

Physicochemical Quality Assessment of Palm Oil Sold in Azare Metropolis, Bauchi State, Nigeria: A Case Study of Vendors in the Katagum Zone

K. Dafuwa¹, S. Mohammed², K. Mohammed², B. Alkali¹

^{1,4}Department of Physics — School of Secondary Education (Science). Aminu Saleh College of Education Azare Bauchi State.

^{2,3}Department of Chemistry — School of Secondary Education (Science.) Aminu Saleh College of Education Azare Bauchi State.

DOI: <https://doi.org/10.47772/IJRISS.2026.100800558>

Received: 22 August 2026; Accepted: 27 August 2026; Published: 12 September 2026

ABSTRACT

This work assessed the physicochemical make-up and overall quality of palm oil marketed in Azare Metropolis, Bauchi State, Nigeria. As a staple edible oil in Nigeria, palm oil is prone to quality loss and adulteration stemming from substandard processing, unhygienic handling, and extended storage — all of which can put consumers' health at risk. Five samples were randomly gathered from major markets and wards across the metropolis: Sabuwar Kasuwa, Central Market, Kasuwar Kaji, Matsango, and Garin Arab, and each was tested for the key quality indicators of Free Fatty Acid (FFA) content, Iodine Value, Saponification Value, and Hydroxyl Value using standard analytical protocols, with results benchmarked against Standard Organisation of Nigeria (SON) specifications. Saponification Values across all samples (196.35–203.36 mg KOH/g) fell inside the SON-acceptable band of 195–205 mg KOH/g, pointing to no adulteration with foreign fats or oils, and Iodine Values (39.87–54.40 I₂/100g) for four of the five samples sat within or near the SON range of 45–53 I₂/100g. By contrast, Free Fatty Acid content — the key marker of spoilage — was markedly elevated in every sample, spanning 7.60 to 12.30 mg KOH/g and far exceeding the SON ceiling of 3.30 mg KOH/g. The study concludes that although the oils showed no sign of adulteration, their overall quality is poor and unfit for human consumption owing to advanced hydrolytic rancidity reflected in the elevated FFA readings, a deterioration traced to inadequate post-harvest handling, unsanitary processing, and poor storage. Regulatory enforcement of quality standards and adoption of more hygienic processing practices by producers are recommended to safeguard consumers.

Keywords: Palm oil; Quality analysis; Free fatty acids; Adulteration; Food safety.

INTRODUCTION

A. Background of the Study

Palm oil ranks as Nigeria's most extensively used vegetable oil, and gauging its quality is central to evaluating its many end uses. Roughly 55% of domestic consumption is met by local production, with the remaining 45% supplied through imports from leading producers such as Indonesia and Malaysia. Together, Malaysia and Indonesia currently supply around 89% of the world's palm oil, Thailand, Colombia, and Nigeria contribute a further 6%, and the remaining oil-palm-growing nations account for the last 5% (Ohimain & Izah, 2015).

At room temperature palm oil is semi-solid and highly saturated, and its natural antioxidant content allows it to withstand considerable heat without readily oxidizing. Its colour ranges from orange-red to brownish or yellowish-red (Akinola et al., 2010; Izah & Ohimain, 2015). It does not dissolve in common solvents such as water but readily dissolves in organic solvents like trichloromethane and alcohol (Ohimain et al., 2013). Beyond its use as food and in animal feed, palm oil serves industries ranging from pharmaceuticals, soaps and detergents, and confectionery to margarine, cosmetics, and biofuel manufacture, including biodiesel.

How hygienically Nigerian processors handle the milling stage has a major bearing on the eventual quality of the oil produced. Imported supplies are not immune either, since extended storage, unsanitary transfer conditions, or poor container choice can likewise degrade them (Ohimain & Izah, 2015). When physicochemical quality slips, this hampers downstream uses such as biodiesel production (Ohimain & Izah, 2015), while the microbial load of the oil separately governs its fitness for food and traditional-medicine applications, with knock-on health consequences.

Widely grown across South Asia and Equatorial Africa, the oil palm (*Elaeis guineensis*) (Muhammad, Zainudin & Bakar, 2012) ranks among Malaysia's most productive cash crops, yielding roughly 3.66 tons/ha/year (Basiron, 2017). Malaysia alone supplies about 27% of global fats-and-oils exports and around 13% of world oil production, second only to Indonesia as a palm oil producer and exporter (Pakiam, 2013).

Two distinct oils come from the fresh fruit bunches: crude palm kernel oil, drawn from the seed, and crude palm oil, drawn from the fruit's fleshy mesocarp (Tan et al., 2009). In Malaysian crude palm oil, triacylglycerols, diacylglycerols, monoacylglycerols, and free fatty acids together make up 95–99% of the total, with the remaining 1–5% consisting of carotenoids, tocopherols, sterols, phosphatides, and aliphatic alcohols (Kumar & Krishna, 2014). Globally, about four-fifths of palm oil output goes toward human consumption, with the remaining fifth channelled into non-food uses such as oleochemical manufacture (Basiron & Weng, 2004).

Nigeria produced 1.4 million metric tonnes of palm oil in 2023 (Sasu, 2025). Output trended upward across 2009–2023, peaking at a growth rate of about 14% in 2010 and climbing steadily again from 2014, a trajectory that has placed the country among the world's top producers. Consumption for the 2023/2024 crop year was projected at around 1.9 million metric tonnes — a ten-year high, reflecting the crop's expanding domestic role — with industrial demand outweighing household use (Sasu, 2025). Import volumes, meanwhile, exceeded 370 million units in 2022, down roughly 36% on the prior year, continuing a pattern of fluctuation seen since 2015 (Sasu, 2025).

Nigerian crude palm oil's composition can be broken down into fatty acids, minor components, and minerals. Palmitic, oleic, and linoleic acids together account for roughly 6.4–15% of the oil, while minor constituents span tocopherols, carotenoids, phytosterols, phospholipids, glycolipids, and both terpenic and aliphatic hydrocarbons; mineral content includes magnesium, manganese, iron, copper, zinc, phosphorus, sodium, and potassium. The oil remains semi-solid at room temperature and consists mainly of triacylglycerols (TAGs) (Susan, 2025). Heavy rainfall, humidity, and substandard storage conditions together accelerate the breakdown of triacylglycerols, releasing free fatty acids in the process. Once free fatty acid content climbs past 5%, the oil is considered unsafe for human consumption (Ngando et al., 2018), and good-quality oil is expected to stay below this 5% threshold (Pakiam, 2013). Extended storage and microbial contamination before processing both push free fatty acid levels higher, producing rancidity that shows up in the oil's taste and smell (Akinola, Oguntibeju, Adisa & Owojuyigbe, 2010). Peroxide value, moisture content, iodine value, saponification value, and impurity level are among the other physicochemical parameters commonly used to gauge oil quality.

Close scrutiny of the market, however, has found that a considerable share of oils and fats sold are adulterated in some way, usually to stretch volume and boost profit (Pakiam, 2013). Common tactics include harvesting unripe fruit, using bacterially contaminated tallow, cutting corners in processing, or blending in other fruits or animal fats — practices that lower oil quality and raise real health concerns for consumers (Okegeri, 2013). Within West Africa specifically, palm oil adulteration with hazardous additives such as the carcinogenic dyes Sudan III and IV, or with natural agents like sorghum bicolor leaf sheaths, remains a notable food-safety issue (MacArthur et al., 2021; Newsroom, 2024; Okogeri & Okoro, 2024).

B. Statement of the Problem

Despite its ubiquity as a cooking oil, palm oil's physicochemical properties are not well standardized, leaving quality inconsistent and consumers exposed to potential health risks (Anuradha, 2017). Most buyers, moreover, know little about the physicochemical make-up of the oil they purchase, and its vulnerability to adulteration and contamination can further undermine its quality, safety, and nutritional worth. This gap points to a clear need to characterize the physicochemical properties of palm oil sold in local markets.

C. Aim and Objectives of the Study

This study set out to establish the physicochemical properties of a range of palm oil samples sold within Azare Metropolis, with the following specific objectives:

1. determine the physicochemical properties of palm oil samples;
2. determine the quality of palm oil samples based on their physicochemical properties; and
3. determine the relationship between the different physicochemical properties of palm oil samples.

D. Research Questions

The study was guided by the following research questions:

1. What are the physicochemical properties of palm oil samples?
2. What is the quality of palm oil samples based on their physicochemical properties?
3. To what extent are the different physicochemical properties of palm oil samples related?

E. Significance of the Study

The findings of this study are expected to:

1. provide valuable data for household and industrial applications;
2. provide information on the physicochemical properties of palm oil relevant to human consumption; and
3. provide a basis for further research and development in food science, nutrition, and biotechnology.

F. Scope of the Study

The scope of this work was confined to a select group of markets and wards selling palm oil within Azare Metropolis, and to four physicochemical parameters: Free Fatty Acid content, Iodine Value, Saponification Value, and Hydroxyl Value.

G. Definition of Key Terms

Physicochemical: Relating to the physical and chemical properties of a substance.

Free Fatty Acids (FFAs): Non-esterified fatty acids released from triglycerides, which act as an important energy source.

Adulteration: The act of reducing the quality of a substance through the addition of another substance.

Palm oil: The edible vegetable oil derived from the mesocarp (reddish pulp) of the fruit of the oil palm.

Saponification Value: The amount of potassium hydroxide, in milligrams, required to saponify one gram of fat or oil.

Characterization: The description of the distinctive nature or features of a substance.

MATERIALS AND METHODS

A. Study Area and Sample Collection

Palm oil on sale was purchased as five separate samples from different wards and markets across Azare Metropolis — Sabuwar Kasuwa, Central Market, Kasuwar Kaji, Matsango, and Garin Arab — and each was transferred to a labelled transparent container (A through E) for storage.

B. Reagents and Materials

Every reagent used was of analytical grade, including hydrochloric acid, methanol, toluene, ethanol, potassium hydroxide, sodium sulphate, potassium iodide, acetone, cyclohexane, sodium thiosulphate, Wij's solution (iodine monochloride in acetic acid), and phenolphthalein, all sourced from the Chemistry Laboratory of the School of Undergraduate Studies (affiliated with the University of Maiduguri), Aminu Saleh College of Education, Azare.

C. Experimental Procedure

Determination of Free Fatty Acids (FFA), Iodine Value, specific gravity, colour, Saponification Value, moisture content, and Hydroxyl Value followed procedures adapted from Abd Al-Wali et al. (2017), summarized below to allow replication. Free Fatty Acid content was determined by dissolving a weighed oil sample in a neutralized ethanol/toluene mixture and titrating against standardized potassium hydroxide solution using phenolphthalein as indicator, with FFA expressed as mg KOH required to neutralize the free acids in 1 g of oil. Iodine Value was determined by Wij's method: a weighed sample was dissolved in cyclohexane, treated with excess Wij's solution (iodine monochloride in acetic acid) in the dark, and after the reaction period the unreacted iodine was liberated with potassium iodide and titrated against standardized sodium thiosulphate solution using starch as indicator, alongside a reagent blank. Saponification Value was determined by refluxing a weighed sample with excess alcoholic (ethanolic) potassium hydroxide solution until saponification was complete, then back-titrating the excess KOH against standardized hydrochloric acid using phenolphthalein as indicator, against a parallel blank. Hydroxyl Value was determined by acetylating the free hydroxyl groups in a weighed sample with a pyridine-acetic anhydride reagent, then hydrolyzing the excess reagent with water and titrating the liberated acetic acid, together with the unreacted acid in the sample itself, against standardized potassium hydroxide solution using phenolphthalein as indicator.

D. Method of Data Collection and Analysis

Each parameter was measured in replicate using the procedures described above, and the mean of these replicates was used in subsequent calculations. Results were then compiled into tables to support the discussion that follows. Pearson correlation analysis was additionally used to explore relationships between the four measured parameters across the five samples, in line with the study's third objective.

Results

Table 1 sets out the physicochemical profile of the palm oil samples — Free Fatty Acid, Iodine Value, Saponification Value, and Hydroxyl Value — the four parameters that chiefly govern palm oil quality.

Table 1. Physicochemical Properties of Palm Oil Samples

Parameter	Sabuwar Kasuwa	Central Market	Kasuwar Kaji	Matsango	Garin Arab	SON Reference
Free Fatty Acid (mg KOH/g)	9.30	8.50	10.50	12.30	7.60	≤ 3.30
Iodine Value (I ₂ /100g)	44.40	50.40	42.40	39.87	54.40	45–53
Saponification Value (mg KOH/g)	197.75	196.35	203.36	200.56	196.35	195–205
Hydroxyl Value (mg KOH/g)	31.97	35.90	30.23	41.00	42.08	Not specified

Note: Values represent single determinations per sampling site, as reported in the original dataset.

Figure 1. Physicochemical Parameters of Palm Oil Samples Across Sampling Sites



DISCUSSION

Free Fatty Acids (FFA)

Free fatty acid percentage serves as a marker of how degraded palm oil has become and, by extension, of its overall quality (Abd Al-Wali et al., 2017). Across the five samples — Sabuwar Kasuwa, Central Market, Kasuwar Kaji, Matsango, and Garin Arab — FFA content came to 9.30, 8.50, 10.50, 12.30, and 7.60 mg KOH/g respectively (Table 1), all comfortably above the SON benchmark of 3.30 ± 0.27 mg KOH/g. A comparable pattern emerged in work by Ibrahim and Rabi'at (2022) across Farin Gada, Terminus, and Bukuru markets, where FFA readings of 9.93, 32.30, and 13.60 mg KOH/g likewise breached the SON limit. The elevated FFA seen here is likely tied to how the fruit was processed, and signals broadly poor quality among the sampled oils.

B. Iodine Value

Iodine value, expressed as grams of iodine absorbed per 100 grams of substance, serves as a proxy for the degree of unsaturation in fatty acids (Gungshik, Ibrahim & Onyemowo, 2022) — a higher value signals a greater share of C=C double bonds. Samples from Sabuwar Kasuwa, Central Market, Kasuwar Kaji, Matsango, and Garin Arab returned iodine values of 44.40, 50.40, 42.40, 39.87, and 54.40 I₂/100g respectively, all falling inside the SON range of 45–53 I₂/100g for edible oil apart from the Garin Arab sample, which sat marginally above it. Elevated iodine values point toward greater chemical reactivity, weaker stability, and a higher tendency to oxidize. For comparison, Abd Al-Wali et al. (2017) reported an iodine value of 53.1 ± 0.4 I₂/100g in Yemeni palm oil.

C. Saponification Value

Saponification value denotes the milligrams of potassium hydroxide needed to saponify 1.0 g of fat, giving an indication of the average molecular weight of its fatty acids and serving as a check for possible adulteration. Values recorded for Sabuwar Kasuwa, Central Market, Kasuwar Kaji, Matsango, and Garin Arab were 197.75,

196.35, 203.36, 200.56, and 196.35 mg KOH/g respectively — all comfortably within the SON range of 195–205 mg KOH/g, suggesting the sampled oils showed little to no adulteration.

D. Hydroxyl Value

Hydroxyl value tracks the number of hydroxyl groups present and can shift with the oil's processing history and overall quality. Recorded values for Sabuwar Kasuwa, Central Market, Kasuwar Kaji, Matsango, and Garin Arab were 31.97, 35.90, 30.23, 41.00, and 42.08 mg KOH/g respectively; SON has no explicit hydroxyl-value standard for palm oil, but Abd Al-Wali et al. (2017) reported a Yemeni range of $32.5\text{--}36.5 \pm 0.6$ mg KOH/g for comparison. Most present-day results sit broadly in line with that range, the exceptions being Kasuwar Kaji, which fell below it, and Matsango and Garin Arab, which came in above it.

E. General Discussion of Findings

Taken together, the samples from Sabuwar Kasuwa, Central Market, Kasuwar Kaji, Matsango, and Garin Arab displayed a mixed quality picture. Every sample's FFA content breached the SON limit, pointing to poor quality rooted in inadequate processing, whereas most iodine values stayed within range, indicating acceptable unsaturation apart from a single sample that edged slightly over. Saponification values held within SON bounds throughout, signalling minimal adulteration, while hydroxyl values were more variable, some matching prior literature and others diverging from it. Collectively, these results underscore a clear need for better processing and quality-control practices among vendors in these markets.

F. Relationship Between the Physicochemical Parameters

In line with the third research objective, Pearson correlation coefficients were computed across the five samples to explore relationships among the four measured parameters. A strong negative correlation emerged between Free Fatty Acid and Iodine Value ($r = -0.94$, $p = 0.018$), the only relationship reaching conventional statistical significance; Free Fatty Acid and Saponification Value showed a moderate positive association ($r = 0.75$, $p = 0.14$), and Iodine Value and Saponification Value a moderate negative one ($r = -0.79$, $p = 0.12$), while Hydroxyl Value showed little relationship with any other parameter ($|r| \leq 0.44$). The FFA–Iodine Value relationship is chemically plausible: as hydrolytic rancidity proceeds, free fatty acids increase while some of the more unsaturated fatty acid chains are preferentially cleaved or oxidized, lowering the oil's overall degree of unsaturation and thus its iodine value.

These correlations should be read cautiously: with only five samples (three degrees of freedom), the estimates are imprecise and vulnerable to a single influential point — in this case, the Garin Arab sample, which was simultaneously the lowest in FFA and highest in Iodine Value, likely drives much of the FFA–Iodine Value association. A formal ANOVA comparing sites was not performed, since the results table reports one value per site rather than the underlying replicate readings needed to estimate within-site variance; this is addressed further in the Study Limitations below. The relationships reported here should be treated as preliminary and worth confirming with a larger, replicated sample set.

G. Study Limitations

Several limitations bear on how these findings should be interpreted. With only five samples, one per market, the study has limited statistical power and its findings cannot be generalized beyond the specific vendors sampled in Azare Metropolis; contamination or quality problems at markets outside this set may differ. Only four physicochemical parameters were assessed; other established quality indicators — peroxide value, moisture content, impurity level, carotenoid content, and microbial load — were outside the present scope but would give a fuller quality picture. The study also did not record data on each vendor's processing method, storage duration, or fruit quality at the point of milling, so the FFA elevation observed here can be attributed to poor post-harvest handling only in general terms, not traced to a specific stage or vendor practice. Finally, comparing sites statistically (for example, by ANOVA) would require replicate measurements at each site with the individual readings retained, rather than a single reported value per site; future work should record and report replicate-level data, including standard deviations, to support that comparison.

SUMMARY AND CONCLUSION

A. Summary

This research gauged the quality of palm oil sold in Azare Metropolis by profiling its physicochemical properties, drawing on five samples from Sabuwar Kasuwa, Central Market, Kasuwar Kaji, Matsango, and Garin Arab and testing each against four core quality indicators: Free Fatty Acid (FFA) content, Iodine Value, Saponification Value, and Hydroxyl Value.

- Free Fatty Acids (FFA): every sample returned FFA levels of 7.60–12.30 mg KOH/g, far exceeding the SON ceiling of 3.30 mg KOH/g and pointing to substantial oil degeneration and poor quality overall.
- Iodine Value: four of the five samples (39.97–50.40 L/100g) landed within or close to the SON range of 45–53 L/100g for edible oil, while Garin Arab's sample (54.40 L/100g) edged slightly above it, hinting at greater unsaturation and a higher oxidation risk.
- Saponification Value: all samples (196.35–203.36 mg KOH/g) stayed within the SON range of 195–205 mg KOH/g, suggesting little to no blending with other oils or fats.
- Hydroxyl Value: results (30.23–42.08 mg KOH/g) were broadly in line with published figures, with most samples matching or approaching the expected range — a spread that reflects differences in processing and quality among vendors.

B. Conclusion

In sum, while the acceptable saponification values indicate that the palm oil sold in Azare Metropolis shows no meaningful sign of adulteration, its overall quality is largely poor and unfit for human consumption. This stems chiefly from Free Fatty Acid content that, across every sample, ran well past the SON regulatory limit — a strong signal of hydrolytic rancidity driven by low-quality fruit, unhygienic processing, and prolonged or improper storage. As a result, the palm oil sold in these markets carries real health risks for consumers and falls short of acceptable quality.

RECOMMENDATIONS

A. Regulatory Bodies (e.g., SON, NAFDAC)

1. Step up monitoring and enforcement of quality standards for locally produced and sold palm oil, with particular attention to Free Fatty Acid content.
2. Run public-awareness campaigns aimed at processors and sellers on why hygienic practices matter and what health risks come with selling rancid oil.

B. Palm Oil Processors and Sellers

3. Switch to improved, more hygienic processing methods that limit oil hydrolysis and the resulting rise in FFA.
4. Process fruit while it is still fresh, and avoid holding either raw material or extracted oil in storage for long periods.
5. Store palm oil in suitable, airtight, non-reactive containers that shield it from moisture and air, both of which speed up deterioration.

C. Consumers

6. Buy palm oil from trustworthy sources and stay alert to signs of quality.

7. Watch for warning signs of poor-quality oil, such as a strong sour smell (rancidity) or an unusually dark colour, keeping in mind that adulterants can sometimes disguise these cues.

D. Future Research

8. Broaden this study to additional locations and a larger sample size, to build a fuller picture of palm oil quality nationwide.
9. Examine more closely what is driving the high FFA levels found here, with particular attention to the processing methods used by local mills.

REFERENCES

1. Abd Al-Wali, J. S., Salimon, J., Derawi, D., Bahadi, M., Al-Shuja'a, M., & Yusop, M. R. (2017). Physicochemical characteristics of Yemeni palm oil stored in traditional and modern containers. *Asian Journal of Chemistry*, 29(11), 2559–2562.
2. Akinola, F. F., Oguntibeju, O. O., Adisa, A. W., & Owojuyigbe, O. S. (2010). Physico-chemical properties of palm oil from different palm oil local factories in Nigeria. *Journal of Biological Sciences*, 10(8), 758–762.
3. Anuradha, R. (2017). Palm oil: The hidden truth behind its use in processed foods.
4. Basiron, Y., & Weng, C. K. (2004). The oil palm and its sustainability. *Journal of Oil Palm Research*, 16, 1–10.
5. Basiron, Y. (2017). The Malaysian palm oil industry: A story of success. Malaysian Palm Oil Council (MPOC).
6. Gungshik, J. M., Ibrahim, A., & Onyemowo, O. (2022). Comparative analysis of the quality of palm oil sold in major markets in Jos Metropolis. University of Jos.
7. Ibrahim, A., & Rabi'at, M. (2022). Assessment of free fatty acid content in palm oil from selected markets in Plateau State. University publication.
8. Kumar, R. S., & Krishna, A. G. (2014). A review on the nutraceutical and therapeutic importance of palm oil.
9. MacArthur, R. L., Teye, E., & Darkwa, I. A. (2021). Adulteration of palm oil with Sudan IV dye: A review of detection techniques. *Food Control*, 130, 108372.
10. Muhammad, S. K. S., Zainudin, B. H., & Bakar, J. (2012). Agronomic principles and practices of oil palm cultivation.
11. Ohimain, E. I., & Izah, S. C. (2015). The physico-chemical and microbial quality of refined palm oil sold in major markets in Yenagoa, Nigeria. *Point Journal of Botany and Microbiology Research*, 1(2), 023–030.
12. Okegeri, M. E. (2013). Economic impact of palm oil adulteration in south-eastern Nigeria.
13. Pakiam, R. (2013). Commodities: Palm oil. In *The Oxford Encyclopedia of Economic History*. Oxford University Press.
14. Sasu, D. D. (2025). Palm oil production and consumption in Nigeria from 2009 to 2024. Statista. Retrieved January 20, 2025.
15. Susan, A. (2025). Composition and nutritional analysis of Nigerian crude palm
16. Tan, Y. A., Ghazali, H. M., Kuntom, A., Tan, C. P., & Ariffin, A. A. (2009). Extraction and characterization of palm kernel oil from palm kernel. *Journal of Food Lipids*.