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A comparative study of the effect of bleaching red palm oil with fuller's earth, kaolin, charcoal and activated carbon

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ABSTRACT

This study was carried out to investigate the effect of bleaching red palm oil with fuller's earth, kaolin, charcoal and activated carbon on some of the physico-chemical characteristics. Each of the adsorbent materials was separately employed in the bleaching of the crude palm oil sample. In the removal of colour, fuller's earth showed highest ability (67.23%) in the removal of carotenes (R-Band). Charcoal (56.50%) compared favourably to fuller's earth in the removal of carotenes. However, the adsorbent materials- fuller's earth (3.96%), kaolin (4.32%) and charcoal (5.04%) showed very poor, but comparable abilities in the removal of xanthophylls (Y-Band) from the palm oil sample. Bleaching of the red palm oil sample with the adsorbents resulted in total colour reduction of 58.20% with fuller's earth, 40.14% with kaolin; 49.50% with charcoal and 38.87% with activated carbon. The lovibond tintometer scale was used in the colour measurements. Generally, bleaching with the adsorbents resulted to reductions in the colour mixture content, free fatty acid (FFA) content, peroxide value (POV) and the unsaponifiable matter content but increased the melting point (M.Pt.^{O}C) and the cloud point of the bleached oil samples. The treatment with the adsorbents showed no pronounced effect on the saponification numbers, iodine values, specific gravities and the refractive indices of the bleached oil samples.

Introduction

Red palm oil is the mesocarp oil of the oil palm fruit (*Elaeis guineensis*). In its natural (crude) state, it consists mainly of a balanced mixture of saturated fatty acids, which constitutes the yellow/orange-red solid fraction and unsaturated fatty acids (oleic, linoleic) that constitute the reddish liquid fraction [1, 2]. Typically, crude palm oil contains 500–700 mg/kg of carotenoids and 800 mg/kg of tocopherols. The major carotenoids of palm oil are α- and β-carotenes, which constitute more than 80% of the total carotenoids in palm oil [3].

Palm oil is a very important industrial raw material. It is a satisfactory oil for blending in substantial amounts in margarine and shortening for domestic uses and also for commercial baking and biscuit manufacturing [2].

Crude palm oil extracted commercially from the fresh fruit bunches contains a small but variable amount of undesirable components and impurities. These include some mesocarp fibers, moisture and insolubles, free fatty acids, phospholipids, trace metals, oxidation products and odoriferous substances. As a result, palm oil is normally refined to a bland, stable product before it is used for direct consumption or for formulation of edible products. In Africa, however, crude palm oil is often consumed in the crude form

The usual processing of vegetable oils involves degumming and/or steam refining, adsorptive bleaching, hydrogenation and deodorization. Winterization is a specialized processing method used to produce salad oils.

Bleaching is a refining process whereby pigments, impurities, trace metals, gums and oxidized materials are removed from oils and fats. It is accomplished by the use of adsorptive clays for edible oils and alternatively by chemical reactions for non-edible oils.

Fuller's earth has been the most common and utilized clay material employed by oil processors in oil bleaching process. High grade fuller's earth has not been reported in Nigeria. Hence, oil processors have depended on imported fuller's earth for oil bleaching. Activated carbon, kaolin and charcoal are in abundance in Nigeria and can serve as absorptive materials which can equally be employed by oil processors in oil bleaching process.

Therefore, this research seeks to study the effect of bleaching crude red palm oil with imported fuller's earth and the locally available absorptive materials like activated carbon, kaolin and charcoal. The results obtained from this study will reveal the potentials of activated carbon, kaolin and charcoal as bleaching agents and, as such, encourage their utilization in oil processing.

Materials and methods

The crude palm oil sample used for this study was obtained from commercial red palm oil producers at Isiala in Ikwuano Local Government Area of Abia State, Nigeria. Activated carbon, kaolin and charcoal were bought from dealers in industrial chemicals in Lagos, Lagos state, Nigeria.

Each of the adsorbents was ground and sieved with 2µm mesh to obtain the sample used for the bleaching process. Atmospheric bleaching process was employed in the bleaching of the crude red palm oil.500g of the crude palm oil was mixed with 50g of each of the adsorbents in a 1000ml beaker and stirred for complete mixing. The slurry was subsequently transferred to the steel bleaching pan and heated to 120^{0}C for twenty (20) minutes. The mixture was filtered with suction filtration pump. The residual oil was employed in the tests. The colours of the crude and bleached samples were measured using the lovibond tintometer scale [4]. The percent colour reduction was calculated using the Krishnan's equation:

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$$\text{Colour Reduction} = 100 \times \frac{(10R + Y) - (10R_1 + Y_1)}{(10R + Y)}$$

10R + Y = Total Colour of Crude Oil, $10R_1 + Y_1$ = Total Colour of Bleached Oil. Conventional methods of analyses were employed in the determination of the physico-chemical properties such as melting point [5], refractive index, %moisture content, unsaponifiable matter, iodine value, saponification number, peroxide value, free fatly acid and specific gravity [4]. The cloud point [6] was also determined.

Results and discussion

The result of the colour analyses of the crude and bleached oil samples is presented in table 1. The residual colours of the oils after bleaching with the various adsorbent materials revealed that bleaching with fuller's earth resulted to loss of 67.23% of carotenes (R-band) and 3.96% of xanthophylls (Y-band) and with a total of 58.64% colour reduction.

Table 1: Colour Analyses Of The Crude and Bleached Oil Samples

Sample	Lovibond Colour Readings R-Band %loss Y-Band %loss	Total Colour Reduction (%)
Crude Palm oil	17.7 - 27.8 -	-
Oil +Fuller's earth	5.8 (67.23) 26.7 (3.96)	58.64
Oil +Kaolin	9.6 (45.76) 26.6 (4.32)	40.14
Oil +Charcoal	7.7 (56.50) 26.4 (5.04)	49.51
Oil +A. Carbon	9.8 (44.63) 27.2 (2.16)	38.87

Bleaching with charcoal resulted to loss of 56.50% of carotenes (R-band) and 5.04% of xanthophylls (Y-band) and with a total of 49.50% colour reduction while bleaching with kaolin resulted to loss of 45.76% of carotenes (R-band) and 4.32% of xanthophylls (Y-band) and with a total of 40.14% colour reduction. Activated carbon showed the poorest ability in the removal of carotenes (44.63%) (R – Band) and xanthophylls (2.16%) (Y – Band) and with a total of 38.87% colour reduction. However, amongst the local adsorbent materials used for the study, charcoal appears to have the highest bleaching ability of the red palm oil sample used for the study.

Result of the physical properties of the crude and bleached oil samples is presented in table 2. The local bleaching earths, except activated carbon, have equal abilities with fuller's earth in the removal of moisture. This implies that they have comparable abilities in the removal of water from the palm oil sample. The specific gravities of the bleached oil samples ranged from 0.879 g/ml for the sample bleached with fuller's earth to 0.891g/ml for the sample bleached with activated carbon.

Table 2: Physical Properties Of The Crude and Bleached Oil Samples

Sample	Moisture (%)	S.G (g/ml)	R.I	Cloud Pt. (^{0}C)	Slip M.Pt. (^{0}C)
Crude palm oil	1.34	0.936	1.473	24	28-29
Oil +Fuller's earth	0.04	0.879	1.444	36	36-37
Oil +Kaolin	0.05	0.887	1.450	33	34-35
Oil +Charcoal	0.04	0.892	1.462	34	35-36
Oil +A. carbon	0.80	0.891	1.453	32	33-34

The refractive indices of the bleached oil samples ranged from 1.444 for the sample bleached with fuller's earth to 1.462 for the sample bleached with charcoal. These values are comparable and reflect acceptable degrees of purity of the bleached oil samples with the various adsorbent materials. The specific gravity and refractive index values of the bleached oil samples fall within acceptable standards for specific gravities and refractive indices of Malaysian palm oil [7]. The higher specific gravity (0.936g/ml) and refractive index (1.473) values of the crude palm oil sample must have resulted from impurities and moisture in the crude oil sample.

Table 3: Chemical Properties Of The Crude and Bleached Oil Samples

Sample	S.N mgKOH/g	I .V Wij's	Unsap. Matter (%)	FFA mgKOH/g	POV mEq/kg
Crude Palm oil	189.18	59.99	0.84(0.00%)	23.55(0.00%)	6.00 (0.00%)
Oil+Fuller's earth	201.94	59.07	0.36(57.14%)	2.82(88.03%)	1.60 (73.33%)
Oil+Kaolin	200.08	59.25	0.44(47.62%)	4.10(82.59%)	1.80 (70.00%)
Oil+Charcoal	199.90	59.60	0.48(42.86%)	5.63(76.09%)	2.00 (66.67%)
Oil+A. carbon	200.60	59.12	0.40(52.38%)	2.33(90.11%)	1.40 (76.67%)

(Value in Parenthesis Represents percent Loss)

The cloud points of the bleached oil samples increased after the bleaching process and with the sample bleached with fuller's earth having the highest value (36^{o}C). The increased values also affected the slip meeting points as they also increased. The increase in the cloud point suggests that the bleaching must have removed some phospholipids as well, such a lecithin. Lecithin is a class of phospholipids. It is a triglyceride with one fatty acid replaced by a phosphoric acid ester of choline. It is waxy and soluble in fats and oils. Lecithin is a natural emulsifier, instanizer, antioxidant and flavour protector. Its commercial source is soybean [8]. Lecithin has been employed by food processors to minimize sticking in confectionery manufacture. It also reduces viscosity, improves wetting and lowers melting point by several degrees [8]. It is also used in the non-food industries. Lecithin is a crystal inhibitor and prevents or reduces cloud formation in oils. Thus, the removal of certain quantities of phospholipids, such as lecithin, in the bleaching process resulted to increased crystallization (solidification) of oils. Hence, the observed high cloud points (32-36^{o}C) against the cloud point of the crude oil sample (24^{o}C) and consequently, the high melting point of the oils (34-37^{o}C) after the bleaching process and against the melting point of the crude oil sample (29^{o}C).

Result of the chemical properties of the crude and bleached oil samples is presented in table 3.The saponification numbers of the bleached oil samples range from 199.90 mgKOH/g (for the sample bleached with charcoal) to 201.94 mgKOH/g (for the sample bleached with fuller's earth). These values fall within a range of reported values of 190.1-201.7 for Malaysian palm oil sample [7]. The iodine values range from 59.07 (for the sample bleached with fuller's earth) to 59.60 (for the sample bleached with charcoal).The reported iodine value for Malaysian palm oil sample range from 50.6–55.1 [7].

Bleaching of the crude oil sample with the various adsorbent materials has equal effect on the saponification numbers and iodine values of the bleached oil samples. It has been reported that each fat/oil has, within the limits of biological variation, a constant fatty acid composition and also the concentrations and types of unsaturated fatty acids present in the fat/oil are fairly constant [9].This suggests that bleaching has no appreciable effect on the average molecular weight of fats or oils. However, the variation in the saponification numbers of the treated oil samples and that of the crude palm oil sample must have resulted from the high concentration of unsaponifiable matter in the crude oil sample. Values of the unsaponifiable matter range from 0.36, representing 57.14% loss of unsaponifiable matter (for the sample bleached with fuller's earth) to 0.48, representing 42.86% loss of unsaponifiable matter (for the sample bleached with charcoal).The reported unsaponifiable matter for Malaysian palm oil sample range from 0.15–0.99% (Anon, (1983) [7].The slip melting points of the samples bleached with the local adsorbents range from 33-34 ^{O}C (for the sample bleached with activated carbon to 36-37 ^{O}C (for the sample bleached with fuller's earth).The reported slip melting point for Malaysian palm oil sample range from 30.8–37.6 ^{O}C (Anon, 1983) [7]. These values are comparable.

Bleaching of the crude oil sample with fuller's earth resulted to reductions in the values of the unsaponifiable matter (57.14%), free fatty acid (88.03%) and peroxides (73.33%).These values are comparable to reductions in the values of the unsaponifiable matter (52.38%), free fatty acid (90.11%) and peroxides (76.67%) for the oil bleached with activated carbon. These results imply that activated carbon compares favourably with fuller's earth in the removal of unsaponifiable matter, free fatty acid and peroxides from crude palm oil. However, kaolin with reductions in the values of the unsaponifiable matter (47.62%), free fatty acid (82.59%), peroxides (70%) and charcoal with reductions in the values of the unsaponifiable matter (42.86%), free fatty acid (76.09%) and peroxides (66.67%) also have appreciable potentials in their abilities to reduce unsaponifiable matter, free fatty acid and peroxides in crude palm oil.

Conclusion

The adsorbent materials-fuller's earth, kaolin and activated carbon have reasonable abilities in the removal of carotenes (R-Band). They have very poor, but comparable abilities in the removal of xanthophylls (Y-Band) from crude palm oil. Activated carbon compares favourably with fuller's earth in the removal of unsaponifiable matter, free fatty acid and peroxides from crude palm oil. However, kaolin and charcoal also have appreciable potentials in their abilities to reduce unsaponifiable matter, free fatty acid and peroxides in crude palm oil.

The local adsorbent materials can equally serve well in oil refining process. However, a blend of fuller's earth and the local adsorbent materials may yield a more satisfactory result.

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