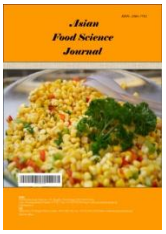

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Proximate Composition of Some Selected Legumes and Quality Attributes of Oils Extracted from Soybean, Oil Bean and Groundnut Seeds

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Oil contents through analysis of proximate composition of the seeds of six legumes were investigated in order to assess the quality attributes of some of their oils. These legumes were cowpea (*Vigna unguiculata*), bambara groundnut (*Voandzeia subteranea*), yam bean (*Sphenoostylis stenocarpa*), oil bean (*Pentaclethra macrophylla*), soybean (*Glycine max*) and groundnut (*Arachis hypogaea*) seeds. The oil yields ranged from 2.5% in cowpea to 40.3% in groundnut seeds. Crude protein contents ranged from 20.86% in bambara groundnut seeds to 43.02% in soybean seeds indicating they are good sources of protein. Cowpea seeds had highest content (57.76%) in carbohydrate, followed by yam bean (56.54%) and bambara groundnut (51.64%), while oil bean had the lowest value of 6.92%. The physicochemical properties of the oils from soybean, oil bean and groundnut seeds were further examined since their oil yields were above 10.00%. Seventy grams of oil in each case were extracted from these legumes for these analyses. The specific gravity ranged from 0.910 in oil bean oil to 0.917 in soybean oil. Oil bean oil, with highest values in moisture content (0.75 %) and peroxide value (21.2 mg/g oil) had highest saponification number of 306.86 mg/g oil while soybean oil with lowest values both in moisture

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content (0.43 %) and peroxide value (9.80 mg/g oil) had the lowest saponification number of 187.94 mg/g oil. Free fatty acid ranged from 0.17 in soybean oil to 0.48 in groundnut oil. Iodine value was highest (98.22 mg/100g) in soybean oil, followed by oil bean oil (98.22 mg/100g) and was lowest (93.40 mg/100g) in groundnut oil. These results obtained highlighted the potentials of these three oils in the manufacture of soaps, cosmetics, paints, confectioneries, margarines and edible oils. The results also maintained that soybean oil exhibited the best physicochemical properties amongst them and thus could be used better as edible oil and for industrial applications.

Keywords: Legumes; proximate composition; oil bean oil; soybean oil; groundnut oil; quality attributes and applications.

1. INTRODUCTION

Several plants are known to have oil-bearing seeds but only few are of significant importance commercially. In many of the developing countries and tropical areas, like Nigeria, legumes are common crops. In 2017, legumes had a worldwide market value of 44.9 billion U.S dollars with a production volume of 42.33 million metric tons [1-2]. Surprisingly, about 40% of the world production of the grain legumes and 20% of the soybeans are produced within the tropics and, Interestingly Nigeria is the world's largest producer of cowpeas [3-4]. Studies also have shown that Nigeria produces about 3.9 million tons (57%) of groundnuts grown in West Africa, and yet legumes suffer declining utilizations and, worst-still some minor legumes (like oil bean, bambara groundnut, African yam bean) are at the verge of extinction [5]. Therefore, these tropical legumes, commonly found in our country should be exploited for food, medicine, agriculture and other useful potentials in order to unlock their values and promote them in the domestic and industrial sectors.

The legumes refer to the edible seeds of leguminous plants belonging to the *Leguminosae* family.

Leguminous plants are those that are able to form their proteins from the air, with the help of the bacteria in the nodules of their roots [6-8]. Tropical grain legumes are an important component of the farming systems and generate income, provide improved nutrition, food security and soil fertility because of their ability to fix nitrogen from the atmosphere [5,4,9]. Thus legumes are next in importance to cereals as food source and contain more protein than any other products [7,10,8,11]. The importance of *Leguminosae* family in the context of human nutrition is very considerable [10,9] since the member-crops provide sources of protein and some also provide sources of vegetable oils. Besides, their residues after extraction of oils are high protein cakes for feed formulations.

Vegetable oils (i.e derived from the seeds and fruits of plants) are of higher importance to the food processor than animal fats [12-15]. They provide not only energy, vitamins and essential fatty acids in our diets but are also useful in the treatments of patients with obesity, hair dandruffs, muscle spasms, varicose veins, wounds and familial hypercholesterolemia because of their high contents of polyunsaturated fatty acids [16,12,13,14]. Vegetable oils serve as carriers of fat-soluble vitamins as well as play important roles in repair of worn-out tissues, cell formations and constitute vital components of our daily diet [13,17]. According to Weiss [18] vegetable oils are of a higher commercial importance than animal fats. In food industries, vegetable oils are used in the manufacture of confectionaries, margarines, cooking oils, shortenings and salad oils. They are also important as the basis for a variety of industries which manufacture oil creams, lubricants, personal care products, varnishes, paints, cosmetics, soaps, lacquers, linoleum, emulsions, textile improvers, pharmaceutical products, surface active materials and biofuel [12-14,17,15].

The present study investigates the proximate composition (with emphasis on oil yields) of selected commercially available legumes in the Southern Nigeria and thus evaluates the quality attributes of the oils extracted from the legumes with oil yields above 10.00%. The commercially available legumes selected are cowpea (*Vigna unguiculata*), bambara groundnut (*Voandzeia subteranea*), yam bean (*Sphenoostylis stenocarpa*), oil bean (*Pentaclethra macrophylla*), soybean (*Glycine max*) and groundnut (*Arachis hypogaea*).

2. MATERIALS AND METHODS

2.1 Materials

Leguminous seeds of cowpea (*Vigna unguiculata*), bambara groundnut (*Voandzeia subteranea*), yam bean (*Sphenoostylis stenocarpa*), oil bean (*Pentaclethra macrophylla*), soybean (*Glycine max*) and groundnut (*Arachis hypogaea*) were purchased at Owerri main market in Imo state, Nigeria.

2.2 Methods

Preparation of samples: The seeds of the legumes were cleaned, de-hulled and efficiently ground to a uniform thickness with an attrition mill. The milled samples were weighed and dried in the oven at a temperature of 110^{0}C for 1 h. Dried samples were hermetically stored at room temperature (27^{0}C) in readiness for further analyses.

Proximate analyses of the samples: Proximate analyses were carried out on the samples to determine the moisture, ash, crude fibre, fat, protein and carbohydrate contents using the method outlined by the Association of Official Analytical Chemists [19].

Moisture Content: The moisture content was determined by hot air oven method as described by AOAC [19]. Dried ground sample (2 g) was weighed into an empty dish. This was placed into the hot air oven to dry for 24 hours at 100^{0}C. The dish and its contents were cooled in the desiccator and their weights were taken. The loss in weight was recorded as moisture content and expressed as percentage of the original weight of the sample. This experiment was carried out in triplicates.

$$\%\ Moisture\ Content = \left(\frac{W_2 - W_3}{W_2 - W_1}\right) X\ 100$$

W_1= weight of cooled empty dish
W_2 = weight of empty dish + un-dried sample
W_3= weight of dish + dried sample

Ash Content: Ash content was determined using the method of AOAC [19]. Dried ground sample (5 g) was weighed into empty crucible and then the sample was incinerated in a muffle furnace at 550°C until a light grey ash was observed and a constant weight obtained. The sample was cooled in the desiccator to avoid absorption of moisture and then weighed to obtain ash content. The percentage ash content was expressed as percentage of the original weight of the sample on dry basis. The experiment was done in triplicates.

$$\%\ Ash\ Content = \left(\frac{W_3 - W_1}{W_2 - W_1}\right) X\ 100$$

W_1= weight of cooled empty crucible
W_2 = weight of empty crucible + un-dried sample
W_3= weight of crucible + dried sample

Crude Fibre Content: Crude fibre content was determined using the method of AOAC [19]. Dried ground sample (5 g) was weighed into a 500 ml Erlenmeyer flask and 100 ml of TCA digestion reagent was added. It was then brought to boiling and refluxed for exactly 40 minutes counting from the start of boiling. The flask was removed from the heater, cooled a little then filtered through a 15.0 cm number 4 Whatman paper. The residue was washed with hot water stirred once with a spatula and transferred to a porcelain dish. The sample was dried overnight at 105°C. After drying, it was transferred to a desiccator and weighed as W_1. It was then burnt in a muffle furnace at 500°C for 6 hours, allowed to cool, and reweighed as W_2.

$$\%\ Crude\ fibre = \left(\frac{W_2 - W_1}{W_0}\right) X\ 100$$

W_1= Weight of crucible + fibre + ash
W_2= Weight of crucible + ash
W_0= Dry weight of food sample

Fat Content: The soxhlet extraction method described by AOAC [19] was used in determining fat content of the dried ground samples. Dried ground sample (2 g) was weighed into a weighed flat bottom flask with the extractor mounted on it. The thimble was held half way into the extractor and the weighed sample. Extraction was carried out using boiling point of 40 - 60^{0}C. The thimble was plugged with cotton wool. At completion of extraction which lasted for 8 hours, the solvent was removed by evaporation on a water bath and the remaining part in the flask was dried at 80^{0}C for 30 minutes in the air oven to dry the fat and then cooled in a dessicator. The flask was reweighed and percentage fat calculated as follows:

$$\%\ Crude\ fat = \left(\frac{weight\ of\ fat}{weight\ of\ sample}\right) X\ 100$$

Protein Content: The micro Kjeldahl method as described by AOAC [19] was used to determine crude protein. Dried ground sample (2 g) was weighed into the digestion flask. Ten grams (10 g) of copper sulphate and sodium sulphate (catalyst) in the ratio 5:1 respectively and 25 ml concentrated sulphuric acid were added to the digestion flask. The flask was placed into the digestion block in the fume cupboard and heated until frothing ceased giving clear and light blue green coloration. The mixture was then allowed to cool and diluted with distilled water until it reached 250 ml of volumetric flask. Distillation apparatus was connected and 10 ml of the mixture was poured into the receiver of the distillation apparatus. Also 10 ml of 40% sodium hydroxide was added. The released ammonia by boric acid was then treated with 0.02 N of hydrochloric acid until the green color changed to purple. Percentage of nitrogen in the sample was calculated using the formula below:

$$Nitrogen\ (\%) = \left(\frac{(Titre - blank)X14.008XNormalityX100}{Weight\ of\ Sample}\right)X100$$

$$\%\ Protein = \%\ N\ X\ 6.25$$

Carbohydrate Content: The carbohydrate content was calculated by difference method according to Ihekoronye and Ngoddy [3]. This was done by summing up the moisture, crude protein, crude fat, crude fibre and ash contents and then subtracting from 100.

$$\%\ Carbohydrate = 100 - (\%\ MC + \%CP + \%CF + \%CFb + \%A)$$

Where MC = Moisture content
CP = Crude Protein
CF = Crude fat
CFb = Crude fibre
A = Ash

Oil extraction from the samples: Oils were extracted from ground groundnut, oil bean and soybean seed samples using the method outlined by the Association of Official Analytical Chemists [19]. Dried ground sample (10 g) was weighed into a weighed flat bottom flask with the extractor mounted on it. The thimble was held half way into the extractor and the weighed sample. Extraction was carried out using boiling point of 40 - 60^{0}C. The thimble was plugged with cotton wool. At completion of extraction which lasted for 8 hours, the solvent was removed by evaporation on a water bath and the remaining part in the flask was dried at 80^{0}C for 30 minutes in the air oven to dry the fat and then cooled in a dessicator. The flask was reweighed and percentage fat calculated as follows:

$$\%\ Crude\ fat = \left(\frac{weight\ of\ fat}{weight\ of\ sample}\right)X\ 100$$

Then 70.00 g of oil sample each was extracted from legumes (with oil yield of above 10 %) for use in assessing the quality attributes of their oils.

2.3 Assessment of the Quality Attributes of the Oil Samples Extracted from Soybean, Oil Bean and Groundnut Seeds

Determination of Colour: The colours of the oil samples were determined by direct visual inspection method.

Determination of the Moisture Content: The moisture contents of the oil samples were determined in accordance with the method described by Association of Official Analytical Chemists [19]. The oil sample (2 g) was weighed into an empty dish. This was placed into the hot air oven to dry for 24 hours at 100^{0}C. The dish and its contents were cooled in the desiccator and their weights were taken. The loss in weight was recorded as moisture content and expressed as percentage of the original weight of the sample. This experiment was carried out in triplicates.

$$\%\ Moisture\ Content = \left(\frac{W_2 - W_3}{W_2 - W_1}\right)X\ 100$$

W_1= weight of cooled empty dish
W_2 = weight of empty dish + un-dried sample
W_3= weight of dish + dried sample

Determination of the Specific Gravity: It was determined using the procedure described by Association of Official Analytical Chemists [19]. The determination was done at 27^{0}C. A weighed specific gravity bottle was filled with distilled water and re-weighed. The specific gravity bottle was again filled with oil sample and the weight recorded. The experiment was carried in triplicates.

$$Specific\ Gravity\ (S.G)\ of\ Oil = \left(\frac{Weight\ of\ oil\ sample}{Weight\ of\ distilled\ water}\right)$$

Determination of Free Fatty Acid (FFA) and Acid Value: The method described by Uzomah et al. (2002) was adopted for the determination of free fatty acid contents of the oil samples. Petroleum ether (25.0 ml) and alcohol (25.0 ml) were mixed together in a 250.0 ml conical flask. Then 1.0 ml of phenolphthalein (1.0%) was added and the mixture was neutralized with 3 drops of 1.0 M NaOH. Oil sample (5.0 g) was dissolved in the neutral solvent mixture and then titrated with 0.1 M NaOH, shaking constantly until a pink colour persisted for 15 seconds. The experiment was done in triplicates and the titre value was used to determine the % FFA and the acid value.

$$FFA = \left(\frac{X - 2.82}{W}\right)$$

$$Acid\ value = (FFA\ x\ 2)$$

Where FFA = Free fatty acid
W = Weight of the oil sample
X = Average titre value

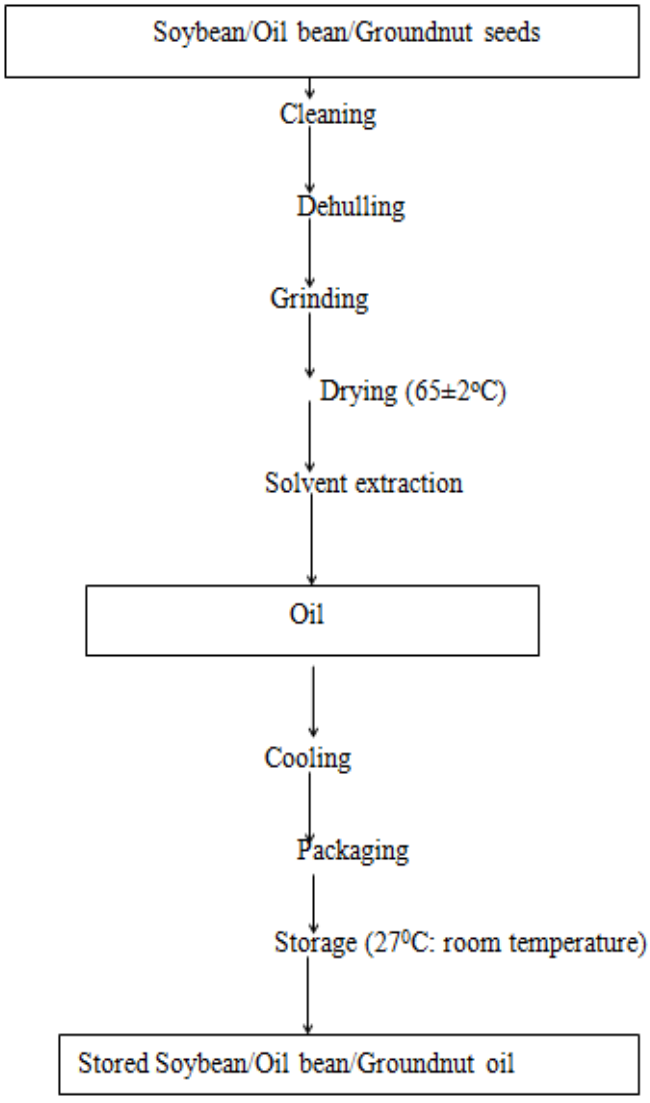

Fig. 1. Flow chart for extraction of oil samples from legume seeds
Source: Modified AOAC, 2005

Determination of Peroxide Value (IV): The method described by Uzomah et al. [20] was adopted in the determination of peroxide values of the oil samples. Oil sample (5.0 g) of the oil sample was transferred into a 250 ml conical flask and then added 30.0 ml of acetic acid-chloroform solution. The flask was swirled till the sample dissolved in the solution. Saturated potassium iodide (0.5 ml) was added. The solution was allowed to stand with occasional shaking for one minute and then added 30.0 ml of distilled water. The mixture was then titrated with 0.1N Sodium thiosulphate solution using 0.5 ml starch indicator until the blue colour disappeared. A blank sample experiment was also carried out. The determination was performed in triplicates and the peroxide value calculated as follows:

$$\text{Peroxide Value (PV)} = \left(\frac{(\text{S} - \text{B})(\text{N})(100)}{\text{Weight of the oil sample}}\right)$$

Where B=Titre value for the blank sample
S= Titre value for the oil sample
N= Normality of $Na_2S_2O_3$

Determination of Saponification Value (SV): The experiments were carried out in accordance with the method described by Association of Official Analytical Chemists [19]. Oil sample (2 g) was weighed into a conical flask. Twenty-five milliliter of 0.5N alcoholic potassium hydroxide was added. A blank experiment was also carried out at the same time. Reflux condensers were fitted to both experimental flasks and the contents were boiled for half an hour while swirling the flasks at frequent intervals. Saponification was indicated by the absence of an oily matter and appearance of a clear solution. The KOH was titrated with 0.5 M HCL using a phenolphthalein indicator. The determination was done in triplicates and the saponification value calculated as follows:

$$\text{Saponification Value (SV)} = \left(\frac{(\text{B} - \text{S})\text{x}(100)}{\text{Weight of the oil sample}}\right)$$

Where B= Titre value for the blank
S = Titre value for the oil sample

Determination of Iodine Value: Iodine values of the oil samples were determined in accordance with the method described by Association of Official Analytical Chemists [19]. Oil sample (0.5 g) was weighed into a 500 ml flask. Carbon tetrachloride (5.0 ml) was added and swirled. Wij's solution was added and a stopper was fitted on top of the flask to prevent evaporation and absorption of CO_2 from the air. The sample was kept in a dark cupboard for 30 minutes. Ten percent Potassium iodide (10.0 ml) solution and distilled water (50.0 ml) were added. The solution was titrated with 0.1 N sodium thiosulphate solution till aqueous layer became very pale yellow after shaking. Starch solution (2.0 ml) was added to give a blue-black colour disappeared. A blank sample experiment was carried out alongside the oil sample experiment. The experiment was performed in triplicates and then iodine value was calculated as follows:

$$\text{Iodine Value (IV)} = \left(\frac{(\text{B} - \text{S})\text{x M x}12.69}{\text{Weight of the oil sample}}\right)$$

Where B= Titre value for the blank
S = Titre value for the oil sample
M – Molarity/Normality of $Na_2S_2O_3$
Atomic weight = 12.69

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of the Legume Seeds

The results of the proximate composition of the seed samples namely, cowpea (*Vigna unguiculata*), bambara groundnut (*Voandzeia subteranea*), yam bean (*Sphenoostylis stenocarpa*), oil bean (*Pentaclethra macrophylla*), soybean (*Glycine max*) and groundnut (*Arachis hypogaea*) are presented in Table 1.

Moisture content was highest (36.44%) in oil bean seeds, followed by cowpea seeds (11.30%) though with a tremendous difference, and then lowest in soybean and groundnut seeds with a common value of 9.98%. The low moisture levels of soybean, cowpea, groundnut, yam bean and bambara groundnut seeds indicate they could store for longer time without spoilage than cowpea seeds and especially, oil bean seeds since a higher moisture content could lead to food spoilage through an increasing microbial action [21].

Crude protein was distinctly highest (43.02%) in soybean seeds, followed by oil bean seeds (22.94%) and was lowest in Bambara groundnut seeds (20.86%). Therefore, the high protein contents of these six selected legumes indicate they are good sources of protein [7,10,8,11], and thus suggest that they could contribute to the

daily protein need of 0.8 g per kilogram of body weight of a sedentary adult as recommended by Dietary Reference Intake Report for macronutrient [22,11].

The crude fat content was highest (40.30%) in groundnut seeds, followed by oil bean seeds (25.50%) that had soybean seeds follow it with a value of 19.50% while yam bean seeds had lowest value of 2.50%. These results project groundnut seeds, oil bean seeds and soybean seeds as good oil bearing seeds when compared with others. Vegetable oils (derived from plant sources) are recommended for consumption and food preparations, and of course utilized in the manufacture of margarines, soaps, paints, lubricants, varnishes, cosmetics and pharmaceutical products [21,17,12,8,15]. The rest of the seeds (cowpea, bambara groundnut and yam bean) had very low oil contents and thus would require large amount of materials and other resources for extraction of tangible quantities of their oils.

The crude fibre content was highest (5.45) in bambara groundnut seeds, proceeded by yam bean seeds (5.00%), closely followed by oil bean seeds (4.95%) and was toddled by soybean seeds (1.25%). Cowpea and groundnut seeds had close values of 1.78% and 1.63% respectively. Therefore bambara groundnut, yam bean and oil bean seeds could be good sources of dietary fibres. Though crude fibre, has little food value but it provides bulk necessary for peristaltic action in the intestinal tract [23]. Studies have revealed that increased consumption of dietary fibre could significantly reduce the risks for obesity, type-2 diabetes, constipation, coronary heart diseases and colon cancer [23].

Ash content was highest (5.40%) in soybean seeds, followed by bambara groundnut seeds with a value of 3.55% which did not differ significantly from those of cowpea seeds (3.53%) and oil bean seeds (3.26%) and then lowest in groundnut seeds (2.70%). These values suggest that all the six selected legumes are good sources of minerals with soybean seeds as the best source since ash content is an index of mineral content of foods [24, 21].

The carbohydrate contents ranged from 57.76% in cowpea seeds to 6.90% in oil bean seeds. These values indicate that cowpea seeds (57.76%), yam bean seeds (56.54%) and bambara groundnut seeds (51.64%) are relatively good sources of carbohydrates and besides, are also rich in protein. This property could make them to be utilized as high protein bean flour fractions that can be substituted in wheat flour to produce acceptable nutritious cookies, doughnuts, biscuits, breads and cakes [25-27,21,23] while the paste could be used for '*moin-moin*' and akara manufacture [24,28-30]. However, the low carbohydrate content of oil bean seeds could be attributed to its high moisture, protein and fat contents.

These results of the proximate composition of the selected legumes are in agreement with published literatures [31-34]; [21-22] and slight difference(s) could be attributed to differences in varieties of legume seeds or method of sample preparations.

3.2 Assessment of the Quality Attributes of Oil Samples Extracted from Soybean, Oil Bean and Groundnut Seeds

Oil yields of yam bean seeds (2.50%), cowpea seeds (2.80%) and Bambara groundnut seeds (7.90%) were poor and thus would require a lot oils for the assessment of their quality attributes.

Therefore, groundnut (*Arachis hypogaea*), oil bean (*Pentaclethra macrophylla*) and soybean (*Glycine max*) seeds with high oil yields of 40.30%, 25.50% and 19.50% respectively were the legume seeds considered for the assessment of the quality attributes (physical and chemical properties) of their oils. The results on the physical and chemical properties such as specific gravity (SG), colour, moisture contents, free fatty acids (FFA), acid value, peroxide value, saponification value and iodine value of the three oils (groundnut, oil bean and soybean) are presented in Table 2.

The colours were golden yellow for soybean oil, amber for groundnut oil, and brown for oil bean oil. The state at room temperature (27^0C) was generally liquid. The specific gravity was highest in soybean oil (0.917), followed by groundnut oil (0.913) and was lowest in oil bean oil (0.910). This indicates that soybean oil was the heaviest among the three oils while oil bean oil was the lightest: this could help in the separation of a mixture of the three oils. These specific gravity values are in line with WHO limits and also are within the range of values reported for other fats

Table 1. Mean proximate composition of the legume seeds

Parameter	Cowpea (*Vigna unguiculata*)	Bambara (*Voadzeia subterranea*)	Yam bean (*Sphenostylis stenocarpa*)	Oil bean (*Pentaclethra macrophylla*)	Soybean (*Glycine max*)	Groundnut (*Arachis hypogaea*)
Moisture (%)	11.30	10.60	10.20	36.44	9.98	9.98
Crude protein (%)	22.83	20.86	22.86	22.93	43.02	22.45
Crude fat (%)	2.80	7.90	2.50	25.50	19.50	40.30
Crude fibre (%)	1.78	5.45	5.05	4.95	1.25	1.63
Ash (%)	3.53	3.55	2.85	3.26	5.40	2.70
Carbohydrate (%)	57.76	51.64	56.54	6.92	20.85	22.93

**Values are means of triplicate values*

Table 2. Quality attributes of soybean oil, oil bean oil and groundnut oil samples

Quality attributes	Soybean (*Glycine max*) oil	Oil bean (*Pentaclethra macrophylla*) oil	Groundnut (*Arachis hypogaea*) oil
Colour	Golden yellow	Brown	Amber
Specific gravity	0.917	0.91	0.913
Moisture content (%)	0.43	0.75	0.60
Free fatty acid	0.17	0.37	0.48
Acid value	0.34	0.73	0.96
Peroxide value (mg/g oil)	9.80	21.20	18.00
Saponification value (mg/g oil)	187.94	306.86	194.95
Iodine value (mg/ 100g)	122.21	98.22	93.40

**Values are means of triplicate values*

and oils [35,36,15,37]. The specific gravity could also serve as index for determinations of adulterated products as lower values could connote poor quality.

The moisture content was highest (0.75%) in oil bean oil, followed by groundnut oil (0.60%) and was lowest in soybean oil (0.43%). This could indicate that soybean oil could store for a longer period of time without much deteriorations (i.e through development of rancidity) than groundnut and oil bean oils since the higher the moisture content, the higher the expected free fatty acid level [38]. The results are in agreement with the report of Hasan et al. [39] Studies have revealed that the higher the value of the moisture content of the oil, the greater the value used for food texturizing, baking and industrially in the manufacture of soaps, detergents, cosmetics and oil paints [40]; Hassan et al. [39].

The percentage free fatty acid (% FFA) ranged from 0.48% in groundnut oil to 0.17% in soybean oil, thus indicating that all the oils had percentage free fatty acid concentrations much below maximum limit of 5.00% reported for high grade in Nigeria Palm Oil [41]. Furthermore, these values are within the limits of 0.00 – 3.00% desired of cooking vegetable oils in the tropics [42-44]. For instance, on enquiries, it was discovered that Slok Vegetable Oil Nigeria Ltd accepts oils with percentage free fatty acid of 0.00 – 5.00%; International Equitable Association (IEA) Aba, Nigeria, PZ Industries Ltd and Unilever Nigeria Ltd accept oils with percentage free fatty acid of 0.00 – 7.00%. However, on comparison among the three oils, soybean oil with the lowest percentage free fatty acid of 0.17% was least deteriorated via oxidative or hydrolytic rancidity and thus, would be better in edibility than oil bean and groundnut oils. Fats and oils are degraded by the process of hydrolysis, which occurs in the presence of moisture, and enzyme known as lipase. The lipase splits triglycerides of the fats and oils into their basic components of glycerols and free fatty acids. The free fatty acids, especially if odorous, contribute to rancid flavours and odours in fats and oils. Therefore, as rancidity is usually accompanied with free fatty acid formations, the determination is often used as general indication of the condition and edibility of oils [44,13,43].

Acid value was highest in groundnut oil (0.96), followed by oil bean oil (0.73) and then lowest in soybean oil (0.34%). The acid value, which is a measure of the total acidity of the oil, is a preferred quality control parameter used by paint manufacturers to monitor the concentrations of acids in resins [45-46] [12,15]. It is an important index for oxidation of oil. According to Sharma and Jain [47] the acid value of good oil should be low (< 0.1). Thus increase in acid value should be taken as an indicator of oxidation of oil which may lead to gum and sludge formations.

Oil bean oil had the highest peroxide value of 21.20 mg/g oil, followed by groundnut oil (18.00 mg/g oil) while soybean oil had the lowest value of 9.80 mg/g oil. Peroxide value estimates degree of oxidation of an oil or how prone an oil can go rancid, but it is not a complete measure of oxidation of oils and fats. From the results, soybean oil would be less prone to go rancid or deteriorate than groundnut and oil bean oils since fresh oils have been shown to have peroxide values lower than 10.00 mg/g oil (WHO/FAO limits), and oils deteriorate or become rancid when the values change from 20.00 – 40.00 mg/g oil [48,37].

Peroxides are the first oxidation products of unsaturated fats and oils. These peroxides will breakdown to produce secondary oxidation products (aldehydes and ketones) that indicate rancidity.

The saponification value was highest in oil bean oil (306.86 mg/g oil), followed by groundnut oil (194.95 mg/g oil) and was lowest in soybean oil with a value of 187.84 mg/g oil and thus these values agree with reported values [18, 36, 13, Hasan et al. [39]. The result of soybean oil (187.84 mg/g oil) was slightly lower than the results reported by Katkade et al. [15] for soybean oil (199.91 mg/g oil) but higher for safflower oil (162.96 mg/g oil). These differences could be attributed to varietal differences of the seeds. These values indicate that these oils especially groundnut and oil bean oils (with high saponification values) could be utilized for manufacture of soaps and detergents [49,36,40,39]. For example, International Equitable Association (IEA) Nigeria, PZ Industries Ltd and Unilever Brothers Nigeria Ltd accept oils with saponification values ranging from 190.00 – 250.00 mg/g oil for manufacture of soaps and detergents [36]. Soap is formed during saponification, which primarily involves the hydrolysis of oil's basic constituent, triglycerides with metallic alkali (e.g potassium or sodium hydroxide) into glycerols and salt of fatty acids. Thus a saponification value or number is a measure of milligrams of potassium hydroxide

required to saponify one gram of fat or oil. The higher the saponification value, the lower the fatty acids average length and the lower the mean weight of triglycerides and vice versa.

Soybean oil had the highest iodine value of 122.21 mg/g oil, followed by oil bean oil (98.22 mg/g oil) while the groundnut oil had the lowest value of 93.40 mg/g oil. This result reflects that soybean oil contains more unsaturated bonds than both oil bean and groundnut oils. However, though with much preference to soybean oil, oil bean and groundnut oils contain high unsaturated bonds in relative to palm oil with iodine value of 52.00 mg/g oil [49,13]. Iodine value measures the proportions of unsaturated fatty acids present in the oil or fat. Practically, all edible fats and vegetable oils have iodine values ranging from 65.00 – 130.00 [39,15]. Therefore, soybean, oil bean and groundnut oils have wide applications in food industries in food preparations owing to their health benefits in controlling coronary heart problems. For instance they could be utilized in the manufacture of cooking oils, margarines, seasoning, salad oils, shortenings, medium chain triglyceridesetc [36,12,13,14,8].

4. CONCLUSION

Proximate composition of the six selected legumes analyzed, revealed that they were good sources of protein, but only three legumes (i.e with oil yields above 10.00%) were good sources of vegetable oils. These three legumes were soybean (*Glycine max*), oil bean (*Pentaclethra macrophylla*) and groundnut (*Arachis hypogaea*) with oil yields of 19.50%, 25.50% and 40.30% respectively. Assessment of the quality attributes of these three oils highlighted their potentials for utilizations in a variety of industries for the manufacture of margarines, seasonings, cooking oils, salad oils, shortenings, confectioneries, soaps, paints, cosmetics, lubricants, pharmaceutical products and many other products, but soybean oil remains the best oil in edibility and many other food applications. Besides, the resulting cakes are rich in proteins and could be utilized in feed formulations.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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