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Review

Occurrence and levels of mycotoxins and their metabolites in human breast milk associated to dietary habits and other factors: A systematic literature review, 1984–2015

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ABSTRACT

Background: Many studies around the world reported the occurrence of many mycotoxins and their metabolites in human breast milk. However the contamination by aflatoxin M1 and ochratoxin A were the most investigated by several countries.
Scope and approach: To scrutinize all papers reporting quantitative data on the prevalence and the levels of mycotoxins and their metabolites in breast milk, also the circumstances of exposure.
A systematic literature search in Pubmed, Science direct and Google scholar databases were performed to identify relevant studies, published in English from 1984 through May 2015.
Key findings and conclusion: 63 studies met the inclusion criteria and assessed the occurrence of 29 mycotoxins & their metabolites in breast milk, regarding 7194 subjects of 31 countries. The maternal dietary habits, the socio demographic status of the mother, the seasonal variations and the sensitivity of the analytical method were the factors related to the high concentrations of AFM1 and OTA in breast milk.
Studies where contamination exceeds maximum limits and exhibit real risk of public health were highlighted.

1. Introduction

Breastfeeding benefits are well established and acknowledged as the most suitable and complete nutrition for the newborn. In spite of breast milk's nutritionally and immunologically valuable components, it may sometimes contain considerable amounts of toxic chemicals, because of maternal dietary exposure (Landrigan, Sonawane, Mattison, Mccally, & Garg, 2002). For that reason the quality of human milk is crucial and requires the safety and hygiene of the food consumed by the mothers.

One of these toxic chemicals is a family of naturally occurring contaminants; mycotoxins which are secondary metabolites produced by fungi especially of the genera fusarium, aspergillus and penicillium, and may contaminate various agricultural commodities either before harvest or under post harvest conditions (Binder, 2007). Mycotoxicosis is the toxic effect of mycotoxins on animal and human health. Its severity depends on the extent of exposure, age and nutritional status of the individual and possible synergistic effects of other chemicals to which the individual is exposed (Peraica, Radic, Lucic, & Pavlovic, 1999). Consequently, many human diseases are related to intake of mycotoxins, especially carcinogenicity, genotoxicity, hepatotoxicity, nephrotoxicity, oestrogenicity,

Abbreviations: AFB1, aflatoxin B1; AFB2, aflatoxin B2; AFG1, aflatoxin G1; AFG2, aflatoxin G2; AFM 1, aflatoxin M1; AFM2, aflatoxin M2; AFL, aflatoxicol; AFs, aflatoxins; BEA, beauvericin; ENA, enniatin A; ENA1, enniatin A1; ENB, enniatin B; ENB1, enniatinB; DAS, diacetoxyscirpenol; DON, deoxynivalenol; 3-ADON, 3-acetyldeoxynivalenol; ELISA, enzyme-linked immunosorbent assay; HPLC, high performance liquid chromatography; HT-2, HT-2 TOXIN; FUS X, fusarenon-X; FB1, fumonisin B1; FB2, fumonisin B2; FB3, FumonisinB3; FLD, fluorescence detection; LLE-LTP, liquid liquid extraction-low-temperature purification; NEO, neosolaniol; NIV, nivalenol; OTA, ochratoxin A; α OT, ochratoxin α; PS, positive sample; SETR, sterigmatocystin; T-2, T-2 TOXIN; TLC, thin layer chromatography; ZEA, zearalenone; αZOL, α zearalenol; βZOL, β zearalenol..

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reproductive disorders, immunosuppression and dermal irritation (Anfossi, Baggiani, Giovannoli, & Giraudi, 2010).

Biomonitoring studies around the world reported the occurrence and even the multioccurrence of diverse mycotoxins and their metabolites in human milk; among mycotoxins, those were searched in human milk: aflatoxins (AFs), ochratoxins (OAs), sterigmatocystin (SETR), fusarium toxins: fumonisins (FMNs), zearalenone (ZEN) and trichothecenes type A and type B, also emerging fusarium mycotoxins: beauvericin (BEA), enniatins (ENNs) and fusarinon -X (FUS X). Thus, many mycotoxins were discovered in breast milk, but the contamination by AFM1 and OTA was the most investigated and found; this caution is due to their highly acute toxicity.

International agency of research on cancer IARC has classified aflatoxins as carcinogenic to humans in Group 1, especially AFB1 which is the most potent carcinogenic substance naturally produced by aspergillus species. As regards ochratoxin A (produces by aspergillus and penicillium species), sterigmatocystin (produces by aspergillus species) and fumonisins (produced by fusarium species), The IARC classified them in Group 2B as a possibly carcinogenic to humans; While trichothecenes type A and B (produced by fusarium species) and zearalenone (produced by fusarium species) were evaluated in Group 3, as not classifiable regarding its carcinogenicity to humans. Nevertheless, trichothecenes A have been associated to fatal and chronic toxicosis and acute toxicity was reported for trichothecenes B, in both human and animals (IARC, 1993, 2002, 2012).

Several Countries have established regulations to limit human exposure to mycotoxins and to protect consumers from the adverse effects of these toxic contaminants. No specific legislation for mycotoxins in human milk is available, but the regulation of maximum limits of mycotoxins in milk and dairy product is limited generally for AFM1 and available for baby and young children food, such as formulas, cereals and infant milk only for a few mycotoxins as AFB1, OTA, DON, ZEN, FMNs. The maximum limits for mycotoxins in milk also baby and young children food established by the Commission of the European Communities (Commission, 2006), Food and Drug administration (FDA, 2005) and Codex Alimentarius Committee (CODEX-ALIMENTARIUS, 2001) are recapitulated in Table 1.

Accordingly, We performed a systematic review of the literature to explore all papers reporting quantitative data on the frequency of detection and the concentration of mycotoxins and their metabolites in human breast milk of world population, published from 1984 to May 2015 and evaluating the relationship between the occurrence and the level of this contaminants and the related affecting factors, like maternal dietary habits, Socio demographic status of the mother, Seasonal variations and the sensitivity of the analytical method.

2. Methods

2.1. Search strategy

A systematic literature search in Pubmed, Science direct and Google scholar databases was conducted using the following key terms: “Aflatoxins” OR “Ochratoxins” OR “Mycotoxins” AND “Breast milk” OR “Human milk” OR “Maternal milk” OR “Colostrum” to locate all relevant articles that investigate the occurrence of mycotoxins and their metabolites in human breast milk of the general population. Reference lists of included publications were also manually searched to identify other suitable studies.

2.2. Study selection

Only articles reporting quantitative levels of mycotoxins in human breast milk in English language were included. Papers reporting data about mycotoxins exposure and levels in animal milk were not considered, as well as data from books, thesis, reviews and posters abstracts from workshop or congresses.

2.3. Data collection

The following information was extracted from each study: Country, period of samples collection, lactation time, age of mothers, total samples, mycotoxins, number of positive samples, concentration, method of detection, limit of detection, limit of quantification, the use of diet questionnaire, the other specimen analyzed, the approval of the ethics committee and the discussed factors.

For 5 studies, the full text was not available, even after requesting the copies from the authors; accordingly, the corresponding information was taken from their abstracts and from other studies that provide information on their results.

3. Results

After screening, pertinent studies were retrieved for eligibility, so from 180 bibliographic records identified, 63 papers fulfilled the inclusion criteria.

Searching, screening and inclusion criteria are summarized in Fig. 1 (Flow diagram of evidence searches and inclusion).

3.1. Description of the studies

In the reviewed studies, Methods of biomonitoring and surveys were employed to assess levels of mycotoxins in maternal milk; therefore, the most of studies have used a cross sectional study

Table 1
Legislation for AFM1 in milk and some other mycotoxins in baby & young children food.

Mycotoxins	European union commission regulation		Food & drug administration		FAO/WHO codex alimentarius commission	
	Foodstuffs	Max levels (μg/kg)	Food stuffs	Max levels (μg/kg)	Food stuffs	Max levels (μg/kg)
AFB1	Processed cereal-based foods and baby foods for infants and young children	0.1		–	Milk producing animals	5
AFM1	Infant formulae and follow-on formulae, including infant milk and follow-on milk.	0.025	Milk	0.5	Milk	0.05
	Raw milk, heat-treated milk and milk for the manufacture of milk-based products.	0.05				
OTA	Processed cereal-based foods and baby foods for infants and young children	0.5		–		–
DON	Processed cereal-based foods and baby foods for infants and young children	200		–		–
ZEN	Processed cereal-based foods (excluding processed maize-based foods) and baby foods for infants and young children	20		–		–
FMNs (B1+B2)	Processed maize-based foods and baby foods for infants and young children	200		–		–