PRINT ISSN 1119-8362
Electronic ISSN 2659-1499

Full-Text Available Online At
https://www.ajol.info/index.php/jasem
https://www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 28 (11B Supplementary) 3809-3813 Nov. 2024

Evaluation of the Physicochemical Parameters of Refined Palm Oil and Palm Olein

[*1]ESAN, AO; AYODELE, ET

Department of Pure and Applied Chemistry Ladoke Akintola University of Technology Ogbomosho, Nigeria

**Corresponding Author Email: aoesan@lautech.edu.ng*
**ORCID: https://orcid.org/0000-0003-0578-7458*
**Tel: +2348034397212*

Co-Author Email: etayodele@lautech.edu.ng

ABSTRACT: Refined palm oil (RPO) and palm olein (PO) are significant products in the vegetable oil industry, widely used across various sectors. Therefore, the objective of this paper was to investigate the physicochemical Parameters such as free fatty acid content, acid value, peroxide value, saponification value, and iodine value of Refined Palm Oil (RPO) and Palm Olein (PO) using appropriate standard methods. Data obtained show that the physicochemical parameters of RPO and PO were Acid value (5.24 ± 0.49; 20.94 ± 0.82), Peroxide value (6.73 ± 0.13; 2.56 ± 0.07), Saponification value (161.28 ± 5.48; 163.34 ± 5.62), Free fatty acid (0.06 ± 0.01; 0.46 ± 0.01) and Iodine value (16.8 ± 0.86; 8.37 ± 3.22) respectively. The results of this study are expected to promote the adoption of RPO and PO in environmentally friendly energy solutions, while also enhancing their economic viability and performance in the marketplace.

DOI: https://dx.doi.org/10.4314/jasem.v28i11.39

Cite this Article as: ESAN, A. O; AYODELE, E. T. (2024). Evaluation of the Physicochemical Parameters of Refined Palm Oil and Palm Olein. *J. Appl. Sci. Environ. Manage.* 28 (11B Supplementary) 3809-3813

Dates: Received: 21 September 2024; Revised: 27 October 2024; Accepted: 04 November 2024 Published: 30 November 2024

Keywords: Refined palm oil; palm olein; physicochemical properties; renewable energy; industrial applications.

Refined palm oil (RPO) and palm olein (PO) are key products in the global vegetable oil industry, with diverse applications in both food and industrial sectors (Talib *et al*., 2024). One of the most produced and used edible oils in the world is palm oil, which is made from the fruit of the oil palm (Elaeis guineensis) (Goncharenko *et al*., 2024). Crude palm oil undergoes refining to produce refined palm oil and palm olein, each of which has unique qualities (Izuddin *et al*., 2023). PO, the liquid fraction of the oil, is preferred for frying and cooking because of its greater oxidative stability and heat tolerance, whereas RPO is mostly employed in food processing. To evaluate refined palm oil and palm olein's quality, shelf life, and appropriateness for different applications, it is crucial to investigate their physicochemical characteristics. Color, density, viscosity, melting point, refractive index, saponification value, iodine value, free fatty acid (FFA) content, and peroxide value are some examples of these attributes. These characteristics are crucial markers of the oil's durability, nutritional content, and operational effectiveness in both industrial and food production settings. A key component of quality control is knowing the physicochemical characteristics of palm oil and palm olein. It guarantees that the oil satisfies requirements for industrial safety and consumption (Baquero, 2024). For instance, the amount of hydrolysis in the oil may be determined by the free fatty acid content, and the amount of oxidation can be determined by the peroxide value. Both of these factors are essential in assessing the quality of the oil. These characteristics also aid in determining the oil's shelf durability (Tufail *et al*., 2024). The oil's resistance to rancidity over time is determined by its oxidative stability, which is impacted by its iodine and peroxide levels (Nor *et al*.,

**Corresponding Author Email: aoesan@lautech.edu.ng*
**ORCID: https://orcid.org/0000-0003-0578-7458*
**Tel: +2348034397212*

2021). Palm olein is commonly utilized in deep-frying applications because of its strong oxidative stability (Hennebelle *et al*., 2024). Characteristics like the oil's peroxide value and free fatty acid content provide information about the possible health effects of consuming it, since larger values may suggest degradation that poses a risk to health when consumed (Jonas, 2024). The oxidative stability of palm olein guarantees that food will not quickly deteriorate during frying, maintaining its flavor and quality (Waisundara, 2023). When making soaps and detergents, the saponification value of refined palm oil and palm olein is also important (Chabi *et al*., 2023). The ability of the oil to react with an alkali to form soap is referred to by this attribute (Visković *et al*., 2024). By reason of the refining process, refined palm oil and palm olein have a comparatively low concentration of free fatty acids (FFA). In order to preserve the oil's quality and avoid rancidity, this low FFA percentage is essential. Another crucial characteristic is the iodine value, which gauges the oil's level of unsaturation (Arumugam *et al*., 2024). Since palm oil has a lower iodine value than many other vegetable oils, it is more oxidatively stable, but it can't be used in products that need higher levels of unsaturation, like some spreads and margarine (İnanlar & Altay, 2024). Refined palm oil and palm olein are desirable ingredients in the pharmaceutical and cosmetics sectors because of their comparatively high concentration of natural antioxidants such tocopherols and tocotrienols. These antioxidants improve the attractiveness of skin-care formulations and other personal care products by protecting the skin and preserving cosmetics. RPO and PO are becoming more well-known for their potential applications outside of the food industry, such as manufacturing, chemicals, and renewable energy. These oils are being investigated as raw materials for the development of biodiesel and other biodegradable goods, as there is a growing focus on environmentally friendly and sustainable energy sources. This study's goals are to identify and measure contaminants such as free fatty acids, water, and dirt, as well as to extensively examine the physicochemical characteristics of refined palm oil and palm olein. The goal of this study is to offer insightful information on how to best utilize them as renewable feedstocks and strengthen their contribution to the advancement of environmentally friendly industrial processes (Tufail *et al*., 2024). Finding these characteristics is therefore essential for assessing the general quality and suitability of refined palm oil and palm olein. Consequently, the objective of this paper is to investigate the physicochemical Parameters of Refined Palm Oil (RPO) and Palm Olein (PO)

MATERIALS AND METHODS

Sample Collection: Samples were obtained from a vegetable refining Industry in Penang, Malaysia and were utilized without any pretreatment.

Free fatty Acid value: The procedure outlined by (Febrianto *et al*., 2019) was used in determining the free fatty acid value. Five grams of the oil samples were weighed and put into a 250-millilitre Elenmeyer, previously considered empty weight. 40°C was reached after adding 50ml of 96% ethanol. Following cooling, two drops of phenolphthalein indicator were added to the oil. It is not lost for 30 seconds after titration with 0.1M NaOH to create a pink solution. The titrant's volume was noted. For every sample, there were three titrations. The following formula was used to determine each sample's free fatty acid value:

$$\%\text{Free fatty acid} = \frac{\mathrm{V} \times \mathrm{N} \times \mathrm{BM}}{\mathrm{m} \times 1000} \quad (1)$$

Where: V= volume NaOH titration (mL), N= Normality of NaOH, BM = molecular weight fatty acid (gram) and m = Mass of oil sample.

Acid value: Using the procedure outlined by (Esan *et al*., 2024), the acid value was calculated. 100ml of ethanol was added to each 1g oil sample, which was then weighed and dissolved in the flask. A 0.1N potassium hydroxide solution (KOH) was used to titrate two drops of phenolphthalein indicator to the pink end point, which lasted for fifteen minutes. It was noted how much the titrant was. Each sample underwent three iterations of the titration. We used the following formula to determine each sample's acid value:

$$\text{Acid value} = \frac{56.1 \times \mathrm{v} \times \mathrm{c}}{\mathrm{m}} \quad (2)$$

Where: 56.1 = Equivalent weight of KOH, V = Volume in ml of standard volumetric KOH, C = Concentration in KOH (0.1N) and m = Mass in grams of the oil sample.

Iodine value: The iodine value was determined using the Hanus iodine solution method (Hilp, 2002), which is described as follows: Weigh 0.25g oil into a 500ml conical flask and distillate in 10ml chloroform. Using a measuring cylinder, add 25ml Hanus iodine solution and let it stand in dark for 30 minutes, shaking occasionally for an accurate result. Add 10ml 15% KI solution, shake thoroughly, and add 100ml fresh boiled and cooled H_2O. Titrate iodine with standard 0.1N $Na_2S_2O_3$, adding it gradually, with constant shaking, until yellow solution turns almost colorless. Add 0.5ml starch indicator and continue titrate until blue completely disappears towards the end of reaction and shake violently, so that any iodine remaining in solution in chloroform may be absorbed by KI solution. The black test was carried out in addition to the sample determination. Each sample underwent two titrations, and the iodine value was calculated using the following formula:

$$\text{Iodine value } = \frac{(\text{B} - \text{S}) \times \text{N} \times 12.69}{\text{wt of sample}} \quad (3)$$

Where: B = volume in ml of blank solution, S = volume in ml of standard $Na_2S_2O_3$ and N = Normality of $Na_2S_2O_3$.

Saponification value: The method outlined by Triyasmono *et al*. (2022) approach was used to calculate the saponification value. 5g of the oil sample was weighed into 50 ml of alcoholic hydroxide (KOH + ethanol) in a round-bottom flask. Using aluminium foil as a catalyst, the first 50ml of the distillation was discarded. For the same predetermined amount of time, reflux the samples. Add a few drops of the indicator phenolphthalein, then use 0.5N HCL to titrate. The disappearance of the pink colour indicates the saponification value. The blank determination procedure was carried out in the same way. The following formula was used to determine the saponification value for each sample:

$$\text{Saponification value } = \frac{28.05 \times (\text{Vb} - \text{Vc})}{\text{Ws}} \quad (4)$$

Where: V_b = Volume in ml of standard HCL solution used for blank test, V_s = Volume in ml of standard HCL solution used for sample and W_s = Weight of sample

Peroxide value: The methodology outlined by Hardy and Barrows (2002) was used to calculate the peroxide value. A conical flask containing 10–12g of oil sample was filled with 30 ml of a solvent mixture of glacial acetic acid and chloroform. After a vigorous shake, clockwise and counterclockwise, 1 ml of saturated KI was added. After adding 30 ml of distilled water and vigorously shaking it for a minute, 0.5 ml of starch indicator was added, and the mixture was titrated using a 0.01N $Na_2S_2O_3$ solution. Shake vigorously until the black colour turns white to initiate the reaction. Alongside the oil samples, a blank was made. Each sample's peroxide value was determined using the following formula:

$$\text{Peroxide value } = \frac{\text{V} \times \text{N} \times 1000}{\text{Ws}} \quad (5)$$

Where: V = Volume in ml of standard $Na_2S_2O_3$, N = Normality of $Na_2S_2O_3$ and Ws is the weight of oil.

RESULTS AND DISCUSSION

The physicochemical parameters of palm olein (PO) and refined palm oil (RPO) are displayed in **Table 1** and exhibit notable variances, each of which reflects the particular qualities of the oil and its applicability for various industrial applications. PO has a much higher acid value (20.94 ± 0.82 mg KOH/g) than RPO (5.24 ± 0.49 mg KOH/g), which suggests that PO contains more free fatty acids. This implies that PO is more vulnerable to hydrolytic breakdown, which can be brought on by improper handling or storage. RPO's lower acid value makes it a better choice for uses requiring oil with less acidity and more oxidative stability, like food processing, where less acidity improves flavor and prolongs shelf life (Mukesh *et al*., 2024). PO greater acid value, on the other hand, makes it less appropriate for some food applications but more appropriate for industrial uses, such as the generation of biodiesel, where higher amounts of free fatty acids are not always harmful (Germond et al., 2024). RPO is more susceptible to oxidation than PO, as evidenced by its greater peroxide value (6.73 ± 0.23 meq O_2/kg) than PO (2.56 ± 0.07 meq O_2/kg). The peroxide value can indicate oil rancidity and is a crucial marker of the early phases of lipid oxidation (Elshaer *et al*., 2024). PO is more stable for high-temperature operations like frying because of its lower peroxide value, which indicates greater resistance to oxidation. This is consistent with PO's widespread use as frying oil because of its resistance to heat-induced oxidative damage. Because of its greater PV, RPO would need extra antioxidants or cautious storage to avoid rapid deterioration in oxidation-sensitive applications (Bhopal, 2022). Comparable saponification readings for RPO (161.28 ± 5.48 mg KOH/g) and PO (163.34 ± 5.62 mg KOH/g) indicate that the fatty acid chain lengths in the two oils are comparable. The slight variation between them suggests that they have comparable amounts of medium-chain triglycerides, which are useful for making detergents, soaps, and other chemicals. Their appropriateness for industrial use is confirmed by a high saponification value, especially in applications like soap manufacture where a high triglyceride content is necessary (Oparanti *et al*., 2024). PO has 0.46 ± 0.01% more free fatty acids than RPO (0.06 ± 0.01%). An important quality factor that affects the oil's stability, flavor, and general quality is its FFA content. RPO is a higher-quality oil with a low FFA percentage, which makes it better suited for culinary items like margarine and shortening that need to have a low acidity level. PO's higher FFA suggests that it is more likely to hydrolyze, which is common for oils that don't go through as much refinement. PO is a good choice for non-food applications, like as the generation of biodiesel, where higher FFA levels are acceptable (Van Gerpen *et al*., 2004). RPO (32.74 ± 0.59 g I_2/100g) and PO (8.37 ± 3.22 g I_2/100g) differ significantly in the iodine value, which gauges the oil's level of unsaturation. RPO is more reactive and susceptible to oxidation because of its higher iodine value, which indicates a higher degree of unsaturation that is, more double bonds in its fatty acids (Priyanti *et al*., 2024). On the other hand, PO's significantly lower iodine value suggests a higher level of saturation, which improves heat stability and prolongs shelf life. With regard to this, PO is perfect for high-temperature uses like frying, whereas RPO may be more appropriate for chemical companies that need oils with higher unsaturation levels due to its increased reactivity. The distinctions between RPO and PO's physicochemical characteristics highlight each compound's benefits for a range of applications. RPO is better suitable for companies' needing oils with particular reactivity and for food manufacturing because of has higher iodine and peroxide levels and lower FFA. However, PO is more suited for non-food industrial applications like frying and biodiesel manufacturing, where oxidation resistance and a larger fatty acid content are crucial, due to its higher FFA concentration and superior oxidative stability (Khan, 2024)

Table1: Physicochemical parameters of Refined Palm Oil (RPO) and Palm Olein (PO).

Parameters	Refined palm oil (RPO)	Palm olein (PO)
Acid value	5.24 ± 0.49	20.94 ± 0.82
Peroxide value	6.73 ± 0.13	2.56 ± 0.07
Saponification value	161.28 ± 5.48	163.34 ± 5.62
Free fatty acid	0.06 ± 0.01	0.46 ± 0.01
Iodine value	16.8 ± 0.86	8.37 ± 3.22

Conclusion: Refined palm oil (RPO) and Palm olein (PO) offer unique benefits with variation in their physicochemical properties according to this investigation. Although Palm olein's higher acid and FFA level may compromise its long-term quality, its lower peroxide value and increased oxidative stability make it perfect for frying and having a long shelf life. However, Refined palm oil could be stored for longer time and is more stable over time due because it contains to its lower amounts of acid and FFA. The characteristics of each oil make them useful for specific industrial applications.

Acknowledgements: The authors extend their appreciation to African-German Network of Excellence in Science (AGNES) and LAUTECH TETFUND Institution based research grant for funding this research.

Declaration of Conflict of Interest: The authors declare no conflict of interest.

Data Availability Statement: Data are available upon request from the authors.

REFERENCES

Arumugam, S; Muthaiyan, R; Dhairiyasamy, R; Rajendran, S (2024). Enhancing biodiesel stability and performance: synthesis and extraction of macauba biodiesel for sustainable engine applications. *Dis. Chem. Eng. 4*(1). https://doi.org/10.1007/s43938-024-00041-0

Baquero, A (2024). Optimizing green knowledge acquisition through entrepreneurial orientation and resource orchestration for sustainable business performance. *Mark. Intell. Plan*. https://doi.org/10.1108/mip-07-2023-0330

Bhopal, MP (2022). Community medicine and health. *Int. J. Hea. Sci.* 6166–6276. https://doi.org/10.53730/ijhs.v6ns8.13751

Chabi, IB; Aïssi, MV; Zannou, O; Kpoclou, YE; Ayegnon, BP; Badoussi, ME; Ballogou, VY; Goksen, G; Khaneghah, AM; Kayodé, AP. (2023). New value chain Pentadesma nuts and butter from West Africa to international markets: Biological activities, health benefits, and physicochemical properties. *Food Sci. Nut. 12*(2), 907–920. https://doi.org/10.1002/fsn3.3806

Elshaer, SE; Hamad, GM; Sobhy, SE; Darwish, AMG; Baghdadi, HH; Nahas, HHA; El-Demerdash, FM; Kabeil, SSA; Altamimi, AS; Al-Olayan, E; Alsunbul, M; Docmac, OK; Jaremko, M; Hafez, EE; Saied, EM (2024). Supplementation of Saussurea costus root alleviates sodium nitrite-induced hepatorenal toxicity by modulating metabolic profile, inflammation, and apoptosis. *Front. Pharm., 15*. https://doi.org/10.3389/fphar.2024.1378249

Germond, A; Fardet, A; García, CÁ; Boland, M; Hoang, HM; Mullen, A; Kaur, L (2024). Analyzing the complexity of animal products' processing and its impact on sustainability. *Front. Sustain. Food Sys. 8*. https://doi.org/10.3389/fsufs.2024.1424282

Goncharenko, O; Zolotova, S; Goryunova, O (2024). Analysis of the palm oil quality for the production of DIY non-food products. *E3S Web of Conf., 486*, 01008. https://doi.org/10.1051/e3sconf/202448601008

Hennebelle, M; Villeneuve, P; Durand, E; Lecomte, J; Van Duynhoven, J; Meynier, A; Yesiltas, B; Jacobsen, C; Berton-Carabin, C (2024). Lipid oxidation in emulsions: New insights from the past two decades. *Prog. Lip. Res.* 101275. https://doi.org/10.1016/j.plipres.2024.101275

İnanlar, B; Altay, F (2024). The method that makes oils and fats healthier: interesterification. *Black Sea J. Eng. Sci.*, *7*(5), 1081–1091. https://doi.org/10.34248/bsengineering.1310721

Izuddin, WI; Loh, TC; Nayan, N; Akit, H; Noor, AM; Foo, HL (2023). Blood lipid profiles, fatty acid deposition and expression of hepatic lipid and lipoprotein metabolism genes in laying hens fed palm oils, palm kernel oil, and soybean oil. *Front. Vet. Sci.*, *10*. https://doi.org/10.3389/fvets.2023.1192841

Jonas (2024). Essential oils - recent advances, new perspectives and applications. In *Biochem.*. https://doi.org/10.5772/intechopen.107782

Khan, IU (2024). Review, Biodiesel Production from Basic to Advance Level Through Using Different Mechanism, Techniques, Approaches and How to Make It Commercialized. *Prog. Petrochem. Sci.*, *6*(1). https://doi.org/10.31031/pps.2024.06.000629

Mukesh, C; Huang, G; Qin, H; Liu, Y; Ji, X (2024). Insight into lignin oxidative depolymerization in ionic liquids and deep eutectic solvents. *Biom. Bioe.*, *188*, 107305. https://doi.org/10.1016/j.biombioe.2024.107305

Nor, NFA; Ya'akob, H; Ngadiran, S; Idris, A; Anuar, NS; Sarmidi, MR (2021). Evolutions in virgin coconut oil: liquid to powder. *J. Teknologi*, *83*(3), 119–132. https://doi.org/10.11113/jurnalteknologi.v83.16265

Oparanti, S; Fofana, I; Zarrougui, R; Jafari, R; Yapi, K(2024). Improving some physicochemical characteristics of environmentally friendly insulating liquids for enhanced sustainability in subpolar transformer applications. *Sus. Mat. Tech.*, *41*, e00996. https://doi.org/10.1016/j.susmat.2024.e00996

Palm oil - current status and updates. (2022a). In *Intech Open eBooks*. https://doi.org/10.5772/intechopen.104286

Priyanti, I; Wongsawaeng, D; Kongprawes, G; Ngaosuwan, K; Kiatkittipong, W; Hosemann, P; Sola, P; Assabumrungrat, S (2024). Enhanced cold plasma hydrogenation with glycerol as hydrogen source for production of trans-fat-free margarine. *Sci. Rep.*, *14*(1). https://doi.org/10.1038/s41598-024-68729-5

Talib, TH; Chatterjee, NS; Banerjee, K; Petchkongkaew, A; Elliott, CT; Wu, D (2024). A Two-Tier approach for the detection of contaminants and adulterants in sunflower oil to protect consumer safety. *Trends in Food Sci. Tech.*, *150*, 104559. https://doi.org/10.1016/j.tifs.2024.104559

Tufail, T; Ain, HBU; Chen, J; Virk, MS; Ahmed, Z; Ashraf, J; Shahid, NUA; Xu, B (2024). Contemporary views of the extraction, health benefits, and industrial integration of rice bran oil: a prominent ingredient for holistic human health. *Foods*, *13*(9), 1305. https://doi.org/10.3390/foods13091305

Van Gerpen, J; Shanks, B; Pruszko, R; Clements, D; Knothe, G (2004). *Biodiesel Prod. Tech.: August 2002--January 2004*. https://doi.org/10.2172/15008801

Visković, J; Dunđerski, D; Adamović, B; Jaćimović, G; Latković, D; Vojnović, Đ (2024). Toward an Environmentally Friendly Future: An Overview of Biofuels from Corn and Potential Alternatives in Hemp and Cucurbits. *Agronomy*, *14*(6), 1195. https://doi.org/10.3390/agronomy14061195

Waisundara, VY (2023). Elaeis guineensis - New Insights. In *Intech Open eBooks*. https://doi.org/10.5772/intechopen.107796

Zou, R; Yang, W; Rezaei, B; Tang, K; Zhang, P; Andersen, HR; Keller, SS; Zhang, Y (2024). Sustainable bioelectric activation of periodate for highly efficient micropollutant abatement. *Water Res.*, 121388. https://doi.org/10.1016/j.watres.2024.121388