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COMPARATIVE EVALUATION OF SOME PHYSICOCHEMICAL CHARACTERISTICS OF SELECTED BRANDS OF REFINED EDIBLE VEGETABLE OILS MARKETED IN RIVERS STATE, NIGERIA

***Okidhika, C.U., & Ekpete, O.A.**
Department of Chemistry, Ignatius Ajuru University of Port Harcourt, Rivers State, Nigeria

***Corresponding Author (Email):** okidhis@gmail.com

Abstract

Globally, people have been over the years faced the challenges of consuming sub-standard edible vegetable oils which affects the health of humans. These issues necessitated this work aimed at assessing the compliance of edible vegetable oils to both international and local specifications. The physicochemical properties of two sets of ten refined edible vegetable oils (Active oil, Golden penny oil, Mammador oil, Sunola oil, Kings oil, Jumac oil, Grand oil, Adan oil, Laziz oil and Power oil**)** purchased from four different supermarkets and open markets in Port Harcourt metropolitan city, Rivers State, were assessed for their compositional quality. The above-listed oil samples were characterized for free fatty acids, acid value, ester value, saponification value, peroxide value, iodine value, flash point, cloud point, pour point, smoke point, refractive index, specific gravity and moisture content using accepted standard operating procedures. The result indicates that some of the oil samples manifested impermissible value when compared with physicochemical parameters stipulated by the Codex Alimentations Commission of FAO/WHO and the specification of NAFDAC standards. Triplicate batches of the samples were purchased from four supermarkets and open markets and the physicochemical parameters were analyzed in the laboratory using both gravimetric and titrimetric methods. The results obtained for physical properties for both categories of oils: flash point, smoke point specific gravity, refractive index, pour point, cloud point and moisture content were 319.7^{o}C and 314.7^{o}C, 251.7^{o}C and 247.7 ^{o}C, 0.918 and 0.917, 1.465 and 1.464, -12.12^{o}C and -11.70^{o}C, -4.9^{o}C and – 4.4^{o}C, 0.06 and 0.10 respectively for the oils sold in supermarkets and open markets. Results obtained for chemical properties for both categories of oils: acid value, %FFA, iodine value, peroxide value, ester value and saponification value were; 0.26mgKOH/g and 0.27mgKOH/g, 0.13% and 0.13%, 109.9I_2/100g and 108.30g I_2/100g, 0.75MeqO_2/g and 1.18MeqO_2/g, 194.03mgKOH/g and 194.76 mgKOH and 194.47 mgKOH/g and 195mgKOH/g. The parameters studied varied significantly depending on the brand of oil, poor storage, distribution, and marketing conditions of the oils which could express their poor quality. To supply consumers with high-grade oils, frequent monitoring and controls must be put in place by stakeholders to educate consumers and middlemen on where the oils should be stored and/ or marketed to avert the rapid oxidation of the oil.

Keywords: Assessment, comparative, edible vegetable oils, oxidation, rancidity, physicochemical properties

Introduction

Refined edible vegetable oils play an essential role in our diet and thus provide a nutritional role, they add to the energy supply of human foods and are sources of essential fatty acids particularly linoleic and alpha-linolenic acids (FAO, 2009, Okparanta et al., 2018). They are also involved in the supply and transport of fat-soluble vitamins, such as vitamins A, D, E, K, and other components of nutritional value such as phytosterols compounds especially for vegetable oils (Mengistie et al., 2018). The high nutritional potential of these oils is attributed to their stability (Benmohamed et al., 2020). Vegetable oils act as carriers of fat-soluble vitamins like A, D, E, and K (Kostik et al., 2013). Apart from the vital roles of these oils in nutrition, their handling process also poses a great challenge because of the quick oxidative deterioration if poorly handled, which reduces their acceptability to end-use consumers. These oils usages are globally becoming more valuable in man's daily living; it is generally utilized both in cooking, food processing and production of oleum-chemicals that offers better applications including biodiesel, pharmaceuticals, chemical industries and in cosmetics. The physical and chemical properties of these oils express the quality of any oil and thus show its global acceptability. The approved value of the

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parameters gives a benchmark of the nutritive quality as well as the physical quality of the vegetable oil. These parameters include iodine value, peroxide value, saponification value, unsaponifiable matter, free fatty acid, the colour of oil, vegetable oil volatility, acid value, flash point, cloud point, cold point, refractive index, ash content, moisture content, density (expressed as specific gravity), kinematic viscosity amongst others. Studies have shown that oils with low melting points are vulnerable to fast deterioration which is induced by a high degree of unsaturation.

Exposing oils to ultraviolet radiation, heat or moisture for too long has the potential of adversely altering some of the quality indicators. The degree of deterioration of vegetable oils over time is a function of their exposure to light, temperature and storage conditions (Fekarurhobo *et al.*, 2009). The stability of vegetable oil to oxidation is a vital indicative index in monitoring oil shelf life and quality (Choe and Min, 2006). Studies have shown that some of the oils sold in our markets agree with both local and international specifications for refined edible oils but the challenge is in the storage and transportation (Reyes - Hernendez et al., *2*007). Recently, studies have been devoted in recent times to evaluating the degree and source of oxidation of vegetable oils. Peroxide value which is employed in determining the primary oxidation products of oils is a value that expresses the amount of hydroperoxides in the oil (Maduelosi et al., 2012). The decomposition of some products due to oxygenation is linked to degenerative sicknesses like membrane damage, rapid ageing, cardiovascular disease and even cancer; as a result research on lipid oxidation has attracted great attention in recent times (Angaye et al., 2015). The sources and properties of a large number of these refined edible oils are not yet established. As a result of this singular reason, It has become very imperative that the quality and oxidative stabilities of commercially available vegetable oils be assessed to know their safety and suitability for consumption by human beings. Features and sources of most refined vegetable oils have been established and it is therefore imperative to evaluate and monitor the oxidative stabilities and quality of commercially sold vegetable oils to determine their suitability for consumption.

In Nigeria, most foods like chicken, fish, plantain, potatoes and other sausages are prepared by frying them deep in vegetable oil. The realities of the economic situation of the country had left most users of such oils for frying with the choice of storing oils after subsequent frying to be reused for a very long period. This habit adversely affects the texture, stability, flavour and even colour of such fried products which may eventually affect the tissues and organs of humans when consumed. However, scholars have convincingly argued that substituting edible saturated fats for polyunsaturated fats reduces the chance of cardiovascular health challenges. Therefore, foods that are rich in polyunsaturated fats like marine Omega-3 supplements, vegetable oils and fatty fish are always being advocated for (Sharoba & Mohammed, 2012). The physicochemical properties of these oils lie largely on the type of oil, its source, climatic conditions of the environment, the packaging of the oils, storage conditions, processing, transportation and above all, compliance of stakeholders to local and international standards. This study is aimed at investigating and comparing the physiochemical properties of different refined edible vegetable oils sold in the open markets under harsh weather conditions and those sold in supermarkets of the Port Harcourt metropolis. Food is very useful for the survival and well-being of man and other living organisms. As a result of vegetable usefulness in man's health, it is advisable to ensure the presence of vegetables in our meals. The fruits and nuts from which the various vegetable oils are processed are consumed by almost everybody in their meals. If these oils are poorly processed or stored, they will be prone to contaminants which may adversely affect human organs when consumed. Taking cognizance of the harmful effect of the products of oil oxidation if poorly handled, and reuse of vegetable oils at elevated temperatures for frying foods, it is therefore imperative to ascertain the status of these vegetable oils if they are safe for human consumption. This study aims to compare the quality of some brands of vegetable oils sold in supermarkets and open markets in the Port Harcourt metropolis by determining the physicochemical properties and comparing them with both international and local standards.

Materials and Methods

The study area Rivers State lies between latitude 4°45'N and longitude 6°50'E total of 11,077km^2. Rivers State is among the 36 States of Nigeria and is situated in the Niger Delta oil-rich region of Nigeria. The chief occupation of the people of Rivers State is farming and fishing.

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Sample collection and pre-treatment: A total of two sets of ten (10) brands of refined edible vegetable oils were purchased from five different supermarkets in the Port Harcourt metropolis and open market. Ten (10) brands were purchased from air-conditioned supermarkets (Spar Shopping Mall and Timeless Supermarket) and ten (10) from Mile 3 and Rumuokoro open markets. The samples were bought randomly and were stored in a cupboard at the laboratory to avoid exposure to moisture, light, air and heat which can affect their properties before analysis.

Quality assurance: To ensure quality assurance of the experimental processes, instrument calibration and pre-testing for optimal performance were properly carried out where necessary before the laboratory analysis. All analyses involving blank measurements and all the measurements were carried out in triplicate wise. Standard operating procedures/methods were strictly adhered to and results were recorded for each analysis.

Determination of physicochemical properties of edible vegetable oils

Measurement of free fatty acid and acid value: The method reported by Enyoh and Amaobi, *(*2017) was used to analyse free fatty acid and acid values. The acid number of oil is the number of milligrams of potassium hydroxide needed to neutralize the free fatty acid in 1g of oil sample. 5ml of diethyl ether and 5ml of ethanol was measured and poured into a 250ml conical flask and 0.5ml of (1%) phenolphthalein was added to the solution. Two grammes of oil samples were measured and added to the conical flask and titrated with 0.1M KOH. Constant agitation of the conical flask was ensured as the titration was going on until a pink colouration persisted for about 15 seconds. The amount of KOH expended to achieve the endpoint was recorded. The above process was repeated and also carried out for a blank titration.

Calculation:

$$\text{Acid Value (mg KOH/g sample)} = \frac{V \times 5.61}{\text{weight of oil sample used}}$$

Where

V = volume of KOH used

5.61 (56.1/10) = constant for molecular weight of KOH

$$\text{Free fatty acid (mg KOH/g sample)} = \frac{\text{Acid value}}{2}$$

Measurement of ester value: Ester value was obtained from the expression, Ester Value = Acid Value - Saponification Value (Akinola et al., 2010)

Ester value = saponification value - acid value

Measurement of moisture content: The oven-dry method was used to analyse the moisture content of the vegetable oils. An empty evaporation dish was measured and 5g of each of the oil samples was added and remeasured and recorded as W1. The triplicate of each oil sample was measured and placed in an oven for one hour at 105^{o}C until a constant weight was obtained amongst the triplicate samples. After the drying of the sample, they were re-measured and cooled in desiccators, re-measured and recorded as W2 (Ekpete & Horsefall, 2011; Ohimain et al., 2013).

$$\text{Moisture content (\%)} = \frac{W_1 - W_2}{W_1} \times 100\%$$

Where :

W1 = weight of dish plus weight of oil before drying

W2 = weight of dish plus weight of oil after drying

Measurement of specific gravity: For specific gravity determination of oil, a specific gravity bottle was used. An empty clean dry specific gravity bottle was measured and recorded as (A). The bottle was filled to the brim with boiled and cooled distilled water and corked with a stopper. The bottle was cleaned with a cloth and measured and recorded as (B). The oil was filtered with filter paper to eliminate oil impurities and moisture that may be present. The specific gravity bottle was filled with each oil sample, the bottle was cleaned and corked with a stopper. The bottle and its content were subsequently weighed and recorded as (C), (Ohimain et al., 2013, Oji et al., 2015).

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Specific gravity (SG) = $\frac{C - B}{A - B}$

Where :
B = weight of bottle only
A = weight of bottle plus water
C = weight of bottle plus oil

Measurement of peroxide value: An empty 250ml conical flask was weighed. 5 g of the oil sample was measured and poured into the 250ml conical flask. 30ml of 3:2 ratio combination of acetic acid and chloroform was added. The flask was swirled on the hot plate to completely homogenize the mixture. 0.5ml saturated potassium iodide solution was measured and added to the solution and swirled for 60 seconds. 30ml of deionized water was measured and mixed with the solution and shaken vigorously to evolve iodine. This was slowly titrated with 0.1 M sodium thiosulphate until a lighter yellow colouration was observed. 1 ml of starch solution indicator was measured and added which gave it a blue colouration. The titration continues with vigorous shaking until the blue colour disappears which signifies the endpoint. The volume of sodium thiosulphate used was recorded. The procedure was repeated for a blank titration without an oil sample as reported by (Oji et al., 2015).

Peroxide value (Meq/kg) = $\frac{(Vo - V_1) \times N \times 1000}{\text{weight of sample}}$

where :
Vo = sample titre
V1 = Blank titre
M = Normality of sodium thiosulphate

Measurement of iodine value: The titrimetric method was used to measure the iodine value of oil. 8g of iodine trichloride (ICl_3) was measured and dissolved in 200ml glacial acetic acid and 9g of iodine was measured and dissolved in 300ml carbon tetrachloride (CCl_4) and both solutions were mixed and diluted to 1L in glacial acetic acid to form the Wij's solution. The two solutions were thoroughly mixed in a conical flask after dissolution and diluted to 1 litre with glacial acetic acid. 0.3g of oil sample was measured and poured into a 250ml conical flask and 25ml of Wij's solution was added. The mixture was homogenized and kept in the dark for 30 minutes. A mixture of 20ml of 10% potassium iodide solution, 100ml of deionized water and starch solution was added. This mixture was titrated with sodium thiosulphate (0.1N) to a colourless endpoint. The change in colour from blue to green indicates the endpoint. A blank titration was carried out with the same quantities of reagents used previously to evaluate the weight of iodine equivalent to the halogen contained in 25 ml of Wij's solution to measure the quantity of the iodine absorbed by the oil under the conditions of the measurement (Akinola et al., 2010). The iodine value was expressed as I_2 g/100g oil.

Iodine value (Wij's) = $\frac{(V_1 - V_2) \times N \times 1.269}{\text{sample weight in gram}}$

Where :
V_1 = volume of sodium thiosulphate used to titrate blank
V_2 = Volume of sodium thiosulphate used to titrate oil sample
M = Normality of $Na_2S_2O_3$
1.269 = constant calculated from the molecular weight of Iodine (126.9/100 = 1.269)

Measurement of refractive index: Refractive indices of vegetable oil samples were determined using Abbe's refractometer as reported by Ufuk et al. (2008). The device was adjusted with a light compensator (water at 20 °C), and then the oil was smeared on the lower prism of the refractometer and closed immediately after the oil was smeared. There was a transmission of light using an angled mirror. This was followed by the adjustment of the telescope tube using the fine adjustment till the black shadow was in a centralized position of the cross-wire indicator. The refractive index of the oil was at this point read out and recorded. This was repeated three times for all the oil samples and the mean values were calculated accordingly.

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Measurement of smoke point: The smoke point of oil was measured according to the method reported by Onwuka and Akaerue (2006) 10 ml of the oil was measured and placed in an evaporating dish. A laboratory thermometer was inserted and allowed to suspend at the centralized position in the dish containing the oil, preventing any contact with the bottom of the dish. After which the temperature was gently raised using a stove. The smoke point of the oil was measured at the point the oil gave off a thin bluish smoke persistently and recorded as the smoke point.

Measurement of saponification value: The saponification number of the oil was measured via the titrimetric method proposed by Pearson (1981). 2g of the oil was measured and poured into a 250ml conical flask and 20 ml of 0.5 M potassium hydroxide was added. The mixture was heated for 10 minutes and allowed to cool. The cooled solution was then titrated with 0.5M HCl (burette solution) and 0.5 ml of 1 % phenolphthalein was added as an indicator. The endpoint was recorded at the point of disappearance of pink colouration. A blank titration was carried out and the endpoint was recorded (Ohimain et al., 2013; Olorunfemi et al., 2014; Oji et al., 2015).

$$\text{Saponification value (mgKOH/g)} = \frac{(V_1 - V_o) \times M \times 56.1}{\text{Sample weight}}$$

Where :
V1 = Sample titre value
Vo = Blank titre
M = Molarity of HCl
56.1 = Molecular weight of KOH

Measurement of cloud point: The cloud point of vegetable oil is the minimum temperature an oil attains before it forms a cloudy appearance or wax. The vegetable oil cloud point is measured by the constant cooling rate method. 60ml of vegetable oils samples were measured and poured into test tubes and subjected to heating at a temperature of approximately 36 °C and then cooled in a freezer. The oil was observed periodically for the possible build-up of clouds at a cooling rate interval of 10 minutes and the point at which the oil turns cloudy or hazy was recorded as the cloud point of the vegetable oil (Fapetu et al., 2018).

Measurement of pour point: 60 ml of samples of vegetable oils were measured and poured into test tubes and kept in a refrigerator at -180 °C. The fluidity of the oil was checked periodically after every 20 minutes. The test tubes with the content of the oil were taken out after a 5 °C decrease and observed and the particular point at which the oil stops to flow when tilted is recorded as the pour point of the oil (Fapetu et al., 2018).

Measurement of flash point: In determining the flash point, the oil sample was poured into a dry-cleaned crucible and a thermometer was inserted in the middle of the sample. The temperature was adjusted in such a way that there was a 0.5 ^{o}C increase in temperature every 60 seconds. The flame was intermittently passed over the sample until a point when a flash was visible in the sample. This temperature is recorded as the flash point and usually falls within the range of 275 ^{o}C to 330 ^{o}C (AOCS 1993).

Determination of vegetable oil colour: The colours of the various samples of vegetable oil were determined by matching the colour of the oils with a colour chart through visual inspection and recorded accordingly (Anyasor et al., 2009)

Statistical analysis: All values from the physical and chemical analysis were presented as mean ±Standard deviation. Data gotten from all the experiments were subjected to a one-way analysis of variance (ANOVA) test using the statistical package for social science (SPSS). The relationship between the studied parameters of the vegetable oils to determine the correlation coefficient between the quality parameter pairs of the oil samples was calculated by the application of Pearson correlation analysis to indicate the nature and the sources of the oil rancidity and instability. All analyses were determined at the significant level of $p < 0.05$.

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Results

The results of the physicochemical properties of the selected refined edible vegetable oils studied are shown in Tables 1 - 4 below:

Table 1: Physical Properties of Oils Sold in Supermarkets

Sample	Flash point (°c)	Smoke point (°c)	Specific Gravity @ 20°c	Refractive index @ (40°c)	Pour point (°c)	Cloud point (°c)	Moisture content (%)	Colour
SA	314.6±0.10	246.6±0.71	0.920±0.003	1.468±0.003	-12.10±0.03	-4.8±0.2	0.08±0.02	Light yellow
SGR	315.5±0.20	255.6±0.75	0.924±0.004	1.468±0.003	-12.14±0.02	-4.9±0.2	0.06±0.01	Dark yellow
SM	311.7±0.56	246.4±1.17	0.906±0.002	1.455±0.002	-12.10±0.01	-4.9±0.3	0.06±0.01	Golden yellow
SS	326.8±0.62	251.6±0.92	0.923±0.002	1.468±0.003	-12.14±0.02	-4.9±0.2	0.03±0.02	Light yellow
SK	337.6±1.20	266±0.85	0.917±0.004	1.467±0.002	-12.14±0.03	-4.9±0.3	0.04±0.03	Golden yellow
SJ	318.4±0.72	246.3±0.51	0.919±0.003	1.468±0.003	-12.14±0.02	-4.9±0.2	0.05±0.02	Golden yellow
SG	332.4±0.66	245.5±1.36	0.918±0.003	1.468±0.003	-12.10±0.02	-4.9±0.2	0.06±0.03	Orange yellow
SAD	318.4±1.12	246.5±0.81	0.923±0.003	1.466±0.001	-12.13±0.03	-4.8±0.3	0.09±0.02	Light yellow
SL	310.7±1.10	246.6±0.31	0.918±0.002	1.468±0.003	-12.14±0.02	-4.9±0.2	0.04±0.03	Golden yellow
SP	311.3±1.17	266.1±0.82	0.912±0.003	1.454±0.001	-12.10±0.03	-4.8±0.3	0.07±0.02	
NIS 1992	300-350	>170°	0.899-0.925	1.466-1.470(RSBO)			0.2%max	
CODEXSTAN 1990				1.454-1.456 (RPO)	-9°Cmax	-5°-10°C		

Data are presented as means ± S.D, SA = supermarket active, SGR = Supermarket Golden penny, SM = Supermarket Mammador, SS = supermarket Sunola, SK= Supermarket kings, SJ = supermarket Jumac, SG = supermarket Grand, SAD = supermarket Adan, SL = supermarket Laziz, SP = supermarket Power.

Table 2: Physical Properties of Oils Sold in an Open Market

Sample	Flashpoint (°c)	Smoke point (°c)	Specific Gravity @ 20°c	Refractive index @ (40°c)	Pour point (°c)	Cloud point (°c)	Moisture content (%)	Colour
OA	311.7±0.10	244.3±0.46	0.918±0.003	1.468±0.003	-11.90±0.03	-4.3±0.3	0.12±0.02	Light yellow
OGR	314.6±0.35	253.2±0.31	0.922±0.002	1.468±0.003	-11.60±0.003	-4.1±0.3	0.10±0.03	Dark yellow
OM	308.5±0.20	243.7±0.90	0.905±0.001	1.455±0.002	-11.80±0.02	-4.4±0.1	0.09±0.01	Golden yellow
OS	323.9±0.76	250.9±1.27	0.921±0.002	1.468±0.003	-11.70±0.03	-4.6±0.3	0.09±0.03	Light yellow
OK	314.5±1.30	264.4±0.71	0.916±0.004	1.467±0.002	-11.80±0.02	-4.5±0.2	0.08±0.02	Golden yellow
OJ	315.9±1.57	244.2±0.30	0.917±0.003	1.468±0.003	-11.50±0.04	-4.4±0.3	0.10±0.02	Golden yellow
OGP	330.5±0.67	243.6±0.76	0.917±0.002	1.468±0.003	-11.90±0.02	-4.7±0.2	0.12±0.03	Orange yellow
OAD	315.5±0.98	243.2±0.93	0.922±0.003	1.466±0.001	-11.80±0.03	-4.2±0.3	0.14±0.02	Light yellow
OL	309.1±0.82	244±0.70	0.916±0.002	1.468±0.003	-11.60±0.02	-4.3±0.2	0.07±0.02	Golden yellow
OP	303.2±0.45	263.6±0.78	0.911±0.002	1.454±0.001	-11.70±0.03	-4.2±0.2	0.10±0.03	Orange yellow
NIS 1992	300-350	>170°	0.899-0.925	1.466-1.470(RSBO			0.2%max	
CODEXSTAN 1990				1.454-1.456 RPO	-9°Cmax	-5°-10°C		

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Data are presented as means ± S.D, OA = Openmarket active, OGR = Openmarket Golden penny, OM = Openmarket Mammador, OS = Openmarket Sunola, OK= Openmarket kings, OJ = Openmarket Jumac, OG = Openmarket Grand, OAD = Openmarket Adan, OL = Openmarket Laziz, OP = Openmarket Power

TABLE 3: Chemical Properties of oils sold in Supermarkets

Sample	Acid value MgKOH/g	Ester value MgKOH/g	%FFA	Iodine value I_2g/100g	Peroxide value $MegO_2$/g	Saponification value MgKOH/g
SA	0.26±0.06	192.04±0.60	0.13±0.01	123.81 ±0.93	0.86±0.21	192.6±0.56
SGR	0.26±0.04	204.54±1.66	0.13±0.02	126.92 ±0.55	0.66±0.92	204.9±1.87
SM	0.25±0.06	191.94±0.57	0.125±0.01	52.28±0.33	0.83±0.20	192.4±0.72
SS	0.27±0.03	195.96±1.69	0.135±0.03	124.82 ±0.59	0.66±0.03	196.3±1.21
SK	0.25±0.04	193.15±1.70	0.125±0.02	123.33 ±0.22	0.63±0.10	193.5±1.63
SJ	0.26±0.05	194.54±1.92	0.13±0.04	123.78 ±0.38	0.68±0.28	194.9±1.81
SG	0.26±0.02	190.25±0.87	0.13±0.02	123.80 ±0.54	0.80±0.60	190.7±0.54
SAD	0.24±0.03	194.56±0.52	0.12±0.03	124.69 ±0.92	0.92±0.86	195.2±0.43
SL	0.25±0.03	190.36±2.6	0.125±0.03	123.50 ±0.26	0.62±0.53	190.7±2.1
SP	0.26±0.04	192.94±0.74	0.13±0.03	52.68±0.33	0.88±0.43	193.5±0.66
NIS 1992	0.6max		<0.15	- 50 - 56 RPO 124 - 139 RSBO	10Meq Max	- 190-202
CODEXSTAN			0.3max			-

Data are presented as means ± S.D, SA = supermarket active, SGR = Supermarket Golden penny, SM = Supermarket Mammador, SS = supermarket Sunola, SK= Supermarket kings, SJ = supermarket Jumac, SG = supermarket Grand, SAD = supermarket Adan, SL = supermarket Laziz, SP = supermarket Power

Table 4: Chemical Properties of oils sold in an Open Market

Sample	Acid value MgKOH/g	Ester value MgKOH/g	%FFA	Iodine value I_2g/100g	Peroxide value $MegO_2$/g	Saponification value MgKoH/g
OA	0.29±0.04	193.11±0.58	0.145±0.02	121.56 ±0.81	1.28±0.33	193.4±0.36
OGR	0.28±0.03	204.92±1.64	0.14±0.03	125.66 ±0.36	1.11±0.40	205.2±1.56
OM	0.26±0.02	191.72±0.53	0.13±0.01	51.94 ±0.48	1.18±0.46	192.6±0.66
OS	0.29±0.05	196.74±1.62	0.145±0.03	122.74 ±0.64	1.06±0.82	197.1±0.65
OK	0.27±0.02	193.94±1.67	0.135±0.02	121.84 ±0.21	1.08±0.28	194.3±1.82
OJ	0.28±0.03	195.22±1.88	0.14±0.04	121.33 ±0.24	1.18±0.60	195.6±0.62
OG	0.28±0.04	191.18±0.84	0.14±0.01	121.30 ±0.66	1.22±0.10	191.6±0.46
OAD	0.25±0.06	196.05±0.47	0.125±0.03	123.80 ±0.18	1.38±0.86	196.7±0.99
OL	0.26±0.01	191.14±0.46	0.13±0.02	121.96 ±0.36	1.06±0.28	191.5±0.77
OP	0.28±0.03	193.62±0.66	0.14±0.05	50.90±0.32	1.25±0.37	194.2±1.54
NIS	0.6max		<0.15	50 - 56 RPO 124 - 139 RSBO	10Meq Max	190-202
CODEXSTAN			0.3max			-

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Data are presented as means ± S.D, OA = Openmarket active, OGR = Openmarket Golden penny, OM = Openmarket Mammador, OS = Openmarket Sunola, OK= Openmarket kings, OJ = Openmarket Jumac, OG = Openmarket Grand, OAD = Openmarket Adan, OL = Openmarket Laziz, OP = Openmarket Power

Discussion

The flash point of all the different brands of vegetable oils studied falls within the range of 303ºC - 337ºC for both oils sold in the supermarket and open markets respectively. The 303°C trend shows a decrease in flash points from oils sold in supermarkets compared to oils sold in open markets. The values were within the permissible limit of specification by NIS and CODEX STAN (300ºC - 350ºC). This result revealed that oils sold in an open market at elevated temperatures are lower in flashpoints. However, the result showed that all the brands of oils studied have good quality for frying food and suggest that the flammability of oil during the frying of food will be minimal (Fapetu et al., 2018). The smoke points of the oils studied fall within the range of 243ºC - 260ºC. The results obtained are in agreement with the specification limit of NIS, NAFDAC and CODEX STAN of >170 ºC. The results showed that the oils are suitable for frying and thus suggest that if the oils are handled safely it will reduce the risk of fire outbreaks during the frying of food (Akintayo, 2004). However, all samples showed values within the recommended values. This indicates that oil samples were properly refined because smoke point and free fatty acid content properties are employed to determine the extent of refinement of the oil. Better refinement of oil yields higher smoke points because the refining process of oil gets rid of impurities that can cause unnecessary smoking of oil (Mengistie et al., 2018).

The specific gravity of the selected types of oils studied has their specific gravity within the range of 0.906 - 0.924 respectively. The specific gravity values obtained are within the permissible specification and are probably due to the presence of high content of linoleic acid in the oil (Mengistie et al., 2018). The different brands of oils studied had refractive indices within the range of 1.454 - 1.468 at 40 ºc respectively. The values also fall within the permissible limit of 1.466-1.471 for refined soya bean oil and 1.454-1.456 for refined palm oil as set by CODEX STAN and NAFDAC. This is proof of the oils purity and suitability for consumption and other application like biodiesel (Aremu et al., 2015). The pour point of the selected brands of oils studied falls within the range of -11.50- (-12.14) respectively. These values were within the ASTM and CODEX STAN of -9ºC maximum for vegetable oils. The continuous exposure of the oils to harsh weather increases the pour point of the oils as they will gradually lose their flow property and ability to stay at a minimal temperature. The pour point of oils usually falls below the cloud point (Gopakumar, 2012).

The cloud points of these oils determined falls within the range of -4.1ºC - (-4.9ºC) respectively. This is the temperature at which wax is noticed in an oil (cloudy appearance of oil). The figures obtained from the test agree with the CODEX STAN specification of -5ºC for vegetable oils. This is proof that the oils will remain liquid in extremely cold weather conditions suggesting a long time storage ability and will not have the tendency of inducing high blood pressure-related illnesses in the body (Kelle & Udeozu, 2015). Although exposure of oils to harsh weather tends to increase the cloud point of oils over time (Gopakumar, 2012). The moisture content (in percentage) of the different brands of oil studied falls within the range of 0.03% - 0.16% respectively. The presence of water in vegetable oils poses a serious rancidification challenge to the oil and may adversely affect its shelf life. The moisture content of the oils studied was within the permissible specification limit set by NIS, NAFDAC and CODEX STAN of 0.2% Max respectively. Higher moisture content could be attributed to the extraction processes and could affect the conservation of the oil by thus promoting the hydrolysis of free fatty acids leading to the oxidation of the oil (Odoh et al., 2017). Oil undergoes more rapid alteration during storage which is a fertile ground for the growth of microorganisms (Macarthur et al., 2021). The continuous exposure of oils to high temperature increases the moisture content and promote various chemical reactions (hydrolytic reaction). This increment in the moisture content of the oil adversely affects other parameters like the Iodine value and peroxide value (Madras et al., 2004).

The acid numbers of the various brands of oil evaluated fall within the range of 0.24MgKOH/g - 0.29 MgKOH/g for refined palm oil and soya bean oil. Moreso, the values agree with the standard specification of NIS and CODEX STAN of 0.6max (Kelle & Udeozu., 2015). The low value of an acid number may be a result of the

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presence of anti-oxidants and autogenous enzymes that does not promote the hydrolysis of fatty acids (Benguendouz et al., 2017).

The ester values were obtained for oils sold in the supermarkets and open markets respectively. The values fall within the range of 190.7 MgKoH/g-204.92 MgKoH/g. Higher ester values of oils suggest a closer ester bond between the glycerol molecule and the fatty acids. The implication of the high figures obtained showed that the oils are of high quality with long time storage potential (Akinola et al., 2017). The percentage of free fatty acids was obtained from all the brands of oil studied. The values were between the range of 0.12%-0.14%. The figures agree with the specifications of NIS and CODEX STAN (<0.15%). The result showed that the hydrolytic rancidity of these oils exposed to harsh weather is eminent over time thereby reducing oils' shelf life (Ohimain et al., 2012; Angaye and Maduelosi, 2015). High FFA values are traceable to decomposition, poor method of extraction, use of damaged seeds and improper or prolonged storage that can be facilitated by light and temperature. According to the result, the edibility of the oils is very high and is recommended for consumption. The iodine values for all the brands of oil studied fall within the range of 50.90 I_2g/100g - 52.68 I_2g/100g for refined palm oil and 121.30 I_2g/100g - 126.92 I_{2g}/100g for refined soyabean oil. The study revealed a drop in the iodine value of oils sold in the open market compared to the same brand of oil sold in an air-conditioned supermarket. This is a prove of the gradual oxidative rancidity of the oils. However, all the oils studied showed an agreement with CODEX STAN and NAFDAC specifications for refined palm oil (50.00 56.00 I_2 g/100g) and refined soyabean oil (124 - 139 I_2g/100g) respectively. The high Iodine values of oils refined from soya bean oils show that the free fatty acids in the oil are highly unsaturated compared to the oils refined from palm oil (Siyanbola et al., 2015). The iodine value implies the double bond sites of the molecule of oil that determines its shelf life and stability qualities because the unsaturation of oil makes it very reactive. Higher iodine values of the oil imply a higher degree of unsaturation leading to higher vulnerability of the oil to oxidative rancidity which may, in turn, contribute to heart-related diseases. Studies have shown that reducing the iodine value of oils helps in the stability of the oil (Akinola, 2010).

Peroxide values of the oil obtained from the study ranged from 0.62 -1.38 mEqO2/g. The figures showed that the oils sold in the open markets are more prone to oxidative rancidity compared to the oils sold in supermarkets. However, figures for both categories of oils agree with NAFDAC, SON and CODEX STAN specification limit of 10Meq max. This further showed that the oils will be stable if stored under mild temperature conditions compared to storage in harsh weather conditions (Ibironke et al., 2015). The peroxide value of the oil showed a very high correlation with moisture content (r = 0.891) and a very low correlation with %FFA (-0.218) and acid value (-0.218). Peroxide value of oil greater than 15 meqO2/kg may be hazardous to health by growing reactive oxygen species and secondary products of lipid peroxidation, which are sources of cardiovascular and inflammatory diseases (Konuskan et al., 2018). The saponification numbers of the oils studied fall within the range of 190.7MgKOH/g - 205.2MgKOH/g. These values are in agreement with the specifications by NAFDAC and CODEX STAN (190-202) apart from SMGR and OMGR which is a little above the maximum limit of the permissible specification limit. The higher saponification value of the oil renders them valuable raw materials for soaps and cosmetics (Nangbes et al., 2013).

Conclusion

The physiochemical parameters of these brands of edible oils sold in supermarkets and open markets in Rivers State were studied. The continuous subjection of vegetable oils to heat, light and moisture amounts to the gradual deterioration of the oils and alteration of their physiochemical parameters. The average result of all the parameters studied showed that the vegetable oils have high shelf lives and can therefore be stored for a very long time if this is strictly done in friendly weather conditions as against the harsh weather conditions that these oils are subjected to in the open markets. In addition to the above, it also showed good nutritional values all falling within the specification limit stipulated by supervising agencies like SON, NAFDAC and CODEX STAN. From this research, it can be observed that virtually all the oil samples examined displayed acceptable physicochemical characteristics. However, acid value, peroxide value, free fatty acid, moisture content, and iodine value in some samples are of great concern to public health. To achieve a better quality of the oils sold in different markets across the state, it would be necessary for the monitoring agencies to establish qualified structure across the length and breadth of the state for proper quality control measures of the products; this will assist in the preservation of the health of the populace. Furthermore, it would be imperative to create awareness among stakeholders in the

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industry on the extraction methods, condition of storage and conservation processes that determines the stability of oils. However, the figures of the parameters observed from the oils sold in the open markets show a gradual departure from normal to degradation of the oils. These parameters are of utmost concern to scientists because the rancidity of oils degrades their quality and is connected to some illnesses like brain cell damage, inflammation/increase in the risk of diabetes, cardiovascular diseases, increase in blood pressure and genotoxic changes in the body. The effects will be more in the oils sold in the open markets compared to the oils sold in the supermarkets.

Recommendations

1. Based on the observed trends of the physicochemical parameters of vegetable oils sold in an open market and supermarket (air condition), it is recommended that vegetable oils should not be stored in an environment that is exposed to direct rays of ultraviolet radiation, moisture and high heat.
2. Vegetable oils exposed to direct heat, light and moisture are susceptible to autooxidation resulting in rapid rancidification and deterioration of the oils as a result of the formation of alkanols, alkenals and other toxic carbonyl compounds. The shelf life and nutritional value of these oils are determined by the oils' oxidative stability hence the need to carefully manage the transportation and storage of the oils.

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