Evaluation and Determination of Toxic Metals, Lead and Cadmium, in Incoming Raw Milk from Traditional and Industrial Farms to Milk Production Factories in Arak, Iran

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ABSTRACT

Background: Milk is regarded as a unique source of food for all ages. When milk is exposed to various contaminants, including lead and cadmium, it is considered a risk to humans. The presence of some metal pollutants, especially Cd and Pb, facilitates their entry into the food chain and thus increases the possibility of their toxic effects on humans and animals. Therefore, we decided to check lead and cadmium levels in incoming raw milk in milk production factories in Arak city, Iran.

Methods: In this study, 48 samples of milk were obtained from 28 industrial and 20 traditional farms. After the digestion process, at first, the metals were extracted with complexing agents, APDC, and MIBK solvent. Then atomic absorption method with graphite furnace was applied.

Results: The results were analyzed by analytical tests such as Npar, Mann-Whitney, Kruskal-Wallis, and t-test using SPSS software and it was specified that the means of lead and cadmium were equal to 16.0456 and 20.09 ppb in raw milk. P-values equal to 0.009 and 0.002 ppb were considered significant for lead and cadmium, respectively. The standard levels for lead and cadmium in milk were 1000 and 100 ppb, respectively. In all milk samples, lead and cadmium pollution were less than the standard limit.

Conclusion: The amounts of toxic metals (lead and cadmium) in raw milk produced in traditional and industrial farms in all seasons were lower than the standard limits. Also, the mean amounts of lead and cadmium in all milk samples were less than the standard limits for milk.

Keywords: Arak, Cadmium, Lead, Raw Milk, Toxic Metals.

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INTRODUCTION

Milk and milk products are one of the most important ingredients of human diet worldwide and many efforts have been made for increasing the quality and hygiene of milk and decreasing the total contamination of milk (1). Some of the major contaminations are due to toxic metals like Pb and Cd which their presence in the milk as a part of human diet has irrecoverable effects. The presence of high amounts of Pb in diet results in anemia and kidney, liver, heart, immune system, reproductive system, digestion system, and central nervous system disorders (2,3). Cadmium is a carcinogenic agent that specifically causes tumors in the lungs and prostate (4). Cadmium causes failure in kidneys, bones, lungs, liver, heart, and vessels (5). The effects of cadmium contamination on pregnant women can be malformations, fetal weight reduction, and abnormality in the baby's DNA and proteins as well as abortion due to high levels of contamination (6).

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From the standpoint of health and sanitation, the maximum allowable levels of toxins in food have already been set by global health organizations such as FAO and WHO. The amounts of lead and cadmium in milk have been determined to be 1000 ppb and 100 ppb, respectively (4).

Food materials get contaminated with toxic metals in different ways. The amount of contamination in different foods is variable. Hence, choosing a suitable method for measuring these toxic metals in food materials is highly important. In this study, our purpose is to measure Pb and Cd contaminants in raw milk, compare the results with world standards, and prepare a good method for continuous measurement of these toxic metals in milk. If the amounts of these toxic metals are more than standard level, these tests should be done routinely in all food control laboratories (8).

MATERIALS AND METHODS

Sampling

Sampling is one of the most important steps in research. If the number of the samples increases, the possibility for errors goes down. In this study, raw cow milk was sampled from four different traditional and industrial farms around Arak, including Khondab (southwest), Gavar and Aghil Abad (southeast), Farahan (west), and Arak-Qom Road (north). Overall, for each season, 12 samples (a total of48 samples) were prepared, and each sample was analyzed two times. Measurement of lead and cadmium amounts by atomic absorption method was done in the following way:

First, 25 g of each sample was weighed in ceramic crucibles and dried in 450 °C by heater. Then the crucibles were put on a flame and burnt. After that, crucibles containing the samples were put in the oven at 450°C for 4 hours until the sample turned to ash.

In the next step, 0.1 mol of nitric acid was added to the vessel containing the sample. Then it was flattened in a balloon and the volume was increased to 50 ml with nitric acid 0.1 molar. Then 20 ml of the sample was transferred into a funnel decanter (separation), few drops of bromocresol was added to the detector, and eventually4 ml of citric acid was added to it. The samples pH was regulated on 5.4 by ammonia in 4.5 pH.

In the above-mentioned step, the amount of lead and cadmium was measured by graphite furnace atomic absorption spectroscopy along with Varian brands (8-13).

Statistical analysis

In order to make accurate judgments about the obtained results, statistical tests such as Npar tests, Mann-Whitney, and Kruskal-Wallis were run.

RESULTS

According to Tables 1 and 2 and the reported amounts of P-value, there was not a significant difference between the pollution levels of lead and cadmium in traditional and industrial farms in each season.

Table1. The comparison between the mean value of lead (pb) in different seasons and types of farms

Season	Total mean	Mean between traditional	Mean between industrial farms	P-Value
Spring	7.31	8.53	6.43	0.408
Summer	0.94	0.75	1.048	0.406
Fall	1.037	0.83	1.18	0.500
Winter	0.935	1.069	0.48	0.411
Total mean in year	2.56	2.79	2.37	0.002
P-value	0.649	0.635	0.658	-

Table 2. The comparison between the mean values of cadmium in different seasons and types of farms

Season	Total mean	Mean between traditional	Mean between industrial farms	P-Value
Spring	7.31	8.53	6.43	0.408
Summer	0.94	0.75	1.048	0.406
Fall	1.037	0.83	1.18	0.500
Winter	0.935	1.069	0.48	0.411
Total mean in year	2.56	2.79	2.37	0.002
P-value	0.649	0.635	0.658	-

However, there was a significant difference between lead and cadmium amounts in different seasons. The amounts of lead and cadmium in spring were significantly different from the other three seasons. In spring, the contaminations were higher than other seasons. In spring, summer, and winter the amount of lead in industrial livestock was more than traditional ones, while in winter, they were similar. The amounts of cadmium in summer and fall in industrial livestock were more than traditional ones and they were lower in winter and spring.

Table 3 presents minimum and maximum values, mean, standard deviation, and variance in test results.

Table3. The obtained results of analyzing lead and cadmium with frequency distribution method

Metal	Lead	Cadmium
Minimum	1.53	0.03
Maximum	64.53	20.09
Mean	16.0456	20.09
SD of mean	2.21429	0.57538
Variance	15.18042	3.94458

DISCUSSION

According to the results in Table 3, lead and cadmium amounts in raw milk are lower than the allowed limit.

In a study done by Javadi *et al*. in 2005, the mean amounts of toxic metals like lead, cadmium, chromium, and quick silver in cow milk in Isfahan city using the atomic absorption apparatus were 49.1, 9.8, 38.8, and 0.05, respectively (14).

Also, in 2005, Naz Awan *et al*. measured zinc and lead amounts in raw milk in Islam Abad International University, Pakistan, and they concluded that mean concentrations of lead in raw milk were about 0.08-0.014 ppm and 0.13 ppm in processed milk, which in both samples mean concentrations were more than allowable limit (0.025 ppm) (15).

In 2007, the remaining lead in raw milk was measured in different regions of Iran by Taj Karimi in Tehran University. They collected and analyzed 97 samples of raw milk from 15 dairy factories in different regions of Iran. The mean amount of lead in 97 samples was 7.9 ng/ml in the range of 1 to 41 ng/ml and the standard deviation was 8.8.

The results showed that 10% of the samples had a lead proportion of more than 22 ng/ml, and 60% of the samples had levels between 5.7 and 1.1 ng/ml. Three series of samples from Tehran, Isfahan, and West Azarbaijan showed a higher level of contamination but more studies are needed (16).

The existing resemblance between these studies is because all of them considered raw milk samples and analyzed them with atomic absorption method, but the difference between the results can be due to the existence of sources of creating lead pollution.

According to the findings of the present study, the pollution level withcadmium is more than lead, whereas measurement of lead and cadmium in raw milks in California University by Bruhn and colleagues showed that lead concentration in 350 samples of raw milk was 91 ppm and in 222 samples it was below 100 ppm while the mean concentration of cadmium in 315 samples of raw milk was 6ppm, in 40 samples was 10 ppm or less, in 225 samples was below 10 ppm. All samples were collected from markets (17).

Jeng *et al*. measured lead and cadmium levels in raw milk in Taiwan Biologic University in 107 samples in 1993.The prevalence of cadmium concentration was between 21.0, 0.173, 2.03 ng/ml and the prevalence of concentration of lead was between 0.98-4.45 ng/ml. They did not find a significant difference among 6 villages.

Zamanian and Shahsavari in their study determined lead and cadmium pollution levels in milk in Food and Medicine Laboratories Office of Tehran. Sixty samples from factories A and B in Tehran were obtained and analyzed. The mean lead concentration of factory A was 0.25 mg/kg and maximum and minimum levels of lead concentration were 0.11 and 0.9 mg/kg, respectively.

The mean lead concentration of factory B was 0.3 mg/kg and the maximum and minimum levels of lead concentration were 14.0 mg/kg and 0.42 mg/kg, respectively. It was shown that cadmium mean was more than standard limit and lead mean was below the standard limit.

It can be concluded that the differences between the results of this study and other studies lies in the sources of creating cadmium pollution in raw milk in considered regions of this study which include industrial factories, kind of soil, seasons rainfall or transferable factors of cadmium to raw milk which can be more than lead (18,19).

CONCLUSION

Overall, the results of this study showed that lead contamination in milk is relatively low while cadmium contamination is higher; however, both of these contaminations (lead and cadmium) in milk samples are lower than the standard limits. The amount of pollution with these toxic metals in industrial and traditional farms is similar. In addition, more pollution is observed in spring season while there is less pollution in winter.

Soil is one of the important sources for lead and cadmium pollution; therefore, the amount of lead and cadmium in soli is related to human activities or the air. Transfer and absorption of these metals from soil depends on different factors like pH, mineral combination, type, and organic combination of the soil.

The pH of soil is a basic factor in solution lead and cadmium mean concentrations, but other factors like capacity affect the amount of desorption in milk. Hence, existence of acidic rains can change the pH of soil in superficial waters in spring season.

It is worth mentioning that the test results for lead and cadmium contamination levels were below the standard limit. Fortunately, lead and cadmium levels of raw milk which come to the factory were lower than the standard limit and there is no need for continuous testing in food control laboratories. However, milk is one of the important materials in food baskets for household consumption and disposal of these metals from the body requires a very longtime and may accumulate over time, which eventually amounts to jeopardizing human health.

Therefore, it is recommended that the safety of foods be ensured and the products be randomly checked for reducing the risk of contamination with toxic metals.

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