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QUALITY ASSESSMENT OF REFINED VEGETABLE OILS FROM SELECTED MAJOR MARKETS IN LAGOS METROPOLIS, NIGERIA

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ABSTRACT

The physical compositions and chemical properties of refined vegetable oils determine their quality and storage stability. This study assessed the physical and chemical quality indices of selected refined vegetable oils in Lagos markets. Eight samples of branded oils coded as: VEG-MMD, VEG-EMP, VEG-DVK, VEG-GINO, VEG-SNF, VEG-PWR, VEG-GDS, VEG-GLN and one unbranded, VEG-UBD, were purchased. Three categories of oils were assessed: fresh oils (≤3 months from manufactured date), oils which were mid-way to expiration and those at verge of expiration (≤ 3 months to expiration). Results were subjected to analysis of variance and means were separated using Duncan's multiple range test. Range of values obtained for colour, cloud-point, moisture, percentage-purity, free-fatty-acid, iodine and peroxide values were 0.57 to 5.82 R, 4.47 to 8.43 °C, 0.03 to 0.08%, 99.27 to 99.93%, 0.07 to 0.15%, 54.74 to 119.85 and 0.15 to 0.71 mEq/kg respectively. Results showed significant ($p<0.05$) differences in colour, cloud-point, moisture, free-fatty-acids, iodine and peroxide values in all categories of oils. The result also showed significant ($p<0.05$) difference in percentage-purity of fresh vegetable oils and those midway to their expiry dates while no significant ($p<0.05$) difference existed in those at verge of expiration.

Keywords: Refined vegetable oil, Chemical properties, Physical composition, Free-fatty-acid, Percentage-purity.

INTRODUCTION

Refined vegetable oil belongs to the class of food called lipid. They are derived from plant sources like soya beans, melon, groundnut, corn, palm fruit, shea butter, coconut, palm kernel, and others. These oil seeds usually have the oil encased in minute cells that are deeply embedded in fibrous structures (Tayde *et al.,* 2011). Vegetable oil could either be extracted by traditional crude method of crushing the seeds or by scientific process which involves removal of lint, decortications, separation of hulls and extraction of the oils by organic solvent. The crude vegetable oils obtained from various oil mills are further refined before use for edible purpose. Nigeria is the fifth largest producer of oil palm in the world with domestic production of 930 thousand metric tonnes accounting for about 1.5% of global output (Izah *et al.,* 2016). Palm oil including palm kernel oil, accounted for about 65% of the total vegetable oil production in Nigeria (Anyanwu *et al.,* 2011). Other vegetable oils had a share of 17% production while deficit and imports accounted for the balance of 18%. The common brands of refined vegetable oils that are available in major markets in Lagos metropolis include Mamador, Power oil, Alfa sunflower oil, Grand soya oil, Emperor oil, Golden penny oil, Devon king's oil, Gino oil, and others. It was reported by the United States Department of Agriculture that 168.85 million metric tonnes of vegetable oils are estimated to be produced globally at the end of 2013-2014 season (Leong *et al.,* 2015). The net consumption of vegetable oils in Nigeria stood at 1.6 million tonnes per annum with the domestic supply estimated at 1.3 million tonnes, leaving a deficit of 0.3 million tonnes which represented imports (Anyanwu *et al,.* 2011). As the yearly consumption of vegetable oil hit 1.6 million tonnes, the Federal Government of Nigeria banned the importation of bulk crude vegetable oil to support local producers in 2005. However,

domestic production of vegetable oils had not kept pace with its rising demand. This deficiency, coupled with the ban which was in place, had resulted to increase in price of the limited available vegetable oils. According to Asrat and Ermias (2015), vegetable oils, fat and other food commodities are prone to food adulteration. There is an urgent need for scientific study to determine the prevalence of food adulteration at household level in the country especially adulteration of vegetable oil.

The main objective of this research was to assess the quality indices of the selected refined vegetable oils and their respective market variations in Lagos metropolis. The specific objectives of this study were to determine the physical characteristics of the selected refined vegetable oils as sold in the selected major markets in Lagos metropolis and to determine the percentage purity and chemical properties of the selected refined vegetable oils.

MATERIALS AND METHODS

Sampling Method

Simple Random Sampling (SRS) method was used in the course of this research work.

Experimental Design

A factorial design was employed in this study. Three categories of refined vegetable oils were examined: fresh vegetable oils (≤ 3 months from production date), those that were mid-way to their expiry date and those that were at the verge of their expiration (≤ 3 months to expiry date). The experiment was replicated twice**.** The sampling was carried out twice at an interval of two months. The collected samples (branded and unbranded) were poured into cleaned, dried and air-tight 100 mL sampling bottles which were well labelled. The samples were taken to the laboratory for analysis under a controlled temperature (28±2 °C).

Determination of colour

This test was carried out with the aid of universal Lovibond Tintometer Model F and Lovi bond spectrocolorimeter, PFX-i series (United Kingdom). The oil sample was heated to 60±2 °C with the aid of heater and it was allowed to cool to room temperature before measurement. The colour of the oil sample was determined by varying the colour racks in the ratio of 10 yellow to 1 red until an accurate colour match was obtained (ISO 15305:1998).

Determination of cloud point

Approximately 65 g of oil was weighed into a beaker and it was heated to a temperature of 50 °C. The oil was allowed to cool to room temperature. The cooled oil inside the beaker was then inserted into a water bath operating at 2 °C. With the aid of a thermometer, the oil was subjected to a continuous stirring in a circular motion to prevent the super cooling and solidification of fat crystals on the side and bottom of the beaker. The temperature at which the graduation marks on the thermometer immersed in the oil were no longer visible when viewed horizontally through the beaker was recorded as the cloud point (AOCS, 2017).

Determination of moisture

The method of American Oil Chemists' (AOCS 2017) was used. Air oven operating at 130 ±1 °C was used to determine the moisture content of the selected vegetable oils. The oil sample was thoroughly mixed to distribute the water in it uniformly. Approximately 5 g of oil was weighed into a tarred moisture dish that has been dried and cooled previously in a desiccator. The sample was then placed in the air oven for 30 min. Thereafter it was removed, cooled to room temperature in a desiccator and weighed.

Calculation:

$$\text{Moisture Content (\%)} = \frac{(W_2 - W_1)}{W3} \times 100$$

W_1 = weight of dish and oil sample after drying

Where W_2 = weight of dish and oil sample before drying, and

W_3 = oil sample weight.

Determination of percentage purity of oil

Approximately 10 g of residue from the moisture determination was weighed into a beaker and 50 mL of petroleum ether was added to dissolve the oil. The solution was then filtered through Gooch crucible with the aid of vacuum. Extra 10 mL of petroleum ether was used to wash the solution five times to enhance the filtration process. The crucible with its content was dried to a constant weight by an electric oven operating at 101 ± 1 °C,

and then cooled to room temperature in a desiccator and weighed (ISO 663:2017).
Calculation:
Percentage purity = 100% - Percentage insoluble impurity;
Insoluble impurities (%) = (gain in mass of crucible/mass of sample taken) × 100

Determination of free fatty acid
Approximately 10 g of the oil sample was weighed into 250 mL conical flask and 75 mL of hot isopropyl alcohol solution (IPA) was then added to the oil sample to dissolve it. This was followed by addition of 2 drops of phenolphthalein indicator. The solution was titrated against 0.05 M sodium hydroxide (NaOH), until the appearance of first permanent pink colour appeared (AOCS, 2017).
Calculation:

$$\% \text{ FFA} = \frac{V \times M \times C}{Wt.}$$

Where
V is volume of alkali
M is the molarity of NaOH (0.05 M),
Wt. is the weight of the sample
C = constant (25.6) as Palmitic for vegetable oil Products (constant).

Determination of iodine value
The test sample was thoroughly mixed and heated to 68 °C. It was filtered through two pieces of 10" / 25 cm filter paper to remove any solid impurities. About 0.5 g of the filtered oil sample was weighed into a conical flask, 20 mL mixture of cyclohexane and acetic acid in the ratio 1:1 was then added to the conical flask to dissolve the sample. About 25 mL of wijs solution was dispensed into the conical flask containing the test sample with the aid of pipette. The conical flask was stoppered and swirled to ensure intimate mixture. The solution was immediately transferred into a dark cupboard for 1 h after which it was removed from the dark, 20 mL of potassium iodide (KI), followed by 100 mL of distilled water were added to it content. The solution was well mixed. The solution was then titrated against 0.1 M sodium thiosulphate solution ($Na_2S_2O_3$) until the yellow colour of iodine had almost disappeared. About 2 mL of starch indicator solution was then added and the titration continued with vigorous shaking until the blue colour just disappeared. The blank test was also carried out simultaneously under the same conditions (AOCS, 2017).
Calculation:

$$\text{Iodine Value} = \frac{12.96\ M\ (V_2\text{-}V_1)}{W}$$

Where:
M is the exact molarity of thiosulphate solution used,
V_2 is the volume of sodium thiosulphate solution used for blank and
V_1 is the volume of sodium thiosulphate solution used for sample.
W is the sample weight.

Determination of peroxide value
The oil sample was melted to 65 °C after thorough stirring. About 10 g of the sample was weighed into a conical flask and 30 mL of acetic acid-chloroform in the ratio of 3:2 (v/v) mixture was added and swirled in the flask to dissolve the sample.
With the aid of a pipette, 0.5 mL of freshly prepared saturated potassium iodide was added into the mixture and swirled in the flask continuously for 1 min and thereafter 30 mL of distilled water was added. About 0.5 mL starch indicator was added to the solution as it was being titrated against saturated-freshly prepared 0.1 M sodium thiosulphate solution until the blue colour has just disappear. The blank was simultaneously carried out under the same conditions. AOCS (1998).
Calculation:

$$\text{Peroxide Value} = \frac{V \times N \times 1000}{W}$$

Where:
V is the volume of sodium thiosulphate solution used for the sample,
N is the molarity of sodium thiosulphate and W is the sample weight.
W is the sample weight.

Statistical Analysis
Statistical Package for Social Scientists (SPSS) version 21.0 was used to analyse the data generated in this research. The mean was calculated from triplicate determinations and the

result obtained from each determination was presented as mean±SD (standard deviation) (IBM Corp, 2012). Duncan's Multiple Range Test (DMRT) was used to separate the mean of the results generated. Variations in results were considered significant at $p < 0.05$

RESULTS

Physical and Chemical Properties of Fresh Vegetable Oils from Ikorodu Market

In Table 1, there were significant differences ($p < 0.05$) in colour, cloud point, moisture content, percentage purity, free fatty acids, iodine and peroxide values of the samples respectively. The colour of the samples ranged from 0.57 ± 0.05 to 5.82 ± 0.08 R with VEG-GDS having the lowest colour while VEG-UBD had the highest colour. The cloud point ranged from 4.44 ± 0.07 °C to 7.23 ± 0.06 °C with VEG-GDS having the least cloud point while VEG-UBD had the highest cloud point. VEG-MMD had the lowest moisture content of 0.04 ± 0.00% while VEG-UBD had the highest moisture of 0.08 ± 0.00%. The percentage purity of the oil samples ranged from 93.94 ±1.02 to 99.95 ± 1.00% with VEG-GLN having the highest percentage purity while the VEG-UBD had the least percentage purity. The free fatty acid ranged from 0.06 ± 0.00 to 0.15 ± 0.01% with VEG-GDS having the lowest free fatty acid while VEG-UBD had the highest free fatty acid. The iodine value also ranged from 55.44 ± 0.65 to 119.18 ± 0.78 with VEG-GDS having the highest iodine value while VEG-UBD had the least value. The peroxide value ranged from 0.15 ± 0.04 to 0.71 ± 0.05 (meq/kg) with VEG-ASF having the least peroxide value while VEG-UBD had the highest peroxide value.

Table 1: Physical and chemical properties of fresh oil samples from Ikorodu market.

Brand	Colour (R)	CP (°C)	Moisture (%)	Purity (%)	FFA (%)	IV	PV (meq/kg)
VEG-MMD	2.12 ± 0.04^{d}	4.57 ± 0.21^{a}	0.04 ± 0.00^{a}	99.62 ± 0.58^{b}	0.07 ± 0.00^{b}	61.26 ± 0.58^{e}	0.34 ± 0.03^{b}
VEG-EMP	2.30 ± 0.06^{e}	6.80 ± 0.10^{c}	0.07 ± 0.00^{d}	99.42 ± 0.50^{b}	0.07 ± 0.01^{b}	59.04 ± 0.05^{c}	0.19 ± 0.05^{a}
VEG-DVK	2.48 ± 0.11^{e}	6.49 ± 0.04^{b}	0.06 ± 0.01^{c}	99.93 ± 0.03^{b}	0.08 ± 0.00^{c}	57.79 ± 0.04^{b}	0.31 ± 0.03^{b}
VEG-GINO	4.70 ± 0.06^{g}	6.50 ± 0.11^{b}	0.06 ± 0.001^{c}	99.24 ± 1.13^{ab}	0.07 ± 0.00^{b}	58.39 ± 0.55^{bc}	0.21 ± 0.02^{a}
VEG-ASF	0.70 ± 0.02^{b}	4.50 ± 1.00^{a}	0.05 ± 0.01^{b}	99.89 ± 0.11^{b}	0.08 ± 0.00^{c}	119.17 ± 0.64^{g}	0.15 ± 0.04^{a}
VEG-PWR	3.50 ± 0.06^{f}	6.72 ± 0.07^{c}	0.06 ± 0.001^{c}	99.81 ± 0.06^{b}	0.07 ± 0.00^{b}	60.38 ± 0.51^{d}	0.34 ± 0.01^{b}
VEG-GDS	0.57 ± 0.05^{a}	4.44 ± 0.07^{a}	0.05 ± 0.01^{b}	99.64 ± 0.57^{b}	0.06 ± 0.00^{a}	119.18 ± 0.78^{g}	0.16 ± 0.01^{a}
VEG-GLN	0.86 ± 0.07^{c}	4.47 ± 0.12^{a}	0.05 ± 0.003^{b}	99.95 ± 1.00^{b}	0.08 ± 0.00^{c}	113.56 ± 0.04^{f}	0.20 ± 0.01^{a}
VEG-UBD	5.82 ± 0.08^{h}	7.23 ± 0.06^{d}	0.08 ± 0.00^{e}	93.94 ± 1.02^{a}	0.15 ± 0.01^{d}	55.44 ± 0.65^{a}	0.71 ± 0.05^{c}

Values are means of triplicate determination.

Mean values with different superscripts within the same column are significantly different ($p < 0.05$).

Where:

VEG-MMD- Mamador vegetable oil; VEG-EMP- Emperor vegetable oil; VEG-DVK- Devon King's vegetable oil; VEG-GINO- Gino vegetable oil;VEG-ASF- Alfa Sun flower vegetable oil; VEG-PWR- Power vegetable oil; VEG-GDS- Grand soya oil; VEG-GLN- Golden vegetable oil; VEG-UBD- Unbranded vegetable oil; FFA-Free fatty acid, IV-Iodine value, PV-Peroxide value, CP-Cloud point.

Physical and Chemical Properties of Fresh Vegetable Oils from Mushin market

In Table 2, there were significant differences ($p < 0.05$) in colour, cloud point, moisture content, percentage purity, free-fatty acids, iodine and peroxide values of the samples respectively.

Table 2: Physical and chemical properties of fresh oil samples from Mushin market.

Brand	Colour (R)	CP (°C)	Moisture (%)	Purity (%)	FFA (%)	IV	PV (meq/kg)
VEG.MMD	2.20 ± 0.10^{b}	4.72 ± 0.18^{a}	0.04 ± 0.01^{b}	99.05 ± 1.59^{b}	0.06 ± 0.00^{a}	61.19 ± 0.16^{c}	0.41 ± 0.06^{c}
VEG-EMP	2.26 ± 0.12^{b}	6.67 ± 0.14^{b}	0.06 ± 0.01^{d}	97.81 ± 1.95^{b}	0.07 ± 0.01^{c}	58.18 ± 0.82^{b}	0.26 ± 0.00^{ab}
VEG-DVK	2.42 ± 0.08^{b}	6.73 ± 0.21^{b}	0.05 ± 0.00^{bc}	98.87 ± 0.94^{b}	0.07 ± 0.00^{c}	58.16 ± 0.77^{b}	0.34 ± 0.01^{bc}
VEG.GINO	4.79 ± 0.17^{d}	6.66 ± 0.15^{b}	0.05 ± 0.00^{c}	99.02 ± 1.31^{b}	0.06 ± 0.05^{b}	58.48 ± 0.07^{b}	0.36 ± 0.18^{bc}
VEG-ASF	0.81 ± 0.09^{a}	4.53 ± 0.11^{a}	0.05 ± 0.01^{c}	98.63 ± 1.79^{b}	0.08 ± 0.00^{d}	119.09 ± 0.33^{f}	0.15 ± 0.01^{a}
VEG-PWR	3.46 ± 0.15^{c}	6.76 ± 0.13^{b}	0.03 ± 0.00^{a}	99.77 ± 0.16^{b}	0.08 ± 0.00^{d}	59.94 ± 0.97^{c}	0.33 ± 0.02^{bc}
VEG-GDS	0.60 ± 0.10^{a}	4.48 ± 0.13^{a}	0.04 ± 0.00^{bc}	99.27 ± 0.96^{b}	0.06 ± 0.00^{a}	120.51 ± 0.21^{g}	0.15 ± 0.00^{a}
VEG-GLN	0.60 ± 0.10^{a}	4.70 ± 0.10^{a}	0.05 ± 0.00^{c}	99.81 ± 0.23^{b}	0.06 ± 0.00^{a}	111.28 ± 0.05^{e}	0.25 ± 0.00^{ab}
VEG-UBD	5.70 ± 0.10^{e}	7.59 ± 0.09^{c}	0.08 ± 0.00^{e}	95.63 ± 0.55^{a}	0.12 ± 0.01^{e}	54.74 ± 0.05^{a}	0.84 ± 0.01^{d}

Values are means of triplicate determination.

Mean values with different superscripts within the same column are significantly different ($p<0.05$).

Where:

VEG-MMD- Mamador vegetable oil; VEG-EMP- Emperor vegetable oil; VEG-DVK- Devon King's vegetable oil; VEG-GINO- Gino vegetable oil; VEG-ASF- Alfa sun flower vegetable oil; VEG-PWR- Power vegetable oil; VEG-GDS- Grand soya oil; VEG-GLN- Golden vegetable oil; VEG-UBD- Unbranded vegetable oil. FFA-Free fatty acid, IV-Iodine value, PV-Peroxide value, CP-Cloud point

The sample colours ranged from 0.60 ± 0.10 to 5.70 ± 0.10 R. The temperature of the cloud was 4.48 ± 0.13 to 7.59 ± 0.09 °C. The moisture content of VEG-PWR was the lowest (0.03 ± 0.00%) and that of VEG-UBD was the highest (0.08 ± 0.00%). The range of the oil samples' purity percentages was 95.63 ± 0.55 to 99.81 ± 0.23%. The free fatty acid concentration ranged from 0.06 ± to 0.12%.

Aside from that, the iodine value varied from 54.74 ± 0.05 to 119.09 ± 0.33.

VEG-ASF had the lowest peroxide value and VEG-UBD had the highest peroxide value, with a range of 0.15 ± 0.00 to 0.84 ± 0.01 (meq/kg).

Physical and Chemical Properties of Vegetable Oils which were Mid-way to Expire from Ikorodu Market

As shown in Table 3, there were significant differences ($p< 0.05$) in colour, cloud point, moisture content, percentage purity, free fatty acids, iodine and peroxide values of the samples respectively. However, no significant difference was observed in the percentage purity of the samples. The colour of the samples ranged from 0.66 ± 0.25 to 4.40 ± 0.30 R with VEG-GDS having the least colour while VEG-GINO had the highest colour. The cloud point also ranged from 4.56 ± 0.35 to 7.37 ± 0.24 °C.

Table 3: Physical and chemical properties of oil samples at mid-way to expiry date from Ikorodu market.

Brand	Colour (R)	CP (°C)	Moisture (%)	Purity (%)	FFA (%)	IV	PV (meq/kg)
VEG.MMD	2.40 ± 0.20^{b}	4.77 ± 0.15^{a}	0.04 ± 0.00^{a}	99.73 ± 0.19^{a}	0.08 ± 0.00^{b}	60.37 ± 0.43^{b}	0.44 ± 0.03^{d}
VEG-EMP	2.45 ± 0.25^{b}	6.50 ± 0.20^{b}	0.07 ± 0.01^{d}	99.59 ± 0.32^{a}	0.07 ± 0.01^{ab}	58.29 ± 0.27^{a}	0.28 ± 0.02^{b}
VEG-DVK	2.46 ± 0.15^{b}	6.50 ± 0.31^{b}	0.07 ± 0.00^{d}	99.53 ± 0.34^{a}	0.06 ± 0.01^{a}	58.22 ± 0.34^{a}	0.36 ± 0.03^{c}
VEG.GNO	4.40 ± 0.30^{d}	7.37 ± 0.24^{d}	0.05 ± 0.00^{b}	99.67 ± 0.23^{a}	0.07 ± 0.05^{ab}	58.49 ± 0.05^{a}	0.26 ± 0.02^{b}
VEG-ASF	0.80 ± 0.10^{ab}	4.56 ± 0.35^{a}	0.06 ± 0.00^{c}	99.67 ± 0.25^{a}	0.08 ± 0.01^{b}	119.48 ± 0.13^{e}	0.17 ± 0.02^{a}
VEG-PWR	3.46 ± 0.35^{c}	6.87 ± 0.25^{c}	0.06 ± 0.01^{c}	99.71 ± 0.22^{a}	0.07 ± 0.01^{ab}	60.65 ± 0.19^{b}	0.34 ± 0.06^{c}
VEG-GDS	0.66 ± 0.25^{a}	4.60 ± 0.30^{a}	0.04 ± 0.00^{a}	99.80 ± 0.14^{a}	0.07 ± 0.01^{ab}	118.58 ± 0.32^{d}	0.18 ± 0.02^{a}
VEG-GLN	0.86 ± 0.25^{ab}	4.57 ± 0.32^{a}	0.04 ± 0.01^{a}	99.27 ± 0.58^{a}	0.07 ± 0.00^{ab}	111.19 ± 0.19^{c}	0.33 ± 0.03^{c}

Values are means of triplicate determination.

Mean values with different superscripts within the same column are significantly different ($p < 0.05$).

Where:

VEG-MMD- Mamador vegetable oil; VEG-EMP- Emperor vegetable oil; VEG-DVK- Devon King's vegetable oil; VEG-GINO- Gino vegetable oil; VEG-ASF- Alfa sun flower vegetable oil; VEG-PWR- Power vegetable oil; VEG-GDS- Grand soya oil; VEG-GLN- Golden vegetable oil.

FFA-Free fatty acid, IV-Iodine value, PV-Peroxide value, CP-Cloud point.

The moisture content of VEG-MMD was the lowest (0.04 ± 0.00%) and that of VEG-DVK was the highest (0.07 ± 0.00%).
The oil samples' percentage purity levels ranged from 99.27 ± 0.58 to 99.80 ± 0.14%.
The percentage of free fatty acids ranged from 0.06 ± 0.01 to 0.08 ±0.01%.
Additionally, the iodine value varied from 58.22 ± 0.34 to 119.48 ± 0.13, with VEG-ASF having the greatest value and VEG-DVK having the lowest.
The peroxide value also ranged from 0.17 ± 0.02 to 0.44 ± 0.03 (meq/kg).

Physical and Chemical Properties of Vegetable Oils which were mid-way to Expire from Mushin Market

In Table 4, there were significant differences ($p<0.05$) in colour, cloud point, moisture, free fatty acid, iodine value and peroxide value of the samples respectively. No significant difference was also observed in the percentage purity of the samples. The colour of the samples ranged from 0.80 ± 0.02 to 4.80 ± 0.04 R with VEG-GLN having the least colour while VEG-GINO had the highest colour. The cloud point also ranged from 4.53 ± 0.15 to 6.89±0.04 °C. VEG-MMD had the lowest moisture content of 0.03 ± 0.00% while VEG-EMP had the most moisture of 0.07 ± 0.00%. The percentage purity of the oil samples ranged from 99.18 ±1.04 to 99.84 ± 0.08% while the free fatty acid ranged from 0.07 ± 0.01 to 0.08 ± 0.01%.

Table 4: Physical and chemical properties of oil samples at mid-way to expiry date from Mushin market.

Brand	Colour (R)	CP (°C)	Moisture (%)	Purity (%)	FFA (%)	IV	PV (meq/kg)
VEG.MMD	2.61 ± 0.06^{c}	4.90 ± 0.10^{c}	0.03 ± 0.00^{a}	99.18 ± 1.04^{a}	0.07 ± 0.01^{a}	60.73 ± 0.09^{d}	0.43 ± 0.02^{e}
VEG-EMP	2.56 ± 0.12^{c}	6.93 ± 0.11^{e}	0.07 ± 0.00^{c}	99.39 ± 0.53^{a}	0.07 ± 0.00^{a}	58.35 ± 0.03^{ab}	0.28 ± 0.01^{c}
VEG-DVK	2.53 ± 0.04^{c}	6.55 ± 0.05^{d}	0.06 ± 0.00^{bc}	99.23 ± 0.66^{a}	0.08 ± 0.00^{b}	58.45 ± 0.08^{b}	0.37 ± 0.02^{d}
VEG-GINO	4.80 ± 0.04^{e}	6.77 ± 0.11^{de}	0.05 ± 0.00^{b}	99.46 ± 0.42^{a}	0.07 ± 0.01^{a}	58.26 ± 0.03^{a}	0.25 ± 0.03^{bc}
VEG-ASF	1.05 ± 0.13^{b}	4.82 ± 0.06^{bc}	0.05 ± 0.00^{b}	99.67 ± 0.24^{a}	0.08 ± 0.00^{b}	119.60 ± 0.09^{g}	0.15 ± 0.01^{a}
VEG-PWR	3.61 ± 0.11^{d}	6.89 ± 0.04^{e}	0.06 ± 0.00^{c}	99.44 ± 0.52^{a}	0.08 ± 0.00^{b}	60.48 ± 0.06^{c}	0.23 ± 0.03^{c}
VEG-GDS	0.97 ± 0.15^{ab}	4.53 ± 0.15^{a}	0.05 ± 0.00^{b}	99.62 ± 0.35^{a}	0.08 ± 0.00^{b}	119.37 ± 0.07^{f}	0.15 ± 0.02^{a}
VEG-GLN	0.80 ± 0.02^{a}	4.66 ± 0.25^{ab}	0.05 ± 0.00^{b}	99.84 ± 0.08^{a}	0.08 ± 0.01^{b}	111.47 ± 0.10^{e}	0.26 ± 0.02^{bc}

Values are means of triplicate determination.
Mean values with different superscripts within the same column are significantly different ($p < 0.05$).
Where:
VEG-MMD- Mamador vegetable oil; VEG-EMP- Emperor vegetable oil; VEG-DVK- Devon King's vegetable oil; VEG-GINO- Gino vegetable oil; VEG-ASF- Alfa sun flower vegetable oil; VEG-PWR- Power vegetable oil; VEG-GDS- Grand soya oil; VEG-GLN- Golden vegetable oil; FFA-Free fatty acid, IV-Iodine value, PV-Peroxide value, CP-Cloud point.

The iodine value also ranged from 58.26 ± 0.03 to 119.60 ± 0.09 and the peroxide value ranged from 0.15±0.01 to 0.43 ± 0.03 (meq/kg).

Physical and Chemical Properties of Vegetable Oils which were at Verge of Expiration from Ikorodu Market

Table 5 also showed similar pattern. There were significant differences ($p< 0.05$) in colour, cloud point, moisture, free fatty acid, iodine and peroxide values of the samples. However, there was no significant difference in the purity of the selected oils. The colour of the samples ranged from 0.76 ± 0.11 to 4.75 ± 0.15 R with VEG-ASF having the least colour while VEG-GINO had the highest colour. The cloud point also ranged from 6.76 ± 0.25 to 8.43 ± 0.35°C. VEG-MMD had the lowest moisture content of 0.04 ± 0.00 % while VEG-GLN had the highest moisture of 0.07 ± 0.05%. The percentage purity of the oil samples ranged from 99.32±0.89 to 99.95 ± 0.02%. The free fatty acid ranged from 0.09 ± 0.00 to 0.14 ± 0.04%. The iodine value also ranged from 57.21 ± 0.61 to 117.48 ± 0.77. The peroxide value ranged from 0.43 ± 0.02 to 0.64 ± 0.02 (meq/kg) with VEG-ASF having the least peroxide value while VEG-MMD had the highest peroxide value.

Table 5: Physical and chemical properties of vegetable oils that were at verge of expiration from Ikorodu market.

Brand	Colour (R)	CP (°C)	Moisture (%)	Purity (%)	FFA (%)	IV	PV (meq/kg)
VEG-MMD	2.56 ± 0.15^{b}	7.63 ± 0.30^{ab}	0.04 ± 0.00^{a}	99.95 ± 0.02^{a}	0.10 ± 0.01^{a}	59.92 ± 0.02^{c}	0.64 ± 0.03^{c}
VEG-EMP	2.63 ± 0.25^{bc}	8.43 ± 0.35^{d}	0.07 ± 0.00^{e}	99.74 ± 0.39^{a}	0.09 ± 0.00^{a}	57.50 ± 0.53^{a}	0.55 ± 0.03^{b}
VEG-DVK	2.76 ± 0.15^{c}	7.50 ± 0.26^{b}	0.06 ± 0.00^{d}	99.53 ± 0.37^{a}	0.13 ± 0.00^{b}	57.21 ± 0.61^{a}	0.64 ± 0.02^{c}
VEG-GINO	4.75 ± 0.15^{e}	6.86 ± 0.35^{a}	0.05 ± 0.00^{bc}	99.33 ± 0.53^{a}	0.14 ± 0.02^{b}	58.54 ± 0.26^{b}	0.55 ± 0.03^{b}
VEG-ASF	0.76 ± 0.11^{a}	6.76 ± 0.25^{a}	0.05 ± 0.00^{b}	99.32 ± 0.89^{a}	0.09 ± 0.00^{a}	117.48 ± 0.77^{d}	0.43 ± 0.02^{a}
VEG-PWR	3.52 ± 0.19^{d}	8.09 ± 0.2^{cd}	0.06 ± 0.00^{c}	99.68 ± 0.23^{a}	0.14 ± 0.02^{b}	59.63 ± 0.32^{c}	0.45 ± 0.02^{a}
VEG-GDS	2.24 ± 0.12^{b}	8.40 ± 0.21^{d}	0.07 ± 0.02^{e}	99.75 ± 0.36^{a}	0.14 ± 0.04^{b}	117.43 ± 0.14^{d}	0.63 ± 0.02^{c}
VEG-GLN	0.76 ± 0.22^{a}	6.84 ± 0.22^{a}	0.07 ± 0.05^{c}	99.53 ± 0.41^{a}	0.13 ± 0.02^{b}	111.67 ± 0.05^{cd}	0.63 ± 0.03^{c}

Values are means of triplicate determination.

Mean values with different superscripts within the same column are significantly different ($p < 0.05$).

Where:

VEG-MMD- Mamador vegetable oil; VEG-EMP- Emperor vegetable oil; VEG-DVK- Devon King's vegetable oil; VEG-GINO- Gino vegetable oil; VEG-ASF- Alfa sun flower vegetable oil; VEG-PWR- Power vegetable oil, VEG-GDS- Grand soya oil; VEG-GLN- Golden vegetable oil; FFA-Free fatty acid, IV-Iodine value, PV-Peroxide value, CP-Cloud point.

Physical and Chemical Properties of Vegetable Oils which were at Verge of Expiration from Mushin Market

The sample values for colour, cloud point, moisture, free fatty acid, iodine, and peroxide were significantly different ($p < 0.05$) in table 6.

However, the percentage purity of the studied oils showed no appreciable variation.

The samples' colours ranged from 0.75 ± 0.23 to 4.26 ± 0.30 R.

The cloud point varied from 5.00 ± 0.20 to 8.53 ± 0.400 °C.

The moisture content of VEG-MMD was the lowest ($0.07 \pm 0.00\%$) and that of VEG-GLN was the highest ($0.08 \pm 0.01\%$). The sample's varying levels of oil percentage purity were 99.46 ± 0.41 to $99.66 \pm 0.24\%$. Between 0.13 ± 0.02 and $0.16 \pm 0.03\%$ were free fatty acids values. The peroxide value ranged from 0.44 ± 0.03 to 0.76 ± 0.02 (meq/kg), whereas the iodine value ranged from 57.91 ± 0.10 to 117.31 ± 0.12. VEG-GDS had the highest iodine value and VEG-DVK had the lowest value.

Table 6: Physical and chemical properties of oil samples at the verge of expiration from Mushin market.

Brand	Colour (R)	CP (°C)	Moisture (%)	Purity (%)	FFA (%)	IV	PV (meq/kg)
VEG~MMD	2.66 ± 0.25^{b}	8.43 ± 0.30^{c}	0.07 ± 0.00^{a}	99.56 ± 0.33^{a}	0.13 ± 0.02^{a}	60.02 ± 0.19^{d}	0.73 ± 0.02^{d}
VEG-EMP	2.73 ± 0.15^{b}	8.46 ± 0.45^{c}	0.07 ± 0.01^{a}	99.50 ± 0.37^{a}	0.14 ± 0.02^{b}	58.39 ± 0.12^{b}	0.66 ± 0.04^{c}
VEG-DVK	2.76 ± 0.20^{b}	8.53 ± 0.40^{c}	0.08 ± 0.00^{b}	99.52 ± 0.36^{a}	0.16 ± 0.02^{c}	57.91 ± 0.10^{a}	0.75 ± 0.02^{d}
VEG-GINO	4.26 ± 0.30^{d}	7.40 ± 0.30^{b}	0.08 ± 0.00^{b}	99.60 ± 0.30^{a}	0.14 ± 0.03^{b}	58.79 ± 0.14^{c}	0.76 ± 0.02^{d}
VEG-ASF	3.63 ± 0.30^{c}	8.46 ± 0.25^{c}	0.07 ± 0.01^{a}	99.46 ± 0.41^{a}	0.13 ± 0.04^{ab}	117.21 ± 0.03^{ef}	0.55 ± 0.03^{b}
VEG-PWR	0.80 ± 0.02^{a}	5.00 ± 0.20^{a}	0.07 ± 0.01^{a}	99.66 ± 0.24^{a}	0.16 ± 0.03^{c}	58.92 ± 0.22^{c}	0.44 ± 0.03^{a}
VEG-GDS	2.42 ± 0.21^{b}	8.53 ± 0.21^{d}	0.08 ± 0.01^{b}	99.53 ± 0.26^{a}	0.15 ± 0.02^{bc}	117.31 ± 0.12^{ef}	0.65 ± 0.02^{c}
VEG-GLN	0.75 ± 0.23^{a}	7.41 ± 0.32^{b}	0.08 ± 0.00^{b}	99.62 ± 0.37^{a}	0.16 ± 0.02^{c}	111.22 ± 0.04^{e}	0.72 ± 0.02^{d}

Values are means of triplicate determination.

Mean values with different superscripts within the same column are significantly different ($p < 0.05$).

Where:

VEG-MMD- Mamador vegetable oil; VEG-EMP- Emperor vegetable oil; VEG-DVK-Devon king's vegetable oil; VEG-GDS- Grand soya oil; VEG-GINO- Gino vegetable oil; VEG-ASF- Alfa sun flower vegetable oil; VEG-PWR- Power vegetable oil; VEG-GLN-Golden vegetable oil, FFA-Free fatty acid, IV-Iodine value, PV-Peroxide value, CP-Cloud point.

DISCUSSION

The physical and chemical properties of the selected refined vegetable oils were presented in Tables 1–6. The colour intensity of the different brands of the selected vegetable oils had values that were within the range of 0.75 to 4.80 R. The colour of the vegetable oils was observed to increase in intensity as shelf life progressed as a sign of deterioration in oil quality. The physical analysis also showed that the oils' cloud points were satisfactory except in unbranded vegetable oil (VEG-UBD) whose origin cannot be traced.

The relatively high value of the cloud point in VEG-UBD was an indication of high stearin which can render the oil cloudy at room temperature (O'Brien and Richard, 2014). The clarity of the vegetable oil was also observed to decrease as its shelf life progressed as seen in those samples which were at their verge of expiration. The accumulation of crystals led to settlement of whitish substances (stearin particles) at the base of the container which made the vegetable oils to congeal (Appendix 1).

The chemical analysis showed that the moisture content of all the samples were within standard limit of 0.1% maximum as approved by SON (2000). The low moisture content obtained in all the branded samples helped in the oils' keeping quality and enhances their storage stability.

The peroxide value (PV) determines the degree of oil oxidation; it is a measure of oxidation during storage and the freshness of the lipid matrix (Agbaire, 2012). The peroxide value of all the samples were also within standard limit of 10 meq/kg maximum as approved by SON (2000). The free fatty acids of all the samples were within the stipulated range of 0.1% maximum as approved by SON, except in VEG-UBD and those samples that were at the verge of their expiration, where they fell below the recommended standard before their respective expiration. The iodine value is a measure of the level of unsaturation in oils. The value is a useful index of detecting adulteration of oils. The obtained iodine values were within the stipulated specification of 56 minimum as approved by SON (2000) in all the oil samples, except in VEG-UBD. The characteristics of the unbranded (VEG-UBD) were indications that they were of lower quality in comparison with the branded samples. This is in agreement with the report of Hati *et al.* (2009) on 'Comparative Quality Assessment of Branded and Unbranded Edible Vegetable Oils in Nigeria'. The iodine value also indicates that VEG-GLN, VEG-GDS and VEG-ASF consist of oleic and linoleic acids (≥100) while other brands consist of palmitic acid (50-60).

CONCLUSION

The results obtained from this research showed that the selected branded and unbranded refined vegetable oils in Lagos major markets varied in physical and chemical quality parameters as reflected by the tests carried out on them. The unbranded samples showed significant deviations in all its quality indices when compared with standards. The research also showed that some of the chemical properties of the selected refined oils were significantly out of recommended standards before their respective expiry date which may be attributed to compromise in quality during production.

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Appendix 1: Congealed vegetable oil