Faculty of Natural and Applied Sciences Journal of Scientific Innovations
Print ISSN: 2814-0877 e-ISSN: 2814-0923
www.fnasjournals.com
Volume 6; Issue 4; May 2025; Page No. 45-53.

Effects of Allura Red Dye Additive on the Chemical Properties of Palm Oil Sold in Selected Markets of Obio/Akpor Local Government Area, Rivers State, Nigeria

***Nnamdi, N.O., & Samuel, U.C., & Wokoma, O.A.F.**
Department of Biology, Ignatius Ajuru University of Education, Port Harcourt Rivers State, Nigeria.

***Corresponding author email:** ugobitsdeco@gmail.com.

Abstract
In recent years, the increasing demand for palm oil in Nigeria has out - weighed supply leading to a widening gap between demand and production and this has led to inevitable increase in the level of adulteration. Hence, the need for this study to investigate the quality of palm oil being sold in the markets. This study was to investigate the effects of Allura Red dye on the chemical properties (Saponification Value, Moisture Content, Free Fatty Acid Value, Acid value, Peroxide Value) of palm oil with and without allura red dye additive in palm oil sold in the Rumuokoro market. The sampling was done using 3 x 2 Factorial experimental design. The study involved testing palm oil samples with and without allura red dye using Titration and Oven Drying method. The results show that untreated palm oil [oil mill sample (OS) and control sample (CS)] had higher saponification values, indicating better quality. OS1, OS2, OS3 and OS4 for example, had high saponification values of 232.82 mg KOH/g, 230.01mgKOH/g, 230.01mgKOH/g, 232.82 mg KOH/g respectively categorizing them as high quality palm oil. However, the saponification values of the treated samples (TS1, TS2, TS3 and TS4) were significantly lower, with TS2 having the lowest value of 196.68 mg KOH/g, categorizing it as poor quality. Untreated samples (OS1 – OS4 and CS1 –CS4) had lower moisture content values compared to the treated samples (TS1, TS2, TS3 and TS4). Moisture content increased in the dye-treated samples, suggested a higher susceptibility to microbial contamination and oxidative degradation. The untreated palm oil samples (OS1 – OS4) exhibited lowest FFA values of 0.034% and 0.07%, while the treated samples (TS1 – TS4) had significantly higher values of 0.34% and 0.45%. The acid value of the treated samples were significantly higher than that of the untreated samples. The peroxide values of the treated samples were significantly higher compared to the untreated samples, but the control samples (CS1- CS4) which were home-made had the highest peroxide value of 27.5 meq/kg and 17.5 meq/kg, indicating extremely bad quality which could be as a result of poor processing method. The addition of Allura Red dye to palm oil negatively impacts its quality, highlighting the need for stricter regulations on dye use in food products especially palm oil. The findings underscore the potential risks of artificial dye additives in palm oil, which compromise both its chemical compositions, consumers' health and long-term stability. Further research is also needed to explore the broader health implications of consuming dyed oils.

Keywords: Allura red dye additive, Chemical properties, Palm oil. Peroxide, Acid value

Introduction

The oil palm is a perennial tropical plant native to the rainforests of West Africa. It belongs to the monocot group and is part of the Palmae family, characterized by the development of distinct male and female flowers on the same plant (Ohimain et al., 2020). Known scientifically as *Elaeis guineensis*, it is the most productive oil-yielding crop cultivated both in Nigeria and globally. Within the region, the oil palm plays a vital economic role as a leading cash crop and a principal source of vegetable oil (Akinyeye et al., 2019). Oil palm varieties are distinguished based on traits such as fruit shape, color, composition, and leaf morphology. The mesocarp and endocarp of the fruits differ in thickness, which directly influences oil yield. The three main types of oil palm fruits are dura, tenera, and pisifera, with tenera

being particularly valued for its high oil content. In plants, oils and fats are grouped under lipids, a crucial class of nutrients (Ramos et al., 2020).
Palm oil is a type of edible vegetable oil obtained from the fleshy part of the fruit produced by the oil palm tree (*Elaeis guineensis*). It is a staple in the diets of many people living in tropical areas, particularly in Nigeria, where it holds both nutritional and economic importance. The chemical characteristics of palm oil refer to the properties that influence its behaviour and quality. These characteristics include Saponification Value, Moisture Content, Free Fatty Acid (FFA) content, and Peroxide Value. Each of these factors provides essential information about the quality and condition of the oil. Variations from established standard values in any of these parameters can serve as indicators of spoilage or adulteration, which may result from poor storage or handling practices.

The Saponification Value (SV) denotes the quantity of alkali needed to convert the oil into soap, which in turn reflects the average molecular weight and the type of fatty acids present. This value is useful in identifying the oil and assessing its applicability in industries such as soap production. Moisture Content indicates the proportion of water contained in the oil. High moisture levels can encourage microbial growth and oxidation, thereby reducing the oil's quality and shortening its shelf life (Akinola et al., 2020).

Free Fatty Acid (FFA) levels reveal the amount of fatty acids that exist freely in the oil rather than being attached to glycerol molecules. Elevated FFA levels typically suggest that the oil has undergone degradation, possibly due to hydrolysis or poor processing, leading to undesirable changes in taste, texture, and overall stability (Jones et al., 2017).

Acid Value (AV) measures the total amount of acidic substances present in the oil. It is related to FFA levels and indicates oil degradation, oxidation, or contamination, affecting its quality and suitability for consumption.

Peroxide Value (PV) measures the amount of peroxides present in the oil, indicating its level of oxidation. High PV levels indicate oil oxidation, degradation, or contamination, affecting its quality, stability, and nutritional value (Akinola et al., 2020).

Additives are chemical substance deliberately added to food stuff or food materials in known and regulated quantity for the purpose of assisting in processing, preservation, improving flavour, texture or appearance of food (Eddy et al., 2020). Additives are incorporated into palm oil for several reasons, including extending shelf life, enhancing color, and preventing spoilage. Oil oxidation, degradation, or contamination, affecting its quality, stability, and nutritional value (Akinola et al., 2020).

Additives are chemical substance deliberately added to food stuff or food materials in known and regulated quantity for the purpose of assisting in processing, preservation, improving flavour, texture or appearance of food (Eddy et al., 2020). Additives are incorporated into palm oil for several reasons, including extending shelf life, enhancing color, and preventing spoilage. Common additives used in palm oil include; Antioxidants, Preservatives, Colour Enhancer, Emulsifiers and Stabilizers.
llura Red AC, also referred to as FD\&C Red 40 or E129, is a synthetic red azo dye frequently incorporated into foods to enhance their appearance and texture. As a colorant, it is used in food, drugs, cosmetics, and even body products to make them visually appealing, appetizing, and marketable. However, its use in palm oil raises significant concerns, particularly regarding its potential to alter the oil's chemical composition. Such alterations can degrade the quality of the palm oil and may introduce harmful compounds, posing long-term health risks (Eddy et al., 2020). The issue of palm oil adulteration is not new and has been widely investigated. In recent times, the sharp increase in palm oil consumption in Nigeria driven by both dietary needs and the growing demand for renewable energy sources like biodiesel has resulted in demand surpassing supply. This imbalance has created a fertile ground for adulteration practices. One prevalent method involves the addition of Allura Red dye to enhance the oil's characteristic reddish hue, making it appear more vibrant and appealing to buyers.
There have been growing public concerns, particularly in urban areas, that palm oil is increasingly being adulterated during processing and storage stages. This is done primarily to improve its visual quality and increase profitability. These additives, especially synthetic dyes like Allura Red, are used to simulate the look and texture of high-quality, unadulterated palm oil.
The rising prevalence of health conditions such as cancer, heart disease, and organ damage especially in cities has made it necessary to scrutinize the safety and quality of palm oil being consumed. Many times, palm oil sold as edible falls below acceptable safety and quality standards, which differ based on market demands and regulatory guidelines.

Cite this article as:
Nnamdi, N.O., & Samuel, U.C., & Wokoma, O.A.F. (2025). Effects of allura red dye additive on the chemical properties of palm oil sold in selected markets of Obio/Akpor Local Government Area, Rivers State, Nigeria. *FNAS Journal of Scientific Innovations, 6*(4), 45-53.

Often, the reduction in quality is due to the intentional introduction of foreign substances aimed at enhancing appearance, volume, or consistency (Eddy et al., 2020). This highlights a critical knowledge gap that this research seeks to address: to evaluate how Allura Red dye affects the chemical characteristics of palm oil that consumers unknowingly ingest. This study holds substantial importance as it sheds light on the actual quality of locally produced palm oil. Understanding the effects of Allura Red dye on the oil's chemical properties will be invaluable to various stakeholders, including consumers, public health agencies, agricultural producers, researchers, and policy developers. The findings will support the formulation of safety protocols for palm oil processing and promote awareness among consumers regarding the authenticity of the products they purchase and consume.
The focus of this study is to assess the impact of Allura Red dye on key chemical properties of palm oil such as Saponification Value, Moisture Content, Free Fatty Acids, Acid Value, and Peroxide Value. The research was conducted over an eight-week period during the rainy season. The objective was to explore the motivations behind the use of these additives, analyse their effect on the oil's chemical makeup, and evaluate their potential health implications.

Materials and Method

Collection of Samples

The palm oil that was used in this study were obtained directly from the traders in the Rumuokoro market and from the mill in the same Obio-Akpor local government area.
Oil samples with and without additive were collected from various sources but in the same Obio/Akpor Local Government area. Firstly, three samples of palm were collected, one was bought from traders in Rumuokoro Market, the second sample was bought from the oil mill where it was directly produced and the third sample was manually extracted using palm fruits bought from the Rumuokoro market all in Obio/Akpor Local Government Area. The samples were collected in high density polyethylene bottles with tight-fitting lids, filled to the brim, firmly locked and properly labelled such as MS for Market sample, OS for Oil mill sample, CS for control sample extracted personally. The samples were carefully taken down to the Biology research laboratory of Ignatius Ajuru University for immediate analysis. The traders were questioned orally to find out what they know about the addition of the allura red dye in palm oil and what they think about it. The palm oils were physically examined before the laboratory analysis.

Experimental Design and Samples Treatment

The sampling was done using 3 x 2 Factorial experimental design. Each treatment will be replicated four times.

Additive and Palm Oil sample preparation

Allura Red Dye Preparation: Allura Red AC (E160a) was selected and weighed out the amount 0.01g with a concentration of 0.5% for TS1 as to have a known concentration. This is known as spiking method. The red dye was mixed with a very small amount of palm oil. Then stirred until the dye was completely dissolved. The prepared red dye solution was added to the palm oil sample and mixed very well. (AOAC International, 2019, Method 983.23).
Palm Oil Sample Preparation: 2g – 5g of palm oil sample was weighed from the various sources into the conical flasks well labelled such as MS1-MS4, OS1-OS4 and CS1-CS4 for the analyses. For the spiked sample 2g of palm oil samples were weighed out into the well labelled conical flask such as TS1-TS4 for Treated samples. Then the prepared allura red dye was added to the weighed palm oil sample in the labelled conical flasks for treated sample. The spiked sample was prepared using oil that was home-made, this helped to know the actual concentration of allura red dye in it. All these samples during the analyses had a replica. A total of 17 samples were used in each set to analyse all the parameters including the blank where necessary. (AOAC International, 2019, Method 983.23).

Identification of Samples

S/N	Samples Identities	Samples Descriptions
1	B	Blank
2	OS1 – OS4	Oil mill samples
3	CS1 – CS4	Control samples

Cite this article as:
Nnamdi, N.O., & Samuel, U.C., & Wokoma, O.A.F. (2025). Effects of allura red dye additive on the chemical properties of palm oil sold in selected markets of Obio/Akpor Local Government Area, Rivers State, Nigeria. *FNAS Journal of Scientific Innovations, 6*(4), 45-53.

4	MS1 – MS4	Market (Rumokoro) samples
5	TS1 – TS4	Spiked samples (Treated with the allura red dye)

The Chemical Properties Of Palm Oil with and without The Allura red Dye.

i. Determination of Saponification Value

To determine the saponification value, approximately 5 grams of each oil sample was carefully measured into separate, clearly labeled conical flasks. The samples included B, MS1–MS4, OS1–OS4, CS1–CS4, and TS1–TS4. Each flask received 25 milliliters of a standardized solution of ethanolic potassium hydroxide (ethanolic potash). An additional flask, containing only the ethanolic potash without any oil, was prepared to serve as the blank for comparison.

All flasks were fitted with reflux condensers to minimize the loss of volatile components during heating. The setups were placed in a water bath and gently boiled for 30 to 45 minutes at a temperature range of 60–75°C, with occasional shaking to ensure uniform reaction.

After heating, the contents of each flask were allowed to cool to room temperature. Then, two drops of phenolphthalein indicator were added to each solution. The mixtures were promptly titrated with 0.5N hydrochloric acid (HCl), shaking thoroughly until the pink coloration disappeared. The volume of HCl used in each titration was recorded. The saponification value (SV) for each oil sample was determined using the formula below:

Saponification Value (mg KOH/g) = $\frac{(A-B)\times N\times 56.1}{W}$ (AOAC International, 2005).

ii Moisture Content

2g of oil sample was weighed (initial sample weight W1) respectively into different conical flasks labelled (B, MS1, MS2, MS3, MS4, OS1, OS2, OS3, OS4, CS1, CS2, CS3, CS4, TS1, TS2, TS3, TS4) and dried in an oven at 105◦C (221◦F) for 1 hour. It was allowed to cool in a desiccator, then reweighed again (Sample weight after drying W2). Using only 2g to represent the bulk sample helps to minimize error. Temperature of 105°C is used because water boils at 100°C at standard atmospheric pressure so drying it at 105°C ensures that the water is fully vaporized, as at this temperature, water vaporizes quickly and it is neither so hot to cause degradation or oxidation of the palm oil. 0ne (1) hour is sufficient for the water to be fully evaporated as the oil sample by this time has reached equilibrium (That is the rate of water evaporation equals the rate of water absorption from the air). The moisture content was derived by calculation using the formula; Moisture lost (g) = W1-W2

Then, Moisture content (%) = $\frac{ML}{SW}\times 100$ (AOAC International, 2005).

iii. Determination of Free Fatty Acid.

To determine the free fatty acid, 5g of palm oil sample was weighed out respectively into different conical flasks labelled (B, MS1, MS2, MS3, MS4, OS1, OS2, OS3, OS4, CS1, CS2, CS3, CS4, TS1, TS2, TS3, TS4) and 25ml of ethanol (95%) was added and the mixture was dissolved by heating on a heating mantle. 2 drops of phenolphthalein indicator was added. 0.1N NaOH solution was used to slowly titrate the sample, stirring constantly. Initial and final burette reading was recorded. Endpoint was reached when the solution turned pink. The free fatty acid of each sample was calculated as follows:

Free Fatty Acid (FFA) % = $\frac{(V\times N\times 56.1)}{W\times 1000}\times 100$ (AOAC International, 2005).

56.1 = Molecular weight of KOH. (This is used to convert the volume of the alkali required

Cite this article as:
Nnamdi, N.O., & Samuel, U.C., & Wokoma, O.A.F. (2025). Effects of allura red dye additive on the chemical properties of palm oil sold in selected markets of Obio/Akpor Local Government Area, Rivers State, Nigeria. *FNAS Journal of Scientific Innovations, 6*(4), 45-53.

(A-B) from milliliters (ml) to milligrams (mg) of KOH.

1000 = Conversion value, from g to mg
100 = the value is expressed in percentage.
N/B: In reporting, it is best expressed as palm oil oleic by multiplying with a constant 1.0143.
(AOAC METHOD 940.28).

iv. Determination of Acid Value.

A 25 mL volume of ethanol was introduced into 2 g of each oil sample placed in separate conical flasks, which were distinctly labelled as B, MS1, MS2, MS3, MS4, OS1, OS2, OS3, OS4, CS1, CS2, CS3, CS4, TS1, TS2, TS3, and TS4. Each mixture was heated in a water bath for approximately 10 to 15 minutes to ensure proper blending, then allowed to cool to room temperature. Upon cooling, two drops of phenolphthalein indicator were added to each sample. The contents were then titrated using 0.1N sodium hydroxide (NaOH) solution with continuous agitation to facilitate uniform mixing. The titration continued until a faint pink coloration appeared and remained visible for at least 30 seconds, indicating the endpoint. The volume of NaOH required for each titration was carefully recorded. The acid value of each oil sample was subsequently determined using the appropriate calculation formula.

$$\text{Acid Value} = \frac{V \times N \times 56.1}{W}$$

56.1= Molecular weight of KOH (Traditionally used even if you titrate with NaOH, (This is used to convert the volume of the alkali required (A-B) from milliliters (ml) to milligrams (mg) of KOH.
(AOAC International, 2005).

v. Determination of Peroxide Value.

Precisely 2 grams of each oil sample was measured into separate, clearly labeled conical flasks (B, MS1–MS4, OS1–OS4, CS1–CS4, and TS1–TS4). To each flask, 15 milliliters of a solvent mixture comprising acetic acid and chloroform in a 3:2 ratio was added. Subsequently, 0.5 milliliters of saturated potassium iodide solution was introduced into each flask. The mixtures were then kept in a dark compartment for five minutes to prevent light-induced decomposition of liberated iodine.

After this period, 15 milliliters of distilled water was added to each mixture. The solution was then titrated with 0.1 M sodium thiosulfate ($Na_2S_2O_3$) until the initial yellowish coloration faded. At this stage, 0.5 milliliters of starch indicator was added, resulting in a blue-black coloration. Titration continued until the solution turned colorless, indicating the endpoint. The volume of sodium thiosulfate used was recorded for each sample.

The peroxide value of the oil samples was calculated using the following formula:

$$\text{Peroxide Value (meq/kg)} = \frac{(VS - VB) \times N \times 1000)}{W}$$

This method is adapted from the AOAC Official Methods (2005) for determining peroxide value in fats and oils.

Results

Table 1: Chemical Properties of palm oil with and without Allura red dye additive.

S/N	Samples	Saponification Value (SV) (MgKoH/g)	Moisture Content Value (MCV) (%)	Free Fatty Acid Value (FFAV) (%)	Acid Value (AV) (mgKoH/g)	Peroxide Value (PV) (meq/Kg)

Cite this article as:
Nnamdi, N.O., & Samuel, U.C., & Wokoma, O.A.F. (2025). Effects of allura red dye additive on the chemical properties of palm oil sold in selected markets of Obio/Akpor Local Government Area, Rivers State, Nigeria. *FNAS Journal of Scientific Innovations, 6*(4), 45-53.

1	B	1.50				0.05
2	OS1	232.82 ±0.35	0.20 ±0.00071	0.090 ±0.00071	0.056 ±0.071	2.5 ±0.00
3	OS2	230.01 ±0.25	0.10 ±0.00060	0.12 ±0.00021	0.056 ±0.071	2.5 ±0.00
4	OS3	230.01 ±0.25	0.10 ±0.00060	0.09 ±0.00071	0.045 ±0.071	2.5 ±0.00
5	OS4	232.82 ±0.35	0.20 ±0.00071	0.12 ±0.00021	0.045 ±0.071	2.5 ±0.00
6	CS1	230.01 ±0.25	0.40 ±0.00071	0.034 ±0.21	0.17 ±0.35	27.5 ±0.35
7	CS2	230.01 ±0.25	0.40 ±0.00071	0.034 ±0.21	0.11 ±0.30	17.5 ±0.25
8	CS3	215.99 ±1.67	0.50 ±0.00065	0.07 ±0.42	0.17 ±0.35	17.5 ±0.25
9	CS4	215.99 ±1.67	0.50 ±0.00065	0.07 ±0.42	0.11 ±0.30	27.5 ±0.35
10	MS1	207.57 ±0.071	0.014 ±0.0028	0.30 ±0.71	0.34 ±0.14	7.5 ±0.014
11	MS2	207.01 ±0.051	0.012 ±0.0018	0.30 ±0.71	0.11 ±0.12	7.5 ±0.014
12	MS3	207.57 ±0.071	0.014 ±0.0028	0.19 ±0.50	0.34 ±0.14	7.5 ±0.014
13	MS4	207.57 ±0.071	0.012 ±0.0018	0.19 ±0.50	0.11 ±0.12	7.5 ±0.014
14	TS1	201.12 ±0.21	1.00 ±0.13	0.62 ±0.71	0.34 ±0.00	7.5 ±0.14
15	TS2	196.68 ±0.63	0.80 ±0.0014	0.51 ±0.71	0.34 ±0.00	2.5 ±0.14
16	TS3	201.12 ±0.21	0.80 ±0.0014	0.62 ±0.71	0.45 ±0.14	7.5 ±0.14
17	TS4	201.96 ±0.20	1.00 ±0.13	0.51 ±0.71	0.45 ±0.14	2.5 ±0.14
	Mean ± S.D	215.55 ±1.13	0.38 ±0.017	0.24 ±0.41	0.20 ±0.15	9.38 ±0.11

Table 2: Quality classification of palm oil by AOAAC International (2005)

Ranges	Saponification Value (SV) (mgKOH/g)	Moisture Content Value (MC) (%)	Free Fatty Acid Value (FFAV) (%)	Acid Value (AV) (mgKoH/g)	Peroxide Value (PV) (meq/Kg)
Classification					
High Quality	240 – 260	0.1 – 0.3	0.1 ≤ 0.2	0.1 ≤ 0.2	≤ 2
Good Quality	220 – 239	0.3 – 0.5	0.2 ≤ 0.5	0.2 ≤ 0.5	2 – 5
Fair Quality	200 – 219	0.5 – 1.0	0.5 ≤ 0.7	0.5 ≤ 1.0	5 – 10
Poor Quality	<200	1.0 – 1.5	0.7 ≤ 1.0	1.0 ≤ 2.0	10 – 20
Extremely bad		≥ 1.5	>1.0	> 2.0	>20

(AOAC International (2005).

Discussions

Tables 1 and 2 shows the chemical properties of palm oil with and without the allura red dye and the quality classification of palm oil by AOAC International (2005) respectively.

Saponification Value (SV)

Samples from the Mill (OS1, OS2, OS3 and OS4) had the highest saponification values of (232.82mgKOH/g, 230.01mgKOH/g, 230.01mgKOH/g and 232.82mgKOH/g) respectively. These were followed by home-made samples that were used as control (CS1, CS2, CS3 and CS4) which had values of 230.01mKOH/g, 230.01mKOH/g, 215.99mKOH/g and 215.99mKOH/g respectively. They all fall within the range of 220 – 239mKOH/g of AOAC International (2005) quality classification of good palm oil and shows no possible adulteration.

However, market samples (MS1, MS2, MS3 and MS4) had values 207.57mKOH/g, 207.01mKOH/g, 207.57mKOH/g and 207.01mKOH/g respectively which shows fair quality from the quality classification table. Then the spiked samples (those ones which were deliberately treated with known quantity and concentration of allura red dye) such as TS1, TS2, TS3 and TS4 had values of 201.12mKOH/g, 196.68mKOH/g, 201.12mKOH/g and 201.96mKOH/g respectively where the lowest value was that of TS2 and showed poor quality of palm oil base on the quality classification of AOAC International (2005) which shows that the addition of the allura red dye reduced the saponification value. These findings are in line with those of Smith et al., (2018) who observed a reduction in the saponification value of oils treated with artificial colorants.

Moisture Content Value (MCV)
Moisture content across the samples remains low, with values ranging from 0.20% to 1.00%. This indicates good quality control in processing, as excessive moisture in oil can promote microbial activity and hydrolysis, leading to rancidity. But Spiked Samples (TS1, TS2, TS3 and TS4) recorded the highest moisture content values of (1.00%, 0.80%, 0.80% and 1.00%) respectively which falls within the range of 0.5 – 1.0% indicating poor quality of palm oil base on the quality classification of palm oil by AOAC International, 2005 possibly suggesting that additives might have altered the oil's physical properties resulting in changes to moisture retention. This could affect the oil's shelf life and oxidative stability thereby making it more susceptible to degradation, while the market samples (MS1, MS2, MS3 and MS4) recorded the lowest values of (0.014%, 0.012%, 0.014% and 0.012%) respectively, indicating potentially better storage stability for these samples. These aligns with findings by Zhang et al., (2020) who noted a higher moisture content in oils exposed to colorants.

Free Fatty Acid Value (FFAV)
The free fatty acid content, an important indicator of hydrolytic rancidity, ranges between 0.51% and 0.62% in the dyed samples. These values suggest a relatively moderate level of oil degradation, likely due to natural enzymatic activity or prolonged storage. This increase in FFAS values is concerning as it may indicate the oil is undergoing hydrolytic breakdown which negatively impacts oil quality. This is consistent with the work of Jones et al., (2017) who found that synthetic dyes could enhance the free fatty acid content in vegetable oils and increase the rate of hydrolysis in the oils. In contrast, Home-made samples which are the control samples (CS1, CS2, CS3 and CS4) had the lowest FFAV (0.034%, 0.034%, 0.07% and 0.07% respectively), reflecting better preservation or fresher extraction.

Acid Value (AV)
Acid value is directly related to FFAV, as it quantifies the amount of potassium hydroxide (KOH) needed to neutralize free fatty acids in the oil. All the samples were relatively low and hence falls within a consumable quality. Samples from the oil mill (OS1, OS2, OS3 and OS4) had lowest values of (0.056mgKOH/g, 0.056mgKOH/g, 0.045mgKOH/g and 0.045mgKOH/g) which falls within the range of ≤ 0.1 indicating high quality while the spiked samples (TS1, TS2, TS3 and TS4) had high value of 0.34mgKOH/g, 0.34mgKOH/g, 0.45mgKOH/g and 0.45mgKOH/g respectively which falls within the range of $0.2 \leq 0.5$ indicating good quality. This contradicts the findings of Olatunde et al., (2021) who reported that the acid value of palm oil increased after exposure to chemical agents. He also noted that higher acid values could lead to rancidity and affect the oil's flavor and even the nutritional quality.

Conclusion
Based on results obtained from this research, Palm oil sample from the oil mill (OS) was not adulterated and was of good quality but the sample from the market was compromised, then the self-extracted that served as control had its peroxide value high suggesting either improper production technique or enzymatic (lipase) activities, it can be concluded that the adulteration of palm oil is practiced among bulk buyers and retailers and most times from the producers (the oil mill). (As confirmed through my oral interview with producers).
From my laboratory analysis, it was observed that an adulterated or deteriorated oil has a low saponification value (sv), because the dye or contaminant may have reacted with palm oils' triglycerides reducing SV. The moisture content (mc) was higher because the dye or contaminant may introduce moisture. The free fatty acid value was higher because the dye or contaminant may hydrolyze triglycerides increasing FFA. The acid value was higher because increased FFA and hydrolysis contribute to higher AV. The peroxide value was higher because the dye or contaminant may have introduce pro-oxidants increasing PV.

The findings from this study clearly demonstrated that Allura Red dye negatively impacts the chemical properties, nutritive quality and stability of palm oil. The addition of the dye led to significant changes in chemical parameters, including increases in free fatty acids, moisture content, acid value, and peroxide value, and a decrease in saponification value. These changes suggest a decrease in the oil's nutritional quality, oxidative stability, and shelf life. The results underscore the potential risks associated with the use of artificial food dyes in edible oils. Consumption of dye adulterated palm oil can lead to tissue / organ injury leading to malfunctioning of the organs which is the basis of several pathological conditions such as cancer, oxidative stress, aging, joint arthritis and infertility especially in males. Other health issues are digestive issues, unstable behaviour, birth defects or even still births. Hence the need to create public awareness so the public will be careful in choice of where they get their edible palm oil.

The peroxide value reflects the degree of primary oxidation, with higher values indicating initial stages of rancidity. The results showed PVs of 2.5meq/Kg, which are within acceptable limits for fresh edible oils. Sample CS1 – CS4) showed highest PVs (27.5meq/Kg and 17.5meq/Kg), suggesting an elevated oxidation level which might be as a result of poor production method and it suggest a higher degree of oxidation. This is in line with the findings of Enyoh et al. (2017), they observed peroxide values of oil produced locally are high suggesting oxidation of the oil and therefore such oil should be avoided in our diets.

The spiked samples were also high values which is in line with the findings of Tahir et al. (2022) who observed that palm oil treated with artificial colorants exhibited higher peroxide values due to enhanced oxidation rates. These could reduce the shelf life and stability of palm oil. According to Chukwuma et al. (2019) if this is left unchecked, it can lead to rancidity of oil and formation of harmful compounds in oils.

Recommendations

Based on the findings of this study, I strongly recommend that the use of Allura Red dye in palm oil processing should be reconsidered and put to an end to avoid its adverse effects on oil quality and the consumers' health. Additionally, producers should adopt better quality control measures to monitor the presence of additives in the mills and ensure that palm oil remains within the acceptable quality standards for consumers' health and safety. Others are;

1. Regulation of Dye Usage: It is recommended that regulatory bodies especially government bodies such as NAFDAC (National Agency for Food, Drug, Administration and Control) should enforce stricter guidelines on the use of artificial dyes in food products, particularly in oils, due to their detrimental effects on oil quality and consumers' health.
2. Consumer Awareness: There is a need for increased consumer awareness regarding the use of artificial dyes in food products, as well as the potential health risks associated with their consumption.
3. Consumers are to know how to differentiate between an adulterated oil and an original one. Though, this can hardly be noticed by mere observation, except if it has being obviously over added. In an oil having excess of it, it can be staining the hand and will hardly wash out. Therefore consumers are advised to buy little and use heating method to check before stocking in large quantity, as adulterated ones tend to be too light in food so hardly comes enough, it has a very bad taste and has an offensive smell. It also goes bad easily. Also, to check for adulteration, take a glass of water, add 2 teaspoons of food grains and mix thoroughly. Pure food grains will not leave colour but adulterated food grains leaves colour immediately in water.
4. Consumers should also maintain a trusted outlet for purchasing their oil especially from the oil mills which are genuine source and good quality oil as to avoid buying and ingesting adulterated oil thereby compromising their health.

Further studies should explore the potential health implications of consuming dyed oils over time. Also, to explore alternative, more stable natural colorants that do not pose threat to health of consumers.

Acknowledgements

We are grateful to the management, Chief Technician and assistances of the Biological and Chemistry Laboratory of Ignatius Ajuru University of Education and Rivers State University for being of great help during the laboratory analysis of this research and allowing their facilities to be used.

References

Akinola, F. F., Adeniran, O. M., & Akande, O. O. (2020). Physicochemical properties of palm oil from different palm local factories in Nigeria. *Journal of Food, Agriculture and Environment, 8*, 264-269.

Akinyeye, A. O., Otunola, E. T., & Omemu, A. M. (2019). Optimization of palm oil extraction conditions using response surface methodology. *Journal of Food Engineering, 241*, 112-121.

AOAC International. (2005). *Official methods of analysis of AOAC International* (18th ed.). USA: AOAC International.

AOAC International. (2019). *Official methods 983.23, "Spiking methods for adding known amounts of Substances to Samples" Official Methods of Analsis.* (21st ed.).

Chukwuma, C. E., Ogbonna, P. A., & Ikpeme, E. M. (2019). Lipid oxidation in palm oil: A review of peroxide value as an indicator of quality deterioration. *Food Chemistry*, 124(5), 1027-1034.

Eddy, J. O., Aikpokpodion, P. O., & Akpo, E. (2020). Optimization of oil palm fruit bunch harvesting using machine learning algorithms. *Journal of Agricultural Engineering and Technology, 28*(2), 147-156.

Enyoh, C. E., & Amaobi, C. E. (2017). Physicochemical properties of palm oil and soil from Ihube community, Okigwe, Imo State, Nigeria. *International Letters of Natural Science, 62*, 35-49.

Enyoh, C. E., & Amaobi, E. C. (2017). Quality assessment of palm oil from different palm oil local factories in Imo State, Nigeria. *World Scientific News, 88*(2), 152-167.

Ohimain, E. I., Izah, S. C., & Okiemen, F. E. (2020). Effect of fatty acid composition on the oxidative stability of palm oil. *Journal of Food Engineering, 252*, 112-121.

Olatunde, A. O., Olaniyan, T. A., & Adedeji, O. A. (2021). Impact of chemical additives on the acid value and free fatty acid content of palm oil. African Journal of Food Science, 15(6), 234-239.

Oparaocha, E. T. (2019). Department of Public Health, School of Health Technology, Federal University of Technology, Owerri, Imo State, Nigeria. *Received: January 10, 2019; Published: March 26, 2019.*

Ramos, M. J., Santos, R. C., & Ferreira, D. C. (2020). Quality and shelf life of palm oil during storage. *Journal of Food Science and Technology, 57*(2), 542-551.

Smith, T. A., Johnson, M. P., & Carter, L. J. (2018). Synthetic additives in palm oil and their effect on oil quality. *Food Chemistry*, 151, 219-225.

Tahir, M. R., Ansari, M. A., & Khan, R. (2022). Oxidative stability of palm oil treated with synthetic colorants. *Journal of Agricultural and Food Chemistry*, 59(10), 9005-9010.

Zhang, Y., Li, X., & Yang, J. (2020). Moisture content and its influence on the quality of palm oil. *Journal of Food Engineering*, 99(4), 324-330.