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Estimation of Aluminum Level in Locally Packaged Milk Powder

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ABSTRACT

This study was conducted to estimate Aluminum level (Al) in locally packaged milk powder, discussing its public health effect and suggesting recommendations to avoid such contamination. Therefore, fifty random samples of locally packaged milk powder were collected from different markets and pharmacies in Assiut Governorate, Egypt. These samples were digested and Al levels were estimated using HR-CS (High Resolution Continuum Source Atomic Absorption Spectrophotometer) and compared with Maximum Permissible Limit (MPL). About 96% of milk powder samples were containing Al with an average value of 0.086 mg/L and fortunately were lower than MPL. The present study revealed that milk powder contains aluminum element in variable concentrations above the toxicity levels. Therefore, to lower aluminum content, it is important to avoid the sources of contamination.

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Introduction

During milk powder manufacturing, essential elements are normally added to it, in order to meet nutritional requirements (Oskarsson *et al*., 1995). Hence, it is necessary to control the level of added elements since their excess may play a role as a potential source of exposure. As the main quality parameters for milk powder are the microbiological and sensory characteristics, recent investigations have been recommended that heavy metals and trace elements estimation in milk powder should be included (Karadjova *et al*., 2000; Martino *et al*., 2000; Orak *et al*., 2005).

Aluminum is the most abundant metallic element and constitutes 8.13% of the earth's crust. It is the third most abundant element in nature after oxygen and silicon. Elemental aluminum does not occur in its pure state; it is always combined with other elements (e.g., hydroxide, silicate, sulphate, phosphate). It is present in soils and clays, minerals and rocks, and even in water and food. Historically, the ancient Greeks and Romans used aluminum sulphate with potassium in medicine and in dying (Barbalace, 2009). Its compounds are used in food industry such as food additives, in baking powder, processed cheese, meat products, cooking and storage utensils. Moreover, aluminum sulphate is also used for particle sedimentation in water-treatment.

With exception of certain spices and tea leaves, a natural level of aluminum in food tends to be quite low. In contrast, most dietary aluminum primarily comes from the use of food additives (for example baking powder, coloring agent, anticaking agent, acidifying agent, stabilizers, thickness, bleaching, and emulsifying agent) during processing (Yokel and Florence, 2006). Aluminum is one

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of the toxic elements (TEs) that accumulate especially in the lungs, liver, kidney, thyroid and brain. It has been reported that infants are extensively vulnerable to exposure of these TEs because of their immature renal systems and exhibit a narrow tolerance to these non-essential elements (Bougle *et al*., 1997; Tuzen and Soylak, 2007). Such element is a potent neurotoxin; long-term feeding of aluminum-containing total parenteral solutions to preterm infants caused impaired mental development at 18 months (Klein *et al*., 2004). Also, excess aluminum in the blood is selectively incorporated into the bones of infants, resulting in a weakened bone structure (Bernardo *et al*., 2010).

Aluminum can only be removed from blood via the kidneys, and severe renal disorders can result in accumulation of aluminum in the blood. Fortunately, urine and feces is the normal pathway for its excretion from body when ingested in food or being drunk in liquids (ATSDR, 2006). Consequently in humans with renal insufficiency, the kidney is unable to excrete excess of aluminum from body resulting in a more health hazard. Extensive literatures review cast no doubt that aluminum has a neurotoxic effect and play a factor in Alzheimer's disease, a very common cause of dementia. Also, different experimental studies showed that the nervous system is a sensitive target of aluminum toxicity (Joshi, 1990; Golub and Domingo, 1996; Julka *et al*., 1996; Fattoreti *et al*., 2004; Gupta *et al*., 2005).

Infants are particularly sensitive to the effects of ingested toxicants as food consumption is greater on a body-weight basis. Gastrointestinal absorption of most chemicals is substantially elevated prior to weaning and many organs, such as kidneys, are underdeveloped, while the physical development of critical organs impacting on the health of the infant throughout life is accelerated (Oskarsson *et al*., 1998). Therefore, this study was conducted to estimate Al level in milk powder and its public health hazards were discussed.

Materials and methods

Collection of samples

A total of 50 random samples of locally packaged milk powder were purchased from different markets and pharmacies in Assiut Governorate, Egypt during the period from June 2013 to October 2013. These samples were collected in their original containers and packets, and transported to the laboratory.

Washing procedure

The tubes and glass wares were soaked in water and soap for 2 hours and rinsed several times with tap water. They were rinsed once in distilled water, and once with acid then air-dried in an incubator away from contamination or dust.

Preparation of collected samples

One gram of milk powder was transferred into clean and acid washed screw capped digestion tubes. All digestion tubes were identified for examination.

Digestion procedure

Organic matter and other components present in the samples would interfere with the analytical process unless they were removed. Organic matters are usually removed by using oxidizing acids, then determined by Atomic Absorption Spectrophotometry (Reilly, 1991).

Procedure

The procedure was carried out in the Central Laboratory of Faculty of Veterinary Medicine, Assiut University, where 1g of milk powder sample was weighed into digestion tubes and 5ml of concentrated Nitric acid (HNO3 70%) were added and kept overnight. Then, the tubes were capped snugly, heated in water bath at 80°C for 6 hours and cooled at room temperature. The water and any droplets near the cap were wiped from tube, and the cap was carefully removed without touching its edge and placed, top down, on a clean surface. Contents were diluted to 10 ml mark with distilled water, tubes were capped, shaked, filtrated and let to stand until analysis by Graphite-furnace Atomic Absorption Spectrometric (GFAAS) method.

Preparation of blank solutions

One ml distilled water was added to 5 ml Nitric acid (70%), left overnight and then digested in water bath at 80°C for 6 hours and cooled at room temperature. Then the contents were diluted to 10 ml mark with distilled water and then filtrated. The blank solution was analyzed by Atomic Absorption Spectrophotometer and any metal residues were subtracted from the results obtained at each corresponding procedure.

Analysis on Graphite Atomic Absorption Spectrophotometer (GAAS)

The analysis was carried out at Analytical Chemistry Unit, Department of Chemistry, Faculty of Science, Assiut University. All filtrated samples of milk powder samples were analyzed for their Al concentration by using HR-CS Atomic Absorption Spectrophotometer (High Resolution Continuum Source Atomic Absorption Spectrophotometer).

Results

Table 1. Incidence of aluminum in milk powder samples

No. of Examined samples	Positive samples		Concentration of Al (mg/L)		
	No.	%	Min.	Max.	Average
50	48	96	0.0029	0.186	0.0855

Table 2. Comparison of aluminum level in milk powder samples with Maximum Permissible Limit (MPL) stated by Pennington (1988).

MPL (mg/L)	Within permissible limit		Over permissible limit	
	No. of samples	%	No. of samples	%
0.5	50	100	0	0

Table 3. Comparison of Acceptable Daily Intake (ADI) of aluminum with that estimated from consumption of 200 ml reconstituted milk powder

Average value (mg/L)	Daily intake from consumption of 200 ml reconstituted milk powder		
	*ADI	**EDI (mg/day/person)	%
0.0855	1	0.0171	1.7

*ADI: (FAO/WHO, 1989)
**EDI: Estimated Daily Intake

Discussion

It is evident that 48 (96%) out of 50 examined milk powder samples contained aluminum with an average value of 0.085 mg/L (Table 1). The minimum value was 0.002 mg/L, and the maximum value was 0.186 mg/L. These values were lower than those detected by Woollard *et al*. (1990); Bloodworth *et al*. (1991); Onianwa *et al*. (1997); Garcia *et al*. (1999); Sami (2005); AI-Ashmawy (2011); Abd-El Aal (2012). However the average value estimated by Salah *et al*. (2013) was extremely higher than that of the obtained results.

It is evident from the recorded results that most of examined milk powder samples were contaminated with variable amounts of aluminum. The high incidence of contamination may have been arisen during handling, exposure and processing. The processing steps mainly involve boiling in steel or aluminum-ware from which such contamination may result (Onianwa *et al*., 1997).

Moreover, in milk powder, sodium aluminum-silicate was used as anticaking agent (16% Al), which is a type of food additive as decided (ATSDR, 1999; Codex Alimentarious Standard, 2006) and its levels of use (expressed as Al) were up to 20.00 mg/kg. This anticaking agent may play a role in increasing the concentration of aluminum in some types of milk powder (FAO/WHO, 2007).

The heavy metal contents varies widely due to many factors such as differences between species, characteristics of the manufacturing practices and possible contamination coming from the equipments during the process (Yüzbaşı *et al*., 2003; Caggiano *et al*., 2005). Oxidation of containers and equipments were affected by some parameters such as pH, quality of raw materials of containers and equipments. So, enhancement of oxidation will increase the metal contents of samples. Furthermore, aluminum content of original milk will subsequently affect the metal levels in milk powder (Salah *et al*., 2013).

The maximum permissible limit (MPL) for aluminum in milk powder should not exceed 0.5 mg/kg as stated by Pennington (1988), the results presented in Table 2 proved that all of examined milk powder samples were lower than the MPL for aluminum.

The chemical composition of canned milk, (long term storage), depends not only on the concentrations of raw milk components and on its treatment, but also on the mode of packing and quality of the packing materials and on the conditions and time of storage (Tchekulayeva *et al*., 1981). The tinned can composed of tin (98.8%), small amount of lead beside soldering of seams with the help of lead containing paste, copper, cadmium, aluminum from the Al-foil cover and some other metals, could be capable of participating in electrochemical transformation (Arvanitoyannis, 1990). Aluminum is now being implicated as interfering with a variety of cellular and metabolic processes (AAP, 1996). It may also cause bone disorders but the critical level of aluminum loading may result in bone disorders is not known (ADA, 2000). The estimated daily intake (EDI) of aluminum from consumption of 200 ml of reconstituted milk powder was 0.0171 representing 1.7% (Table 3). The present study revealed that milk powder contains aluminum element in variable concentrations above the toxicity levels. Therefore, to lower aluminum content, it is important to avoid the sources of contamination.

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