



ORIGINAL ARTICLE

Phthalates in breast milk

Alžběta Jarošová*, Vendula Kloudová

Department of Food Technology, Mendel University in Brno, Brno, Czech Republic

OPEN ACCESS

*Correspondence: alzbeta.jarosova@mendelu.cz**Citation:** Jarošová, A., Kloudová, V., 2026: Phthalates in breast milk. *Folia Veterinaria*, 70, 3, 76–84.**Received:** June 24, 2026**Accepted:** September 6, 2026**Published:** September 15, 2026**Copyright:** 2026 Jarošová, Kloudová. This work is licensed under the [Creative Commons Attribution-Non-Commercial-NoDerivatives 4.0 International License](https://creativecommons.org/licenses/by-nd/4.0/).

Ethical considerations: When reporting experiments on animals Observation of the ARRIVE guidelines 2.0: Updated guidelines for reporting animal research, published on July 14, 2020 (DOI: [10.1371/journal.pbio.3000410](https://doi.org/10.1371/journal.pbio.3000410)), is applied. The authors ensure that all procedures were performed in compliance with the guidelines for animal care of their institutions or with national/international guidelines.

ABSTRACT

Breast milk collected from the 10th day through the 5th month after delivery was analyzed for DEHP (di-2-ethylhexyl phthalate) and DBP (dibutyl phthalate) content. Dibutyl phthalate concentrations ranged from 5.17 µg/L to 2.81 µg/L, and di-2-ethylhexyl phthalate was not detected in breast milk. Statistical analysis showed that the time factor influenced phthalate levels in breast milk, with a gradual decrease observed. The expected trend of increasing phthalate levels with the duration of breastfeeding was not statistically confirmed. In none of the monthly milk samples did phthalate intake exceed the tolerable daily intake (TDI) for infants. The estimated daily intake of dibutyl phthalate for infants ranged from 0.848 µg/kg to 0.355 µg/kg of body weight. The tolerable daily intake for DBP is set at 10 µg/kg of body weight per day and for DEHP at 50 µg/kg of body weight per day.

Keywords: breast milk; liquid chromatography; phthalic acid esters; plasticizers

INTRODUCTION

Phthalates are a group of widely used industrial chemicals that are primarily employed as plasticizers and are therefore found in a wide range of everyday products—from food and cosmetic packaging to flooring and medical devices [1–6].

Due to their widespread use, they are released into the air, dust, food, and water, leading to continuous exposure of the human population [7, 1]. Phthalates can enter the human body via inhalation, skin contact, and ingestion and are considered endocrine disruptors that can interfere with hormonal balance and immune system function [8, 9]. Scientific studies report their potential impact on reproductive health, fetal development, and metabolic processes, as well as links to certain chronic diseases [10–13].

One of the most vulnerable groups is breastfeeding mothers and their infants, as phthalates, being lipophilic substances, can accumulate in adipose tissue and subsequently pass into breast milk [14, 15].

Breast milk is a complex food for infants containing a significant amount of biologically active substances. The composition of breast milk undergoes changes during lactation to meet the biological needs of the growing child. The mother's diet and lifestyle also significantly influence the composition of her milk [16, 17].

Breast milk contains approximately 3–5% fat, which increases the likelihood of phthalate transfer from the mother to the newborn through breastfeeding. Through this exposure, phthalates can exert toxic effects and negatively impact the health and development of newborns. It is therefore

important to educate mothers to minimize the risk of children's exposure to these harmful substances [18, 19, 7].

A team of researchers Gajdůšková et al. [20] investigated the concentrations of polychlorinated biphenyls (PCBs), chlorinated pesticides, and phthalate-like contaminants in the breast milk of women from the Brno area. The authors found that the measured concentrations varied significantly between individual samples and in the days following childbirth. Contamination of breast milk was detected in all samples, with some showing higher levels of PCBs, while others were more heavily contaminated with pesticides. Significant differences in the levels of toxic substances were also demonstrated among individual mothers. This can be attributed to the variability of factors such as individual exposure to environmental contaminants, age, lifestyle, and overall health status.

The aim of the study was to verify the presence and levels of phthalates in real breast milk samples and to monitor their concentrations over a 5-month breastfeeding period following the mother's delivery.

MATERIALS AND METHODS

Materials and Methodology

To collect breast milk samples, three participants were contacted during their pregnancies and briefed on the sampling procedure. Breast milk from one participant served as a control sample. Another participant who had planned to provide experimental samples had to be excluded from the experiment because she was unable to provide samples continuously throughout the sampling period.

The third participant, who provided samples for the experiment, was not occupationally exposed to phthalates. She was 31 years old, weighed 64 kg before giving birth, and had a body mass index (BMI) of 23. The participant reported that she had always consumed a varied diet and did not use cosmetic products in excessive amounts.

The participants for milk collection (both test and experimental) used exclusively manual expression to minimize the potential risk of secondary contamination of the milk with phthalates from the use of manual breast pumps. During the milk collection process itself, emphasis was placed on the participant's comfort and individual preferences (it was not necessary to express milk, let the baby nurse, or specifically collect foremilk or hindmilk).

The experiment took place in 2023. The first sample collection occurred on the 10th day postpartum and lasted for 5 consecutive days. Subsequent collections were performed once a month until the fifth month postpartum, with each collection lasting 5 days within a given week. Due to the small volume of milk collected (10 to 50 mL per day), the five-day collection period was divided into two samples. Sample I was collected in the first half of the collection week; Sample II was collected in the second half of the week.

The five-month period, beginning on the 10th day postpartum, was chosen based on the assumption that if phthalates are present in milk, they may exhibit variability during lactation. For this reason, it was more appropriate to collect samples at different time intervals after delivery, which allowed for a more accurate estimate of exposure in breastfed infants and better reflected potential changes in phthalate levels during lactation.

The breast milk samples were stored by the participants in the refrigerator. After the sampling period ended, they were transferred to a freezer and stored at -18 °C.

Methods Used

Sample analysis was conducted at the Institute of Food Technology at Mendel University in Brno. Milk samples were analyzed for DEHP and DBP because the legislative limits for food were established specifically for these two, most commonly occurring phthalates. Milk fat content was determined according to the ČSN ISO 1211 (570534) [21] standard for the gravimetric determination of milk fat.

After thawing, the milk samples were tempered to 38 °C for 10 minutes. Then, 30 g of homogenized milk was weighed and quantitatively transferred to a separating funnel; the fat was extracted three times using ethanol, diethyl ether, and hexane.

The combined (three) extracts were evaporated on a vacuum rotary evaporator at 47 °C and 60 revolutions per minute and subsequently dried under a stream of nitrogen. The fat content in the milk was determined gravimetrically by weighing the evaporating flask before and after extraction. The fat was transferred to a vial and subsequently stored in a freezer (-18 °C) for further analysis using gel permeation chromatography (GPC). A blank test was prepared with each series of samples, which did not contain milk, only mixtures of organic solvents.

The separation of phthalates from the fat was performed by GPC using a mobile phase consisting of a mix-

ture of organic solvents (dichloromethane : cyclohexane, 1:1), with a mobile phase flow rate of 1 mL/min. The mobile phase was evaporated on a vacuum rotary evaporator, and the phthalate residue was quantitatively transferred to a vial for determination by high-performance liquid chromatography with UV detection. The mobile phase was acetonitrile with isocratic elution at a flow rate of 0.8 mL·min⁻¹, and the sample injection volume was 10 µL. A Zorbax Eclipse chromatographic column with a length of 150 mm, a width of 4.6 mm, and a particle size of 5 µm was used. The column temperature was 25 °C. A diode array detector (DAD) was used for the detection of DEHP and DBP, and measurements were taken at a wavelength of 224 nm. The analysis software was Agilent OpenLAB CDS (Agilent Technologies, USA).

The detection limit providing a statistically significant signal was set at 0.02 mg·kg⁻¹ for breast milk samples.

Phthalate quantification was performed using a calibration curve. Microsoft Excel and Statistica 14 software tools were used to quantify the results. A significance level of $p = 0.01$ (1%) was selected for the analysis, representing a strict criterion for the statistical evaluation of the results. All $p < 0.01$ values were considered statistically significant. This level was chosen to minimize the risk of error. The rationale for this approach was that breast milk is a biologically valuable matrix for which a high level of statistical reliability must be ensured ($p = 0.01$ is standard in pharmacological and medical studies). To analyze relationships between variables in data exhibiting a normal distribution, Pearson's correlation coefficient was used, which quantifies the linear dependence between two continuous variables.

Furthermore, one-way analysis of variance (ANOVA) was used to analyze the results. Tukey's test was applied for multiple comparisons (post hoc analysis).

Equipment Used

Analytical balances (OHAUS®, USA).

Ultrasonic bath (Ultrasonic Compact Cleaner 10L PS 10000).

Vacuum rotary evaporator (LabTech EV400H), water bath (HandyLab® System).

Gel permeation chromatography, precolumn 50 x 8 mm, LCP 400 pump, LCD 2083 spectrophotometric detector, WARTEX column (ECOM, spol. s.r.o., Czech Republic).

Agilent Technologies 1260 Infinity II liquid chromatograph (Agilent Technologies, USA).

RESULTS AND DISCUSSION

Results of the Analysis of Fat in Breast Milk

Twelve samples were analyzed to determine the fat content in breast milk. Table 1 shows the fat content in milk from the 10th day postpartum through the 5th month postpartum. The fat content in milk ranged from 2.33% to 4.26%. The highest fat percentage (4.73%) was recorded as early as the 1st month postpartum and then in the 5th month postpartum (4.26%). Conversely, the lowest fat content (2.12%) was found in a sample collected 3 months postpartum.

Table 1. Fat content in breast milk from the 10th day postpartum to the 5th month postpartum

Postpartum milk sample	Fat content in breast milk [g/100g]	
	Sample I	Sample II
10th day	2.33	2.34
1st month	2.52	4.73
2nd month	3.04	3.29
3rd month	2.12	3.51
4th month	2.63	2.38
5th month	4.26	3.79

Given the small amount of breast milk collected on individual days throughout the week, composite samples were created. Sample I – first half of the week (Monday–Wednesday); Sample II – second half of the week (Thursday and Friday)

A statistical analysis was performed to determine whether there is a significant relationship between the duration of lactation and the fat content of breast milk. Pearson's correlation coefficient was used to determine the strength of this correlation, and a linear regression model was subsequently constructed.

The results of the analysis did not show a statistically significant relationship between the duration of lactation and the fat content in milk ($p > 0.01$). The calculated correlation coefficient was close to zero, indicating a very weak linear relationship. The statistical analysis did not show a significant increase in fat content in breast milk with the duration of lactation. The results of the regression analysis are presented in Table 2.

Table 2. Results of the regression model showing the relationship between fat content and the duration of lactation

Dependent variable	Independent variable	Correlation coefficient R	Coefficient of determination R ²	Regression model	p-value
Fat in milk	The Days Following Childbirth	0	0	$y = 2,67 + 0,0046 \cdot x$	$p > 0,01$

$p > 0.01$ – the independent variable (duration of lactation in days) was found to be statistically insignificant

Although the expected trend of increasing fat content with advancing lactation was not clearly confirmed, the average fat values in the analyzed breast milk ranged from 3% to 4.5%. This amount corresponds to physiological norms and is consistent with values reported by a number of experts [16, 19].

Results of Phthalate Analysis in Breast Milk

To determine the content of DBP and DEHP in breast milk, 24 samples were analyzed. Samples from each measurement were analyzed in duplicate. Including the analysis of blank samples, a total of 30 analyses were performed.

DEHP was not detected in any of the analyzed samples collected from the 10th day to the 5th month postpartum. The presence of DBP in breast milk was detected from the 10th day to the 2nd month postpartum. During the lactation phase, the concentration of DBP in milk gradually decreased until it fell below the limit of detection. The average results of the phthalate analysis in breast milk are presented in Table 3.

A regression model was constructed to analyze the statistical relationship between DBP concentration and the number of days postpartum. The degree of linear correlation was assessed using Pearson's correlation coefficient. The independent variable (number of days postpartum) was found to be statistically significant ($p < 0.01$). The co-

efficient of determination R^2 was 0.81. This indicates that the time since delivery accounted for 81% of the variation in phthalate levels in breast milk.

Based on the above results, it can be concluded that the time factor had a statistically significant effect on the reduction of DBP levels in breast milk. The regression results are presented in Table 4.

No statistical analysis was performed for DEHP. DEHP was not detected in the breast milk samples.

DBP and DEHP levels in the breast milk of Canadian mothers were analyzed over a six-month period. Samples were collected manually to avoid potential contamination from manual breast pumps [22]. The authors recorded the highest DBP level in the 6th month postpartum (1.86 $\mu\text{g/L}$), with the most significant increase in concentrations occurring after the 3rd month. In contrast, in our subject, the highest DBP concentrations were detected as early as the first month postpartum (5.17 $\mu\text{g/L}$), followed by a gradual decline to below the limit of detection.

The authors observed the opposite trend, with DBP concentrations in breast milk increasing over time, whereas in our subject, the highest concentrations were recorded at the beginning of lactation and subsequently decreased. In the case of DEHP, the highest measured concentration was 483 $\mu\text{g/L}$, also in the 6th month postpartum. However, the authors' statistical analysis did not confirm that time

Table 3. Concentrations of DEHP and DBP in breast milk from the 10th to the 15th day postpartum through 5th month postpartum

Postpartum milk sample	Sample I		Sample II	
	DEHP	DBP	DEHP	DBP
	[$\mu\text{g/L}$ milk]		[$\mu\text{g/L}$ milk]	
10th day	ND	4.83	ND	4.18
1st month	ND	5.17	ND	4.52
2nd month	ND	3.52	ND	2.81
3rd month	ND	ND	ND	ND
4th month	ND	ND	ND	ND
5th month	ND	ND	ND	ND

ND – not detected; Given the small amount of breast milk collected on individual days throughout the week, composite samples were created. Sample I – first half of the week (Monday–Wednesday); Sample II – second half of the week (Thursday and Friday)

Table 4. Results of the regression model for DBP concentration as lactation progresses

Dependent variable	Independent variable	Correlation coefficient R	Coefficient of determination R ²	Regression model	p-value
DBP	The Days Following Childbirth	0,827	0,810	$y = 5,41 - 0,0376 \cdot x$	$p < 0,01$

had a significant effect on its increase. In comparison with our subject's results, DEHP was not detected at all in the analyzed breast milk samples.

Main et al. [23] analyzed the levels of phthalate metabolites, specifically mono(2-ethylhexyl) phthalate (MEHP) (a metabolite of DEHP) and mono-butyl phthalate (MBP) (a metabolite of DBP), in breast milk from mothers in Finland ($n = 65$) and Denmark ($n = 57$). The aim was, similarly to the case of the subject we studied, to assess the temporal evolution of phthalate exposure over a period of several months. Due to the difficulty of regular sampling, a single composite sample was ultimately created, consisting of milk collected once a month over a three-month period.

The average concentration of MEHP was 9.5 µg/L and MBP 4.3 µg/L in the Danish milk samples. Higher average concentrations were measured in the Finnish samples, namely 13 µg/L MEHP and 12 µg/L MBP.

The authors noted significant variations in phthalate concentrations. Although 45.6% of Danish participants used a manual breast pump, their average phthalate concentration was lower compared to the Finnish samples. The results indicate that the use of a manual breast pump did not affect the variability of the measured values.

Analysis of the measured DBP concentrations in our subject during the period from day 10 to 2 months postpartum averaged 4.17 µg/L. Metabolites typically reach higher concentrations than their parent compounds (they are more hydrophilic). This is a possible explanation for why DBP concentrations (4.17 µg/L) in our subject were approximately two to five times lower than those in Danish and Finnish mothers. At the same time, repeated handling of a single composite sample could have significantly contributed to higher phthalate levels due to secondary contamination.

Breast milk samples for DBP and DEHP analysis were provided by 35 mothers from China. Breast milk samples were collected manually one week after delivery, and the mothers were not professionally exposed to phthalates, just as with our subject [24]. DBP was detected in 80% of

all milk samples one week after delivery, with concentrations ranging widely from 5.3 to 137.3 µg/L. The range of DEHP concentrations was not as wide but still significant, ranging from 0.5 to 66.5 µg/L, and it was detected in 74% of the samples. The mean contamination levels were 32.9 µg/L for DBP and 13.6 µg/L for DEHP.

In our subject, DBP concentrations of 4.83 µg/L and 4.18 µg/L were detected starting on the 10th day postpartum. This comparison shows that the measured concentrations in our subject were significantly lower than those in the study by Fan et al. [24].

The research team of Cao et al. [14] analyzed DBP and DEHP levels in breast milk from 305 women in Canada. The mothers provided a single milk sample, which was collected during the second month postpartum. DBP was detected in 21 of the 305 samples, with an average concentration of 13.29 µg/L. DEHP was detected in 23 samples, with an average concentration of 244.11 µg/L.

Compared to the subject we studied, the DBP concentration in the second month postpartum was 3.52 µg/L and 2.81 µg/L, which is approximately 4 times lower than the concentration (13.29 µg/L) reported in the Canadian study. At the same time, the DEHP concentration in the Canadian study was up to 200 times higher, as the DEHP concentration in our subject was below the limit of detection.

This discrepancy in results is not attributed to the sampling method, as the sampling procedure was identical to the one described in our study methodology. Environmental factors and the subjects' dietary habits, which can significantly influence phthalate exposure, are considered the more likely cause of these differences. Regional differences in the use of plastic packaging, the presence of phthalates in food and personal hygiene products, as well as various lifestyle habits, can significantly influence phthalate concentrations in breast milk.

Cao et al. [14] attribute the difference in DEHP and DBP concentrations to the primary uses of these phthalates. DEHP is primarily used as a plasticizer in food packaging, which leads to significantly higher exposure through the food chain. In contrast, DBP is most commonly used in

cosmetic products, where exposure occurs primarily via the dermal route, resulting in significantly lower accumulation compared to DEHP.

Results of Estimated Daily Intake and Risk Assessment of Phthalates

The results of the analysis of phthalates in breast milk demonstrated the presence of DBP, while DEHP was not detected in the milk. The presence of phthalates in breast milk has also been confirmed by a number of other authors [25, 26]. This fact underscores the importance of assessing the estimated daily intake of phthalates in infants and its potential impact on their health. Based on these results, the estimated daily intake of phthalates was calculated.

The estimated daily intake of phthalates (EDI) was calculated using the following equation:

$$EDI = \frac{c \times DI}{BW} [\mu g \cdot kg^{-1}]$$

where:

c..... amount of detected phthalate in [$\mu g/L$ of milk]

DI.....estimated daily milk intake [l]

BW....infant weight [kg]

The equation for calculating EDI and the average daily breast milk intake, which was set at 0.7 L, are based on studies by Liu et al. [25] and Kim et al. [26]. The infant's weight was recorded monthly by our study participant.

The EDI results for DBP are presented in Table 5. To assess the health risk of DBP and DEHP exposure to infants, the EDI results were compared with tolerable daily intake (TDI) values. For DEHP, the TDI is set at 50 $\mu g/kg$ body weight per day, while for DBP, the TDI is 10 $\mu g/kg$ body weight per day [27, 28].

The results of the phthalate analysis in breast milk showed that DEHP was not detected in any sample. For

this reason, DEHP did not exceed the TDI (50 $\mu g/kg$) in any month following delivery.

The estimated daily intake for DBP was 0.848 $\mu g/kg$ starting on the 10th day postpartum, 0.748 $\mu g/kg$ in the first month postpartum, and 0.355 $\mu g/kg$ in the second month. Starting from the third month postpartum, DBP was no longer detected in breast milk. A comparison of the EDI and TDI values confirms that the established TDI for DBP (10 $\mu g/kg$) was not exceeded in any month postpartum.

Liu et al. [25] also conducted an analysis of phthalates in breast milk, but only in the first month postpartum. They then compared the EDI with the TDI. The EDI was 0.228 $\mu g/kg$ for DEHP and 0.048 $\mu g/kg$ for DBP. The authors ruled out any exceedance of the TDI, indicating that the use of phthalates during breastfeeding does not pose any apparent health risk to infants. However, they note that risk assessment based solely on dietary intake may underestimate the actual health risk of phthalate exposure. The EDI values for DBP in the first month postpartum (0.748 $\mu g/kg$) in the subject we monitored were up to 16 times higher than those reported by Liu et al. [25].

The estimated daily intake of DBP and DEHP in breast milk samples from Korea, collected between the 1st and 2nd month postpartum, showed a very wide range of measured concentrations. For DEHP, the EDI ranged from 0.61 $\mu g/kg$ to 6.72 $\mu g/kg$, and for DBP, it ranged from 0.08 $\mu g/kg$ to 0.58 $\mu g/kg$. The authors ruled out EDI exceedances and attributed the wide range of measured concentrations to various factors, such as lifestyle, diet, or daily exposure to toxic substances [26]. For comparison, the EDI values for DBP in our subject in the second month postpartum were 0.355 $\mu g/kg$, which is close to the average EDI value reported by Kim et al. [25].

The estimated daily intake of phthalates during the six-month analysis conducted by Zhu et al. [22] showed that

Table 5. Estimated daily intake of DBP depending on the period of breast milk collection and infant weight

Postpartum milk sample	Average value DBP [$\mu g/L$ milk]	Weight of an infant [g]	Estimated daily intake (EDI) DBP [$\mu g/kg$]
10th day	4.509	3 720	0.848
1st month	4.845	4 540	0.748
2nd month	3.165	5 550	0.355
3rd month	ND	6 180	-
4th month	ND	6 580	-
5th month	ND	6 815	-

ND – not detected

values for DBP ranged from 0.38 to 0.65 µg/kg and DEHP reached values of 82–167 µg/kg. In this case, the TDI for DEHP was exceeded. The study authors describe these findings as alarming and emphasize that infants' actual exposure to phthalates could have been significantly higher. They highlight the ubiquitous presence of these contaminants. In addition to breast milk, infants may be exposed to phthalates through the air, cosmetics, packaging materials, and toys, which further increases their overall exposure. In our study participant, the average EDI value for DBP from day 10 to the 5th month postpartum was 0.18 µg/kg, which is lower than the value reported by Zhu et al. [22].

CONCLUSION

Based on the results of DBP concentrations in breast milk, DBP was present in the samples from the 10th day to the 2nd month postpartum. During this period following delivery, a gradually decreasing concentration of DBP in milk was observed. The average DBP concentration was 4.5 µg/L from the 10th to the 15th day postpartum, 4.84 µg/L in the first month postpartum, and 3.16 µg/L in the second month postpartum. From the 3rd to the 5th month postpartum, DBP was no longer detected in breast milk samples. Statistical analysis confirmed that the duration of lactation had a significant effect on phthalate levels in breast milk, with a gradual decrease observed in 81% of cases. In all analyzed samples collected from the 10th day to the 5th month postpartum, the presence of DEHP was not detected.

The results showed that even higher fat content in the samples did not cause increased accumulation of phthalates in breast milk.

To assess the health risk of DBP and DEHP exposure in infants, the estimated daily intake results were compared with the tolerable daily intake (TDI) values. The results of this study indicate that the tolerable daily intake for DBP was not exceeded in any month following delivery. Since DEHP was not detected in the breast milk samples, the tolerable daily intake was not exceeded in this case either. None of the analyzed breast milk samples exceeded the tolerable daily intake.

The fact that only DBP was detected in breast milk, while DEHP was not, can be explained by the different physical-chemical properties of these two phthalates. DEHP is much more lipophilic, has a higher molecular weight, and breaks down in the body into its hydrolyzed

and oxidized metabolites, which get into milk differently than the original compound. On the other hand, DBP is less lipophilic, more stable in its original form, and its transfer into biological samples, including breast milk, is more common. These differences may explain why only DBP was found in the analyzed samples.

The main limitation of this study is that breast milk analyses were ultimately done on just one donor. Such a small number of samples doesn't allow the results to be generalized to the wider population and doesn't let us assess individual differences in DEHP and DBP concentrations.

The obtained data should be interpreted as pilot results, serving primarily to verify the analytical methodology and to highlight the potential health risk associated with the presence of phthalates in breast milk. To confirm these findings, it is necessary to analyze a larger set of samples.

At the same time, it is important to note that in the Czech Republic, very little scientific attention has been devoted to the issue of phthalates in breast milk. The limited amount of data and research studies in this area points to the need for more systematic monitoring and more thorough investigation of phthalate exposure via breast milk.

Data Availability Statement

The raw data of this article will be made available by the authors, without undue reservation.

Ethical Statement

Ethical approval was not necessary for this work.

Conflict of Interest

No conflict of interest.

Funding

This research received no specific grant from any funding agency.

Generative AI Statement

The authors acknowledge the use of generative AI in the preparation of this manuscript. The AI tool was used solely for language editing and stylistic improvements.

The authors reviewed, validated, and take full responsibility for the final content.

Authors' Contributions

A.J. – experiment design, methodological supervision, manuscript drafting

V.K. – procurement of samples, conducting analyses, data processing

Acknowledgments

We would like to thank all participants for their willingness to provide breast milk samples, which enabled the conduct of this study. We also thank our colleagues for their technical and professional support, which contributed to the successful completion of this work.

REFERENCES

1. Sokolowski, A., Konczak, M., Oleszczuk, P., Gao, Y., Czech, B., 2024: Environmental and food contamination by phthalic acid esters (PAEs): Overview. *Water Air Soil Pollut.*, 235, 5. DOI: [10.1007/s11270-024-07121-5](https://doi.org/10.1007/s11270-024-07121-5)
2. Tan, H., Yang, L., Huang, D., Chen, H., Yang, Y., Chen, D., 2023: Contamination of baby foods by plastic additives: A pilot screening study. *Environ. Sci. Technol. Lett.*, 10, 4, 322–327. DOI: [10.1021/acs.estlett.3c00100](https://doi.org/10.1021/acs.estlett.3c00100)
3. Haji Harunarashid, N. Z. I., Lim, L. H., Harunsani, M. H., 2017: Phthalate sample preparation methods and analysis in food and food packaging: A review. *Food Anal. Methods*, 10, 12, 3790–3814. DOI: [10.1007/s12161-017-0938-7](https://doi.org/10.1007/s12161-017-0938-7)
4. Zhang, Y., Chen, L.-B., Shen, H.-Y., Wu, Z.-C., Zhu, N.-Z., Gao, C.-J., Guo, Y., 2025: Occurrence, migration behavior, and environmental burden of phthalate esters in flooring materials used in newly renovated chinese homes. *Toxics*, 13, 7, 517. DOI: [10.3390/toxics13070517](https://doi.org/10.3390/toxics13070517)
5. Fan, J.-C., Ren, R., He, H.-L., Jin, Q., Wang, S.-T., 2020: Determination of phthalate esters in breast milk before and after frozen storage in milk storage bags. *Food Addit. Contam. Part A*, 37, 11, 1897–1905. DOI: [10.1080/19440049.2020.1815862](https://doi.org/10.1080/19440049.2020.1815862)
6. Wang, Y., Zhu, H., Kannan, K., 2019: A review of biomonitoring of phthalate exposures. *Toxics*, 7, 2, 21. DOI: [10.3390/toxics7020021](https://doi.org/10.3390/toxics7020021)
7. Khishdost, M., Dobaradaran, S., Goudarzi, G., Takdastan, A., Babaei, A. A., 2023: Contaminant occurrence, distribution and ecological risk assessment of phthalate esters in the Persian Gulf. *PLoS One*, 18, 7, e0287504. DOI: [10.1371/journal.pone.0287504](https://doi.org/10.1371/journal.pone.0287504)
8. Dutta, S., Haggerty, D., Rappolee, D. A., Ruden, D. M., 2020: Phthalate exposure and long-term epigenomic consequences: A review. *Front. Genet.*, 11, 405. DOI: [10.3389/fgene.2020.00405](https://doi.org/10.3389/fgene.2020.00405)
9. Wang, Y., Qian, H., 2021: Phthalates and their impacts on human health. *Healthcare*, 9, 5, 603. DOI: [10.3390/healthcare9050603](https://doi.org/10.3390/healthcare9050603)
10. Almeida-Toledano, L., Navarro-Tapia, E., Sebastiani, G., Ferrero-Martínez, S., Ferrer-Aguilar, P., García-Algar, Ó., et al., 2024: Effect of prenatal phthalate exposure on fetal development and maternal/neonatal health consequences: A systematic review. *Sci. Total Environ.*, 950, 175080. DOI: [10.1016/j.scitotenv.2024.175080](https://doi.org/10.1016/j.scitotenv.2024.175080)
11. Ito, Y., Kamijima, M., Nakajima, T., 2019: Di(2-ethylhexyl) phthalate-induced toxicity and peroxisome proliferator-activated receptor alpha: A review. *Environ. Health Prev. Med.*, 24, 47. DOI: [10.1186/s12199-019-0802-z](https://doi.org/10.1186/s12199-019-0802-z)
12. Fang, H., Wang, H., Zeng, C., Fu, H., Zhao, B., Liu, A., et al., 2022: A preliminary cumulative risk assessment of Diethylhexyl phthalate and Dibutyl phthalate based on the inhibition of embryonic development via the PPARγ pathway. *Toxicol. In Vitro*, 84, 105430. DOI: [10.1016/j.tiv.2022.105430](https://doi.org/10.1016/j.tiv.2022.105430)
13. Kim, S., Lee, J., Park, J., Kim, H.-J., Cho, G., Choi, K., et al., 2015: Concentrations of phthalate metabolites in breast milk in Korea: Estimating exposure to phthalates and potential risks among breast-fed infants. *Sci. Total Environ.*, 508, 1, 13–19. DOI: [10.1016/j.scitotenv.2014.11.019](https://doi.org/10.1016/j.scitotenv.2014.11.019)
14. Cao, X.-L., Sparling, M., Zhao, W., Arbuckle, T., 2021: GC-MS Analysis of phthalates and di-(2-ethylhexyl) adipate in canadian human milk for exposure assessment of infant population. *J. AOAC Int.*, 104, 1, 98–102. DOI: [10.1093/jaoacint/qsaa108](https://doi.org/10.1093/jaoacint/qsaa108)
15. Fromme, H., Gruber, L., Seckin, E., Raab, U., Zimmermann, S., Kiranoglu, M., et al., 2011: Phthalates and their metabolites in breast milk — Results from the bavarian monitoring of breast milk (BAMBI). *Environ. Int.*, 37, 4, 715–722. DOI: [10.1016/j.envint.2011.02.008](https://doi.org/10.1016/j.envint.2011.02.008)
16. Loughnan, M., MehringLeDoare, K., 2020: Breast Milk Composition. In: *Encyclopedia of Evolutionary Psychological Science*. DOI: [10.1007/978-3-319-16999-6_828-1](https://doi.org/10.1007/978-3-319-16999-6_828-1)

17. Muro-Valdez, J. C., Meza-Rios, A., Aguilar-Uscanga, B. R., Lopez-Roa, R. I., Medina-Díaz, E., Franco-Torres, E. M., et al., 2023: Breastfeeding-related health benefits in children and mothers: Vital organs perspective. *Medicina*, 59, 9, 1535. DOI: [10.3390/medicina59091535](https://doi.org/10.3390/medicina59091535)
18. Bi, M., Liu, W., Luan, X., Li, M., Liu, M., Liu, W., et al., 2021: Production, use, and fate of phthalic acid esters for polyvinyl chloride products in China. *Environ. Sci. Technol.*, 55, 20, 13980–13989. DOI: [10.1021/acs.est.1c02374](https://doi.org/10.1021/acs.est.1c02374)
19. Yi, D. Y., Kim, S. Y., 2021: Human breast milk composition and function in human health: From nutritional components to microbiome and microRNAs. *Nutrients*, 13, 9, 3094. DOI: [10.3390/nu13093094](https://doi.org/10.3390/nu13093094)
20. Gajdůšková, V., Černá, M., Malý, M., Šmíd, J., 1996: Concentrations of polychlorinated biphenyls and chlorinated pesticides in human breast milk-case study. *Cent. Eur. J. Public Health*, 4, 2, 110–114. ISSN 1210-7778.
21. ČSN ISO 1211, 2011: Mléko – Stanovení obsahu tuku – Vážková metoda (Referenční metoda). Praha: Úřad pro technickou normalizaci, metrologii a státní zkušebnictví, 24 s. Třídící znak 57 0534.
22. Zhu, J., Phillips, S. P., Feng, Y.-L., Yang, X., 2006: Phthalate esters in human milk: Concentration variations over a 6-month postpartum time. *Environ. Sci. Technol.*, 40, 17, 5276–5281. DOI: [10.1021/es060356w](https://doi.org/10.1021/es060356w)
23. Main, K. M., Mortensen, G. K., Kaleva, M. M., Boisen, K. A., Damgaard, I. N., Chellakooty, M., et al., 2006: Human breast milk contamination with phthalates and alterations of endogenous reproductive hormones in infants three months of age. *Environ. Health Perspect.*, 114, 2, 270–276. DOI: [10.1289/ehp.8075](https://doi.org/10.1289/ehp.8075)
24. Fan, J.-C., Ren, R., Jin, Q., He, H.-L., Wang, S.-T., 2019: Detection of 20 phthalate esters in breast milk by GC-MS/MS using QuEChERS extraction method. *Food Addit. Contam. Part A*, 36, 10, 1551–1558. DOI: [10.1080/19440049.2019.1646435](https://doi.org/10.1080/19440049.2019.1646435)
25. Liu, Y., Xiao, M., Huang, K., Cui, J., Liu, H., Yu, Y., et al., 2024: Phthalate metabolites in breast milk from mothers in Southern China: Occurrence, temporal trends, daily intake, and risk assessment. *J. Hazard. Mater.*, 464, 132895. DOI: [10.1016/j.jhazmat.2023.132895](https://doi.org/10.1016/j.jhazmat.2023.132895)
26. Kim, J. H., Kim, D., Moon, S.-M., Yang, E. J., 2020: Associations of lifestyle factors with phthalate metabolites, bisphenol A, parabens, and triclosan concentrations in breast milk of Korean mothers. *Chemosphere*, 249, 126149. DOI: [10.1016/j.chemosphere.2020.126149](https://doi.org/10.1016/j.chemosphere.2020.126149)
27. EFSA, 2005: Opinion of the scientific panel on food additives, flavourings, processing aids and materials in contact with food (AFC) related to di-butylphthalate (DBP) for use in food contact materials. *EFSA J.*, 3, 9, 242. DOI: [10.2903/j.efsa.2005.242](https://doi.org/10.2903/j.efsa.2005.242)
28. Silano, V., Barat Baviera, J. M., Bolognesi, C., Chesson, A., Cocconcelli, P. S., Crebelli, R., et al., 2019: Update of the risk assessment of di-butylphthalate (DBP), butyl-benzyl-phthalate (BBP), bis(2-ethylhexyl)phthalate (DEHP), diisononylphthalate (DINP) and di-isodecylphthalate (DIDP) for use in food contact materials. *EFSA J.*, 17, 12, e05838. DOI: [10.2903/j.efsa.2019.5838](https://doi.org/10.2903/j.efsa.2019.5838)