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EDXRF analysis of local and imported pica soil samples

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Several studies have implicated trace metal metabolism with some human diseases. Energy Dispersive X-Ray Fluorescence(EDXRF) method was used to analyse pica soil samples, which are consumed by some pregnant mothers in Kenya. The levels of potassium, calcium, titanium, manganese, iron, copper, zinc and lead in samples obtained locally and some imported varieties from India are reported. The health implications for consumption of these products are discussed.

Key words: EDXRF; trace elements; pica; geophagia; soils

INTRODUCTION

The act of clay (pica) eating amongst pregnant mothers (geophagia) may be indicative of the body's need to replace depleted stores of trace metals required for normal metabolism (Fairbanks *et al.*, 1971; Prasad, 1966). For example, neonatal bone density is related to inadequacy of calcium while anaemia is a common complication in pregnancy, especially if iron is lacking in the diet (Raman *et al.*, 1979; Pit-Kin *et al.*, 1972). Incidents of congenital malfunction of the nervous system have been reported where the common diet is low in zinc (Sewer & Emmanuel, 1972).

Pregnant mothers develop a craving for non-food items such as pica when certain essential elements are lacking in the diet (Worthington-Roberts & Williams, 1993). The most commonly consumed pica material amongst pregnant women in Kenya are certain soils often obtained from salt licks, mudhouses or ant-hills from various parts of the country. Pica soils are also imported from the Indian subcontinent and the Far East and are openly sold in certain stores in Nairobi. In this study, elemental contents of some pica soils used in Kenya are assessed for their elemental levels and their effects on health are discussed.

EXPERIMENTAL

Sampling

The samples were randomly bought from Nairobi stores, at Gikomba and Mathare open air markets, and Ukwala supermarket in the city centre. Other samples were obtained from the rural areas in Naivasha and Murang'a Districts. Those from Nairobi stores and open air markets had their origins traced to Kangundo in Machakos District, and those from Ukwala Supermarket had been imported from India and the Far East.

Sample preparation and analysis

Samples for analysis were oven dried at 100°C for 48 hours and later ground to fine particle size of less than 50 μm. For each sample, 5 pellets, 2.5 cm in diameter and weighing 100–200 mg/cm^2, were prepared for analysis by use of maize starch as a binder. The X-ray spectrometer used consisted of Cd^{109} radioisotope source, Ortec Si(Li) detector and associated electronics interfaced to a personal computer with appropriate software for spectral data storage and quantitative analysis (Kinyua, 1982; Kump, 1993). The detector resolution was 190 ev for the Mn-K_α line at 5.9 Kev. Evaluation of the elemental concentration was done according to fundamental parameter technique algorithm (Van Espen & Jansens, 1985).

RESULTS AND DISCUSSION

The results of this analysis (Table 1) indicate that local and imported pica soil samples contain various essential trace elements. These pica soil samples provide partially, fully, or in excess, the recommended daily allowances of these minerals depending on their source. This interpretation is true only if it is assumed that all the trace elements in all the pica soil samples are in a biologically available form. This can be so if the chemical nature of the elements as found in the pica soil samples and their interaction between one another and with other nutrients does not interfere with their absorption and metabolism. The levels of toxic minerals mercury and cadmium in the pica soil samples were below the detection limit, while those for lead were below the toxic levels.

The potassium levels of the local soil samples are over 5 times higher than those of the imported samples. The Naivasha samples were obtained from a salt lick. However, the potassium levels were similar to those imported. The Murang'a pica samples were obtained from a mudhouse. Imported and Murang'a pica samples partially provide the recommended daily allowance of 400 mg of potassium for pregnant and lactating mothers (Worthington-Roberts & Williams, 1993), since their daily intake on average is 100 g of pica (G. Mark, pers. comm.).

Calcium levels of the Nairobi and Naivasha pica soil samples are over 2 and 15 times higher, respectively, than those imported. The levels of calcium in the pica samples from Murang'a are similar to those imported. However, the imported, Nairobi and Murang'a pica samples partially provide the recommended daily allowance of calcium for pregnant and lactating mothers of 1200 mg (Worthington-Roberts & Williams, 1993).

Manganese level in the imported pica samples is half that found in the pica samples from Nairobi; while the levels of manganese in the samples from Naivasha are similar to those imported. However, the Nairobi, imported and the Murang'a pica samples partially provide the recommended daily allowance of 280 mg of manganese to pregnant and lactating mothers (Worthington-Roberts & Williams, 1993).

Iron level in the imported pica samples is half that of Nairobi, but is comparable to those sampled from Naivasha, while Murang'a samples are 3 times higher. However, both the local and the oriental pica samples provide iron in excess of the recommended daily allowance of 30 mg for pregnant and lactating mothers (Worthington-Roberts & Williams, 1993). Iron is needed for the biosynthesis of haemoglobin in both maternal and foetal blood cells (Harper, 1971) so as to prevent maternal anaemia, a clinical consequence of iron deficiency (Worthington-Roberts & Williams, 1993).

Copper levels in the Nairobi and imported pica samples are similar, while those from Naivasha and Murang'a are over 4 and 28 times higher than those imported. However, both the

oriental and local pica samples had an excess of the recommended daily allowance of 2–3 mg of copper to pregnant and lactating mothers (Worthington-Roberts & Williams, 1993).

Zinc is a vital mineral element in pregnancy. Maternal deficiency of zinc results in foetal malfunction (Jameson *et al.*, 1991; Bothwell *et al.*, 1979). Zinc levels in the Nairobi, Naivasha and Murang'a pica samples are over 1.5 and 1.9 times higher than those imported. However, imported pica samples from Naivasha and Murang'a partially provide the recommended daily allowance of 20–25 mg of this mineral to pregnant and lactating mothers.

The role of Ti in biological functions is unknown. Titanium levels in the imported and Naivasha pica samples are over 6 and 7 times higher than those from Nairobi and over 20 times higher than those from Murang'a. Whether these samples provide, partially, fully or in excess, the recommended daily allowance of this mineral element is not known. This is because its recommended daily allowance is also unknown.

Table 1. The mineral content of various pica soils (mg/g)

RDA (mg/day)	**Mineral**	**Nairobi** Mean ± SD n = 8	**Imported** Mean ± SD n = 5	**Naivasha** Mean ± SD n = 5	**Murang'a** Mean ± SD n = 5
400	K	23.76 ± 6.2	2.68 ± 0.13	14.8 ± 2.4	3.3 ± 0.32
1200	Ca	8.05 ± 0.53	3.52 ± 0.35	56.05 ± 25.95	5.0 ± 0.24
	Ti	5.84 ± 1.14	43.88 ± 32.30	40.3 ± 37.0	1.9 ± 0.13
280	Mn	1.20 ± 0.30	0.60 ± 0.16	0.85 ± 0.26	1.2 ± 0.04
30	Fe	74.54 ± 12.67	39.98 ± 8.91	27.2 ± 7.3	1.52 ± 0.10
2–3	Cu	0.038 ± 0.007	0.046 ± 0.021	1.08 ± 1.02	0.18 ± 0.03
20–25	Zn	0.235 ± 0.047	0.066 ± 0.008	0.13 ± 0.06	0.10 ± 0.03
	Pb	0.037 ± 0.009	0.028 ± 0.004	0.015 ± 0.005	0.03 ± 0.003

Results are expressed as means ± standard deviation of the number of samples shown in each column.
RDA is the Recommended Daily Allowance.

Elemental intakes above the recommended daily allowance for potassium, calcium, manganese, iron, copper and zinc by pregnant and lactating mothers is not expected to result in toxicity because these elements are selectively absorbed by the intestines by specific saturable protein carrier systems (Ashmead *et al.*, 1985).

The nutritional value of microelements as well as the toxic effects of metals such as mercury, lead and cadmium (Bowen, 1982), are well documented. The levels of mercury and cadmium in the pica samples were below the detection limit while those of lead were below the toxic level (Gachago, 1991). While the pica samples from Nairobi, imported, and Murang'a have similar levels of lead, those from Naivasha had reduced levels.

CONCLUSION

The results of this investigation show that pica soil samples provide partially, fully or in excess, the recommended daily allowances of these minerals depending on the origin of the pica. The levels of the toxic metals from the pica samples, mercury and cadmium were below the detection limit while those for lead were below the toxic levels. While there are medical rules regarding the sale, use and health effects associated with the consumption of pica during pregnancy in the developed countries, this does not exist in the under-developed and developing countries. On the basis of this study, further research on pica with regard to suitability for human consumption and as a trace element supplement to pregnant and lactating mothers should be carried out.

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