serious oversight. The properties of the oils enumerated in this work make some of them good substitutes to the conventional oils. We therefore suggest that the potentials of the non-conventional seed oils should be tapped for both domestic and industrial uses. Based on the physicochemical properties of the oilseeds examined in this work, we believed that it should be profitable to tap oils from these non-conventional sources to supplement the ever-increasing demands on conventional oils and use the abundant availability of the oilseeds to expand the economic horizon of the countries where the weather permits the growth of the oilseeds.

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