DETERMINATION OF PHYSICOCHEMICAL PROPERTIES OF SELECTED VEGETABLE OILS IN MINNA

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Abstract: The present study investigates the physicochemical properties of selected brands of vegetable oils (groundnut, soya bean oil, palm oil and palm kernel oil) sold in Minna, using standard procedure. The specific gravity of the oil ranged from 0.93±0.30 to 0.96±0.20. There was a significant difference in the relative densities of the oils studied. Natural palm oil has the highest relative density (1.42±0.26) while natural grand pure oil has the least (1.36±0.13). The refractive index varied from 1.35±0.05 to 1.45±0.35. The high refractive index of the oil samples showed that there was high number of carbon atoms in their fatty acids. The saponification values for oils investigated in this study ranged from 151.16±0.25 to 207.90±0.10 mgKOH/g. The iodine value ranged from 31.61±0.55 mgI_2/g to 103.16±0.76 mgI_2/g, which indicates that the oil samples contained appreciable level of unsaturated bonds. Palm oil has the highest acid value (1.13±0.21 mg NaOH/g) while the least value was found in Baron oil (0.42±0.03 mg NaOH/g). The acid values of the oil brands did not differ significantly. The peroxide values varied from 0.37±0.06 to 6.97±0.4 meq/kg. The values of all these parameters were within FAO recommended standard for edible oil. Thus indicating that, the sample oils under study are of good quality and suitable for consumption.

Keywords: Physicochemical, vegetable oil, saponification value, acid value, peroxide value

Introduction

Vegetable oil is the name usually given to any oil product derived from plant of any description, be it fruit, vegetable or anything else. Some oils, such as olive, are derived from the fruits of the plant. Others, like sunflower oil or groundnut oil are pressed from the seeds. Some other oils such as herbs oils are usually extracted from the leaves or roots, often using steam or other heat sources to aid the process (Adedokun, 2014). Oils, such as those extracted from herbs and plant roots are thought by many to have direct medicinal effects. Usually theses oils are very potent and are used in minutes quantities, diluted with other oils or lotions, as in aromatherapy. Such essential oils are also the basis for virtually all of the fragrances and perfumes widely available (Oguntibeju *et al*., 2010).

Vegetable oils are derived from plants sources like soya beans, melon, groundnut, corn, oil, sheabutter, coconut, etc. Some of these vegetable oils are used for domestic purposes (edible). Nutritionally, vegetable oils are usually preferred to animal fat because of the presence of polyunsaturated fatty acids. The oils are sometimes referred to as fixed oils because they are not as volatile as essential oils. Vegetable oils have wide range of uses, and whilst many of these involve processes that are too technical for small scale ventures. There are still many ways in which we can employ them as food or as lubricants, as fuel for paraffin lamps and as wood preservatives (Goldberg and Gunstone, 2002). Some of them also have medicinal properties and act as excellent solvent for the dilution of essential materials for body and skin care products. The characteristics of oils from different sources depend mainly on their compositions; no oil from a single source can be suitable for all purposes thus the study of their constituents is important (Riechart, 2002).

Oils are often divided into three categories according to their qualities, these categories are non-drying, semi-drying and drying (Gunstone, 2002). Non-drying oils are slow to oxidize and so remain liquid for a long time. This quality makes them particularly useful as lubricants and as fuel for lamps. Drying oils, on the other hand, are quite quick to oxidize and become solid, thus they are often used in paints and varnishes; a good example being linseed oil while semi-drying oils have qualities intermediate between the above two groups (Rhadika *et al.*, 2003). Soya beans oil is a vegetable oil extracted from the seeds of soybeans (*Glacine max*). It is the dominant valuable edible oil from oilseed produced in the world, due to its favourable agronomic characteristics and high quality protein content (Amos-Tautua, 2013). It is a drying oil, which means that it will slowly harden upon exposure to air, forming a flexible transparent, and water proof solid. Because of this property, it is used in some printing and oil paint formulation. It is used as fixative to extend the short duration of action of essential oil such as geranium oil in several industrial products (Adedokun, 2012). Soya bean oil is considered to be the most suitable for food formulation as well as drying oil in pharmaceutical, paints, soap and perfume industries because of its higher level of unsaturated fatty acid contents (Amos-Tautua, 2013).

Groundnut oil is derived from groundnut (*Arachis hypogea*). It is a vegetable oil which contains only a small proportion of non-glycerides constituents. Its fatty acid composition is complex including saturated fatty acids covering a wide range of molecular weights. Groundnut oil has a high smoke point relative to many other cooking oils (Aluyor *et al.*, 2009). Palm oil is produced from the fruit of oil plant *Elaeis guinnesis* which is found in Africa, South East Asia and Latin America. Palm oil is extracted and refined through pressing and crushing rather than through using chemical solvents such hexane. Palm oil can be further refined into palm olein (liquid) and palm stearin (solid). Palm olein is used as frying oil because it is very stable to heat; while palm stearin is used in biscuits and cakes and in non-hydrogenated margarine (Oguntibeju *et al.*, 2010).

A wide variety of vegetable oils of varying quality are available in Nigerian markets. Some of these oils are usually adulterated by adding other additives which could affect their chemical compositions and suitability for some industrial uses. It is therefore paramount to continually investigate the chemical parameters of oils in the market. To this end, the aim of the study is to investigate some physicochemical properties of selected vegetable oils (groundnut, soybean oil, palm oil and palm kernel oil) sold in Minna metropolis in order to ascertain whether they meet the standard recommended by regulatory agencies for consumption and other uses.

Materials and Methods

Sample collection and preparation

Five vegetable oil samples were bought from the central market in Minna, under various brand names and the samples were stored in light proof and airtight container in the laboratory and stored at room temperature. The brand names and their compositions are as shown in Table 1.

Table 1: Sample of oil analysed and their major composition

Brand names	Composition
Baron oil (BO)	Palm kernel vegetable oil
Ideal oil (IO)	Palm kernel vegetable oil
Natural grand pure oil (NGPO)	Soybeans
Natural groundnut oil (NGO)	Local groundnut oil
Natural Palm oil (NPO)	Local palm oil

Determination of specific gravity of the oil

50 ml pycometer bottle was thoroughly washed with detergent, water, petroleum ether. It was then dried and weighed, the bottle was filled with water and weighed after which the bottle was dried and filled with the oil sample and re-weighed. The specific gravity and relative density were calculated as

Relative density = weight of oil/volume of oil

Specific gravity = (weight of X ml of oil)/weight of X ml of water

Determination of chemical properties

This was done following standard procedures of AOAC (2006). The properties analysed include: peroxide, iodine, saponification and acid values.

Determination of peroxide value

25 ml of acetic acid-chloroform mixture 2:1 was added to one gram (1 g) of oil sample in a beaker. After shaking, 1 ml of potassium hydroxide and 35 ml of distilled water was added. This was then followed by 1 ml of starch solution. This was then allowed to stand for 1 min. The mixture was titrated with 0.002 M sodium thiosulphate solution to end point. The procedure was repeated for blank sample. The peroxide value of oil was calculated as:

Peroxided value of oil = A-B x M x 1000 meq/kg/W

Where: A = titre value of oil sample; B = titre value of blank; M= molarity of sodium thiosulphate; W= weight of oil sample used

Determination of acid value of oil

50 ml of rectified ethanol was added to 5 g of the oil sample in a beaker. The mixture was heated for thorough mixing after which 3 drops of phenolphthalein indicator was added. It was then titrated with 0.1 M potassium hydroxide to obtain a pink colour end point. The procedure repeated for blank sample. The peroxide value of oil was calculated as:

Acid value of oil = (A-B) x M x 56.1/W

Where molecular mass of KOH was expressed as 56.1

A= titre value for oil sample; B = titre value for blank; M = molarity of NaOH; W= weight of oil sample used

Determination of iodine value of oil

0.1 g of the oil sample was weighed into a glass tube which was placed in a 300 ml conical flask. 15 ml of carbon tetrachloride and 25 ml of Wiji's reagent were then added. A stopper was inserted to mix it. This was allowed to cool for 1 hour at room temperature in a dark place. Thereafter, 10 ml of potassium iodide solution was added with continuous agitation. The content was titrated with 0.1 M sodium thiosulphate using starch solution as indicator. The flask was vigorously shaken till a yellow colour end point was obtained. The procedure was repeated for blank sample. The iodine value of oil was calculated as:

Iodine value of oil = 126.9 x M x ($V_1 - V_2$)/W

Where the molecular mass of iodine was expressed as 126.9

M = molarity of sodium thiosulphate

V_1 = volume of sodium thiosulphate used for oil

V_2 = volume of sodium thiosulphate used for blank

W = weight of the oil used

Determination of the saponification value of oil

2 g of the oil was weighed and refluxed with constant stirring with 25 ml of ethanolic potassium hydroxide solution in a flask filter with a reflux condenser with about 60 min. Thereafter, 2 drops of phenolphthalein was added to the solution immediately and a pink colour solution was noticed. The solution was then, titrated with standardized hydrochloric acid in the burette to give a colourless end point. Saponification value of oil was calculated as:

Saponification value of oil = 56.1 M x (V_1-V_2)/W

V_1= volume of HCl for oil sample; V_2= volume of HCl for blank sample; M= molarity of HCl used; W= weight of oil used; 56.1 = molar mass of KOH

Statistical analysis

Triplicate analyses were done in all cases. The result obtained was expressed as Mean ± SD. Statistical differences among means were done using ANOVA and means were separated according to Duncan's multiple range analysis (P<0.05).

Results and Discussion

Physical Properties of the Oils

The physical properties of the oil samples investigated are shown on Table 2. There was a significant difference in the relative densities of the oils studied. Natural palm oil (NPO) has the highest relative density (1.42±0.26) while natural groundnut (NGO) has the least (1.36±0.13). The high relative density could be an indication of high molecular weight and unsaturation as the density of an oil increases with increasing molecular weight and unsaturation (Onyeka *et al.*, 2005).

Table 2: Physical properties of oil samples investigated

Oil brands	Relative density	Specific Gravity	Refractive index
BO	$1.37{\pm}0.10^{ab}$	$0.93{\pm}0.30^{a}$	$1.43{\pm}0.30^{b}$
NGPO	$1.41{\pm}0.18^{cd}$	$0.96{\pm}0.20^{a}$	$1.35{\pm}0.05^{a}$
NGO	$1.36{\pm}0.13^{a}$	$0.95{\pm}0.53^{a}$	$1.42{\pm}0.10^{b}$
NPO	$1.42{\pm}0.26^{d}$	$0.96{\pm}0.10^{a}$	$1.44{\pm}0.09^{b}$
IO	$1.39{\pm}0.10^{bc}$	$0.95{\pm}0.15^{a}$	$1.45{\pm}0.35^{b}$

Results are expressed as mean ± SD. Values with the same superscript on the same column do not differ significantly at (P<0.05) according to Duncan's multiple range analysis. Baron oil= BO; Natural palm oil= NPO; Natural grand pure oil=NGPO; Ideal oil=IO; Natural groundnut = NGO

The specific gravity of all the samples did not differ significantly. The range was from 0.93±0.30 to 0.96±0.20. The specific gravity of all the oils were less than 1, this implies water is heavier than the oils. The specific gravity of oil obtained in this study is higher than 0.82-0.92 range reported by Akubugwo and Ugbogu, 2007 for *L. owariens* seed oil and *N. imperalis* seed oil. These values are comparable with 0.82 and 0.84 reported for the pulp and seed oil respectively of *D. edulis* by Ajayi and Oderinde (2002). The highest refractive index obtained in the study was 1.45±0.35 for ideal oil, while the least was 1.35±0.05 for NGO. This is in close agreement with 1.47 reported by Aremu *et al.* (2015) in a similar study. This is lower than

1.79 reported by Brenes *et al*. (2000). Thus, suggesting that there was no significant difference in the degree of flow or thickness of all the oils at room temperature. The high refractive index of this oil suggests that there is high number of carbon atom in their fatty acids (Falade *et al*., 2008).

Chemical properties of the oils

Table 3 shows the chemical properties of the oils analysed. The saponification values for oils investigated in this study ranged from 151.16±0.25 to 207.90±0.10 mgKOH/g. The lowest and highest values were found in atural grand pure oil (NGPO) and ideal oil (IO), respectively. Differences in the saponification values of all the samples investigated were significant at level p <0.05. The saponification values were in the order IO>BO>NPO>NGO>NGPO.

Saponification value (SV) shows the extent of usefulness of the oil in soap making. It is an indication of the milligrams of KOH necessary to saponify 1g of oil sample. The SV obtained in this work is within the range of 5.58 - 249.90 mgKOH/g reported by Aremu *et al*. (2015) in some Nigeria oil seeds. The value obtained for ideal oil is higher than 178.03±1.25 mgKOH/g reported by Abdulhamid (2014) for egusi oil. The saponification value obtained for Baron oil (BO) (205±0.90 mgKOH/g) and Ideal oiI (IO) (207.90±0.10 mgKOH/g) are lower when compared to 242-254 mgKOH/g recorded by AOCS (2006), for palm kernel oil. The values for some of the investigated oil brands are in agreement with the result of 179.04 ± 1.60 mg KOH/g reported by Muibat *et al*. (2008) in their work on seed oil of *Telfairia occidentalis*. The SV of 198.76±0.31 mgKOH/g obtained for natural palm oil (NPO) is higher than 190-202 mgKOH/g for palm oil as recorded in AOCS (2006). The result for SV showed that most of the oils studied could be useful in soap making (Amoo *et al*., 2004).

There was a wide variation in the iodine value among the various samples of oils. Baron oil (BO) recorded the lowest iodine value (31.61±0.55 mgI_2/g). The iodine value of natural grand pure oil (NGPO) was the highest among those analysed (103.16±0.76 mgI_2/g). This value for NG was more than three times that of BO. Iodine value gives the extent of unsaturation in oil sample. It is the amount of iodine (in grams) that is required to bring about the complete saturation of 100 g of oil sample. The iodine values of BO (31.61±0.55 mgI_2/g) and IO (34.90±0.86 mgI_2/g) in this study are higher than the range of 16-23 mgI_2/g reported in AOCS (2006) for palm kernel oil. The iodine values of all the oil brands investigated were lower when compared to the result reported by Muibat *et al.* (2008) in their study of seed oil of *Telfairia occidentalis* and 132.7 mgI_2/g reported for soya beans oil by Aremu *et al*. (2015). The value obtained for BO is also lower when compared to 49.10±0.32 mg I_2/100g obtained in egusi oil by Abdulhamid (2014). The iodine value of NP (57.50±0.51 mgI_2/g) is higher than 50-55 mgI_2/g documented in AOCS (2006) for palm oil and 15.10±0.08 - 45.86±80±2.00 mg I_2/100g reported by Akubugwo and Ugbogu (2007) in oil from *L. owariensis* and *N. imperialis*.

The iodine value of oil is an index of for assessing the level of unsaturation and ease with which the oil can go rancid (Amoo *et al*., 2004). The iodine values obtained in this study indicate that the oils contain appreciable level of unsaturated bonds. The high value of iodine value obtained for natural grand pure oil sample suggests the presence of fatty acids that are less saturated. The appreciably high levels of unsaturated fatty acids in both soybeans and groundnut oils showed that these oils can be classified as drying. This unique attribute qualifies the oils for use in the paint industry (Dosunmu and Ochu, 1995).

Acid value is an indication of the quality and suitability of oil for consumption and its usability in paint making. It shows the free fatty acid content of the oil (Akubuguwo *et al*., 2008). Among the various brands oil analysed, palm oil has the highest acid value (1.13±0.21 mg NaOH/g) while the least value was found in Baron oil (0.42±0.03 mg NaOH/g). The acid values of most of the samples studied did not differ significantly. The acid values are used to measure the extent to which glycerides in the oil have been decomposed by lipase and other physical changes palm oil has undergone. The acid value reported in this study is lower than 3.56±0.20 documented by Akubuguwo *et al*. (2008) for *C. albidum* oil and 3.48 ± 0.06 mg KOH/g reported by Muibat *et al.* (2008) in a similar study.

Table 3: Chemical properties of the oil samples investigated

Oil brands	Peroxide value (meq/kg)	Acid value (mg NaOH/g)	Iodine value (mgI_2/g)	Saponification value (mgKOH/g)	Unsaponifiable Matter (g/kg)
BO	$2.13±0.05^b$	$0.42±0.03^a$	$31.61±0.55^a$	$205±0.90^d$	$8.37±0.25^a$
NGPO	$6.63±0.25^c$	$0.44±0.04^a$	$103.16±0.76^e$	$151.16±0.25^a$	$13.20±0.34^d$
NGO	$6.97±0.41^c$	$1.00±0.96^b$	$98.50±0.50^d$	$190.33±0.81^b$	$8.87±0.70^b$
NPO	$0.37±0.06^a$	$1.13±0.21^b$	$57.50±0.51^c$	$198.76±0.31^c$	$11.00±0.20^c$
IO	$1.90±0.30^b$	$0.60±0.10^a$	$34.90±0.86^b$	$207.90±0.10^e$	$8.88±0.90^b$

Results are expressed as mean±SD. Values with the same superscript on the same column do not differ significantly at p≥0.5
Baron oil: BO; Natural palm oil: NPO; Natural grand pure oil: NGPO; Ideal oil: IO; Natural ground nut: NGO

From Table 3, the peroxide values of the various samples analysed ranged from 0.37±0.06 to 6.97±0.4 meq/kg. The highest value was found in the natural groundnut oil while palm oil has the least. The peroxide value for the natural grand pure oil (NGPO) and that of the natural groundnut oil (NGO) did not differ significantly. The value is lower than 290.00 $mEqO_2/kg$ reported by Aremu *et al.* (2015). With the exception of NGPO and NGO which have peroxide values of 6.63±0.25 and 6.97±0.41 meq/kg, respectively, the values obtained in the oil investigated are less than 2.26 mEq/kg of seed oil of *Telfairia occidentalis* as reported by Muibat *et al*. (2008). The peroxide value is used as an indicator of deterioration of oils. Fresh oils have values less than 10 mEq/kg. The values between 20 and 40 resulted to rancid taste. It shows the quantity of oxidizable substances, normally hydroperoxides that liberate iodine from potassium iodide under specified conditions (Bala, 2005).

Conclusion

The physical properties of the various brands of oils investigated in this study did not differ significantly. The wide variations among their chemical properties account for the differences in their compositions. Their physicochemical properties as obtained in this study showed that they are all suitable for consumption as they are within the permissible ranges set by various standards. The high saponification values obtained showed that the oils could be recommendable for soap production.

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