Damanhour Journal of Veterinary Sciences 1 (2019) 27–30

Damanhour Journal of Veterinary Sciences

Journal homepage: www.damanhourjvetsci.com

E-ISSN 2636-3003 | ISSN 2636-2996

Heavy metals in raw milk and some dairy products at local markets

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ABSTRACT

A total of seventy-five random samples of dairy products (15 each of raw cow's milk, raw buffalo's milk, condensed milk, baby formula, and milk powder) were collected from different markets and pharmacies at Damanhour, Behera governorate, Egypt. All examined samples were analyzed by Atomic Absorption Spectrophotometer to determine heavy metals residues namely such as Lead (Pb), Cadmium (Cd), Aluminum (Al), Chromium (Cr), and Nickel (Ni). The results obtained revealed that highly toxic metals lead (Pb) and cadmium (Cd) were detected above the recommended daily intake, While aluminum (Al), chromium (Cr), and nickel (Ni) were detected below the recommended daily intake as Lead levels in raw cow milk, raw buffalo milk, condensed milk, baby formula and milk powder were (0.11 ± 0.038 , 0.14 ± 0.040, 0.20 ± 0.049, 0.21 ± 0.052, and 0.27 ± 0.054), Cadmium levels were (0.03 ± 0.021, 0.09 ± 0.037, 0.11 ± 0.044, 0.12 ± 0.036, and 0.17 ± 0.046), Aluminum levels were (0.15 ± 0.078, 0.162 ± 0.062, 0.23 ± 0.077, 0.24 ± 0.086, and 0.26 ± 0.066), Chromium levels were (0.06 ± 0.05, 0.073 ± 0.04, 0.11 ± 0.046, 0.21 ± 0.062, and 0.20 ± 0.061), and Nickel levels were (0.00, 0.025 ± 0.015, 0.04 ± 0.03, 0.05 ± 0.023, and 0.093 ± 0.04), respectively. Public health significance of heavy metals was discussed.

Keywords: Heavy metals; Raw milk; Dairy products; Local markets

1. Introduction

Milk and milk products are one of the main sources of minerals and rich in calcium, phosphorus, vitamins and proteins, also are basic foods in the human diet (Rezaei et al., 2014).

Heavy metals are persistent contaminants in the environment that can cause serious environmental and health hazards. Some heavy metals like Cu, Fe and Zn are essential to maintain proper metabolic activity in living organisms, others like pb and cd are non-essential and have no biological role. However, at high concentrations, even essential metals also cause toxicity to living organisms (Belete et al., 2014).

Cadmium and lead are both most toxic food chain contaminants. Cd damages the lungs and cause the painful Itai-Itai disease. Lead (Pb) affects blood, numerous organs, and the nervous system (Malhat et al., 2012).

Aluminum is one of the most toxic elements (TES) that accumulate especially in the lung, liver, kidney, thyroid glands and brain. Aluminum has a neurotoxic effect and play a factor in Alzaheimer's disease (Abdel-Hameid et al., 2016).

Exposure to high level chromium can damage and irritate nose, lungs, stomach and intestines. Ingesting of very large amounts of chromium can cause stomach upsets and ulcers, convulsions, kidney and liver damage and even death (Kochare and Tamir, 2015).

Nickel is an essential in small doses, but it can be dangerous when the maximum tolerable amounts are exceeded and cause various kinds of cancer (Wuana and Okieimen, 2011).

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P ISSN: 2636-3003 EISSN: 2636-2996
DOI: 10.5455/DJVS.27082

Received: January 5, 2019; Received in revised form: January 14, 2019; accepted: January 19, 2019.

Milk and dairy products become contaminated with heavy metals either through contamination of the original cow's milk or from other sources as water used in food processing or cooking, equipments, containers, and utensils used for processing and packaging, storage and cooking (Abdelkhalek et al., 2015).

Several analytical methods have been reported for the determination of trace metals in milk and dairy products including inductively coupled plasma-mass (ICP-MS) spectrometry or, atomic absorption spectroscopy (Sahar et al., 2016). The aim of this work was to evaluate the levels of some metals as Cadmium, Lead, Aluminum, Chromium, and Nickel in in raw cow and buffalo milk, milk powder, baby formula milk powder and condensed milk that sold at local market at Damanhour city at El-Behera, Governorate, Egypt.

2. Material and methods

2.1. Collection of samples

Seventy-five random samples of dairy products (15 of each raw cow's milk, raw buffalo's milk, condensed milk, baby formula and milk powder) were randomly collected from different markets and pharmacies in Damanhour city at Behera, Governorate, Egypt. All samples were prepared analyzed before their expiry date AND were taken to the laboratory with a minimum of delay. Each sample was labeled to identify the date of sampling as well as sources and the site of collection.

2.2. Washing procedures (AOAC,2006)

Washing of equipment is an important process to avoid contamination with the analyzed element. Glass wares and vessels were thoroughly cleaned with deionized water and soaked in hot diluted HNO_3 (10%) for 24 hours and rinsed several times with deionized water and dried to ascertain that all the equipments were metal free.

2.3. Digestion technique

Accurately, 2 gm of each sample were digested by 10 ml of digestion mixture (60 ml of 65 % Nitric acid and 40 ml of 70 % perchloric acid) in screw capped tube (Tsoumboris and Papodoulou, 1994).

2.4. Preparation of blank and standard solutions

Instrumental procedures for various analyses were based on those suggested in the operator manual of the Atomic Absorption Spectrophotometer. However, blank and standard solutions were prepared in the same manner as applied for wet digestion and by using the same chemicals (Shibamoto and Bjeldanes, 2000).

2.5. Analysis

The digest, blanks, and standard solutions were aspirated by Flame Atomic Absorption Spectrophotometer (VARIAN, Australia, model AA240 FS) and analyzed for lead, cadmium, aluminum, chromium, and nickel concentration according to table 1.

2.6. Quantitative determination of heavy metal residues

Absorbency of lead, cadmium, aluminum, chromium and nickel was directly recorded from the digital scale of it and its concentration was calculated.

3. Results and Discussion

Analysis of the samples to indicate the contamination with some heavy metals as Lead, Cadmium, Aluminum, Chromium, and Nickel. It considered hazardous impact on human health if exceeded the maximum permissible limit.

Table 1. Analysis conditions

Condition	Lead	Cadmium	Aluminum	Chromium	Nickel
Lamp wave length (nm)	**283.3**	**228.8**	**275.6**	**357.9**	**232.0**
Lamp current (m/amp)	**3**	**2**	**4**	**2**	**7**
Slit width (nm)	**0.7**	**0.7**	**0.5**	**0.7**	**0.2**
Used gas	**N2O/A/AC***	**N2O/A/AC***	**AC/N2O****	**AC/N2O****	**A-AC ***

N2O/A/AC* = Nitrous oxide/Air/Acetylene AC/N2O** = Acetylene / Nitrous oxide A-AC*** = Air/Acetylene

Table 2. Lead levels (ppm) in the examined raw milk and some dairy products samples and Comparison with Egyptian standards

Product	No. of Examined samples	Positive samples		Mean ± SE	Permissible limit (ppm)
		No.	%		
Raw Cow Milk	15	6	40	0.11 ± 0.038	0.02
Raw Buffalo Milk	15	8	53.33	0.14 ± 0.040	0.02
Condensed milk	15	9	60	0.20 ± 0.049	0.02
Baby formula	15	9	60	0.21 ±0 .052	0.02
Milk powder	15	11	73.33	0.27 ± 0.054	0.02

Table 3. Cadmium levels (ppm) in the examined raw milk and some dairy products samples and Comparison with Egyptian standards

Product	No. of Examined samples	Positive samples		Mean ± SE	Permissible limit(ppm)
		No.	%		
Raw Cow Milk	15	3	20	0.03 ± 0.021	0.05
Raw Buffalo Milk	15	4	26.66	0.09 ± 0.037	0.05
Condensed milk	15	5	33.33	0.11 ± 0.044	0.05
Baby formula	15	7	46.66	0.12 ± 0.036	0.05
Milk powder	15	8	53.33	0.17 ± 0.046	0.05

Table 4. Aluminum levels (ppm) in the examined raw milk and some dairy products samples and Comparison with Egyptian standards

Product	No. of Examined samples	Positive samples		Mean±SE	Permissible Limit (ppm)
		No.	%		
Raw Cow Milk	15	3	20	0.15 ± 0.078	0.5
Raw Buffalo Milk	15	5	33.33	0.162 ± 0.062	0.5
Condensed milk	15	4	26.66	0.23 ± 0.077	0.5
Baby formula	15	5	33.33	0.24 ± 0.086	0.5
Milk powder	15	7	46.66	0.26 ± 0.066	0.5

Table 5. Chromium levels (ppm) in the examined raw milk and some dairy products samples and Comparison with National standards

Product	No. of Examined samples	Positive samples		Mean ± SE	Permissible limit(ppm)
		No.	%		
Raw Cow Milk	15	2	13.33	0.06 ±0.05	0.4
Raw Buffalo Milk	15	3	20	0.073 ±0.04	0.4
Condensed milk	15	3	20	0.11 ± 0.046	0.4
Baby formula	15	4	26.66	0.21 ± 0.062	0.4
Milk powder	15	4	26.66	0.20 ± 0.061	0.4

Table 6. Nickel levels (ppm) in the examined raw milk and some dairy products samples and Comparison with National standards

Product	No. of Examined samples	Positive samples		Mean ± SE	Permissible limit(ppm)
		No.	%		
Raw Cow Milk	15	0	0.00	0.00	0.2
Raw Buffalo Milk	15	2	13.33	0.025 ± 0.015	0.2
Condensed milk	15	2	13.33	0.04 ± 0.03	0.2
Baby formula	15	3	20	0.05 ± 0.023	0.2
Milk powder	15	3	20	0.093 ± 0.04	0.2

Results obtained in Table (2) revealed that the higher level of lead observed in milk powder as it's level ranged from (0.02 to 0.58) ppm with a mean value of (0.27 ± 0.054) ppm ,followed by baby formula was a level ranged from (0.01 to 0.49) ppm with a mean value of (0.21 ± 0.052) ppm ,followed by condensed milk with a level ranged from (0.01 to 0.44) ppm with a mean value of (0.20 ± 0.049) ppm , followed by raw buffalo milk with a level ranged from (0.01 to 0.32) ppm with a mean value of (0.14±0.040) ppm . Lower level observed in raw cow milk with a level ranged from (0.01 to 0.25) ppm with a mean value of (0.11 ± 0.038) ppm. Results obtained in table (2) cleared that 4 samples (26.66%) of raw cow milk, 5 samples (33.33%) of raw buffalo milk ,7 samples (46.66%) of condensed milk ,7 samples (46.66%) of baby formula milk and 9 samples (60%) of milk powder were exceeding the permissible limit (0.02 ppm) as established by (Egyptian standards, No 7136/2010).

The main sources of lead exposure include the drinking water, food, dust, soil, paints, enameled soil cookware, soldered metal containers, water pipes, cosmetics, insecticides, cell battery, cigarette, gasoline, and printing houses where lead(pb) is used (Yurdakok et al., 2015). Regarding the public health hazards of the detected metals, lead is found among the main metals present in the environment that have major toxic effects. The increased level has been associated with learning deficiencies in children (Lutfullah et al., 2014).

Table (3) showed that the higher level of cadmium were observed in milk powder as it's level was ranged from (0.01 to 0.33) ppm with a mean values of (0.17 ± 0.046) ppm ,followed by baby formula milk as it's level ranged from (0.01 to 0.27) ppm with a mean value of (0.12 ± 0.036) ppm , followed by condensed milk with a level ranged from (0.01 to 0.25) ppm with a mean values of (0.11 ± 0.044) ppm ,followed by raw buffalo milk with a level was ranged from (0.01 to 0.19) ppm with a mean value of (0.09+0.037) ppm . Lower level observed in raw cow milk as it's ranged from (0.01 to 0.07) ppm with a mean value of (0.03 ± 0.021) ppm.

Results obtained in table (3) cleared that 1 sample (6.66%) of raw cow milk, 3 samples (20%) of raw buffalo milk, 3 samples (20%) of condensed milk, 5 samples (33.33%) of baby formula, 6 samples (40%) of milk powder were exceeding the permissible limit (0.05 ppm). Human exposure to cadmium occurs chiefly through inhalation or ingestion. cigarette smoking is the most significant source of human cadmium exposure. inhalation due to industrial exposure can be significant in occupational settings. cadmium exposure occurs from ingestion of contaminated food and can produce long-term health effects. contamination of drugs and dietary supplements may also act as a source of contamination (Bernhoft, 2013).

Cadmium is carcinogenic agent that specifically causes tumors in the lungs and prostate, kidneys, bones, lungs, liver, heart, and vessels. The effects of cadmium contamination on pregnant women can cause malformations, fetal weight reduction, and abnormality in the baby’s DNA and proteins as well as abortion due to high levels of contamination (Delavar et al., 2012).

Table (4) revealed that the higher the level of aluminum was observed in milk powder as it's ranged from (0.04 to 0.53) ppm with a mean values of (0.26 ± 0.066) ppm ,followed by baby formula with a level ranged from (0.03 to 0.51) ppm with a mean value of (0.24 ± 0.086) ppm , followed by raw buffalo milk with a level ranged from (0.02 to 0.31) ppm with a mean value of (0.162 ± 0.062) ppm. Followed by condensed milk samples with a level ranged from (0.02 to 0.39) ppm with a mean value of (0.23 ± 0.077) ppm. Lower levels were observed in raw milk as it's ranged from (0.01 to 0.28) ppm with a mean value of (0.15 ± 0.078) ppm.

Results obtained in table (4) cleared that raw cow milk samples, raw buffalo milk samples and condensed milk samples not exceed the recommended permissible limit (0.5 ppm). While 1 sample (6.66%) of baby formula and 1 sample (6.66%) of milk powder were exceeding the permissible limit (0.5 ppm).

Food is unquestionably the main source of aluminum intake (Stahl et al., 2011). Humans are frequently exposed to aluminum, primarily from foods, water, airborne dust, and pharmaceuticals (Semwal et al., 2006).

Chronic Aluminum exposure has contributed directly to hepatic failure and dementia. Other symptoms that have been observed in individuals with high internal concentrations of Aluminum are colic, convulsions, esophagitis, gastroenteritis, kidney damage, liver dysfunction, loss of appetite, loss of balance, muscle pain, psychosis, shortness of breath, weakness, fatigue and birth defects in new born (ATSDR 2008).

Results obtained in Table (5) revealed that the higher level of chromium observed in milk powder as it's ranged from (0.03 to 0.32) ppm with a mean value of (0.20 ± 0.061) ppm ,followed by baby formula with a level ranged from (0.02 to 0.24) ppm with a mean value of (0.21 ± 0.062) ppm , followed by condensed milk with level ranged from (0.02 to 0.18) ppm with a mean value of (0.11 ± 0.046) ppm , followed by raw buffalo milk with a level ranged from (0.01 to 0.15) ppm with a mean value of (0.073 ± 0.04) ppm . Lower level was observed in raw cow milk that ranged from (0.01 to 0.11) ppm with a mean value of (0.06 ± 0.05) ppm, respectively.

Results obtained in table (5) cleared that the examined raw milk and some dairy products were parallel with National standards. All examined samples were polluted with chromium with permissible limit (0.4 ppm) as established by National standards.

Sources of chromium contamination are stainless steel welding, chromate or chrome pigment production, chrome plating, leather tanning, handing or breathing saw dust from chromium treated wood (Kochare and Tamir 2015). The primary health hazards caused by chromium are bronchial asthma, lung and nasal ulcers and cancers, skin allergies. Moreover, reproductive and developmental problems as well as chromium is carcinogenic in nature when taken in excess it may cause death (Shekhawat et al., 2015).

Table (6) cleared that the higher the level of nickel observed in milk powder as it's ranged from (0.02 to o.16) ppm with a mean value of (0.093 ± 0.04) ppm ,followed by baby formula that ranged from (0.01 to 0.09) ppm with a mean value of (0.05 ± 0.023) ppm ,followed by condensed milk that ranged from (0.01 to 0.07) ppm with a mean value of (0.04±0.03) ppm ,followed by raw buffalo milk with a level ranged from (0.01 to 0.04) ppm with a mean value of (0.025 ± 0.015) ppm . All examined raw cow milk samples were nickel free.

Table (6) cleared that all examined samples contaminated with nickel were within the permissible limit (0.2 ppm) as established by National standards. Pollution mainly results from effluent disposal from mining, smelting, electroplating industries as well as from sewage sludge and compost (Chen et al., 2009).

The most form of nickel (Ni) do not pose any threat to human health, however, large doses of it such as accidental ingestion, have been recognized with effects as stomach ache, heart failure, lung tumors, cancer, allergic skin reactions and dermatitis (Adams and Happiness 2010).

5. Conclusion

From all previously results showed that the examined samples were contaminated with heavy metal residues with variable amounts, but these amounts were exceeded through manufacturing, packaging and several stages. Heavy metals residues in milk could be controlled by monitoring of water and feed for livestock as well as application of appropriate containers in transit of raw milks may be helpful for production of healthier milks. Strict and regular monitoring of heavy metal residues of imported milk and milk products at different ports and that which above the permissible limits should be refused and return to the original exported countries.

Competing Interests

The authors have no conflict of interest.

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