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Characterization of the Chemical Properties of Some Selected Refined Vegetable Oils Commonly Sold in Nigeria

Kelle Henrietta Ijeoma[1*] and Udeozo Ifeoma Prisca[2]

[1]Chemistry Unit, School of Science and Technology, National Open University of Nigeria, Victoria Island, Lagos, Nigeria.
[2]Department of Chemical Sciences, Tansian University, Umunya, Anambra State, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author KHI designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript and managed literature searches. Author UIP managed the analyses of the study and literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To ascertain the suitability for consumption of some selected refined vegetable oils commonly found and sold in most of the markets located in Nigeria.
Study Design: Five different brands of vegetable oils commonly sold in Nigeria market, namely; Grand ground nut oil obtained from groundnut seed, turkey refined palm olein oil obtained from palm fruit, gino refined palm olein oil obtained from palm fruit, ideal refined palm kernel oil obtained from palm kernel seed and baron refined palm kernel oil obtained from palm kernel seed were subjected to Chemical analysis via determination of iodine value, acid value, peroxide value, saponification value and ester value of these oils.
Place and Duration of Study: The chemical analysis was carried out in the Chemistry laboratory of the National Open University of Nigeria suited on Ahmadu Bello Way, Victoria Island, Lagos State between May – June, 2014.
Methodology: The iodine value, acid value, Peroxide value and saponifcation value were

**Corresponding author: E-mail: henriettachima@yahoo.com;*

determined by standard procedures described by AOAC (1980) while the ester value was determined by baltes, 1964 method.
Results: The analysed chemical parameters shows that the iodine value of the oils are in the range of 21.83 g/100g to 79.95 g/100g, while the Saponification values of the oils are in the range of 235.62 mg/kOH/g to 274.19mg. The acid values and peroxide values of the oils are in the range of 0.39 mgKOH/g to 1.54 mgKOHg and 0.26 meq/kg – 1.17 meq/kg respectively while the ester value range from 206.70 mgKOH/g to 272.65 mgKOH/g.
Conclusion: The result of the study shows that the oils are non drying oils of low saturation, slow to oxidation and rancidity, will remain liquid for a long time and are suitable for consumption.

Keywords: Iodine value; acid value; non drying oil; oxidation and low saturation.

1. INTRODUCTION

Vegetable oils and fats are composed predominantly of triglycerides, which are long-chain fatty acid esters of glycerol [1,2]. The predominant fatty acids present in vegetable oils and fats are saturated and unsaturated compounds with straight aliphatic chains. An even number of other fatty acids may be present in same Vegetable sources, including a small amount of branched chain, cyclic and odd number straight chain acids [3]. The (minor) non ester portion of vegetable oils and fats include; Phospholipids (or phosphatides), sterols, vitamins and their precursors. The non-ester portion is usually less than 2% of the total oil. The glycerides themselves contain about 95% fatty acids and 5% glycerol [2]. The amount of glycerol is the same in all vegetable oils, hence, the differences on properties of different oils are largely determined by the variations on the fatty acid structure [2,3]. Glycerides composed mostly of unsaturated fatty acids are oils (liquids) at room temperature, while those composed mostly of saturated fatty acids are fats (solid) at room temperature [2]. An important feature common to most plant origin oils and fats is the high percentage of unsaturated fatty acids in the glyceride [3].

Vegetable oils are one of the major components of human diets comprising as much as 25% of average caloric intake [3]. While high levels of saturated fatty acids is desirable to increase oil stability, on the other hand, nutritionally they become undesirable. At room temperature (25ºC), the saturated fatty acids from 12 to 24 carbon length have a waxy consistency, whereas unsaturated fatty acids of these lengths are only liquids [4]. This difference is due to different degrees of packing of the fatty acids molecules. In the fatty saturated compounds, free rotation around each carbon-carbon bond gives the hydrocarbon chain great flexibility, the most stable conformation is the fully extended form in which the stearic hindrance of neigbouring atom is minimized. These molecules can pack together tightly in nearly crystalline arrays, with atoms all along their length. Van der waals contacts with atoms of neighbouring molecules. In unsaturated fatty acids, a cis double bond (the double bond in most naturally occurring unsaturated fatty acids are in the cis confuration) forces a kink in the hydrocarbon chain. Fatty acids with one or several such kink cannot pack together as tightly as fully saturated fatty acids and their interactions with each other are therefore weak [4,5]. Because of the waxy consistency of the saturated fatty acids, oils rich in saturated fatty acids tend to form diets, which result in the commonly known coronary diseases. When this oils are constantly consumed, they form solid fats deposit at both the cardiac region, the arteries and the veins. These fats tends to block the free flow of blood in these arteries and veins and thus increases the pressure to the blood flow and this eventually result to high blood pressure in which case if not treated carefully can lead to stroke and finally kills the victim [4].

Though the presence of unsaturated fatty acids in oils is preferred to saturated fatty acids in terms of consumption, high amount of unsaturated fatty acids in an oil makes it susceptible to polymerization and gum formation caused by oxidation during storage [6,7]. The polymerization product is a dry or hardened (solid) film. This imparts on the oil a level of industrial utility than edibility [2,7].

The quality and purity of oils are assessed by determining the number of physical and chemical constants. The chemical constants include acid value, iodine value, saponification value etc [2]. Of particular interest is the iodine value, because depending on its value, oils can classified into drying, semi drying and non drying. The ability of an oil to be converted into a solid film in the presence of oxygen is known as drying.

The vegetable oils to be tested in the study are grand vegetable oil obtained from groundnut seed, turkey vegetable oil obtained from palm olein, gino vegetable oil obtained from palm olein, ideal vegetable oil obtained from palm kernel seed and baron vegetable oil obtained from palm kernel seed. Groundnut oil is highly unsaturated, it is mainly composed of oleic acid, linoleic acid and palmitic acid [8]. Oleic acid is a monounsaturated fatty acid, linoleic acid is a polyunsaturated fatty acid containing two double bonds while palmitic acid is a saturated fatty acid. The lipid profile of groundnut oil is oleic acid 46.8%, linoleic acid 33.4% and palmitic 10.0% [8]. Palm olein is the liquid fraction derived from the fractionation of palm oil [9]. Its lipid profile is oleic acid 46%, palmitic acid 37%, linoleic acid 11%, stearic acid 4% and myristic acid 1% [9,10]. Myristic acid and stearic acid are saturated fatty acids. Palm kernel oil is a highly saturated vegetable oil. It is semi solid at room temperature, it is commonly used in commercial cooking because of its relative low cost, and because it remains stable at high cooking [11]. The lipid profile of palm kernel oil is lauric acid 48.2%, myristic acid 16.4%, palmitic acid 8.4%, capric acid 3.4%, caprylic acid 3.3%, stearic acid 2.5%, oleic acid 15.3%, linoleic acid 2.3%. Lauric acid, capric acid and caprylic acid are saturated fatty acids [11].

There are various brands of vegetable oils sold in the markets located in Nigeria, some are produced in the country while some are imported. Despite the strict regulations and enforcement by relevant regulatory agencies of sale of standard commodities to consumers, a times, manufacturers and importers do not comply to standards. Again, despite the tight security measures at the Nigerian sea ports, airports and borders, banned and substandard products still find their way into the country and eventually the markets [12].

In the light of the possible consequences of consuming oils high in saturated and unsaturated fatty acids, this study was undertaken, so as to access the quality of oils commonly sold in the Nigeria, if they are good for consumption, through examination of their chemical properties.

2. MATERIALS AND METHODS

Five different brands of vegetable oils found in almost all the market places in Nigeria, were purchased from the market. The five different brands of vegetable oils are Baron vegetable oil, Gino, Turkey, Ideal and Grand vegetable oils. Gino and Turkey are imported vegetable oils into the country while Ideal, Baron and Grand are produced in the country (Nigeria). The chemical properties of the oil namely the iodine value, saponification value, peroxide value and acid value were determined by standard procedures described by AOAC [13] while the ester value was obtained by subtracting the acid value from the saponification value [14].

2.1 Determination of Iodine Value [13]

0.2g of oil sample was weighed into a 250ml conical flask and dissolved with 15ml CCl_4 and 250ml of wijs reagent was added to the mixture. The flask was then stopped and gently shaken and placed in the dark for 30 minutes. The excess iodine was determined by adding 20cm^3 of 10% (w/v) KI solution and 150cm^3 water and titrating this with 0.1 M sodium thiosulphate using starch as indicator. The titration was continued until blue colour just disappeared after a vigorous shaking. A blank determination was carried out without addition of oil and the iodine value was determined using the equation:

$$\text{Iodine value (gI/100g oil} = \frac{12.69 \times C \times (V_1 - V_2)}{\text{Weight of sample}}$$

Where

C = Concentration of sodium thiosulphate used
V_1 = Volume of sodium thiosulphate used for blank
V_2 = Volume of sodium thiosulphate used for oil sample.

2.2 Determination of Acid Value [13]

5.0g of oil sample was weighed into a 250cm^3 conical flask. 50cm^3 solvent mixture (1:1) of 95% ethanol and diethyl ether were added and the solution was titrated with 0.1M KOH using 1 cm^3 of 1%(w/v) of phenolphthalein as indicator until pink coloration persists. The acid value was computed from the expression:

$$\text{Acid value (mgKOH/g oil)} = \frac{56.1 \times C \times V}{\text{Weight of oil}}$$

Where

C= Concentration of KOH used
V = Volume of KOH used
56.1 = Molecular weight of KOH.

2.3 Determination of Peroxide Value [13]

0.5g of oil was weighed into 250cm^3 conical flask. 10ml of chloroform and 15cm^3 of acid acetic were added and the mixture stirred after which 1cm^3 of (10% w/v) KI was added. The flask was stopped and shaken for one minute. The flask was placed in the dark for five minutes and 75cm^3 of water was added. The iodine liberated was titrated with standard sodium thiosulphate solution until yellow colour almost disappeared. 0.5 ml of (1 %) starch solution was added and the titration continued until blue colour just disappeared. Blank determination was performed. The peroxide value was calculated from the relationship:

$$\text{Peroxide value (meq}O_2\text{/Kg oil)} = \frac{(V_O - V) \times C}{\text{Weight of oil}}$$

Where

C = Concentration of sodium thiosulphate used
V_o = Volume of sodium thiosulphate used for blank
V = Volume of sodium thiosulphate used for oil sample.

2.4 Determination of Saponification Value [13]

20g of oil was weighed into a 250 cm^3 flask and 25 cm^3 of freshly prepared 0.5M alcoholic potassium hydroxide was added. The mixture was boiled under reflux for 1 hour and then titrated with 0.5m hydrochloric acid using phenolphthalein indicator. A blank determination was carried out and the saponification value was determined from the relationship.

$$\text{Saponification value (mgKOH/g oil)} = \frac{56.1 \times C \times (V_0 - V)}{\text{Weight of oil}}$$

Where

C = Concentration of HCl used
V_o = Volume of HCl used for blank
V = Volume of HCl used for oil sample.

2.5 Determination of Ester Value [14]

The ester value was obtained by subtracting the acid value from the saponification value.

The iodine value, saponification value, peroxide value and acid value were determined in triplicate then their mean and standard deviation were calculated.

3. RESULTS AND DISCUSSION

The iodine value is a measure of the unsaturation of an oil. The higher the iodine value, the more the double bonds (unsaturation) present, which consequently reflects the reactivity of the oil; i.e the oil becomes more susceptible to oxidation and rancidification (15). Oleic acid containing one double bond absorbs 90% of iodine, linoleic acid (2 double bonds) absorbs 181% iodine and linolenic acid (3 double bonds) absorbs 274% iodine [16]. Non drying oils, such as olive oil, used for soap making and in the food products have 1 double bond and have relatively low iodine values below 90. Semi drying oils such as soya bean oil contain some proportion of double bonds and have intermediate iodine values about 130 (below 140). Drying oils used in the paint and varnish industry have relatively high iodine values (about 190) [16]. Table 1 and Fig. 1 shows the iodine values of the oils and iodine value standard for one double bond fatty acid, the result classifies/suggest that these oils are non-drying oil of low unsaturation. Some commonly used drying oils include linseed oil, tung oil etc, these oils are susceptible to drying and are often unsuitable for cooking [17]. Drying oils are characterized by high levels of polyunsaturated fatty acids which makes it susceptible to oxidation, resulting in a polymer net. This polymerization results in stable films that do not flow or deform readily [17]. Non drying oils contain low unsaturation, hence will be slow to oxidize and will remain liquid for a long time. Since the oils of this study contains one double bond on the basis of their classification as non-drying oils, they are expected to be less reactive, more stable, slow to oxidation and remain liquid for a long time. This suggest or gives an insight that they are suitable for consumption.

According to benerdin [18], the characteristics that are necessary for the confirmation of identity and edibility include acid value. High acid value are poisonous for livestock and consumption [19]. Acid value is a measure of the free fatty acid present in fats and oils and it is a measure of hydrolytic rancidity [20]. The higher the acid value, the higher the level of free fatty acid which translates into hydrolysis of triglycerides and decreased oil quality [21]. According to Codex Standards for Edible Fats and Oils [22] the maximum level of acid value for refined fats and oils is 0.6mgKOH/g fat or oil. From the scoring table Table 2 and Fig. 2, except for Gino vegetable oil, the other brands of vegetable oils had acid value a little above the maximum level for acid value quoted for refined oils. This suggests that Gino vegetable oil is suitable for consumption. An increment in the amount of free fatty acid in an oil sample indicates inadequate processing and storage conditions [21], probably poor storage conditions brought about oxidative and chemical changes in the oil leading to increase in free fatty acid. The acid value of the other brands may still be considered low, which implies that the oils may be considered edible.

Table 3 and Fig. 3 show the saponification value of the oils studied. The saponification value of most edible oils are in the range of 180-200mgKOH/g [23]. Most of the oils namely sun flower oil, coconut oil, cotton seed oil, palm oil, sesame oil, soybean oil used as salad and cooking oils have soponification values ranging from 186mgKOH/g to 265mgKOH/g [9,24]. Also, saponification values of 200mgKOH/g and above had been reported to possess low molecular weight fatty acids [25]. Therefore, it reveals that the oils studied possessed low molecular weight fatty acids and are edible.

Table 1. Iodine value in mg/100g of the five selected refined vegetable oils

Brands of refined vegetable oils	Iodine value
Baron vegetable oil	57.70±0.92
Gino vegetable oil	79.95±0.12
Ideal vegetable oil	67.89±0.61
Grand vegetable oil	50.13±1.35
Turkey vegetable oil	21.83±0.07
Standard for one double bond fatty acid	Below 90 - 90

The results are mean ± standard deviation of triplicate determination

Table 2. Acid value in mgKOH/g of the five selected refined vegetable oils

Brands of refined vegetable oils	Acid value
Baron vegetable oil	1.49±0.14
Gino vegetable oil	0.39±0.02
Ideal vegetable oil	1.17±0.01
Grand vegetable oil	1.00±0.35
Turkey vegetable oil	1.54±0.33
Codex standard for acid value for edible oils	0.6

The results are mean ± standard deviation of triplicate determination

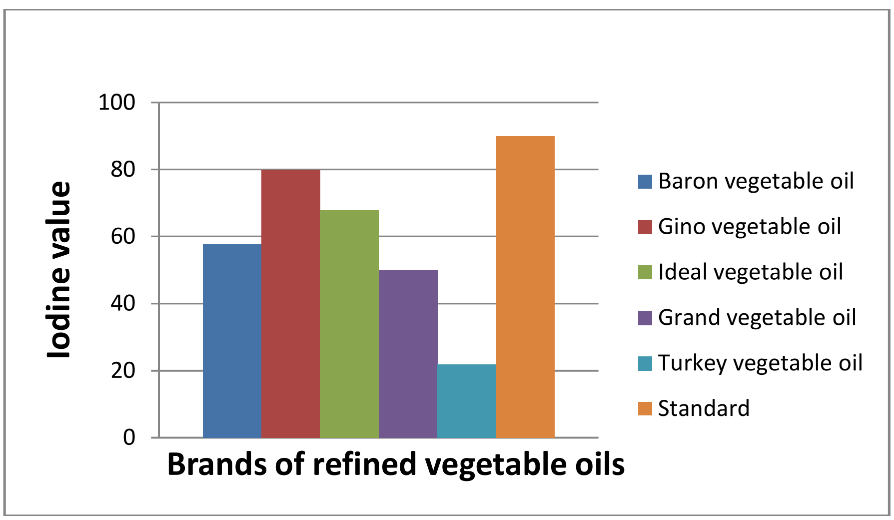

Fig. 1. Iodine value in mg/100g of the five selected refined vegetable oils and standard for one double bond fatty acid

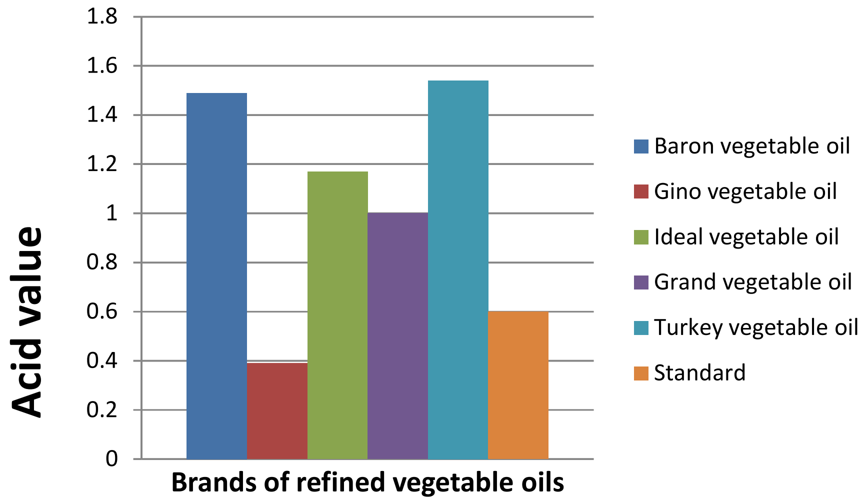

Fig. 2. Acid value in mgKOH/g of the five selected refined vegetable oils and codex standard for maximum acid value in edible fats and oils

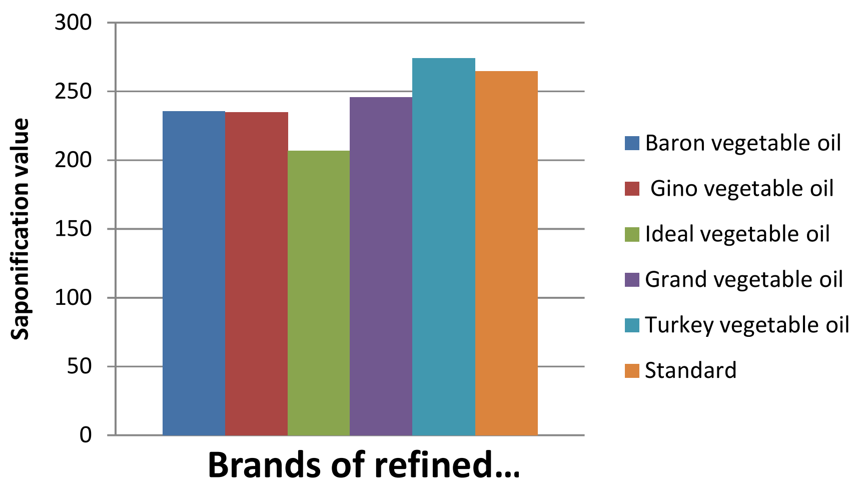

Fig. 3. Saponification value in mgKOH/g of the five selected refined vegetable oils and the range of saponification value of most edible oils

Table 3. Saponification value in mgKOH/g of the five selected refined vegetable oils

Brands of refined vegetable oils	Saponification value
Baron vegetable oil	235.62±0.8
Gino vegetable oil	234.92±0.3
Ideal vegetable oil	206.87±0.07
Grand vegetable oil	246.14±0.42
Turkey vegetable oil	274.19±1.70
Range of saponification value of most edible oils	185 - 265

The results are mean ± standard deviation of triplicate determination

The peroxide value gives a measure of the extent to which an oil sample has undergone primary oxidation [26]. Oils with a high degree of unsaturation are most susceptible to oxidation. The maximum level of peroxide value for fats and oils is 10 milliequivalent of active oxygen /kg oil [9]. From Table 4 and Fig. 4, the peroxide values of the different brands of oils can be said to be very low indicating very low oxidation/ rancidity. These peroxide values also suggest that these oils contain low molecular weight fatty acids of low unsaturation hence, it further reveals that the oils are slow to polymerization and will remain liquid for a long time. Summarily, they are suitable for consumption.

Table 5 and Fig. 5 shows the esther value of the oils investigated. Ester value of the oil is very high compared with the acid value which is a very essential characteristics of edible oil [27]. Oils having higher ester value are more intact and are less prone to oxidation [28].

Table 4. Peroxide value in meq/kg of the five selected refined vegetable oils

Brands of refined vegetable oils	Peroxide value
Baron vegetable oil	0.81±0.06
Gino vegetable oil	1.17±0.06
Ideal vegetable oil	0.26±0.03
Grand vegetable oil	0.88±0.02
Turkey vegetable oil	0.74±0.01
Codex standard of peroxide value for edible fats and oils	10

The results are mean ± standard deviation of triplicate determination

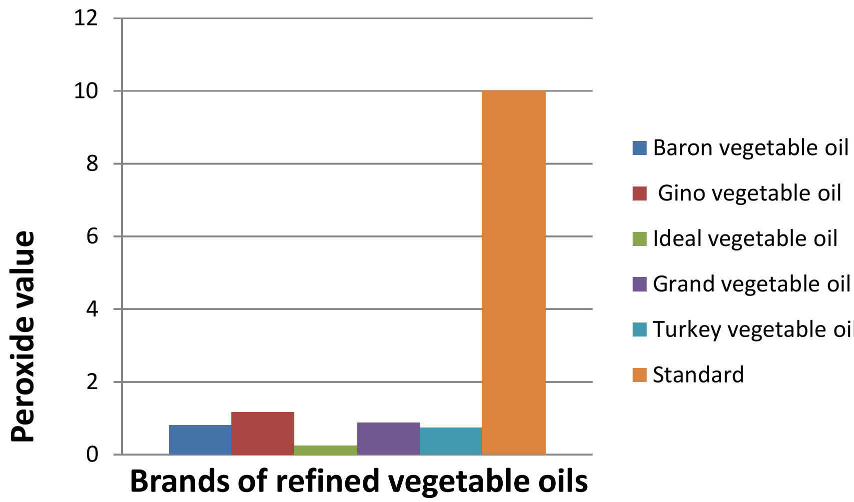

Fig. 4. Peroxide value in meq/kg of the five selected refined vegetable oils and Codex standard of peroxide value for edible fats and oils

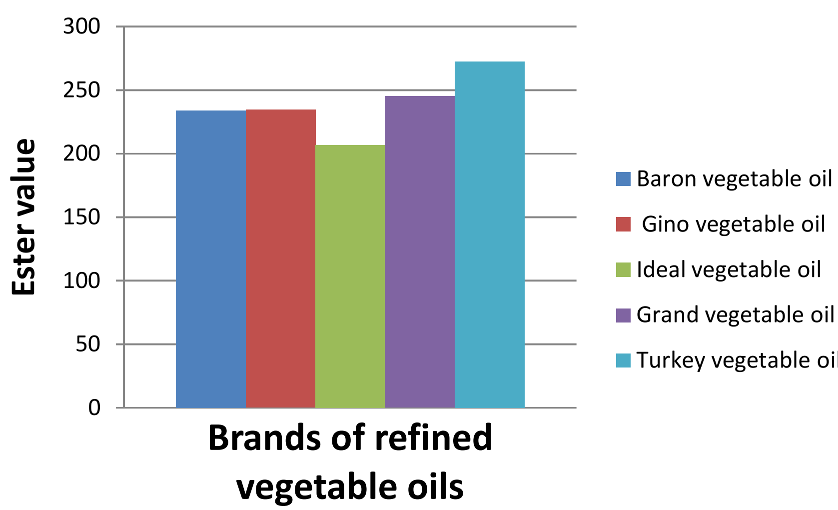

Fig. 5. Ester value in mgKOH/g of the five selected refined vegetable oils

Table 5. Ester value in mgKOH/g of the five selected refined vegetable oils

Brands of refined vegetable oils	Ester value
Baron vegetable oil	234.13
Gino vegetable oil	234.53
Ideal vegetable oil	206.70
Grand vegetable oil	245.14
Turkey vegetable oil	272.65

4. CONCLUSION

The iodine value of the oils suggest that the oils are non drying oil of low unsaturation. It shows also that the oils are slow to oxidation, will remain liquid for a long time and may not induce high blood pressure disease.

The acid value of the oils reveals that the oils are less susceptible to rancidification, hence, the oils are not likely to develop objectionable flavours and odours. This suggest that the oils are suitable for consumption.

The saponification values of the oils further affirms/confirms that the oils contain low molecular weight fatty acids of low unsaturation, hence they are not liable/susceptible to oxidation. This makes them suitable for consumption as polymerization reaction could be negligible or reduced. Also the saponification values obtained, shows that, these values are within that of most edible oils, this further affirms/confirms their suitability for consumption.

The peroxide values of the vegetable oils suggest that the oils contain low molecular weight fatty acids of low unsaturation, and therefore confirms the oils suitable for consumption.

The ester values is suitable for edible oils.

COMPETING INTERESTS

Authors declare that there are no competing interests.

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