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PURIFICATION OF SHEABUTTER USING ANIMAL BONE ACTIVATED CARBON

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Abstract

Animal bones were carbonized and chemically activated using orthophosphoric acid according to standard procedures. The activated charcoal was employed in the purification of sheabutter. Physicochemical properties and individual fatty acid profiles were monitored hourly. Melting point, odour and colour were determined for crude and purified samples. The result showed that unsaponifiable and saponification values increased from 5.2 to 7.2 % and 167.0 to 194.0 respectively in sheabutter. The data showed that adsorption tends to equilibrium within 3 – 4 h. Melting point reduced from 29 to 24.5 °C. Odour and colour improved after 4 h. The Freundlich isotherm model showed that animal bone activated carbon is quite suitable for the purification of sheabutter.

Key words: Animal bone, carbonized, Sheabutter, crude, purification.

INTRODUCTION

Activated carbon is developed from a wide range of organic-based materials such as straw, corn cob, wood fibre, sawdust, clay, etc. [1,2]. Activated carbons or adsorbents can be used once and discarded or it can be employed on a regenerative basis and re-used for a number of cycles. Commercial adsorbents are divided into five major classes: Molecular-sieve zeolites, activated alumina, silica gel, synthetic polymers or resins and activated carbons [3].

The raw materials for activated carbon development were first carbonized to obtain the char or carbonaceous material which is activated to yield the highly porous final product. The general process to prepare activated carbon is based on carbonizing and activating the natural carbonaceous biomass [4]. Activation step of activated carbon process may be achieved either physically or chemically. The chemical activation has been shown as a more efficient method to obtain activated carbons with high surface area and narrow micropore distribution [5]. Of the activation agents, H_3PO_4 is widely considered better in the preparation of activated carbons because it offers some advantages such as non-polluting character and ease of elimination by washing with water [6]. Moreover, H_3PO_4 introduces physical and chemical modifications on the

biomass by penetration, particle swelling and partial dissolution of biomass, bond, cleavage and reformation of new polymeric structures resistant to thermal decomposition [7,8].

Typically, surface areas ranging from 500 - 1400 m^2/g are obtained for the activated material [9]. The activated carbon particle has two types of pores existing in it by which adsorption takes place. These are the macropores (> 10^{-1} μm) and the micropores (10^{-3} - 10^{-1} μm).

The macropores provide passageway to the particles interior and to the micropores but do not contribute substantially to the particle surface area. The micropores, on the other hand, are responsible for the large surface area of activated carbon particles and are created during the activation process [10]. It is in the micropores that adsorption largely takes place. As a result, two main parameters are relevant to the performance of the activated carbon namely the surface area and the pore volume.

Activated carbon has several important uses such as in clean up of industrial effluents [11,12] removal of taste and odour from domestic and industrial water supplies, vegetable and animal fats and oil, alcoholic beverages, chemicals and pharmaceuticals and in waste water treatment [13].

Traditionally, sheabutter production consists of roasting, milling to paste and pressing to collect the deep brown oil. This is further purified by boiling and skimming, the associated impurity is removed in the scum. By this method only about 25 – 27 % crude oil is obtained. Despite the considerable impurities and objectionable odour, the oil is still suitable for both domestic and industrial purpose.

A larger percentage of sheabutter produced in Nigeria is exported, where it is further purified and sent back to Nigeria. Therefore a search for a cheap and convenient technology for the purification of sheabutter to meet industrial and domestic grade is a worthy venture.

MATERIALS AND METHODS

Source of Materials and chemicals

Animal bones were bought from the abattoir in Bida, Niger state, while most of the chemicals used were of the analytical grade from BDH, London. Sheabutter was purchased from local producers.

Carbonization

The animal bones were cleaned, sun-dried and charged into an automated muffle furnace (Gallenkamp FSE - 624 - 0100). The bones were heated for 2 – 3 h at 800 – 900 °C, the charred products were allowed to cool in a desiccators and then ground to 75 μm. The charred products were washed with HCl (0.5 M) to purify the carbon. The product was rinsed several times with distilled water. The sample was then dried in an oven at 100 °C for 1 h, and stored in air tight polythene bags.

Chemical activation of charred bones

Chemical activation of animal bones using orthophosphoric acid (H_3PO_4) was done following the method described by [12], samples of charred bone were mixed with

0.5 M solution of orthophosphoric acid (I:2 w/v) and heated to form a paste. The paste was transferred into a crucible and heated at 500 °C for 2 to 3 h in a furnace, allowed to cool to room temperature, washed with distilled water and dried at 100 °C. The final product was stored in an air tight polythene bag ready for use.

Purification of sheabutter

Activated carbon prepared as stated above was added to oil samples at a ratio of 1:8 (v/w), stirred and maintained at 80 – 100 °C. Sample (20 ml) was withdrawn at 1 h interval, centrifuged at 1500 xg and the clear supernatant (oil) collected and stored for physicochemical analysis.

Determination of physio-chemical properties of purified sheabutter

Melting point was determined using Gallenkamp melting point apparatus (MFB-600-01 0f), Colour was determined using Lovibond tintometer and recorded as Hezen point, while odour was determined by a 33 member panelist. Samples where scored for 5 points were 1 is for least odour and 5 for the highest odour.

Saponification values, unsaponifiable matter, iodine value, peroxide value, free fatty acid were determined in crude and purified oil samples according to the method of ISO, [14]. Refractive index was detemined using Abbe refractometer while pH was determined using a standard laboratory bench pH meter (EIL model 7020).

Fatty acid profile

Fatty acid composition of crude and purified oil samples was determined using gas-liquid-chromatography method (Varian Chromatography Model 3400cx).

Results and Discussion

The process technology of sheabutter as well as other less popular oil can be improved for domestic and industrial uses. The melting point, odour and colour parameters of sheabutter before and after purification with activated carbon prepared in our laboratory using animal bone is shown in table I.

Table I: Physico-chemical properties of sheabutter before and after purification with activated carbon.

Sheabutter		
Parameters	*Crude*	*Purified*
Melting point(°C)	29.0	24.4
Odour	5.0 ± 0.01	2.3 ± 0.70
Colour	Brown pale yellow	Golden yellow
Hezen point	199.6	99.8

The reduction in melting point and odour, and the improvement on the colour of the oils indicate that impurities have been removed from the oil samples. It is known that impurities usually increase the melting point of substances; thus the reduction of melting point is an indication of removal of impurity from the oil samples after treatment with animal bone activated carbon. One of the major problems of popularizing sheabutter as cooking oil or industrial oil is the objectionable odour. The problem of objectionable odour can therefore be solved by treatment with animal-bone based charcoal. This observation has also been reported [15]. In the present study therefore, the treatment of sheabutter with Chemically Activated Animal bone Carbon (CAAC) may not only remove the impurities but also make the oil samples more acceptable and more industrially useful.

Table II shows the physiochemical properties of sheabutter after treatment with CAAC. The result showed that percentage unsaponifiable matter increased with purification time for both sheabutter samples. This result suggests that the crude oil samples are affected by impurities. By removing the impurities, the unsaponifiable matter becomes concentrated. Saponification value increased with purification time in sheabutter samples.

This observation suggests that the bulk of impurities in sheabutter may not contribute to the saponification value of the oil hence the crude sheabutter contains low saponification value per unit volume of oil as impurities, and when the impurity is removed, the unit saponification value increased. This observation is supported by the report of Moma *et al* [16], who have shown that impurities can increase or decrease saponification value depending on the nature of the impurity. The result further shows that refractive index reduced with time which further confirmed the removal of impurities by CAAC treatment. The results from Table II also show that the parameters like unsaponifiable matter (%), saponifiable value (%), iodine value, etc. tended to equilibrium within 3 – 4 h. This observation is an indication of favourable adsorption system. Absorption systems that tend to equilibrium are judged effective [17, 18]. However, the ease of attaining equilibrium is a function of the mesh size and surface area [19].

Table II: Physiochemical properties and fatty acid profile of sheabutter oil purified with animal bone activated charcoal.

Parameters	Time (H)				
	0	1	2	3	4
Unsaponifiable matter (%)	5.20	5.70	6.40	7.10	7.10
Saponification Value (mg/g)	167.00	175.00	188.00	193.00	194.00
Iodine Value (%)	70.30	64.00	60.50	56.90	53.00
pH Value	10.90	10.60	9.70	8.40	8.50
Peroxide Value (%)	1.95	1.8"0	1.72	1.54	1.40
Acid Value (%)	2.13	2.06	1.99	1.94	1.19
Refractive index	1.4781	1.4633	1.4631	1.4630	1.4630
Oleic acid (%)	57.90	52.50	50.10	50.10	50.10
Linoleic Acid (%)	3.80	4.20	4.20	4.60	4.60
Stearic Acid (%)	36.70	37.00	38.10	39.30	40.50
Palmitic Acid (%)	5.00	5.10	5.50	7.30	7.50

It is interesting to note that the sheabutter has high saponification values, which make them useful raw materials for the cosmetic industries and since the results of the present study suggest that equilibration could be attained in a short reasonable time (≈4 h), a model for large scale purification of sheabutter could be established or formulated.

This is demonstrated by the adsorption isotherm (Fig. 1). The heterogenicity factor (n) calculated from Freundlich isotherm plot of 1.01 sheabutter samples, while the equilibrium adsorption coefficient (k) was 4.153 for sheabutter oil samples purified by CAAC. The Freundlich model assumes that the uptake of any adsorbate occurs on a heterogeneous surface by multilayer adsorption and that the amount of adsorbate increases infinitely with an increase in concentration. From these assumptions it can be concluded that the purification of sheabutter occur on a heterogeneous surface by multilayer adsorption.

The present observation indicates that chemically activated animal bone charcoal (CAAC) used for this study is suitable for the purification of sheabutter.

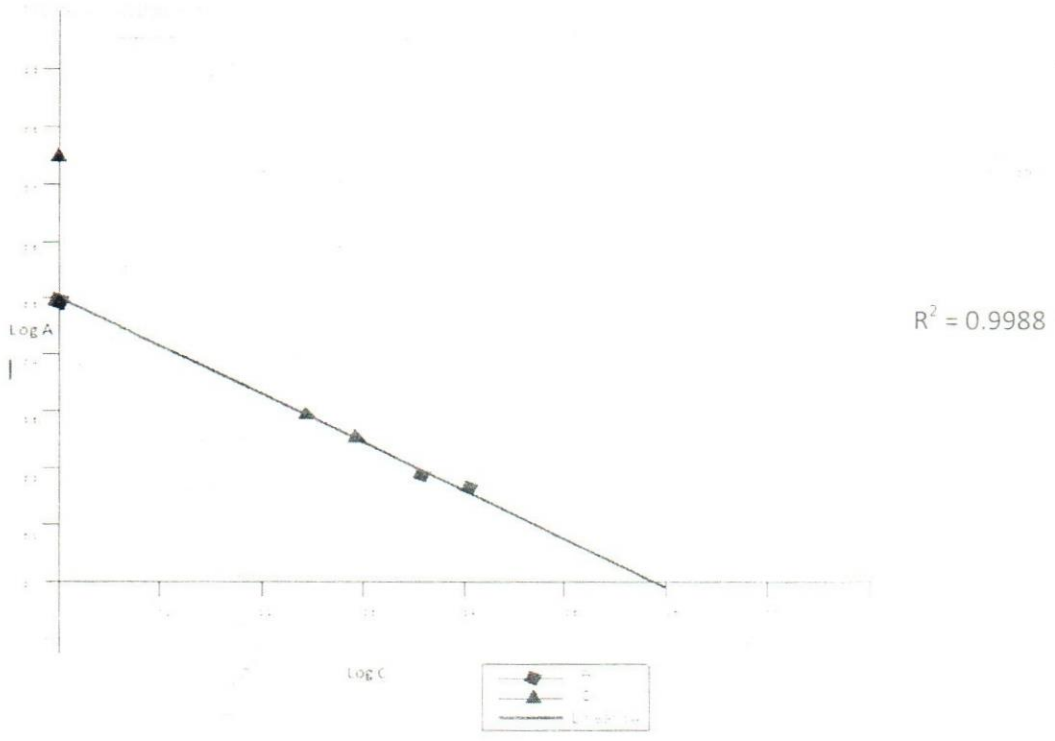

Fig. 1: Freundich plot for sheabutter oil purification using activated bone charcoal at 800°c and 150µm particle size

It is also known that when a value is greater than 1.0, the conditions are favourable for adsorptions. Hence it is clearly proved that the purification of sheabutter by animal bone activated charcoal agrees with the Freundlich adsorption model. Fig. 1 clearly shows that the Freundlich isotherm model fits the analyzed data well with its correlation coefficient (R^2) values of 0.9988.

The work concludes that animal bone activated carbon is quite suitable for the purification of sheabutter.

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