# Preliminary investigation of Ghanaian clays for decolorisation in the vegetable oil industry

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SUMMARY

Eight samples of clay obtained from several regions in Ghana have been examined for their decolorisation potential on vegetable oils. The results obtained from the preliminary investigation with palm kernel oils showed that the clay types are very similar to Bentonite from other parts of the world. All the clay samples had decolorisation potential, and it was also shown that with acid/heat activation, their decolorisation efficiency was raised to almost that of imported Fuller's Earth. This then raises the hope of a future exploitation of the clays in this direction.

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RÉSUMÉ

ATA, J. K. B. A. : *Recherches préliminaires sur les argiles ghanéennes, en vue de la décoloration industrielle des huiles végétales.* Huit échantillons d'argiles provenant de diverses régions du Ghana ont été examinés quant à leurs potentialités en vue de la décoloration des huiles végétales. Les résultats obtenus à la suite de premières investigations avec des huiles de palmiste ont montré que les argiles du Ghana sont très semblables à la bentonite provenant d'autres parties du monde. Tous les échantillons d'argile avaient des potentialités de décoloration; il a aussi été démontré qu'après une activation par un acide et le chaleur, leur pouvoir de décoloration s'est élevé sensiblement au niveau de celui de la terre de Fuller importée. Tout cela laisse espérer une future exploitation des argiles dans cette voie.

## Introduction

Fuller's Earth is the popular name for material that is used for decolorisation, through adsorption, in many industries including the vegetable oil refining industry. This material appears to be the same as Bentonite (Heilmann, 1958). Bentonite was the name given to a particular type of clay discovered near Fort Benton, in Wyoming (Knight, 1898). The clay which was composed essentially of montmorillonite, displayed colloidal properties. In recent times, the term Bentonite has been generalised and any clay displaying the above mentioned property is called bentonite.

Joshi *et al.* (1961) differentiated between Fuller's Earth and bentonites. The authors suggested that whilst Fuller's Earth had decolorising properties in the natural state, bentonites were either inactive or weak decolorising agents. Other types of clay such as the Pyzhevsk bentonite, the Kuteinikove tripolite and gumbrin which exist in large deposits in India, the United States and Russia, have been studied by Ozherel'ev, Gaivoronskaya & Bulat (1958) and found to have adsorption properties with respect to water vapour, ethyl alcohol, o-xylene and benzene. With all these clay types, it was shown that an activation treatment was necessary to increase the adsorption power. From the review, therefore, it is evident that clays, in general can be activated to improve their adsorption properties though there might be differences in origin and composition.

Various studies have been conducted into the activation of clays as reported, among others, by Bradley & Grim (1951), Kulcar (1953), Kuwada & Sagaware (1953), Preston & Raikes (1953), Sawyer & Gary (1959) and Grim & Kulbicki (1962). These have shown that one of the uses of clays, among others, is for the production of Fuller's Earth used for decolorisation in the vegetable oil industry.

The vegetable oil industry in Ghana is currently small but a sudden expansion seems likely to occur due to the increased oilseed production and the anticipated increase in oil mill capacity. The demand for Fuller's Earth, which is now about 600 tonnes per annum, is expected to increase. At present, clay types found in various parts of Ghana have commercial importance only with respect to their traditional decorative use.

Clay in Ghana is moulded into small oblong shaped balls, dried to reduce the moisture and sold in the open markets. This product which is called *Exe* (Ewe), *Hyirew* (Akan), *Ayilor* (Ga) and *Farinkasa* (Hausa) serves traditional purposes as follows:

(1) A large number of expectant mothers can be seen chewing the clay during pregnancy. This practice may have some nutritional backing because of the calcium oxide content, but it appears its function is to act as an adsorbent thus, minimising nausea, which is a common feature of pregnancy.

(2) During festive occasions such as (a) the sprinkling of yam by the fetish priest to mark the success of a good harvest, and (b) the performance of puberty rights and rituals for girls, the clay is mixed with other ingredients and used to make decorative marks and symbols on the body of the persons performing or undergoing the ritual.

With urbanisation and industrialisation, the traditional uses of clay are expected to reduce. In view of the possible similarity of the local clay to others developed for industrial uses, the experiments were designed to investigate the following areas:

(i) the chemical nature of Ghanaian clays;
(ii) the bleaching potential in a number of samples; and
(iii) parameters for activation.

## Materials and methods

*Investigating various clay samples*

Eight samples of clay obtained from different parts of the country and labelled as Accra, Kpando 1, Kpando 2, Takoradi, Barekese, Ashanti, Patakro and Brong Ahafo were all examined. All dried clay was milled and sifted to pass through a mesh size 12xx, BS 410. Imported Fuller's Earth, obtained from the vegetable oil mills division (GIHOC) was used as control. A market sample of palm kernel oil was used as the oil to be bleached. A standard bleaching technique was employed throughout the trials, i.e. 100 $cm^3$ of oil sample was placed in 500 $cm^3$ beaker over a hot plate. The temperature of the oil was raised to 90°C and 2 per cent (w/v) of Fuller's Earth or clay material was added and the oil stirred continuously for 30 min maintaining the temperature at 90 °C. After 30 min, the oil was filtered over a Buchner funnel using Whatman filter paper No. 1. The filtrate was cooled to room temperature (27 -28 °C) and its colour determined in a Lovibond tintometer using a 1-cm cell.

*Activation of clays*

The clay samples under investigation were subjected to an activation process. The method of activation was compounded from various methods described by Bradley & Grim (1951), Grim & Kulbicki (1961) and Joshi *et al.* (1961). In order to determine the exact parameters required for optimum activation, various trials were made by varying the temperature of activation and time of digestion in acid. Samples thus treated were compared for their decolorising efficiency using the method already described. For activation, 100 g of local clay powder (12xx, BS 410) was digested with 250 $cm^3$ of concentrated sulphuric acid for 3 h in a pyrex glass apparatus. After cooling, the acid was decanted and the solids washed with distilled water several times until the washings were neutral. The washing water was decanted and the solids dried at 100 °C for 1 h and then heated between 350-500 °C in an ashing furnace for about 2½ h.

The solids obtained after heat activation were sifted to obtain particle size passing through mesh size 12xx and used for subsequent decolorising trials.

In order to test whether the formula obtained for activation was reproducible, the Patakro sample was subjected to this treatment at random time intervals and its decolorisation efficiency tested, using the standard procedure. The yield of activated clay was also studied and expressed as a percentage on the original weight of clay material.

## Results and discussion

The results of the chemical analysis of the Ghanaian samples are shown in Table 1. The results show a close similarity between all the samples. The figures also compare favourably with figures quoted in the literature on bentonites. This would confirm the observation of Joshi *et al.* (1961) that clays are the same as the products generally described as bentonites.

The results in Table 2 show the bleaching potential of the clay samples in the native form, compared with Fuller's Earth, on unrefined palm kernel oil. The results clearly showed that there was colour improvement with each of the clay samples tested though not to the same extent as

the imported Fuller's Earth. This indication motivated the further exploration of the clay in its activated form.

Results shown in Tables 3 and 4 indicate the performance of the clay under various activation parameters. These were used to determine optimum condition of digestion and heat activation for the subsequent examination of the various clay samples. Acid digestion for 3 h followed by heat activation at 500 °C for 2½ h (Tables 3 and 4) was adopted as producing activated clay material with optimum bleaching. The results also confirmed the observation of Grim & Kulbicki (1962) that the natural decolorisation power of bentonite is greatly increased by acid heat activation.

The results shown in Table 5 indicate that the activation process described above is reproducible. The colour obtained from four trials with different batches of activated sample were very similar.

The results in Table 6 are an expression of the weight of activated dry clay obtained from 100 units of weight of raw clay sample. Six samples comprising three from Accra and three from Patakro gave fairly consistent figures. This also confirms the reproducibility of the method.

## Conclusion

The preliminary results obtained have shown that Ghanaian clays have similar chemical composition to clays described in other parts of the world as bentonites. The clays have decolorisation potential and when activated using acid and heat, the decolorisation effect increases. In some of the trials the decolorising effect of the clay after activation was close to imported Fuller's Earth. Even though only two clay samples out of the eight identified were used extensively in the trials, the results obtained with their performance prove the potential in them as decolorising agents in the vegetable oil industry. During the trials it was observed that the clay samples did not affect the flavour or chemical nature of the oil except to improve its colour through the adsorption of the coloring matter. The possibility of toxicity was not questioned because the analytical composition of the clays does not give rise to suspicion. Secondly, it is believed that the acid digestion and the heat activation processes render the product

TABLE 1

*Chemical Composition of Eight Samples of Ghanaian Clays*

| *Sample* | *$SiO_2$* | *$Al_2O_3$* | *$Fe_2O_3$* | *CaO* | *MgO* | *$Na_2O$* | *$K_2O$* | *$H_2O$* | *Total* |
|---|---|---|---|---|---|---|---|---|---|
| Patakro | 63.53 | 23.10 | 0.90 | 1.15 | 1.26 | 0.06 | 1.28 | 8.29 | 99.57 |
| Accra | 56.80 | 22.94 | 3.49 | 0.61 | 1.51 | 0.64 | 3.84 | 8.54 | 98.28 |
| Brong Ahafo | 62.99 | 23.25 | 1.25 | 0.31 | 0.76 | 0.26 | 2.56 | 7.59 | 98.97 |
| Ashanti | 66.82 | 18.80 | 2.00 | 0.91 | 1.26 | 0.18 | 2.08 | 7.35 | 99.40 |
| Kpando 1 | 67.84 | 13.70 | 2.25 | 1.40 | 2.02 | 0.64 | 3.20 | 8.67 | 99.72 |
| Kpando 2 | 47.17 | 29.94 | 3.74 | 0.35 | 1.51 | 1.04 | 2.72 | 11.42 | 97.89 |
| Takoradi | 58.16 | 22.78 | 2.74 | 0.85 | 2.52 | 0.18 | 3.36 | 9.41 | 100 |
| Barekese | 55.38 | 30.10 | 1.50 | 1.05 | 0.88 | 0.02 | 1.12 | 11.08 | 99.13 |
| Literature values of bentonites 1 | 55.44 | 20.14 | 3.67 | 0.50 | 2.49 | 2.75 | 0.60 | 14.70 | 100 |
| 2 | 50.20 | 16.19 | 4.13 | 2.18 | 4.12 | 0.17 | 0.16 | 15.58 | 92.75 |
| 3 | 49.78 | 17.12 | 2.95 | 0.90 | 3.71 | 1.27 | 0.27 | 15.48 | 91.48 |
| 4 | 67.42 | 15.83 | 0.88 | 2.64 | 1.29 | 0.90 | 1.00 | 10.80 | 100.71 |

TABLE 2

*Bleaching Potential of Some Local Clay Samples*

| *Sample* | *Colour of oil in Lovibond after bleaching at* | | | | | |
|---|---|---|---|---|---|---|
| | *2 per cent level* | | | *4 per cent level* | | |
| | *Red* | *Yellow* | *Blue* | *Red* | *Yellow* | *Blue* |
| Unbleached sample oil (1) | 4.3 | 25.0 | 0.3 | 4.3 | 25.0 | 0.3 |
| Imported Fuller's Earth | 1.1 | 4.0 | - | 0.3 | 1.2 | - |
| Takoradi | 1.5 | 8.0 | - | 0.9 | 3.6 | - |
| Barekese | 2.3 | 13.0 | - | 0.4 | 8.0 | - |
| Ashanti | 1.0 | 10.0 | - | 1.4 | 8.0 | - |
| Patakro | 2.2 | 14.5 | - | 1.7 | 9.0 | - |
| Unbleached sample oil (2) | 3.2 | 17.0 | - | 3.2 | 17.0 | - |
| Imported Fuller's Earth | 0.7 | 4.1 | - | 0.4 | 0.9 | - |
| Accra | 1.3 | 7.0 | - | 1.0 | 5.0 | - |
| Kpandu 1 | 1.6 | 7.0 | - | 0.9 | 4.0 | - |
| Kpandu 2 | 1.6 | 10.0 | - | 1.4 | 7.0 | - |

TABLE 3

*Lovibond Colour Comparison of Palm Kernel Oil Bleached with Clay Activated under Various Trial Conditions*

| *Sample* | *Lovibond colour* | | *Digestion time (h)* | *Heating temperature for 3 h (°C)* |
|---|---|---|---|---|
| | *Red* | *Yellow* | | |
| Unbleached sample oil | 5.2 | 27.5 | | |
| Bleached with Fuller's Earth 2 per cent | 2.6 | 13.0 | | |
| Accra sample | 3.4 | 19.1 | ½ | 500 |
| | 3.3 | 16.4 | 1 | |
| | 2.9 | 18.0 | 1½ | |
| | 2.5 | 14.0 | 2 | |
| | 2.4 | 13.0 | 2½ | |
| | 2.3 | 13.0 | 3 | |

TABLE 4

*Lovibond Colour Comparison of Palm Kernel Oil Bleached with Clay Activated under Various Trial Conditions*

| *Sample* | *Lovibond colour* | | *Digestion time (h)* | *Heating time at 500 °C (h)* |
|---|---|---|---|---|
| | *Red* | *Yellow* | | |
| Unbleached sample oil | 5.2 | 27.5 | | |
| Bleached with Fuller's Earth 2 per cent | 2.6 | 13.0 | | |
| Accra sample | 2.9 | 17.0 | 2½ | 1 |
| | 2.5 | 15.0 | | 2 |
| | 2.4 | 12.0 | | 2½ |
| | 2.2 | 13.0 | | 3 |

TABLE 5

*Lovibond Colour of Oil Bleached with Activated Clay Produced on Different Occasions*

| *Sample* | *Lovibond colour* | |
|---|---|---|
| | *Red* | *Yellow* |
| Patakro activated batch 1 | 1.6 | 8.0 |
| Patakro activated batch 2 | 1.4 | 7.6 |
| Patakro activated batch 3 | 1.4 | 7.6 |
| Patakro activated batch 4 | 1.4 | 7.7 |
| Imported Fuller's Earth | 1.3 | 6.5 |
| Original oil | 4.2 | 19.6 |

TABLE 6

*Laboratory Yield Figures on Production of Activated Earth*

| *Sample* | *Percent yield* |
|---|---|
| Accra 1 | 42 |
| Accra 2 | 46 |
| Accra 3 | 45 |
| Patakro 1 | 42 |
| Patakro 2 | 42 |
| Patakro 3 | 44 |
| Average | 43.5 |

microbiologically safe. Fuller's Earth prepared in a similar fashion does not present any toxic hazard.

From the point of view of its commercialisation, the yield figures have indicated that about 42 per cent of the original clay can become available as activated Fuller's Earth and it is hoped that attention will be drawn to the local resource in the development of activated earth for the future use of the food industry.

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