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# Craving Edible Clays: Anaemia or Androgens

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## Abstract

**Background:** The edible raw clay is common in Nigeria and other African countries, occurring mostly like white and grey clays and used frequently in traditional medicine as anti-diarrhoeal and skin smoothner. Some pregnant women swear by it as a solution to morning sickness typified by nausea and general malaise. There has been a noticeable increase in its consumption in recent times which for some individuals is a craving and notably so among pregnant women who most probably acquired the habit from their mothers. There is definitely, a dearth of information on its chemical constituents and therefore possible deleterious effects on the human system, to that end, this study was aimed at ascertaining the cause of the craving for the clays and acquire knowledge about its constituents, to check its health safety to consumers.

**Methodology:** Ethno-survey of edible raw clay consumption in Nigeria was carried out with more than 850 respondents from Lagos State, a cosmopolitan city of about 16 million people using a semi structured questionnaire. Mineralogical characterization using Proximate analysis, FTIR analysis, Atomic Absorption Spectroscopy, Acute toxicity studies, GC/MS analysis, Phytochemical assays and Haematological analysis on collected clays were used for evaluating the chemical constituents and effects on the living system.

**Results:** The survey results confirmed that the consumers are aware of possible side effects of raw clay consumption, the chemical analyses showed presence of metalloids like arsenic and silicon and heavy metals e.g. Mercury and Cadmium in the tested clays but they were in minute insignificant amounts. Phytochemical assays showed presence of anthraquinone, but not glycosides, alkaloids, saponins etc. GC analysis surprisingly showed presence of small quantities of androgens and steroids; dihydrocortisone and its metabolites in both the white and grey clays. No anaemia was recorded after 28 days of animal studies. The acute toxicity test showed that it is not toxic as no deaths were recorded at 5000 mg/kg dosage after 72 hours. The edible clays are not toxic to consumers but care should be taken because of possible adverse health effects from over-consumption and accumulation of contaminants.

**Keywords:** Atomic Absorption Spectroscopy; Androgens, Traditional Medicine; Gas Chromatography/Mass Spectrometry and Edible raw clay.

## Background

The edible raw clay is properly named "kaolin" which is derived from the word Kau-Ling, or high ridge, the name given to a hill near Jau-Chau Fu, China, where clay was first mined by Sepulveda, et al. [1]. Clay occurs as a mixture of different minerals and commonly contains 10-95% of the mineral kaolinite and traces of other minerals like mica, pyrophyllite talc etc, all in different colours depending on its geological formation and composition Mudi et al. [2] white or grey ones are consumed in Nigeria (**Figures 1A and 1B**). It is used in traditional medicine as anti-diarrhoeal and for smoothening the skin Bukola, et al. [3-8]. In this report, we use clay and kaolin interchangeably to mean the same thing.

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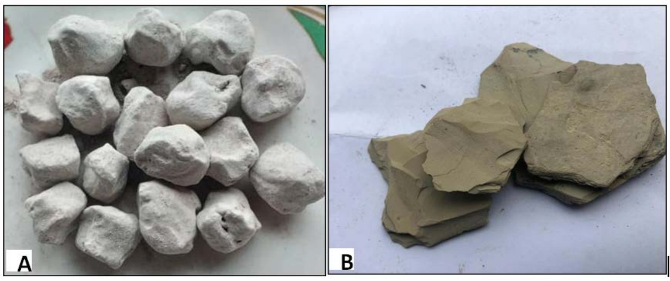


**Figure 1:** A; White clay B; Grey clay.

The study area; Lagos, is the largest city in the Nigerian state of the same name as well as in Nigeria and Sub-Saharan Africa. It is one of the fastest-growing cities in the world [9-12] and one of the most populous urban areas. It is inhabited by people from diverse ethnic groups; Igbos, Yorubas and Hausas.

Kaolin is distinguished from other industrial clays based on its fine particle size and pure colouring [3]. It is consumed by many people in the African continent and particularly in Nigeria [6]the behaviour/habit of eating soil is known as geophagia and usually classified as pica. Pica is the craving and purposive consumption of substances not culturally defined as food [3]. It is also defined as a psychological eating disorder shown by continuous consumption of largely non-nutritive substances,such as ice (pagophagia); hair (trichophagia); paper (xylophagia) or soil, (geophagia) [4,13].

Geophagia is global though most common with people of African descent [14, 15] whether living at home in Africa or abroad and can have serious negative effects on the health [6]. The consumption has been linked to the low educational background but the opposite is true for Nigeria where most of the sampling was carried out though some respondents lived abroad. Geophagia cuts across social strata and age, men and women purchase the clays from markets (**Figure 2**) or supermarkets and consume them , educated people and not so educated also do this. It seems to be a habit gets passed down from parents to offsprings or from friends to friends so it has a very social dimension.

**Figure 2:** Edible white clay on display at a local market. (Arrow on displayed clays).

There is a compulsion to the behaviour that defies reason as the materials being craved are dirt. It is endemic in different communities in the world though it is observed typically but not surprisingly at pregnancy [16,17] and because expectant women crave all sorts of things and locally believed to be as a result of anaemia and nausea associated with early trimesters of pregnancy but recent surveys have shown that non-expectant women and children also crave clays [16-19].

The root cause for soil craving has not been well described in the past and we deemed it necessary to know why these minerals, in particular are craved instead of assuming it has the same roots as other pica habits. We surveyed with specific questions to reveal the sometimes hidden reasons for the compulsion.

This research aims to chemically evaluate clay mined in Nigeria for their chemical contents and find out through semi-structured questionnaires, the reasons for raw clay consumption and possible craving. Our sample area was mushin and surulere local government areas in Lagos State, Nigeria. This area is in the Western part of Nigeria but is mostly cosmopolitan populated by people from all over Nigeria. The local names of edible clays are Igbo; Nzu, Hausa; Farar kasa, Benin; Eko and Efik/Ibibios; Ndom (**Figure 3 and 4**).


**Figure 3:** Map of Mushin and Surulere study areas of ethno-survey.

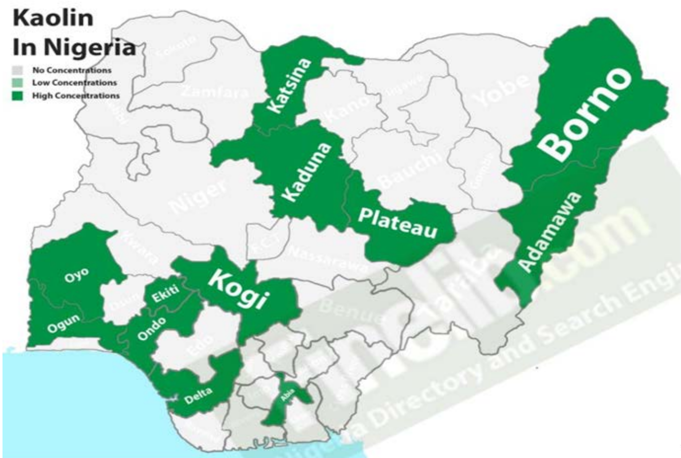


**Figure 4:** Map of Nigeria showing the distribution of raw clay [20].



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## Materials and Methods

**Materials**

The clay samples were bought from Mushin market located at 6°32′N 3°21′E Lagos,Nigeria in July 2019.

Beakers, test tube , test tube rack, conical flask, spatula, funnel, measuring cylinder, paper tapes, atomic absorption spectrophotometer (Thermo scientific, Series model 2004), oven, Kjeldahl digestion apparatus, Agilent cary 630, Analytical weighing balance, crucibles, electrical furnace, desiccator.

## Methodology

**Reagents:** Absolute ethanol, Methanol, Chloroform, Fehling A and B, Hydrochloric acid, Distilled water.

## Ethno-survey

A survey of clay consumption was carried out within Mushin and Surulere local governments in Lagos State, Nigeria. 850 respondents were given questionnaires (**Appendix 1**) and they responded and returned the papers. The study population was among adolescents and adults in Lagos state on their knowledge and consumption habit of clay. Data was collected from the study population and analyzed accordingly.

## Determination of the mineral contents using AAS spectroscopy

The method described by (Association of Official Analytical Chemists, 2005) was adopted. Calcium, potassium, sodium, magnesium iron, cadmium, lead, were analyzed from the triple acid digestion (wet digestion method). The concentration of metal is detected in mg/litre or ppm. The metal mg/100g= (Concentration of metal in ppm/weight of sample).

## Phytochemical assays

Phytochemical analysis was conducted on clay samples according to [8] using a modified analytical method.

## Fourier Transformer Infra-Red Spectroscopy analysis

The procedure used for FTIR spectroscopy analysis is that mentioned by Galindo and Viseras [7].

## Proximate analysis

## Determination of moisture content

The method described by (Association of Official Analytical chemist, 2005) was adopted.

## Ash content

The procedure uses a high-temperature muffle furnace capable of maintaining the temperature between 500°C and 600°C. Water and other volatile materials are vaporized and organic substances are burnt in the presence of oxygen to give $CO_2$, $H_2O$ and $NO_2$. The ash content is determined by the ignition of a known weight of food sample at 550°C until all carbon has been removed. The residue is the ash which is taken to represent the inorganic constituents of the food.

## Determination of Nitrogen and crude protein

The micro Kjeldahl method as described by (Association of Official Analytical chemist, 2005) was used.

## Carbohydrate determination (Anthrone method)

1 g of sample was weighed into a mortar, homogenized with 10ml 2.5% $H_2SO_4$, poured into a boiling tube and heated for 15 minutes at 100°C. The boiled mixture was allowed to cool and then filtered. Next, the filtrate was made up to 250 ml with distilled water. 10 ml was taken from the 250 ml and diluted to 100 ml with distilled water. Then, 1 ml was taken from the 100 ml into a clean boiling tube, 4 ml of Anthrone reagent (0.1g Anthrone powder dissolved in 100 ml concentrated sulphuric acid) was added and the reaction mixture was boiled for 10 minutes at 100°C. It was then cooled and the absorbance was recorded at 620nm wavelength. Glucose standard was also prepared by dissolving 0.1g D-glucose in 100 ml distilled water (i.e. 100 mg/100 ml glucose solution). 10 ml was taken from the 100 L of glucose solution and it was diluted to 100 ml with distilled water. Next, a serial dilution of glucose standard was prepared, 4 ml Anthrone reagent was added to it, boiled for 10 minutes and absorbance was read at 620 nm wavelength.

## Gas chromatography analysis

The sample to be tested was prepared by adding 10 mg of white and grey clay previously dissolved in 5 ml of water separately. GC analysis was then conducted on the samples using an aliquot of the sample, which was injected into the column and allowed to run for about an hour.

## Gas chromatography/Mass spectrometry

Each kaolin sample was extracted for the analysis by accurately weighing the test sample into a conical flask; n-Hexane and Dichloro-ethane were used for the derivatization. The mixture was filtered using Whatman-42 filter paper. The filtrate was taken through column chromatography in a glass column packed with pre-heated/cooled silica gel as its stationary phase while n-Hexane was the mobile phase. (The silica gel was pre-activated in an oven at 103°C for 2 hours). Anhydrous Sodium sulphate was added to absorb any available moisture in the system. The resulting evaluate from the chromatographic column was concentrated to about 2 ml in the fume cupboard and stored in a glass vial for subsequent injection into the Gas Chromatography-Mass Spectrometer. Agilent 7820 Å Gas chromatograph coupled to a 5977E Mass spectrometer was used in analyzing the sample for about 30 minutes.



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## Hematology

20 female Wister rats randomly distributed into 4 groups were used for these studies. They were housed in the animal house of the college of Medicine campus following stipulated ethical procedures for animal studies (Approval: CMUL/HREC/0728/19). Animals were fed and observed for a period of 28 days, the blood sample was randomly collected from 5 animals for hematology before the first treatment with the test sample, then after 14 days of treatment with the test drug and lastly on the 28th day of treatment with the test drug (**Table 1**).

| Groups | Amount of edible clay fed the animal |
|---|---|
| Control | Water |
| Low Dose | 250 mg/kg |
| Medium Dose | 500 mg/kg |
| High Dose | 1000 mg/kg |

**Table 1:** Treatment Plan.

## Acute toxicity

A total of six albino mice were used for the studies, Test drug; 1 g of kaolin powder was weighed and mixed in 5 ml of purified water was administered orally to the animals and they were observed for 72 hr.

## Result

| Variables (Age Years) | Frequency(N=850) | Percentage% |
|---|---|---|
| 13-20 | 128 | 15.1 |
| 21-40 | 482 | 56.7 |
| 41-60 | 204 | 24 |
| >60 | 36 | 4.2 |

**Table 2:** Socio-demographic data of respondents in ethno-survey of edible clay consumption in Nigeria.

The ethno-surveys showed that 574 (67.5%) of the respondents know white clay and 493 (58.0%) know grey clay while 276 (32.5%) do not know white and grey clay. The level of knowledge of clay and its consumption result showed that 445 (52.4%) respondents had eaten either white or grey clay while 405 (47.6%) have not. More respondents had eaten clay as teenagers 215 (25.3%) than as adults 58 (6.8%). Respondents who felt the need to eat clay were 390 (45.9%), This is significant as they experienced an urge to eat it though 405 (47.6%) says it is not applicable which could be out of natural reticence or not been willing to real craving dirt. This is based on information during an oral interview where the respondent was ashamed to let her family know that she craves and eats clay. 55 (6.5%) did not feel a need while did not have a response which could be that they may be embarrassed about the habit. Some respondents, Table 3, 149 (17.5%) like the taste of clay, 91 (10.7%) liked the odour, 138 (16.2%) ate clay because their friends ate it while 67 (7.9%) cannot seem to help themselves while 405 (47.6%) had no response (**Tables 2-4**)

| Variables | Frequency (N=850) | Percentage % |
|---|---|---|
| Do you know white clays? | | |
| Yes | 574 | 67.5 |
| No | 276 | 32.5 |
| Do you know grey clays? | | |
| Yes | 493 | 58 |
| No | 357 | 42 |
| Have you ever eaten white or grey clays? | | |
| Yes | 445 | 52.4 |
| No | 405 | 47.6 |
| When did you first eat clay? | | |
| As a child | 172 | 20.2 |
| Teenager | 215 | 25.3 |
| Adult | 58 | 6.8 |
| Not applicable | 405 | 47.6 |
| Do you know other people who eat clay? | | |
| Yes | 390 | 45.9 |
| No | 55 | 6.5 |
| Not applicable | 405 | 47.6 |
| Do you feel a particular need to eat clay? | | |
| Yes | 224 | 26.4 |
| No | 221 | 26 |
| Not applicable | 405 | 47.6 |
| Can you get clay easily? | | |
| Yes | 300 | 35.3 |
| No | 144 | 16.9 |
| Not applicable | 406 | 47.8 |

**Table 3:** Knowledge of edible clay and behaviors.

The silicon content in white clay is greater than that of grey clay figure 5A. Aluminum, potassium, sodium and magnesium were all present in both clays. There is very little iron recorded. Proximate analysis data shows that white clay has the highest ash content (94.83%) (**Figures 5A-C and 6-9**).



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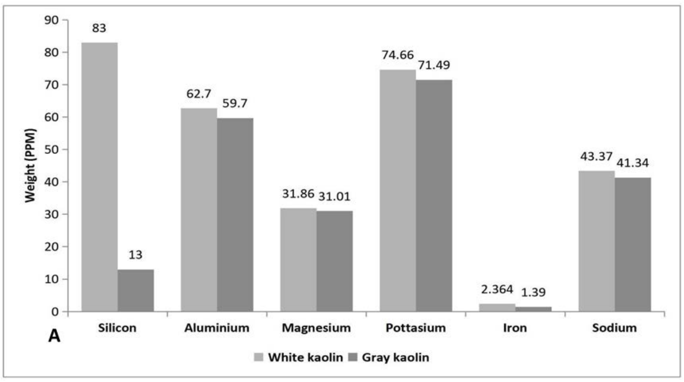
| Variables | Frequency (N=850) | Percentage % |
|---|---|---|
| Why do you eat clay? | | |
| I like the taste | 149 | 17.5 |
| I like the odour | 91 | 10.7 |
| My friends were eating it | 138 | 16.2 |
| I can't seem to help myself | 67 | 7.9 |
| Not applicable | 405 | 47.6 |
| Is there a particular time you eat clay? | | |
| Morning | 18 | 2.1 |
| Afternoon | 47 | 5.5 |
| Evening /Night | 55 | 6.5 |
| Any time | 325 | 38.2 |
| Not applicable | 405 | 47.6 |
| Do you feel any discomfort after eating clay? | | |
| Yes | 148 | 17.4 |
| No | 297 | 35 |
| Not applicable | 405 | 47.6 |
| What kind of discomfort? | | |
| Stomach pain | 42 | 4.9 |
| Constipation | 76 | 8.9 |
| Diarrhoea | 10 | 1.2 |
| Bloating | 20 | 2.4 |
| Not applicable | 702 | 82.6 |

**Table 4:** Knowledge of effects of consuming clay.



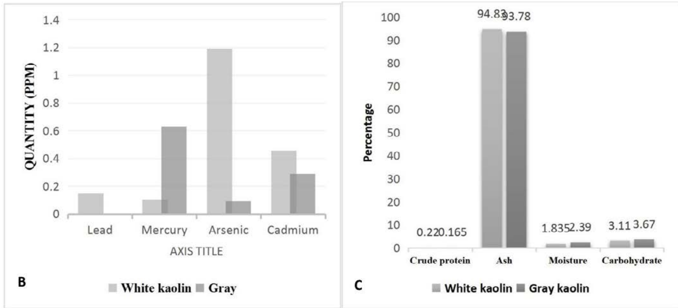




**Figure 5A-C:** A: Metals in clay samples measured in weight PPM from AAS analysis; B: Heavy metals as found in grey and white clay from AAS analysis(PPM); C: Constituents of grey and white clay from proximate analysis.

## FTIR Assay

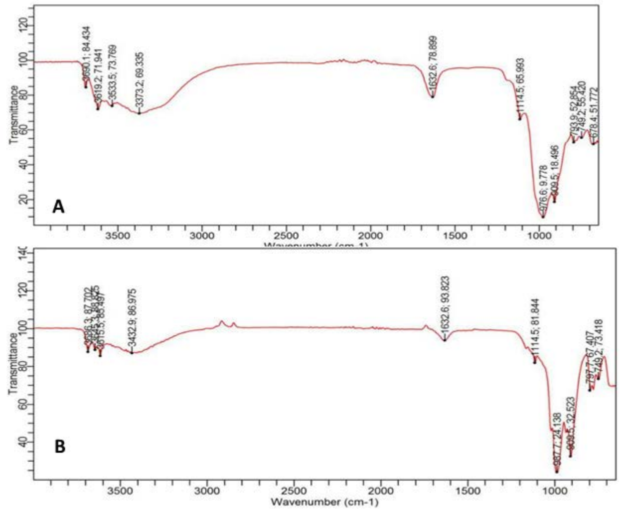



**Figure 6A-B:** A: FTIR interferogram of gray clay; B: FTIR interferogram of white clay.

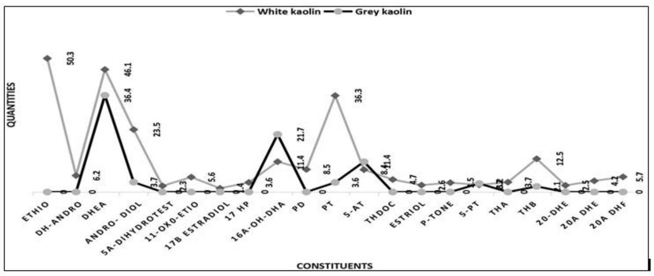



**Figure 7:** Organic compounds present in white and grey clay from GC analysis.

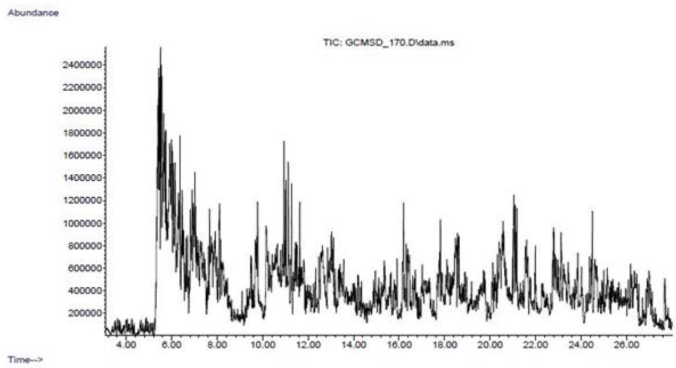



**Figure 8:** GC Chromatogram for grey clay.



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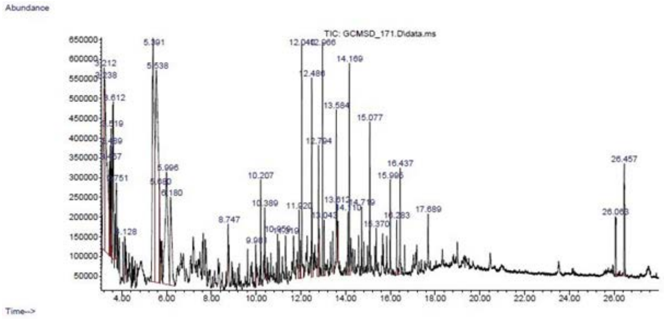


**Figure 9:** GC Chromatogram for white clay.

There was a significant reduction in lymphocyte values at 250mg and 1000mg dosage treatment when compared to the control at day 14 and 28 (**Figures 10 A and B**). Hemoglobin values did not change significantly as the days of treatment progressed.

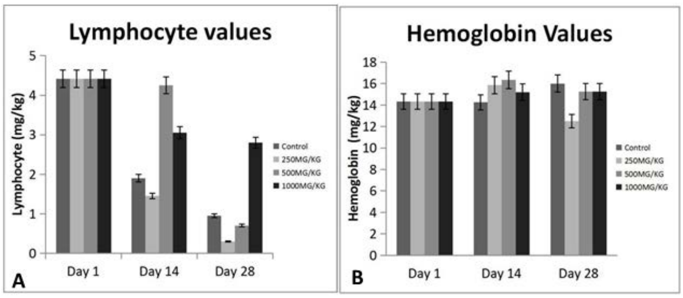
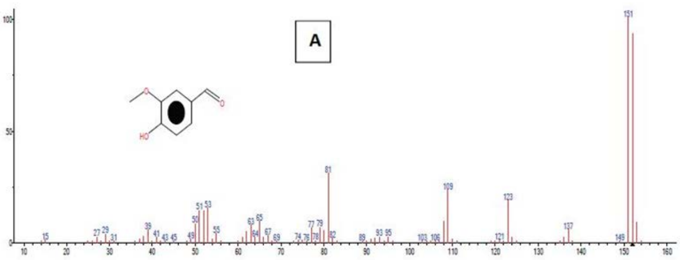



**Figure 10A-B:** A: Effects of different concentration of white clay on blood lymphocytes of Wistar rats; B: Effects of different concentration of clay in the Hemoglobin.



## Discussion and Conclusion

The knowledge of health benefits and side effects derived from clay showed that 226 (22.6%) of respondents felt white clays are useful for health, 219 (25.8%) Table 4, felt it was not useful to health. Respondents who noticed side effects of clay were 263 (30.9%), 182 (21.4%) who did not notice any side effect of clay, most respondents 405 (47.6%) did not get any response. The belief of side effects of anaemia occurred in 158 respondents, constipation in 79 respondents, and cancer in 29 respondents. However, 587 had no response. Respondents who had stomach discomforts were 42 (4.9%), 76(8.9%) had constipation, 10 (1.2%) had diarrhea, 20 (2.4%) had bloating while 702 (82.6%) had no discomfort. The understanding was that women ate clay more than men [21-23] and the results collected from the survey seems to point that way 62% of respondents are female who ate clay. (**Figures 11 A-D, Figures 12 A-B**).

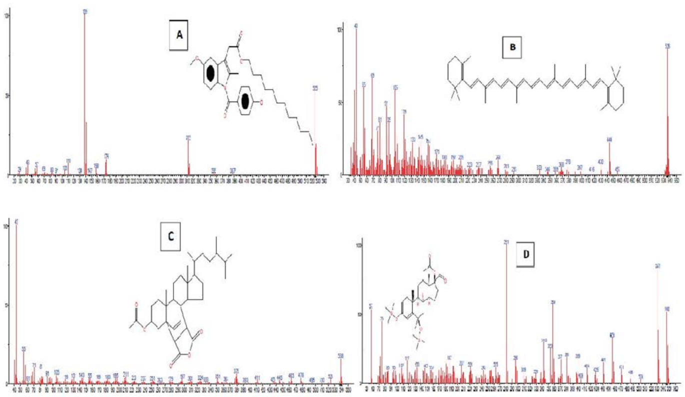


**Figure 11A-D:** A: Chromatogram of Indomethacin in grey kaolin; B: Chromatogram of beta Carotene in grey kaolin; C: Chromatogram of Cholestan-6-en-3-ol in grey kaolin; D: Chromatogram of Pregna-2,4-dien-20-one in grey kaolin**.**

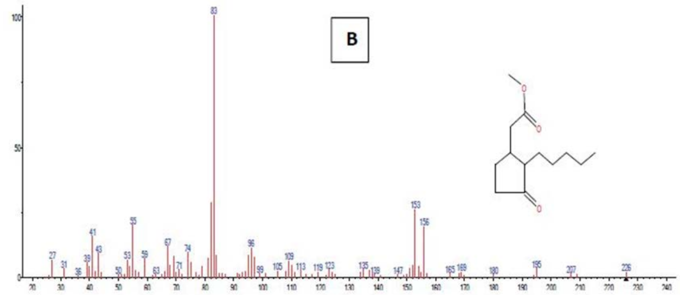


**Figure 12A-B:** Chromatogram of Vanillin in white kaolin B. Chromatogram of cyclopentaneacetic acid in white kaolin.

Female respondents showed that 98 (11.5%) women eat clay while pregnant, 133 (15.6%) do not eat clay while pregnant while 619 (72.8%) do not fit into the category. Amongst the women who eat clay while pregnant 24 (2.8%) eat clay because it prevents nausea, 33 (3.9%) eat clay because it helps the child and they feel like eating it while 8 (0.9%) had no reason. Association between respondent's knowledge of white clay and side effects of clay shows that there's a significant association between respondent's knowledge of white clay and their side effects with a p-value $< 0.05$ indicating significance. The strength of FTIR applied to clay mineralogy lies in its ability to characterize the functional group and fingerprint regions of very small quantities of samples (**Figures 6A and B**) [17].

Proximate analysis data shows that white clay has the highest ash content (94.83%) (**Figures 5A-C**), generally, high ash content is an indication that the compound contains abundant mineral content. The moisture content was lower when compared to grey clay suggestive that low moisture content is desirable as it discourages growth of bacteria and mould, which decreases instability and increase shelf storage capacity [14]. Previous studies [15] on geophagia found out that glucose levels were much greater in mice in the clay stationary groups compared to rotated mice and "No clay" controls. This may indicate the presence of a carbon source in the clay samples, which might explain the euphoria and satisfaction felt after consumption by people practicing clay



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geophagia however this data cannot be fully supported from the result established above.

The crude protein present in the sample is too minute to make a significant contribution to dietary consumption. Elemental analysis data carried out on the samples using AAS showed that white clay contains 0.149 ppm of Lead (Pb) which compared to the standard set by Kariuki et al [18] is 0.2, 0.1 and 0.3 ppm respectively for Pb, Cd and Hg. The value of lead in clay is below accepted limits. However suggested maximum value of lead consumption is 0.01 ppm or 3 mg/week [19]. Grey clays had no trace of lead which typically targets multiple organs in the body due to its systemic toxicity causing cardiovascular, renal, gastrointestinal and hematological effects [21].

White and grey clays contained 0.101 ppm and 0.631 ppm of mercury respectively. The value of grey clay is above the standard limit, it has been established that consumption of mercury may lead to kidney damage [22]. They also contained 0.458 and 0.289 ppm of cadmium respectively. White clay had above the limit compared to the standard which is 0.1 ppm.

However, The Joint FAO/WHO had recommended a 0.007 mg/kg bodyweight limit for cadmium. Elevated concentrations of Cadmium in foodstuffs have been associated with kidney disorders [15]. Arsenic present are 1.191 ppm and 0.092 ppm in white and grey clay respectively. Chronic oral exposure of humans to inorganic arsenic at doses as low as 0.05-0.1 mg/kg/day is frequently associated with neurological or hematological toxicity [15] .The safety limit of arsenic in soil ranges 5-20 ppm that will not have harmful effects for a long time [23]. Arsenic at over 0.01 ppm is toxic [24]. Huge soil consumption could lead to severe vomiting, disturbances in blood circulation, damage to the nervous system and eventually death [21]. Magnesium was 31.86 and 31.01 ppm, Potassium, 74.66 ppm and 71.49 ppm and Sodium 43.37 ppm and 41.34 ppm in white clay and grey clays. Geophagious ingestion of these clay minerals could cause Potassium absorption increase due to altered cat ion exchange capacity, in a biological system; potassium is required in the amount of 4700 mg/day [25]. The level of potassium in the samples can cause a deleterious effect depending on the level of consumption.

Iron present in the clays was 2.364 ppm and 1.39 ppm respectively in white and grey. Recommended daily value for iron is 8 mg/day, furthermore, the safety limit of iron intake suggests a maximum of 45 mg/day. Several studies about clay consumption depicted iron deficiency leading to anaemia. This can be easily inferred that Iron mal absorption is very common due to the ion exchange capacity of the soil and contaminants [26] but our results (**Figures 10 A & B**) show iron present in the samples was high which suggest its abundance in clay. There were noticeably high levels of potassium and iron in geophagia clayey samples can result in anaemia among pregnant women and children [15]. The Aluminum content was 62.7 ppm and 59.7 ppm and Silicon was 83.0 ppm and 13.0 ppm white and grey clays respectively. Aluminum content is higher in grey than in white clay.

Phytochemical analysis carried out on the clay samples showed that the samples did not contain tannins, saponins, flavonoids, cardiac glycosides, alkaloids, steroids or reducing sugar. This is different from a 2017 finding who reported presence of reducing sugars and steroidal nucleus in grey clay. However, a test for anthraquinone was positive in white clay but not in the grey clays.

To eliminate the uncertainty of minerals identification based on functional grouping FTIR spectrophotometry was used. The IR bands representing the Kaolinite hydroxyls for white and grey kaolin have been experimentally observed as 3533 $cm^{-1}$, 3373 $cm^{-1}$, 3686 $cm^{-1}$, 3645 $cm^{-1}$, 3615 $cm^{-1}$ and 3432 $cm^{-1}$. The OH, deformation bands were observed at 913 and 909 cm-1. Bands associated with SiO stretching were 793 $cm^{-1}$, 797 $cm^{-1}$, 749 $cm^{-1}$ and 691 $cm^{-1}$, whereas SiO deformation bands were 1099 $cm^{-1}$ and 1114 $cm^{-1}$. Peaks for theoretical kaolinite, defined as pure kaolinite with the chemical formula $Al_2Si_2O_5(OH)_4$, are also given. Other peaks corresponding to smectites, muscovite and quartz were equally observed.

Kaolinite has an absorption band between 3500 $cm^{-1}$ and 3700 $cm^{-1}$ corresponding to the stretching frequency of the OH group. When the four characteristic bands (3700 $cm^{-1}$, 3760 $cm^{-1}$, 3650 $cm^{-1}$ and 3620 $cm^{-1}$) are well defined, the structure of kaolin is ordered. When the band at 3670 $cm^{-1}$ disappears, the kaolinite structure is disordered and easier to dehydrate [27].

Peak values obtained for the highest frequencies observed in the kaolinite samples were the stretching OH vibrations occurring for these samples between 3620 $cm^{-1}$ to 3697 $cm^{-1}$, but only white kaolin exhibited a peak at 3432 $cm^{-1}$ which is suggestive of mica. There was no interference of peaks occurring at these highest frequencies where stretching the OH vibrations occur in white and grey kaolin similar to the observations of [22]. Interferences of peaks were however observed at lower frequencies (between 111 $cm^{-1}$ _ 500 $cm^{-1}$) of bending vibrations [27]. Within this range of wavelength, main functional groups were SiO and Al-OH. The Al-OH absorption peak was identified for grey kaolin and white kaolin at 909 $cm^{-1}$ for theoretical kaolinite it is at 919 $cm^{-1}$, 909 $cm^{-1}$. Possible peak interferences of quartz in the region of 697$cm^{-1}$; smectites at 797$cm^{-1}$ and muscovite at 749 $cm^{-1}$ for white and grey kaolin could only be inferred.

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