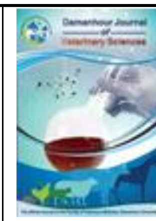
Damanhour Journal of Veterinary Sciences 5 (2), (2021) 13-16

Damanhour Journal of Veterinary Sciences

Journal homepage: https://djvs.journals.ekb.eg/



# Lead, cadmium, and aluminium residues in cow's and buffaloes' milk with a reference to the effect of heat treatment of the milk in different cooking wares on the metal load

**Seham Elbadry**

Educational Veterinary Hospital, Faculty of Veterinary Medicine, Zagazig University, 44511, Egypt

**A B S T R A C T**

Heavy metals such as lead (Pb), cadmium (Cd), and aluminium (Al) characterized by their bioaccumulation and bio-magnification in the animal and human bodies causing multiple organ damage. The present study aimed at estimation of the residual content of Pb, Cd, and Al in the retailed cow's and buffaloes' milk collected from urban and rural areas in Sharkia Governorate, Egypt. In addition, the effects of the heat treatment of the milk in different cooking wares (made from aluminium, glass, and stainless steel) were further examined. The public health significance of the studied metals was discussed. The obtained results revealed detection of the tested metals in all examined samples at variable concentrations. In general cow's milk had higher contents of Pb, Cd, and Al compared with the milk of buffaloes. Moreover, milk sampled from rural areas had significantly higher metal load compared with that sampled from urban areas. Heating of the milk in aluminium-made cooking wares significantly increased Al residues in the heat-treated milk with slight increase in the load of Pb, and Cd. While heating of the milk in cooking wares made from glass had slight reduction in the metal load of the milk. Therefore, it is highly recommended to use glass wares for heating of the milk instead of aluminium wares to avoid leaching of toxic metals to the heated milk.

**Keywords:** Heavy metals; raw milk; cooking wares; aluminum

## 1. Introduction

Milk is considered as a rich source in the bioactive peptides, vitamins, and essential trace elements such as calcium and magnesium (Stadnik and Kęska, 2015). At the same time, milk is considered as a bioindicator for the exposure of the animal to xenobiotics as such chemicals are released into milk, and subsequently find their way into the consumers' bodies if contaminated milk is ingested (Thompson and Darwish, 2019).

Heavy metals are among xenobiotics which are found naturally in the environment or released via anthropogenic activities such as mining, burning of the organic matter, or direct disposal of the agricultural and industrial wastes. Heavy metals are known for their bio-accumulative and biomagnification nature. Heavy metals such as lead (Pb), cadmium (Cd), and aluminum (Al) are of no-known physiological values and have linked to many cases of intoxication (Thompson and Darwish, 2019).

Exposure of children to Pb is linked to many cases of intoxication and deaths worldwide (Darwish et al., 2016). In addition, Pb can affect the mental and intellectual abilities and have several adverse effects on the gastrointestinal tract (Cunningham and Saigo, 1997). Cd is another toxic metal that was responsible for many cases of renal dysfunction and bone softening or what is called itai-itai disease in Japan (Nishijo et al., 2017). Cd is also classified as a group B1 carcinogen (IARC, 2016). In addition, human exposure to even small concentrations of Cd on a regular basis is linked to multiple organ damage such as testes, breast, liver, kidney, and nervous system (Darwish et al., 2019).

*Corresponding author:

E-mail address: alnouracademy@yahoo.com

Educational Veterinary Hospital, Faculty of Veterinary Medicine, Zagazig University, 44511, Egypt

Aluminum is one of the industrial elements which can find the way to the animal body accidently. Furthermore, Al can contaminate milk via using milk packages lined with Al. Besides, heating of the milk in cooking wares made from Al is another source for the milk contamination with Al (Boudebbouz et al., 2021). Investigation of the residual contents of Al in packaging materials was done in Egypt in canned fish (Morshdy et al., 2013). However, estimation of Al in milk had been less investigated. Al is implicated in many cases of human illnesses such as anemia, dementia, and osteomalacia (Gupta et al., 2019).

In sight of the previous facts, this study aimed at estimation of Pb, Cd, and Al residues in the major milk types (cow's and buffaloes') mostly consumed in Egypt and collected from stores at both urban and rural sites. Furthermore, the effects of heat treatment of the milk in different cooking wares made from aluminum, glass, and stainless steel on the residual contents of such metals were further investigated.

## 2. Materials and Method

All reagents used were of the highest quality available and the standard solutions of Pb, Cd, and Al were purchased from Merck, Darmstadt, Germany.

*Collection of samples*

A total of 80 random milk samples were collected equally from urban (n=40) and rural (n=40) areas in Sharkia governorate, Egypt. The collected samples from each designed area included cow's and buffaloes' milk (n=20/each). Samples (500 mL of each) were transferred cooled to the laboratory for extraction and heavy metal analysis.

*Sample preparation and extraction*

The extraction and measurement of the tested heavy metals was done according to Darwish et al. (2015). In brief, one mL from each milk sample was mixed with 10 mL of the digestion mixture (3 parts of $HNO_3$ and 2 parts of $HClO_4$). The mixture was left overnight at room temperature for digestion, and then placed at heated water bath (70ºC) with swirling at 30 min intervals for 3 h. Metal concentrations were directly measured using an atomic absorption spectrophotometer (PerkinElmer 2380).

Effect of different cooking wares on the metal load in heat-treated milk

Five samples (500 mL/each) from the cow's milk sampled from rural areas were used for the experimental trial to test the effect of different cooking wares on the metal load in the milk. Then one hundred mL from each sample (n=5) were heated till boiling in cooking wares made from aluminum, glass, and stainless-steel. Then samples were left to cool, and heavy metal extraction and analysis were proceeded as mentioned before.

*Statistical analysis*

The Tukey-Kramer HSD difference test (JMP) (SAS Institute, Cary, NC, USA) was used for statistical comparisons ($p < 0.05$). Data are presented as mean ± SD.

## 3. Results and Discussion

*Residual contents of heavy metals in milk*

*Lead*

The obtained results in the present study revealed detection of Pb in all examined milk samples. Cow's milk sampled from rural areas had significantly ($p < 0.05$) the highest residual Pb content (ppm) (0.23 ± 0.05), followed by buffaloes' milk sampled from rural areas (0.14 ± 0.03), cow's milk sampled from urban areas (0.13 ± 0.02), and buffaloes' milk sampled from rural areas (0.09 ± 0.04), respectively (Fig. 1).

In line with the obtained results in the current investigation, Sujka et al. (2019) detected Pb in raw cow's milk samples from various regions in Poland at 0.01–0.23 ppm. Besides, Pšenková et al. (2020) detected Pb at levels < 0.1 ppm in raw cow's milk in Slovakia. However, Castro-González et al. (2018) reported lower levels of Pb in raw cow's milk (0.03 ppm) in Mexico. In addition, lower Pb levels (0.006-0.01 ppm) were reported in milk samples from Tabriz, Iran (Beikzadeh et al., 2019). Higher Pb residues (60 ppm) were detected in raw cow's milk samples collected in area consists of granites and granite gneisses in India (Boudebbouz et al., 2021).

*Cadmium*

Cadmium was detected in all examined samples in the current study. Raw cow's milk sampled from rural areas had significantly the highest Cd residues (ppm) (0.23 ± 0.02), followed by buffaloes' milk collected from the same areas (0.13 ± 0.03), raw cow's milk sampled from urban areas (0.11 ± 0.02), and raw buffaloes' milk collected from urban areas (0.04 ± 0.01), respectively (Fig. 2). Nearly similar levels (0.28 ± 0.16 ppm) were reported in cow's milk marketed in Benha, Egypt (Malhat et al., 2012). Higher Cd residues (~5.57 ppm) were reported in the pasteurized milk samples retailed in Iran (Sobhanardakani, 2018). Furthermore, Boudebbouz et al. (2021) reported higher Cd (12 ppm) levels in barite mining area in India. Lower Cd residues (0.0001-0.007 ppb) were detected in milk samples from different regions in Poland (Sujka et al., 2019).

*Aluminum*

Aluminum was also detected in all examined milk samples. Similar to Pb, and Cd, raw cow's milk sampled from rural areas had the highest residual concentrations (ppm) of Al (23.95 ± 0.81), followed by cow's milk collected from the urban areas (14.79 ± 2.42), buffaloes' milk sampled from rural areas (14.08 ± 2.52), and buffaloes' milk sampled from urban areas (6.60 ± 1.80), respectively (Fig. 3). In agreement with the obtained results in the present study, Totan and Flazi (2020) recorded Al residues at 29.88 ± 32.00 ppm in raw whole cow's milk retailed in Ankara, Turkey. Besides, Boudebbouz et al. (2021) reported that Al level was 22.50 ppm in raw cow's milk collected close to food producing plants region in Turkey. Unlikely, lower Al concentrations (0.08 ± 0.01 ppm) was reported in retailed market milk in Mansoura city, Egypt (Al-Ashmawy, 2011). However, higher Al levels (up to 270.63 ppm) was recorded in milk taken directly from cows in Egypt (Meshref et al., 2014). Heavy metals occur naturally in the environment and find their way into the animal body via contaminated feed and water. Such metals accumulate in the animal tissues such as muscles and mammary glands and might pass into the milk (Morshdy et al., 2019; Thompson and Darwish, 2019). One possible explanation for the high accumulation of the metals in the cow's milk than buffaloes' is their inter-species differences in their xenobiotic metabolizing enzymes (Darwish et al., 2010). Therefore, future studies are still needed for further explanation of this variation.

Milk is usually heat-treated for the purpose of the destruction of the microorganisms contaminating the milk. The effect of heat treatment of the milk in different cooking wares is less investigated. Therefore, the effect of heat treatment of the milk in glass, aluminum, and stainless-steel containers was investigated. Heat-treatment of milk in aluminum wares significantly increased all tested metals including Pb, Cd, and Al. Interestingly, heat treatment of milk in glass and stainless-steel containers reduced the content of Al, and Cd with no change in the Pb residues (Figs 4-6). In agreement with the obtained results in the current investigation, Al-Ashmawy (2011) reported leaching of Al from Al-made containers to the milk causing significant increase in Al load. The same author added that glass is the best container to avoid leaching of metals from the milk containers to the milk itself.

Ingestion of milk contaminated with heavy metals such as Pb, Cd, and Al has several health adverse effects such as toxicities, organ damage, cancer, and several cases of deaths (Thompson and Darwish, 2019). Therefore, continuous monitoring and screening of heavy metal contents in milk and other dairy products and ensuring safety of such products in relation to food-chemical contaminants of significant importance for both public health and food safety sectors.

## 4. Conclusions

The obtained results in the present study revealed detection of Pb, Cd, and Al in all examined samples at variable concentrations. Milk samples collected from rural areas had significantly higher metal residues than that collected from urban areas. Cow's milk had higher contents of Pb, Cd, and Al compared with buffaloes' milk. This inter-species difference in their accumulation of metals might be due to their physiological differences in xenobiotic metabolism. Boiling of the milk in aluminum wares led to an increase in the residues of all tested metals in the milk, while glass reduced the metal load in the tested milk samples.

**Conflict of interest**: None

## 5. References

Al-Ashmawy, M.A., 2011. Prevalence and public health significance of aluminum residues in milk and some dairy products. J. Food Sci. 76(3), T73-6. doi: 10.1111/j.1750-3841.2011.02064.x.

Beikzadeh, S., Ebrahimi, B., Mohammadi, R., Beikzadeh, M., Asghari-Jafarabadi, M., Foroumandi, E., 2019. Heavy metal contamination of milk and milk products consumed in Tabriz. Curr. Nutr. Food Sci. 15(5), 484-492.

Boudebbouz, A., Boudalia, S., Bousbia, A., Habila, S., Boussadia, M.I., Gueroui, Y., 2021. Heavy metals levels in raw cow milk and health risk assessment across the globe: A systematic review. Sci. Total Environ. 751, 141830. doi: 10.1016/j.scitotenv.2020.141830.

Castro-González, N.P., Calderón-Sánchez, F., Castro de Jesús, J., Moreno-Rojas, R., Tamariz-Flores, J.V., Pérez-Sato, M., Soní-Guillermo, E., 2018. Heavy metals in cow's milk and cheese produced in areas irrigated with wastewater in Puebla, Mexico. Food Addit. Contam. Part B Surveill. 11(1), 33-36. doi: 10.1080/19393210.2017.1397060.

Cunningham, W.P., Saigo, B.W., 1997. Environmental Science a Global Concern, 4th ed.; WMC Brown Publisher: New York, NY, USA, p. 389.

Darwish, W.S., Chiba, H., Elhelaly, A.E., Hui, S.P., 2019. Estimation of cadmium content in Egyptian foodstuffs: health risk assessment, biological responses of human HepG2 cells to food-relevant concentrations of cadmium, and protection trials using rosmarinic and ascorbic acids. Environ Sci. Pollut. Res Int. 26(15), 15443-15457. doi: 10.1007/s11356-019-04852-5.

Darwish, W.S., Hussein, M.A., El-Desoky, K.I., Ikenaka, Y., Nakayama, S., Mizukawa, H., Ishizuka, M., 2015. Incidence and public health risk assessment of toxic metal residues (cadmium and lead) in Egyptian cattle and sheep meats. Int. Food Res. J. 22(4), 1719-1726.

Darwish, W.S., Ikenaka, Y., Eldaly, E.A., Ohno, M., Sakamoto, K.Q., Fujita, S., Ishizuka, M., 2010. Cytochrome P450 1A-dependent activities in deer, cattle and horses. J. Vet. Med. Sci. 72(5), 561-566.

Darwish, W.S., Ikenaka, Y., Nakayama, S.M., Mizukawa, H., Ishizuka, M., 2016. Constitutive effects of lead on Aryl Hydrocarbon Receptor gene battery and protection by β-carotene and ascorbic acid in human HepG2 cells. J. Food Sci. 81(1), T275-81. doi: 10.1111/1750-3841.13162.

Gupta, Y.K., Meenu, M., Peshin, S.S., 2019. Aluminium utensils: Is it a concern? Natl. Med. J. India 32(1), 38-40. doi: 10.4103/0970-258X.272116.

International Agency for Research on Cancer, 2016. IARC monographs on the identification of carcinogenic hazards to humans. https://monographs.iarc.fr/agents-classified-by-the-iarc/

Malhat, F., Hagag, M., Saber, A., Fayz, A.E., 2012. Contamination of cow's milk by heavy metal in Egypt. Bull. Environ. Contam. Toxicol. 88(4), 611-3. doi: 10.1007/s00128-012-0550-x.

Meshref, A.M., Moselhy, W.A., Hassan, N.E., 2014. Heavy metals and trace elements levels in milk and milk products. Journal of food measurement and characterization. 8(4), 381-8.

Morshdy, A.E., Hafez, A.E., Darwish, W.S., Hussein, M.A., Tharwat, A.E., 2013. Heavy metal residues in canned fishes in Egypt. Jpn. J. Vet. Res. 61 Suppl, S54-57.

Morshdy, A.E.M.A., Darwish, W.S., Daoud, J.R.M., Sebak, M.A.M., 2019. Estimation of metal residues in Oreochromis niloticus and Mugil cephalus intended for human consumption in Egypt: a health risk assessment study with some reduction trials. J. Consumer Protect. Food Safety 14, 81-91.

Nishijo, M., Nambunmee, K., Suvagandha, D., Swaddiwudhipong, W., Ruangyuttikarn, W., Nishino, Y., 2017. Gender-specific impact of cadmium exposure on bone metabolism in older people living in a cadmium-polluted area in Thailand. Int. J. Environ. Res. Public Health 14(4), 401. doi: 10.3390/ijerph14040401.

Pšenková, M., Toman, R., Tančin, V., 2020. Concentrations of toxic metals and essential elements in raw cow milk from areas with potentially

undisturbed and highly disturbed environment in Slovakia. Environ. Sci. Pollut. Res. Int. 27(21), 26763-26772. doi: 10.1007/s11356-020-09093-5.
Stadnik, J., Kęska, P.. 2015. Meat and fermented meat products as a source of bioactive peptides. Acta Sci. Pol. Technol. Aliment., 14(3), 181-190. doi: 10.17306/J.AFS.2015.3.19.
Sobhanardakani, S., 2018. Human health risk assessment of Cd, Cu, Pb and Zn through consumption of raw and pasteurized cow's milk. Iran J. Public Health 7(8), 1172-1180.
Sujka, M., Pankiewicz, U., Kowalski, R., Mazurek, A., Ślepecka, K., Góral, M., 2019. Determination of the content of Pb, Cd, Cu, Zn in dairy products from various regions of Poland. Open Chemistry 17(1), 694-702.
Thompson, L.A., Darwish, W.S., 2019. Environmental Chemical Contaminants in Food: Review of a Global Problem. J. Toxicol. 2019, 2345283. doi: 10.1155/2019/2345283.
Totan, F.E., Filazi, A., 2020. Determination of some element levels in various kinds of cow's milk processed in different ways. Environ. Monit. Assess. 192(2), 112. doi: 10.1007/s10661-020-8088-6.

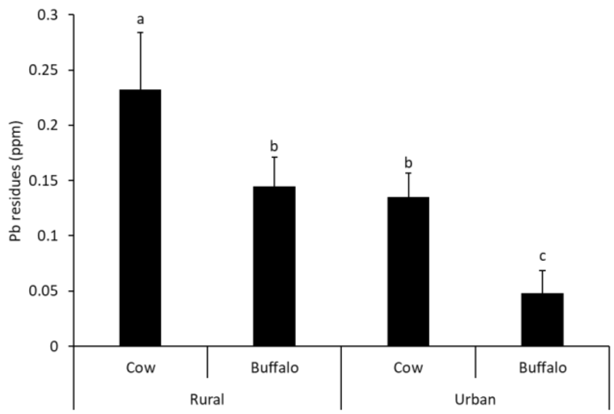



Fig. 1: Lead (Pb) residual contents (ppm) in raw cow’s and buffaloes’ milk sampled from rural and urban areas in Egypt. Data represent means ± SD (n = 20). Columns carrying different letter are statistically significant at p <0.05.

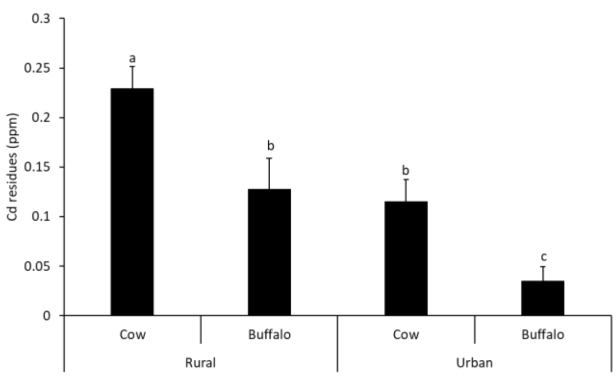



Fig. 2: Cadmium (Cd) residual contents (ppm) in raw cow’s and buffaloes’ milk sampled from rural and urban areas in Egypt. Data represent means ± SD (n = 20). Columns carrying different letter are statistically significant at p <0.05.

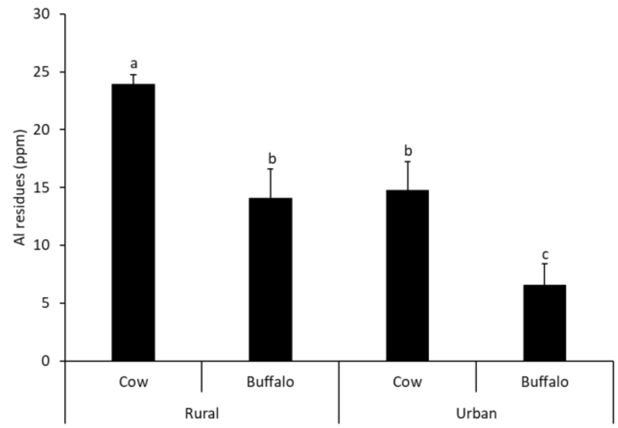



Fig. 3: Aluminum (Al) residual contents (ppm) in raw cow’s and buffaloes’ milk sampled from rural and urban areas in Egypt. Data represent means ± SD (n = 20). Columns carrying different letter are statistically significant at p <0.05.

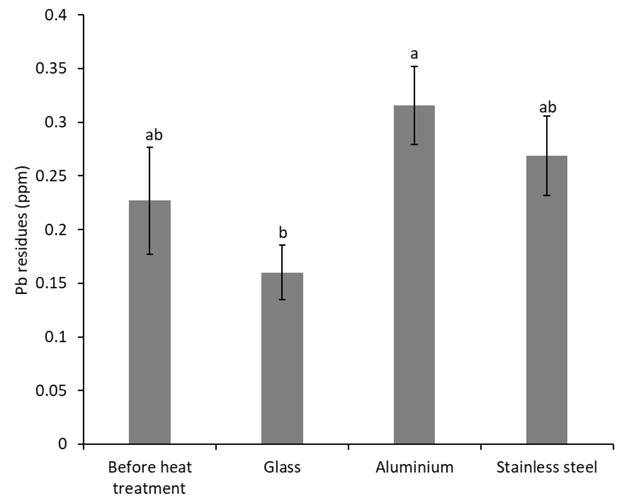



Fig. 4: The effect of heat treatment of the raw cow’s milk in different cooking wares on Pb residues. Data represent means ± SD (n = 5). Columns carrying different letter are statistically significant at p <0.05.

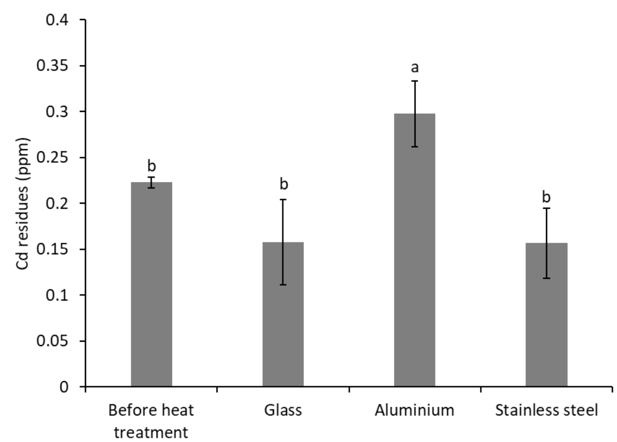



Fig. 5: The effect of heat treatment of the raw cow’s milk in different cooking wares on Cd residues. Data represent means ± SD (n = 5). Columns carrying different letter are statistically significant at p <0.05.

Fig. 6: The effect of heat treatment of the raw cow's milk in different cooking wares on Al residues. Data represent means ± SD (n = 5). Columns carrying different letter are statistically significant at $p < 0.05$.