The Nigerian Journal of Pharmacy
AS MEN OF HONOUR WE JOIN HANDS
ISSN 0331 - 670X
THE OFFICIAL ORGAN OF THE PHARMACEUTICAL SOCIETY OF NIGERIA | FOUNDED 1927 | VOL. 54, ISSUE. 1, 2020

ORIGINAL RESEARCH

QUALITY ASSESSMENT OF BRANDS OF VEGETABLE OIL MARKETED IN LAGOS, NIGERIA

*Celina O. Ogah[1], Modupe O. Ologunagba[2] and Paul O. Ogundeyi[1]

[1] Department of Pharmaceutical Chemistry, Faculty of Pharmacy, University of Lagos, Nigeria.

[2] Department of Pharmaceutics and Pharmaceutical Technology, Faculty of Pharmacy, University of Lagos, Nigeria.

*Corresponding Author

Email: onotsec@yahoo.com; Telephone: +234802 314 8053

ABSTRACT

Background: Vegetable oils are widely used in the preparation of food for human and animal consumption. They are an essential component of human diet and therefore affect health and quality of life. The aim of the this study was to analyze available brands of vegetable oils in Lagos market for selected quality parameters and compare same with standard values of Codex Alimentarius Commission of FAO/WHO.

Methods: Ten brands of vegetable oil (of soya bean, palm olein and palm fruit source) were purchased from shops in Lagos markets and analyzed for volatile content, refractive index, specific gravity, acid value, iodine value and saponification value using standard methods. Values obtained were compared to Codex Alimentarius standard values for each oil type as a means of assessment of oil quality.

Results: The study revealed that 80% of the samples met Codex Alimentarius standards on all the parameters studied. One soya bean oil sample failed the iodine value test, with a value of 101.2 g/100g as against the standard range of 120 -141g/100g. The palm oil sample did not meet standards for volatile content, refractive index and acid value.

Conclusion: The brands of vegetable oil studied (except the palm oil sample) were generally of good quality and in compliance with Codex Alimentarius standards for refined vegetable oil.

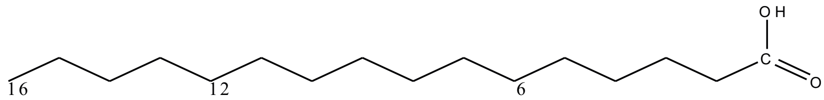
Keywords: Vegetable oil, Quality, Triglycerides, Rancidity, Iodine value.

INTRODUCTION

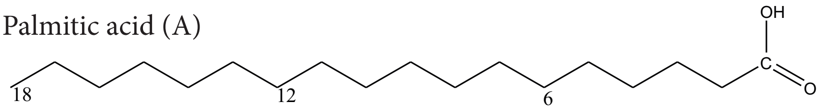
The term "vegetable oil" is a generic name for oil of plant origin, purified for use in the preparation of food for human and animal consumption. Hence, it is also known as cooking or edible oil. Examples of vegetable oil include peanut oil, palm olein, coconut oil, olive oil, soyabean oil, sunflower oil, canola oil, sesame oil and palm oil. Apart from their use as edible oil, vegetable oils are also useful in pharmaceutical, cosmetic and paint industries.

Vegetable oils are composed mainly of triglycerides which make up 95 - 98 % of the oil. A triglyceride is an ester made up of one glycerol molecule bound to three fatty acids. Triglycerides may be simple (when the three fatty acids are identical) or mixed (if two or all three of the fatty acids are different). Mixed triglycerides are more common in vegetable oils. Triglycerides may be made up of saturated fatty acids (SFAs), monounsaturated fatty acids (MUFAs) or polyunsaturated fatty acids (PUFAs) with the double bonds (points of unsaturation) at specific positions[1]. Some vegetable oils are high in saturated fatty acids while others contain more of unsaturated fatty acids. Unsaturated fatty acids do not pack tightly together, thus oils with a high proportion of these acids are liquid at room temperature while those rich in saturated fatty acids may occur as semi solids, especially at low temperatures[2].

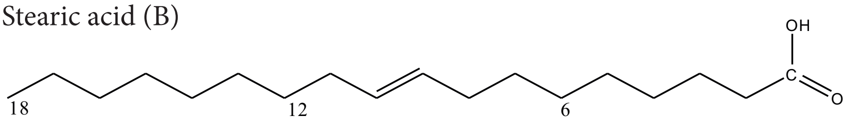
The physical and chemical properties of vegetable oil, as well as its nutritional value depend on the nature of the fatty acid component. Heat and oxidative degradation can also affect the characteristics and nutrient value of oil. Thus, the quality of oil may vary with vegetable source, fatty acid composition, degree of refinement and processing method[3, 4, 5, 6]. In other words, there could be inter-brand variation. Storage in high temperature conditions and display under hot sun as often obtains in a tropical environment like Nigeria, may affect vegetable oil quality after production. Routine analysis of brands in the market is therefore



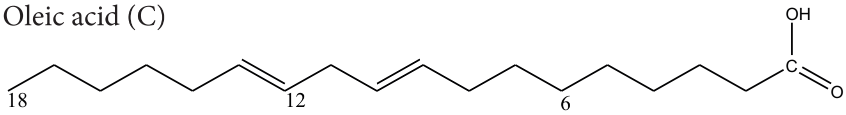
Palmitic acid (A)



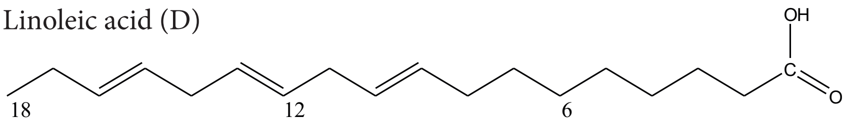
Stearic acid (B)



Oleic acid (C)



Linoleic acid (D)



α-Linolenic acid (E)

Figure 1: Structures of Saturated (A and B) and Unsaturated (C, D and E) Fatty Acids Commonly Found in Vegetable Oils

necessary to protect the health of the consuming public.

Diet is a key factor in maintaining human health and also plays an important role in the premature development of chronic diseases, their progression, morbidity and mortality[7]. Cooking oils and fats are recognized as an essential source of nutrients in both human and animal diet. They provide a concentrated source of energy, supply essential fatty acids (which are precursors for important hormones), contribute greatly to the feeling of satiety after a meal. They also serve as carriers for fat-soluble vitamins and make foods more palatable. However, saturated fatty acids have been associated with increased blood cholesterol in the form of low-density lipoprotein (LDL) which is a risk factor for cardiovascular disease[8].

Oils high in SFAs produce more health hazards than those with high content of MUFAs and PUFAs. Among the PUFAs, Omega 3 fatty acids are healthier than Omega 6 as the former have been shown to prevent dementia while both are cardioprotective[9, 10, 11,12]. Hence some vegetable oils may be healthier for human use than others depending on their relative content of SFAs, MUFAs and PUFAs.

Various brands of vegetable oil are available in the local market in Nigeria, they are oils which have undergone series of processes including deodorizing, bleaching and refining. The choice of vegetable oil by an individual may depend on differences in cost, taste, and purpose of the oil as well as the nutritional value. Some available brands of vegetable oils in the local market include: Power oil, Mamador oil, Devon King oil, Activa oil, Emperor oil, Laziz oil, Golden Penny oil, Sunola oil, Grand oil and Bliz oil. Differences in plant sources as well as processing methods may affect oil quality among brands. The quality of vegetable oil can be determined by measuring parameters such as iodine value, acid value, saponification number, among others. A set of standard values, guidelines and codes of practice, referred to as the "Food Code" has been adopted by the Codex Alimentarius Commission (CAC). CAC is an international food standard body established jointly by Food and Agriculture Organization (FAO) and World Health Organization (WHO) to protect the health of consumers by ensuring food safety and fair practices in food trade. It is a statutory obligation for food commodities in international trade to comply with these regulatory standards.

The aim of this study was to determine general quality parameters of brands of vegetable cooking oil in Lagos markets and evaluate their level of compliance with regulatory standards.

MATERIALS AND METHODS

Collection of Samples

Ten brands of vegetable oil were purchased from three major markets (Mushin, Ikeja and Agege) in Lagos metropolis and code named. They include Activa oil, Devon Kings oil, Emperor oil, Golden penny oil, Grand pure oil, Laziz oil, Mamador oil, Power oil, Sunola oil and Bliz palm oil. They were all within their shelf lives and manufactured in Nigeria. For all except the palm oil brand, the oil was clear and free from any form of sediments or suspended matter. The label information and physical characteristics of each brand were observed and recorded.

Determination of Values

The following parameters were determined for each sample: Volatile content, refractive index, specific gravity, acid value, iodine value and saponification value.

Volatile Content

The thermogravimetric method[13] was used for this determination. The oil sample (10g) was weighed into a stainless-**steel** dish of 8cm diameter and the weight of dish with oil was recorded. The oil was then heated in an oven at 105^{0}C for 1 hour, after which it was cooled in a desiccator and re-weighed. The procedure was repeated until a constant weight was obtained. The determination was carried out in triplicates for each sample and the content of volatile matter was calculated as follows:

$$\%\ \text{Volatile content} = \frac{Wl \ x \ 100}{W}$$

Where Wl = Weight loss in gram
W = Initial weight in gram

Refractive Index

The refractive index of each oil sample was determined by means of an Abbe Refractometer and the values were read off in triplicates.

Specific Gravity

The weight of 25 mL of oil sample was determined by difference in a previously weighed measuring cylinder and used to calculate the density of the oil. The specific gravity was then calculated as the ratio of its density to the density of water.

Acid Value

Each oil sample (10 g) was weighed into a 250 mL conical flask and dissolved in 50 mL ethanol after which 1 mL of phenolphthalein was added as indicator. The resulting mixture was boiled for about 5 minutes and titrated while hot against 0.1 M aqueous potassium hydroxide (KOH) solution until the colourless mixture turned light pink. The acid value was calculated using the following formula:

$$\text{Acid value} = 56.1 \frac{VN}{W}$$

Where:
V = Volume (in mL) of KOH solution used
N = Normality of the KOH solution
W = Weight (in g) of oil sample
56.1 = Equivalent weight of KOH

Iodine Value

Each oil sample (0.2 g) was dissolved in 10 mL chloroform in a conical flask, 25 mL Hanus reagent (0.2N ICl) was added and the resulting mixture was kept in the dark for 30 minutes. 10 mL of 10% KI was then added to the mixture and immediately titrated with 0.1 M sodium thiosulfate until the mixture turned pale yellow in color. Starch solution (5 mL) was added as indicator and titration was continued until the blue black colour of the mixture was discharged. A blank titration was carried out using the same procedure as for the sample and determination was done in triplicates . The iodine value was calculated using the following formula:

$$\text{Iodine Value} = \frac{\text{Eq. Wt.} \times V \times N \times 100 \times 10^{-3}}{W}$$

Eq. Wt. = Equivalent weight of iodine
V = Volume of sodium thiosulfate used
N = Normality of sodium thiosufate
W = Weight of oil sample

Saponification Value

Each oil sample (2 g) was weighed into a 250 mL flask, 25 mL of alcoholic potassium hydroxide (KOH) was added and mixed thoroughly. The flask was connected to a reflux condenser on a water bath, boiling gently until saponification was complete as indicated by the absence of any oily matter on the clear solution. The flask was allowed to cool and the mixture was transferred into a conical flask, using 10 mL of hot ethanol to rinse. The mixture was titrated with 0.5 N hydrochloric acid (HCl) to a colourless end point, using 1 mL of phenolphthalein as indicator. A blank titration was carried out and determinations were done in triplicates. Saponification value was calculated as follows:

$$\text{Saponification Value} = \frac{56.1\ VN}{W}$$

Where
V = Volume in ml of standard HCl used

N = Normality of the standard HCl
W = Weight in gram of oil sample
56.1 = Equivalent weight of KOH

Statistical Analysis

Values were expressed as mean ± standard deviation. Results of sample analysis were compared with reference values using student t-test to determine statistical significance at 95% confidence level ($p \leq 0.05$).

RESULTS

The names, observed physical characteristics and label information of the samples used for the study are presented in Table 1. The palm oil sample, though packaged and labelled with manufacturer's name and address, did not have NAFDAC Number on its label. All samples except the palm oil were clear liquids and light or bright yellow in colour. The palm oil had a liquid, dark-red upper layer over a thick orange red bottom layer. Six of the samples were of palm olein source while three were from soya bean.

Table 1: Names, label information and description of the samples

S/N	Sample Name	Sample Code	NAFDAC No.	Oil Source	Physical State	Colour
1	Activa	AVA	08-6141	Palm olein	Liquid	Light Yellow
2	Devon King	DVK	08-2360	Palm olein	Liquid	Light Yellow
	Emperor	EMR	08-2745	Palm olein	Liquid	Light Yellow
4	Laziz	LAZ	08-1530	Palm olein	Liquid	Light Yellow
	Mamador	MAM	B1-7532	Palm olein	Liquid	Light Yellow
6	Power	POW	B1-6488	Palm olein	Liquid	Light Yellow
	Golden Penny	GPY	08-0894	Soya bean	Liquid	Bright yellow
8	Grand	GRD	08-2894	Soya bean	Liquid	Bright yellow
	Sunola	SUN	01-0553	Soya bean	Liquid	Bright Yellow
10	Bliz Palm Oil	BPO	----------	Palm fruit	Semi ‐ liquid	Orange Red

Results of quality parameters assessed are presented in two categories (Tables 2 and 3). Table 2 contains the physical parameters: volatile content, refractive index and specific gravity. The reference range for each parameter is the Codex Alimentarius standard for the oil type. Values for volatile content are expressed as weight of volatile matter per weight of oil while specific gravity values are derived from the density of each oil. Figure 2 shows the volatile content of the samples along with a horizontal line indicating the reference maximum.

Table 2: Physical parameters of the samples studied

SN	Sample Code	Volatile Content (%w/w)	Reference Value	*Refractive Index	Reference Range	Specific Gravity	Reference Range
1	AVA	0.05		1.459 ± 0.03	1.458 - 1.460	0.912	0.899 - 0.920
2	DVK	0.05		1.460 ± 0.10		0.905	
3	EMR	0.13		1.458 ± 0.03		0.908	
4	LAZ	0.14	≤0.20	1.460 ± 0.09		0.904	
5	MAM	0.09		1.458 ± 0.11		0.901	
6	POW	0.14		1.460 ± 0.05		0.899	
7	GPY	0.06		1.469 ± 0.07	1.466 - 1.470	0.922	0.919 - 0.925
8	GRD	0.06		1.468 ± 0.03		0.920	
9	SUN	0.06		1.466 ± 0.04		0.921	
10	BPO	[a]0.25		[b]1.462 ± 0.41	1.454 – 1.456	0.896	0.891 – 0.899

*Values are expressed as mean ± standard deviation (n=3); [a]not significantly different from the reference value (p >0.05); [b]Significantly different from reference maximum (p <0.05).

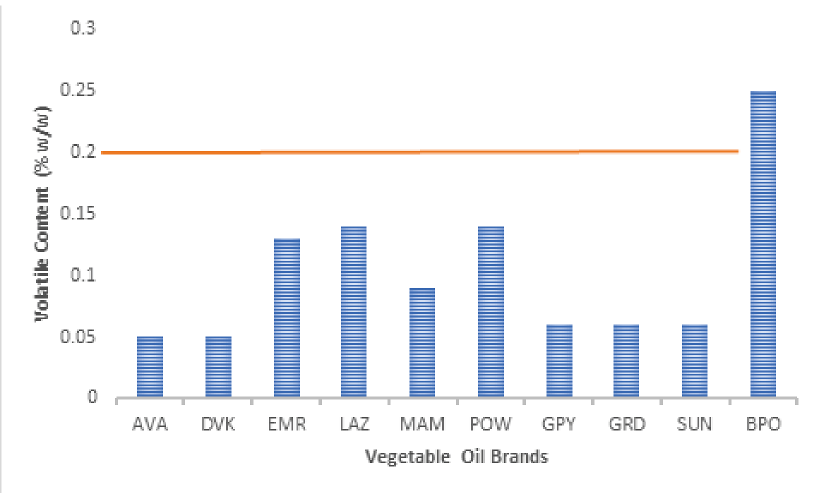


Figure 2: Volatile content of samples showing reference maximum

Chemical parameters (Acid, iodine and saponification values), expressed as mean ± standard deviation, are presented in Table 3. The reference range for each parameter is the Codex Alimentarius standard for the oil type. The mean iodine value for the soya bean oil brands was higher than the mean for palm olein oil brands and the palm oil. In Figure 4, the high saponification values and low acid values for all the samples are displayed for clarity.

Table 3: Selected chemical parameters measured

S/N	Sample Code	*Acid Value (mg KOH/g)	Reference Range	*Iodine Value (g/100g)	Reference Range	*Saponification Value (mg KOH/g)	Reference Range
1	AVA	1.52 ± 0.37	≤ 6.0	60.5 ± 0.32	54 - 62	202.6 ± 0.41	195 - 205
2	DVK	1.68 ± 0.26		60.5 ± 1.21		196.5 ± 1.10	
3	EMR	0.73 ± 0.27		57.1 ± 0.11		197.8 ± 0.34	
4	LAZ	0.95 ± 0.11		55.6 ± 0.05		195.1 ± 0.41	
5	MAM	0.86 ± 0.25		58.7 ± 0.08		198.0 ± 0.15	
6	POW	2.36 ± 0.22		61.0 ± 0.21		200.4 ± 0.24	
7	GPY	0.34 ± 0.03	≤ 2.5	123.3 ± 0.04	120 - 141	192.3 ± 0.59	189 - 195
8	GRD	0.56 ± 0.07		126.5 ± 0.98		190.1 ± 0.21	
9	SUN	0.45 ± 0.15		[y]101.2 ± 0.15		190.6 ± 0.97	
10	BPO	[x]12.06 ± 0.30	≤ 10.0	52.5 ± 0.07	45 -56	204.1 ± 1.20	195 - 205

*Values are expressed as mean ± standard deviation (n=3). [x]Not significantly different from reference value; [y]Significantly different from reference minimum ($p < 0.05$).

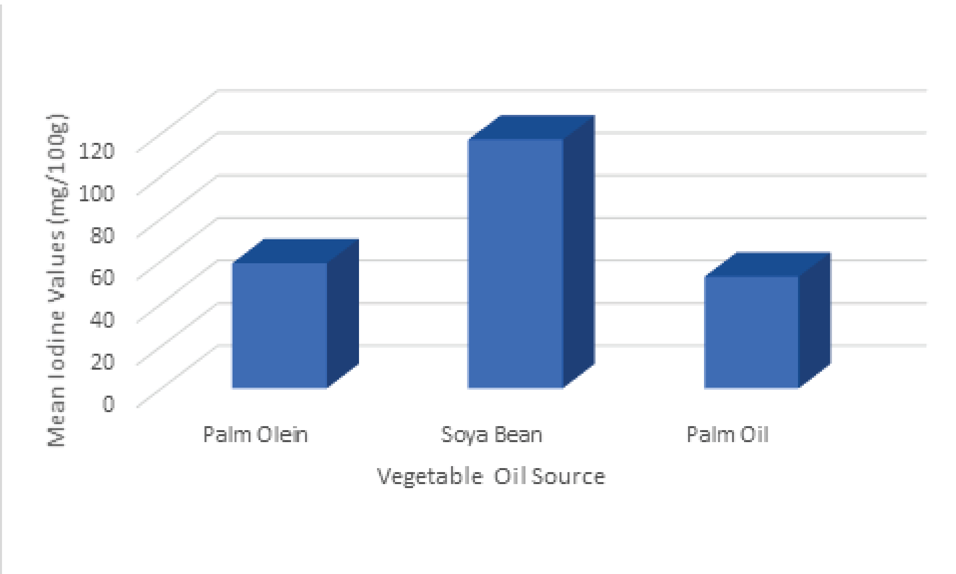


Figure 3: Mean iodine values of the three oil types

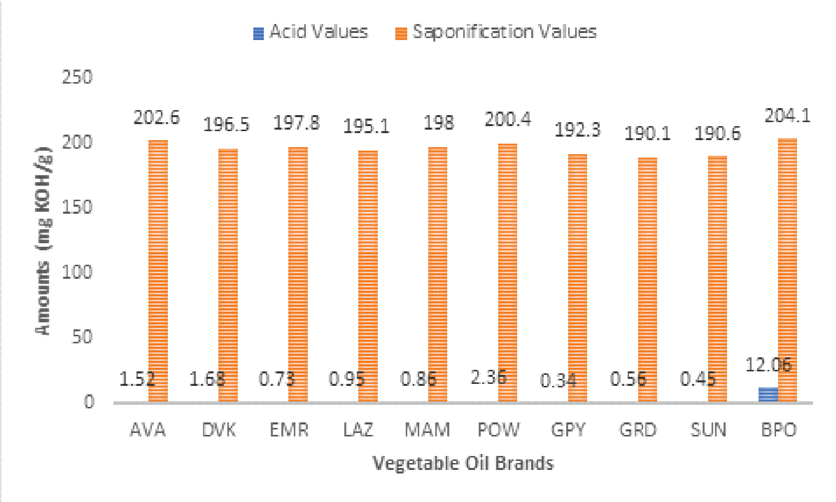


Figure 4: Saponification values of the samples in comparison with their acid values

DISCUSSION

Vegetable oil is a source of essential fatty acids which are required by the human body for a variety of functions. It is therefore very important that vegetable oil for human consumption be of optimum quality. The samples studied were of three types: Palm olein, soya bean and palm oil. Palm oil is extracted from the flesh of the fruit of oil palm (*Elaeis Guineesis)* while palm olein is obtained from palm oil by fractionation after bleaching and deodorizing. Soya bean oil is obtained by extraction from soya bean *(Glycine max)* seed. The quality parameters of vegetable oil vary according to the vegetable source of the oil.

Volatile content of vegetable oil is an important quality parameter as it affects the shelf life of the oil. The palm olein and soya bean oils analyzed in this study had volatile content ranging from 0.05 to 0.14% w/w while the palm oil sample had a volatile content of 0.25 % w/w. The reference (Codex Alimentarius, 2015)[14] standard value for volatile content in refined vegetable oil is 0.2% w/w or less. All samples were in compliance with this standard except the palm oil (Sample BPO) as illustrated in Figure 2. The difference was however, not statistically significant. High volatile content, which is often equivalent to high moisture content, makes oil less stable and susceptible to hydrolysis and rancidity during storage. At elevated temperatures, moisture in vegetable oil reacts with the triglycerides, hydrolyzing them into glycerol and the component fatty acids. The formation of free fatty acids gives rise to unpleasant taste and odour, and the oil is said to be rancid[4, 15 16]. Considering that in our tropical environment, storage temperatures may be high (25°C to 35°C) and it may take 3 – 6 months (out of an average shelf life of 12 – 18 months) for the oil to get to the consumer, low moisture content is especially desirable. Vegetable oils should also be stored away from direct sunlight to avoid oxidative rancidity which has the same effect as hydrolytic rancidity. High volatile content of an oil may be due to low efficiency of extraction and clarification steps in the production process.

The standard values for refractive index were 1.458-1.460, 1.466-1.470 and 1.454-1.456 for palm olein, soya bean and palm oil respectively, as shown in Table 2. In this study, all the oil samples were within standard limits except for the palm oil sample which had a significantly higher value than the reference value. The general pattern observed in the study was that the palm olein brands had lower values of refractive index than the soya bean brands. This is consistent with the fact that refractive index of vegetable oils increases with increase in unsaturation and chain length of the fatty acids. Palm olein contains 46% unsaturated (poly- and mono-) fatty acids as against 87% in soya bean oil which also has fatty acids of longer chains.[1,2].

The specific gravity of oil is a measure of the density of the oil relative to water, hence it is also referred to as relative density. In this study, all the samples met the Codex Alimentarius standard for the oil types. The higher values for the soya bean oils is consistent with their content of longer chain fatty acids (16 – 20 carbon atoms) as against palm oil and palm olein with fatty acid chain length of 12 –

18 carbon atoms[1].

Acid value is usually measured as the weight of potassium hydroxide (KOH) in mg required to neutralize the organic acids in 1 g of oil. It is related to the amount of free fatty acids (FFA) in a sample of oil and therefore a measure of rancidity as free fatty acids are usually formed as products of decomposition of triglycerides. In this study, acid values of oil samples of palm olein source ranged from 0.73 to 2.36 mg KOH which were within the limit of not more than 6.0 mg KOH. The range of acid values for soya bean oil samples was 0.34 to 0.56 mg KOH which complied with the Codex Alimentarius standard of not more than 2.50 mg KOH. The palm oil sample had acid value of 12 mg KOH which was slightly higher than the Codex Alimentarius limit of not more than 10.0 mg KOH but the difference was not statistically significant. High acid value is an indication of inadequate processing and/or poor storage conditions such as high temperature and relative humidity. It reflects the age and extent of deterioration of the oil[17,18]. The low acid values recorded for the palm olein and soya bean oil brands indicate absence of rancidity.

The iodine values of all the palm olein samples were within the standard range of 54-62 g/100g. The soya bean oil samples studied were within standard limits of 120-141 g/100g of oil except for sample SUN which had a significantly low iodine value of 101.2 g/100g of oil. The iodine value of the palm oil sample was within the standard limit of 45-56 g/100g of oil. Iodine value of oil is a measure of the amount of unsaturation in the fatty acid component of the oil. It is estimated as the mass of iodine in grams that is required to halogenate 100 grams of oil. The higher the iodine value, the more the C=C bonds present and so the healthier the oil[1]. Low iodine values are indicative of deterioration of the oil involving oxidation of the double bonds. Hence vegetable oils that have been used for frying have lower iodine values than fresh oil[19].

Saponification value of vegetable oil is the number of milligrams of (KOH) required to neutralize the fatty acids resulting from the complete hydrolysis of 1g of the oil. In this study, saponification values for both palm olein and palm oil samples were within the standard range (195-205 mg KOH/g Oil). Soya bean oil brands had saponification values that were also within the standard range of 189-195 mg KOH/g Oil. Saponification value is a measure of the molecular weights of the triglycerides in oils[18]. Long chain (high weight) fatty acids have relatively fewer number of carboxylic functional groups per unit mass of the oil, as compared to short chain fatty acids. Therefore, oils containing long chain fatty acids have lower saponification values than those containing short chain acids, hence the lower values for soya bean oil samples. The high saponification values and low acid values of the samples indicate that the number of esters are high relative to the molecular weight of the fatty acid content of the oils. Ester value of vegetable oil is the difference between the saponification value and the acid value.

Data on physicochemical analysis of banded oils in Nigeria market is scanty but required to ensure that vegetable oil brands in circulation are of acceptable quality. This study was limited to brands produced in Nigeria and available in Lagos markets. Future studies that include imported brands in different parts of Nigeria may give a clearer picture.

CONCLUSION

The brands of vegetable oil analyzed in this study were generally of good quality using Codex Alimentarius standards of quality for the parameters measured. All the palm olein and soya bean samples were within limits of Codex Alimentarius standards except sample SUN which fell significantly below standard in terms of iodine value. The palm oil sample also failed to meet standards for volatile content, refractive index and acid value. Overall, 80% of samples studied met Codex Alimentarius standards for all the parameters measured. A study of broader scope is required to assess the quality of vegetable oils marketed in different parts of Nigeria.

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