

**EFFECT OF LYE PRETREATMENT ON PROXIMATE COMPOSITION OF
BENTONITE BLEACHED OIL**

BY

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CERTIFICATION

This is to certify that the research project reported here was conducted by SADIQ, Nafisa Abubakar(2010304011) and has been approved as meeting part of the requirement for the award of Bachelor of Science (B.Sc) degree in Biochemistry of the Usmanu Danfodiyo University, Sokoto.

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DEDICATION

I dedicate this project to the Almighty Allah for His blessings, mercy and abundant knowledge that He granted on me throughout my journey in the university

I also dedicate this project to my parents, Malam Sadiq Jimoh and Salamatu Sadiq, for their relentless parental care, efforts, support and encouragement which has been of great contribution to my academic pursuit, may the blessings of the Almighty Allah in His blessings continue to be with them.

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ABSTRACT

Poor oil quality is a major problem in the food industries, responsible for product shelf life due to oxidative rancidity. This study explores the use of bentonite bleaching earth to improve palm oil quality after 0.1 N lye pretreatment. Palm oil was purchased from a local market in Sokoto metropolis. Exactly 100 g of oil was subjected to 0.1 N lye pretreatment and the percentage oil recovery was calculated. Afterwards, 5% and 10% bentonite clay were used to bleach the recovered oil at 80–90 °C for 15 minutes with constant stirring. The cooled oil was then filtered and proximate composition determined. The results revealed that 75% oil recovery in the 5% bentonite treated oil. The acid and peroxide value dropped significantly in the bleached oil when compared with the raw oil. The saponification value suggest an increased concentration of short-chain fatty acids in the bleached oil. In conclusion, combination of lye pretreatment followed by 5% bentonite bleaching efficiently improved the quality attributes of red palm oil and attained 75% oil recovery.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Palm oil is a globally significant edible oil, prized for its high yield, versatility in food and non-food applications, and economic importance, particularly in tropical producing nations (Mba, Dumont, & Ngadi (2015). In its crude form, however, it contains various impurities and degradation products that impair its quality, shelf life, and consumer acceptability(De Greyt, 2013).

Crude palm oil naturally contains undesirable components such as free fatty acids, pigments, phospholipids, moisture, and oxidation products, which negatively affect oil quality, shelf life, and consumer acceptability. These impurities necessitate refining before the oil can be safely used for consumption or industrial purposes (Awogbemi *et al.*, 2024).

To render the oil edible and stable, a series of refining steps are employed. A common initial step is lye pretreatment or alkali neutralization, where sodium hydroxide (NaOH) is used to react with and remove FFAs, forming soapstock. This process significantly reduces the acid value (AV), a direct measure of FFA content (O'Brien, 2008). Following neutralization, bleaching is a critical physical adsorption process, typically using activated clays like bentonite. The bleaching earth removes pigments, residual soaps, trace metals, and oxidation products, thereby decolorizing the oil and improving its oxidative stability (Güçlü-Üstündağ & Mazza, 2007).

The efficacy of refining is monitored through key oil quality indices. The acid value (AV) indicates hydrolytic rancidity. The peroxide value (PV) measures primary oxidation products

(hydroperoxides), indicating the initial stage of oxidative rancidity. The iodine value (IV) reflects the degree of unsaturation in the fatty acid profile, which influences oxidative stability. The saponification value (SV) provides an estimate of the average molecular weight of the fatty acids present (Frankel, 2005). These indices collectively determine the oil's shelf life, nutritional integrity, and suitability for various industrial uses.

Following neutralization, bleaching is carried out to remove color pigments, residual soaps, trace metals, and oxidation products. Adsorbent clays such as bentonite are commonly used due to their high surface area and adsorption efficiency. Bentonite bleaching improves the color, purity, and oxidative stability of refined oils (Alhaji *et al.*, 2024).

1.2 Statement of the Problem

Crude palm oil inherently contains high levels of free fatty acids, pigments, and oxidation precursors which compromise its quality and commercial value (Azeman, Yusof, & Othman, 2021). While bentonite bleaching is known to improve oil colour and stability, its efficiency in removing impurities is influenced by the prior processing steps. Specifically, there is limited and inconsistent scientific data on how lye pretreatment directly modifies the chemical composition of the oil in a way that subsequently affects the action of bentonite clay on critical quality parameters (AV, PV, IV, and SV). The interaction between these two consecutive unit operations and their combined effect on these indices requires clearer elucidation.

1.3 Justification

Optimizing the refining sequence is essential for enhancing palm oil quality, maximizing yield, and reducing operational costs. A scientific understanding of how alkali pretreatment influences

the effectiveness of subsequent bentonite bleaching provides valuable insights for both small-scale processors and large industrial refiners. This study will generate empirical data on the synergistic effect of lye and bentonite treatments, contributing to improved processing protocols that yield oil with better oxidative stability, longer shelf life, and preserved nutritional quality. Ultimately, this supports food security and economic efficiency in the vegetable oil industry.

1.4 Aim and Objectives

The aim of this study is to determine the effect of lye (NaOH) pretreatment on the acid, saponification, iodine, and peroxide values of bentonite-bleached crude palm oil.

1.5 Objectives

1. To pretreat a sample of crude palm oil using lye (sodium hydroxide solution).
2. To bleach samples of both untreated and lye-pretreated crude palm oil using bentonite clay.
3. To determine the physiochemical properties of crude and lye-pretreated bentonite bleached oil.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview of Palm Oil: Sources and Composition

Palm oil is produced from the oil palm, *Elaeis guineensis*, which belongs to the Arecaceae family. This family contains two main species that are cultivated for palm oil production (Basha *et al.*, 2009). The development of palm fruits from fertilization to full maturity usually takes about five to six months.

The fruits grow in large clusters known as bunches, which typically weigh between 10 and 20 kg. Each bunch can contain up to 2,000 small fruits, with each fruit approximately the size of a plum. The palm fruit consists of a fleshy outer layer called the pericarp, which is rich in oil, and a single inner seed known as the kernel, which also contains oil (Hossain *et al.*, 2018).

Palm oil is primarily obtained from the mesocarp, which is the fleshy outer part of the palm fruit. Edible palm oil is extracted from this pulp, while palm kernel oil (PKO) commonly used in soap and detergent manufacture—is obtained from the kernel. From ripe red palm fruits, crude palm oil (CPO) is produced, and the oil extracted from the kernel of the same fruit is referred to as crude palm kernel oil (CPKO), which is considered a secondary product.

Although palm oil and palm kernel oil originate from the same fruit, they differ significantly in their chemical composition and nutritional properties. Apart from olive oil, the oil palm is unique among oil-bearing plants in that it produces two commercially valuable oils derived from different parts of the fruit.

In its unrefined form, palm oil has a bright orange-red color due to its high carotene content.

Palm oil contains roughly 48% saturated fatty acids (SFA) and 52% unsaturated fatty acids (UFA). Its SFA content is higher than that of oils such as sunflower, olive, or rapeseed, which are generally regarded as healthier, but lower than coconut oil, which is rich in myristic and lauric acids (Bamba *et al.*, 2023). Palmitic acid is the dominant saturated fatty acid, making up about 85% of total SFAs, while oleic acid is the main unsaturated fatty acid, constituting approximately 88% of total UFAs. Minor saturated fatty acids, including lauric acid (C12:0) and myristic acid (C14:0), together account for only around 1.5% of SFAs, which is considerably lower than in coconut oil.

A significant feature of palm oil is that nearly 80% of oleic acid is located at the sn-2 position of triacylglycerols (TGs), enhancing its absorption as monoacylglycerols (MAG). This positional specificity suggests that, despite its SFA content, palm oil may behave similarly to monounsaturated fats in influencing plasma lipid profiles (Bamba *et al.*, 2023).

Palm oil is fractionated into liquid and solid components for different industrial applications. Palm olein, the liquid fraction, contains about 44% SFA and 56% UFA, making it suitable for frying oils and snack production. Palm stearin, the solid fraction, contains approximately 68% SFA and 32% UFA, which provides the firmness required for products such as baked goods and serves as a healthier alternative to hydrogenated oils, thereby reducing trans-fat intake (Bamba *et al.*, 2023).

2.2 Crude Oil Impurities and Their Effect

Crude palm oil and palm kernel oil contain impurities such as peptizing impurities, free fatty acids, pigments, peculiar smell substances, etc. which will affect the stability, taste and flavor of palm oil and palm kernel oil.

Free fatty acid (FFA) content is an important parameter used to assess palm oil quality. High levels of FFA accelerate oxidative rancidity, thereby reducing the suitability of the oil for food consumption (Basha *et al.*, 2009; Sambanthamurthi *et al.*, 2000). According to the standards of the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), crude palm oil (CPO) intended for edible purposes should contain no more than 5% FFA (FAO/WHO, 2011). When this limit is exceeded, additional refining processes such as neutralization or stripping become necessary, often resulting in oil losses (Choo *et al.*, 2007).

The accumulation of FFA in palm oil has been strongly associated with lipolytic activity in oil palm fruits (Morales & Mendez, 2012; Tee *et al.*, 2015). Lipase enzymes are naturally present within the oil bodies and their activity increases as the fruits mature (Tan *et al.*, 2009). Microbial contamination has also been reported as an external source of lipase, promoting hydrolysis and increasing FFA formation (Zulkifli *et al.*, 2010). Fruit bruising during harvesting and handling, as well as prolonged post-harvest storage, further enhances lipase activity (Hadi *et al.*, 2012). In addition, moisture content plays a significant role, since autocatalytic reactions are likely to occur when moisture levels exceed 0.2% (Rossell, 2001).

Crude palm oil contains naturally occurring pigments, mainly chlorophyll, which imparts green coloration, and carotenoids, which are responsible for yellow to red hues. Although carotenoids are generally beneficial due to their provitamin A activity, chlorophyll and excessive pigments can negatively affect the appearance and oxidative stability of the oil by promoting photo-

oxidation (Gunstone, Harwood, & Dijkstra, 2007; Rossi *et al.*, 2001). Consequently, pigment removal is an essential step during the refining of crude palm oil to improve its quality and consumer acceptability.

Activated clay is commonly used as an adsorbent during the bleaching process due to its high surface area, typically ranging from 100 to 300 m²/g, and its microporous structure, which enhances its ability to remove color bodies and other impurities (Boki *et al.*, 1992; Hossain *et al.*, 2010). Acid-activated clays, usually treated with sulfuric acid (H₂SO₄) or hydrochloric acid (HCl), exhibit superior adsorption capacity compared to natural clays. Acid activation increases pore volume and surface acidity, thereby improving pigment removal efficiency and producing a lighter, more visually appealing oil that meets commercial and market quality standards (Patterson, 2009; Sabah & Celik, 2002).

Beyond pigments, crude palm oil often contains oxidation by-products such as peroxides, aldehydes, and ketones that are formed during extraction, handling, and processing. These compounds contribute to rancidity and the development of off-flavors, leading to a significant reduction in shelf life (Gunstone *et al.*, 2007; Choe & Min, 2006). Effective removal of these oxidation products is therefore essential to maintain oil quality and consumer acceptability.

Activated clay plays a critical role in adsorbing oxidation products during the bleaching stage, thereby improving the oxidative stability of palm oil (Patterson, 2009). In addition to removing peroxides and secondary oxidation compounds, activated clay also adsorbs trace metals such as iron and copper, as well as residual phospholipids, all of which are known to catalyze further oxidative degradation of oils (Hossain *et al.*, 2010). This purification step is crucial for producing refined oils with extended shelf life, improved freshness, and minimal taste defects.

2.3 Lye Pretreatment (Alkali Neutralization)

Neutralization is a key step in the chemical refining of oils, aimed at eliminating free fatty acids (FFAs) and other undesirable components remaining after degumming. During this stage, residual phospholipids, pigments, and waxes are removed, as these substances can cause unfavorable color and odor and may also accelerate oxidative degradation in the final oil. The process typically involves the addition of a sodium hydroxide (NaOH) solution to the crude or degummed oil at an excess level of about 0.1–0.5% above the stoichiometric requirement for FFA neutralization (Wang & Johnson, 2001; Wei *et al.*, 2015).

The concentration of the NaOH solution is usually determined using a specific-gravity hydrometer calibrated in degrees Baumé (°Be). The use of excess alkali ensures complete neutralization of FFAs while preventing unreacted alkali from remaining in the oil. During neutralization, FFAs and residual phospholipids react with NaOH to form insoluble soaps, which are subsequently removed by centrifugation. The neutralized oil is then washed with hot water (90–95°C), typically at 10–20% of the oil volume, to eliminate any remaining soap residues and improve oil quality.

Previous studies have reported that neutralization during chemical refining is commonly performed at temperatures between 65 and 90 °C (Karabulut *et al.*, 2005; Farhoosh *et al.*, 2009). However, (Chew *et al.* 2017) demonstrated that a lower temperature range of 40–50 °C was more effective for free fatty acid (FFA) removal in kernel seed oil. Similarly, Wei *et al.* (2015) found

that neutralization at 25 °C was inadequate for FFA reduction, whereas temperatures of 45 °C, 65 °C, and 85 °C produced comparable neutralization efficiencies in tea seed oil. Lower processing temperatures are generally preferred because they help preserve lipid bioactive compounds, while higher temperatures during neutralization can accelerate lipid oxidation and lead to increased peroxide values (PV) (Farhoosh *et al.*, 2009).

During neutralization, free fatty acids (FFAs) are converted into their sodium salt form and, together with triacylglycerols and residual phospholipids, form a by-product known as soapstock. This soapstock can be acidified to recover free fatty acids, which are then used in soap manufacturing or as additives in animal feed. Additionally, the neutralization process may lead to partial degradation or adsorption of coloring pigments such as chlorophylls and carotenoids, while metal ions can bind to remaining phospholipids, contributing to improved oil quality.

Despite these benefits, neutralization can result in the loss of valuable bioactive constituents. Tocopherols may be removed through adsorption onto the soapstock, while phytosterols can be transferred into the soapstock via liquid–liquid partitioning. These processes reduce the concentration of nutritionally important compounds in the refined oil.

2.4 Bleaching With Bentonite Clay

Bleaching is a critical stage in the refining of crude palm oil (CPO), aimed at improving both its visual and chemical quality. This process removes pigments such as carotenoids and chlorophyll, which impart red, yellow, and green hues to the oil, producing a lighter, visually appealing product suitable for food and industrial applications (Hailemariam, Desta, & Mekonnen, 2022;

Nweke & Ajemba, 2024). Beyond pigments, bleaching also targets oxidation by-products, including peroxides, aldehydes, and ketones, which contribute to rancidity, off-flavors, and reduced shelf life (Siregar *et al.*, 2019; Choe & Min, 2021).

Bentonite, a naturally occurring smectite clay, is widely used as a bleaching earth due to its high surface area and strong adsorption capacity, enabling effective removal of pigments, polar impurities, and residual soaps (Hailemariam *et al.*, 2022). Activation of bentonite, typically through acid treatment with sulfuric or hydrochloric acid, enhances its porosity, surface acidity, and total pore volume, allowing it to adsorb chlorophyll, carotenoids, residual soaps, oxidation products, and phospholipids more efficiently (Nweke & Ajemba, 2024; Thaithong *et al.*, 2023). This modification increases adsorption sites and improves the interaction between the clay surface and polar or colored impurities, making the bleaching process more effective.

The efficiency of bleaching is influenced by several process parameters. Temperature, clay dosage, contact time, and mixing intensity determine the extent of impurity removal (Usman, Oribayo, & Adebayo, 2019). Studies show that optimal bleaching conditions can achieve pigment removal efficiencies of over 90% while simultaneously reducing peroxide values and residual free fatty acids (Siregar *et al.*, 2019; Thaithong *et al.*, 2023). The type of clay (e.g., Na-bentonite versus Ca-bentonite), activation method, and chemical composition (silica/alumina ratio) also play critical roles in performance (JOPR, 2023).

Bleaching clay also effectively removes trace metals such as iron and copper, which act as pro-oxidants and catalyze further oxidative degradation of the oil (Siregar *et al.*, 2019; Thaithong *et al.*, 2023). Additionally, clay-based bleaching can reduce phospholipids and residual gums, which otherwise impair transparency, filterability, and shelf life. Some studies indicate that

integrated bleaching-degumming processes can remove up to 96% of phosphorus in CPO, highlighting the multifunctionality of activated clays in refining (IJOP, 2023).

Despite its advantages, bleaching has some limitations. Over-bleaching or the use of excessive clay may lead to the adsorption of beneficial minor components, including natural antioxidants and carotenoids, and can also result in oil losses trapped in the clay (Grand View Research, 2022; ScienceDirect, 2024). Therefore, a balance must be struck between maximum impurity removal and retention of desirable oil qualities. Local clays, when properly activated, have been shown to match or even exceed the performance of imported bleaching earths, offering cost-effective and sustainable options for industrial refining (Link Springer, 2025).

2.5 Effects of Pretreatment and Bleaching On Physicochemical Parameters

The quality of bleached oil is typically evaluated using standard oil quality indices, which provide insight into the chemical stability, purity, and nutritional integrity of the oil. Both lye pretreatment and bentonite bleaching significantly influence these indices, ensuring that the refined oil meets food and industrial quality standards. Understanding these parameters is crucial for optimizing refining processes and achieving a high-quality final product.

2.5.1 Acid Value (Av)

The acid value measures the concentration of free fatty acids (FFAs) in the oil, which are indicators of hydrolytic degradation and potential rancidity. Elevated AV can lead to undesirable flavors, reduced shelf life, and poor frying stability. Lye pretreatment reduces AV by converting FFAs into soap through a neutralization reaction with sodium hydroxide (NaOH), which is subsequently removed from the oil (Giwa & Ogunwole, 2020). Bleaching with bentonite further

lowers AV by adsorbing residual soap and polar impurities that remain after neutralization, resulting in oil with reduced acidity and enhanced stability (Fadhil & Dheyab, 2021). This dual action ensures that the refined oil has minimal hydrolytic degradation, extending its usability for both domestic and industrial purposes.

2.5.2 Peroxide Value (Pv)

Peroxide value indicates the level of primary oxidation products, mainly hydroperoxides, which are formed during oil extraction, handling, and storage. High PV is associated with early-stage oxidation, off-flavors, and potential formation of secondary toxic compounds. Bentonite bleaching effectively lowers PV by adsorbing hydroperoxides and other polar oxidation products from the oil, thus improving its oxidative stability (Belete, Abate, & Huang, 2019). Lye pretreatment also contributes to lowering PV by removing pro-oxidant substances such as trace metals and phospholipids, which catalyze oxidative reactions (Sulaiman, Umar, & Ibrahim, 2019). Maintaining low PV is essential for ensuring longer shelf life and safer consumption of palm oil.

2.5.3 Iodine Value (IV)

Iodine value reflects the degree of unsaturation of the oil, corresponding to the number of double bonds in the fatty acid chains. It is an important indicator of the oil's nutritional quality and susceptibility to oxidation. Refining steps, including neutralization and bleaching, may cause a slight reduction in IV due to the removal of unsaturated impurities and minor oxidized compounds. However, the core triglyceride structure remains largely intact, preserving the primary unsaturated fatty acids that contribute to health benefits and functional properties

(Adejumo & Alamu, 2021). A controlled reduction in IV during refining is considered acceptable, as it reflects the removal of undesirable substances without compromising the nutritional value of the oil.

2.5.4 Saponification Value (SV)

Saponification value indicates the average molecular weight of fatty acids in the oil and provides insight into the composition and quality of the triglycerides. Refining processes, such as neutralization and bleaching, may lead to slight variations in SV because free fatty acids and low-molecular-weight impurities are removed (Sulaiman *et al.*, 2019). These changes are generally minimal and do not alter the overall fatty acid profile significantly. Monitoring SV ensures that the refining process effectively removes impurities while preserving the oil's structural integrity and functional properties, which is particularly important for industrial applications such as soap production and biodiesel.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Material

Table 3.1 and 3.2 presents some of the apparatus, equipment, solvents, chemicals and reagents used for the study

Table 3.1: List of Apparatus and Equipment used in this Study

NAME	MODEL	MANUFACTURER
Filter paper	Whatman	Finland.
Beakers	1000-600	Pyrex.
Conical Flasks	3295/14AS	Pyrex
Analytical balance (0.001 g)		Ohaus
Oven		
Hot plate		Thermo Scientific
Titration Apparatus		
Measuring cylinder(50–250 mL)		Pyrex
Burette (50 mL)		Pyrex

Table 3.2: List of Chemicals, Reagents and Solvents Used in this Study

NAME	MODEL	MANUFACTURER
Sodium hydroxide (NaOH)	Analytical Grade	Merck
Hydrochloric acid	37% Analytical Grade	Merck
Phenolphthalein Indicator	Analytical Grade	Merck
Potassium iodide (KI)	Analytical Grade	Merck
Crude palm oil (CPO)	Commercial	Local mil

3.1.1 Sample Collection

Crude palm oil was purchased from local market in Sokoto metropolis. The bentonite clay bleaching earth was purchase commercially from a company in Lagos. Both samples were stored in clean containers to avoid contamination before use.

3.2 Methodology

3.2.1 Lye Pretreatment of Palm Oil

The palm oil was pretreated with sodium hydroxide to remove impurities and improve bleaching efficiency

Procedure

Exactly 100 g of crude palm oil was weighed into a beaker. The oil was then heated to 70–80°C to reduce viscosity. Afterwards, 5 mL of 0.1 M sodium hydroxide (NaOH) was added to the oil before it was allowed to cool and then filtered using whatman filter paper No. 1. The filtered oil was measured and the percentage oil recovery was calculated. The oil was stored for further use.

3.2.2 Bentonite Bleaching of NaOH Pre-Treated Oil

Exactly 100g of the oil sample was weighed and heated to 100-110°C in which the temperature was monitored using a thermometer. Afterwards, 10g of the bleaching earth was then added to the oil and the mixture was stirred continuously for 15 minutes and the oil turned darker as expected. After 15 minutes in which the oil was left to cool at 35°C, it was then filtered using whatman filter paper No. 1. The percentage oil recovery was then calculated and the oil was stored for further use.

3.3.3 Determination of Physico-chemical Parameters

Physicochemical parameters determined for treated oils include acid value, peroxide value, iodine value, and saponification value.

3.3.3.1 Acid Value

Principle

Acid value is determined by titrating free fatty acids in the oil with a standard KOH solution. The amount of KOH used indicates the level of hydrolytic rancidity.

Procedure

2.00 g of the oil sample was weighed into a 250 mL conical flask 50mL of hot neutralized ethanol was added to dissolve the oil, the mixture was warmed gently on a water bath 2–3 drops

of phenolphthalein indicator were added, the hot solution was titrated with 0.1 M KOH until a persistent light-pink color appeared, the titre value was recorded.

3.3.3.2 Peroxide Value

Principle

Peroxide value measures the concentration of peroxides formed during primary oxidation. Iodide ions are oxidized to iodine, which is then titrated with sodium thiosulphate.

Procedure

5.00 g of the oil sample was weighed into a dry conical flask 30 mL of acetic acid chloroform mixture (3:2) was added, 0.5 mL of saturated KI was introduced and the flask was swirled, the mixture was allowed to stand in the dark for 1 minute, 30 mL distilled water was then added,

The liberated iodine was titrated with 0.01 M sodium thiosulfate until pale yellow, starch indicator was added and titration continued until the blue color disappeared, a blank titration was performed under the same conditions.

3.3.3.3 Iodine Value

Principle

Iodine value is based on the ability of unsaturated fatty acids to absorb iodine from Wijs solution, indicating degree of unsaturation.

Procedure

0.25 g of oil sample was weighed into a clean, dry iodine flask, 10 mL of chloroform was added to dissolve the sample, 25 mL of Wijs reagent was introduced and the flask was stopped, the mixture was kept in the dark for 30 minutes, 15 mL of 10% KI was added, followed by 100 mL distilled water, the liberated iodine was titrated with 0.1 M sodium thiosulfate until pale yellow, starch indicator was added and titration continued until the blue color disappeared, a blank titration was run under the same conditions.

3.3.3.4 Saponification Value

Principle

Saponification involves hydrolysis of triglycerides by alcoholic KOH. The unused KOH is titrated with HCl, and the quantity of alkali used indicates fatty acid chain length.

Procedure

2.00 g of the oil sample was weighed into a 250 mL round-bottom flask, 25 mL of 0.5 M alcoholic KOH was added, a reflux condenser was attached and the mixture was then heated on a boiling water bath for 30 minutes, after refluxing, 2–3 drops of phenolphthalein were added, the hot mixture was titrated with 0.5 M HCl until the pink color disappeared, a blank determination was carried out using the same reagents without the oil sample. The experiment was conducted in triplicate, represented as Samples A, B, and C to ensure accuracy and reproducibility. Each sample (A, B, and C) followed the same pretreatment and bleaching procedure under identical conditions. All results were reported as the mean of the triplicate values.

3.3 Statistical Analysis

Results are presented in mean $\pm$ S.D where triplicate determination were done.

CHAPTER FOUR

RESULT, DISCUSSION, CONCLUSION AND RECOMMENDATION

4.1 RESULT

4.1.1 Percentage Oil Recovery

Table 4.1 presents the percentage oil recovery of 5% and 10% lye-pretreated bleached oil. The results show that the 5% treatment produced a higher percentage recovery compared to the 10% treatment.

Table 4.1: Percentage oil recovery of the lye-pretreated bleached oil.

Treatment	%Recovery
5%	72.20 ± 3.00
10%	57.07 ± 3.23

4.1.2 Physico-chemical Properties of Bleached and Raw Oil

Table 4.2 presents the physiochemical properties of lye-pretreated bleached oil and the raw oil. The proximate analysis shows that treatment markedly reduced all key chemical quality indices of the raw oil. The acid value decreased from 4.43 ± 0.11 mgKOH/g in the raw oil to 0.18 ± 0.03 and 0.27 ± 0.03 in the 5% and 10% treatments, respectively, indicating a substantial reduction in

free fatty acids. Similarly, the peroxide value dropped from 4.60 ± 0.03 meq O₂/kg to 0.90 ± 0.10 (5%) and 1.40 ± 0.20 (10%), reflecting lowered oxidative deterioration after treatment. The iodine value also declined significantly from 53.79 ± 0.45 g I₂/100 g to 30.70 ± 0.21 and 10.00 ± 0.20 , showing a reduction in unsaturation with increasing treatment concentration. In addition, the saponification value fell sharply from 210.02 ± 0.43 mgKOH/g in the raw oil to 10.00 ± 1.76 and 10.50 ± 1.40 in the 5% and 10% treatments, respectively, suggesting considerable alteration of the oil's molecular composition. Overall, the results demonstrate that both treatments substantially improved the chemical quality of the oil, with the strongest reductions in chemical indices observed at the 10% level.

Table 4.2: Physiochemical properties of the bleached and raw oil.

Proximate Composition	Raw Oil	5%	10%
Acid Value (mgKOH/g)	4.43 ± 0.11	0.18 ± 0.03	0.27 ± 0.03
Peroxide Value (meq O ₂ /kg)	4.60 ± 0.03	0.90 ± 0.10	1.4 ± 0.2
Iodine Value (g I ₂ /100g oil)	53.79 ± 0.45	30.70 ± 0.21	10.00 ± 0.20
Saponification Value (mgKOH/g)	210.02 ± 0.43	10.00 ± 1.76	10.50 ± 1.40

4.2DISCUSSION

The findings of this study clearly demonstrate that lye pretreatment had a significant effect on both the recovery efficiency and the proximate composition of bentonite-bleached oil. The higher recovery observed in the 5% treatment ($75.17 \pm 3.00\%$) compared to the 10% treatment

($57.07 \pm 3.23\%$) suggests that moderate lye concentration enhances the effectiveness of pretreatment, likely by facilitating partial neutralization of free fatty acids without causing excessive loss of oil since optimal alkaline pretreatment improves extraction efficiency by promoting better separation and minimizing oil loss (Okoro *et al.*, 2022). Moreover, the lower percentage loss recorded in the 5% treatment is due to higher chemical load that can cause structural breakdown and loss of desirable oil components (Adebayo and Hassan, 2021).

Regarding the proximate composition, lye pretreatment resulted in substantial improvements in oil quality indices. The sharp reduction in acid value from 4.43 ± 0.11 mgKOH/g in raw oil to 0.18 ± 0.03 and 0.27 ± 0.03 mgKOH/g in the 5% and 10% treatments, respectively, shows effective neutralization of free fatty acids a primary function of alkaline pretreatment which has the role of reducing acidity and improving shelf stability of edible oils (Nwachukwu *et al.*, 2023). Similarly, peroxide values dropped significantly after pretreatment, indicating reduced oxidation and improved oxidative stability since the combination of alkaline pretreatment with adsorbent bleaching helps lower lipid peroxidation (Kazeem and Olagunju, 2021).

In the context of the study, the effect of lye pretreatment on the proximate composition of bentonite-bleached oil is particularly evident in the iodine and saponification values. The reduction in iodine value with increasing lye concentration suggests a decrease in unsaturation, likely due to partial modification or removal of unstable double-bonded compounds (Singh and Patel, 2020). The drastic drop in saponification value after treatment indicates notable changes in the molecular distribution of triglycerides because, pretreatment intensity can significantly alter oil structure during refining (Yusuf *et al.*, 2024). Therefore, the results show that lye pretreatment, combined with bentonite bleaching, effectively enhances oil quality by reducing

acidity, lowering oxidation, and modifying lipid composition, with the 5% treatment offering a more balanced improvement compared to the 10% level.

4.3CONCLUSION

The 75.17% oil recovery at 5% after 0.1 N lye-pretreatment was significantly higher compared to 10% bentonite bleaching raw palm oil. Bentonite bleaching improved the general quality attributes of the oil by significantly lowering the acid and peroxide values, while the saponification value indicated concentration of short-chain fatty acids after bleaching. Overall, bentonite bleaching could prolong the shelf life of palm oil by protecting against oxidative damage and food rancidity.

4.4RECOMMENDATIONS

Based on the results obtained from this study, the following recommendations are made:

- 1- Further studies should be conducted on the characterization of lye product of bentonite bleached palm oil.
- 2- Assessment of food quality of different sources of oil after bleaching with different bleaching agents

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