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COMPARATIVE STUDY OF BLEACHING EFFECTIVENESS OF ACTIVATED CARBON PRODUCED FROM NATURAL COAL ON PALM OIL AND SOYABEAN OIL

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Abstract

Bleaching of edible oils by adsorption involves selective adsorption of pigments from oils and fats on clay or carbon specifically chosen and activated for specific effects. The essence of this study is to establish the optimum condition necessary for producing activated carbon from natural coal and preparation as regards temperature and time. Activation of carbon is the process of treating the carbon to open an enormous number of pores in the 1.2-20nanometer diameter range. Chemical activation was preferably used due to its shorter production time and lower temperature required to produce activated carbon. During chemical activation, the source material is impregnated with certain chemicals typically an acid, a strong base or a salt (phosphoric acid, potassium hydroxide, calcium chloride and zinc chloride) such that the raw material is carbonized at a low temperature, usually $450^0{}_C – 900^0{}_C$. This process results in a very large surface area that is about 600-1200 square feet per grams depending on the source material.Natural coal was carbonized and activated to obtain a high degree of degummed and less resinous oils and oils freed from impurities. The experiment was carried out in a furnace that could be heated up to 500^0C after the natural coal has been dried. The natural coal was subjected to chemical activation such that it was weighed and mixed with 100mls of 35% phosphoric acid in an oven operating between 60^0C-80^0C for about 14400secs. Adsorption was carried out on palm oil and soyabean oil using activated carbon produced from natural coal. The absorbance and concentration of the two samples of neutralized oils were measured using a UV spectrophotometer at a wavelength of 460nm. The results obtained as %absorption for palm oil are 31.20, 30.90, 30.80, 29.30, 20.20 and 09.50 while the % absorption for soya bean oil are 86.90, 85.90, 86.90, 79.70, 78.40 and 29.60 respectively. Conclusively; according to this research work, it was recorded that activated coal is more effective in bleaching palm oil than it does on soya bean oil.

Keywords: Activated carbon, bleaching effectiveness, natural coal, palm oil, soyabean oil

I. Introduction

Adsorption-based bleaching of edible oils comprises the selective adsorption of colors from fats and oils onto clay or carbon that has been specially selected and activated for a desired outcome. Along with the color, minor components are also eliminated during bleaching. Peroxides are broken down and eliminated, soap residues and a small amount of Cu and Fe are removed, phospholipid residues are partially hydrolyzed, and the resistance of oil to rancidity is lowered **[1, 2, 3]**. In the production of vegetable oils, carbonaceous materials like fruit stones, apricot pits, and walnut shells are used either as a small component or ready-made mixture with bleaching clays where the carbon content does not exceed 5–10% of the clay's weight, or by bleaching with activated carbon first **[2]**. Carbon is utilized in addition to clay because it is highly selective to phospholipids, freeing up the clay's adsorption sites for the adsorption of pigments **[4]**. Additionally, activated clays are not as effective at adsorbing polycyclic aromatic hydrocarbons as active carbon **[2]**. However, the charcoal or carbon employed in this study was derived from natural coal using the carbonization method, even though other materials such nutshells, fruit stones, etc. are also extremely suitable. Because it contains fatty acids, palm oil is one of the many kinds of vegetable oils that are classified as lipids. The majority of fats have some coloring, either naturally occurring or from processing-induced discoloration. The carotenoid, which gives colors like yellow and red, and the chlorophyll, which gives colors like green, are the principal naturally occurring pigments found in vegetable oils. The extraction process can also result in color degradation, particularly when using the regional extraction technique that is employed in the majority of the eastern portions of Nigeria. Due to its outstanding taste, extended shelf life, and good stability at high temperatures, palm oil is the most widely used vegetable oil in the world **[6]**. A critical step in the refinement of palm oil is bleaching. After the degumming or neutralization phase, it is completed. This stage involves the removal of pollutants like free fatty acids (FFAS), phosphatides, heavy metals, oxidized products, and color pigments **[6]**. Bleaching is required not only because fat with a light color conveys a sense of purity, but also because the color of the fat can affect how food will look when it is cooked and, more importantly, because the pigment it contains can affect the flavor and stability of the fat and the food it is used to make. Decolorization or bleaching can be accomplished using adsorption techniques, heat treatment, or chemical activation. This study compared the efficiency of activated carbon derived from natural coal in bleaching palm oil and soyabean oil via Langmuir adsorption isotherm (model).

2.0. Materials And Methodology

2.1. Carbonization (Activation process)

The sample (natural coal) which was obtained from the coal site at Emene in Enugu State was grounded to pass through 3mm sieve and was retained in 1.5mm sieve. The raw material sample was weighed to be 537.87g. 200g of natural coal was weighed out and mixed with 100mls of 35% phosphoric acid. The mixture was stirred using a glass rod to mix well and left for 86400secs for the activating agent to work properly. At the end of 86400secs the mixture were drained and dried in an operating between 60^{o}C-80^{0}C for about 4hrs.The sample was carbonized using muffle furnace at a temperature of about 500^{o}C (7200secs). The sample was allowed to cool and washed with distilled water until the P^{H} of the water washed out becomes neutral or nearly neutral. The sample was dried at 105^{o}C for 14400secs and they are stored in an air tight container for 86400secs thereafter, it was pounded and sieved again to obtain fine particles for adsorption purposes. In a nut shell, the activation process was carried out to open up the pore structure that will bring about large surface area responsible for adsorption phenomenon and carbonization process is to covert the organic matter into elemental carbon that is, the driving off non-carbon portion in order to obtain carbon that can aid adsorption. Adsorption

2.2. Filtration Process

The sample (natural coal) was diluted with distilled water and hence filtered by means of filter paper. The filtrate was tested by means of litmus paper to determine the level of its acidity or alkalinity. This filtration process was repeated for more six times until P^{H} level of 5-6 was attained. Thus; the activated carbon residue was collected and emptied on a dried pan and was taken to an oven to dry at 105^{o}C for 14400secs.

2.3. Absorption process

The activated carbon from natural coal was subjected into absorption process separately to see the differences in their absorbance. Six different grams of 0.5, 1, 1.5, 2, 2.5, and 3 were absorbed against 10cm^{3} of the affluent in each case.

2.4. Degumming

Degumming was done with 500cm^{3} of oil (palm oil and soya bean oil respectively) and hot water at 100^{o}C thus; hot water was poured into the oil and the process was repeated until clear water was observed below oil layer in the separating funnel.

2.5. Neutralization

60% of degummed oils (palm oil and soyabean oil) were neutralized separately at 80^{0}C at about 600secs, then; 10cm^{3} of 0.l M NaOH was added into the oils followed by 6g NaCl. It catalyses immediately the NaOH is poured into the oil such that soap is formed (triglyceride). Hot water was poured again into the oils to wash off the soap thus; this process was repeated until soap –free oils were obtained.

2.6. Bleaching process

0.5g, 1.0g, 1.5g, 2.0g, 2.5g, and 3.0g of activated carbon respectively were measured and were poured into 10cm^{3} of the neutralized oils and were stirred very well then; poured into the beaker and boiled for 1800secs (the essence of the activated carbon was to adsorb the oil pigment). After heating, the oil was filtered into a conical flask using cotton wool.

2.7. Readings using Ultra Violet (UV) spectrophotometer

UV spectrophotometer is an instrument for recording the absorbance and concentration of a sample. The oils (palm oil and soyabean oil) were poured into covet (5cm) then; buffer solution was poured into another covet therefore; the UV spectrophotometer was switched on and allowed to stay for about 1800secs before usage. After 1800secs; the absorbance and the concentration of the two oil samples were taken. This was done after adding the oil samples and the buffer solution (Acetone) into the covett thus; the reading code was adjusted to 10%, such that water proof material was used to cover the covet in order to prevent light from transmitting into the oil samples. The reading code was adjusted to 0% then; the water proof material was removed. The UV spectrophotometer's handle was raised in order to read the absorbance while the mode was switched on to read the concentration.

2.8. Adsorption Isotherm and Langmuir Equation

Adsorption is the concentration of a fluid component (gas or liquid phase) onto the surface of a solid while adsorption capacity is the accumulation of the solute molecules at the surface of a solid. The adsorption capacity of the oil samples used in this research was predicted using Langmuir isotherm thus; adsorption isotherm is a graph that represents the variation in the amount of adsorbate adsorbed on the surface of the adsorbent with the change in pressure at a constant temperature. Langmuir isotherm equation is given as $\mathbf{C_e/Q_c = 1.Ce/Q^o + 1/bQ^o}$, where Ce = equilibrium concentration, Q_c = percent absorption, $1/Q^o$ = slope, Q^o = adsorption capacity, and b = Langmuir constant.

2.9.0. Analysis

2.9.1. Percentage Absorption of palm oil and soya bean oil using activated coal

The % absorption for the two samples of oil (palm oil and soyabean oil) were calculated using the formula; $qc = C_o - C_e / C_o X 100/1$, where C_o and C_e are absorption before adsorption and absorption after adsorption thus; the % absorption for palm oil and soya bean oil adsorbed by activated coal were calculated and recorded in table 1, 2 and 3 respectively.

3.0. Results and Discussion

The table 1 below shows the result of absorbance, %absorption and concentration of palm oil and soya bean oil adsorbed by activated carbon produced from natural coal (activated coal) using UV spectrophotometer thus; the lower the weight of concentration, the higher the absorbance while results from table 2showed the values of weight of concentration/%absorption for palm oil and soyabean oil and results from table 3showed that activated carbon produced from natural coal has higher adsorption capacity on palm oil than on soyabean oil.

Table 1: Table of results for activated carbon produced from natural coal.

Wt of Conc. Of	**Palm oil**	**Soya bean oil**

adsorbents (g)						
	Absorbance	Conc.(g/cm^3)	% Absorption	Absorbance	Conc. ((g/cm^3)	% Absorption
3.0	2.99	0.03	31.20	0.10	0.01	86.90
2.5	3.01	0.03	30.90	0.11	0.01	85.90
2.0	3.02	0.02	30.80	0.10	0.01	86.90
1.5	3.07	0.03	29.50	0.16	0.02	79.70
1.0	3.48	0.03	20.20	0.17	0.02	78.40
0.5	3.94	0.04	09.50	0.55	0.05	29.60

Table 2: Table of values obtained from weight of concentration/% absorption (Ce/qc).

Activated Coal	
Palm oil	**Soyabean oil**
0.096	0.035
0.081	0.029
0.065	0.023
0.051	0.019
0.050	0.013
0.053	0.017

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

Samples of oil	**Slope (1/Q^0)**	**Intercept (1/bQ^o)**	**b (Langmuir constant)**
Palm oil	0.02	0.030	1.5
Soya bean oil	0.01	0.004	0.4

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

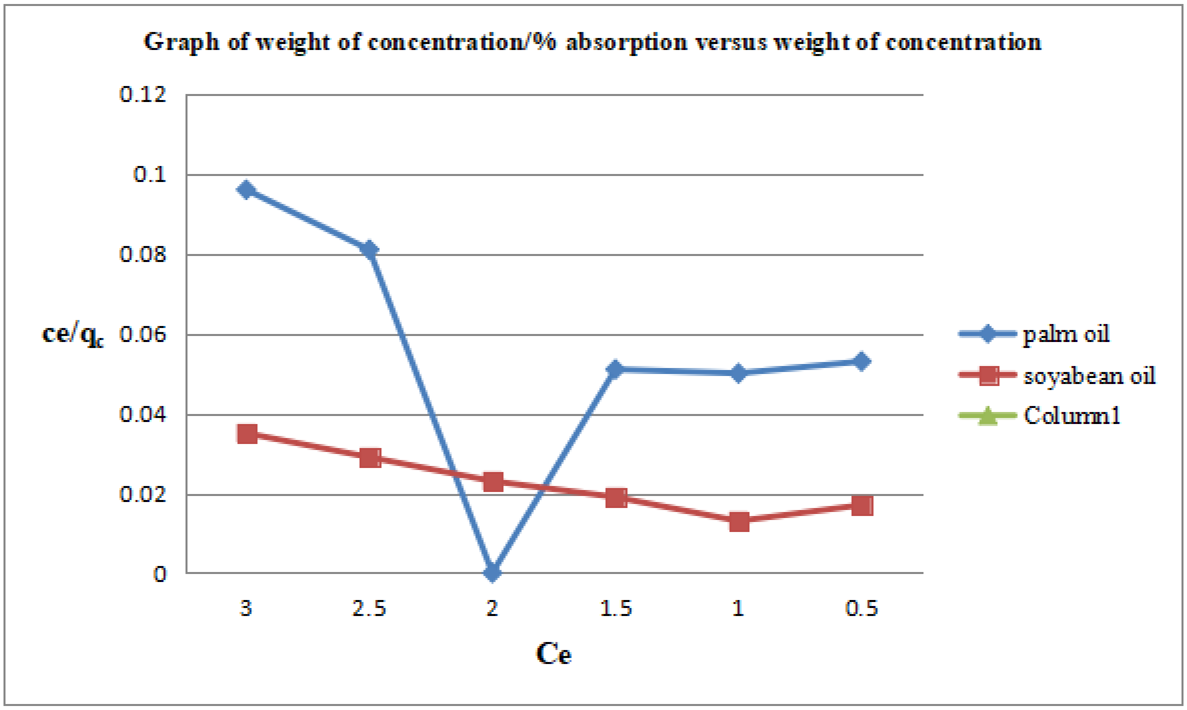
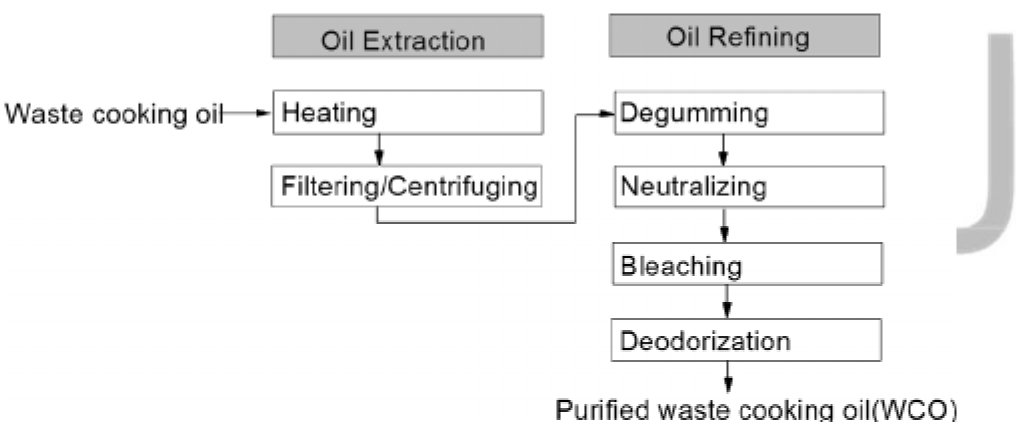


Figure 2: Diagrammatical representation of steps involved in refining edible oil



Conclusions

This research study confirmed the usefulness of activated coal in bleaching palm oil and soya bean oil. Also, from the table of results and graph shown, it was discovered that palm oil has higher adsorption capacity than soyabean oil which is also an indication that palm oil has higher percentage of purity than soyabean oil thus; activated coal is more effective in bleaching palm oil than it does on soya bean oil.

Recommendation

More experimental work should be carried out on the rate of adsorption of palm oil and soyabean oil using activated carbon produced from other carbonaceous materials.

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