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CONTENT AND SOURCES OF CONTAMINATION OF DONKEY MILK BY HEAVY METALS - REVIEW

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Abstract

Agricultural practice, the methods used in increasing and feeding of animals, may be a main factor in the appearance of harmful elements in the products obtained from them. Due to the high consumption of milk worldwide, the question has arisen of determining the compounds that can be harmful to consumers, such as the presence of heavy metals. Heavy metals are toxic to the human body, consumed even in small proportions, and their sources in milk, its products or by-products, can be both natural and anthropogenic, as the main sources being water used in irrigation, agricultural practices, air pollution and contaminated feed used in the ration of animals. The most common heavy metals determined in fresh donkey milk are iron, copper, magnesium, lead, zinc, cadmium, arsenic and chromium, their determination being possible both by means of standard methods and by means of the mass spectrometry method. The determination of these toxic compounds which may be present in milk is of importance, in particular as regards babies and children, on which they may have a carcinogenic effect.

Key words*: donkey, factor, heavy metals, lead, milk, zinc.*

INTRODUCTION

In the human diet, milk and milk products are almost always found, because of this, the determinations of the potentially harmful and chemical compounds that may appear in these products are of increasing interest (Meshref et al., 2014).

Milk is an important source of nutrients, being indispensable for the growth and development of children, and donkey milk being rich in elements such as lactose and whey proteins, its usefulness in making milk substitutes has been demonstrated, thus attracting the attention of researchers (Brumini et al., 2016).

Due to the medical and nutritional benefits of donkey milk, obtained from domestic donkeys, the question was raised of determining the possible contamination of this product and determining the benefits it presents for the body (Li et al., 2021).

Also once, the level of protein it contains, donkey milk is recognized as having a high biological value, being similar to human milk (Proikakis et al., 2021).

Also, donkey milk has aroused great interest, due to its antiallergenic properties, being otherwise named as a pharmaceutical product (Perna et al., 2015) having anti-inflammatory action and acting on oxidative stress (Li et al., 2022).

Being a product that is becoming increasingly consumed internationally, with a high comercial value at the moment, the importance of determining possible risks is increasing (Conte et al., 2019).

As uses, donkey milk has been frequently used to obtain cosmetics and also to obtain supplements with antioxidative, anti-inflammatory and immunomodulatory roles (Li et al., 2021).

In order to maintain a high level of consumer health and to avoid the most significant dangers that may arise in donkey milk, it is important to consider risk analysis also in the case of this species, the main consumers of which are children and the elderly (Conte et al., 2019).

The main heavy metals found in both milk and dairy products were mercury, chromium, arsenic, lead and cadmium, their level being dependent on both contamination from the external environment and feed and materials used in product packaging (Yan et al., 2022), all of which were determined in milk by means of standard methods for determining heavy metals (Hasan et al, 2022).

MATERIALS AND METHODS

We systematically reviewed the latest and pertinent research papers accessible through prominent databases such as PubMed, MDPI, Research Gate. This review aims to present a comprehensive synthesis of the scientific findings related to the specified topics regarding the heavy metals in donkey milk.

RESULTS AND DISCUSSIONS

Heavy metals in donkey milk

In milk, various chemical hazards may occur, many of which are introduced during production or various processes for the production and packaging of milk products, also other factors may be veterinary medicinal products, radionuclides, mycotoxins, pesticides and, last but not least, heavy metals, which consumed by animals, leave their residues in their productions (Conte & Panebianco, 2019).

According to the legislation of our country, the maximum limits of heavy metals in milk should not exceed values of 0.1mg /1 l in the case of lead and arsenic and 0.01 mg / 1 l in terms of mercury and cadmium (Hygienic-sanitary norm for food from 16.12.1998).

The translocation of heavy metals and their storage in milk is possible due to non-biodegradation and their ability to keep themselves under the action of temperatures being extremely persistent in the environment (Abdel-Rahman, 2022).

The main consumers of milk are represented by vulnerable people, children and the elderly, who are the most exposed to heavy metal contamination (Ismail et al., 2017).

Heavy metal concentrations in milk and dairy products are one of the main risk factors that have been determined lately, with a harmful action on consumers (Meshref et al., 2014).

Not being metabolized, their retention occurs in all tissues of animals and in its intestine, being transported to the product or products we obtain from animal species (Eskandari & Pakfetrat, 2014).

Due to the accumulation in different organs, heavy metals can cause various liver, nervous and cardiovascular diseases, therefore solutions have been sought over time to eliminate their concentrations in the environment and food (Masoud et al., 2022).

As a result of studies carried out in Italy, residues of toxic metals such as arsenic, lead, cadmium, nickel, mercury and antimuonium were determined in donkey milk and feed used to grow and maintain them (Conte & Panebianco, 2019).

As factors that influence the presence of heavy metals in donkey milk, the lactation period and the geographical area from which the animals come are listed (Longodor et al., 2018), the highest concentrations being highlighted in the 4th lactation, compared to the first lactation, when the values of heavy metals are much lower (Longodor et al., 2019).

Compared to cow's milk in terms of the amount of vanadium and titanium, concentrations were similar or lower, and molybdenum, caesium and strontium showed higher values (Conte et al., 2019).

Also, in other studies conducted this time on donkey breeds in Turkey, the level of Ni, Cd, V and barium concentrations, were 1 mg/L, being lower than the permissible limit (Conte, 2019).

The level of heavy metals found in milk are dependent on their level in the environment, this being associated primarily with the risks to which consumers are exposed (Yan et al., 2022).

Both fresh and processed milk and spilled products, such as butter, cheeses or yogurts, showed high concentrations of heavy metals such as cadmium, zinc, copper and lead (Meshref et al., 2014).

As for copper, it does not have a carcinogenic effect for humans and animals, but in large quantities, it can cause liver and kidney damage (ATSDR, 2004)

Studies have determined, however, that due to the biological filter that the udder of dairy animals presents, the transport of heavy metals is still small being reported as 1:5000, but even so contamination with them is harmful (Ismail et al., 2017).

According to the studies carried out by other authors in Romania, variations in heavy metals depends on the number of lactation were found, thus identifying lead concentrations of 29.7 µg/L, while the identified cadmium concentrations were 5.66 µg/L (Longodor et al., 2018).

However, in the studies carried out on the concentration of heavy metals in donkey milk in donkey breeds in Turkey, they have not been detected, however, with concentrations of essential elements such as magnesium, calcium, potassium and copper being found (Paksoy et al., 2018).
Within our country, the level of heavy metal concentrations in different areas, respectively in Cluj and Sălaj, were determined, being determined differences in the concentrations detected between the two regions (Longodor et al., 2018).
The level of lead concentrations, being lower in the case of Cluj County, respectively 19.59 µg/L, resulting in a weaker contamination with heavy metals of pastoral soils in this county (Longodor et al., 2018).

Table 1. Standard for milk

Heavy metals	Standard for milk and milk product	Reference
Mercury	500 mg/l	Aggarwal et al., 2022
	0.002 mg/kg	Masoud et al., 2022
Arsenic	20 mg/l	Aggarwal et al., 2022
Lead	140 mg/l	Aggarwal et al., 2022
	0.2 mg/kg	Masoud et al., 2022
	0.40 ppm	Meshref & Moselhy, 2014
Cadmium	200 mg/l	Aggarwal et al., 2022
	0.02 mg/kg	Masoud et al., 2022
	0.104 ppm	Meshref & Moselhy, 2014

Sources of heavy metal contamination

The source of contamination by toxic compounds is dependent for both humans and animals on the period of exposure and the level of contaminants found in food or feed (Hasan et al., 2022).
Described as a group of very heterogeneous elements that vary widely in terms of chemical properties and biological functions, heavy metals, are very harmful to the body, and their appearance is determined mainly due to industrialization and high urbanization (Sharma & Agrawal, 2005).
Following the recent industrialization of all processes, and also due to agricultural practices, the emission of heavy metals is favored, both in the air and in water, soil and plants (Meshref et al., 2014).
Heavy metals found in milk and dairy products can be grouped according to their toxicity, into essential elements such as zinc, iron and copper, and into toxic and non-essential elements of the body, such as cadmium and lead (Meshref et al., 2014).
Studies conducted on heavy metal contamination have shown that, on a daily basis, this contamination occurs on animals and humans, and their sources can be multiple, from water to food (Pandey & Madhuri, 2014).
Milk-producing animals are increasingly exposed to these toxic compounds, so ingesting heavy metals from pastures or after feeding with contaminated feed, and their transfer to the body to milk is very variable (Meshref et al., 2014).
As a result of studies carried out in Italy, residues of toxic metals such as arsenic, lead, cadmium, nickel, mercury and antimuonium were determined in donkey milk and feed used to grow and maintain them (Conte et al., 2019).
The food chain and feed are the main gateway to toxic substances for animals and higher organisms (Caggiano et al., 2005).
The source of heavy metals in the body is usually an anthropogenic one, as they come from the external environment as a result of massive industrialization and urbanization (Caggiano et al., 2005).
Through the alloying of animals with contaminated feed (Dai et al., 2016) or due to emissions from atmospheric air, they are exposed to heavy metals, being bioaccumulated by the body, lead to the appearance of toxicity, depending on the degree of exposure (Pandey et al., 2014).
The consumption of food contaminated with heavy metals poses an increased risk to human health, many of which are considered the main factors of different types of cancer (Meshref et al., 2014).
Some toxic substances may be found in additive feed or even in medicinal products administered to animals which are generally metabolized into non-clinical constituents, but if this feeding stuff or medicines are contaminated with heavy metals and dioxins, they will remain in the tissues of the consuming animals and then in their products, having a negative effect (Eskandari et al., 2014).
In both the United States and Europe, the presence of heavy metals in feed used in the ration of animals has been reported (Dai et al., 2016).

In concentrated feed for farm animals, it is known that arsenic, zinc and copper can be introduced as additive minerals that prevent the growth and growth of bacteria, which are consumed by animals, the spread of metals on land is favored (Zhang et al., 2012), also contamination of plants on pastures is inevitable (Eskandari et al., 2014).

Animals raised on pasture are prone to contamination by heavy metals, so, as a result of fertilization processes through the use of inorganic fertilizers, such as phosphate, a variable quantity of heavy metals will accumulate in plants (Sharma et al., 2005.).

Lead reaches the animal organism through plants, in which it is bioaccumulated, this happens especially in pastures close to rivers contaminated with this metal (Puschner et al., 2010).

As the main source of arsenic contamination of pasture plants and forages, it is polluted water used in irrigation, which is absorbed by plants (Eskandari et al., 2014), its action leads to the slowing down of the activities of enzymes such as peroxidases in the leaves and changes the hydrolytic activity of chlorophyll, thus affecting plants (Sharma et al., 2005).

It is known that manure used to fertilize the soil has beneficial properties on it (Zhang et al., 2012), but studies have determined that overuse of it can have a negative and corrosive effect on the soil, leading to its bioaccumulation with heavy metals, then affecting the plants used in animal feed and then the animals themselves, but manure obtained from donkeys shows a low level in these compounds (Adesoye et al., 2014).

The accumulation in the leaves in very large quantities of cadmium is responsible for the use of these fertilizers, and the long repetition of fertilizers such as phosphate creates in the agricultural soil an excessive accumulation of these elements (Sharma et al., 2005), especially favoring the contamination with cadmium (Pandey et al., 2014).

Other extremely important sources are the chemical amendments, the pesticides used in the grain crops, also sewage sludges are the most important sources of heavy metals, affecting the soil, the plants and then the animals on the pasture (Sharma et al., 2005).

The transport to arable land of different types of agricultural machinery, the incineration or keeping of waste on them, has an important source of heavy metals, with a negative effect on future feed (Sharma, 2005).

In addition to feed that can be contaminated with heavy metals, another important source can be drinking water, if it is contaminated as a result of human activity due to soil erosion processes (Pandey & Madhuri, 2014).

Lead can have as a source of contamination in addition to feed, and drinking water, having a toxic effect on the synthesis of haemoglobin, the gastrointestinal tract and the reproductive system (Pandey et al., 2014).

Studies conducted on equines have shown that heavy metals such as arsenic, cadmium, iron, molybdenum, zinc, copper and lead were accumulated in various organs other to the body, among which, the largest reserves were in the liver and kidneys, and their concentrations were higher in animals over 2 years old (Plumlee et al., 1996).

Areas where industrially developed metallurgic or overpopulated ones, which have heavy traffic of motor vehicles, have been determined to be extremely contaminated with heavy metals and other chemical contaminants that can end up in animal productions, having hepatotoxic and even neurotoxic effect on consumers (Porova et al., 2014).

In donkeys, studies have been carried out on the level of heavy metals in the blood, with an emphasis on toxic metals such as lead, which causes cardiovascular, renal, gastrointestinal and nervous system diseases, but also infertility, obesity and seizures (Yipel et al., 2014).

Lead and cadmium are mainly occurring as a result of the irrigation of the soil, of the contaminated waters used in this agricultural practice, also as a result of thermal processes carried out in different factories, where materials containing heavy metals are used, cause their emission of snub vapor form, which in combination with water leads to the formation of atmospheric aerosols, which affect both plants and animals directly (Sharma et al., 2005).

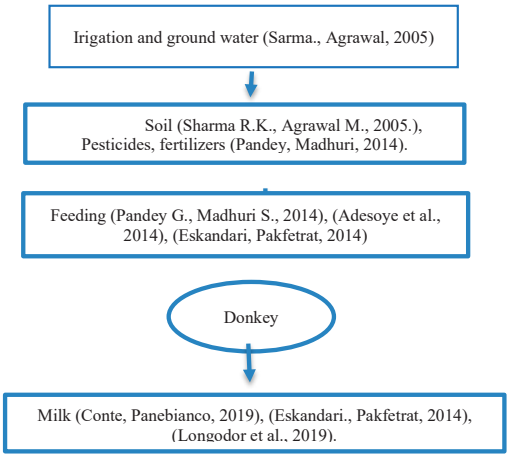

Figure 1. The main sources of heavy metals in donkey milk

The action of heavy metals on the animal organism

For living organisms, heavy metals are highly toxic, having bioaccumulation properties, are persistent, causing serious health problems, morbidities or even death (Pandey & Madhuri, 2014).

The danger that heavies metals cause on the animal and human body is extremely high, toxic elements such as lead and mercury can cause neurodegenerative conditions such as Alzheimer's disease and multiple sclerosis (Giacoppo et al., 2014).

Heavy metals, have a very high toxicity, being very quickly accumulated by extra and intra-cellular proteins, affecting all the time the functions of cells and the body (Buckler et al., 1986).

As regards elements such as zinc, iron and copper, which usually have benefits and have an important role in the various biological functions of organisms, their high content with these elements and their consumption in too large quantities can have negative effects on the body, producing toxicity (Meshref et al., 2014).

Of all heavy metals, not all of them are necessary for the functions of the body, they have toxic action, but even those necessary for functioning processes, such as iron, in large quantities can have a negative effect (Pandey & Madhuri, 2014).

In some circumstances, beryllium can be toxic to the body, also the essential elements can undergo changes caused by these compounds, causing toxicity (Pandey & Madhuri, 2014).

Some heavy metals can mimic the action of organoleptic compounds, for example radium, can be strained in bones, imitating the action of calcium (Pandey & Madhuri, 2014).

Another heavy metal, determined by studies from Iran, in animal feed, is cadmium, which accumulates in the body, especially in the liver and kidneys, contamination with it is favored in highly industrialized areas (Eskandari & Pakfetrat, 2014).

Antibiotics and medicines used in animals can also cause contamination with residues in their milk (Rezaei et al., 2014).

Studies by Porova et al., in 2014, demonstrated that the use of methods such as that of low-frequency ultra-sound, on the production lines of dairy products, would solve the problem of heavy metals in them, without affecting all at once the chemical and physical properties of milk.

CONCLUSIONS

Studies show the problem that the accumulation of heavy metals represents for animal production and ultimately for the human body.

Thus, their accumulation in the case of donkey milk is, as in the case of other species, a problem.

The main problem that causes this contamination is represented by grazing on surfaces on which chemical treatments have been applied or due to the wastewater used in irrigation.

But studies have shown that in terms of this species, heavy metal accumulations are not so high compared to other species.

REFERENCES

Abdel-Rahman, G.N.E. (2022). Heavy metals, definition, sources of food contamination, incidence, impacts and remediation: A literature review with recent updates. *Egyptian Journal of Chemistry,* 65(1), 419-437.

Adesoye, A. M., Adekola, F. A., Olukomaiya, K. O., Olukomaiya, O. O., & Iwuchurkwu, O. O. (2014). Evaluation of physical properties and heavy metal composition of manure of some domestic animals. *International journal of innovation and scientific research,* 9(2), 293-296.

Aggarwal, A., Verma, T., & Ghosh, S. (2022). Heavy metal residues in milk and milk products and their detection method. *IntechOpen.* doi: 10.5772/intechopen.105004

Brumini, D., Criscione, A., Bordonaro, S., Vegarud, G. E., & Marletta, D. (2016). Whey proteins and their antimicrobial properties in donkey milk: a brief review. *Dairy Science & Technology,* 96, 1-14.

Buckler, H. M., Smith, W. D., & Rees, W. D. (1986). Self poisoning with oral cadmium chloride. *Br. Med. J.,* 292, 1559-1560.

Caggiano, R., Sabia, S., D'Emilio, M., Macchiato, M., Anastasio, A., Ragosta, M., & Paino, S., (2005). Metal levels in fodder, milk, dairy products, and tissues sampled in ovine farms of Southern Italy. *Environmetal research,* 99(1), 1-57.

Conte, F., & Panebianco, A. (2019). Potential hazards associated with raw donkey milk consumption: a review. *International Journal of Food Science,* 11 (1), 1-11.

Dai, S. Y., Jones, B., Lee, K. M., Li, W., Post, L., & Herman, T. J. (2016). Contamination of animal feed in Texas. *Journal of regulatory science*, 4(1), 21-32

Eskandari, M. H., & Pakfetrat, S. (2014). Alfatoxins and heavy metals in animal feed in Iran. *Food additives & Contaminants: Part B,* 7(3), 202-207.

Giacoppo, S., Galuppo, M., Calabro, R. S., D'Aleo, G., Marra, A., Sessa, E., Bua, D. G., Potorti, A. G., Dugo, G., Bramanti, P., & Mazzon, E., (2014). Heavy metals and neurodegenerative diseases: An observational study. *Biological Trace Element Research,* 161(2), 151-60.

Hasan, G. M. M. A., Kabir, M. H., & Miah, M. A. S., (2022). Determination of heavy metals in raw and pasteurized liquid milk of Bangladesh to assess the potential health risks. *Food research,* 6(1), 233-237.

Ismail, A., Riaz, M., Saeed, A., Goodwill, J. E., & Sun, J. (2017). Heavy metals in milk: global prevalance and health risck assessment. *Toxin Review, 38(*1),1-12.

Li, Y., Ma, Q., Liu, G., & Wang, C. (2021). Effects of donkey milk on oxidative stress and inflammatory response. *Journal of Food Biochemistry,* 46(4), e13935

Longodor, A. L., Mireșan, V., Odagiu, A., Marchiș, Z., Balta, I., Andronie, L., & Coroian, A. (2019). Heavy metals from donkey *(Equus asinus)* milk. *ProEnviroment,* 12(40), 384-387.

Longodor, A. L., Mireșan, V., Răducu, C., & Coroian, A. (2018). Influence of the area and lactation on physico-chemical parameters and the content of heavy metals in the donkey milk. *Scientific papares. Series D. Animal science,* 61(1), 127-131.

Masoud, R., Mirmohammad-Makki, F., & Zoghi, A. (2022). Evaluation of the biosorption capacity of *Saccharomyces cerevisiae* for heavy metals in milk. *Emerging challenges in agriculture and food science,* 5(25), 13-23.

Meshref, A. M. S., Moselhy, W.A., & Hassan, N.E.H.Y. (2014). Heavy metals and trace elements levels in milk products. *Journal of food measurement and characterization*, 8, 381-388.

Paksoy, N., Dinc, H., & Altun, S. K. (2018). Evaluation of levels of essential elements and heavy metals in milk of dairy donkey, goats and sheep in Turkey. *Pakistan journal of zoology,* 50(1), 1-9

Pandey, G., & Madhuri, S. (2014). Heavy metals causing toxicity in animals and fishes. *Journal of animal, veterinary and fishery sciences,* 2(2), 17-23.

Perna, A., Intaglietta, I., Simonetti, A., & Gambacorta, E. (2015). Donkey milk for manufacture of novel functional fermented beverages. *Journal of food science*, 80(6), S1352-S1359

Plumlee, K. H., Johnson, B., & Gardner, I. A. (1996). Heavy metal concentrations in injured racehorses. *Vet. Hum. Toxicol*., 38(3), 204-206.

Porova, N., Botvinnikova, V., Krasulya, O., Cherepanov, P., & Potoroko, I. (2014). Effect of ultrasonic treatment on heavy metal decontamination in milk. *Ultrasonics Sonochemistry,* 21(6), 2107-2111.

Proikakis, S. C., Bouroutzika, E. V., Anagnostopoulos, A. K., & Tsangaris, G. T., (2021). Proteomic data of donkey's milk. *Data in brief,* 39, 107507.

Psenova, M., Toman, R., & Tancin, 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. science and pollution research international,* 27(21), 26763-26772.

Puschner, B., & Aleman, M. (2010). Pb toxicosis in the horse: A review. *Equine Vet. Educ.,* 22(10), 526-530.

Rezaei, M., AkbariDastjerdi, H., Jafari, H., Farahi, A., Shahabi, A., Javdani, H., Teimoory, H., Yahyaei, M., & Malekirad, A.A. (2014). Assessment of dairy products consumed on the Arakmarket as determined by heavy metal residues. *Health,* 6(5), 323-327.

Sharma, R.K., & Agrawal, M. (2005). Biological effects of heavy metals: An overview. *Journal of enviromental biology,* 26(2), 301-313.

Yan, M., Niu, C., Li, X., Wang, F., Jiang, S., Li, K., & Yao, Z. (2022). Heavy metal levels in milk and dairy products and health risk assessment: A systematic review of studies in China. *Science of the total enviroment*, 851 (1), 158131.

Yipel, M., Cellat, M., & Yipel, F. A. (2014). Blood lead concentrations of horses and donkeys in the vicinity of heavily polluted river by intensive industry in southeastern turkey. *International conference on advanced materials and systems*, 5, 497-502.

Zhang, F., Li, Y., Yang, M., & Li, W. (2012). Content of heavy metals in animal feed and manures from farms of different scales in Northeast China. *International journal of environmental research and public health*, 9 (8), 2658-2668.

*** https://www.atsdr.cdc.gov/toxprofiles/tp132.pdf

***https://lege5.ro/Gratuit/ge4dcnjx/norma-igienico sanitara-pentru-alimente-din-16121998?pid=10529884#p-10529884

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