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ORIGINAL RESEARCH ARTICLE

Comparative characterization of vegetable oils from bulk suppliers/vendors in Nasarawa town market in Nigeria

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ABSTRACT

The comparative characterization of vegetable oils from bulk suppliers/vendors was made in Nasarawa town market in Nigeria. For this a total volume of 400 cm^3 vegetable oils were collected (200 cm^3 from the top and 200 cm^3 from the bottom of storage after stirring) separately into labeled plastic bottles from three major suppliers. Composite of each sample were made and physicochemical properties including densities, temperatures, boiling points, viscosities, refractive indexes free fatty acid, iodine values, saponification values and peroxide values were determined using standard procedures. The results showed the density of sample ranging from 0.91 ± 0.007 to 0.92 ± 0.007 gcm^{-3}; temperature of sample: 27.3 ± 0.578 to 30.3 ± 1.525 °C; boiling point of sample 230.7 ± 1.528 °C to 202 ± 2.000 °C; viscosity of sample A: 1.03 ± 0.183 to 0.72 ± 0.106 mPa.S; refractive index of sample: 1.47012 ± 0.00002 to 1.45709 ± 0.00005; free fatty acid of sample A: 0.73 ± 0.057 mgKOH/g to 0.6 ± 0.173 mgKOH/g; iodine value of sample: 87.979 ± 5.870 mgKOH/g to 54.144 ± 3.595 mgKOH/g; saponification value of sample: 195.830 ± 0.499 mgKOH/g to 197.846 ± 0.856 mgKOH/g, and peroxide value of sample A: 10.1 ± 0.741 mgKOH/g to 9.9 ± 0.663 mgKOH/g. These parameters were also compared with the standards prescribed by NAFDAC and SON, which suggest that the sampled oil is suitable for consumer use. Thus, processing of vegetable oils from industrial and locally/traditionally extracted vegetable oils and vegetable oils supplied by the three vendors in the Nasarawa town market are hereby recommended as long as the suppliers maintain the standards of production, packaging and handling.

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INTRODUCTION

Vegetable oils are group of fats that are obtained from plants and plant produce like seeds, nuts, cereal grains and fruits (Claudia *et al*., 2021). It is important to note that not all of these vegetable oils are liquid oils at ambient temperature (Jan, 2018). In addition, not all of the oils are produced in commercial quantities and of those that are, not all are considered edible as in the sense of being a typical dietary component (Gupta, 2017). For this reason, vegetable oils that are solid at room temperature are sometimes called vegetable fats (Syed, 2015; Jan, 2018). Vegetable oils are composed of triglycerides, as contrasted with waxes, which lack glycerin in their structure. Although many plant parts may yield oil, in commercial practice, oil is extracted primarily from seeds (Philip, 2022; Zhou *et al*., 2020; Ying *et al*., 2020; Purcaro *et al*., 2016; Kumar *et al*., 2016). Brahmi *et al*. (2020); Keogh-Brown *et al*. (2018) reported that vegetable oils are of great economic importance to human, industrially, vegetable oils are also used as ingredients or components in many manufactured products. Many other uses of vegetable oils have been recorded by (Norzahir *et al*., 2019; Owuna, 2020). Many vegetable oils are consumed directly or indirectly as ingredients in food. These oils get bad on exposure to oxygen, light or heat subjecting them to oxidation eventually turning them rancid (Mark and Pat, 2018). Vegetable oils therefore, should be tightly sealed and stored away from any heat or sunlight. Also, Okparanta *et al*. (2018) reported that, if fats and oils are in contact with moist air at room temperature, they would eventually undergo oxidation and hydrolysis reactions that cause them to turn rancid, acquiring a characteristic disagreeable odor. A cause of this odor is the release of volatile fatty acids by hydrolysis of the ester bonds (Said, 2022; Lamas *et al*., 2016). Talbot (2016) reported three pathways for acidification to include hydrolytic, oxidative and microbial rancidification. Uses and applications of vegetable oils have been documented by Kumar *et al*. (2016); Roy *et al*. (2020); Abbas and Ong (2019); Pechurai *et al*. (2015); Moresco *et al*. (2016); Hayichelaeh *et al*. (2020); Zhang *et al*. (2016).

Vegetable oils are mostly exposed to unconditional temperature, light, air, moisture and microorganisms at the processing and selling point which can lead to rancidification of these oils. Such oils have adverse health effects when consumed. In view of this, vegetable oils from vendors in Nasarawa town market were sampled and characterized with the aim of providing qualitative indices of the vegetable oils sold in the market.

MATERIALS AND METHODS

Sampling

Currently, there are three suppliers/suppliers of bulk vegetable oil, commonly referred to as groundnuts oil in cans/barrels, from which retailers store their stores at Nasarawa Town Market. 400 cm^3 of vegetable oil (200 cm^3 from the top and 200 cm^3 from the bottom of the container after stirring) was collected in plastic bottles from three major suppliers. Composite of each sample were made and labeled A, B and C, respectively.

Physicochemical characterization

Various analyses were carried out on the samples, which were categorized by compositing all sampled vegetable oils purchased: Composite traditionally extracted groundnut oil as A, composite traditionally extracted palm oil as B and composite branded oil as C. The following physical properties including Densities, temperatures, boiling points, viscosities, refractive indexes were determined using standard procedures (AOAC, 2000; AOAC, 2003; and Amin, 2019). However, free fatty acid (acid number or acid value), iodine values, saponification values and peroxide values were determined according to the standard procedure reported by AOAC (2010) was used.

RESULTS AND DISCUSSION

Tables 1-5 show physical properties; density, temperature, boiling point, viscosity, refractive index and chemical properties/ quality factors of the sampled oils (acid value, iodine value, saponification value and peroxide value) in tables 1-5. All measurements were done in triplicates and their mean calculated. However, physical and chemical properties of the samples are being compared relative to the standard specifications reported by NAFDAC/ SON in Table 5. The results show different parameters of the samples. This is to check deviation of the samples from standard value for each parameter.

Density and temperature

Mean density of sample (Table 1) A, 0.88 ± 0.007 g cm^{-3}, is within the standard range, 0.89-0.9 g cm^{-3} specified by Standard Organization of Nigeria (2000) but that of B and C; 0.91 ± 0.007 g $cm^{-3}$and 0.92 ± 0.007 g cm^{-3} respectively are slightly off the standard specifications. Density, one of the parameters used to check oil samples for impurities. Mean temperature (Table 1) for sample B and C are within acceptable values (25-30°C) specified by the (S.O.N, 2000) while that of sample A is slightly above the range. Temperature is used to monitor the rate of oil deterioration. The result indicates that the samples were not deteriorated.

Boiling point and viscosity

The results of boiling point and viscosity are presented in Table 2. The exact boiling temperature of oil depends on how pure the oil is based on the standard range of standard: 205-235 °C stipulated by S.O.N (2000), samples A and B met this specification. Sample C is however, slightly below the specifications. Viscosity is a parameter used to describe oil quality, also used to determine the flow rate of oils. Viscosity is greatly influenced by temperature variance, the higher the temperature, the greater the viscosity and the lower the temperature, the lesser the viscosity. The result shows an interval in the flow rates of the samples, A having a higher rate followed by B and C respectively.

Table 1. Density of Sampled Oils at 20°C and Temperature of Sampled Oils

Sample	First	Density (gcm^{-3}) Second	Third	Mean (gcm^{-3})
A	0.92	0.91	0.91	0.91 ± 0.007
B	0.88	0.89	0.88	0.88 ± 0.007
C	0.91	0.92	0.92	0.92 ± 0.007
Sample	**First**	**Temperature (°C) Second**	**Third**	**Mean (°C)**
A	30	32	29	30.3±1.525
B	29	28	29	28.6±0.668
C	27	28	27	27.3±0.578

Table 2. Boiling Points of Sampled Oils and Viscosity of Sampled Oils at 20°C.

Sample	First	Boiling Points (°C) Second	Third	Mean (°C)
A	231	229	232	230.7±1.528
B	233	233	231	232.3±1.155
C	202	200	204	202.0±2.000
Sample	**First**	**Viscosity (mPa.S) Second**	**Third**	**Mean (mPa.S)**
A	1.02	0.87	0.94	1.003±0.183
B	1.11	1.22	1.22	1.18±0.090
C	0.81	0.68	0.68	0.72±0.106

Table 3. Refractive Index of Sampled Oils[(a)] Free Fatty Acid of Sampled Oils.

Sample	First	Refractive index Second	Third	Mean
A	1.47013	1.47015	1.47010	$1.470\pm2x10^{-5}$
B	1.45775	1.45675	1.45677	$1.457\pm5x10^{-5}$
C	1.46013	1.46011	1.46009	$1.460\pm2x10^{-5}$
Sample	**First**	**Free fatty acid (mgKOH/g Second**	**Third**	**Mean (mgKOH/g)**
A	0.8	0.7	0.7	0.73±0.057
B	0.7	0.7	0.7	0.7±0.000
C	0.8	0.5	0.5	0.6±0.173

Table 4. Iodine Value of Sampled Oils, Saponification Value of Sampled Oils and Peroxide Value of Sampled Oils.

Sample	First	Iodine value (mgKOH/g) Second	Third	Mean (mgKOH/g)
A	81.200	91.368	91.368	87.979±5.870
B	55.836	55.836	50.144	54.144±3.595
C	86.292	91.368	86.292	87.984±2.930
Sample	**First**	**Saponification value (mgKOH/g) Second**	**Third**	**Mean (mgKOH/g)**
A	196.350	196.350	195.789	195.830±0.499
B	198.594	198.033	196.911	197.846±0.856
C	195.228	196.911	193.545	195.228±1.189
Sample	**First**	**Peroxide value (mgKOH/g) Second**	**Third**	**Mean (mgKOH/g)**
A	10.2	9.8	10.2	10.1±0.741
B	9.2	10.6	9.8	9.9±0.663
C	10.4	10.0	9.6	10.0±0.400

Table 5. Comparison of Physicochemical Properties of Samples Relative to NAFDAC/ SON.

Parameter	A	B	C	NAFDAC/ SON
Temperature (°C)	30.3±1.525	28.6±0.668	27.3±0.578	25-30
Density (gcm^{-3})	0.91 ± 0.007	0.88± .007	0.92 ± 0.007	0.89 - 0. 9
Boiling point (°C)	230.7±1.528	232.3±1.155	202.0±2.000	
Viscosity (mPa.S)	1.003±0.183	.18±0.090	0.72±0.106	
Refractive index	$1.470\pm2x10\text{-}^{5}$	$1.457\pm5x10^{-5}$	$1.460\pm2x10^{-5}$	0.6
F.F.A. (mgKOH/g)	0.73±0.057	0.7±0.000	0.6±0.173	
I.V. (mgKOH/g)	87.979±5.870	54.144±3.595	87.984±2.930	
S.V. (mgKOH/g)	195.830±0.499	197.846±0.856	195.228±1.189	
P.V. (mgKOH/g)	10.1±0.741	9.9±0.663	10.0±0.400	10

F.F.A.= Free fatty acid, I.V.= Iodine value, S.V.= Saponification value, P.V= Peroxide value.

Refractive index and free fatty acid

Mean refractive index for the three samples (1.470 ± 0.00002, 1.457 ± 0.00005 and 1.460 ± 0.00002) (Table 3) are within the standard 1.467-1.471 as recorded by S.O.N (2000). The values were similar to those reported by Amin *et al.* (2019). The refractive index (RI) is the ratio of the speed of light in a vacuum to the speed of light through a given material (Mengistie *et al.*, 2019). Hence, as any change in their optimal composition will affect the refractive index, therefore providing an insight to their quality. Normally, an acid value denotes the mg KOH required to neutralize the free fatty acid in 1 g of oil whereas free fatty acid is representing percentage by weight of a specified fatty acid such as percent oleic acid in oil (Mengistie *et al.*, 2019). Hence, acid value is a good indicator of oil degradation initiated by hydrolysis or enzymes (Mengistie *et al.*, 2019). The result indicates a low level of unesterified fatty acids (Table 3).

On the other hand, since fats and oils are triglycerides, the free fatty acids should be very low in high graded sample. Free fatty acid (FFA) is the percentage by weight of a specified fatty acid (e.g. oleic or lauric acid). For fatty acids, the acid value, in conjunction with the saponification value, can be used to give a measure of the amount of neutral fat present (William and Vida, 2015). A of threshold less than or equal to 0.6 mgKOH/g free fatty acid is specified for edible oils by S.O.N (2000). Values for samples A and B: 0.53± 0.057 mgKOH/g, 0.58 ± 0.000 mgKOH/g respectively are within the acceptance value while that of sample C (0.62 ± 0.173 mgKOH/g) is slightly above the standard specification. Hence, sample C needs additional treatment to lower its acid content to meet human consumption. Mengistie *et al.* (2019) reported unacceptably the highest (15.89) and lowest (1.49) FFA value compared to our present study and attributed to decomposition, poor extraction techniques, use of damaged seeds and incorrect or lengthy storage that can be accelerated by light and temperature.

Iodine value

Iodine values of samples A and C, 87.979 ± 5.870 mgKOH/g and 87.984 ± 2.930 mgKOH/g. An iodine value >100 means that it can be regarded as a drying oil (Amin *et al.*, 2019), however, the oil reported in this work was <100 but within the range of the standard specification (77-107 mgKOH/g) by the National Agency for Food and Drug Administration and Control, NAFDAC (2019). This implies that they do not contain more than expected level of unsaturated fatty acid in the triglycerides. Value of sample B, 54.144 ± 3.595 mgKOH/g falls below the specifications. Iodine value is a measure of the degree of unsaturation (C=C) of oils and expresses the susceptibility of the oil to oxidation and the extent of its contamination (Abdul-Hammed *et al.*, 2020). Hence, the higher the iodine value the greater the degree of unsaturation. This is used to characterize fat and oil, to follow the hydrogenation process in refining and as an indication during oxidation (Pike and O'Keefe, 2017). It gives the extent to which the lipid sample can be inclined to oxidation and thus become rancid.

Saponification value

Saponification values of the three samples, A, B and C are within the range of the standard (187-196 mgKOH/g, 190-209 mgKOH/g and 181-196 mgKOH/g) specified by NAFDAC (2019) i.e., 195.830 ± 0.499 mgKOH/g, 197.846 ± 0.856 mgKOH/g mgKOH/g and 195.228 ± 1.89 mgKOH/g. Saponification value (SV) is used to determine the saponification number of a fat or oil, which is an index of the average molecular weight of the triglyceride in the samples. Hence, the higher saponification values reported is an indication of higher molecular weight fatty acids in triglyceride (Abdul-Hammed *et al.*, 2020). Saponification number is a very important factor in soap production, the smaller the saponification value, the higher or longer the average fatty acid chain length. Equally, adulteration of fat or oil especially with unsaponifiable substances could also lead to a decrease in value of saponification value.

Peroxide value

The peroxide value is used in assessing the extent of oil spoilage (Abdul-Hammed, 2020). The Mean peroxide values of sample B and C: 9.9 ± 0.663 mg KOH/g and 10 ± 0.400 mg KOH/g varies within the standard: not more than 10 mg KOH/g stipulated by NAFDAC (2019), while that of sample A, 10.1 ± 0.741 mgKOH/g is above the standard. Peroxide value is used to check the presence of unsaturation just like the iodine value. Peroxide value is used as a measure of the degree to which rancidity reactions have occurred during storage and it is used as a good criterion for the prediction of the quality of oils (Mengistie *et al.*, 2019). Peroxide value measures the degree of lipid oxidation in fats and oils but not their stability. Peroxide value measures a transient (temporary) product of oxidation. Low or high values may represent early or advanced oxidation; which can be distinguished with time. High peroxide value could be resulted from high degree of unsaturation and found to increase with the storage time, temperature, light and contact with atmospheric oxygen (Mengistie *et al.*, 2019).

Conclusion

In conclusion, various analyses carried out on samples A, B and C shows sample B having eight parameters falling within accepted or standard specification followed by C and A although the failed tests for C and A have values slightly less or more than standard specifications of such parameter. In general, the sampled oils are averagely found to be within the various standards set by NAFDAC and SON, which indicate that these oils are good for consumers use. Vegetable oils supplied by the three vendors in the Nasarawa town market are hereby recommended as long as the suppliers maintain the standards of production, packaging and handling. We recommend that further work on retailers purchase from these bulk suppliers for further sales to consumers, to further check changes and deviations of their parameters values from standard it is recommended that scholars carry out this study on oils in the stores of retailers to check changes and deviations of their parameter's values from standard specifications hence quality of vegetable oil sold in the market.

Conflict of interest

The authors declare no conflict of interest

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