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# Analysis of geophagic materials consumed by pregnant women in Eldoret municipality, Kenya

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Pregnancy period is the most nutritionally demanding time of a woman's life. All the nourishment needed by the developing fetus comes from the mother; either from the foods she eats or the supplements she may take. It is important that a pregnant woman eats the right foods everyday for proper tissue and organs development. However a high percentage of pregnant women experience *geophagy* - the most common of an array of 'cravings' for exceptional foods or non-food substances occurring during pregnancy. The craving for substances with little or no nutritional value is associated with mineral deficiency. The geophagic materials from Kamukunji quarry, Eldoret open market and leading supermarkets in Eldoret town in Kenya were subjected to standard digestion procedures and analyzed for Fe, Zn, Mg, Cu, Na, Pb and Cd by Atomic Absorption spectroscopy. Analysis results showed that the geophagic materials contain elevated concentrations of the mineral nutrients, the highest being that of Fe (15.04ppm) for a 0.3 g sample. Geophagic materials from Kamukunji quarry and Eldoret open showed the highest amounts of lead, with an average of 8.34ppm and 9.34ppm respectively for a 0.3g sample material. The concentration of Cadmium was negligible in all samples analyzed.

*Key words*: Pregnancy, Mineral nutrients, Heavy metals, geophagy, Kenya

## Introduction

The changes in nutritional needs during pregnancy are related to the body's adaptation to its present condition. Food cravings and aversions sometimes accompany pregnancy as a result of taste bud changes often reflecting the body's nutritional needs. Such changes are partly due to the nourishment demands of the fetus and partly due to other physiological variations that affect absorption and metabolism of nutrients. They help to ensure normal development of the baby and fill the subsequent demand of lactation or nursing (Tessmer, 2005; Willis, 1990)

To give birth to a healthy thriving baby, the nutritional value of a woman's diet is just as important as the total intake of calories. The consequences of maternal malnourishment may include health problems for the mother, and an infant of low birth weight who may have nutritional and other deficiencies (Christian and Greger, 1994)

Nutrients for the fetus come from the mother's diet, stored nutrients in the mother's bones and tissues, and synthesis of certain nutrients in the placenta. The placenta facilitates the transfer of nutrients, hormones and other substances from mother to fetus. Sometime, a mother to be requires vitamin or mineral supplements, especially iron, calcium, and folate while some women require vitamin D. During pregnancy, a woman's protein requirements are greater than normal. The functions and deficiencies of some mineral nutrients are highlighted below (Willis, 1990)

Iron is the main component of haemoglobin, which carries oxygen through the body. Pregnant women should eat iron-rich foods to prevent iron deficiency. During pregnancy, a woman's blood supply increases to supply nutrition to the growing fetus. Iron deficiency may cause iron-deficiency anemia. It is practically impossible to get enough iron from food and supplements are usually recommended. Routine prenatal care is a good way to determine if a woman should take an iron supplement during pregnancy (Tessmer, 2005).

Calcium is essential for maintaining the bone integrity of a pregnant woman and providing the skeletal development of the fetus. Women should increase their intake of calcium-rich foods, such as milk products. Although sodium need not be restricted during pregnancy, excessive intake of salt can cause high blood pressure. It can also lead to excessive weight gains. "Junk" foods that are high in sodium should be avoided (Jones and Hudson, 2003). Low zinc levels during pregnancy are associated with long labor and small babies who may have health problems (Rohrs, 1999; Brown 1995).

Magnesium is an essential mineral and is needed for bone, protein, and fatty acid formation, making new cells, activating B vitamins, relaxing muscles, clotting blood, and forming ATP—the energy the body runs on. The secretion and action of insulin also require magnesium. It also improves our natural immunity and protects the cells against a range of diseases. Magnesium deficiency is rare (Abbott, 1993; Apovian, 2005).Presence of heavy metals such as lead could be a heath risk if consumed in large amounts as this can cause defects to the fetus. Lead poisoning builds up slowly over time and accumulates in the bones. This occurs from repeated exposure to small amounts of lead. In this case, there may not be any obvious symptoms, but the lead can still cause serious health problems over time, such as difficulty sleeping or lowered IQ in children. Lead is much more harmful to children than adults because it can affect children's developing nerves and brains. The younger the child, the more harmful lead can be. Unborn children are the most vulnerable (Bleecker, 2005; Markowitz, 2000). Exposure to low levels of cadmium presents the risk of hypertension through cadmium-accelerated atherosclerosis. Exposure to cadmium may cause kidney damage (Nomiyama, 2000; Järup *et al.*, 2000).

Geophagy is the habit of deliberately eating clay or earth and is common in many societies (Abrahams and Parsons, 1996; Luoba et al., 2004). Whilst geophagy is not limited to certain geographical areas or human societies, the practice can be recognized to be more common among some groups of people. These include societies of low economic status living within the tropics (Abrahams *et al.*, 2006).

Geophagy is regarded as the most common of an array of 'cravings' for exceptional foods or non-food substances occurring during pregnancy (Lacey, 1990; Geissler *et al.*, 1998).

The study aimed at establishing the mineral nutrient content of the geophagic materials consumed by pregnant women in Eldoret municipality, Kenya. The study also aims to establish the amount lead and cadmium in these geophagic materials.

## Materials and methods

### *Sampling*

The geophagical sample materials were collected from Kamukunji quarry, at the Western outskirt of Eldoret town. Eldoret town is 350km West of Nairobi. Other geophagic materials were purchased from leading supermarkets and from the open markets in Eldoret town. The geophagic materials from leading supermarkets are labeled as roasted clay and sold in 50g and

100g polythene packets. Geophagic materials obtained from the open market are commonly sold in accordance with the purchasing power of the consumer, the least amount going for as low as KShs 2, with a weight range of 20 g to 35 g.

*Sample texture analysis*

A 50g portion of air-dried sample was weighed into a 400 ml beaker and saturated with distilled water and 10 ml of 10% calgon (sodium hexametaphosphate) solution. The mixture was allowed to stand for 10 minutes. The suspension was transferred to a dispensing cup and 300 ml of tap water added. The suspension was mixed for 2 minutes with a magnetic stirrer. After transferring the suspension into a graduated cylinder, a hydrometer was inserted into the suspension and 1130 ml of water added. The hydrometer was removed, the cylinder covered with a tight-fitting rubber bung and the suspension mixed thoroughly by inverting the cylinder several times. The time was noted and 2 drops of amyl alcohol added quickly to the sample suspension to remove froth. A hydrometer was placed gently into the column after 20 seconds, and its readings and that of the temperature taken after 40 seconds. The suspension was mixed again by inverting several times and allowed to stand for 2 hours. The hydrometer and temperature readings were taken and necessary temperature corrections made. The percentage sand, silt and clay were calculated according to a formula given by Okalebo *et al.,* 2002.

*Digestion of samples and preparations of stock solutions*

A digestion mixture for sample material treatment for extractions was prepared by adding 0.42g selenium powder and 14g lithium sulphate to 350ml of 30% hydrogen peroxide and thoroughly mixed. A volume of 420ml of concentrated $H_2SO_4$ was added slowly to the mixture while cooling in an ice bath. The mixture was stored at $2^0$C. A 0.3g of oven dried (at $70^0$C) geophagic material was finely ground and put in a dry clean digestion tube. Four replicates were prepared. A volume of 4.4ml of the prepared digestion mixture was added to each tube as well as to two reagent blanks for each batch of samples. The mixture was digested at $360^0$C for 2 hours. The resulting colourless solution was cooled to room temperature. A volume of 25 ml distilled water was added and mixed well to dissolve the sediment. The solution was topped up to 50 ml mark with distilled water in a volumetric flask and allowed to settle.

Standard procedures for the preparation of stock solutions for Na, Ca, Fe, Zn, Mg, Pb and Cd were employed. The standard stock solutions were used to prepare serial solutions for the determination of these elements in the samples using Atomic Absorption Spectroscopy.

## Results and Discussions

Analysis of soil texture of the samples indicated that samples collected from the Super Market had by far the greatest percentage of sand and clay particles. Material from Kamukunji quarry and open market had higher percentage of silt. Results of the analysis are summarized in Table I.

**Table I. A**nalysis of sample soil texture

| | Geophagic material | | |
|---|---|---|---|
| | Kamukunji Quarry | Open Market | Supermarket |
| % Sand | 48 | 49 | 66 |
| % Clay | 8 | 8 | 22 |
| % Silt | 44 | 44 | 12 |
| Textural Class | Silt Loam | Silt Loam | Sandy Loam |

Samples from Kamukunji quarry gave a mean value of 14.2ppm for Fe for a 0.3g sample. The mean values for Zn, Mg, Cu, Na, Pb and Cd were 0.5, 0.9, 0.1, 0.4, 8.3 and 0.01ppm respectively. The results showed a high concentration of Fe and Pb compared to other elements analyzed. These results are summarized as descriptive data in Table II.

**Table II.** Descriptive data analysis of the results for the samples from the Eldoret Kamukunji quarry

| | Element | | | | | | |
|---|---|---|---|---|---|---|---|
| | Fe | Zn | Mg | Cu | Na | Pb | Cd |
| Mean | 14.18 | 0.50 | 0.92 | 0.11 | 0.41 | 8.34 | 0.01 |
| Standard Error | 0.78 | 0.10 | 0.05 | 0.02 | 0.16 | 0.92 | 0.00 |
| Standard Deviation | 3.49 | 0.46 | 0.23 | 0.08 | 0.71 | 4.11 | 0.01 |
| Sample Variance | 12.19 | 0.22 | 0.06 | 0.01 | 0.51 | 16.87 | 0.00 |
| Minimum | 5.80 | 0.0000 | 0.50 | 0.00 | 0.00 | 0.70 | 0.00 |
| Maximum | 18.26 | 1.06 | 1.25 | 0.22 | 2.62 | 17.90 | 0.04 |
| Sum | 425.40 | 14.97 | 27.54 | 3.23 | 12.41 | 250.20 | 0.24 |
| Sample size | 30 | 30 | 30 | 30 | 30 | 30 | 30 |

Samples obtained from the Eldoret open market showed a mean value of 15.0ppm for Fe. The mean values for Zn, Mg, Cu, Na, Pb and Cd were 1.0, 0.5, 0.2, 0.3, 9.3 and 0.03 ppm respectively. The results indicated a high concentration in Fe and Pb compared to other elements analyzed. These results are summarized as descriptive data in table III.

Samples obtained from the Eldoret town leading supermarkets showed a mean value of 9.8ppm for Fe. The mean values for Zn, Mg, Cu, Na, Pb and Cd were 0.3, 0.4, 0.5, 0.5, 4.1 and 0.03ppm respectively. Compared to the other geophagic materials analyzed, the samples from the Eldoret town supermarkets had lower concentrations of Fe and Pb. These results are summarized as descriptive data in table IV.

**Table III.** Descriptive data analysis of the results for the samples from the Eldoret open market

| | Element | | | | | | |
|---|---|---|---|---|---|---|---|
| | Fe | Zn | Mg | Cu | Na | Pb | Cd |
| Mean | 15.04 | 0.97 | 0.51 | 0.23 | 0.26 | 9.34 | 0.03 |
| Standard Error | 0.50 | 0.02 | 0.04 | 0.00 | 0.07 | 0.41 | 0.00 |
| Standard Deviation | 2.25 | 0.07 | 0.19 | 0.02 | 0.29 | 1.83 | 0.02 |
| Sample Variance | 5.08 | 0.01 | 0.04 | 0.00 | 0.09 | 3.37 | 0.00 |
| Minimum | 11.25 | 0.87 | 0.30 | 0.19 | 0.00 | 5.70 | 0.00 |
| Maximum | 18.25 | 1.12 | 0.87 | 0.26 | 0.88 | 12.68 | 0.06 |
| Sum | 451.16 | 28.98 | 15.18 | 6.87 | 7.70 | 280.32 | 0.95 |
| Sample size | 30 | 30 | 30 | 30 | 30 | 30 | 30 |

**Table IV.** Descriptive data analysis of the results for the samples from Eldoret town supermarkets

| | Element | | | | | | |
|---|---|---|---|---|---|---|---|
| | Fe | Zn | Mg | Cu | Na | Pb | Cd |
| Mean | 9.81 | 0.33 | 0.43 | 0.53 | 0.51 | 4.13 | 0.03 |
| Standard Error | 0.66 | 0.03 | 0.01 | 0.02 | 0.04 | 0.38 | 0.01 |
| Standard Deviation | 2.96 | 0.08 | 0.03 | 0.10 | 0.16 | 1.68 | 0.05 |
| Sample Variance | 8.75 | 0.01 | 0.00 | 0.01 | 0.03 | 2.83 | 0.00 |
| Minimum | 5.50 | 0.12 | 0.38 | 0.39 | 0.31 | 2.24 | 0.00 |
| Maximum | 14.96 | 0.46 | 0.49 | 0.66 | 0.85 | 6.60 | 0.16 |
| Sum | 294.36 | 9.92 | 12.81 | 15.95 | 15.34 | 123.77 | 0.83 |
| Sample size | 30 | 30 | 30 | 30 | 30 | 30 | 30 |

Geophagy is very common among pregnant women (Luoba *et al.*, 2004). These geophagic materials supplement the much-needed nutrients in the body, especially for the pregnant women who crave for these materials. A pregnant woman requires higher amounts of mineral nutrients compared to a non-pregnant woman. The daily mineral nutrient requirements of Ca, Mg Fe and Zn are presented in table V.

**Table V.** Mineral nutrient needs during pregnancy: Recommended daily Allowances (RDA)

| Mineral nutrient | Non-pregnant | Pregnant |
|---|---|---|
| Calcium (mg) | 1000 | <19yrs.=1300<br>19-50yrs.= 1000 |
| Magnesium (mg) | 700 | <19yrs.=1250<br>19-50yrs.= 700 |
| Iron (mg) | 15 | 30 |
| Zinc (mg) | 12 | 15 |

**Source:** Committee on Dietary Allowances. Food and Nutrition Board Washington, D.C.: National Academy of Sciences, 1989, 1997, and 1998.

Consumption of 10g of geophagic material from Kamukunji quarry would provide 0.14mg of Fe. Similarly, a 10g geophagic material from the open market and supermarkets would provide 0.15mg and 9.8x $10^{-3}$ mg of Fe respectively.

Samples from the open market whose main source is the Kamukunji quarry showed the highest levels of lead concentrations compared to the other samples. This could be due to the fact that the material is sold in the open without any prior packaging. The materials are exposed to exhaust fumes from the heavy traffic common in the area. The concentration of Pb in the geophagic materials from the open market was higher compared to those from Kamukunji quarry. However, the amounts of lead in all the samples did not exceed the recommended EPA (Environmental Protection Agency) standard levels. The EPA's standard for lead in bare soils in play areas is 400 ppm by weight and 1200 ppm for non-play areas (ATSDR, 2007)

The levels obtained for Cd in all the samples was negligible. The set tolerable weekly intake of dietary cadmium is 7 µg/kg body weight (NTP 2001).

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