2012). This importance and applications of palm kernel oil has made the study of purification of palm kernel oil necessary. Fatty acid composition of palm kernel oil as presented by John (2009) is shown in Table 1.

Table 1: Fatty acid composition of palm kernel oil (John, 2009).

Type of fatty acid	Percentage
Lauric (C12:0)	48.2
Myristic (C14:0)	16.2
Palmitic (C16:0)	8.4
Capric (C10:0)	3.4
Caprylic (C8:0)	3.3
Stearic (C18:0)	2.5
Oleic (C18:1)	15.3
Linoleic (C18:2)	2.3
Others (unknown)	0.4

The aim of this research is to study the effect of activated clay and activated carbon on colour and odour removal by comparing the results obtained in the refining of palm kernel oil with that of the crude sample. The activated carbon can be obtained from carbon containing materials like coconut shells, palm kernel shells, wood chips, animal bones, corn cobs, rice husk (Abubakar *et al.*, 2012).

2. METHODOLOGY

2.1 Materials and Equipment Used

Measuring cylinder, Heating Mantle, Weighing balance, Beakers , Conical flasks, Burette, Pipette, Separating funnel, Viscometer, Spectrophotometer, Retort stand, Filter cloth, Charcoal, clay, Oven, Furnace, Thermometer, filter cloth, filter paper, distilled water.

2.2 Chemical Activation of the adsorbents (charcoal and clay)

2.2.1 Pre-treatment stage: The raw clay from FUT staff quarters, Bosso and charcoal from Kpakungun were washed with water to remove debris, stones, unwanted particles and other impurities. The two adsorbents were dried, crushed and sieved to particle sizes of between 500 µm and 750 µm.

2.2.2 Activation stage: The pre-treated adsorbents (charcoal and clay) were activated using chemical activation method. The process is mainly divided into two stages namely; the carbonization and activation stage. The pre-treated clay was reacted with 85% phosphoric acid to inhibit the formation of tar and other unwanted particles during carbonization (Hernandez-Montoya *et al.*, 2012). The mixture which was exothermic was continuously stirred for two minutes for proper contact of the acid with the pre-treated clay and then mixed with distilled water to dissolve the un-reacted acid. The resulting solution was filtered and the residue was allowed to dry in an oven as suggested by (Osoka, 2012). The dried residue was then carbonized in a furnace at 600°C for 30 minutes after which it was allowed to cool. The same procedure was repeated for the chemical activation of charcoal.

2.3 Characterization of the activated charcoal and activated clay

2.3.1 Ash Content Determination

2 g of dry activated sample was placed in a crucible; weight of the sample was noted to be w_2. The sample was then placed in a furnace at 450°C for 6 hrs, after which it was removed, cooled and its content reweighed and recorded as w_3. The process was repeated twice for each

activated carbon sample to get average ash content value (Abubakar *et al.*, 2012). It was calculated as;

$$\frac{w_2 - w_3}{w_2} \times 100\%$$

2.3.2 Moisture Content Determination

5 g of sample was weighed and recorded as w_2. The sample was kept in an oven at 100°C for 24 hrs, after which it was removed, placed in desiccators and allowed to cool. The sample was reweighed and recorded as w_3. It was repeated twice for each sample to obtain average moisture content value (Abubakar *et al.*, 2012). It was calculated as;

$$\frac{w_2 - w_3}{w_2} \times 100\%$$

2.3.3 Pore Volume Determination

2 g of each sample was weighed into a beaker and recorded as w_1. 50 mL of distilled water was poured into the beaker containing the dry sample and the mixture was boiled for 15 minutes. After the air in the pores had been displaced, the sample was drained, dried superficially and weighed as done by Abubakar *et al.*, (2012). The weight was recorded as w_F and procedure was repeated twice. It was calculated as;

$$\frac{w_F - w_1}{w_1} \times \text{density of water}$$

2.4 Refining of Palm Kernel Oil

The palm kernel oil was refined mainly in three stages namely: the degumming stage, neutralization stage, odour and colour removal stage.

2.4.1 The Degumming Stage

The approach adopted was that of Ibeawuchi, (2012) where 500 mL of crude palm kernel oil put in a separating funnel and 500 mL of distilled water at 100°C was added. The resulting solution was mixed vigorously for about 10 minutes and allowed to settle. Two layers were obtained, the oil layer and the water layer containing the gumming materials. Using density differences, the oil of lesser density settled at the upper part and the gumming materials with water was decanted off.

2.4.2 The Neutralization Stage

0.5 M sodium hydroxide was mixed with the degummed oil as done by Ibeawuchi, (2012). The resulting mixture was well shaken after which it was filtered to obtain the neutralized palm kernel oil.

2.4.3 Odour and Colour Removal Stage

The bleaching process was done using a hollow measuring cylinder of 46 mm × 610 mm as the adsorption column. The cylinder was packed with filter cloth at the bottom to ensure that the adsorbent did not move together with the oil. The activated charcoal was put above the filter cloth to a fixed height of 10 cm and another filter cloth were placed just on top of the adsorbent to prevent impurities from entering with the oil. The measuring cylinder was supported with the retort stand and a beaker was placed at the bottom for the collection of the refined or purified oil. Distilled water was passed through the purifying bed before passing the oil through to ensure that the ashes and dust in the activated carbon was well removed before passing the oil through the bed. The collected water from the bed was compared with pure distilled water until it was clear. The set-up was allowed to dry for about 30 minutes and the oil was passed through it. A fixed volume 200 mL

of oil was passed through the adsorption column for each run. The oil that was collected at the base of the bed was then characterized. The transmittance was measured with the aid of spectrophotometer. The above procedure was repeated for the unactivated charcoal, activated clay, and unactivated clay.

2.5 Characterization of Palm Kernel Oil

2.5.1 Specific Gravity

100 g of crude palm kernel oil was heated to a temperature of 50°C and weighed. The weighed oil was put into a specific gravity bottle of known weight and the total weight was recorded. The specific gravity bottle with the oil was emptied, washed thoroughly with detergent and rinsed with distilled water to avoid contamination. It was then refilled to the same level with water at 50°C and the weight was recorded.

$$\text{specific gravity} = \frac{\text{weight of oil at } 50°C}{\text{weight of water at } 50°C}$$

2.5.2 Free Fatty Acid (FFA) Content

2.8 mL of crude palm kernel oil with unknown FFA content was put into a conical flask and 25 mL of ethanol was added. Two drops of phenolphthalein indicator was added to the mixture. 0.1 M potassium hydroxide was titrated against the resulting solution until a pink colour was observed.

$$\text{FFA} = \frac{V \times M \times N}{W}$$

Where V is volume of KOH,

M is the molecular weight of oil sample used,

W is the weight of the sample,

N is concentration of KOH.

2.5.3 Iodine Value

0.5 g of oil was weighed and poured into a conical flask. 25 mL of both Carbon tetrachloride (CCl_4) and Wij's solution was measured accurately and mixed well. The solution was then added to the oil in the conical flask. The mixture in the flask was shaken well to ensure complete mixing. Standardized sodium thiosulphate solution is taken in a burette and titrated against the contents of the iodine flask as starch was used as the indicator (Ibeawuchi, 2012).

$$Iodine\ Value = \frac{((B-S)\times N\times 0.1269\times 100)}{W}$$

Where B is the volume of the standard thiosulphate solution blank,

S is the volume of standard thiosulphate solution,

N is normality of standard thiosulphate solution,

W is weight of oil sample in grams.

2.5.4 Moisture Content

A beaker and a stirring rod were weighed while empty. It was reweighed after 10 g of the crude palm kernel oil sample was added into the beaker containing the stirring rod. The oil was heated using the heating mantle at a constant temperature until there was no bubbles again which indicate the absence of water. The beaker and its content were allowed to cool after which it was reweighed. The difference in weight indicated the weight of water that has evaporated during heating. Hence the moisture content can be calculated by

$$Moisture\ content\ (\%) = \frac{weight\ of\ moisture}{weight\ of\ crude\ palm\ kernel\ oil} \times 100$$

2.5.5 Saponification Value

1 mL of crude palm kernel oil sample was measured into a conical flask; 25 mL of alcoholic potassium hydroxide was added to the oil. It was heated with the aid of heating mantle for 30 minutes and 1 mL of phenolphthalein solution was added as an indicator. 0.5 M of hydrochloric acid was titrated against the solution and the volume of the acid used was noted at end point.

2.5.6 Flash Point

It is the lowest temperature of a flammable liquid at which it can form ignitable mixture in the air, however if the ignition source is removed the liquid stops to burn. 5 g of palm kernel oil was put in an open cup and continuously heated until the smoke evolved quenched the fire from the matches stick.

3. RESULTS AND DISCUSSIONS

Table 2: Results of properties of activated clay and activated charcoal

Characteristics	Activated Clay	Activated Charcoal
Moisture content (%)	2.2	1.9
Yield (%)	92	89
Pore volume (g)	0.34	0.43
Particle size (µm)	500 – 725	500 – 725
Ash content (%)	Nil	7.50
Color change	Brown to reddish brown	Nil

Table 3: Comparison of results obtained for the characterization of oil after refining using unactivated charcoal and unactivated clay, then activated charcoal and activated clay.

Characteristics	Crude Palm Kernel Oil	Crude Oil refined with Unactivated Charcoal	Crude Oil refined with Activated Charcoal	Crude Oil refined with Unactivated Clay	Crude Oil refined with Activated Clay
FFA(mgKOH/g)	6.57	3.81	1.57	3.60	1.51
Saponification value(mgKOH/g)	417.95	308.50	221.60	283.31	202
Iodine value(g/100g)	47.2	43.20	32.60	42.70	32.20
Acid Value(mgKOH/g)	12.34	7.62	3.14	7.2	3.02
Flash point(°C)	205	215	242	221	247
Moisture content (%)	8.7	6.53	3.9	6.32	3.75
pH	5.24	6.27	6.71	6.35	6.76
Specific gravity	0.93	0.94	0.94	0.94	0.94
Melting point(°C)	31	30.10	29	30.10	29
Transmittance	0.12	0.14	0.47	0.14	0.52

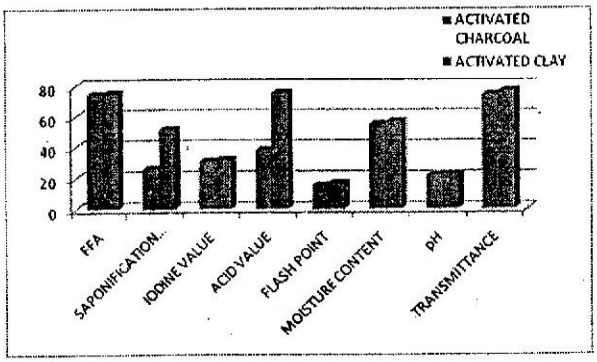

Figure 1: Efficiencies comparison of activated clay and activated charcoal

From the experimental results obtained in table 3, it was shown that the free fatty acid was reduced from (6.57 – 1.51) by the activated clay and from (6.57 – 1.57) by the activated charcoal which is in agreement with (7.2997 – 0.486) as reported by (Viele *et al., 2013)*, the flash point was increased from 205°C to 247°C by the activated clay and from 205°C to 242°C by the activated charcoal. It was also shown that the effect of activation was negligible on the specific gravity of the palm kernel oil. The acid value of crude palm kernel oil of 12.34 mgKOH/g is comparable with 11.60 mgKOH/g as reported by Atasie and Akinhanmi, (2009). The transmittance increased from

0.12 to 0.47 for activated charcoal and from 0.12 to 0.52 using activated clay indicating a reduction in the colour of the palm kernel oil. The iodine value of crude palm kernel oil of 47.2 g/100g is comparable with 41.42 g/100g as reported by Atasie and Akinhanmi, (2009). The decrease in the iodine value of the refined palm kernel oil is an indication of low level of unsaturation in the oil (atasie and Akinhanmi, 2009)

4. CONCLUSIONS

Decolourization and deodorization of crude palm kernel oil was done and results obtained from activated (clay and charcoal) and unactivated (clay and charcoal) was compared.

From the results obtained, it can be concluded that clay is a better adsorbent than charcoal both in its activated and unactivated forms. Also, transmittance was increased due to the removal of impurities and pigments from the oil. The removal of impurities also increased the flash point.

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REFINING AND CHARACTERIZATION OF PALM KERNEL OIL USING TREATED CHARCOAL AND CLAY

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ABSTRACT

This study was aimed at refining palm kernel oil using activated charcoal and activated clay. The effects of activating both the charcoal and clay subjected to the same (chemical) activation process were studied on the refining of palm kernel oil in an adsorption column. From the results obtained, it was shown that there were increase in transmittance of palm kernel oil from 0.12 to 0.47 with activated charcoal and 0.12 to 0.52 with activated clay as a result of the removal of impurities and pigmentation of the oil. A notable change was observed in the free fatty acid (FFA) content of the oil from 6.57 mg(KOH)/g to 1.57 mg(KOH)/g with activated charcoal and 6.57 mg(KOH)/g to 1.51 mg(KOH)/g with activated clay. Hence, activated clay was a better adsorbent than activated clay.

Keywords: *clay, charcoal, adsorption column, activation, palm kernel oil, characterization.*

1. INTRODUCTION

Palm kernel oil is one conceivable item that can be centred on in light of its various employments. In Nigeria, emphasis has been on the agro-lied industries for economy enhancement. Some other types of oil that are been produced in Nigeria include vegetable oil, groundnut oil and palm oil. Palm kernel oil is consumed due to some of its nutritional benefits such as vitamins K for bone formation and it is cholesterol free nature.

The Palm kernel oil is derived from palm kernel seed of the palm tree which are grown as major crops in the southern part of Nigeria. The oil palm tree is available in the tropical rain forest region of West African countries like Ivory Coast, Cameroon, Nigeria, Ghana, Liberia (Olatunde, 2014).

The palm oil is normally obtained from the fleshy part of the palm fruit while the palm kernel oil is obtained from the kernel (seed) inside the palm fruits (Ibeawuchi, 2012). Palm kernel oil is of much economic importance both in commercial and domestic applications. It can be used in food industries such as bakery, the production of cakes, biscuits, margarines and chocolates. Palm kernel oil can also be used in the production of cosmetics like hair and body creams, detergents and soap. They have also been tried as fuels in native lamp for lighting rural communities and as biodiesel for diesel engines.

The purification of the crude palm kernel oil in terms of decolourization of the brownish colour and deodorization of the very sharp smell of the oil was carried out in this research. High adsorbent materials such as activated clay and activated carbon can be used to remove colour and other impurities via adsorption process will be considered in this study. Activated carbon is a form of carbon that has been treated in order to make it extremely porous and have a very large surface area which favours the adsorption process.

Palm kernel oil is stable at moderately high temperature. Palm kernel oil and coconut oil comprises less than 5% of the total natural fats and oils, but they are important feedstock of the oleo chemical industry (Ibeawuchi,