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Occurrence of heavy and trace metals in traditionally fermented milk consumed in Narok and Kericho regions of South Rift in Kenya.

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Abstract

The Kalenjins living in Kericho and the Maasai in the Narok region of Kenya, process and use fermented milk as food after addition of food preservatives. In the present study lead (Pb), cadmium (Cd), mercury (Hg) and chromium (Cr) in fermented cow milk was determined. Samples were collected from selected areas of Kericho and Narok counties of south Rift in Kenya. An atomic absorption spectrometric (AAS) was used for analysis. The amounts of trace metals, copper (Cu) and zinc (Zn) were also similarly quantified. Fermented milk from Narok had higher amounts of copper (0.013±0.03ppm) compared to the other metals Cd (0.012±0.03ppm), Pb (0.206±0.03ppm), Zn (0.222±0.03ppm) and Hg (0.002±0.03ppm). On the other hand, milk samples from Kericho also had a higher copper content (0.127±0.03ppm) than the other metals, Cd (0.004±0.03ppm), Pb (0.100±0.03ppm), and Zn (0.085±0.03ppm). Chromium was not detected in milk samples fro the two regions while mercury was undetected only in milk samples from Narok. Lead levels were higher (0.206±0.03ppm) in milk samples from Narok than in those from with Kericho County with 0.100±0.03ppm. In addition, mercury residues were present in the Narok samples averaging 0.002ppm. Nevertheless, no significant statistical differences were found between the quantities of heavy and trace elements between Kericho and Narok cow milk in reference to the permissible limits by Codex/ WHO. The presence of these heavy and trace metals in fermented milk samples calls for further monitoring in other areas where milk is thus processed and consumed. In addition, some caution in the use of such milk is necessary.

Keywords: Fermented milk, zinc, copper, lead, chromium, cadmium and mercury,

1.0 Introduction

Consumption of fermented milk worldwide contaminated with various undesirable substances, in additives, animal feeds, equipment used, heavy metals pollution of air, water and soil, are a great concern to public health of humans. Despite outstanding improvement in providing healthy foods all over the world in recent decades, incidences of food contamination is still a major concern which raises questions about human health and economic consequences. Semaghiul *et al.*, (2008), indicated that good quality measurements are necessary in ensuring and maintaining process and products quality in manufacturing, trade and industry.

Milk contains proteins and minerals essential for growth and maintenance of human life while for elderly, it is a reliable source of calcium for strong bones (IEA, 2007). Milk products have nutritive value including being excellent sources of calcium, zinc and magnesium, while their consumption has greatly increased in recent years. The consumption of traditionally fermented milk is a dietary component that is part and parcel of the lifestyle of various communities living r in the south rift region of Kenya, in particular, among the Kalenjin and Maasai. This is due to the ease of availability of milk, use of an age-old traditional fermentation process and medicinal and dietary properties (Drewnowski and Fulgoni, 2008). Despite these essential benefits derived from consumption of fresh and fermented milk, Semaghiul *et al.*, (2008) underscored the prevalence of contamination of milk arising from various sources. These include agricultural practices, presence of industrial pollutants, soil and water pollution within the environment, animal feeds and contaminated equipment that is used during milking. It is necessary that, milk should be obtained from healthy animals and it is collected and stored under hygienic conditions that are free from environmental contamination.

Heavy metals have been in use in human societies in many different areas for thousands of years. Ingestion of contaminated food stuffs and water has been reported as the main source of metal residues in milk (Rossipal *et al.*, 2000; Frodello *et al.*, 2002). Contamination of milk also occurs during processing as well (Reilly, 1991). Although adverse health effects due to consumption of heavy metals have been known for a long time, exposure to heavy metals continues and in some countries, it is increasing (Tajkarimi *et al.*, 2008). McCally (2002) and Licata *et al.* (2004) have reported that, presence of heavy metals including cadmium, lead and mercury at very low concentrations levels have been associated with extreme disorders on human health such as body weakness, heart and kidney failure, and cancer. Lead contamination also occurs while skin diseases result from copper contamination (Llobet *et al.*, 2003). Indigenous foods and food additives are being encouraged for human consumption; however, not much research is being done on heavy metal toxicity arising from such substances. Cadmium and lead are among the most abundant heavy metals in the environment and are particularly toxic (WHO, 1992, 1995). Trace heavy metals are significant, either for their essential nature or for toxicity. Excessive intake of zinc or copper is toxic (Somer, 1974).

The aim of this study was to investigate and compare the presence of heavy metals in traditionally fermented milk that is consumed in the south Rift region of Kenya, in particular, in Ainamoi and Kipkelion divisions of Kericho County and Ololunga and Olikinyei divisions of Narok counties.

2.0 Materials and Methods

2.1 Chemicals and reagents

Authentic sodium chloride standard (Merck, Germany) was used for preparation of calibration curve. Ammonium pyrolidine dithiocarbamate (APDC) and 4-methyl-2-pentanone (MIBK) and all reagents used in this study were of analytical grade. All solutions were prepared using double deionized water.

2.2 Methods

2.2.1 Sampling

Through purposive sampling, samples of fermented milk (*mursik* – Kalenjin; and *kule naoto* – Maasai) were collected and/ or purchased directly from households and markets in Kericho and Narok, respectively.

2.2.2 Heavy metals measurements

Since direct determination of heavy metals using flame atomic absorption spectroscopy (FAAS) in concentrated aqueous solutions of milk samples was not possible, an extraction method adapted from AOAC (2000), was used. About 5 ml of fermented milk sample was diluted in 100 ml of double-distilled purified water in a 250 ml polyethylene flask. After adjusting pH to 4.4-4.8 using acetic acid-sodium acetate buffer, 5 ml of APDC and 10 ml of MIBK were added. The treated milk sample was vigorously shaken for 5 min and the organic phase was separated and its absorbance was measured using FAAS. A Perkin-Elmer 1100B model flame atomic absorption spectrometer equipped with deuterium lamp background correction was used for determination of the amounts of heavy metals. In addition, the mercury (Hg) content of the sample was measured using cold vapour atomic absorption spectrophotometry using a BUCK scientific 400A atomic absorption spectrophotometer. A separate calibration curve was determined for each metal using standard solution.

2.3 Statistical analysis

Unpaired Student's t-test ($P < 0.05$) was used for statistical analysis of the results on the salt.

2.4 Results

Concentration of heavy metals in fermented milk samples from *Olikinyei* and *Ololunga* locations of Narok County

Results on concentrations of metals in fermented milk samples from the two different locations in Narok County are summarized in Table 1. The mean concentration of cadmium, copper, lead, zinc and mercury in Olikinyei were 0.010 ± 0.001, 0.123 ± 0.005, 0.329 ± 0.047, 0.049 ± 0.090 and 0.002 ± 0.0002 ppm, respectively. In Ololunga, concentrations for cadmium, copper, lead, zinc and mercury were 0.013 ± 0.001, 0.131 ± 0.005, 0.165 ±, 0.395 ± 0.090, 0.002 ± 0.0002 ppm. However, chromium was undetected in milk samples from both locations. Fermented milk from Ololunga contained the highest levels of mercury (0.002 ± 0.0002 ppm) and zinc (0.395 ± 0.090, ppm) while those from Olikinyei had the highest level of lead at 0.329 ± 0.047 ppm. There was no significant difference in the amounts of cadmium in milk samples collected from Ololunga and Olikinyei.

Concentration of heavy metals in fermented milk samples from *Ainamoi* and *Kipkelion* locations of Kericho county

Data on concentrations of the six heavy metals in fermented milk samples from the two different locations in Kericho County are presented in Table 2. The mean concentrations of cadmium, copper, lead, and zinc in *Ainamoi* were 0.007 ± 0.002, 0.132 ± 0.004, 0.0818 ± 0.027 and 0.143 ± 0.070 ppm, respectively. In *Kipkelion* location, the concentrations of cadmium, copper, lead, and zinc were 0.008 ± 0.002, 0.119 ± 0.004, 0.125 ± 0.027 and 0.009 ± 0.070 ppm. However, chromium and mercury were not detected in the milk samples from the two locations. Fermented milk from Kipkelion contained the highest levels of lead at 0.125 ± 0.027 ppm while those from Ainamoi had the highest levels of copper at 0.132 ± 0.004 ppm. There was no significant difference in the concentration of cadmium in the samples collected from Ainamoi and Kipkelion.

Mean concentrations of metal residues for pooled samples for Kericho and Narok counties against the permissible limit in ppm.

When data on the concentrations of the six heavy metals in fermented milk were pooled for the two locations in each of the two counties and compared, those from Narok contained higher levels of the metal residues (figure 1/Table. 3). In the order of increasing concentrations of metals, in Narok it was Zn> Pb>Cu>Cd>Hg, while in Kericho it was Cu> Pb>Zn>Cd>Hg and Cr. It is clear that, the mean concentrations of heavy metal residuals in all the samples of fermented milk from the two counties were below the permissible limits.

3.0 Discussion

In the South Rift region of Kenya fresh and fermented cow milk are staple dietary components of the communities living there. Routine analysis of heavy metals in dairy products is essential. This is because there is an increase in esophageal cancer cases in this region and these may be associated with composition of the diet of these people. In particular, presence of heavy metal residues in fermented milk together with its acid content predisposes them to increased chances of developing ulcers in the elementary canal.

Heavy metals are widely dispersed within our environment resulting from increased environmental pollution that may be due to heavy use of pesticides, archaricides and fertilizers in agricultural regions including other risk factors associated with heavy metal exposure (Coni *et al.*, 2007). Kericho County is an agricultural region with maize and tea farming, and animal husbandry. Narok County has wheat farming and pastoral lifestyle. These areas are prone to heavy metal contamination of the milk samples since the chemicals used in the farms may find there way to the milk through food chain.

From the findings of this study, Narok milk samples recorded higher levels of most of the metals under study as compared to Kericho County. Chromium was undetected in all the samples collected in both the two counties. Mercury was only detected in samples collected in Narok County with a mean concentration of 0.002 ppm. Narok recorded higher Cd, Pb and Zn metals with 0.012 ppm, 0.206 ppm and 0.222 ppm respectively as compared to 0.004 ppm, 0.100 ppm and 0.085 ppm respectively for Kericho; while copper was equal for both the two counties with a mean concentration of 0.127 ppm. Among the heavy metals studied, copper is important to humans with regard to growth, nerve function, as an anti-oxidant, and functioning of some enzymes (sciafrique.worldpress.com.). The mean concentration of copper in milk samples from both Narok and Kericho counties were below those reported by Licata *et al*. (2004), of less than 0.39ppm., although the mean was same for the two regions as earlier on reported. Zinc is required in the human body for growth and enhanced immunity. Zinc deficiency is characterized by hair loss, diminished appetite, dioarrhea, impotence, eye and skin lesions among others. The mean concentration of zinc in fermented cow milk from *Ainamoi* in Kericho was 0.143 ppm while for Kipkelion was 0.0087 ppm. In Narok, milk samples from *Ololunga* had the highest concentration at 0.395 ppm while those from *Olikinnyei* had 0.049 ppm. However, these values were lower than those recorded for goat milk at 32.10 ppm (Park, 2000). Cadmium level was higher in Narok, 0.012 ppm in the range of 0.01-0.013 ppm than in Kericho with 0.004 ppm in the range of 0.010-0.012 ppm. Mercury and chromium were not found in any of the milk samples from Kericho County. However, a mean of 0.002 ppm of mercury was recorded in milk samples from Narok in the range while chromium was undetected. This level was lower than the permissible Egyptian limit of 0.02 ppm.

The mean concentration of lead in fermented milk samples from Kericho and Narok were 0.100 and 0.247 ppm, respectively. These were higher than the proposed tolerable values of 0.02 ppm in Turkey and 0.05 ppm in Germany. On the other hand, lead concentration in milk samples from Kericho was at 0.10 ppm which is comparable to the 0.1ppm reported for Kazakhstan (Gauthar *et al*., 2011). In the present study, lead concentration in milk was very variable. In Narok, the range was 0.165 -0.392 ppm and 0-0.17 ppm in Kericho. This may be attributed to the high tourism in Narok where cattle graze on pasture in areas of heavy traffic, unlike in the sampled areas in Kericho. Exhaust fumes from vehicles may be a source of heavy metal contamination. In addition, soils and water could be primary sources.

4.0 Conclusion and recommendation

Results obtained in the present study suggest that, fermented milk that is consumed in Narok has a higher nutritive value compared to that in Kericho on the basis of zinc and copper content. On the other hand, the trace amounts of mercury and lead were found to be below the maximum permissible levels recommended by Codex, 2000. Hence, these need to be excluded as possible contaminants. Continued monitoring of the presence of heavy metals in other traditional food stuffs used in these rural areas is necessary. With regard to heavy metal content in fermented milk, no statistically significant differences were found between milk samples from the two regions ($P > 0.05$). The concentrations of the six heavy metals in milk consumed in south rift, Kenya is well below established maximum limits for presence of toxic metals by Codex. Hence indicating the suitability of consumption of the fermented milk. However from the data obtained, Kericho Mursik is more suitable since the trace metals concentrations are lower than that of Narok. There is also need to further establish the exact sources of the high lead levels in Narok among the other heavy metals as reported earlier in this study, and especially so the presence of mercury residues in the milk.

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Figure 1: Pooled mean concentrations (ppm) of heavy metal residues in fermented milk samples from Kericho and Narok counties.

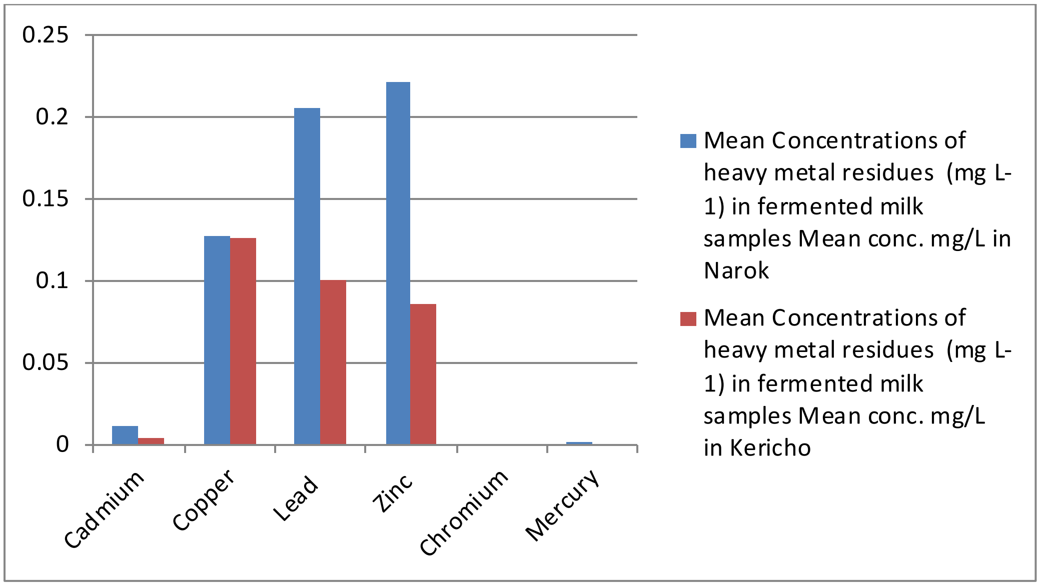

Table 1 Mean concentration of heavy metals in fermented milk samples from *Olikinyei* and *Ololunga* locations of Narok County, n = 6.

Metal	**Concentration (mg kg^{-1}) in Narok samples**						
	Mean concentration *Olikinyei*	Mean concentration *Ololunga*	Mean conc. Narok	S.D[1]	Max.	Min.	S.E[2].
Cadmium	**0.010**	0.013	0.012	0.003	0.013	0.007	0.001
Copper	**0.123**	0.131	0.127	0.010	0.142	0.120	0.005
Lead	**0.329**	0.165	0.206	0.094	0.392	0.165	0.047
Zinc	**0.049**	0.395	0.222	0.179	0.424	0.026	0.090
Chromium	**ND**	ND	ND	ND	ND	ND	ND
Mercury	**0.002**	0.002	0.002	0.0004	0.002	0.001	0.0002

[1] S.D. = Standard deviation; [2] S.E. = Standard error; N.D. = Not detected.

a:Carl (1991); b: Egyptian standard (2001); c: Pennington (1987);

Table 2 Mean concentration of heavy metals in fermented milk samples from *Ainamoi* and *Kipeklion* locations of Kericho County, N= 7

Metal	**Concentration (mg kg^{-1}) in kericho samples**							
	Mean concentration		Mean conc. ppm	**min conc. ppm**	**max conc. ppm**	mean conc. ppm	S.D.[1]	S.E.[2]
	Ainamoi	*Kipkelion*						
Cadmium	**0.007**	0.008	0.004	0.001	0.012	0.004	0.005	0.002
Copper	0.132	0.119	0.127	0.117	0.145	0.127	0.010	0.004
Lead	0.082	0.125	0.100	ND	0.170	0.100	0.069	0.027
Zinc	0.143	0.009	0.085	ND	0.502	0.085	0.184	0.070
Chromium	ND	ND	ND	ND	ND	ND	ND	ND
Mercury	ND	ND	ND	ND	ND	ND	ND	ND

[1] S.D., Standard deviationof the mean; [2] S.E., Standard error of the mean; ND, not detected.

Table 3: Pooled mean concentrations (mg/kg) of heavy metal residues in fermented milk samples from Kericho and Narok counties

Metal	**Mean Concentrations of heavy metal residues (mg L^{-1}) in fermented milk samples**		Permissible limit in ppm
	Narok	Kericho	
Cadmium	0.012	0.004	0.05[b]
Copper	0.127	0.127	0.4[c]
Lead	0.203	0.100	0.2[a]
Zinc	0.222	0.085	5.0[c]
Chromium	ND	ND	
Mercury	0.002	ND	0.02[d]

[a] Carl (1991); [b] Egyptian standard (2001); [c] Citek et al., (1996); [d] Egyptian standard No. 2360(1993)