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Review

Melamine and Cyanuric Acid in Milk and Their Quantities, Analytical Methods and Exposure Risk: A Systematic Review and Meta-analysis

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A R T I C L E I N F O

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A B S T R A C T

Melamine, as a toxic compound, needs to be controlled in food, especially in dairy products. In this systematic study, quantities of melamine and cyanuric acid in various types of milk were investigated. A comprehensive database search was performed using the keywords pasteurized milk, milk, sterilized milk, melamine, and cyanuric acid without time limitation. A total of 24 articles related to melamine and cyanuric acid were thoroughly reviewed. The overall mean concentration of melamine in milk was estimated by meta-analysis to be 11.3 μg/L. Publication bias was not addressed in the associated assays; however, it was addressed as highly heterogeneous between studies. Subgroup analysis was carried out, and the milk type was a cause of heterogeneity. This systematic review investigated a range of melamine in milk products and discussed different analytical methods.

Contents

Both intentional and unintentional contamination of food can harm human health. Regulatory organizations try to reduce the contamination of food by setting standards and continuously monitoring products. Milk and milk-based products are among the products used by babies and the elderly. These products can be contaminated with various chemicals. Melamine ($C_3H_6N_6$) (MA) is one of the compounds that does not occur naturally in foods. In general, the use of this substance in foods, especially in milk, is well known as a fraud. Melamine is frequently combined with cyanuric acid. Cyanuric acid is an impurity that occurs naturally in melamine. When these substances enter the bloodstream, melamine, and cyanurate accumulate and react with the microtubules of the kidneys, forming large numbers of yellow,

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spherical crystals that damage the kidney cells and their ducts. As melamine is not metabolized and has a short half-life, its combination with cyanuric acid may lead to crystallization and formation of kidney or bladder stones and urinary tract obstruction in humans (Melekoğlu et al., 2020; Rajpoot et al., 2021). Therefore, there are pains in the abdomen and damages to the kidney cells (Melekoğlu et al., 2020). In China, this led to urolithiasis and acute kidney injury in exposed infants (Guo et al., 2020). The adulteration of dairy products with melamine causes serious damages to the country's economy in addition to health damages (Singh & Gandhi, 2015).

Several methods based on liquid chromatography (LC) and gas chromatography (GC), as well as novel methods, have been developed for the identification of melamine in milk. Barreto et al. (2021) proposed a rapid method using emission-excitation matrix fluorescence spectroscopy (EEM) and second-order calibration methods (PARAFAC and U-PLS/RBL) for the detection and quantification of melamine in milk (Barreto et al., 2021). The proposed method used an acetic acid clean-up step, resulting in a rapid, inexpensive, and environmentally friendly method in line with green chemistry principles. The two methods, PARAFAC and U-PLS/RBL, were able to detect more than 120.6 and 146.5 mg/kg melamine in milk, respectively, which was sufficient for adulteration above 2% by volume.

Mechanism of melamine-induced toxicity. The most sensitive body organs to melamine are the kidneys. After ingestion, almost 90% of melamine is excreted in the urine (Wu et al., 2021). Based on the results, crystal nephropathy in humans exposed to melamine and cyanuric acid was identical to uric acid nephropathy (Kim et al., 2023). Simultaneous ingestion of these two triazines precipitates melamine-cyanurate crystals in the renal tubules (Fig. 1).

These stones can block different parts of the duct. This eventually leads to abdominal discomfort and kidney cell damage (Brown et al., 2007). Long-term intake of melamine can cause urinary tract infections, nephritis, kidney failure, and the formation of bladder and kidney stones, which can progress to bladder carcinoma (Borts, 2019). Oxidative stress and inflammation may be responsible for the mechanism of melamine toxicity. These complications may occur through the activation of NF-κB/cox-2 and NOX/ROS pathways (Rai et al., 2022). Oxidative stress is caused by an imbalance between the generation of reactive oxygen species (ROS) and antioxidant power (Ahmed et al., 2021; Sadighara et al., 2016). Urinary levels of the two biomarkers of oxidative stress, 8-oxo-2′-deoxyguanosine (8-OHdG) and malondialdehyde (MDA), were higher in workers who produced melamine dishes and hence were exposed to melamine (Liu et al., 2020). Recent studies have shown that melamine causes infertility in exposed female mice (Rajpoot et al., 2021). In addition, melamine has been detected in the amniotic fluid, confirming the transfer of melamine from the mammalian mothers to their fetuses (Wu et al., 2020). Therefore, the aim of this systematic study was to investigate the amount of melamine and cyanuric acid in different types of milk. Furthermore, different analytical methods for the evaluation of these compounds in foods were discussed. Different methods of sample preparation were also reviewed. A meta analysis was performed for the overall estimation of melamine in foods. For health risks, the hazard quotient (HQ) is usually calculated (Zhu & Kannan, 2018). If the HQ for a contaminant in a food is calculated to be less than one, consumption of that food will be without adverse health effects for that contaminant (Nag & Cummins, 2022). In studies, the potential health risk for melamine in food is also calculated with HQ (Shi et al., 2020; Zhu & Kannan, 2018). Therefore, the calculated HQ values of the studies were summarized. Furthermore, possible causes of heterogeneity between the studies were investigated using meta-regression.

Methods

All stages of this systematic review were carried out according to the PRISMA checklist. To reduce potential bias, the review was conducted with the involvement of two team members, who performed each step of the process. In case of disagreement, the corresponding author reported.

Search strategy. Databases were searched on 15 May 2023. All potential articles in the databases were carefully selected without temporal restrictions. A comprehensive search was performed using PubMed, Science Direct, and Scopus databases. The selection of the targeted keywords included ("pasteurized milk" OR milk OR "sterilized milk") AND (melamine OR cyanuric acid).

Inclusion and exclusion criteria. Table 1 shows the inclusion and exclusion criteria of the study. Inclusion criteria for this systematic review were primary articles that used reliable laboratory techniques to quantify the amount of melamine and cyanuric acid in milk. The full text of the selected articles was assessed using a checklist. This checklist was formulated using quintuplet of key points. Inclusion criteria for the present study were articles with a score of three or more. Furthermore, studies without a clearly defined sample size were excluded from the meta-analysis.

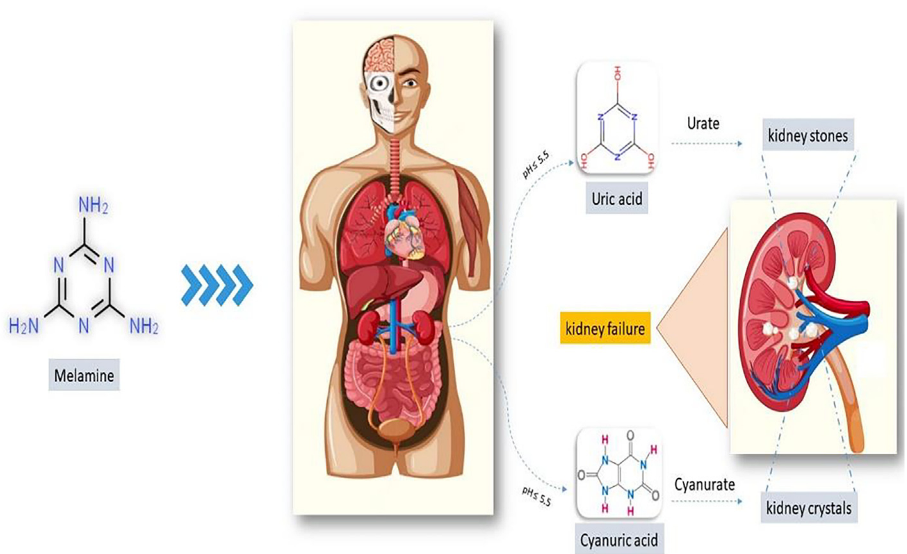

Figure 1. Relationship of kidney stones with increased concentration of melamine in foods.

Table 1
Inclusion and exclusion criteria of this study

Inclusion criteria	Exclusion criteria
Assessing quantity of melamine in milk	Animal study
Assessing quantity of cyanuric acid in milk	*In vitro* study
	Clinical trial
	Method develop
	Protein analysis study
	Other pollutants, including pesticides
	Not available and non-English articles
	Lack of sample size

Data extraction. Table 2 shows all the data extracted from the articles. The table includes sample type, sample size, analytical method, melamine and cyanuric acid content, hazard quotient (HQ), countries, and references. At all stages of data extraction, disagreements were checked with the corresponding author.

Meta-analysis of data. Meta-analysis was performed using Comprehensive Meta-analysis (CMA) v3.3.070 software. Heterogeneity was assessed using I^2 and Q test methods. The egger test was used to assess the presence of publication bias. Meta-regression analysis was also performed to investigate factors contributing to the heterogeneity.

Results

Search processes. Number of the articles linked to the research objectives was 1357. Title and abstract of the articles were carefully reviewed and assessed. Articles that did not meet the predetermined inclusion criteria were excluded from the study. Then, a comprehensive analysis was carried out on all the selected articles, and quality assessment of the articles was carried out. Quality assessment of the article was carried out by two authors. Then, 24 articles were selected for inclusion in the study. The current study was carried out on an established framework of the PRISMA checklist. Fig. 2 shows a diagram of the search strategy.

Table 2
Major data extracted from the published articles (melamine)

Sample type	Analytical method	Sample size	Quantity (mean ± SD)	HQ	Country	Author/year
Raw milk	N-methylmesoporphyrin IX (NMM)/G-quadruplex	3	51.3 ± 0.6μg m/L	–	China	Wang et al., 2020
Whole milk	Spectrophotometry	3	75.8 ± 7.10 μg/L		Türkiye	Altunay et al., 2017
Semi-skimmed milk	Spectrophotometry	3	55.1 ± 8.10 μg/L	–		
Liquid milk (toned milk)	HPLC-UV	5	2.87 ± 0.02μg m/L	–	India	Anirudhan et al., 2017
Raw milk	Novel pincer zinc complex	3	3 ± 0.06 mol/L	–	China	Bao et al., 2021
Whole UHT	Sequential injection chromatography	3	2.64 ± 0.18 m/L	–	Brazil	Batista et al., 2014
Whole UHT	HPLC	3	2.77 ± 0.26 m/L	–		
Whole UHT	Sequential injection chromatography	3	4.30 ± 0.13 m/L	–		
Whole UHT	HPLC	3	4.22 ± 0.44 m/L	–		
Pasteurized skimmed	Sequential injection chromatography	3	1.81 ± 0.11 m/L	–		
Pasteurized skimmed	HPLC	3	1.90 ± 0.01 m/L	–		
Pasteurized skimmed	Sequential injection chromatography	3	3.54 ± 0.14 m/L	–		
Pasteurized skimmed	HPLC	3	3.67 ± 0.03 m/L	–		
Semi-skimmed UHT	Sequential injection chromatography	3	2.12 ± 0.10 m/L	–		
Semi-skimmed UHT	HPLC	3	2.04 ± 0.39 m/L	–		
Semi-skimmed UHT	Sequential injection chromatography	3	3.60 ± 0.17 m/L	–		
Semi-skimmed UHT	HPLC	3	3.42 ± 0.20 m/L	–		
Pasteurized skimmed	Sequential injection chromatography	3	2.09 ± 0.22 m/L	–		
Pasteurized skimmed	HPLC	3	1.95 ± 0.01 m/L	–		
Pasteurized skimmed	Sequential injection chromatography	3	3.03 ± 0.12 m/L	–		
Pasteurized skimmed	HPLC	3	3.14 ± 0.10 m/L	–		
Raw milk	UPLC–MS	5	9.11 ± 1.66 mg/kg	–	United States	Baynes et al., 2010
Liquid milk	Gold nanoparticles-based LSPR via optical fibers	9	0.30 ± 1.28 μM	–	China,	Chang et al., 2017
Liquid milk	Silver nanoparticles functionalized with sulfanilic acid	2	15.7 ± 1.6 M	–	China	Song et al., 2015
Liquid milk	FASI-CE–C^4D	3	0.0076 μg/mL	–	China	Ji et al., 2014
Liquid milk	HPLC–MS	3	0.0080 μg/mL	–		
Liquid milk	LC-MS/MS	15	1.054 ± 0.245 μg/ml	–	Iran	Hassani et al., 2013
Liquid milk (1.5% fat)	Ion-pair-based HF-LPME combined with HPLC	3	0.08 mg/kg	–	China	Gao and Jönsson 2012
UHT milk	HPLC	50	0.00 μg/kg	–	Türkiye	Filazi et al., 2012
Pasteurized milk	HPLC	50	0.00 μg/kg	–		
Raw Milk	Immunogold chromatographic assay (IGCA)	5	0.00 μg/mL	–	China	Li et al., 2011
Fresh milk	GC–MS/MS	1	0.28 mg/kg	–	China	Hong et al., 2009
Raw milk	HPLC	3	0.10 mg/kg	–	Iran	Abdolmohammad-Zadeh et al., 2020a
Milk	HPLC	15	0.23 ± 0.09 mg/kg	–	Iran	Poorjafari et al., 2015
Milk	HPLC	23	0.22 mg/kg	THQ ≤ 1	Iran	Alizadeh et al., 2023
Milk and dairy	HPLC-MS/MS	34	0.48–3.66 ng/g		United States	Zhu and Kannan 2019
Milk	HPLC-MS/MS	42	7.9 ng/g	3.1×10^{-4} (adult) 0.011 (children)	United States	Zhu and Kannan 2018

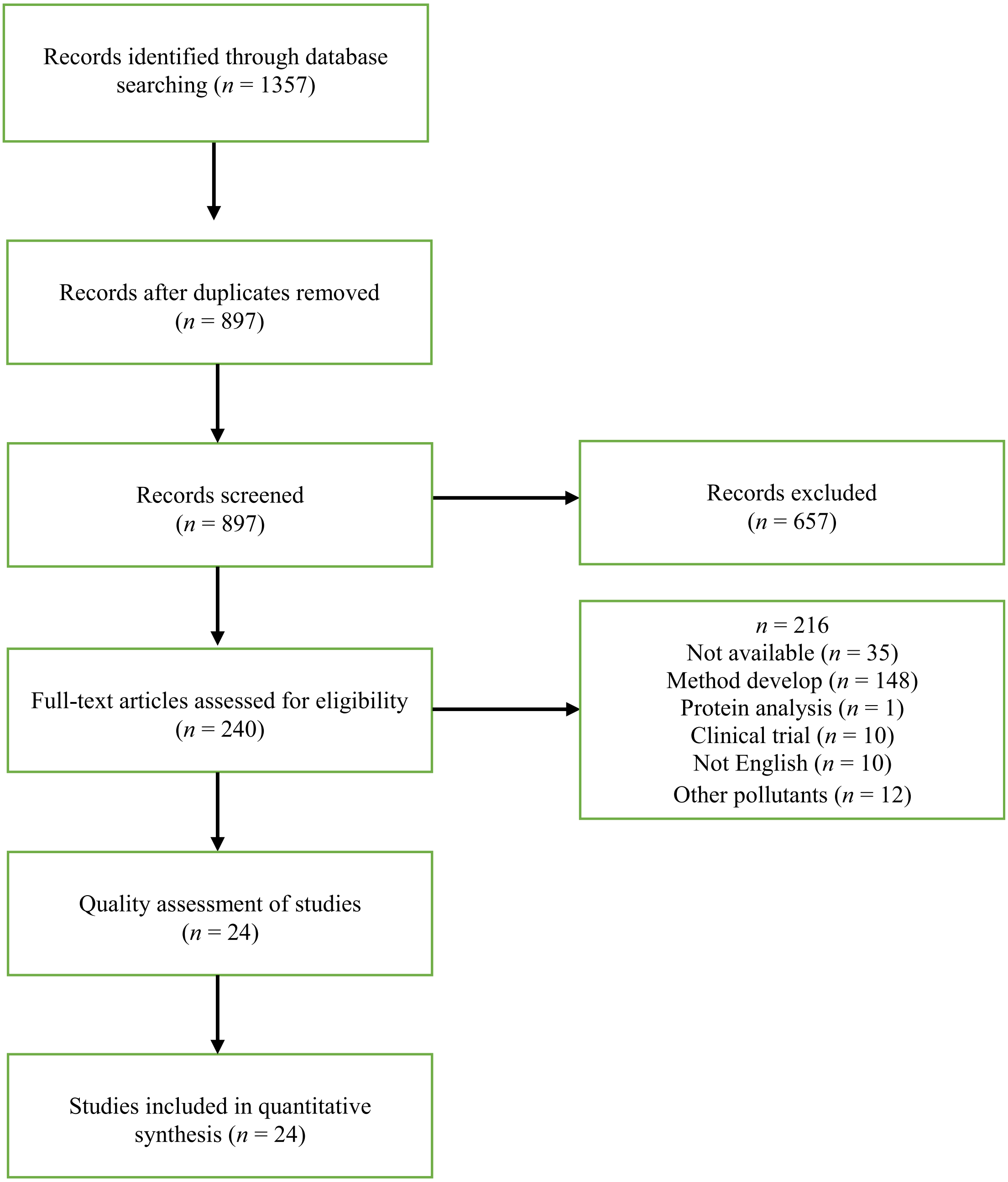

Figure 2. Search process diagram of this study.

Meta-analysis. Meta-analysis of the extracted data for melamine was performed using CMA software. The overall mean concentration of melamine in milk was calculated to be 11.3 ± 0.53 μg/L using the random effect model for melamine in milk. The I-squared test was used to assess heterogeneity. Its value was calculated as 99.98, indicating high heterogeneity. Begg's test and funnel chart (Fig. 3) were performed for publication bias. The *p* value of the Begg test was 0.5.

Descriptive results of the screened articles. A selection of 24 articles was included in the systematic review. Tables 2 and 3 show the relevant data from the articles, including sample type, sample size, analytical method, melamine and cyanuric acid content, hazard quotient (HQ), countries, and references. Melamine ranged from ND to 75.8 μg/mL in different countries. Most of the studies were carried out in China, possibly because of the 2008 melamine in baby foods.

Discussion

Milk containing melamine and cyanuric acid poses potential health risks for all age groups, especially for children. Studies on this topic began in 2009, which indicated the possibility of milk contamination with melamine after the 2008 crisis in China (Table2). Melamine enters milk in several ways. Due to the widespread use of melamine, contamination of water and soil is common. Therefore, there is a possibility of melamine entering the food chain. Melamine may migrate from packaging to food. In some cases, animal feed supplements may be contaminated with melamine. Melamine is also a by-product of cyromazine. This compound is used in veterinary medicine (Melough et al., 2020). Based on European Union (EU) regulations, the permissible limit for melamine is 2.5 mg/kg for dairy products (EFSA Panel on Contaminants in the Food Chain (CONTAM) & EFSA

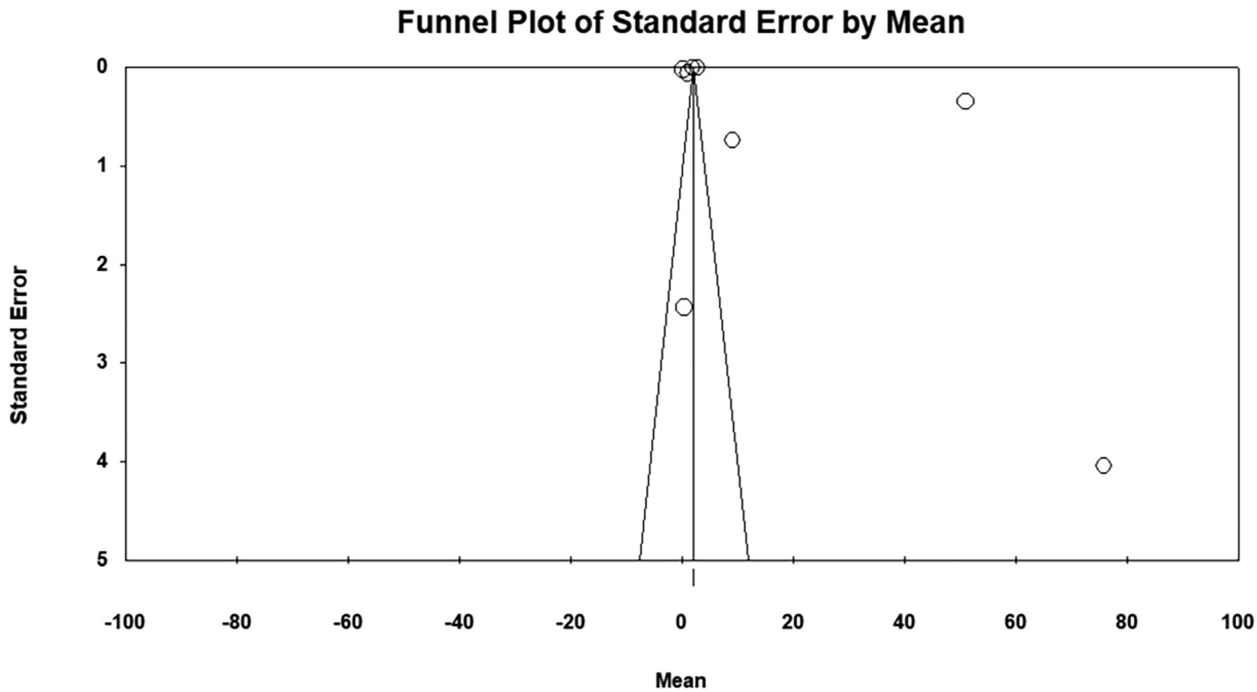

Figure 3. The funnel plot.

Table 3
Major data extracted from the published articles (cyanuric acid)

Sample type	Analytical method	Sample size	Quantity (mean ± SD)	HQ	Country	Author/year
Fresh milk	GC–MS/MS	6	1.64 ± 2.1 mg/kg	–	China	Miao et al., 2009
Milk	Differential Pulse Polarography	5	3.95 ± 5.06 μM	–	Turkey	Yilmaz and Yazar 2010
UHT milk	Micellar electrokinetic chromatography	5	0.08 ± 0.12 μg/mL	–	Thailand	Vachirapatama and Maitresorasun 2013
Milk and dairy	HPLC-MS/MS	34	Range: <0.06–52.7) ng/g	5.03×10^{-5}	United States	Zhu and Kannan 2019

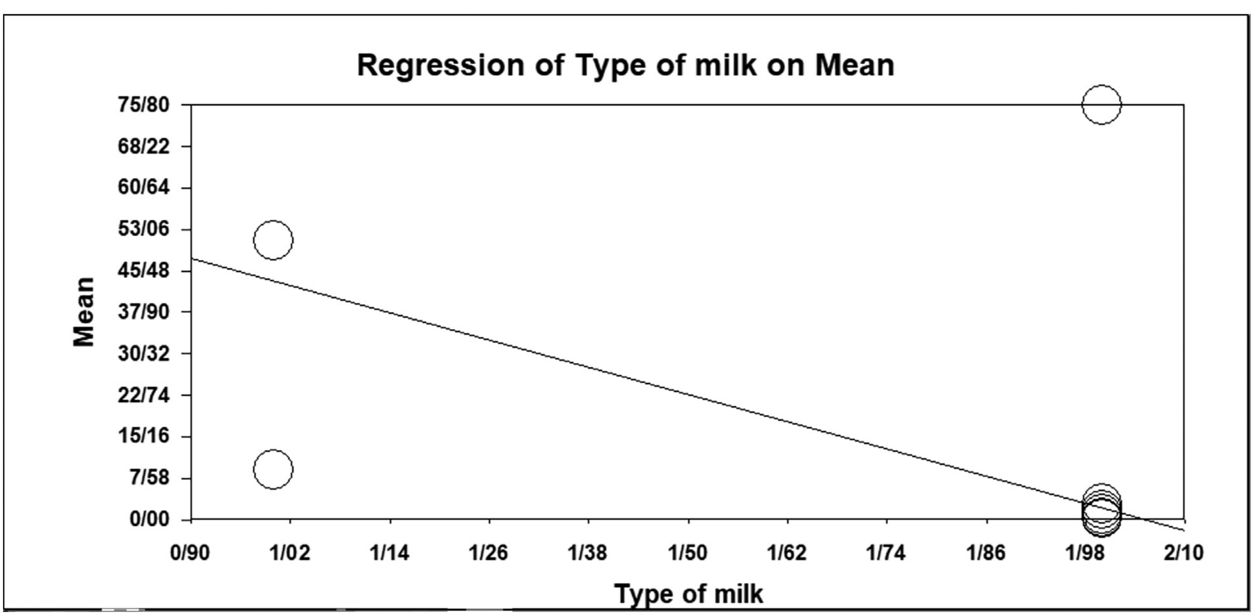

Figure 4. The meta-regression plot based on the type of milk.

Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids (CEF), 2010). Based on the data collected in this study, the amount of melamine detected in all studies was less than the permissible limit.

For potential risk, the HQ calculated in the studies was taken into account. The HQ is the ratio of the estimated daily intake (EDI) to the tolerable daily intake (TDI). The TDI for melamine is estimated to be 63 μg/kg bw/day. The mean daily intake of melamine and its three derivatives, including cyanuric acid, ammeline, and ammelide, for the US population was calculated to be approximately 0.687 μg/kg bw/day for children through infant formula consumption and 0.032 μg/kg bw/day for adults through dairy consumption (Zhu & Kannan, 2019). In this study, the calculated HQ for adults and children was determined to be 5.0×10^{-4} and 0.011, respectively (Zhu & Kannan, 2018). Furthermore, in two recent studies conducted in Iran, the HQ for milk was also calculated to be less than one for adults (Abedini et al., 2023; Ghanati et al., 2023). However, the calculated HQ for melamine was greater than one for some brands tested for children in the study by Abedini et al. (2023).

The reported amounts are in different ranges (Table 2). A subgroup analysis based on the type of milk (raw or pasteurized) was performed to find the reasons for this heterogeneity. The *p* value was 0. Therefore, the type of milk contained effects. Meta-regression was also performed. Figure 4 shows the results of the meta-regression based on the type of milk. Based on the test, the *p* value was also 0, so the type of milk could be related to the effect size. After analyzing and reviewing the data extracted in this systematic review, it was shown that the amount of melamine in raw milk was higher than in processed milk. Contamination of raw milk is either directly caused by the milking animal itself or it may be contaminated indirectly during milking, collection, storage, and transport (Motarjemi et al., 2014). Raw milk may come into contact with melamine containers and equipment during milking, transport, and storage.

Studies have shown that different methods have been used to assess melamine and cyanuric acid in different types of milk (Tables 2 and 3). Currently, the available methods for measuring melamine include gas-chromatography-mass spectrometry (GC–MS), liquid chromatography-tandem mass spectrophotometry (LC-MS/MS), ultrasound-assisted extractive electrospray ionization mass spectrometry (EESI-MS), enzyme-linked immunosorbent assay (ELISA), surface-enhanced Raman spectroscopy (SER), and high-performance liquid chromatography (HPLC) (Liu et al., 2018). Based on the data, most of the methods used to assess melamine were based on liquid chromatography. For samples with low levels of melamine, HPLC-based methods have a favorable analytical capability. Furthermore, spectrophotometry may be used to evaluate melamine in food products in a realistic, accurate, and cost-effective manner (Öztürk & Demir, 2021). Therefore, HPLC-MS/MS method is usually the best method to determine the amount of melamine in food (Hieu-Tran, 2021).

Due to the small and polar structure of the molecule, methods such as liquid chromatography coupled to mass spectrometry (LC-MS) or tandem mass spectrometry (TMS or MS/MS) are the best analytical approaches for the assessment of melamine. However, these methods have disadvantages such as time consumption and the need for preparation, equipment, and specialists (Li et al., 2020). Technically, GC–MS is a practical and sensitive method for the evaluation of melamine in dairy products. The detection limit of this method is less than ng/g (Tzing & Ding 2010). A disadvantage of this method is the need for derivatization (Nascimento et al., 2017). Extraction techniques are an important factor in increasing the efficiency of analytical methods. In cases where the amount of analysis is small, the matrix effect should be minimized (Altunay et al., 2020). Based on the specific identification of melamine, several techniques for sample extraction, cleaning, and enrichment have been established (Ritota and Manzi 2018).

The use of solid-phase extraction (SPE) technique can increase selectivity and purification speed. Efficiency of HPLC with SPE has been verified well (Table 2). Another method of sample preparation is microextraction. This fast and accurate method is one of the green chemistry methods (Altunay et al., 2020). Another optimal method for the extraction of melamine from milk samples is the use of deep eutectic solvents (DES). The DESs have high thermal stability. Furthermore, if DES is combined with paramagnetic materials, it increases efficiency of the analyte extraction from the matrix (Elik et al., 2023). In addition, methods based on magnetic solid-phase extraction (MSPE) have been verified with good efficiency (Abdolmohammad-Zadeh et al., 2020b; Liao et al., 2021a). In this method, the target analyte is effectively extracted from the matrix (Liao et al., 2021b).

The use of novel methods such as artificial intelligence and machine learning may be useful approaches. Key information should be collected on feed, housing, and medications used by dairy animals (Liu et al., 2022). In addition, important information on transportation and important processes that are carried out in the factory on milk-based products should be collected. Integrating these two sets of information can provide important approaches to more rapidly assess melamine and cyanuric acid and predict which types of milk may be more susceptible to adulteration and contamination (Kutyauripo et al., 2023). Accurate assessment of the composition of each type of milk with different proportions of proteins and fats is one of the factors contributing to the increased accuracy of artificial intelligence (AI)-based methods (Marialuisa et al., 2023). In addition, the use of artificial noses and modern photographic methods can significantly increase the accuracy and speed of melamine analysis in milk (Neethirajan 2023).

Conclusion

Due to the importance of melamine presence in dairy products, this systematic study was carried out to investigate the amount of melamine in dairy products, analytical methods, and sample preparation. The mean total melamine in milk was estimated. The estimated value was lower than that of the limits set by the competent authorities. The risk assessment or HQ was partially carried out in studies, all of which were less than one that revealed safety of the consumed products. The most frequently used analytical method was based on LC. The best preparation methods were based on microextraction and SPE columns. Melamine is usually detected at low levels in food, making its separation in food matrices difficult. Therefore, the development of fast, low-cost environmental friendly methods is strongly recommended.

CRediT authorship contribution statement

Amirhossein Abedini: Writing – original draft. **Zahra Hadian:** Investigation. **Mahdie Kamalabadi:** Writing – original draft. **Mahla Salimi:** Methodology. **Paliz Koohy-Kamaly:** Investigation. **Burhan Basaran:** Methodology. **Parisa Sadighara:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

Abdolmohammad-Zadeh, H., Zamani, A., & Shamsi, Z. (2020a). A simple magnetic solid-phase extraction method based on magnetite/graphene oxide nanocomposite for pre-concentration and determination of melamine by high-performance liquid chromatography. *Environmental Science and Pollution Research, 27*, 9826–9834.

Abdolmohammad-Zadeh, H., Zamani, A., & Shamsi, Z. (2020b). A simple magnetic solid-phase extraction method based on magnetite/graphene oxide nanocomposite for pre-concentration and determination of melamine by high-performance liquid chromatography. *Environmental Science and Pollution Research, 27*(9), 9826–9834.

Abedini, R., Khaniki, G. J., Naderi, M., Aghaee, E. M., & Sadighara, P. (2023). Investigation of melamine and cyanuric acid concentration in several brands of liquid milk and its non-carcinogenic risk assessment in adults and infants. *Journal of Food Science and Technology, 60*(12), 3054–3066.

Ahmed, Z. S. O., Galal, M. K., Drweesh, E. A., Abou-El-Sherbini, K. S., Elzahany, E. A. M., Elnagar, M. M., & Yasin, N. A. E. (2021). Protective effect of starch-stabilized selenium nanoparticles against melamine-induced hepato-renal toxicity in male albino rats. *International Journal of Biological Macromolecules, 191*, 792–802.

Alizadeh, A. M., Hosseini, H., Hosseini, M.-J., Hassanzadazar, H., Hashempour-Baltork, F., Zamani, A., & Mohseni, M. (2023). Melamine in Iranian foodstuffs: a systematic review, meta-analysis, and health risk assessment of infant formula. *Ecotoxicology and Environmental Safety, 256*, 114854.

Altunay, N., Demir, Ö., & Gürkan, R. (2017). Ionic liquid based ion-pairing microextraction combined with spectrophotometry for preconcentration and quantitation of melamine in milk and milk-based products. *LWT, 86*, 352–360.

Altunay, N., Elik, A., & Kaya, S. (2020). A simple and quick ionic liquid-based ultrasonic-assisted microextraction for determination of melamine residues in dairy products: theoretical and experimental approaches. *Food Chemistry, 326*, 126988.

Anirudhan, T., Christa, J., & Deepa, J. (2017). Extraction of melamine from milk using a magnetic molecularly imprinted polymer. *Food Chemistry, 227*, 85–92.

Bao, X., Liu, J., Zheng, Q., Duan, L., Zhang, Y., Qian, J., & Tu, T. (2021). Colorimetric recognition of melamine in milk using novel pincer zinc complex stabilized gold nanoparticles. *Chinese Chemical Letters, 32*(10), 3023–3026.

Barreto, M. C., Braga, R. G., Lemos, S. G., & Fragoso, W. D. (2021). Determination of melamine in milk by fluorescence spectroscopy and second-order calibration. *Food Chemistry, 364*, 130407.

Batista, A. D., Nascimento, C. F., Melchert, W. R., & Rocha, F. R. (2014). Expanding the separation capability of sequential injection chromatography: Determination of melamine in milk exploiting micellar medium and on-line sample preparation. *Microchemical Journal, 117*, 106–110.

Baynes, R. E., Barlow, B., Mason, S. E., & Riviere, J. E. (2010). Disposition of melamine residues in blood and milk from dairy goats exposed to an oral bolus of melamine. *Food and chemical toxicology, 48*(8–9), 2542–2546.

Borts, D. J. (2019). Chapter 62 – Biomarkers detection for toxicity testing using metabolomics. In R. C. Gupta (Ed.), *Biomarkers in toxicology* (2nd ed., pp. 1111–1124). Academic Press.

Brown, C. A., Jeong, K.-S., Poppenga, R. H., Puschner, B., Miller, D. M., Ellis, A. E., Kang, K.-I., Sum, S., Cistola, A. M., & Brown, S. A. (2007). Outbreaks of renal failure associated with melamine and cyanuric acid in dogs and cats in 2004 and 2007. *Journal of Veterinary Diagnostic Investigation, 19*(5), 525–531.

EFSA Panel on Contaminants in the Food Chain (CONTAM) & EFSA Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids (CEF) (2010). Scientific opinion on melamine in food and feed. *EFSA Journal, 8*(4), 1573.

Chang, K., Wang, S., Zhang, H., Guo, Q., Hu, X., Lin, Z., Sun, H., Jiang, M., & Hu, J. (2017). Colorimetric detection of melamine in milk by using gold nanoparticles-based LSPR via optical fibers. *PLoS One, 12*(5)e0177131.

Elik, A., Fesliyan, S., Gürsoy, N., Haq, H. U., Castro-Muñoz, R., & Altunay, N. (2023). An air-assisted dispersive liquid phase microextraction method based on a hydrophobic magnetic deep eutectic solvent for the extraction and preconcentration of melamine from milk and milk-based products. *Food Chemistry, 426*, 136573.

Filazi, A., Sireli, U., Ekici, H., Can, H., & Karagoz, A. (2012). Determination of melamine in milk and dairy products by high performance liquid chromatography. *Journal of Dairy Science, 95*(2), 602–608.

Gao, L., & Jönsson, J. Å. (2012). Determination of melamine in fresh milk with hollow fiber liquid phase microextraction based on ion-pair mechanism combined with high performance liquid chromatography. *Analytical Letters, 45*(16), 2310–2323.

Ghanati, K., Eghbaljoo, H., Akbari, N., Mazaheri, Y., Aghebat-Bekheir, S., Mahmoodi, B., Zandsalimi, F., Basaran, B., & Sadighara, P. (2023). Determination of melamine contamination in milk with various packaging: a risk assessment study. *Environmental Monitoring and Assessment, 195*(9), 1095.

Guo, J., Wu, C., Zhang, J., Chang, X., Zhang, Y., Cao, Y., & Zhou, Z. (2020). Associations of melamine and cyanuric acid exposure with markers of kidney function in adults: results from NHANES 2003–2004. *Environment International, 141*, 105815.

Hassani, S., Tavakoli, F., Amini, M., Kobarfard, F., Nili-Ahmadabadi, A., & Sabzevari, O. (2013). Occurrence of melamine contamination in powder and liquid milk in market of Iran. *Food Additives & Contaminants: Part A, 30*(3), 413–420.

Hieu-Tran, Q. (2021). Validation of the method for determination of melamine and investigation its trace in milk from Vietnam by LC-MS/MS. *Asian Journal of Applied Chemistry, 8*(1), 13–19.

Hong, M., Sai, F., Yong-Ning, W., Zhang, L., Ping-Ping, Z., Hui-Jing, C., Yun-Feng, Z., & Jing-Guang, L. (2009). Simultaneous determination of melamine, ammelide, ammeline, and cyanuric acid in milk and milk products by gas chromatography-tandem mass spectrometry. *Biomedical and Environmental Sciences, 22*(2), 87–94.

Ji, Y. L., Chen, X. W., Zhang, Z. B., Li, J., & Xie, T. Y. (2014). Efficient sample clean-up and online preconcentration for sensitive determination of melamine in milk samples by capillary electrophoresis with contactless conductivity detection. *Journal of Separation Science, 37*(20), 3000–3006.

Kim, W.-I., Pak, S.-W., Lee, S.-J., Moon, C., Shin, I.-S., Lee, I.-C., & Kim, J.-C. (2023). Effects of melamine and cyanuric acid on placental and fetal development in rats. *Food and Chemical Toxicology, 113862*.

Kutyauripo, I., Rushambwa, M., & Chiwazi, L. (2023). Artificial intelligence applications in the agrifood sectors. *Journal of Agriculture and Food Research, 11*, 100502.

Li, J., Meng, Z.-J., Huang, Y.-X., Li, Q., & Zheng, L. (2020). Simultaneous determination of bisphenol A and melamine in vegetable protein drinks by gas chromatography-tandem mass spectrometry. *Current Topics in Nutraceutical Research, 18*(3).

Li, X., Luo, P., Tang, S., Beier, X., Wu, X., Yang, L., Li, Y., & Xiao, X. (2011). Development of an immunochromatographic strip test for rapid detection of melamine in raw milk, milk products and animal feed. *Journal of Agricultural and Food Chemistry, 59*(11), 6064–6070.

Liao, W., Ning, Y., Zhang, Y., Wang, W., & Wang, A. J. (2021a). Determination of sulfonamides in milk and egg samples by HPLC with mesoporous polymelamine-formaldehyde as magnetic solid-phase extraction adsorbent. *Journal of Separation Science, 44*(24), 4402–4411.

Liao, Y., Huang, X., Wang, Z., & Gan, R. (2021b). Research progress in the application of magnetic solid phase extraction based on carbon based magnetic materials in food analysis. *Se pu = Chinese Journal of Chromatography, 39*(4), 368–375.

Liu, C.-C., Hsieh, T.-J., Wu, C.-F., Lee, C.-H., Tsai, Y.-C., Huang, T.-Y., Wen, S.-C., Lee, C.-H., Chien, T.-M., Lee, Y.-C., Huang, S.-P., Li, C.-C., Chou, Y.-H., Wu, W.-J., & Wu, M.-T. (2020). Interrelationship of environmental melamine exposure, biomarkers of oxidative stress and early kidney injury. *Journal of Hazardous Materials, 396*, 122726.

Liu, N., Bouzembrak, Y., Van den Bulk, L. M., Gavai, A., van den Heuvel, L. J., & Marvin, H. J. (2022). Automated food safety early warning system in the dairy supply chain using machine learning. *Food Control, 136*, 108872.

Liu, Y., Hu, J., Zhong, M., & Xu, W. (2018). A novel, simple and rapid method for the detection of melamine from milk based on tribology measurements. *Tribology International, 119*, 66–72.

Marialuisa, M., Matteo, M. S., & Muhammad, S. (2023). Optimizing milk-run system and IT-based Kanban with artificial intelligence: an empirical study on multi-lines assembly shop floor. *Production & Manufacturing Research, 11*(1)2179123.

Melekoğlu, A., Ekici, H., Arat, E., & Karahan, S. (2020). Evaluation of melamine and cyanuric acid cytotoxicity: an *in vitro* study on L929 fibroblasts and CHO cell line. *Ankara Üniversitesi Veteriner Fakültesi Dergisi, 67*(4), 399–406.

Melough, M. M., Foster, D., Fretts, A. M., & Sathyanarayana, S. (2020). Dietary sources of melamine exposure among US children and adults in the National Health and Nutrition Examination Survey 2003–2004. *Nutrients, 12*(12), 3844.

Miao, H., Fan, S., Wu, Y.-N., Zhang, L., Zhou, P.-P., Chen, H.-J., Zhao, Y.-F., & Li, J.-G. (2009). Simultaneous determination of melamine, ammelide, ammeline, and cyanuric acid in milk and milk products by gas chromatography-tandem mass spectrometry. *Biomedical and Environmental Sciences, 22*(2), 87–94.

Motarjemi, Y., Moy, G. G., Jooste, P. J., & Anelich, L. E. (2014). Chapter 5 – Milk and dairy products. In Y. Motarjemi & H. Lelieveld (Eds.), *Food safety management* (pp. 83–117). San Diego: Academic Press.

Nag, R., & Cummins, E. (2022). Human health risk assessment of lead (Pb) through the environmental-food pathway. *Science of The Total Environment, 810*, 151168.

Nascimento, C. F., Santos, P. M., Pereira-Filho, E. R., & Rocha, F. R. P. (2017). Recent advances on determination of milk adulterants. *Food Chemistry, 221*, 1232–1244.

Neethirajan, S. (2023). Artificial intelligence and sensor technologies in dairy livestock export: charting a digital transformation. *Sensors, 23*(16), 7045.

Öztürk, S., & Demir, N. (2021). Development of a novel IMAC sorbent for the identification of melamine in dairy products by HPLC. *Journal of Food Composition and Analysis, 100*, 103931.

Poorjafari, N., Zamani, A., Mohseni, M., & Parizanganeh, A. (2015). Assessment of residue melamine in dairy products exhibited in Zanjan market, Iran by high-performance liquid chromatography method. *International Journal of Environmental Science and Technology, 12*, 1003–1010.

Rai, N., Chowdhary, S., Kumar, D., Bhattacharyya, R., & Banerjee, D. (2022). Molecular docking analysis of melamine with nuclear factor erythroid 2-related factor 2 and succinate dehydrogenase. *Bioinformation, 18*(8), 718.

Rajpoot, M., Bhattacharya, R., Sharma, S., Gupta, S., Sharma, V., & Sharma, A. K. (2021). Melamine contamination and associated health risks: gut microbiota does make a difference. *Biotechnology and Applied Biochemistry, 68*(6), 1271–1280.

Ritota, M., & Manzi, P. (2018). Melamine detection in milk and dairy products: traditional analytical methods and recent developments. *Food Analytical Methods, 11*(1), 128–147.

Sadighara, P., Godarzi, S., Bahmani, M., & Asadi-Samani, M. (2016). Antioxidant activity and properties of walnut brown seed coat extract. *Journal of Global Pharma Technology, 8*(11), 26–30.

Shi, X., Dong, R., Chen, J., Yuan, Y., Long, Q., Guo, J., Li, S., & Chen, B. (2020). An assessment of melamine exposure in Shanghai adults and its association with food consumption. *Environment International, 135*, 105363.

Singh, P., & Gandhi, N. (2015). Milk preservatives and adulterants: processing, regulatory and safety issues. *Food Reviews International, 31*(3), 236–261.

Song, J., Wu, F., Wan, Y., & Ma, L. (2015). Colorimetric detection of melamine in pretreated milk using silver nanoparticles functionalized with sulfanilic acid. *Food Control, 50*, 356–361.

Tzing, S.-H., & Ding, W.-H. (2010). Determination of melamine and cyanuric acid in powdered milk using injection-port derivatization and gas chromatography–tandem mass spectrometry with furan chemical ionization. *Journal of Chromatography A, 1217*(40), 6267–6273.

Vachirapatama, N., & Maitresorasun, S. (2013). Simultaneous determination of melamine, ammelide, ammeline and cyanuric acid in milk products by micellar electrokinetic chromatography. *Journal of Food and Drug Analysis, 21*(1), 8.

Wang, J., Wu, Y., Wu, Q., Li, L., Wang, Y., & Yang, H. (2020). Highly sensitive detection of melamine in milk samples based on N-methylmesoporphyrin IX/G-quadruplex structure. *Microchemical Journal, 155*, 104751.

Wu, C.-F., Liu, C.-C., Tsai, Y.-C., Chen, C.-C., Wu, M.-T., & Hsieh, T.-J. (2021). Diminishment of Nrf2 antioxidative defense aggravates nephrotoxicity of melamine and oxalate coexposure. *Antioxidants, 10*(9), 1464.

Wu, C. F., Cheng, C. M., Hsu, Y. M., Li, S. S., Huang, C. Y., Chen, Y. H., Kuo, F. C., & Wu, M. T. (2020). Development of analytical method of melamine in placenta from pregnant women by isotope-dilution liquid chromatography/tandem mass spectrometry. *Rapid Communications in Mass Spectrometry, 34*, e8599.

Yilmaz, Ü. T., & Yazar, Z. (2010). Determination of cyanuric acid in swimming pool water and milk by differential pulse polarography. *CLEAN – Soil, Air, Water, 38*(9), 816–821.

Zhu, H., & Kannan, K. (2018). Continuing occurrence of melamine and its derivatives in infant formula and dairy products from the United States: implications for environmental sources. *Environmental Science & Technology Letters, 5*(11), 641–648.

Zhu, H., & Kannan, K. (2019). Melamine and cyanuric acid in foodstuffs from the United States and their implications for human exposure. *Environment International, 130*, 104950.