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DETERMINATION OF SPECIFIC GRAVITY AND PEROXIDE VALUES OF PALM OIL SAMPLES FROM GAS FLARING AND NON-GAS FLARING LOCATIONS IN BAYELSA STATE

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Abstract
This study was aimed at determining the specific gravity and peroxide values of palm oil samples from gas-flaring and non-gas-flaring locations in Bayelsa State. Six palm oil samples (two each) were purposively selected from three locations (two gas flaring locations and one non-gas flaring location (control samples). The gravimetric and titration methods were employed to analyse the specific gravity and peroxide values respectively. Mean, standard deviations, and Analysis of Variance (ANOVA) were employed for statistical analysis. The results showed that the palm oil samples from gas flaring location A had the highest mean specific gravity (0.92 ± 0.02), followed by that of the non-gas flaring location (0.91 ± 0.002) and that of gas flaring location B (0.90 ± 0.011), however, the difference was not significant ($p>0.05$). The mean peroxide values of palm oil samples from gas flaring locations B (74.30± 9.90mg peroxide/kg) and A (64.86±2.63mg peroxide/kg) were higher than that of non-gas flaring location (6.34± 0.78mg peroxide/kg) and the difference was significant ($p<0.05$). All the mean specific gravity values were within the Standard Organization of Nigeria acceptable range of 0.90 - 0.92 while the mean peroxide values of samples from non-gas flaring locations were lower than the maximum limits of 10mg peroxide/kg and those from gas flaring locations were higher than the maximum limit. Gas flaring is therefore an important factor that affects the peroxide values of palm oil which implies a high level of oxidation of the oil to form free radicals that are detrimental to human health. Consumers of palm oil should avoid purchasing palm oil from gas-flaring locations and gas flaring should be eliminated.

Keywords: Specific Gravity, Peroxide values, Palm Oil, Gas Flaring, Non-Gas Flaring, Bayelsa State

Introduction

Palm oil is produced from the fruits of the popular oil palm tree (*Elaeis guineensis)*. It is a good alternative to partially-hydrogenated oils that contain trans-fatty acids which are harmful to human health. This is because the production process of palm oil does not involve hydrogenation, bleaching and deodorizing like partially-hydrogenated oils. The specific gravity of palm oil is the ratio of the mass of a given volume of oil to the mass of an equal volume of water. The higher the specific gravity value of a palm oil sample, the higher the level of adulteration of the oil. The determination of this value is important because it indicates if particular palm oil is adulterated or not and the extent of the adulteration. For example, the palm oil investigated by Nwosu-Obieogu et al. (2017) with a lower specific gravity of 0.76 is considered less adulterated than that of Negash et al. (2019) with a higher specific gravity of 0.81.

The peroxide value of palm oil is the property of the oil that specifies the content of oxygen as peroxide in the oil. The more the oxygen content of the oil, the more the oil is oxidized to produce dangerous free radicals and cause oxidative rancidity, leaving the oil with a bad taste, smell and flavour. This agrees with Idoko et al. (2018) who stated that a high peroxide value implies that the palm oil has become rancid and not safe for consumption. Oxidation and rancidity of palm oil are to be avoided since oxidation produces free radicals and rancidity gives the oil a bad taste, flavour, and odour that encourages the growth of bacteria that are dangerous to human health. The specific gravity and peroxide values of palm oil which are crucial properties of palm oil are likely to be adversely affected by gas flaring, which is the burning and releasing of gaseous by-products into the atmosphere, during the refining of petroleum products, which is done daily in some communities in Bayelsa State, Nigeria. This is expected because gas flaring has been found to have adverse effects on the physicochemical properties of

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soils (Giwa et al., 2019; Nwagbara & Irondi, 2020), plants' health and growth (Nta et al., 2017; Barati & Pirozfar, 2019) as well as producing soot that can cause cancer and destroy plants (Kalagbor et al., 2019). This study, therefore, determined the specific gravity and peroxide values of palm oil samples from gas-flaring and non-gas-flaring locations in Bayelsa State.

Akinola et al. (2010) investigated the physicochemical properties of palm oil from different local palm oil factories in Nigeria by collecting palm oil samples from different palm oil processing units. The specific gravity of the palm oil samples ranged from 0.904 – 0.918 which were within the Standard Organization of Nigeria permissible range of 0.90-0.92. Nwosu-Obieogu et al. (2017) determined the physicochemical properties of some palm oil samples which included their specific gravity. Four samples of palm oil from four different markets within the Isialangwa Local Government Area of Abia State, Nigeria were used for the study. The specific gravity of each of the samples was determined using a gravimetric method and the findings revealed that three out of the four oil samples had specific gravity values ranging from 0.76 - 0.89, which were lower than the permissible limits of Standard Organization of Nigeria (SON) of 0.90 – 0.92. This implies that the three oil samples were not adulterated and safe for human consumption. Negash et al. (2019) assessed the quality of some edible vegetable oils and the specific gravity was determined using the gravimetric method. The results showed that the specific gravity of the locally made oil samples ranged from 0.807 to 0.823 and were lower than the WHO acceptable limits of 0.891 - 0.899.

Odoh et al. (2016) assessed the physicochemical properties of crude palm oil sold in Jos, Nigeria and found that the average peroxide values ranged from 6.96 – 13.63 mg peroxide/kg and were below and above the acceptable maximum limit of Standard Organization of Nigeria which is 10mg peroxide/kg. The values that were less than or within the maximum acceptable limits are safe for consumption, while the ones above are not safe for human consumption. High peroxide values of palm oil samples were obtained from the study of Okechalu et al. (2011) who investigated the microbiological quality and chemical characteristics of palm oil sold within Jos metropolis, Nigeria. A total of 60 palm oil samples were collected, of which 20 were randomly collected from three different markets in Jos metropolis. The results showed that the peroxide values of the palm oil samples from the three markets ranged from 32.4 - 35.5 mg peroxide/kg which were higher than the NAFDAC (National Agency for Food Drug Administration and Control) permissible limit for palm oil, which is 10 mg peroxide/kg. This implies that the palm oil samples would have high tendencies to be oxidized and form free radicals and easily become rancid, which is bad for human health.

A study that reported low peroxide values in palm oil samples was that of Nwosu-Obieogu et al. (2017). They determined the physicochemical properties of palm oil within the Isialangwa Local Government Area of Abia State, Nigeria. Four samples of palm oil purchased from four different markets were used for the study. The peroxide values were determined using the Association of Official Analytical Chemists (AOAC) (2012) methods and the findings showed that the peroxide values ranged from 6.89 – 8.80mg peroxide/kg and were below the permissible maximum limit of SON, which is 10mg peroxide/kg. The peroxide value is an indication of the quantity of oxygen in the oil (Nagao et al., 2013). This is why the low results of the peroxide values suggest that the palm oil samples were safe for human consumption since they will not easily undergo oxidation to produce free radicals and easily become rancid, which is dangerous to human health.

Damanik et al. (2021) investigated the quality of cooking oil that was repeatedly used for frying. They adopted the titration method to determine the peroxide values using the starch indicator. The results revealed that, after repeated frying, the peroxide values that were initially as low as 5.24 mg peroxide/kg increased as far as 9.98 mg peroxide/kg which almost exceeded the SNI (Indonesian National Standard) maximum limit of 10 mg peroxide/kg. This implies that the quality of the oil was almost destroyed by repeated frying and it became almost unsafe for consumption.

Materials and Methods

The materials used were a pycnometer, palm oil, chloroform, acetic acid, conical flasks, saturated potassium iodide, distilled water and starch indicator.

Sample collection: Two hundred (200) ml of six palm oil samples were purposively selected from three locations, two each from gas flaring location A (Okoroma), gas flaring location B (Oluasiri) and non-gas flaring location (Otatubu), all in the Nembe Local Government Area of Bayelsa State, Nigeria. The palm oil samples were placed

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in three labelled sterile containers, which were filled to the brim, firmly capped, and placed in a dark polythene bag. The samples were then taken to the laboratory for analysis. All the reagents used were of analytical quality grade.

Method of analysis: Gravimetric and titration methods were employed to analyse the specific gravity and peroxide values, respectively. Mean, standard deviations and Analysis of Variance (ANOVA) were used for statistical analysis.

Determination of specific gravity: The specific gravity of the palm oil samples from non-gas flaring and gas flaring locations A and B were determined using the gravimetric method adopted by Akinola et al. (2010). A pycnometer was used to weigh 10 ml of the palm oil sample and record it as W_1 and 10 ml of distilled water which was recorded as W_2. The specific gravity of each palm oil sample was calculated using equation 1:

$$\text{The specific gravity of each palm oil sample} = \frac{W_1}{W_2} \qquad 1$$

Where W_1 = Weight of oil
W_2 = Weight of distilled water

Determination of peroxide value: Titrimetric method was used to determine the peroxide values of the palm oil samples from non-gas flaring and gas flaring locations A and B as reported by Damanik et al. (2021). Five (5) grams of palm oil were added to 30 ml of a solvent (chloroform and acetic acid) in a ratio of 3:2 in a conical flask and swirled until the sample was completely dissolved in the solvent. After which, 0.5 ml of saturated potassium iodide (KI) was added and thoroughly swirled for 1 minute and the solution was kept in the dark for 2 minutes. Thirty (30) ml of distilled water and 1 ml of 1% starch indicator were then added and titrated with 0.05 M $Na_2S_2O_3$ until the blue colour disappeared. A blank titration with the solvent only (without the sample) was also done and the peroxide value in each sample was calculated using equation 2:

$$\text{Peroxide value} = \frac{(Vs - Vb) \times M \times 1000}{W} \qquad 2$$

Where:
Vs = Volume of $Na_2S_2O_3$ for sample titration
Vb = Volume of $Na_2S_2O_3$ for blank titration
M = Molarity of the $Na_2S_2O_3$ solution
W = sample weight (g)

Results

Table 1: Mean± standard deviations of the specific gravity and peroxide values of palm oil samples

Same	Specific Gravity	Peroxide Value (mgperoxide/kg)
Palm oil samples from the non-gas flaring location	0.91 ± 0.002	6.34 ± 0.78
Palm oil samples from gas flaring location A	0.92 ± 0.02	64.86 ± 2.63
Palm oil samples from gas flaring location B	0.90 ± 0.011	74.30 ± 9.90
SON Standard	0.90-0.92	10.00

Table 1 shows that palm oil samples from gas flaring location A had the highest mean specific gravity (0.92 ± 0.02), followed by that of non-gas flaring location (0.91 ± 0.002) and that of gas flaring location B (0.90 ± 0.011). All the specific gravity values were within the Standard Organization of Nigeria acceptable range of 0.90 - 0.92. Table 1 also shows that palm oil samples from gas flaring location B had the highest mean peroxide value (74.30 ± 9.90mg peroxide/kg), followed by that of gas flaring location A (64.86 ± 2.63mg peroxide/kg) and that of non-gas flaring location (6.34 ± 0.78mg peroxide/kg). The peroxide values of the palm oil samples from gas flaring locations A and B were above the SON acceptable maximum value of 10mg peroxide/kg while that of the non-gas flaring location was below the value.

Table 2: Analysis of variance of Specific Gravity and Peroxide Values of palm oil samples

		Sum of Squares	df	Mean Square	F	Sig.
Specific Gravity	Between Groups	.000	2	.000	1.283	.396
	Within Groups	.000	3	.000		
	Total	.001	5			
Peroxide value	Between Groups	5422.354	2	2711.177	77.069	.003
	Within Groups	105.535	3	35.178		
	Total	5527.889	5			

Table 2 shows that the specific gravity values were not significantly different in the palm oil samples from the three locations ($p>0.05$) while peroxide values were significantly different ($p<0.05$).

Discussion of findings

The specific gravity of the palm oil samples

The results revealed that there was no significant difference in the specific gravity values of the palm oil samples from the three locations with $p>0.05$. The specific gravity of an oil sample is an indication of the level of adulteration of the oil. The result, therefore, implies that gas flaring had no significant effect on the level of adulteration of the palm oil samples. This was probably because the effect of gas flaring, which has been known to cause pollution, was countered by the fact that all the palm oil samples were produced from terrains that are surrounded by much water and the producers of the oil must have taken advantage of that to thoroughly wash the palm fruits with much water before processing to get rid of the impurities that would have adulterated the oil samples by gas flaring. This must have reduced the impurities and therefore reduced the specific gravity of the oil samples.

The findings also revealed that the values of the specific gravity of the palm oil samples from the three locations were within the Standard Organization of Nigeria acceptable range of 0.90 - 0.92. This was also likely because of the availability of much water that enabled the producers to thoroughly wash the palm fruits before processing to reduce the impurities and therefore making the specific gravity values of the oil samples fall within the Standard Organization of Nigeria (SON, 2000) acceptable limits. The specific gravity values obtained in this study are consistent with the values reported by Akinola et al. (2010) who investigated the physicochemical properties of palm oil from different local palm oil factories in Nigeria by collecting palm oil samples from different palm oil processing units and their results ranged from 0.904 – 0.918. The values were, however, higher than the values reported by Nwosu-Obieogu et al. (2017) and Negash et al. (2019) which ranged from 0.76 - 0.89 and 0.807–0.820 respectively.

Peroxide values of the palm oil samples

The findings revealed that the peroxide values of the palm oil samples from the gas flaring locations were higher than palm oil samples from the non-gas flaring location and there was a significant difference with $p<0.05$. This means gas flaring had a significant effect on the peroxide values of the palm oil samples. The peroxide value of an oil is an indication of the oxygen content in the oil. This means an increase in the peroxide value of oil implies an increase in the oxidation of the oil to produce free radicals that are dangerous to human health. Nagao et al. (2013) found in their study that an increase in temperature increased the oxygen content in oils. It, therefore, implies that the peroxide values of the palm oil samples from the gas flaring locations were higher than that of the non-gas flaring location probably because of the increase in the oxygen content in the oil due to the increase in the temperature of the oils caused by gas flaring. High oxygen content (high peroxide value) in palm oil is not desirable since it is an indication that the oils are highly prone to oxidation (Idoko et al., 2018). Oxidation produces free radicals that can cause life-threatening diseases like cancer and heart disease. The oxidation of the oils can also cause oxidative rancidity of the oil, producing toxic substances with bad taste, smell and flavour, which increases spoilage and reduces the shelf life of the oil making it unsafe for human consumption.

The obtained mean peroxide value of the palm oil samples from the non-gas flaring location was consistent with the values recorded by Negash et al. (2019) which ranged from 3.4 to 16.25 mg peroxide/kg) and Damanik et al. (2021) which ranged from 5.24 – 9.98 mg peroxide/kg. On the other hand, the peroxide values from the gas flaring locations were above these values but close to the values reported by Okechalu et al. (2011) which ranged from 32.4 - 35.5 mg peroxide/kg. This suggests that the palm oil samples from the gas flaring locations were not safe for human consumption. The findings revealed that the peroxide values of the palm oil samples from the gas flaring locations were above the Standard Organization of Nigeria (SON, 2000) acceptable maximum limit of 10mg peroxide/kg. The results agree with the results of Okechalu et al. (2011) that showed that the peroxide values of the oils they studied (32.4 - 35.5 mg peroxide/kg) were above the maximum permissible limit of SON which is 10mg peroxide/kg. The result implies that all the palm oil samples from the gas flaring locations were not safe for human consumption. The finding also showed that the peroxide value of the palm oil samples from the non-gas flaring location was below the acceptable maximum limit of SON. This result supports the findings of Nwosu-Obieogu et al. (2017) which ranged from 6.89 – 8.80 mg peroxide/kg and was below the maximum permissible limit of SON (10mg peroxide/kg). This means that the palm oil samples from the non-gas flaring location are safe for human consumption. The result that the peroxide values of the palm oil samples from the gas flaring locations were higher than the SON permissible limits is an indication that the oils are highly prone to oxidation. Oxidation produces free radicals that can cause life-threatening diseases such as cancer and heart disease. The oxidation of the oils can also cause oxidative rancidity of the oil, producing toxic substances with bad taste, smell and flavour, increasing spoilage and reducing the shelf life of the oil which makes it unsafe for human consumption.

Conclusion

This study investigated and compared the specific gravity and peroxide values of palm oil samples from gas flaring and non-gas flaring locations in Nembe Local Government Area of Bayelsa State, Nigeria. It also compared the obtained results with the permissible values of the Standard Organization of Nigeria (SON). Gas flaring had no significant effect on the specific gravity of the palm oil samples but had a significant effect on their peroxide values. Gas flaring can therefore be considered a crucial factor that affects the peroxide values (oxidation) of palm oil which reduces the quality of the oil by producing free radicals that are dangerous to human health. Gas flaring is and therefore a crucial factor that affects the quality of palm oil. Palm oil samples close to gas flaring locations can therefore be considered relatively unsafe for human consumption.

Recommendations

1. The dangerous age-long practice of gas flaring should be prohibited or eliminated throughout Nigeria because, in addition to the other numerous potent dangers to health and the environment that have been adequately reported by previous scientific studies, this study specifically found that gas flaring adversely affected the quality of palm oil and makes it unsafe for human consumption.
2. Consumers of palm oil should avoid purchasing palm oil produced from gas-faring locations. This can be achieved through public enlightenment campaigns to enable them to have information on the danger of consuming such palm oils.

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