Eur J Nutr (2004) 43 : 191–197
DOI 10.1007/s00394-004-0458-2

ORIGINAL CONTRIBUTION

Giovanna Turconi
Marianna Guarcello
Chiara Livieri
Sergio Comizzoli
Laura Maccarini
Anna Maria Castellazzi
Amedeo Pietri
Gianfranco Piva
Carla Roggi

Evaluation of xenobiotics in human milk and ingestion by the newborn

An epidemiological survey in Lombardy (Northern Italy)

Received: 14 April 2003
Accepted: 30 September 2003
Published online: 6 January 2004

Dr. G. Turconi (✉) · M. Guarcello · C. Livieri · S. Comizzoli · A. M. Castellazzi · C. Roggi
Dept. of Applied Health & Psycho-behavioural Sciences
Section of Human Nutrition
Faculty of Medicine, University of Pavia
Via Bassi 21
27100 Pavia, Italy
Tel:. +39-382/5075-44
Fax: +39-382/5075-70
E-Mail: gturconi@unipv.it

L. Maccarini
Dept. of Preventive Occupational & Community Medicine
Hygiene Institute
Faculty of Medicine, University of Pavia
Pavia, Italy

A. Pietri · G. Piva
Institute of Food Science and Nutrition
Agricultural Science Faculty
Catholic University of the Sacred Heart of Piacenza
Piacenza, Italy

Summary *Background* Many human milk benefits have been well documented; nevertheless the newborn potential risk to the xenobiotic exposition may be relevant and it requires a biological monitoring in general prevention. Concerning this problem, attention should be paid to mycotoxins and heavy metals. *Aim of the study* Assessing the presence of the xenobiotics aflatoxins, ochratoxin A, lead and cadmium in human milk, defining their level of contamination and evaluate the potential risk for the newborn derived from this xenobiotic ingestion. *Methods* A study has been carried out on lactating women randomly selected in seven hospitals in Lombardy (Northern Italy). Two hundred and forty-seven puerparae were recruited; 231 women participated in the study. Women's milk samples on the third or fourth day after delivery were tested to determine aflatoxins and ochratoxin A levels. Lead and cadmium were determined in 143 women because supplemental milk could be taken only from these women. *Results* Aflatoxin B1 (11.4 ng/l) and aflatoxin M1 (194 ng/l) were found only in one sample, while ochratoxin A was detected in 198 samples (85.7 %) at an average value of 6.01 ± 8.31 ng/l. A total of 75.7 % of samples were positive for lead; the cadmium situation was better with 87.4 % of the sample with values below detection limits (2 μg/l). A high percentage of babies (71 %) are exposed to mycotoxin levels on day 6 greater than the TDI value of 0.2 ng/kg b. w. Lead and cadmium presence in human milk presented risk respectively for 8 % and 0.7 % of newborns on the fourth day; 9.5 % and 1.4 % on the sixth day. *Conclusions* The study points out that mycotoxins and lead are present in maternal milk, and the data confirm the need to continue biological monitoring in general prevention.

Key words mycotoxins – lead – cadmium – human milk – biological monitoring

Introduction

Breast milk provides not only an ideal nutrient composition for the newborn, but it also contains a variety of substances that may actively influence infant growth and development and stimulate neonatal protection against gastrointestinal diseases. Many human milk benefits have been well documented [1]; nevertheless the newborn potential risk to be exposed to xenobiotics may be relevant and it requires a biological monitoring in general prevention. Concerning this problem, attention should be paid to mycotoxins and heavy metals.

Aflatoxins are extremely potent cancerogenous substances in all animal species, classified by the IARC as "cancerogenous substances for man" [2] and are mostly

EJN 458

produced by strains of *Aspergillus flavus* and *Aspergillus parasiticus*, growing on corn, wheat, rice, peanuts, sorgho and dried fruits.

Ochratoxin A is produced by *Aspergillus ochraceus* and *Penicillium verrucosum* and it is found in cereals, legumes, coffee, cacao beans, peanuts, wine and beer, and in pork meat as a carry-over from feed [3]. Ochratoxin A is presently classified in group 2B, as a "possible human cancer agent" [2]. In addition, nephrotoxicity correlation between ochratoxin A in foods and Balkan Endemic Nephropathy has been established by an epidemiological study published by Kuiper-Goodman [4].

Human milk can be a potential source of ochratoxin A as documented by its detection in samples collected in several European countries [5–9].

Breast milk normally contains metals at trace levels, but elevated levels are found after high maternal exposure [10]. In addition, several studies have provided evidence of the xenobiotic transport, including lead and cadmium, from the mother to breast-fed infants [11–13]. The lead toxic effects involve several organs and are the consequence of a variety of biochemical defects. The fetus and young child nervous system is particularly sensitive to lead because it undergoes very rapid growth during this time [14].

The kidneys are the major targets of cadmium toxicity following oral exposure [15]; in these organs cadmium is stored in relation to body total loading exposition. Cadmium-induced kidney damage is also associated with alterations in renal vitamin D metabolism. Secondary to this effect is the imbalance of calcium absorption and excretion [16, 17].

With respect to the problem potential severity, data reported in the literature regarding newborn xenobiotic ingestion are extremely variable and also fragmented [18–22].

The purpose of this study was to: 1) assess the presence of aflatoxins, ochratoxin A, lead and cadmium and the contamination extent in milk of women living in different areas of Lombardy (Northern Italy); 2) verify whether there is a correlation between positive samples and potential risk factors such as area of residence, type of job, dietary pattern and personal habits and 3) calculate the potential intakes of these xenobiotics in the group of newborn to assess health risk factors.

It is necessary to point out that maternal milk is the only food which the newborn consumes in the first few months of life.

Materials and methods

Sampling

Two hundred and forty-seven women were recruited in the study. The sample number was defined by statistical calculation based both on the number of births in different hospitals in Lombardy in 1999 and on the prevalence of mycotoxins in human milk in Europe (18 %) [23]. To have milk samples from different areas, the following hospitals were included: Hospitals of Cremona, Lecco, Lodi, Merate, Milano, Pavia, located in urban and plain areas and Sondrio, located in urban and mountain area. Mothers were selected among women who delivered either spontaneously or by Caesarean section. Every woman staying in the selected hospitals on the third or fourth day after delivery was invited to participate in the study. Some extra-community women living in Italy were included in the study. Two hundred and thirty-one of the recruited subjects (93.5 % of the sample) took part in the survey. Lead and cadmium were determined in 143 women because the supplemental milk amount of 4 ml could be taken only from these subjects.

Questionnaire

For each woman a questionnaire was completed, reporting personal data, occupation, eating and personal habits. Diet and eating habits information was focused on foods which were more likely to contribute to dietary intake of aflatoxins, ochratoxin A, lead and cadmium according to the European Commission Food Science and Techniques indications [24]. Written informed consent was obtained from each participant after having been informed about the aims of the study. Table 1 reports the description of the subjects participating in the study.

Collection and analysis of milk samples

Milk samples were collected between March and July 2000 in the first and third week of each month from women who accepted to join in the research. After washing and sterilization a breast pump was used by each mother to collect milk sample during the third or fourth day after delivery; before the collection, the mother had to wash her breast using only water to avoid milk chemical contamination.

Approximately 20 ml of milk was collected from each mother into polypropylene test tubes and the samples were stored at −20 °C until analysis. Aflatoxins and ochratoxin A determination in human milk was obtained using HPLC. The milk was centrifuged twice ten minutes at 4500 g and at 4 °C. The supernatant was placed in the top of the immune affinity column for ochratoxin A; then the eluate was washed with doubly distilled water followed by 2 ml of methanol and placed at the top of the immune affinity column for aflatoxins. Aflatoxin and ochratoxin A determination was obtained using HPLC with an auto-sampler and a fluorometric

Table 1 Sample characteristics: demographic data, job, personal habits of mothers

Variables		% of subjects
Age (years)	18–28	25.8
	29–35	61.5
	36–42	12.7
Delivery (ies) (numbers)	1	57.8
	2	37.7
	3	3.3
	more	1.2
Residence	Country	50.8
	Town	49.2
Factories near by:	– agricultural plants	39.3
	– industrial plants	41.8
	None	18.9
Job	Farmer	0.0
	Housewife	23.0
	Factory worker	9.0
	Office-worker	52.9
	Other	15.1
Smoker (n° of cigarettes)	Non-smoker	65.2
	Up to 10 cigarettes/day	7.8
	10–20 cigarettes/day	4.1
	More than 20 cigarettes/day	0.0
	Quit smoking 9 months ago	13.5
	Quit smoking years ago	9.4
Hobbies	None	68.9
	Gardening	26.6
	Bricolage	4.5

detector (ecc = 365 nm, em = 440 nm and ecc = 333, em = 470 nm respectively). The detection limit of the method was 0.5 ng/l. OTA recovery was 97 %; OTA was added at a concentration of 50 ng/l. Negative samples were estimated to be equal to 0.25 ng/l.

Lead and cadmium analysis was performed on a 4 ml fresh sample submitted to lyophilization on an Edwards Modulyo 4K lyophilizer and after addition of 4 ml of HNO_3 70 % BDA "Aristar" and 1 ml of H_2O_2 100 vol. 30 % BDA "Aristar". Then the sample was submitted to mineralization in a mineralization unit connected to an exhaust fumes extraction apparatus EM5. The sample, quantitatively transferred to a graduated PLP test tube and brought to a volume of 10 ml with distilled water and de-ionized on an ionic exchange resin, was analyzed in a Perkin Elmer Analyst 600 Atomic Absorption Spectrophotometer, equipped with a Zeeman effect corrected graphite furnace. Detection limit of the method was 4.0 µg/l for lead and 2.0 µg/l for cadmium; the reliability of the method was evaluated by 10 determinations for each element on reference material standard BCR (Community Bureau of Reference) CRM 063 obtaining an output of 97 % for cadmium and 98 % for lead, respectively. Negative samples were estimated to be equal to 2.0 µg/l and 1.0 µg/l for lead and cadmium, respectively.

Xenobiotic ingestion by the newborn

The newborn's ingestion of ochratoxins A, lead and cadmium were evaluated at the first, fourth and sixth lactating day based on the total newborn daily milk intake, estimated in 40 g, 200 g and 300 g of milk respectively, using the milk consumption multiplying by the concentration of the xenobiotics in the milk.

Statistical analysis

All data collected in the questionnaires administered to the puerparae and analytical data were inserted in a D BASE archive. Descriptive statistical elaborations were performed with the statistical package SPSS/PC + V 2.0 [25]. Comparison of average values between groups was calculated using student t-test and Ran tukey test. When the examined variables did not have a normal distribution, variable intergroup comparison was performed with the following non-parametric tests: Mann-Whitney for comparison between two groups; Kruskal-Wallis test for comparison among three or more groups.

Research protocol approval by ethics committee

The research protocol was approved by the Ethics Committee of the Faculty of Medicine and Surgery of the University of Pavia.

Results

Mycotoxins in human milk

Aflatoxin B1 (11.4 ng/l) and aflatoxin M1 (194 ng/l) were found only in one sample, while ochratoxin A was detected in 198 samples (85.7 %). Table 2 reports ochratoxin A values on all 231 milk samples analyzed. With regards to ochratoxin A, 72.3 % of values were below the detection area limit of 0.5 ng/l and 5 ng/l, while 16 % showed values between 6 ng/l and 10 ng/l and the remaining 11.7 % between 11 ng/l and 57 ng/l.

According to geographic location, the greatest average value was detected in the Hospital of Sondrio (8.2 ± 13.0 ng/l), while the lowest value was found in the Hospital of Merate (3.9 ± 3.7 ng/l). However, variance analysis did not reveal significant statistical differences in concentrations between the various hospitals.

Mean ochratoxin A milk concentrations were compared grouping the subjects according to age (≤ 30

Table 2 Statistical parameters of Ochratoxin A, lead and cadmium detected in milk samples analyzed

Xenobiotic	N° of milk samples	Median	25th percentiles	75th percentiles	Maximum	Detection limit
Ochratoxin A (ng/l)	231	4.00	2.17	7.40	57.00	0.5
Lead (µg/l)	143	7.75	4.20	14.30	216.00	2.0
Cadmium (µg/l)	143	1.00	1.00	1.00	20.00	1.0

years, > 30 years), number of childbirth, area of residence (country or town), distance from agricultural or industrial areas, type of job (housewife, factory worker, employee), number of smoked cigarettes and potentially risky hobbies practiced (i. e. gardening). Based on our data, no statistically significant differences (Ran tukey test) emerged from these comparisons.

Data on ochratoxin A were further analyzed in relation to the consumption of food and beverages with probable sources of this toxin such as milk, cheese, bread, cereals, legumes, coffee, peanuts, pork meat and cacao grouping the subjects in two groups: 1) occasional consumers (up to 7 times a week), or 2) habitual consumers (more than 7 times a week).

The largest consumers of milk, cheese, bread cereals, legumes, coffee, peanuts, pork meat and cacao had higher mean values of Ochratoxin A than the occasional consumers, but only a statistically significant difference ($p < 0.05$) emerged for bread. The relationship with consumption of wine and beer, potentially dangerous beverages, were not analyzed because of the only occasional consumption of these beverages during pregnancy.

Lead and cadmium in human milk

Lead and cadmium were measured only on 143 samples (58 % of recruited women) because the extra milk amount of 4 ml could be taken only from these subjects and therefore the data obtained are not representative of the Lombard population; nevertheless we thought that it was useful to give that information.

Statistical analysis applied to all the empirical data revealed a highly asymmetric distribution of the metals in milk with a concentration of values towards the lower levels and, consequently, the trend of the data differed from that Gaussian expected distribution assumed as normal. Data normalization was not possible even using transformation in natural base 10 logarithms.

Position measurements and variations in lead and cadmium concentrations revealed a high degree of data dispersion, especially regarding lead (Table 2).

A total of 75.7 % of subjects were positive for lead. Only 30 % had contamination levels estimated to be "usual in normal conditions" (2–5 µg/l) by the WHO [26]. When considering the value of 20 µg/l, indicated by various authors [27] as an adequate screening value for women with occupational and environmental exposure, 16.4 % presented contamination levels that indicated a possible risk. In particular, the subjects at the 95th percentile presented a very high milk lead content (85.2 µg/l), four times greater than the already cited screening value and, moreover, 17 times greater than the "normal" contamination levels.

A much better situation emerged for cadmium, given that 87.4 % of the sample had values below the detection limit (2 µg/l), thus resulting in the contamination values considered normal by the WHO [28]: < 1 µg/l. Likewise for data on lead, the subjects at the 75th percentile still presented widely acceptable contamination levels (1.0 µg/l), while only the subjects at the 95th percentile presented "risk" values, being higher (7.0 µg/l) than the screening value indicated for exposed women: 5 µg/l [27].

Concentration mean values of the two xenobiotics were analyzed by grouping the subjects according to personal data, lifestyle, residence area, kind of job, number smoked cigarettes and dietary habits. This comparison (Kruskal-Wallis test) did not reveal any statistically significant differences.

Xenobiotic ingestion by the newborn

According to our results, the newborns' intake obtained using the average weight of the babies of 3.3 kg are reported in Table 3.

Discussion

The study confirms the presence of ochratoxin A and lead in human milk and it gives an update on the actual situation in Lombardy (Northern Italy).

Aflatoxins (AFB1 and AFM1) were detected in only one milk sample from Milan hospital. The mother's questionnaire analysis did not reveal any relationship between these values and her lifestyle.

Ochratoxin A was detected in a high percentage of milk samples (85.7 %). The fact that data were widely spread may be explained by the punctiform mycotoxins food contamination. A correlation between the potential risk factors and milk concentration was found only for bread consumption, probably due to the high intake frequency, more than twice a day.

Present results are comparable with those obtained in other similar studies performed in recent years in var-

Table 3 Percentage of babies at risk for ingestion of Ochratoxin A (OTA), lead (Pb) and cadmium (Cd)

	Percentage of babies at risk			
	Total daily milk consumption (g)	Intake of OTA > PTDI (%)	Intake of Pb > PTWI [26, 32, 33] (%)	Intake of Cd > PTWI [26, 32, 33] (%)
1st lactating day	40	7.0 [29]	0.0	0.0
4th lactating day	200	60.0 [29]	8.0	0.7
6th lactating day	300	71.0 [29] 0.4 [30] 0.0 [31]	9.5	1.4

ious European and extra-European countries. Table 4 shows that ochratoxin A concentrations are comparable to those detected in Germany, Sweden and Norway and very much lower than those detected in Sierra Leone and in two previous Italian studies performed in 1991 and 1995 [5, 7]. In these latter studies, the detection limit was 100 ng/l, undoubtedly higher than our 0.5 ng/l. For this reason, our analytical method was more sensitive and it could explain the higher percentage of positive samples.

For genotoxic cancerogenic substances, such as aflatoxins, a threshold value below which the risk value for human health is equal to zero does not exist. The JEFCA [31] does not establish a TDI, but strongly recommends that the level of aflatoxins should be as low as possible (ALARA level, As Low As Reasonably Achievable) [36]. Notwithstanding that, even if the presence of aflatoxin in maternal milk could have a toxicological relevance, there is no risk level for the neonatal population in Lombardy, as there was only a single case positive for aflatoxin.

Considering the Ochratoxin A toxicological characteristics and taking into account that newborns have a not yet mature immunological system and therefore are more sensitive to this substance's toxic action, it seems more opportune to compare the estimated Ochratoxin A ingestion with the lowest value of TDI. This comparison reveals that on the fourth and sixth days, with an estimated intake of 200 and 300 grams of milk respectively, a high percentage of subjects can be considered at risk, given intakes of Ochratoxin A greater than the limit proposed by Kuiper-Goodman and Scott [29].

As far as heavy metals are concerned, the results confirm the problem of lead contamination in human milk even though the obtained concentration value (17.08 ± 31.80 μg/l) is undoubtedly lower than the values reported in previous Italian studies conducted at the end of the 1980's by Sartorelli et al. [27] (36.00 ± 29.30 μg/l) and Coni et al. [37] (range 16.2–77 μg/l).

It could be deduced that the adoption of preventive actions, such as the introduction of unleaded gasoline, the reduction of lead welding in tin cans for food, have produced a decrease in environmental pollution and consequently in food contamination as has occurred in other nations.

Nevertheless, the importance of the problem in Lombardy is confirmed when comparing the data with those of other studies conducted in other countries. Although this comparison may be an approximation, since the metal excretion in milk is greatly conditioned by the day of the sample collection [38, 39], our values are among the highest (Table 5). This contamination can be considered "at risk" only for a small percentage of newborns (Table 3). Comparison of the intakes calculated with the PTWI value (25 μg/kg b. w.) [32, 33], on the basis of the average neonatal weight of 3.3 kg, showed that 8 % of the newborns on the fourth day and 9.5 % of those on the sixth day have a lead ingestion above the tolerable weekly intake.

Table 4 Ochratoxin A concentrations (ng/l) in human milk samples collected in different European and extra-European countries

Country	% positive	Concentrations of OTA in human milk (ng/l)	References
Italy	86	1–57	Present study
Germany	11	17–30	Gareis et al. 1988 [34]
Italy	18	1700–6600	Micco et al.,1991 [5]
Sweden	58	10–40	Breitholtz-Emanuelsson et al. 1993 [6]
Sierra Leone	35	200–337000	Jonsyn et al. 1995 [35]
Italy	20	100–12000	Micco et al. 1995 [7]
Switzerland	10	5–14	Zimmerli et al. 1995 [8]
Norway	33	10–130	Skaug et al. 1998 [9]

Table 5 Lead and cadmium concentrations (μg/l) in human milk samples collected in different European and extra-European countries (Modified by Patriarca et al. 2000) [40]

Country	Year	Lead (μg/l)	Cadmium (μg/l)
Present study	2001	17.08±31.80	1.68±2.37
Canada	1999	0–4.0	//
Australia	1998	0.09–3.1	//
Austria	1998	< 0.1–9.9	< 0.2–0.8
Svezia	1995	0.7±0.4	0.06±0.04
Italy	1990	16.2–77.0	2.1–65.0
Guatemala	1989	3.0	< 1
Nigeria	1989	5.0	3.67
Hungary	1989	15.0	< 1
Italy	1986	36.00±29.30	3.51±2.03

Results regarding cadmium indicate that the problem is less severe. The milk concentrations obtained are within normal levels of contamination in relation to data indicated by the WHO [28] (< 1 μg/l = normal level) and slightly higher than those reported in Table 5, except for Nigeria. Furthermore, the average value (1.68 ± 2.37 μg/l) is lower than those reported by previous Italian studies conducted by Sartorelli et al. [27] (3.51 ± 2.03 μg/l) and Coni et al. [37] (range 2.1–65 μg/l). Also for the newborn group, the risk level is undoubtedly less severe than that regarding lead ingestion since only one subject on the fourth day and two on the sixth day had a cadmium intake above the PTWI (7 μg/kg b.w.) [26, 33]; moreover the calculated intakes are among the lowest values of the WHO-IAEA collaborative study [26].

Conclusions

The results of this study confirm the presence of ochratoxin A and lead in human milk and therefore they point out the need to continue biological monitoring and to set up more specific studies in this area and possible hospital controls for future prevention programs especially when attempting to identify the role of possible risk factors on the quality of human milk.

Acknowledgments The authors thank the Italian Ministry of Health for funding the study

References

1. Lawerence RA (1994) Breast-feeding, a guide for the Medical Professional. Mosby yearbook. Inc, pp 158–180
2. International Agency for Research on Cancer World Health Organization (1993) IARC monographs on the evaluation of carcinogenic risks to humans. Some naturally occurring substances: food items and constituents, heterocyclic aromatic amines and mycotoxins. IARC Lyon France, vol 56
3. Piva G, Pietri A, Moschini M (1996) Formation and carry-over of mycotoxins. In: Residues of Veterinary Drugs and Mycotoxins in Animal Products – New Method for Risk Assessment and Quality Control. Proceedings of the Teleconference held on Internet (Listserver Meatqual) from April 15–August 31, 1994. Wageningen, The Netherlands
4. Kuiper-Goodman T (1991) Risk assessment of ochratoxin A residues in food. IARC Sci Publ 115:307–320
5. Micco C, Ambruzzi MA, Miraglia M, Brera C, Onori R, Benelli L (1991) Contamination of human milk with ochratoxin A. IARC Sci Publ 115:105–108
6. Breitholtz Emanuelsson A, Olsen M, Oskarsson A, Palminger I, Hult K (1993) Ochratoxin A in cow's milk and in human milk with corresponding human blood samples. J AOAC In 76(4): 842–846
7. Micco C, Miraglia M, Brera C, Corneli S, Ambruzzi A (1995) Evaluation of ochratoxin A in human milk in Italy. Food Addi Contam 12:351–354
8. Zimmerli B, Dick R (1995) Determination of ochratoxin A at the ppt level in human blood, serum, milk and some foodstuffs by high-performance liquid chromatography with enhanced fluorescence detection and immunoaffinity column cleanup: methodology and Swiss data. J Chromat B 666:85–99
9. Skaug MA, Storner FC, Saugstad OD, Ochratoxin A (1998) A naturally occurring mycotoxin found in human milk samples from Norway. Acta Paediat 87: 1275–1278
10. Oskarsson A, Palminger Hallen I, Sundberg J (1995) Exposure to toxic elements via breast milk. Analyst 120: 765–770
11. Koppe JG (1995) Nutrition and breastfeeding. Eur J Obstet Gynecol Reprod Biol 61:73–78
12. Fisher J, Mahle D, Bankstone L, Greene R, Gearhart J (1997) Lactational transfer of volatile chemicals in breast milk. Am Ind Hyg Assoc J 58:425–431
13. Becker AB, Manfreda J, Ferguson AC, Dimich-Ward H, Watson WT, Chan-Yeung M (1999) Breast-feeding and environmental tobacco smoke exposure. Arch Pediatr Adolesc Med 153:689–691
14. Needleman HL, Gatsonis CA (1990) Low-level lead exposure and the IQ of children. A meta-analysis of modern studies. J Am Med Assoc 263:673–678
15. Wang XP, Foulkes EC (1984) Specificity of acute effects of cadmium on renal function. Toxicol 30:243–247
16. Kido T, Nowaga K, Honda R, Tsuritani I, Ishizaki M, Yamada Y, Nakagawa H (1990) The association between renal dysfunction and osteopenia in environmental cadmium exposed subjects. Environ Res 51:71–82
17. Nogawa K, Tsuritani I, Kido T, Honda R, Ishizaki M, Yamada Y (1990) Serum vitamin D metabolites in cadmium-exposed persons with renal damage. Int Arch Occup Environ Health 62:189–193
18. Plockinger B, Dadak C, Meisinger V (1993) Lead, mercury and cadmium in newborn infants and their mothers. Z Geburtshilfe Perinatol 197(2):104–107
19. Hallen IP, Jorhem L, Lagerkvist BJ, Oskarsson A (1995) Lead and cadmium levels in human milk and blood. Sci Total Environ 166:149–155
20. Frkovic A, Kras M, Alebic-Juretic A (1997) Lead and cadmium content in human milk from the Northern Adriatic area of Croatia. Bull Environ Contam Toxicol 58(1):16–21

21. Oskarsson A, Palminger Hallen I, Sundberg J, Petersson Grawe K (1998) Risk assessment in relation to neonatal metal exposure. Analyst 123(1):19–23
22. Friel JK, Andrews WL, Jackson SE, Longerich HP, Mercer C, McDonald A, Dawson B, Sutradhar B (1999) Elemental composition of human milk from mothers of premature and full-term infants during the first 3 months of lactation. Biol Trace Elem Res 67(3):225–247
23. Hald B (1991) Ochratoxin A in human blood in European countries. IARC Sci Publ 115:159–164
24. EC (European Commission) Food Science and Techniques. Reports on tasks for scientific co-operation (1997) – Report of experts participating in Task 3.2.2. Assessment of dietary intake of ochratoxin A by the population of EU Member States – Report EU 17523 EN
25. Norusis MJ (1988) Statistical package for the social science/PC + V.2.0 Chicago-SPSS. Inc
26. World Health Organization (WHO) (1989) Minor and Trace Elements. Report of a Joint WHO/IAEA Collaborative Study. World Health Organization, Geneva, Switzerland
27. Sartorelli E, Gori R, Sartorelli S, Buffi C (1986) Valori di piombo e cadmio nel sangue di partorienti non esposte professionalmente, nel sangue dei neonati e nel latte materno. Med Lav 77(5): 515–518
28. World Health Organization (WHO) (1989) Cadmium. In: Toxicological evaluation of certain food additives and contaminants. Geneva, World Health Organization: 163–219 (WHO Food Additives Series, N° 24)
29. Kuiper-Goodman T, Scott PM (1989) Review- risk assessment of the mycotoxin ochratoxin A. Biomed Environ Sci 2:179–248
30. The Nordic Working Group on Food Toxicology and Risk Evaluation (1991) Health evaluation of ochratoxin A in food products. Nordiske Seminar- og Arbejdsrapporter 545, Nordic Council of Ministers, Copenhagen, Denmark
31. Joint FAO/WHO Expert Committee on Food Additives (2001) Safety evaluation of certain mycotoxins in food. Fifty-sixth meeting of the joint FAO/WHO Expert Committee on Food Additives (JECFA). WHO Food Additives Series: 47. World Health Organization, Geneva 2001
32. World Health Organization (WHO) (1987) Lead evaluation of health risks to infants and children. In: Toxicological evaluation of certain food additives and contaminants. Geneva, World Health Organization: 223 (WHO Food Additives Series, N° 21)
33. World Health Organization (WHO) (1993) Evaluation of certain food additives and contaminants. Forty-first report of the Joint FAO/WHO Expert Committee on Food Additives. Geneva, World Health Organization: 223 (WHO Technical Report Series, N° 837)
34. Gareis M, Martlbauer E, Bauer J, Gedek B (1988) Bestimmung von Ochratoxin A in Muttermilch. Zeitsch Lebensmitteluntersuch Forsch 186:114–117
35. Jonsyn FE, Maxwell SM, Hendrickse RG (1995) Ochratoxin A and aflatoxins in breast milk samples from Sierra Leone. Mycopathologia 131:121–126
36. FAO (1999) Food, Nutrition and Agriculture. Preventing mycotoxin contamination. FAO 23
37. Coni E, Falconieri P, Ferrante E, Semeraro P, Boccaloni E, Stacchini A, Caroli S (1990) Reference values for essential and toxic elements in human milk. Ann Ist Super Sanità 26(2):119–130
38. Larsson B, Slorach SA, Hagman U, Hofvander Y (1981) WHO collaborative breast feeding study. II. Levels of Lead and Cadmium in Swedish Human Milk, 1978–1979. Acta Paediatr Scand 70(3): 281–284
39. Abadin HG, Hibbs BF, Pohl HR (1997) Breast-feeding exposure of infants to cadmium, lead and mercury: a public health viewpoint. Toxicol Ind Health 13(4):495–517
40. Patriarca M, Menditto A, Rossi B, Lyon TDB, Fell GS (2000) Environmental exposure to metals of newborns, infants and young children. Microchemical Journal 67:351–361