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ORIGINAL RESEARCH

REDUCTION OF FREE FATTY ACIDS IN PALM KERNEL OIL USING BAGASSE ADSORBENT OF VARYING MASSES

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Abstract

Palm kernel is an important oilseed found in the fruit of the oil palm plant. The kernel serves as the source of palm kernel oil (PKO) rich in vitamin K and has zero trans-fat and zero cholesterol. The quality of crude palm kernel oil is dependent on the content of free fatty acids, moisture, heavy metals, oxidized products, and minor constituents such as phosphatide. The free fatty acid (FFA) content, amongst other parameters, is considered a major determinant of the quality of palm kernel oil as higher contents can be detrimental to the flavor, color, stability, and safety of the oil. Hence, this present study aimed at exploring the possibility of using bagasse adsorbent (sugarcane residue) of varying masses of 1.0 g, 1.5 g, 2.0 g, and 2.5 g to reduce the free fatty acids in crude palm kernel oil. A standard test by AOCS was employed in determining the free fatty acids (%FFA) content in both the crude and bagasse treated palm kernel oil. The result of the use of bagasse adsorbent as free fatty acids reducing agent proved to be effective by reducing the FFA content of the crude palm kernel oil by 74%, 77%, 79%, and 82% for 1.0 g, 1.5 g, 2.0 g, and 2.5 g of bagasse adsorbent respectively. Therefore, the findings of this study advocate the use of bagasse adsorbent in reducing higher levels of FFA in crude palm kernel oil to its acceptable limit.

KEYWORDS:

Adsorbent, Bagasse, Free Fatty Acids, Palm Kernel Oil

1 | INTRODUCTION

Palm kernel oil, which is commonly referred to as tropical oil, is extracted from the nut or kernel of an African oil palm tree (Elaeis guineensis Jacq). Palm kernel oil primarily comprises fatty triglycerides, with approximately 80% saturated fats and 20% unsaturated fats [1]. It is considered the second most consumed lauric acid group oil and is sometimes called lauric oil because of its high lauric acid content [2]. Palm kernel oil is extensively used in both the food and non-food domains. In the food domain, it is used to prepare traditional dishes and as a constituent of food fats. In the non-food domain, its greater proportion of lauric acid gives the oil essential characteristics used in the industries for soaps, creams, emulsions, and cosmetic productions[3].

Bagasse is the residue from sugarcane after the juice is being extracted. The use of bagasse as an adsorbent is not common or apparent as an alternative natural FFA reducing agent. However, the structural constituent of bagasse, which is made up of carbon material, makes it suitable as an adsorbent. The use of bagasse adsorbent reduces solid waste disposal hence reducing one source of environmental pollution[4].

Free fatty acids (FFA) in palm kernel oil are released naturally in the oil palm fruit. It is produced due to enzymes activities in the fruits from which microbial lipases produce the kernel. It is also produced from the reaction of the oil and water during the storage process through hydrolysis of the triglycerides component[5]. The FFA content of crude palm kernel oil is used as an index of oil quality by commercial oil refiners, as it depicts the level of degradation of the oil[6]. Crude palm kernel oil with low FFA is an indication that the oil has been processed from fresh, unbruised fruits and carefully handled during production, storage, and transportation. High FFA content must be avoided, resulting in higher refining losses, potential health risks, and possible bleachability problems during refinery[7]. Hence, it is crucial to determine the FFA content in palm kernel oil and then reduce higher levels to the acceptable limit to produce oil products of high quality. Therefore, this present study seeks to determine the FFA content in crude palm kernel oil and explore the use of a natural bagasse adsorbent to reduce higher levels of FFA to the allowable limit. This research would help establish the prospect of the use of bagasse adsorbent in reducing the FFA content of palm kernel oil and determine the effectiveness of the adsorbent weight variation in the reduction process. The study's outcome would also provide data and information that will help consumers obtain quality palm kernel oil products with less FFA levels, thereby reducing the potential health hazards associated with the consumption of palm kernel oils of high FFA content.

2 | PREVIOUS RESEARCHES

Insufficient works have previously been done on the use of bagasse adsorbent to reduce free fatty acids in palm kernel oil. However, a related study by Wannahari and Nordin[4] on the recovery of used palm cooking oil using bagasse adsorbent established a decrease in FFA content by 82.1%, based on a 150 mL sample of used cooking oil at an effective treatment time of 60 minutes, and a 7.5 g effective weight of bagasse adsorbent. Other studies on activated carbon-based bio-adsorbent for reducing the free fatty acid number of cooking oil, including Rahayu et al.[8], have been conducted. In the study mentioned above by Rahayu et al.[8], bagasse bio-adsorbent was established to produce the lowest FFA value (0.24%) compared to coconut husk (0.28%) and pineapple dregs (0.34%) bio-adsorbents employed in the study. This present work appreciates these previous studies on the reduction of FFA of cooking oils with bagasse adsorbent. However, little or no data is available in the literature on that of palm kernel oil. And because palm kernel oil has been an integral part of human foods, as well as a base and active ingredient in the chemical industries, it is essential to explore the use of a natural adsorbent such as bagasse to reduce the FFA levels to an acceptable limit. This particular research is focused on treating palm kernel oil (of high FFA) with varying masses of 1.0 g, 1.5 g, 2.0 g, and 2.5 g of bagasse to reduce the FFA content and ascertain the effective mass of bagasse that will produce the best FFA reduction result.

3 | MATERIAL AND METHOD

3.1 | Study Design

This research appreciates the several means available to reduce FFA content in palm kernel oil. However, for this study, only bagasse as a natural alternative for FFA reduction was adopted. The study encompasses two key stages. Thus, determining the FFA content in crude palm kernel oil and treating the oil with varying masses of 1.0 g, 1.5 g, 2.0 g, and 2.5 g of bagasse adsorbent. The success of bagasse adsorbent in reducing FFA levels in palm kernel oil can be perceived by comparing the value of FFA in crude or untreated samples with that of bagasse-treated samples. A flowchart of the various stages involved in the study is shown in Figure 1 . The schematic representation of the stages illustrated in block diagrams of Figure 1 summarizes the specific activities undertaken to achieve this study's aim.

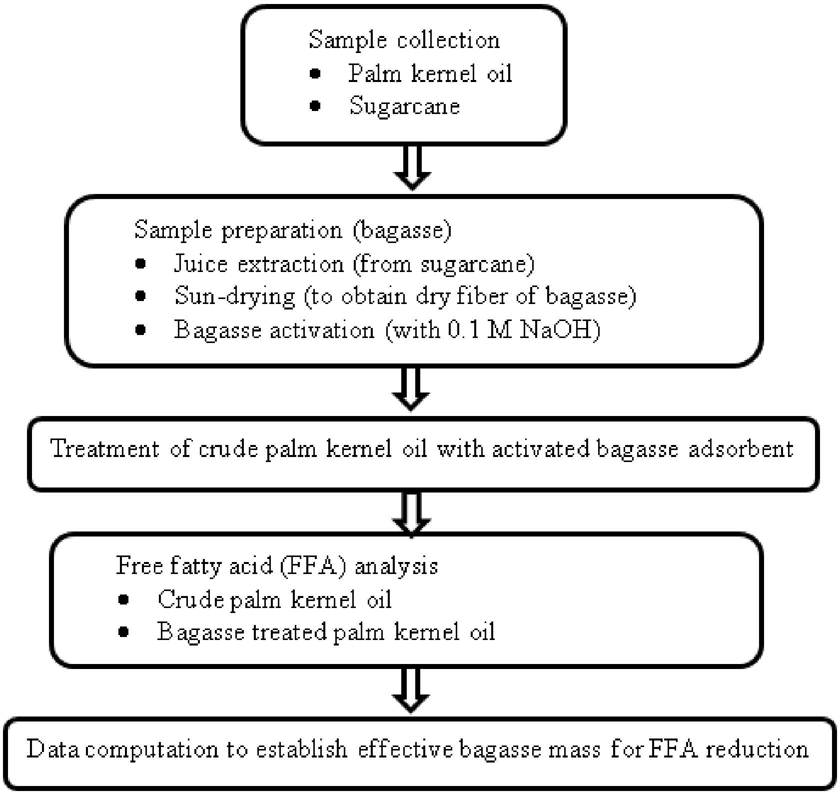

FIGURE 1 Flowchart illustrating the various stages of the research.

3.2 | Collection of Materials

Palm kernel oil and sugarcane samples were purchased from the Abura market in the Cape Coast metropolis in Ghana. Chemical laboratory support equipment and materials, including furnace, conical flasks, pipette, burette, hot plate, mortar and pestle, magnetic stirrer, weighing balance, thermometer, and Whatman filter paper, were obtained from the Chemistry Department, University of Cape Coast, Ghana. Reagents such as NaOH for bagasse activation and phenolphthalein indicator for FFA analysis were obtained from the Chemistry Department of the University of Cape Coast in Ghana.

3.3 | Preparation of Bagasse

A method by AOCS [9] was used to extract the juice from the sugarcane to obtain the fibrous material of bagasse. The sugarcane sample was cleaned and washed with distilled water. It was then placed in a shredder, which chopped the cane into smaller lengths and shredded it into finer pieces. The shredded cane was then passed through a crusher, which extracted the juice to obtain the fiber. The fiber was sun-dried for five hours for easy milling. The dried fiber was then milled into the powdery form using a miller and sifted to obtain finery and smooth powdery substance, as shown in Figure 2 . This figure depicts the whitish dry fiber of bagasse adsorbent obtained from the sugarcane sample, following extraction of the juice and subsequent sun-drying processes.

3.4 | Activation of Bagasse

The powdery bagasse obtained was heated at 200 °C for 120 minutes in a furnace. The heated bagasse was then mixed with 0.1 M NaOH and heated again for another 90 minutes using a hot plate. The mixture was filtered. The filtrate was discarded, and the residue was heated at 200 °C for 60 minutes. The dried residue was then ground using a mortar and a pestle to obtain the powdery substance Karami et al. [9], as shown in Figure 3 . This figure displays the brownish-colored fiber of bagasse after activation with 0.1 M sodium hydroxide solution.

FIGURE 2 Dry fiber of bagasse adsorbent from sugarcane before activation.

3.5 | Oil Treatment with Activated Bagasse

One gram (1.0 g) of the activated bagasse was weighed into a beaker, and 50 mL of palm kernel oil sample was measured into another beaker. The oil was heated at 110 °C for 10 minutes, and the 1.0 g of bagasse adsorbent was added. The mixture was stirred for 60 minutes using a magnetic stirrer and filtered first with a sieve and later with a filter paper to obtain clear oil. The above treatment procedure was repeated for the 1.5 g, 2.0 g, and 2.5 g of the activated bagasse adsorbent[9].

3.6 | Free Fatty Acid Analysis

Five grams (5 g) of crude palm kernel oil was weighed into a conical flask, and 50 mL of pre-neutralized ethanol was added. Afterward, three drops of phenolphthalein indicator were added to the mixture and titrated against 0.1 N of sodium hydroxide (NaOH) solution in a burette until a faint pink color persisted for 30 seconds, indicating the endpoint. The above procedure was repeated three times, and the average titer value was calculated, which was used to determine the FFA value in the crude palm kernel oil. The above-described technique was applied to the bagasse treated palm kernel oil samples, and their FFA contents were determined[9]. The FFA values for both the crude and bagasse treated samples were calculated and expressed as percentage oleic acid equivalent using equation one below;

$$\%FFA = \frac{V \times N \times 28.2}{M} \tag{1}$$

Where V is volume of titration solution (NaOH consumed) in mL; N is normality of titration solution (NaOH); M is mass of palm kernel oil (test portion) in grams; 28.2 is the molar mass of oleic acid divided by 10.

3.7 | Statistical Analysis

The data obtained after the experiment was analyzed with GraphPad Prism version 5.01, and the results were expressed as mean ± standard deviation. A one-way ANOVA using Tukey: compare all pairs of columns at 95% confidence level was used to compare mean values among the various masses of bagasse adsorbent. P-value less than 0.05 ($P<0.05$) was considered statistically significant.

FIGURE 3 An activated dry fiber of bagasse adsorbent from sugarcane.

TABLE 1 Free fatty acid values of crude (untreated) and bagasse treated palm kernel oil.

	Crude PKO	Bagasse Treated PKO				p-Value
		1.0g	1.5g	2.0g	2.5g	
FFA (%)	5.200±0.03	1.352±0.02a	1.196±0.01a	1.092±0.01a	0.936±0.02a	0.052
Δ(%)	-	3.848±0.01	4.004±0.02	4.108±0.02	4.264±0.01	-
% Reduction	-	74	77	79	82	-

4 | RESULTS AND DISCUSSION

The free fatty acid analysis is an extremely significant determination as it influences the overall product quality and trading of the palm kernel oil commodity. Crude palm kernel oil is commonly graded by its FFA content. Based on the 50 mL aliquot of palm kernel oil evaluated in this study, the percentage FFA for both the crude (untreated) and bagasse treated oil samples are presented in Table 1 and Figure 4 . Each FFA value is presented as mean ± standard deviation. Means in a row with the same letter superscript are not significantly different (P>0.05, Tukey's test). The difference in Free Fatty Acid Value Δis represented in percentage. From the results in Table 1 , the percentage FFA of the crude palm kernel oil was initially determined to be 5.200 ± 0.03. This value represents the oleic acid equivalent of the oil since oleic acid constitutes the major fatty acid (about 50%) in the composition of palm kernel oil.

According to the Codex Standard for Named Vegetable Oils[10] and the Malaysian Edible Oil Manufacturer's Association[11] specifications, the maximum standard for FFA (as lauric acid) in crude palm kernel oil is 5%. Based on this standard, the FFA content of the crude palm kernel oil determined in this study tumbles above the maximum 5%, making it crucial to reduce the FFA level to the allowable limit. Following the FFA determination of the crude palm kernel oil, 50 ml of the oil sample was treated with 1.0 g, 1.5g, 2.0 g, and 2.5 g varying masses of bagasse adsorbent for 60 minutes, aimed at reducing the FFA content of the crude palm kernel oil. From table 1, it could be observed that per any variation in treatment (changed in a mass of bagasse

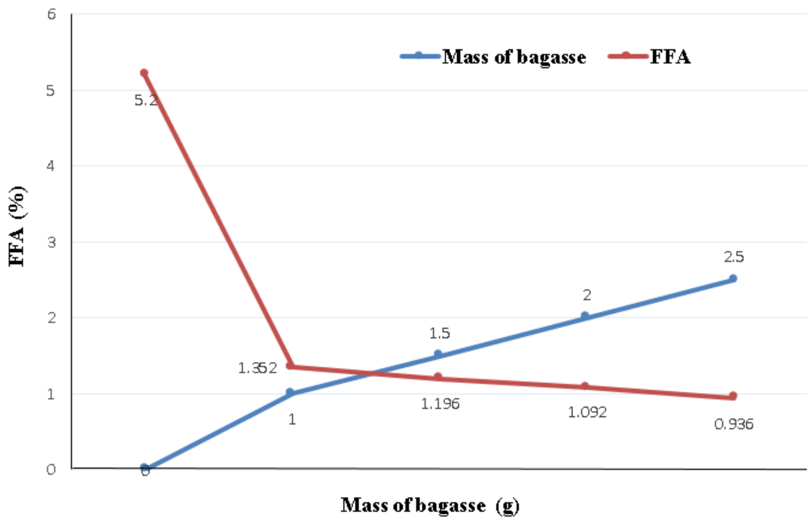

FIGURE 4 A line graph showing the effect of bagasse adsorbent on the FFA content of palm kernel oil.

adsorbent), there was a reduction in FFA value that differed according to the reduction capacity of the bagasse adsorbent based on the weight or mass of bagasse used in the treatment process. Thus, 1.0 g, 1.5 g, 2.0 g, and 2.5 g of bagasse adsorbent treatment on the 50 mL oil sample led to an FFA reduction by 74%, 77%, 79%, and 82%, respectively. The effective reduction of FFA for the study was achieved at a bagasse mass of 2.5 g with a percentage reduction of 82%. This result corroborates the 7.5 g effective weight of bagasse treatment, which produced an 82.1% reduction in FFA on a 150 mL sample of used cooking oil, as reported by Wannahari and Nordin[4]. Also, from Table 1 , no significant difference (P>0.05) in FFA value was observed among the various treatments, even though the FFA levels reduced exponentially with an increase in bagasse masses. With all the bagasse-treated oil samples, the %FFA fell within the acceptable and maximum standard of 5%, established by CODEX[10] and MEOMA[11], proving the weight or mass efficacy of the activated bagasse adsorbent in FFA reduction in palm kernel oil.

5 | CONCLUSION

The free fatty acid content in palm kernel oil is a major factor that indicates the level of degradation of the oil. A higher level of FFA causes off-flavors and reduces the stability of oil for use. Hence, using a natural bagasse adsorbent to reduce the FFA content of crude palm kernel oil (CPKO) was investigated. This study revealed an amount of FFA higher than the recommended 5% maximum in CPKO. With treatment of the CPKO with varying masses of bagasse adsorbent, the FFA contents were found to decrease appreciably, according to the weight of bagasse applied. Based on the 50 mL sample of palm kernel oil analyzed, the effective mass of bagasse in reducing FFA for 60 minutes was 2.5 g, with a reduction percentage of 82%. The findings of this research substantiate the potential use of bagasse adsorbent to reduce free fatty acids in palm kernel oil. However, optimization of this approach and the exploitation of other adsorbents, including bentonite clay and coal ash, should be evaluated in the future.

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CREDIT

Caleb MacCarthy: Conceptualization, Methodology, Writing-original draft preparation and supervision; Formal analysis and investigation; **Stephen Adusei:** Writing-review and editing.

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