Proximate composition of some selected legumes and quality attributes of oils extracted from soybean, oil bean and groundnut seeds.

Abstract

Oil contents through analysis of proximate composition ofthe seeds of six legumes were investigated in order to assess the quality attributes of some of their oils. These legumes were cowpea (*Vignaunguiculata*), bambara groundnut (*Voandzeiasubteranea*), yam bean (*Sphenoostylisstenocarpa*),oil bean (*Pentaclethramacrophylla*), soybean (*Glycine max*) and groundnut (*Arachishypogaea*) 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 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.

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, legumes are common crops. Ihekoronye and Ngoddy (1985) reported that about 40% of the world production of the grain legumes and 20% of the soybeans are produced within the tropics.

The legumes refer to the edible seeds of leguminous plants belonging to the *Leguminosae*family. Leguminous plants are those that are ableto form their proteins from the air, with the help of the bacteria in the nodules of their roots (Hindreth, 1971; Harris, 2004). Thus legumes are next in importance to cereals and contain more protein than any other products (Purseglove, 1991; Maphosa and Jideani, 2017). The importance of *Leguminosae* family in the context of human nutrition is very considerable (Tindall, 1983) 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.

Vegetable oils (i.e derived from the seeds and fruits of plants) are of higher importance to the

food processor than animal fats. They provide not only vitamins and essential fatty acids but are also useful in diet for the treatment of patients with familial hypercholesterolemia because of their high contents of polyunsaturated fatty acids (Subbulakshmi and Udipi, 2001).
According to Weiss (1983) 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, varnishes, paints, cosmetics, soaps, lacquers, linoleum, emulsions, textile improvers, pharmaceutical products and surface active materials.

The present study investigates the proximate composition (with emphasis on oil yields) of selected commercially available legumes 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 (*Vignaunguiculata*), bambara groundnut (*Voandzeiasubteranea*), yam bean (*Sphenoostylisstenocarpa*),oil bean (*Pentaclethramacrophylla*), soybean (*Glycine max*) and groundnut (*Arachishypogaea*).

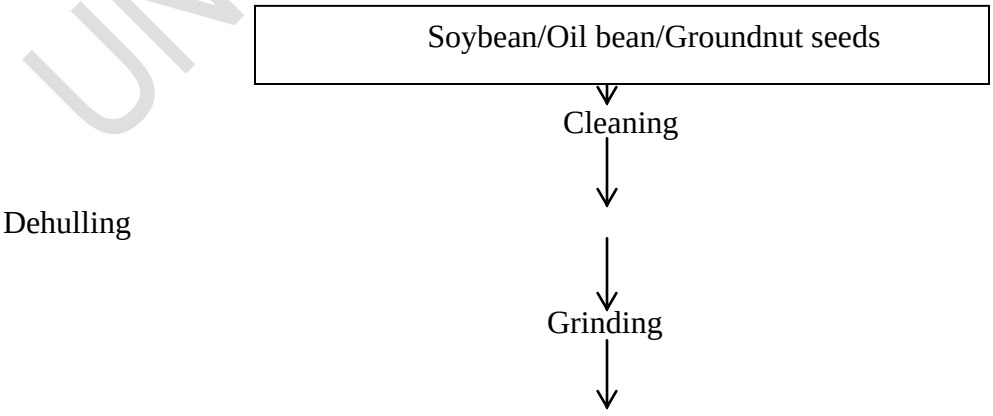
Materials and Methods

Materials

Leguminous seeds of cowpea (*Vignaunguiculata*), bambara groundnut (*Voandzeiasubteranea*), yam bean (*Sphenoostylisstenocarpa*), oil bean (*Pentaclethramacrophylla*), soybean (*Glycine max*) and groundnut (*Arachishypogaea*) were purchased at Owerri main market in Imo state, Nigeria.

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^{o}C for 1 h. Dried samples were hermetically stored at room temperature 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 (AOAC, 2005).
Oil extraction from the samples: Oils were extracted from ground groundnut, oil bean and soybean seed samples using the method outlinedby the Association of Official Analytical Chemists (AOAC, 2005).



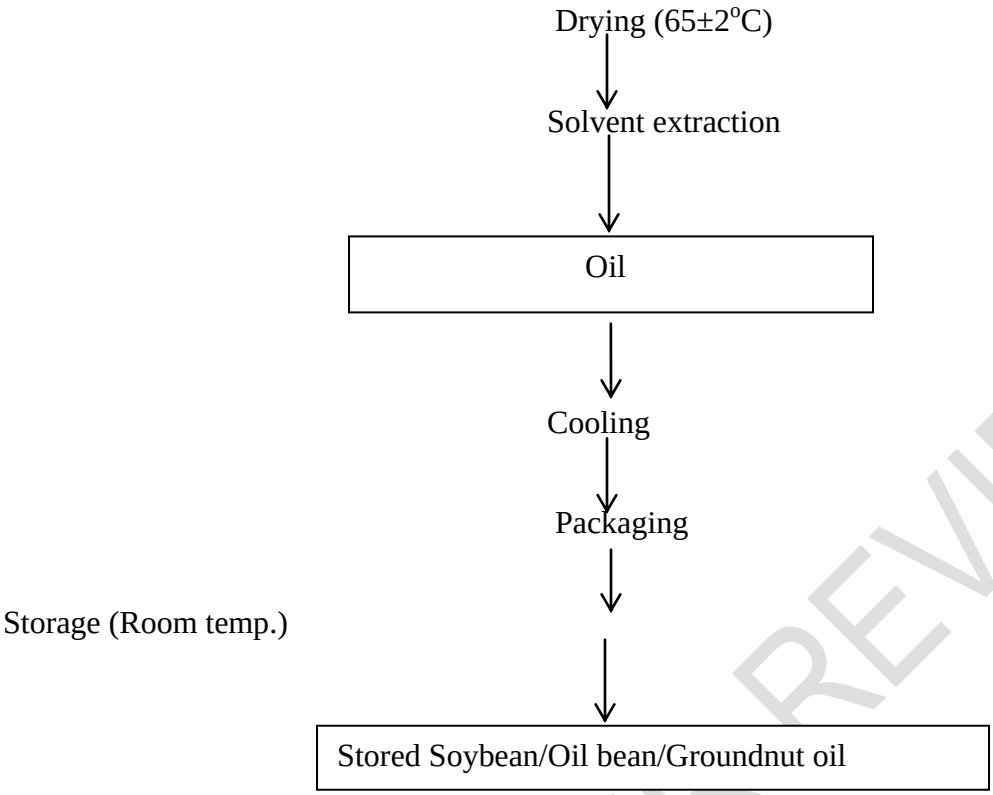


Figure 1. Flow chart for extraction of oil samples from legume seeds

Source: Modified AOAC, 2005

Assessment of the quality attributes of the oil samples extracted from soybean, oil bean and groundnut seeds

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 (AOAC, 2005).

Determination of the Specific Gravity: It was determined using the procedure described by Association of Official Analytical Chemists (AOAC, 2005).

Determination of Free Fatty Acid (FFA): The method described by Uzomah*et al*. (2002) was adopted for the determination of free fatty acid contents of the oil samples.

Determination of Peroxide Value: The method described by Uzomah*et al*. (2002) was adopted in the determination of peroxide values of the oil samples.

Determination of Saponification Value (IV): The experiments were carried out in accordance with the method described by Association of Official Analytical Chemists (AOAC, 2005).

Determination of Iodine Value: Iodine values of the oil samples were determined in accordance with the method described by Association of Official Analytical Chemists (AOAC, 2005).

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

Results and discussion

Table 1. Mean proximate composition of the legume seeds

Parameter	Cowpea (*Vignaunguiculata*)	Bambara(*Voadzeiasubterranea*)	Yam bean (*Sphenostylisstenocarpa*)	Oil bean (*Pentaclethramacrophylla*)
Moisture (%)	11.30	10.60	10.20	36.44
Crude protein (%)	22.83	20.86	22.86	22.93
Crude fat (%)	2.80	7.90	2.50	25.50
Crude fibre (%)	1.78	5.45	5.05	4.95
Ash (%)	3.53	3.55	2.85	3.26
Carbohydrate (%)	57.76	51.64	56.54	6.92

Proximate composition of the legume seeds

The results of the proximate composition of the seed samples namely, cowpea (*Vignaunguiculata*), bambara groundnut (*Voandzeiasubteranea*), yam bean (*Sphenoostylisstenocarpa*),oil bean (*Pentaclethramacrophylla*), soybean (*Glycine max*) and groundnut (*Arachishypogaea*) 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 (Okereke*et al*., 2021[a]).

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 (Kochlar, 1986), and thus suggest that they could contribute to the daily protein need of 23.6 g for adults as recommended by the National Research Council (1974).

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 (Okereke, 2005). 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 (Okereke*et al*., 2021[b]). 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 (Okereke*et al*., 2021[b]).

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 elements of foods (Ayo *et al*., 2010; Okereke*et al*., 2021[a]).

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 (Urbersax and Zabik, 1986; Okereke*et al*., 2021[a]; Okereke*et al*., 2021[b]) while the paste could be used for '*moin-moin*' and akara manufacture (Nzereogu, 1993; Iheanacho, 1998). 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 (Purseglove, 1991; Enwere, 1998; IITA, 1990; Iwe, 2003; Okereke*et al*., 2021[a]; Okereke*et al*., 2021[b]) and slight difference(s) could be attributed to differences in varieties of legume seeds or method of sample preparations.

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 (*Arachishypogaea*), oil bean (*Pentaclethramacrophylla*) 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.

Table 2. Quality Attributes of Soybean oil, Oil bean oil and Groundnut oil Samples

Quality attributes	Soybean (*Glycine max*) oil	Oil bean (*Pentaclethramacrophylla*) oil	Groundnut (*Arachishypogaea*) 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

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 arewithin the range of values reported for other fats and oils (Hilditch and Riley, 1964; Altman and Dittmer, 1972; Gerald, 1976; Okereke, 2005; Negash*et al*., 2019). 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.ethrough development of rancidity) than groundnut and oil bean oils since the higher the moisture content, the higher the expected free fatty acid level (Nkpa*et al*., 1990).

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 (NIFOR, 1989). Furthermore, these values are within the limits of 0.00 – 3.00% desired of cooking vegetable oils in the tropics (Bassir, 1971; Ukom*et al*., 2018). 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 bebetter in edibilitythan 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 (Egan *et al*., 1981).

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 (Ekpa and Ekpe, 1995). It is an important index for oxidation of oil. According to Sharma and Jain (2015) 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 (Pearson, 1976;Negash*et al*., 2019).

Peroxides are the first oxidation products of unsaturated fats and oils. These peroxideswill 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 (Altman and Ditmer, 1972; Weiss, 1983; Okereke, 2005). 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 (Eka, 1989; Okereke, 2005).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 (Okereke, 2005). Soap is formed during saponification, which primarily involves the hydrolysis of oil's basic constituent, triglycerideswith 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 withiodine value of 52.00 mg/g oil (Eka, 1989).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 (Woods and Aurand, 1977). 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 (Okereke, 2005).

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 (*Pentaclethramacrophylla*) and groundnut (*Arachishypogaea*) 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 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..

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. 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.

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