Detection of ochratoxin A in human breast milk in Jiroft city, south of Iran

Ali Kamali¹, Sareh Mehnī², Mohadeseh Kamali³, ⁴, Mehdi Taheri Sarvin⁴*

¹ Department of Infectious Diseases, School of Medicine, Jiroft University of Medical Sciences, Jiroft, Iran
² School of Nursing and Midwifery, Jiroft University of Medical Sciences, Jiroft, Iran
³ Department of Internal Medicine, School of Medicine, Kerman University of Medical Sciences, Kerman, Iran
⁴ Department of Medical Mycology and Parasitology, School of Medicine, Jiroft University of Medical Sciences, Jiroft, Iran

Article Info

Article type: Original article

Article History:
Received: 28 September 2017
Revised: 20 November 2017
Accepted: 16 January 2018

* Corresponding author:
Mehdi Taheri Sarvin
Department of Medical Mycology and Parasitology, School of Medicine, Jiroft University of Medical Sciences, Jiroft, Iran.
Email: mehditaheri.mt@gmail.com

How to cite this paper
Kamali A, Mehnī S, Kamali M, Taheri Sarvin M. Detection of ochratoxin A in human breast milk in Jiroft city, south of Iran. Curr Med Mycol. 2017; 3(3): 1-4. DOI: 10.29252/cmm.3.3.1

Introduction

Myco toxins are toxic low-molecular-weight secondary metabolites produced by some fungal species [1, 2]. These metabolites constitute various groups of chemical compounds that can cause acute, subacute, or chronic diseases in humans [3]. So far, many studies have been performed on fungal toxins such as aflatoxins, ochratoxins, patulin, fumonisins, zearalenone, trichothecenes, and ergot alkaloids in foods, animals, and humans [3-9]. From myriads of mycotoxins, ochratoxin A (Figure 1) is one of the most important and deleterious mycotoxins produced by mold fungi, particularly Aspergillus ochraceus, A. sulphureus, A. niger, Penicillium verrucosum, and P. nordicum [10]. Ochratoxin A is a nephrotoxic, immunotoxic, hepatotoxic, and teratogenic mycotoxin [11]. The kidney is the major target organ in all the mentioned diseases [12]. Nephropathy and cancer are the most important effects of the toxin [13]. Ochratoxin A is mainly a nephrotoxic mycotoxin that is considered as the main etiological factor in Balkan endemic nephropathy, a lethal kidney disease related to the end stage of urothelial tumors [14]. This toxin is classified by International Agency for Research on Cancer as possible human carcinogen (group 2B) [15]. Ochratoxin A can cause cancer by the induction of oxidative DNA lesions coupled with direct DNA adducts through quinone formation [16]. In addition, ochratoxin A in human breast milk can elevate the risk of HIV acquisition in infants via the increase of mucosal HIV target cells and C-X-C

Figure 1. Chemical structure of ochratoxin A
motif chemokine 10 (CXCL10) concentration, as well as reduction in tumor necrosis factor-alpha (TNF-alpha) [17]. This toxin can be found in a variety of food commodities, including cereals, raisins, coffee, cocoa, wine, beer, fruits, and nuts [10, 11, 18, 19].

In the study by Tafuri et al. [18], ochratoxin A was recovered from 50% of cocoa powder samples at a concentration ranging from 0.22 to 0.77 μg/kg with a mean of 0.43 μg/kg. In Petkova-Bocharova et al. study, ochratoxin A was recovered from 16.7% (25–27 μg/kg) of bean samples, 27.3% (25–35 μg/kg) of maize samples, and 9.0% (10–25 μg/kg) of wheat flour samples [19]. Ochratoxin A can be excreted from the body to human milk [20]. Breast milk is the most important food for infants [21]. Infants are considered to be more susceptible than adults to the effects of mycotoxins due to their higher metabolic rate, lower body weight, lower ability to detoxify, and incomplete development of some tissues and organs [11].

Jiroft city in southern Iran, which has a hot and humid climate, is suitable for growth of ochratoxin A-producing fungi. Currently, there is a scarcity of studies performed in Jiroft reporting the level of ochratoxin A in human breast milk. Therefore, we designed this study to investigate the level of ochratoxin A in human breast milk in the city of Jiroft, Kerman Province, south of Iran.

Materials and Methods

In the present study, 84 human breast milk samples were collected from April 2016 to January 2017. Nursing mothers were selected from among the referrals to the number one clinic in Jiroft city, Kerman Province (Jiroft city is located in south-east of Iran). This city is 250 kilometers far from the province capital, and it has a warm and humid weather throughout the year that leads to the growth of various fungi.

The inclusion criteria were healthy mothers with intention to breastfeed their infant. Mastitis and breast abscess were the exclusion criteria. All the mothers were informed of the study objectives and procedure and provided informed consent. About 5 cc of breast milk was taken from each subject. The samples were stored in sterile plastic containers at 4°C and then delivered to the laboratory in refrigerated boxes and frozen at −20°C until analysis. Before starting the experiments, the samples were thawed at laboratory temperature. Ochratoxin A was measured with enzyme-linked immunosorbent assay (ELISA) test kits (Europroxima, the Netherlands). According to the manufacturer’s instructions, breast milk samples were diluted 1:4 in dilution buffer, and 50 μl of the standard positive control and the diluted samples was dispensed into appropriate microplate wells. Then, 25 μl of conjugate (ochratoxin A-HRP) was added to each well. Afterwards, 25 μl of antibody solution was added to each well and incubated for 60 min in the dark at 37°C.

The microplate wells were washed three times with rinsing buffer, and 100 μl of substrate solution was added to each well and incubated for 30 min at room temperature. The reaction was stopped by addition of 100 μl of stop solution. The absorbance of each well was measured at 450 nm. After that, the calibration curve was drawn and used to determine the concentration of ochratoxin A in each sample. According to the kit brochure, quantitation limit was less than 3 ng/ml. Results were analyzed in SPSS using descriptive statistics, Mann-Whitney U test, Kruskal-Wallis test, and Spearman correlation coefficient. P-value less than 0.05 was considered statistically significant.

The Research Ethics Committee of Jiroft University of Medical Sciences approved the study with ethical code of IR.jmu.REC.1394-22.

Results

In this study, 84 human breast milk samples were examined. The mean ages of the mothers and infants were 28.88 years and 7.64 months, respectively. In this study, 50% of the infants were male, and 77 (91.7%) participants lived in urban areas. Forty-one (48.8%) infants were fed breast milk alone and 43 (51.2%) infants received breast milk and supplements. Thirty-two (38%), 38 (45.3%), and 14 (16.7%) mothers had under diploma, diploma, and academic degrees, respectively. Ochratoxin A was found in all (100%) the human breast milk samples (concentration range: 0.11-7.34 ng/ml). The mean concentration of ochratoxin A in the samples was 1.99±1.34 ng/ml. The concentrations of ochratoxin A in the human breast milk samples are shown in Table 1.

The results of Kruskal-Wallis nonparametric test showed no significant association between the mothers’ level of education and ochratoxin A concentration (P=0.69). The mean concentrations of ochratoxin A recovered from samples of the city dwellers and suburban residents were 1.96 ng/ml and 2.27ng/ml, respectively. The results of Mann-Whitney U nonparametric test showed no significant difference between the city dwellers and suburban residents in

Table 1. Concentration of ochratoxin A in human breast milk samples (ng/ml)

| Samples tested (n) | Number and percent of samples with ochratoxin A in ng/ml ranges | Exceeding EC/Codex regulation (3 ng/ml) |
|--------------------|---------------------------------------------------------------|----------------------------------------|
| Level of positive samples (%) | <1 | 1-2 | 2-3 | 3-4 | 4-5 | >5 | Number | Range (ng/ml) |
|--------------------------|----|----|----|----|----|----|-------|--------------|
| 84                       | 84(100%) | 17(20.2%) | 36(43%) | 17(20.2%) | 7(8.3%) | 2(2.4%) | 5(5.9%) | 14(16.7%) | 3.06-7.34 |

Curr Med Mycol, 2017, 3(3): 1-4
ochratoxin A concentration \((P=0.244)\).

Fourteen (16.57%) samples contained ochratoxin A at concentrations exceeding the quantitation limit (3 ng/ml). Samples of 12 (14.3%) city dwellers and 2 (28.6%) suburban residents had ochratoxin A at concentrations exceeding the quantitation limit. In this study, the subjects were aged 18 to 41 years old. The Spearman correlation coefficient showed a significant negative relationship between ochratoxin A concentration and maternal age \((r=-0.3, P=0.005)\).

**Discussion**

Although breastfeeding is highly important for normal growth and health of infants, breast milk can be contaminated with mycotoxins such as ochratoxin A that can cause serious diseases in infants [20]. Various studies from different regions revealed that human milk may contain different concentrations of ochratoxin A [11, 20, 22-25].

In this study, we investigated the concentration of ochratoxin A in human breast milk in Jiroft city. We detected ochratoxin A in all (100%) human breast milk samples. Jiroft city has a warm and humid climate with abundant precipitation, which coupled with varied plants and trees, makes it a suitable environment for many toxin-producing fungi. Fourteen samples containing higher amounts of ochratoxin A than the quantitation limit (3 ng/ml).

In the study by Dehghan et al. [11], ochratoxin A was found in 84 (96.6%) samples, and 16% of the samples had higher amounts of ochratoxin A than the EU limits. In Dostal et al. [20] study, ochratoxin A was found in 23 (30.26%) samples. Nine (11.8%) positive samples were found to contain amounts higher than the quantitation limit. Our results were incompatible with those of Dostal et al. [20], but consistent with the findings of Dehghan et al. [11]. Moreover, in this study, the mean concentration of the toxin was higher than those in the previous studies, such as 0.0175 ng/ml in Brazil [22], 0.0887 ng/ml in Egypt [23], 0.106 ng/ml in Chile [24], and 0.0398 ng/ml in Norway [25], while the mean concentration of ochratoxin A in our study was lower than that in the study performed by Jonsyn et al. in Sierra Leone (7.9 ng/ml) [26].

The differences in results of various studies might be attributed to the moisture and temperature conditions, the number and types of fungi in each region, food storage methods, dietary habits, and measurement method of the toxin. There is limited information regarding the association between the level of education and concentration of this toxin in mothers. For education level, we divided the samples into three main groups of under diploma, diploma, and higher than diploma (collegiate). There was no significant association between the mothers’ level of education and ochratoxin A concentration. This result is incompatible with those of Dehghan et al. [11] study. This difference might be due to the lack of awareness of educated mothers about the toxin or the contamination of foods prepared outside the home.

In this study, 50% of the infants were male. Baby boys need breast milk more than girls [27], hence boys are more exposed to the toxin than girls. The results of this study showed no significant difference in ochratoxin A concentration between residents of urban and suburban regions of the city. This finding is compatible with those of Dehghan et al. [11] and Skaug [28]. This result may be due to high similarity in climate and dietary habits in urban and suburban areas. In this study, the mothers were aged 18 to 41 years old. A significant negative relationship was noted between ochratoxin A concentration and maternal age. We showed that ochratoxin A concentration decreases with increasing maternal age. This result may be due to changes in dietary habits of older mothers. Furthermore, older mothers may have more knowledge regarding the toxin than younger mothers. In this study, 48.8% of the infants were fed breast milk alone and 51.2% of the infants received breast milk and supplements. It is expected that the toxic effects of ochratoxin A to be lower for those fed with breast milk and supplements due to the lower consumption of contaminated breast milk.

**Conclusion**

In conclusion, the results of this study showed that the fungi producing ochratoxin A are present in our region and can cause food contamination with the production of ochratoxin A. In addition, it was discovered that food preservation in our region is probably not performed using the preferred method that has led to the growth of the toxin-producing fungi in them. Therefore, future studies are recommended to identify the fungi present in our area, as well as studies are required to examine the presence of this toxin in various foods. Contaminated foods should be identified and their consumption should be avoided. The amount of the toxin in human breast milk should be measured, and in case of high milk contamination, lactation should be avoided. To prevent the entrance of ochratoxin A into the body of infants, lactating mothers are recommended to use fresh foods.

**Acknowledgments**

The author would like to thank Dr. Shariati for his cooperation.

**Author’s contribution**

M. T.S. designed, supervised, and wrote the draft of the research, S. M. collected the samples, A. K. and M. K. performed the tests.

**Conflicts of interest**

The authors declare no conflicts of interest. The authors are responsible for the content and writing of the paper.

**Financial disclosure**

No financial interests related to the material of this
manuscript have been declared.

References
1. Kumar D, Barad S, Sionov E, Keller NP, Prusky DB. Does the host contribute to modulation of mycotoxin production by fruit pathogens. Toxins (Basel). 2017; 9(9):E280.
2. Alshannah A, Yu JH. Occurrence, toxicity, and analysis of major mycotoxins in food. Int J Environ Res Public Health. 2017; 14(6):E632.
3. Sarvari MT, Hedayati MT, Abastabar M, Shokohi T. Debaryomyces hansenii colonization and its protein profile in psoriasis. Iran J Dermatol. 2014; 17(4):134-7.
4. Andrade PD, Dantas RR, Moura-Alves TLDS, Caldas ED. Determination of multi-mycotoxins in cereals and of total fumonisins in maize products using isotope labeled internal standard and liquid chromatography/tandem mass spectrometry with positive ionization. J Chromatogr A. 2017; 1490:138-47.
5. Chang H, Kim W, Park JH, Kim D, Kim CR, Chung S, et al. The occurrence of Zearalenone in South Korean feedstuffs between 2009 and 2016. Toxins (Basel). 2017; 9(7):E223.
6. Tittlemier SA, Drul D, Roscoe M, McKendry T. Occurrence of ergot and ergot alkaloids in western Canadian wheat and other cereals. J Agric Food Chem. 2015; 63(29):6644-50.
7. Sohrabi N, Gharihkol H. A seasonal study for determination of aflatoxin M1 level in dairy products in Iranshahr, Iran. Curr Med Mycol. 2016; 2(3):27-31.
8. Abastabar M, Akbari A, Akhtari J, Hedayati MT, Shokohi T, Mehrad-Majd H, et al. In vitro antitumor activity of patulin on cervical and colorectal cancer cell lines. Curr Med Mycol. 2017; 3(1):25-9.
9. Nazemi L, Kordbacheh P, Daei Ghazvini R, Moazeni M, Akbari Dana M, Rezaie S. Effects of thiamine on growth, aflatoxin production, and aflr gene expression in Aspergillus parasiticus. J Agric Food Chem. 2017; 65(29):6644-50.
10. Duarte SC, Pena A, Lino CM. Ochratoxin A in Portugal: a review to assess human exposure. Toxins (Basel). 2010; 2(6):1225-49.
11. Dehghan P, Pakshir K, Rafiehi H, Chadeganipour M, Akbari M. Prevalence of Ochratoxin A in human milk in the Khorrambid town, Fars province, South of Iran. Jundishapur J Microbiol. 2014; 7(7):e11220.
12. Chen C, Wu F. The need to revisit ochratoxin A risk in light of diabetes, obesity, and chronic kidney disease prevalence. Food Chem Toxicol. 2017; 103:79-85.
13. Mitchell NJ, Chen C, Palumbo JD, Bianchini A, Cappozzo J, Stratton J, et al. A risk assessment of dietary Ochratoxin a in the United States. Food Chem Toxicol. 2017; 100:265-73.
14. Gifford FJ, Gifford RM, Eddleston M, Dhaun N. Endemic nephropathy around the world. Kidney Int Rep. 2017; 2(2):282-92.
15. Maor U, Sadhasivam S, Zakin V, Prusky D, Sionov E. The effect of ambient pH modulation on ochratoxin A accumulation by Aspergillus carbonarius. World Mycotoxin J. 2017; 10(4):339-48.
16. Pfohl-Leszkowicz A, Manderville RA. Ochratoxin A: an overview on toxicity and carcinogenicity in animals and humans. Mol Nutr Food Res. 2007; 51(1):61-99.
17. Wood L, Jaspan H, Sodora D. Infant activation, HIV susceptibility and ochratoxin A exposure in Khayelitsha, South Africa (P6159). J Immunol. 2013; 190(1):118.
18. Tafuri A, Ferracane R, Ritiene A. Ochratoxin A in Italian marketed cocoa products. Food Chem. 2004; 88(4):487-94.
19. Petkova-Bocharova T, Castegnaro M. Ochratoxin A contamination of cereals in an area of high incidence of Balkan endemic nephropathy in Bulgaria. Food Addit Contam. 1985; 2(4):267-70.
20. Dostal A, Jakusova L, Caji dova J, Hudeckova H. Results of the first studies of occurrence of ochratoxin A in human milk in Slovakia. Bratisl Lek Listy. 2008; 109(6):276-8.
21. Gurbay A, Sabuncuoglu SA, Girgin G, Sahin G, Yigit S, Yurdakok M, et al. Exposure of newborns to aflatoxin M1 and B1 from mothers’ breast milk in Ankara, Turkey. Food Chem Toxicol. 2010; 48(1):314-9.
22. Navas SA, Sabino M, Rodriguez-Amaya DB. Aflatoxin M(1) and ochratoxin A in a human milk bank in the city of Sao Paulo, Brazil. Food Addit Contam. 2005; 22(5):457-62.
23. El-Sayed Abd Alla A, Neamat A, Aly SE. Situation of mycotoxins in milk, dairy products and human milk in Egypt. Mycotoxin Res. 2000; 16(2):91-100.
24. Munoz K, Campos V, Blaszkiewicz M, Vega M, Alvarez A, Neira J, et al. Exposure of neonates to aflatoxin A: first biomonitoring results in human milk (colostrum) from Chile. Mycotoxin Res. 2010; 26(2):59-67.
25. Creppy EE. Update of survey, regulation and toxic effects of mycotoxins in Europe. Toxicol Lett. 2002; 127(1-3):19-28.
26. Jonsyn FE, Maxwell SM, Hendrickse RG. Ochratoxin A and aflatoxins in breast milk samples from Sierra Leone. Mycopathologia. 1995; 131(2):121-6.
27. van Steenbergen WM, Kusin JA, de With C, Lacko E, Jansen AA. Lactation performance of mothers with contrasting nutritional status in rural Kenya. Acta Paediatr Scand. 1983; 72(6):805-10.
28. Skaug MA. Levels of ochratoxin A and IgG against conidia of Penicillium verrucosum in blood samples from healthy farm workers. Ann Agric Environ Med. 2003; 10(1):73-7.