Radionuclide content of pasteurized milk sold in Mafikeng, South Africa

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Abstract

Many food animals which are important components of human food chain are effective collectors of radionuclides from the environment particularly contaminated forages, and therefore represent a significant pathway for the transfer of radionuclides to humans. Many important radionuclides are readily transferred to milk thus the product is considered as one of the basic food items recommended for the assessment of radionuclide exposure within a population. The current study aimed at assessing the radionuclide content of commercial milk commonly sold

in South Africa in other to set a baseline data for radionuclide concentration of the products. Three popular brands of commercial milk (A, B and C) were sampled, with two samples obtained for each brand. The concentration of individual radionuclide in the milk samples, particularly ^{131}I, ^{137}Cs and ^{235}U was measured by gamma spectroscopy. The results showed that brand A had the highest concentrations of ^{235}U and ^{137}Cs (203 and 324 mBq/L respectively) but the lowest concentration of ^{131}I (6.4 mBq/L). The highest concentration of ^{131}I (148 mBq/L) was detected in brand B whereas both ^{235}U and ^{131}I were not detected in brand C. All the values however were well below the new standard limits for individual radionuclides in milk established by the Japanese Ministry of Health, Labour and Welfare and Codex Alimentarius Commission. This

study indicates that the commercial milk brands assessed pose no radiation health threat to the consumers.

Keywords: Milk, cesium, iodine, uranium, radionuclide

Introduction

Milk is one of the most important components of human diet and is valued as a natural and traditional food. It is affordable and provides a substantial amount of vitamins and minerals in relation to its energy content (Table 1). It is therefore considered as a nutrient-dense food and is usually consumed by a large segment of the population (Drewnowski et al., 2010). Consumption of milk has often been a yardstick for an overall healthy diet due to its association with increased nutrient intake (Marshall et al., 2005). Milk however also constitutes a major source for the intake of certain radionuclides into man. It is therefore considered as one of the basic food items recommended by international organizations to assess human exposure to radionuclides through foodstuff consumption. The most common anthropogenic source of milk contamination by radionuclides is consumption of contaminated forage by dairy cattle (Ould-Dada, 2007). Forage meant for dairy animals can in turn become contaminated as a result of nuclear accidents, contamination of agricultural soils by mining activities or excess application of phosphate fertilizers to crop farmlands (Lema et al., 2014). Usually, five major radioactive contaminants are found in milk and include ^{131}I, ^{89}Sr, ^{90}Sr, ^{137}Cs and

^{140}Ba (INFOSAN, 2011). Such radionuclides particularly ^{131}I will appear in milk several hours, reaching a maximum level in 24 hours to several days after the dairy cattle consumes contaminated forage (INFOSAN, 2011). The rate and extent of contamination depend on the amount and number of radionuclide released, distance of accident site to the pasture and the transfer coefficient of each radionuclide (FEMA, 1987). Consuming foods contaminated with radionuclides can increase the amount of radioactivity inside a person and consequently increase the health risks associated with radiation exposure. The rapidity with which radioactive contaminants are transferred to milk makes the monitoring of radionuclides in milk an essential issue. Furthermore, analysis of radionuclides in milk samples provides valuable information of the general population's intake of radionuclides since it is consumed by a large portion of the population (Morrey et al., 1987). Although several studies have been carried out in various geographical areas in order to build up baselines of radionuclide concentration in milk, there is no available information on radionuclide content of milk sold in Mafikeng. The present study aimed at evaluating the concentration of certain radionuclides in commercial milk marketed in Mafikeng as a step towards establishing a baseline data for the environment.

Materials and Methods

Three brands of commercially marketed pasteurized milk samples were obtained from supermarkets in Mafikeng town. The town is the headquarter of the North West Province which is located on latitude 25.8°S and longitude 25.5°E and offers an almost year-round sunshine, with average rainfall of 300 – 500 mm annually. Economic activities within the province consist of agriculture, agro-industries and tertiary sectors.

Table 1 Proximate, mineral and vitamin composition of milk

Nutritional composition	Value (g)
Energy (kcal)	62
Water	87.8
Total protein	3.3
Total fat	3.3

Lactose	4.7
Calcium	112
Iron	0.1
Phosphorus	91
Sodium	42
Vitamin A	37
Carotene	16
Vitamin E	0.08
Vitamin B_6	0.04
Vitamin B_{12}	0.51
Vitamin C	1.0
Vitamin D	0.2
Folate	8.5

Adapted from FSA (2002)

Samples, which were obtained in 2-L quantities were acidified with 1 M HCl at the rate of 10ml L^{-1}. Samples were then sealed and kept in the refrigerator for 21days to allow secular equilibrium between the long-lived radionuclides (e.g. ^{226}Ra) and their daughters.

The radionuclide concentrations in samples were determined using HPGe detector model GC2020 E7500 CSL (Canberra GMbH) {resolution (FWHM) at 122 keV (57Co) is 0.94 keV and at 1332 keV (60Co) is 1.77 keV and relative efficiency for energy 1.33 MeV relative to (NaI)TI is 20%. The detector was coupled to a computer through an MCA (DSA 1000, Canberra). The detector was calibrated for energy and efficiency using the Canberra standard calibration file. Each sample was counted for 24 h. The Genie 2000 software was used for both data acquisition and analysis (nuclide identification).

Results and Discussion

The major radionuclides identified in milk samples and their concentrations are shown in Table 2 below. Cs-137 was detected in all the samples, with the highest activity concentration in samples from brand A which is one of the most popular brands of milk marketed in the study area. Both I-131 and U-235 were detected in samples from brands A and B but not in samples from brand C. In all the analysed samples, the concentration of radioiodine was far lower than the concentration of radiocesium. Although radioiodine can be a potential contamination problem in liquid milk, radiocesium is recognized as a contamination problem particularly in processed milk (FEMA, 1987). All the milk samples analyzed in this study are processed and this could be the reason for the high level of radiocesium compared to radioiodine. Whatever is the route of entry of cesium into the human body, it is rapidly and almost completely absorbed into the blood. In addition, its systemic distribution to internal organs and soft tissues is relatively homogenous with dose factors that are almost independent of age (Morrey et al., 1987).

Table 2 Major radionuclides identified in milk samples

Identified nuclides	Concentration in milk samples (Bq/l)			Standard limit (Bq/l)
	A	B	C	
I-123	0.114	0.145	0.022	300
I-125	4.018	ND	ND	300
I-131	0.006	0.148	ND	300
Cs-137	0.325	0.239	0.035	200
U-235	0.203	0.167	ND	NA

ND = not detected; NA = Not available

Some of the possible health effects of cesium include fatal cancers (highest risk), severe genetic ill-health and severe mental retardation (Goldman et al., 1987; INFOSAN, 2011). Radioactive iodine on the other hand is absorbed in the body mainly by the thyroid cells leading to the destruction of the cells. Thus, the exposure of the rest of body cells to iodine radiation is minimal. However, the concentration of individual radionuclides in all the analyzed milk samples were below the new standard limits for radionuclides in milk established by the Japanese Ministry of Health, Labour and Welfare in year 2012.

Conclusion

This study showed that the commercial milk brands sold in Mafikeng contain mainly cesium and iodine radioisotopes with Cs-137 concentration higher than iodine-131. All the values however were well below the new standard limits for individual radionuclides in milk established by the Japanese Ministry of Health, Labour and Welfare. This indicates that the commercial milk brands assessed pose no radiation health threat to the consumers.

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