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KINETICS STUDIES OF GROUNDNUT OIL BLEACHING USING ACTIVATED CLAY AS ADSORBENT

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ABSTRACT
Kinetic study of the bleaching of crude groundnut oil was carried out using activated clay as the adsorbent to determine its suitability as an adsorbent for the bleaching process. It involved the study of the bleaching process as a refining process to eliminate and reduce unwanted minor components present in crude groundnut oil extracted from seeds through extraction process. The study estimated the effect of time, adsorbent concentration and temperature on the efficiency of the bleaching process. The bleaching efficiency improved with adsorbent concentration and temperature, with time not affecting the process like other parameters. Efficiency of bleaching was estimated by measuring the absorbance using a double-beam spectrophotometer at a wavelength of 450 nm. Using the Association of Analytical Chemists 1990 the physiochemical properties of crude and bleached oil was determined. At optimum conditions of 100^oC temperature, reaction time of 30 mins and 6 % adsorbent dosage concentration. The acid value, free fatty acid content, saponification value and specific gravity all reduced from, 5.61 mgKOH/g to 3.93 mgKOH/g, 2.81% to 1.97%, 216.5 mgKOH/g to 190.2 mgKOH/g and 0.916 to 0.914 respectively whereas pH remained the same. The kinetics of the bleaching process was best described with the pseudo first order isotherm. Freundlich isotherms was more suitable in the description of the bleaching process due to its relatively high linearity and efficiency of adsorption in the liquid phase. With a rate constant of 0.82, it can be concluded that activated clay is a suitable adsorbent for rapid adsorption of materials from crude groundnut oil. From the result, it can be concluded that activated clay is a suitable adsorbent for the bleaching process and bleaching as a refining process is essential to improve oil quality and shelf life of edible oil.
Keywords: *Bleaching. Isotherm, Clay.*

INTRODUCTION
Seeds are the major sources of protein and oil, the oil gotten from these seeds contains free fatty acid, glycerides, and unsaponifiable lipids making the oil edible or non-edible depending on the composition of these substances in the oil. Crude vegetable oil gotten from seed needs to be refined to make it edible. Edible vegetable oil are sourced from seeds which explains their relevance in human diet (Grieshop *et al*., 2001 and Odoemelan, 2005). The major aim of refining crude vegetable oil is to remove and reduce irrelevant materials such as; free fatty acid, phospholipids, peroxides, pigments, moisture content, making it edible with an improved shelf life and commercial superiority (Ceriani *et al*., 2008).

Bleaching of crude oil has been a necessary process involved in the refining of edible vegetable oil as it affects the appearance of oil and its triglyceride performance. For the refining of crude oil, which involves the stabilization, purification and decolourisation of oil, bleaching is a necessary process. Bleaching could be done either by heat treatment or by adsorption method. Heat treatment of oil is a process in which oil is heated at a very high temperature until a colour change is achieved. Adsorption method which is the most common method of bleaching involves the mixing of oil with common adsorbent like activated clay, fuller's earth, ash etc. and heating of the resulting mixture at a temperature of about 90 to 120^oC after which filtration is carried out to recover oil (Okolo and Adejumo, 2014).

Adsorption can be defined as the movement of adsorbate molecules from the bulk of the material to the surface of the adsorbent forming a separate phase. Two types of adsorption exist in relation to the surface of the adsorbent. For the first type the force existing is relatively weak and physical in nature. This type of adsorption is defined by van der waals forces and heat evolved during adsorption is less than 20 KJmol^{-1}, this type of adsorption is known as physical adsorption. In the second type, covalent forces like those between atoms are formed during adsorption. It is thus called chemisorption and heat evolved in the range of 300-500 kJmol^{-1}(Egbuna, 2014 and Topallar, 1998). Adsorption is a common process in the industry and has its application in ion exchange, wastewater treatment, dye removal, activated clay and activated carbon adsorption (Egbuna, 2014).

Adsorption bleaching process using locally sourced adsorbent is a viable cost effective means of oil bleaching. Mustapha *et al.* (2013) compared the effectiveness of some locally sourced adsorbents with that of a commercial adsorbent and reported a bleaching efficiency greater than 90% for both adsorbents. Activated clay, activated carbon and silica gel are important adsorbents utilized in the refining process of edible oil. Activated clay is the most common adsorbent when compared to the other materials due to its cheapness and availability. Acid activation of clay is a crucial process carried out which is aimed at structurally modifying the clay for bleaching of edible oils. When compared to natural clay, activated clays showed a higher bleaching capability (Motlagh *et al.*, 2008, 2011). Bleaching of edible oil by acid activated clay is an important process used to remove colour pigments that reduce the quality of oil (Sabah *et al*., 2007).

Adsorption isotherm which studies the equilibrium relationship between the partitions of concentration of pigments in the solid phase (adsorbent) to concentration in the liquid phase (oil) at a particular temperature describes the adsorption process at equilibrium (Nwabuene and Ekwu, 2013; Mohagir *et al.*, 2014). The Freudlinch and Langmuir adsorption isotherms are used to describe the adsorption of crude vegetable oil using activated clay. The Langmuir isotherm is based on the assumption that the adsorption process takes place on a uniform surface while the Freundlich isotherm generally describes adsorption processes in the liquid phase (Rohani, 2006).

MATERIALS AND METHODS

Materials

Natural clay was sourced from Gidankwano village, Bida Local Government Area, Niger state, Nigeria; screened to a particle size of 500 µm. The clay was then washed with distilled water, until a solution with fewer residues was obtained. The washed clay was sundried for 20 hours. The clay was oven (Genlab N30 C Lab Oven) dried for 4 hours. Set at a temperature of 105^{o}C.

All reagents used for the various analysis were of adequate analytical grade (Sigma Aldrich, 96-98% Conc. HCl).

Methods

Activation of prepared clay

Using a weighing balance (BL2008A Cyber lab) 200 g of clay was measures and placed in a 500 ml beaker. Dilutedhydrochloric acid (250 ml of 1 M) was added into the beaker to activate the sites of the clay. The resulting mixture was allowed to stand for One hour thirty minutes at room temperature. The acid treated clay was then washed, with 500 ml volume of distilled water, and the pH of the solution was measured using a pH meter, to make sure the sample was neutral in pH, this process was repeated until a neutral pH was obtained. The neutral activated clay was air dried, for 30 mins, afterward the clay was oven dried at 110^{o}C for 4hrs. The dried activated clay was sieved using a 500 µm mesh and stored in an air-tight container.

Degumming of crude groundnut oil

Crude groundnut oil in a 500 ml conical flask was placed in a thermostat water bath shaker with the temperature set at 85^{o}C. Two (2) ml of phosphoric acid was added to 500ml of crude groundnut oil to hydrate the non-hydratable phosphatides the mixture was stirred for 10mins this allows for complete acid degumming. This allows for complete acid degumming. About 8 ml of water was added to the hot acid oil mixture separated into layers to aid the separation of the hydratable gums and crude groundnut oil giving a gum free oil. (FSSAI, 2012)

Neutralisation of degummed groundnut oil

Degummed groundnut oil was neutralised by alkaline refining: 10 ml of 0.1 M NaOH was added to 200 g of oil in a 250 ml beaker, the resulting mixture was stirred on a magnetic stirrer for 20 mins, and then filtered using a filter paper (11 µm) after settling at room temperature. (FSSAI, 2012). Equation (2) describes the chemical equation for the neutralization reaction.

Characterisation of groundnut oil

Analysis of groundnut oil was carried out using the official method of American oil chemist society (AOAC, 1990) for analysis and the manual methods of analysis of foods (fats and oil) by the food safety and standards authority of India (FSSAI, 2012).

Acid value determination

The acid value of groundnut oil (both refined and crude), was determined using the method as described by (FSSAI, 2012):one gram (1 g) of the oil sample was measured into a 250 ml conical flask and 50 ml of hot neutralised solvent was added. Three (3) drops of phenolphthalein was added to the mixture. The content of the conical flask was titrated against 0.5 M KOH to the point in which a lasting (about 15 to 30 seconds) pink colouration was obtained. Acid value was determined using Equation (1).

$$\text{Acid value} = \frac{56.1 \times C \times V}{W} \quad (1)$$

Where: 56.1 is the molar mass of potassium hydroxide (KOH)

C *is the concentration of the strong base KOH*

V *is the volume at end point (titre value)*

W *is the measured weight of the oil sample*

Free fatty acid value (oleic acid content) determination

This is estimated as the value of oleic acid ($C_{17}H_{33}COOH$) present in a groundnut oil sample (Daniewski *et al.*, 2003). The percentage free fatty acid value (% FFA) is determined experimentally using the Association of Analytical Chemists AOAC official method (AOAC, 1990): One gram (1 g) of the oil sample was measured into a 500 ml beaker, and 50 ml of hot neutralised solvent was added. Three (3) drops of phenolphthalein was added to the mixture. The content of the beaker was titrated against 0.5 M KOH, the titre volume was obtained when permanent pink colouration was obtained in the beaker. Free fatty acid value was determined using Equation (3).

$$C_{17}H_{33}COOH + KOH \rightarrow C_{17}H_{33}COOK + H_2O \quad (2)$$

Chemical equation that describes the neutralisation reaction of the free fatty acid content against a strong base

$$\%\ \text{FFA} = \frac{28.2 \times C \times V}{W} \quad (3)$$

Where: 28.2 is the equivalent weight of $C_{17}H_{33}COOH$ (oleic acid)

C *is theconcentration of the alkali KOH*

V *is the titre volume*

W *is the weight of the oil sample*

Saponification value determination

Saponification value was determined asdescribed by (AOAC, 1990). Five grams (5 g) of oil sample (crude and bleached), was weighed into a 150 ml conical flask. Twenty-five (25) ml of alcoholic potassium hydroxide was added to the oil sample using a pipette. Twodrops of phenolphthalein indicator were added to the mixture in the conical flask. The content was heated with a water bath with intermittent shaking and then titrated against 0.5 M HCl until the pink colouration present in the mixture disappeared. This process was repeated for a blank. Saponification value was determined using Equation (4).

Saponification value = $\frac{56.1 \times (B-S) \times C}{W}$ (4)

Where: B *is the titre volume (volume of HCl) required for the blank determination*
S *is the titre volume for a particular oil sample*
C *is the concentration of HCl*
W *is the oil sample weight*

Specific gravity

The specific gravity of oil samples (refined and crude) was determined using a pycnometer. . An empty pycnometer was weighed and recorded. Pycnometer consequently it was filled with distilled water at room temperature to overflowing and covered. The pycnometer was placed in a water bath at 25°C for 30 minutes, afterward the pycnometer was then wiped dry and the weight was measured. This process was repeated for each groundnut oil sample instead of distilled water. Equation (5) was used to determine specific gravity was estimated.

Specific gravity (SG) = $\frac{M_s - M_e}{M_d - M_e}$ (5)

Where, M_s = *Weight of SG bottle + oil sample in grams*
M_d= *Weight of SG bottle + distilled water in grams*
M_e = *Weight of empty SG bottle*

Determination of oil pH

Distilled water was heated to 80°C using a magnetic stirrer hot plate (Joanlab SH-4), 5 grams of an oil sample was weighed into a beaker and 10 ml of distilled water was added to the oil sample in the beaker, this was cooled in a water bath to room temperature. The pH meter was calibrated using a buffer solution (sodium ethanoate), and then the pH of the oil sample was measured.

Bleaching process

Five hundred (500) ml of neutralised degummed oil was used for the bleaching process using a heating mantle by heating at a temperature range of 90- 120°C at an operating time of 1 hour. (Okolo and Adejumo, 2014).

Equilibrium adsorption studies

A beaker was used as the bleaching vessel for the bleaching of groundnut oil. Ten (10) ml of unbleached groundnut oil was discharged into the bleaching vessel placed on a magnetic stirrer hot plate a measured quantity of activated clay (2% of clay dosage concentration) was added to the unbleached oil. The oil- activated clay mixture was heated for 30 mins with continuously stirring, at a set temperature of 80°C. Hot oil-clay mixture was then filtered into sample containers and kept for further analysis. The procedure was repeated for 4%, 6%, 8%, and 10% of activated clay dosage concentration at temperature and time conditions of 80°C and 30 mins respectively.

The procedure was repeated by varying the set temperature of the magnetic stirrer hot plate, while keeping the clay dosage concentration and reaction time constant at 6 % and 30 mins. The varied temperatures were 40°C, 60°C, 80°C, and 100°C. The bleached samples were also filtered and stored for further analysis in labelled air tight containers.

Adsorption kinetics experiment

To study the adsorption kinetics of activated clay, 50 ml of unbleached groundnut oil was discharged into the bleaching vessel and 6% activated clay dosage was added to the bleaching vessel. Concurrent stirring and heating at 80°C was carried out using the magnetic stirrer hot plate, the bleaching process was monitored at different ranges. Samples were withdrawn from the bleaching vessel after bleaching times of 5 mins, 10 mins, 15 mins, 20 mins, and 30 mins. These samples were filtered and stored in sample containers for absorbance analysis.

Evaluation of the bleaching performance

The absorbance of the oil was measured using a double beam spectrophotometer (General Science Laboratory; Double Beam 6850). The oil samples absorbance (both crude and refined) were determined at a wavelength of 450 nm. One (1) ml of the oil sample was diluted with petroleum ether at a concentration of 10%v/v to ease analysis of oil samples though the mixture. The absorbance was measured using the spectrophotometer. The efficiency of bleaching was estimated with Equation (6).

Bleaching efficiency = $100\,(A_o - A_t)/A_o$ (6)

%Bleached = $\frac{A_o - A_t}{A_o} \times 100$ (7)

Where: A_0 and A_t are the measured absorbance's for crude and refined groundnut oil at time t respectively.

Determination of rate constant

According to (Topallar, 1998), Equation (8) determines the rate of colour reduction in vegetable oil.

$$\ln \frac{C}{C_0} = -Kt^{0.5} \quad (8)$$

Where:
t = *contact time for adsorbent and oil,*
C = *pigments concentration in oil at time t,*
C_0 = *pigment concentration at the beginning of the adsorption process*
k = *rate constant.*

Beer lambert's law gives a direct relation between concentration and absorbance, so Equation (8) can be written in terms of absorbance instead of concentration as Equation (9).

$$\ln \frac{A}{A_0} = -Kt^{0.5} \quad (9)$$

Where: A is the absorbance of the oil bleached at time t and A_0 the absorbance of crude or unbleached oil. From this equation a plot of $\ln A/A_o$ against $t^{0.5}$ gives a graph with linearity (R) and slope k.

Adsorption isotherm determination

Equations used to describe the adsorption isotherms include Freundlich and Langmuir isotherms. The sorption activity of most adsorbent is described by the adsorption isotherms and differentiates the adsorption process according to form of interaction between molecules Mustapha *et al.* (2013).

The Freundlich isotherm is represented by Equation (10).

$$\frac{x}{m} = KX_e^n \quad (10)$$

Taking logarithm of both sides gives a possible plot of the isotherm.

$$\log\frac{x}{m} = n\log x_e + \log K. \quad (11)$$

Where:
x = *amount of adsorbate*
m= *amount of adsorbent*
X_e = *Coorelation of the amount of adsorbate at equilibrium*, which is 1-x. Values of k and n are gotten from the isotherm plot Mustapha *et al.*, (2013).

Equation that describes the Langmuir isotherm

$$\frac{x_e}{x/m} = \frac{1}{a} + (\frac{b}{a})x_e \quad (12)$$

Where: a and b are constants gotten from a plot of the equation with experimental values (Topallar, 1998).

Adsorption kinetics determination

Results from experimental data can be used to determine the adsorption rate by fitting the data into various kinetic models, predict the interaction mechanism of adsorbent and adsorbate, and simulate the process. For adsorption process of bleaching of groundnut oil, the rate kinetics in this work was fitted into the pseudo first order and pseudo second order kinetics.

RESULTS AND DISCUSSION

Table 1 presents the physicochemical properties of crude and bleached groundnut oil

Table 1: Analysed properties of crude and bleached groundnut oil

S/No.	Physiochemical property	Crude	Bleached
1.	pH	6.86	7.14
2.	Specific gravity	0.916	0.914
3.	Saponification value (mgKOH/g)	216.5	190.2
4.	Acid value (mgKOH/g)	5.61	3.93
5.	Free fatty acid value (%)	2.81	1.97
6.	Odour	agreeable	agreeable

The pH of oil sample remained neutral after the bleaching process, this depicts that the bleaching process does not affect the alkalinity or acidity of crude groundnut oil samples, the pH of the crude groundnut oil was 6.86 slightly less neutral than the pH of the bleached oil, which was 7.14. Aluyor *et al*. (2009), stated that the pH of groundnut cake extracted by alkaline extraction was in the range of 6.8- 10, the pH of groundnut oil is affected by extraction process, and not bleaching process. As the acid or alkaline activated clay used for the bleaching process was washed until it was neutral. This helped to maintain a neutral pH range for edible vegetable oil, both the crude and bleached vegetable are edible in accordance to their pH.

The specific gravity for the refined groundnut oil sample reduced slightly compared to that of the crude sample due to removal of minor components present in crude groundnut oil through the refining process. The specific for crude groundnut oil sample was 0.916 and that of the refined sample was 0.914. These values were in correlation with those of Aluyor *et al*. (2009).From the values of the specific gravities; the change is insignificant, suggesting that the refining process does not affect the specific gravity of vegetable oil samples.

The saponification value of the refined oil decreased significantly as the refining process eliminates minor components in form of soap stock and metals that causes oxidation of vegetable oil. The saponification value is a relation of the alkali responsive class; it entails if a particular vegetable oil is suitable for soap production, and is a measure of the amount (mg) of potassium hydroxide present in a proportional (g) amount of an oil sample. The saponification values for crude and refined groundnut oil samples were determined to be 216.5 mgKOH/g and 190 mgKOH/g respectively, showing the suitability of both oils in the production of soap with a saponification value in the range of 188-220 mgKOH/g. The values gotten for crude and refined groundnut oil samples were similar to that analysed by Nkamafiya *et al*. (2010), with different groundnut oil samples from different species of groundnut seeds.

Groundnut oil as a vegetable oil contains fatty acid in different forms. The main fatty acid present in groundnut oil is oleic acid of about 50%. The acid value is an extent of the glyceride decomposition in a particular oil sample and the free fatty acid is an indication of the shelf life of vegetable oils. The lower the free fatty acid value the longer the shelf

life of an oil sample. The unattached (free) fatty acid causes oxidation of oil samples when exposed to air and reduces the shelf life and overall oil quality.

Bleaching of crude vegetable oil reduces the free fatty acid and acid value of oil samples to improve oil quality. The acid value of the crude and refined oil samples were 5.61 mgKOH/g and 3.93 mgKOH/g respectively while the free fatty acid reduced from 2.81% to 1.97% that depicts that the refining process improved oil quality, which is the aim of the process. The value of free fatty acid value for crude groundnut oil sample showed that the crude oil sample has a good physical quality and is suitable for human consumption. Bleached oil had a significantly lower acid value and free fatty acid value indicating that the bleaching process was efficient. Bleached groundnut oil sample with a significantly lower acid and free fatty acid value is also suitable as an edible product as the free fatty acid of oil did not exceed the limit of 5% estimated to be appropriate by Esuoso and Odetokun, (2001).

The odour of both the crude and refined oil samples was agreeable and that shows that the refining process does not necessarily affect the odour of refined oil samples.

Effect of Absorbent Dosage

The result of this study is shown in Figure 1. The absorbance of the crude groundnut oil sample was measured as 0.412 mg/l. The percentage concentration of adsorbent dosage has a direct effect on the bleaching process as an increase in the adsorbent dosage resulted in a proportionate increase in bleaching efficiency of oil increased from 30.83- 70.15%. The adsorbent dosage was increased from 2- 10 % (0.6 g, 1.2 g, 1.8 g, 2.4 g, and 3.0 g), while the temperature (80^{o}C) and process time (30 mins) were kept constant. An increase in the adsorbent dosage directly increases the number of adsorption sites available for the bleaching processDiaz and Santos, (2001).

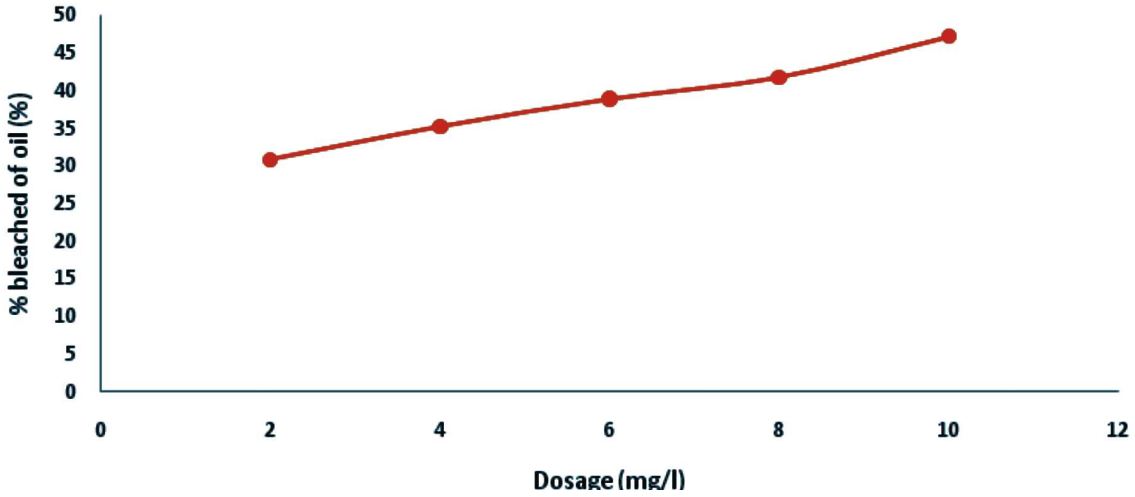

Figure 1: Effect of adsorbent dosage on the bleaching process

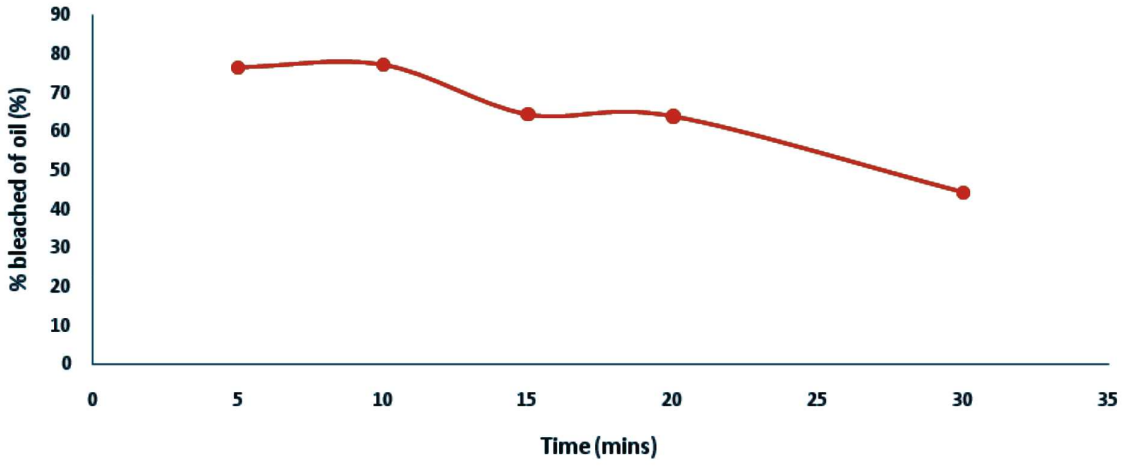

Figure 2: Effect of Reaction Time on Bleaching Efficiency

Figure 1 shows the plot of degree of oil bleaching against adsorbent dosage, a proportionate increase in the % bleached of oil is observed due to the increase in the adsorption power of the clay samples by the availability of higher number of adsorption sites. There is a steady increase of % bleached of oil form 30.83- 47.09% as the clay dosage increased from 2-10%. The adsorbent dosage is an important factor in the bleaching of groundnut oil as an increase in the adsorbent dosage improves the efficiency of the process. The varying results are because of more or less available adsorption sites (Bockish, 1998).

Effect of Contact Time on Groundnut Oil Bleaching

The efficiency of bleaching decreased with time as shown in Figure 2, this might be due to accumulation of clay particles on oil surface even after proper filtration, there is a slight increase of the bleaching efficiency from 76.54% at 5 mins to 77.18% at 10 mins, then a continuous decline of the bleaching efficiency to 44.17% at 30 mins. This explains that bleaching process does not necessarily get better with time. And the most efficient time for a bleaching process is around 15- 30 minutes for bleaching of most vegetable oils according to (Berbesi, 2012),

Effect of Temperature on Groundnut Oil Bleaching

The efficiency of bleaching of groundnut oil is temperature dependent as show in Figure 3, as the temperature increased from 40^{o}C to 100^{o}C the% bleached of oil increased from 21.36% to 64.32%, for the highest temperature of 100^{o}C the best bleaching efficiency of oil was recorded. Berbesi (2012), stated that for efficient bleaching of vegetable oil the process should be carried out within 90- 120^{o}C, and this is through reduction in viscosity and improved clay interaction which causes flow of materials within the oil samples improving the adsorption process.

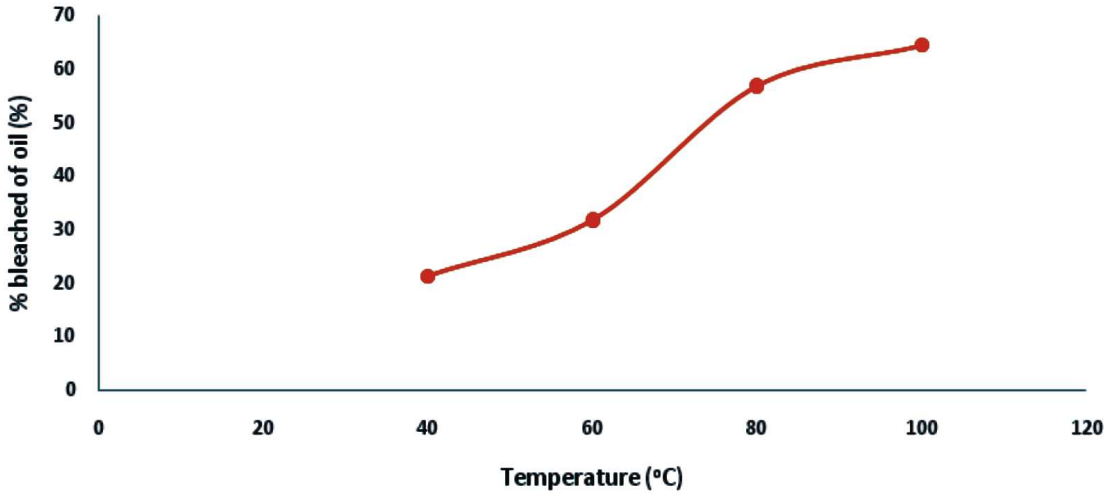

Figure 3: Effect of Operating Temperature of Bleaching Efficiency

Rate constant (K) of the bleaching process

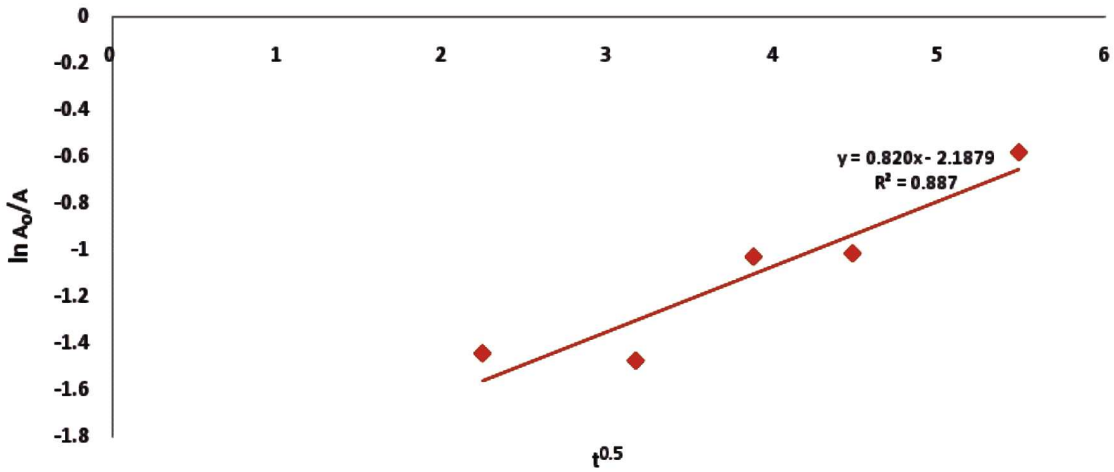

Figure 4: Linearization of the Rate Law

The plot of $\ln A/A_o$ against $t^{0.5}$ gave a rate constant of 0.82 which is relatively high value depicting a quick adsorption of materials from oil sample as expected for activated clay as an adsorbent, and is due to the process conditions in which the natural clay was activated and used as an adsorbent. According to (Ajemba and Onokwuli, 2012), this change occurs as a result of increased kinetic energy of the colour pigment particles, which in turn increases the frequency of collisions between the adsorbent and pigment particles and hence enhancement of rapid adsorption on the surface of the adsorbent. A high value of rate constant indicates quick adsorption by the adsorbent surface.

Kinetics Study

The result of the kinetic study is shown in Figure 5 and 6. This determines what kinetics best describe the bleaching process of pigments from groundnut oil sample using activated clay. The kinetic study of most bleaching processes of vegetable oil are describe by either the pseudo first order or pseudo second order kinetics. Graphical representation of experimentally determined values shows which kinetics best describes the process.

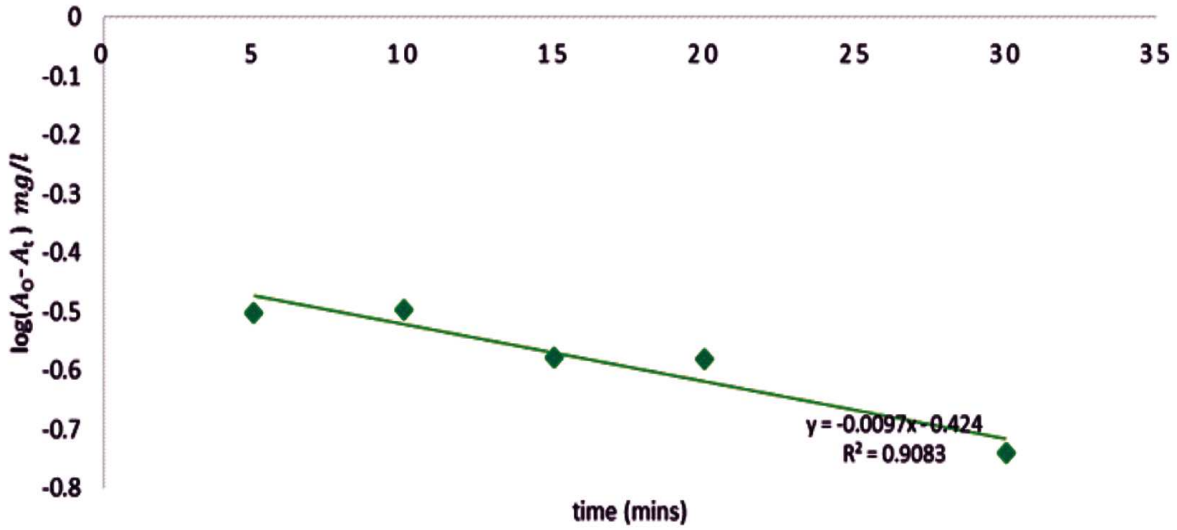

Figure 5: Test for Pseudo first order kinetics

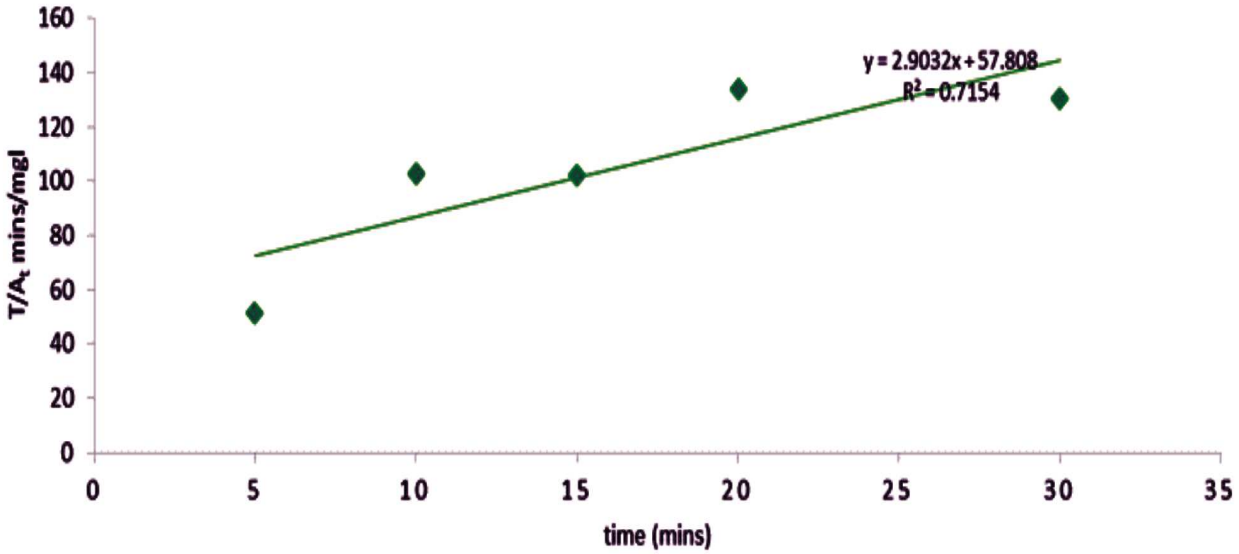

Figure 6: Test for pseudo second order

From the plots above it can be concluded that the bleaching process of groundnut oil sample using activated clay is best described by the pseudo first order due to a higher linearity (R^2) than that of the pseudo second order. For a first order chemical reaction, the rate of change of the reactant directly affects the rate of change of the product, but for a pseudo first order kinetics a first order system acts like a second order system in relation to the rate of change of product and this bleaching process is described by a pseudo first order kinetics with linearity (R^2) of 0.9083, and this is in accordance with (Harriod, 1990).

Isotherm Study

Different adsorption isotherms are suitable for describing a particular adsorption process, due to its surface characteristics, adsorption phase (gas or liquid), interaction between adsorbent and adsorbate. Plots of the Langmuir and Freundlich isotherms are used to show their suitability as isotherms that describes the bleaching process of groundnut oil.

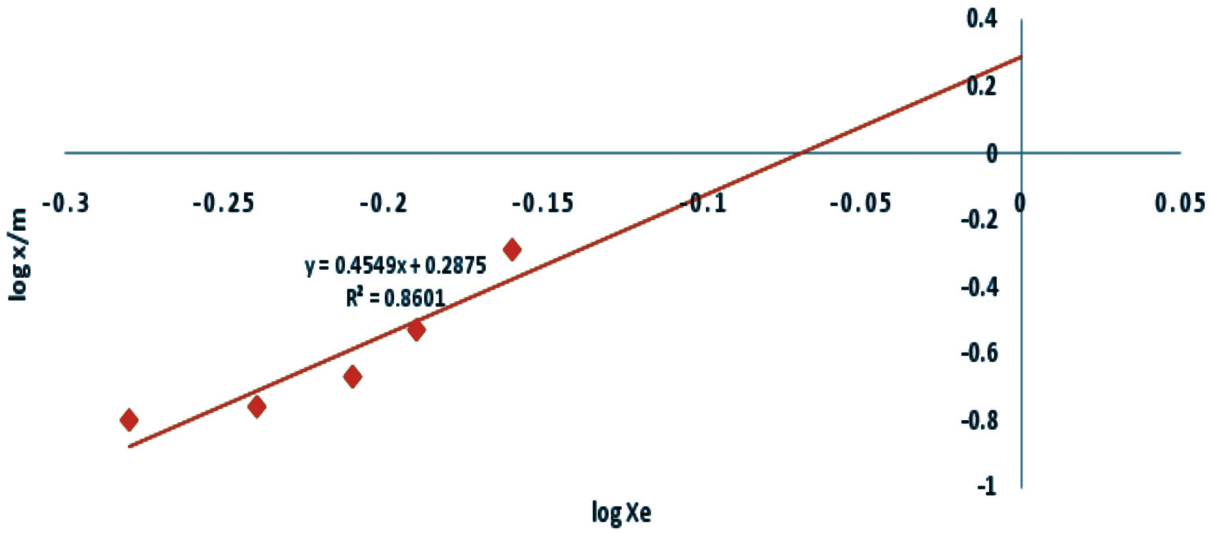

Figure 7: Test for the Langmuir isotherm

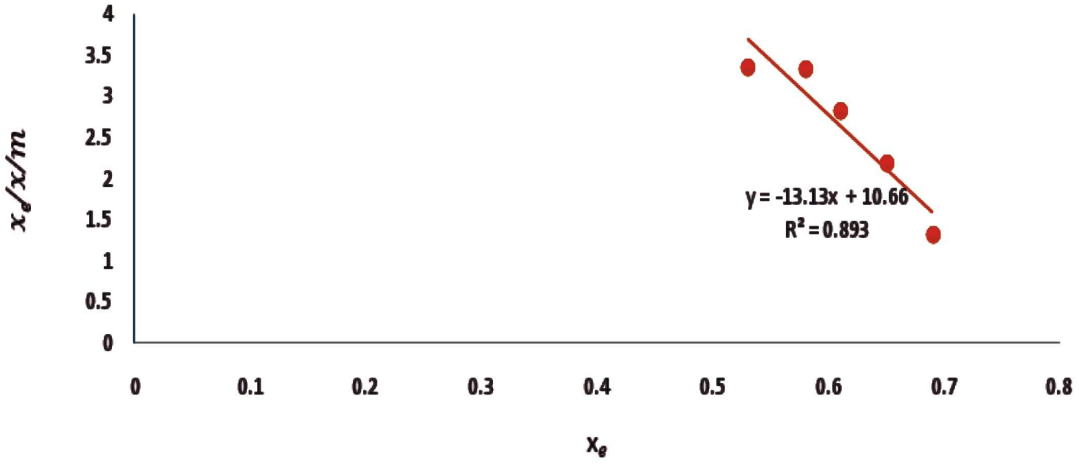

Figure 8: Test for Freundlich isotherm

Table 2: Constant values estimated from plots for adsorption isotherms

	Langmuir isotherm			Freundlich isotherm		
Parameters	R^2	a	b	R^2	n	K_f
	0.8601	0.094	1.232	0.8937	0.46	1.938

The Langmuir and Freundlich isotherms are suitable for describing the bleaching process of groundnut oil using activated natural earth with very high linearity (R2) for both isotherms. Table 2 shows the estimated values of the different constants for both isotherms.

The values calculated for n and K_f for the Freundlich isotherm are 0.46 and 1.938 respectively seen in Table 2. The value of n is less than 0.5, which indicates that activated clay is a good adsorbent for groundnut oil bleaching process according to James *et al.*, (2008). The indication of linearity (R^2) is greater for Freundlich isotherm and that depicts that it is a better isotherm to describe this adsorption process.

CONCLUSIONS

The kinetic study of the adsorption (bleaching) process of crude groundnut oil was found to vary in direct proportion to adsorbent dosage. A steady increase of bleaching efficiency from 30.83- 47.09 % as the clay dosage increased from 2-10%. Also as the temperature increased from 40^{o}C to 100^{o}C the bleaching efficiency of oil increased from 21.36% to 64.32%. For time there is a slight increase of the bleaching efficiency from 76.54% at 5 mins to 77.18% at 10 mins, then a continuous decline of the bleaching efficiency to 44.17% at 30 mins.

From the rate constant value of 0.82, it can be concluded that activated clay (natural earth from Gidankwano village), is a suitable cheap adsorbent for quick adsorption of pigments (by electrostatic adsorption and chemisorption) from crude vegetable oil. For the different adsorption isotherms, Freundlich isotherm was the best isotherm that described the bleaching process as an adsorption process in the liquid phase due to its higher linearity from the different plots.

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