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Assessing the Bleaching Potential of Activated Sawdust on Soyabean and Goya Olive Oils

*[1]Christianah Chinenye Aniobi , [1]Abimbola Deola Olanipekun, [1]Mobolaji Omiye Aduloju, [2]Oluseye Gbadebo Olasunkanmi, [1]Sunday Ayodele Alonge

[1]Department of Chemical Sciences, Bamidele Olumilua University of Education, Science and Technology, (BOUESTI), Ikere Ekiti, Ekiti State, Nigeria.

[2]Department of Chemistry, Federal University of Technology, Akure (FUTA), Ondo State, Nigeria.

Corresponding Author: aniobichigiveth4@gmail.com; aniobi.christiana@bouesti.edu.ng.

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ABSTRACT

The bleaching process is a crucial process in oil refining in which an adsorbent is majorly used to adsorb the unwanted colour pigments and a wide range of other impurities. This study aims to modify sawdust as an adsorbent and process it into powder form. Effects of three factors; temperature, mass and time, were investigated, while the experiment was performed using activation/carbonization, filtration, degumming, neutralization and bleaching methods. The adsorbent (sawdust) was prepared by chemical activation using phosphoric acid. Soyabean and goya olive oils were subjected to adsorption process utilizing the activated sawdust. The concentration of the adsorbent (activated sawdust), ranging from 0.5-3.0 g, enhanced the adsorption bleaching efficiency of the adsorbent. The absorbance and concentration of two neutralized oils were measured at 460 nm using ultra violet spectrophotometer. The values of equilibrium concentration, Ce/q_c, Langmuir constant (b), and slopes for soybean and goya olive oils were obtained from Langmuir isotherm equation: $Ce/Q_c = 1. Ce/Q^o + {}^{1/}bQ^o$; where Ce is the equilibrium concentration, Q_c is the % absorption, $1/Q^o$ is the slope, while Q^o is the adsorption capacity and b is the Langmuir constant. The data obtained were fitted into Langmuir isotherm thereby indicating a monolayer adsorption, where the adsorption capacity (Q^o) for goya olive and soyabean oils were 0.54 and 0.02. The percentage (%) absorption values of goya olive oil were 54.30, 43.60, 14.20, 11.60, 10.20, and 0.40 while that of soyabean oil were 44.00, 26.40, 22.40, 19.50, 5.40, and 1.80 respectively. The results showed that the adsorbent is effective with varying affinities for different oil types considered.

Keywords: Activated sawdust, bleaching, goya olive oil, soyabean oil

INTRODUCTION

Vegetable oils, such as soyabean and olive oils, require bleaching agents to remove impurities and improve colour during refining [1]. Conventional bleaching agents like activated carbon and diatomaceous earth are expensive and pose environmental concerns [2]. Adsorption bleaching using activated carbon and clay minerals may be employed [3]. Activated carbon is widely used for oil bleaching due to its high surface area and adsorption capacity [4]. However, its production from non-renewable sources contributes to environmental concerns [5]. Bamboo charcoal, a sustainable and affordable alternative, has been extensively utilized in various applications [6[. Agricultural waste materials, such as rice husk and coconut shell, have been explored as low-cost bleaching agents [7]. Sawdust, a readily available forestry waste, has shown adsorption potential [8]. Activation methods, such as chemical activation (acid treatment) and thermal activation (pyrolysis), can enhance sawdust's bleaching capacity [1,5].

Olive oil's quality, freshness, and economic value are crucial factors, particularly its free fatty acid (FFA) level [9]. Free fatty acids can cause oxidative degradation and malodorous smells, lowering oil quality [10]. Various techniques, including chemical refinement with sodium hydroxide and physical refining via distillation, can lower FFA levels [11]. However, these methods may result in loss of desirable non-glyceride components [9]. Likewise, charcoal adsorption capacity offers a chemical-free alternative [12]. While activated carbon has been extensively studied for oil bleaching, the potential of activated sawdust as a sustainable and efficient bleaching agent remains largely unexplored [13]. Therefore, this study aims to assess the bleaching potential of activated sawdust on soyabean and goya olive oils.

MATERIALS AND METHODS

Activation and Carbonization

Sample sawdust was collected from Emene sawmill in Enugu State, Nigeria, and crushed to pass through a 3 mm filter while being held in a 1.5 mm sieve with 537.87 g being the weight of the raw material sample. After weighing out 200 g of sawdust, 100 ml of 35% phosphoric acid was added. To ensure the activating ingredient works effectively, the mixture was thoroughly mixed with a glass rod and then left for 24 h. Then, the mixture was drained and dried in an oven between 60 – 80 ^{o}C for about 4 h. The sample was carbonized using muffle furnace at a temperature of about 500 ^{o}C for 2 h. The sample was cooled and washed with distilled water until the pH of the water washed out becomes nearly neutral. The sample was dried at 105 ^oC for 4 h and stored in an air tight container for 24 h. Thereafter, it was pounded and sieved again to obtain fine particles for adsorption purposes [14].

Filtration

After diluting the sawdust with distilled water, it was filtered using a filter paper. The amount of acidity or alkalinity in the filtrate was measured using pH meter. This filtration process was repeated for more six times until the pH level of 5-6 was attained. Then, the leftover activated carbon was placed in a drying pan, and baked in an oven at 105 ^oC for 4 h [15].

Absorption

To observe variations in their absorbance, the sawdust activated carbon was put through the absorption procedure. In each instance, six distinct grams 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 g were absorbed in relation to 10 ml of the effluent [16].

Degumming

About 500 ml of goya olive and soyabean oils in 100 ^oC of hot water were used for degumming. The procedure was continued until clear water was visible beneath the oil layer in the separating funnel [17].

Neutralization

After neutralizing 60% of the degummed goya olive and soybean oils independently for about ten minutes at 80 ^oC, 10 ml of 0.1 M NaOH and 6 g of NaCl were added to the oils. As soon as NaOH is added to the oil, the formation of soap started. In order to remove the soap from the oils, hot water was added. This procedure was continued until the oils were free of soap [18].

Bleaching

Measured amounts of activated carbon (0.5, 1.0, 1.5, 2.0, 2.5, and 3.0) g were added to 10 ml of the neutralized oils and thoroughly mixed. The mixture was put into a beaker and heated for 30 min. Cotton wool was used to filter the oil into a conical flask after it had been heated [19].

Spectrophotometry analysis

A spectrophotometer is a tool used to measure a sample's absorbance and concentration. After pouring the oil samples (goya olive and soybean oils) into a 5 cm cuvette and adding buffer solution to a second cuvette, the UV spectrophotometer was turned on and left for approximately half an hour before being used. The absorbance and concentration of the two oil samples were measured after 30 min. The reading code was changed to 10% after the oil samples and buffer solution (acetone) were added to the cuvette. Waterproof material was then used to cover the cuvette to keep off light from penetrating into the oils. At that point, the water-resistant substance was eliminated and the reading code was changed to 0%. The mode was turned on to read the concentration, and the handle of the UV spectrophotometer was raised to read the absorbance [20].

Percentage absorption of soyabean and goya olive oils using activated sawdust

The formula, $qc = 100(\frac{C_{o-}C_e}{C_o})$, was used to calculate the percentage absorption for the two oil samples (goya olive and soyabean oils), where Co and Ce represent absorption prior to adsorption and absorption after adsorption respectively. As a result, the percentage absorption for the two oil samples adsorbed by activated sawdust was determined and recorded as presented in Tables 1-3.

RESULTS AND DISCUSSION

Tables 1-2 and Figures 1-2 depict the results of absorbance, percentage absorption, and concentration of goya olive and soya bean oils adsorbed by activated carbon made from sawdust. As shown in both tables and figures, the absorbance and concentration of both oils decreased with increasing adsorbent weight, indicating an effective bleaching. Goya olive oil showed lower absorbance and concentration values than soyabean oil thereby suggesting a stronger affinity for the adsorbent. This implies that the absorbance and concentration values in goya olive oil decrease as the adsorbent weight increases (0.33 at 3.0 g to 0.69 at 0.5 g). Also, the activated sawdust is effective in removing colour and impurities from goya olive oil with more significant removal at higher adsorbent weight. However; in soyabean oil, the absorbance and concentration values which also decreased as the adsorbent weight increases (0.43 at 3.0 g to 0.76 at 0.5 g) are higher than those of goya olive oil at corresponding adsorbent weights, thereby indicating that soyabean oil has more color or impurities. Therefore, the small decrease in absorbance values for soyabean oil suggest that the activated sawdust is less effective in removing color and impurities from soyabean oil compared to goya olive oil.

The value of adsorption capacity (Q^o) obtained for goya olive oil is higher than the value obtained for soyabean oil as shown in Table 3 and Figure 3, indicating a stronger binding affinity. The higher adsorption capacity indicates that the activated sawdust is more effective in removing impurities and colorants from goya olive oil while lower adsorption capacity indicates that the activated sawdust is less effective in removing impurities and colorants from soyabean oil. This is plausible due to the oils' chemical composition, molecular size or polarity, which reduces interactions with activated sawdust. As a result, goya olive oil may require less activated sawdust or processing time to achieve desired bleaching levels while soyabean oil may require more activated carbon or processing time to achieve desired bleaching levels.

The Langmuir isotherm equation used fitted the data well, indicating monolayer adsorption. This study is also related to other studies investigated [21, 22]. The adsorption capacity (Q^o) value of 0.54 obtained for goya olive oil in this study is higher than that reported by Gielen et al [21] for soyabean oil with adsorption capacity value of 0.30. However; it is lower than that obtained by Marcia et al [22] for coconut oil with adsorption capacity value of 0.60. Furthermore; the Langmuir constant (b) value of 0.01 for goya olive oil is lower than that reported by Oliveira et al [23] for olive oil with value of 0.05 thereby indicating a weaker affinity however, the value of 0.70 for soyabean oil is higher than that reported byGielen et al [21] for soyabean oil with value of 0.15 indicating a stronger affinity.

Table 1 depicts the results of absorbance, concentration and percentage absorption obtained for goya olive and soya bean oils while Figure 1 represents the plot of adsorbent concentration/% absorption versus adsorbent concentration respectively.

Table 1: Absorbance, concentration and percentage absorption of goya olive and soya bean oils for activated carbon produced from sawdust.

Weight of adsorbent (g)	Goya olive oil			Soya bean oil		
	Absorbance	Conc. (mg/L)	% Absorption	Absorbance	Conc. (mg/L)	% Absorption
3.0	0.33	33.10	54.30	0.43	43.40	44.00
2.5	0.41	40.90	43.60	0.57	51.10	26.40

2.0	0.62	62.20	14.20	0.60	60.20	22.40
1.5	0.64	64.10	11.60	0.62	62.40	19.50
1.0	0.65	65.10	10.20	0.73	73.40	5.40
0.5	0.69	69.20	0.40	0.76	76.20	1.80

Table 2 depicts the results of adsorbent concentration/% absorption of goya olive and soyabean oils respectively.

Table 2: Adsorbent concentration/% absorption (Ce/qc).

Activated Sawdust	
Goya olive oil	Soyabean oil
0.055	0.068
0.057	0.095
0.141	0.089
0.129	0.077
0.098	0.185
1.250	0.278

Table 3 indicates the results of slope, intercept and Langmuir constant (b) obtained for goya olive and soyabean oils respectively.

Table 3: Table of values obtained from Slope, Intercept, and Langmuir constant (b) for goya olive oil and soya bean oil adsorbed by activated sawdust.

Samples of oil	Slope ($1/Q^0$)	Intercept ($1/bQ^o$)	b (Langmuir constant)
Goya olive oil	0.54	0.006	0.01
Soya bean oil	0.02	0.014	0.70

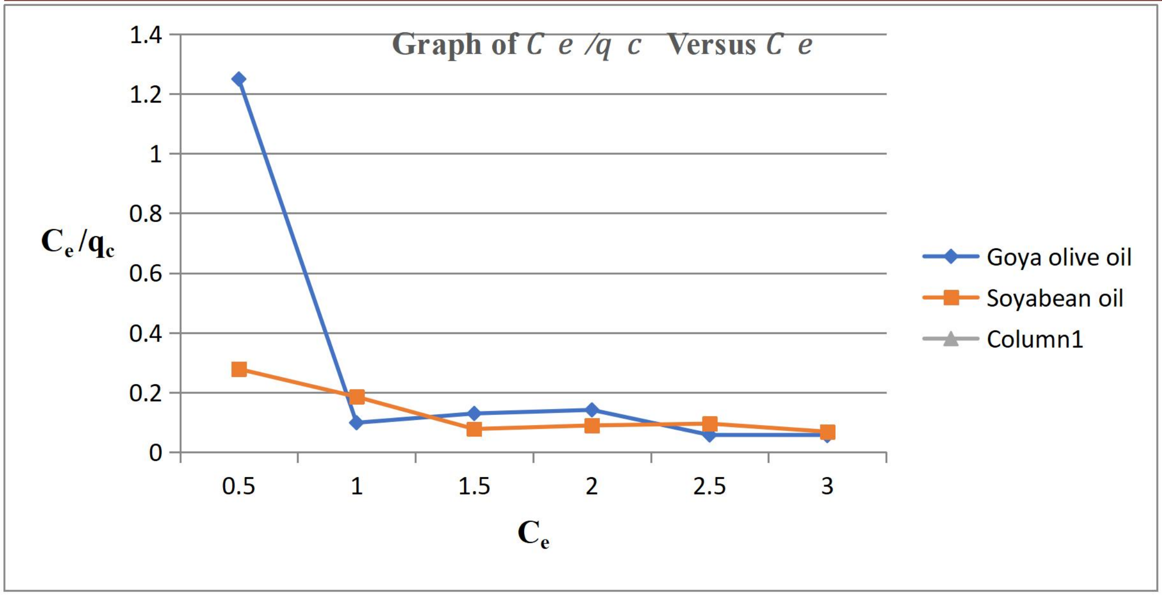

Figure 1: Graph of adsorbent concentration/% absorption versus adsorbent concentration (C_e/q_c versus C_e) for goya olive oil and soya bean oil adsorbed by activated sawdust using Langmuir equation; $C_e/q_c = 1.C_e/Q^o + 1/bQ^o$.

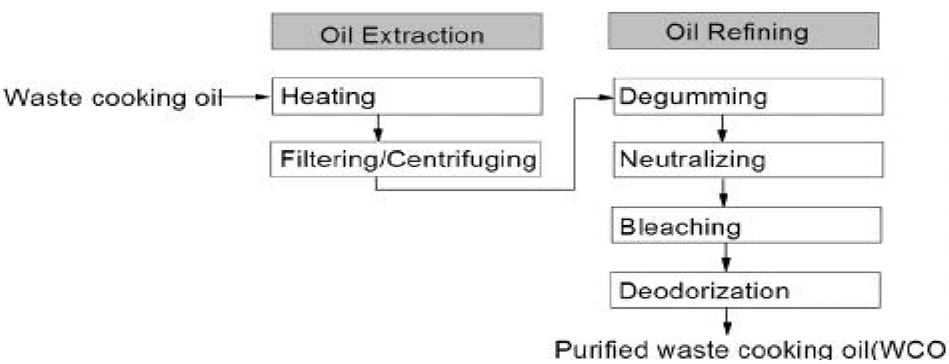

Figure 2: Representation of steps involved in refining edible oil

CONCLUSION

This study investigated the bleaching potential of activated sawdust on goya olive and soyabean oils. The results indicate that the adsorbent is effective with varying affinities for the different oil types considered. The Langmuir isotherm model can be used to predict adsorption behavior. Further research can explore the adsorbent's potential for industrial-scale applications.

RECOMMENDATIONS

The reusability of the adsorbent and regeneration potential should be investigated while exploring the effects of different activation methods and conditions on adsorbent performance. In addition, pilot studies to assess the feasibility of industrial-scale applications should be conducted as well as investigation of the adsorbent potential for bleaching other types of edible oils.

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