A REVIEW OF THE IMPORTANCE, DETECTION AND CONTROLLING OF HEAVY METAL IN MILK AND DAIRY PRODUCTS

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ABSTRACT   Milk and dairy products can be contaminated in different ways. One of the most important and most challenging contaminations is due to heavy metals. In present research key words, including Milk, Dairy products, Heavy metal, Iran in the database pub med, Science Direct, Elsevier, SID, MagIran, Civilica, the World Health Organization and Agriculture Organization of the United Nations were searched. All articles indexed in domestic and international journals related to the topic were collected over the past several years. Heavy metal contamination in milk and dairy products play an important role in public health, as it can be the reason to the prevalence of diverse illnesses and lesions. There are various ways to measure the amount of contamination in milk and dairy products. One of the best and most efficient methods is atomic absorption. Moreover, collecting samples, storing and preparing them with different materials and solutions are also an important method. Heavy metals can enter the food chain in many ways. Sewage, factory waste, garbage, dust and etc are the common ways for heavy metals to enter the food. Cow's body acts like a biological filter about heavy metals, especially Cadmium and the absorbed Lead and Cadmium move to its bones and start to accumulate. Due to extensive consumption of milk and dairy products, it is critical to lessen contamination. Water and foods with both animal and plant resources must be monitored and examined before use. Materials used for food packaging must be harmless for human health so the present elements used in the containers must be reconsidered.

Key words*: Milk, Dairy products, Heavy metal, Iran

INTRODUCTION

Milk and dairy products can be contaminated by different sources such as heavy metals, mycotoxins and veterinary drugs residues. One of the most important and most challenging contaminations is due to heavy metals such as Lead, Cadmium, Cobalt, Nickel, Arsenic and Tin (Rokni., 2007; Mahmoudi et al., 2013; Fallah et al., 2015; Mahmoudi et al., 2015). Heavy metals have higher density comparing to other metal elements. In average their density is higher than 5 gr/cm^3 (Eskandari & Pakfetrat., 2014).

Nowadays heavy metals contaminating milk and dairy products especially Lead and Cadmium play an important role in public health as it can be the reason to the prevalence of divers illnesses and lesions (Rokni., 2007; Fallah et al., 2015). After entering the body, Lead starts to accumulate in different tissues such as liver and kidneys and disrupts their physiological performance. Lead is also known as one of the factors in respiratory inflammation, failure and tumor (Correia et al., 2000; Mahmoudi & Zare., 2013; Mahmoudi & Norian., 2014).

The most common symptoms of lead poisoning are anemia and loss of color factor in the blood, caused by iron deficiency (Jeng et al., 1994). Cadmium is known as one of the important factors in bladder and prostate cancer (Ballantyne et al., 2009).

Cadmium's accumulation in the body increases the risk of developing cancer, high blood pressure, iron deficiency, liver diseases and neurological damages (Jeng et al., 1994).

Heavy metals aren't metabolized in the body and are liable to different bacterial, viral and fungal diseases in the host's body (Rokni.,

2007; Eskandari & Pakfetrat., 2014). It has also been approved that the impact of high concentrations of heavy metals in a short period of time has similar effects as of low concentrations in a long period of time environmental organization has introduced Lead and Cadmium as the most harmful heavy metals (Hamidpour et al., 2011; Mahmoudi et al., 2015).

Lead and Cadmium are not the only sources of chemical contamination caused by heavy metals. Metals and elements such as Iron, Zinc, Manganese and Magnesium components are micronutrients and milk products are major source of these elements. If the amount of these metals and elements exceeds of limit the product is contaminated (Li et al., 2005).

Metals such as lead and cadmium are under no circumstances necessary for the body, but metals such as copper, iron and zinc are necessary for normal functioning of body (Ayar et al., 2009; Qin et al., 2009; Khan et al., 2013; Li et al., 2005; FARID 2004; Goyer., 1995).

Permitted levels of lead and cadmium in raw milk by the Codex Alimentarius 2000 (Committee on Food Additives, Geneva

Study) respectively are 1 ppm and 0.010 ppm (Bonyadian et al., 2006).

METHODS

In this paper key words, including Milk, Dairy products, Heavy metal, Iran in the database pub med, Science Direct, Elsevier, SID, MagIran, Civilica, the World Health Organization and Agriculture Organization of the United Nations were searched. All articles indexed in domestic and international journals related to the topic were collected during the two decades.

RESULTS

Methods of measurement

Various methods for measuring heavy metals in milk and dairy products have been defined. One of the best and most practical methods is atomic absorption spectrometry. The method of sample collection storage and processing them using a variety of materials and solutions is also important (Belete et al., 2014). Another method is graphite oven atomic absorption measurements (Licata et al., 2004).

For the measurement of very small amounts of cadmium on the scale of ppt, micro scatterer distribution of solvent followed by solidification by reducing the temperature can be demonstrated (Jahromi et al., 2007). Cover analysis of potentiometric method is another method of measuring heavy metals in milk and dairy products.The atomic absorption method is cheaper and more accurate comparing to this method (Jeng et al., 1994).

Heavy metals in milk

There have been few researches done on contamination of raw and pasteurized milk. Obtained reports indicate the presence of contamination in Iran (Eskandari & Pakfetrat., 2014).

The study conducted by Rahimi and Derakhshesh (2010) showed that the contamination of cow's raw milk by cadmium has various levels in different cities. Industrial cadmium pollution in densely populated areas such as Tehran and Isfahan, Ahvaz, and Ghom is more compared to Rasht, Shiraz and Yazd (Rahimi & Derakhshesh., 2010).

The survey of some heavy metal contamination in raw milk samples, results

showed that the levels of lead and chromium has exceeded the permissible limit in some areas of the province (Javadi et al., 2005).

The results of Tajkarimi et al (2008) on raw cow milk lead contamination by using atomic absorption spectrometry showed that the average amount of lead in all samples was 7.900 ng/mL, which was calculated by.

Less than 10% of the samples were greater than 22 ng/ml and 60% of the samples were between 1.100 to 5.700 ng/ml. The lead contamination of raw milk in Tehran, Isfahan and West Azarbayjan was more than other areas. Therefore these areas require more attention (Tajkarimi et al., 2008).

In a study Conducted by Bonyadian et al (2006) on lead and cadmium contamination in raw and pasteurized milk in Shahrekord, the results showed that the lead and cadmium levels in all samples were below the limit. also the level of contamination in raw milk is much more significant than in pasteurized milk (Bonyadian et al., 2006). In other study in the industrial city of Arak, the contamination of pasteurized milk to iron, lead and zinc was determined by microwave

digestion, resulting in the fact that the amount of iron was over the permissible limit (Alebi., 1998).

In study of Parveez Mand Zamaian (2001) was conducted on lead and cadmium levels in pasteurized milk in 2 large milk processing factories in Tehran. Lead and cadmium were found in all samples, but the amount wasn't determined (Parveez Mand Zamaian., 2001).

In the study of Chinikar et al (1997) the contamination of four types of milk (Raw milk, Pasteurization milk, Powdered milk and Human breast milk) caused by nickel, lead, copper and cadmium was calculated by atomic absorption spectrometry. The results showed that 2.840% of the samples were contaminated to lead and 4.610% of the samples were contaminated to cadmium. The average amounts of lead, nickel, cadmium and copper were obtained respectively 1.200 ppm, 42 ppm, 14 ppm, 34 ppm, (Chinikaar., 1997).

The results of various studies on heavy metal contamination in milk and dairy products in Iran show that in table 1, 2.

Table 1. Heavy metal Contamination in milk samples and comparing them with the permissible limit

Sample	number of samples	Metal		Standard		Non-standard		Region	Reference
		Measured values (ppb)							
Raw cow milk	12	Cd		*				Isfahan	Rahimi & Derakhshesh., 2010
		0/007							
	8	Cd		*				Tabriz	Rahimi & Derakhshesh., 2010
		0/005							
	6	Cd		*				Sanandaj	Rahimi & Derakhshesh., 2010
		0/002							
	10	Cd		*				Tehran	Rahimi & Derakhshesh., 2010
		0/009							
	5	Cd		*				Yazd	Rahimi & Derakhshesh., 2010
		0/004							
	9	Cd		*				Shiraz	Rahimi & Derakhshesh., 2010
		0/005							
	11	Cd		*				Ghom	Rahimi & Derakhshesh., 2010
		0/007							
	10	Cd		*				Ahvaz	Rahimi & Derakhshesh., 2010
		0/007							
	5	Cd		*				Yasouj	Rahimi & Derakhshesh., 2010
		0/004							
	18	Cd		*				Mashhad	Rahimi & Derakhshesh., 2010
		0/005							
	7	Cd		*				Rasht	Rahimi & Derakhshesh., 2010
		0/004							
	8	Cd		*				Kerman	Rahimi & Derakhshesh., 2010
		0/002							
	100	Pb				*		Tehran	Radmehr et al., 2010
		264							
	100	Cd	Pb	Cd	Pb	Cd	Pb	Zabol	Moallembandani et al., 2014
		4/557	9/175	*	*				
	48	Cd	Pb	Cd	Pb	Cd	Pb	Hamedan	Vahidi nia et al., 2013
		3/210	4/860	*	*				
	25	Cd	Pb	Cd	Pb	Cd	Pb	Yazd	Yasaei Mehrgrdy., 2009
		0/582	7/200	*	*				

							Cd	Pb	Cd	Pb		
	50	Cd		Pb			Cd	Pb	Cd	Pb	Shahr kourd	Bonyadian et al., 2006
		2/870		60/720			*	*				
	50	Cd		Pb			Cd	Pb	Cd	Pb	*Industrial cities of Iran	Fakhari et al., 2014
		14/040		1/100			*	*				
	50	Cd		Pb			Cd	Pb	Cd	Pb	Khozestan	Albokarami., 2015
		2/370		45/640			*	*				
	50	Pb	Cd	Zn	Cu	Se	Cd	Pb	Cd	Pb	*Industrial cities of Iran	Shahbazi et al., 2015
		14	1/110	571	427	2/190	*	*				
Pasteurized milk	50	Cd		Pb			Cd	Pb	Cd	Pb	Shahr kourd	Bonyadian et al., 2006
		1/030		13/570			*	*				
	50	Cd		Pb			Cd	Pb	Cd	Pb	*Industrial cities of Iran	Fakhari et al., 2014
		1/03		9/59			*	*				
	50	Cd		Pb			Cd	Pb	Cd	Pb	Khozestan	Albokarami., 2015
		1/010		12/410			*	*				
	50	Pb	Cd	Zn	Cu	Se	Cd	Pb	Cd	Pb	*Industrial cities of Iran	Shahbazi et al., 2015
		9/590	1	447	378	1/780	*	*				

*Industrial cities of Iran include Isfahan, Ahvaz, Tehran, Tabriz and Mashhad.

The measuring of the samples showed that the heavy metal level in more samples were lower than the global standard, so all of the collected fresh milk was clean, pure and safe and also The pasteurization process may reduce the concentration of lead and cadmium in milk.

Heavy metals in dairy products

There have been few studies on heavy metals in dairy products (yogurt, cheese, butter, cream, whey, doogh, curd and milk powders) in Iran. In study of Mohammadi sani et al (2009) calculated the amount of copper, iron, zinc, arsenic, lead, cadmium and calcium in curd using the atomic absorption spectrometry method in Khorasan province. In this study copper, iron and arsenic levels exceeded the standards set by national organizations (Mohammadi sani et al., 2009).

In another study, the contamination of Ultra Filtrate cheese and yoghurt with cadmium and lead in the province of Isfahan was determined using atomic absorption spectrometry and oven according to AOAC guidelines. The results showed that the concentration of lead and cadmium samples tested are 200 ppb which is in the range of international standards (Jaberi et al., 2013).

In other study on lead and cadmium contamination in milk and its products (skim milk and cream) in Isfahan (Iran), showed

that the amount of lead is in the permissible range but cadmium has exceeded the limit set by the Codex Alimentarius (Shakerian & Karim., 2004).

In study of Emamian (2005) in Shahrekord city was conducted to determine the amount of lead and cadmium using the potentiometric method, using 12 samples of raw milk, 12 samples of skim milk, 12 samples of cream and 12 samples of pasteurized milk. Results showed 58% of

the raw milk samples, cadmium had exceeded the limit (Emamian., 2005).

Another study on the amount of copper and lead in baby food and formula in Iran, showed that the amount of copper had exceeded the limit (Poursartip., 1999).

In another study on two types of powdered milk using the spectrometry method, the amount of lead in both cases was over the permissible amount (Navab irani M., 2000).

Table 2. Heavy metal Contamination in dairy products samples and comparing them with the permissible limit

Sample	Number of samples	Metal					Standard		Non-standard		Region	Reference
		Measured values (ppb)										
Milk powders	25	Cd		Pb			Cd	Pb	Cd	Pb	Tehtran	Mollaei Parvary et al., 2015
		14/110		57/360				*	*			
Milk powders	25	Cd		Pb			Cd	Pb	Cd	Pb	*Some of the cities in Iran	Malakootian & Golpayegani 2013
		7/240		37/600			*	*				
Yogurt	12	Cd		Pb			Cd	Pb	Cd	Pb	Isfahan	Jaberi et al., 2013
		18/070		58/305			*	*				
Cheese	12	Cd		Pb			Cd	Pb	Cd	Pb	Isfahan	Jaberi et al., 2013
		45/730		123/660					*	*		
Cheese	50	Pb	Cd	Zn	Cu	Se	Cd	Pb	Cd	Pb	*Industrial cities of Iran	Shahbazi et al., 2015
		14/500	1/250	586	428	1/680	*	*				
Yogurt	50	Pb	Cd	Zn	Cu	Se	Cd	Pb	Cd	Pb	**Industrial cities of Iran	Shahbazi et al., 2015
		7/540	0/990	431	399	1/230	*	*				
Doogh	50	Pb	Cd	Zn	Cu	Se	Cd	Pb	Cd	Pb	**Industrial cities of Iran	Shahbazi et al., 2015
		7/200	0/840	369	320	0/99	*	*				
Curd	50	As	Cu	Pb	Cd	Zn	Cd	Pb	Cd	Pb	Khorasan	Mohammadi sani et al., 2009
		3/541	3/229	0/216	0/100	8/191	*	*				
Whey	12	Pb	Cd	As	Hg	Al	Cd	Pb	Cd	Pb	Khorasan	Ebdali

18	1	<20	1	2679	*	*	taklou., 2013

*Some of the cities in Iran included Kerman, Tehran, Ahvaz, Tabriz, Sanandaj and Rasht.
**Industrial cities of Iran include Isfahan, Ahvaz, Tehran, Tabriz and Mashhad.

Sources of contaminations

Heavy metals enter the food chain by different ways. Sewage, waste from manufacturing activities, dust and heavy metals in food are the usual ways. Contaminated soil also has high impact (Eskandari & Pakfetrat., 2014; Fallah et al., 2015). Studies have showed that cadmium concentrations in the milk of cows which have been raised in industrial areas and next to the highways or animals which are fed with food contaminated with heavy metals is much higher than of animals that are bred in cleaner areas (Pavlović et al., 2004; Patra et al., 2008).

Phosphate fertilizers contain heavy metals such as cadmium and nickel. Therefore extreme use of fertilizers not only accumulates in the soil, it also reduces soil microbial activity and thus they're absorbed by the plants, and enter the chain of animal and human (Garcia et al., 1999). Cadmium is dispersed with a high extent in the environment, and it is mostly available in industrial compounds and phosphate fertilizers (Jeng et al., 1994).

In the study of Radmehr et al (2010) the amount of lead in milk of dairies around Tehran had lead levels which were higher than the standard limit but in their drinking water, except for 2 samples, others had permissible amount of lead. As a result water cannot be an effective source of lead pollution (Radmehr et al., 2010).

Reducing the contaminations

Cow's body acts like a biological filter about heavy metals (especially Cadmium). The absorbed Lead and Cadmium move to its bones and start to accumulate. Under special circumstances, such as excessive levels of metals in the animal's body or lack of dietary calcium, it can be excreted into breast milk (Eskandari & Pakfetrat., 2014).

Lead and tin can also enter the food through packaging, for instance Lighvan canned cheese in Iran (Essentail Korfali & Hamdan., 2013).

According to the results of a study on metal pollution in cheese and white cheese, lead

contamination had occurred through gallon containers (Abdalla et al., 2013).

Nurdin et al (2013) studied on the effect of some medicinal plants used in the diet which can reduce the amount of lead excreted in the animal's milk. Their results showed that the cumin, white turmeric and mango turmeric can reduce the amount of lead in milk and its products by 98.36, 99.33 and 99.37 percent, respectively (Nurdin et al., 2013).

In another study, the amount of metal elements in milk and its products were examined. The amount of iron, copper, manganese, zinc, lead, cadmium and chromium had reduced by 0.40-15% in cow milk's yoghurt and 0.50-15% in buffalo milk's yoghurt. The amount of nickel, cobalt and tin had reduced by 50-100% in cow milk's yoghurt and 25-50% in buffalo milk yoghurt. As a result, the amount of these metals sharply decreases in the process of yoghurt production, which is due to high acidity and bacterial activity (Enb et al., 2009).

There have been extensive studies on the removal of heavy metal contamination from various sources, especially water resources. This method can be generalized to decontamination of various dairy products, especially lead and cadmium. In the past few years, mineral absorbents such as smectite and Palygorsctite have been used to absorb heavy metals (Farrah & Pickering., 1997).In another study Sepiolite minerals and zeolites were introduced as adsorbents and corrective agents for heavy metals (Shirvani et al., 2006). In another study modified rice husk with different concentrations of sodium bicarbonate were used to absorb low concentrations of cadmium in aqueous environments (Shahmohammadi et al., 2008).

The studies proved that some lactobacillus species use heavy metals in their metabolism. Using these lactobacilli as probiotic agents can reduce the contamination by absorbing heavy metals from products such as yogurt (Penaud et al., 2006).

Heavy metals bond with some lactobacilli specific proteins (LAB), afterwards they are absorbed and eliminated biologically (Kinoshita et al., 2013).

CONCLUSIONS

Heavy metal contamination in milk and dairy products play an important role in public health, as it can be the reason to the prevalence of diverse illnesses and lesions due to extensive consumption of thes products. Water and foods with both animal and plant resources must be monitored and examined before use. Materials used for food packaging must be harmless for human health so the present elements used in the containers must be reconsidered. Using absorbent and neutralizing agents is also an effective way to reduce the contaminations, such as using probiotic bacteria.

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