Toxin Reviews

http://informahealthcare.com/txr
ISSN: 1556-9543 (print), 1556-9551 (electronic)

Toxin Rev, 2014; 33(4): 160–168

DOI: 10.3109/15569543.2014.922580

informa healthcare

REVIEW ARTICLE

The review of aflatoxin M_1 contamination in milk and dairy products produced in Iran

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Abstract

Due to their nutritional value, dairy products are popular in Iran. However, several reports have demonstrated that aflatoxin M_1 (AFM_1) contamination of milk and dairy products are challenging for human health, especially children. This manuscript is a review of some reports about the occurrence of AFM_1 in Iranian dairy products published between 2005 and 2013. The studies analyzed a total of 11 107 dairy products samples composed of raw milk, UHT milk, pasteurized milk, traditional cheese, UF cheese, cream cheese, feta cheese, white cheese, butter, ice cream, infant milk products, Doogh and yoghurt. Current AFM_1 analysis was conducted by various methods including thin layer chromatography, high-performance liquid chromatography and enzyme-linked immunoassays; but the ELISA method is mostly used in Iran because of its rapidity, simplicity and cheapness. The mean contamination level of AFM_1 in autumn and winter samples was significantly higher than spring and summer. According to European Commission limit, i.e. 50 ng/kg, the reported range of contamination in analyzed dairy products exceeded the limit was in the range of 0–100%.

Keywords

Aflatoxin M_1, contamination, dairy products, Iran, milk

History

Received 9 December 2013
Revised 14 April 2014
Accepted 01 May 2014
Published online 9 June 2014

Introduction

A toxin can be defined as a substance that is synthesized by a plant species, an animal or by micro-organisms, that is harmful to other organisms (Turner et al., 2009). Mycotoxins are toxic secondary metabolites produced by species of filamentous fungi growing on seeds during harvesting, storage and processing (Anklam et al., 2002; Binder, 2007; Degrimencioglu et al., 2012; Kumar et al., 2008; Turner et al., 2009). The name mycotoxin is a combination of the Greek word for fungus ''mykes'' and the Latin word ''toxicum'' meaning poison. They can occur both in temperate and tropical regions of the world in both industrialized and developing countries, depending on the species of fungi (Turner et al., 2009). However, environmental conditions especially high humidity and temperatures favor fungal proliferation resulting in contamination of food and feed (Wagacha & Muthomi, 2008).

Mycotoxins are natural contaminants of important raw food commodities including cereals, oilseeds, coffee, nuts, spices, figs and dried fruits all over the world; and they are a serious concern for human and animal health (Degrimencioglu et al., 2012; Fallah et al., 2014; Iamanaka et al., 2007; Kumar et al., 2008; Mozaffari Nejad et al., 2013; Turner et al., 2009). It has been reported that mycotoxins can be carcinogenic, teratogenic, tremorogenic, mutagenic, oestrogenic, genotoxic, neurotoxic or immunotoxic, for various live organisms, and known to cause hepatic carcinoma in humans (Copetti et al., 2012; Jaynes et al., 2007; Kumar et al., 2008; Moricz et al., 2007). More than 300 different mycotoxins have been described that are produced by approximately 200 different fungi (Anklam et al., 2002; Moricz et al., 2007). The most commonly known groups of mycotoxins are aflatoxins (AFs), fumonisins, ochratoxins, cyclopiazonic acid, trichothecenes (deoxynivalenol, T2 toxin and nivalenol), Ergot alkaloids, patulin and zearalenne (Binder, 2007; Bullerman & Bianchini, 2007; Coffey et al., 2009; Kumar et al., 2008; Madbouly et al., 2012; Richard, 2007). Aflatoxins, fumonisins and ochratoxin A are the most harmful mycotoxins for mammals (Madbouly et al., 2012). However, AFs are the best known and most intensively researched mycotoxins worldwide (Mozaffari Nejad, 2012). This study has undertaken a review on the occurrence of AFM_1 in milk and dairy products published by several researchers in Iran during 2001–2013.

Aflatoxins

Aflatoxins were discovered and characterized in the early 1960s, after the death of $>100\,000$ young turkeys on poultry farms in UK (Turkey-X Disease) that were traced to the

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consumption of a mold-contaminated Brazilian peanut meal (Anklam et al., 2002; Bennet & Klich, 2003; Jaynes et al., 2007; Juan et al., 2008; Turner et al., 2009). AFs are produced by different species of Aspergillus (A), namely *A. flavus, A. parasiticus, A. bombycis, A. ochraceoroseus, A. nomius, A. pseudotamarii* and *Emericella venezuelensis*, which contaminate agricultural commodities and feeds particularly in critical temperature and humidity conditions before or during harvesting or storage (Bennet & Klich, 2003; Firdous et al., 2012; Hall & Mutegi, 2011; Lee et al., 2009; Mozaffari Nejad, 2012; Ozsunar et al., 2010; Tavakoli et al., 2013). The main types of AFs are B_1, B_2, G_1, G_2 that are currently produced in plant products, but the other biotransformed AFs may occur in milk, such as AFM_1 and AFM_2 (Arinoa et al., 2009; Moricz et al., 2007; Mozaffari Nejad et al., 2013; Tavakoli et al., 2013). AFP_1 is a urinary metabolite of B_1 in monkeys. All AFs absorb UV light in the range of 362–363 nanometer, a characteristic used in preliminary qualification. AFs are highly toxic, mutagenic, immunosuppressive, teratogenic and carcinogenic compounds that have been implicated as causative agent in human hepatic and extrahepatic carcinogenesis (Ardic, 2009; Aycicek et al., 2005; Dichter, 1984). AFs can be present in several human foods like barley, corn, rice, beans, brazil nuts, pistachio nuts, peanut and peanut products, almonds, nut and nuts products, wheat flour, figs, date fruits, spices, eggs and beer (Firdous et al., 2012; Mozaffari Nejad et al., 2013). Due to the metabolism of these mycotoxins, the consumption of polluted feed is also derived from the contamination of foods of animal origin such as milk and dairy products, meat of food-producing animals and eggs (Jaimez et al., 2000; Richard, 2007).

Milk and dairy products are a good source of many nutrients such as proteins, calcium, vitamins and essential fatty acid for humans, especially for infants and children. On the other hand, milk is not consumed as liquid milk, but also utilized for the preparation of infant formulas, yoghurt, cheese and milk-based confectioneries including chocolate, and pastry. Therefore, it is important to determine AFM_1 levels in milk and dairy products in order to protect consumers of different age groups from its potential hazard (Gurbay et al., 2006; Tekinsen & Ucar, 2008). Therefore, in Iran, The presence of AFM_1 in human breast milk, commercially available milk and dairy products is one of the most serious problems of food hygiene.

Biotransformation of AFM_1 and AFM_2

AFB_1 is notoriously the most common produced mycotoxin; and has been reported to be the most powerful natural carcinogen in mammals (Creppy, 2002). It is metabolized by hepatic microsomal mixed-function oxidase system, but it also can undergo several metabolic conversations depending upon species (Marsi et al., 1974). AFM_1 is the hydroxylated metabolite of AFB_1 found in milk of lactating animals which consumed AFB_1-contaminated feed (Fallah, 2010b; Kamkar, 2008b; Kamkar et al., 2008). AFM_1 is the monohydroxylated metabolite of AFB_1 forming in liver by means of microsomal cytochrome P450-associated enzymes and excreted through body fluids such as milk, urine, feces and blood (Ardic et al., 2009; Cassia Romero et al., 2010; Ghanem & Orfi, 2008). There was a linear relationship between the amount of AFM_1 in milk and AFB_1 in the feed which is consumed by these animals (Ardic et al., 2009; Aycicek et al., 2005; Bakirci, 2001; Kamkar et al., 2011). Monitoring studies reported that approximately 0.3–6.2% of AFB_1 ingested by livestock is transformed to AFM_1 in milk. However, this transmission rate varies from animal to animal, day to day and one milking process to the next. AFM_1 could be detected in milk 12–24 h after the first ingestion of AFB_1. When the intake of AFB_1 is stopped, the AFM_1 concentration in the milk decreases to an undetectable level after 72 h (Ardic, 2009; Ardic et al., 2009; Chin Lin et al., 2004; Creppy, 2002; Fallah, 2010a; Martins & Martins, 2004; Van Egmond, 1989). The International Agency for Research on Cancer (IARC) of World Health Organization (WHO) included AFB_1 as primary and AFM_1 as secondary groups of carcinogenic compounds (Kamkar et al., 2014; Ozsunar et al., 2010; Tavakoli et al., 2012; Unusan, 2006). AFM_1 can also cause DNA damage, gene mutation and chromosomal anomalies in lower eukaryotes, *in vitro*, insects and bacteria. Furthermore, AFM_1 is less mutagenic, and genotoxic comparing to AFB_1 (Prandini et al., 2009). Figure 1 demonstrates several metabolic reactions for products from AFB_1 (Mohammadi, 2011).

Occurrence of AF contamination in the world

Aflatoxicosis is a poisoning condition caused by ingestion of AFs in contaminated feed or food (Celik et al., 2005). Various epidemiological researches have included AFs in the increased occurrence of human gastrointestinal and hepatic neoplasms in Africa, the Philippines and China (Juan et al., 2008). Up-until the mid-1990s, reports of acute AF poisoning approximately 25% of which result in death were found in scientific journals, but subsequent reports are usually in the

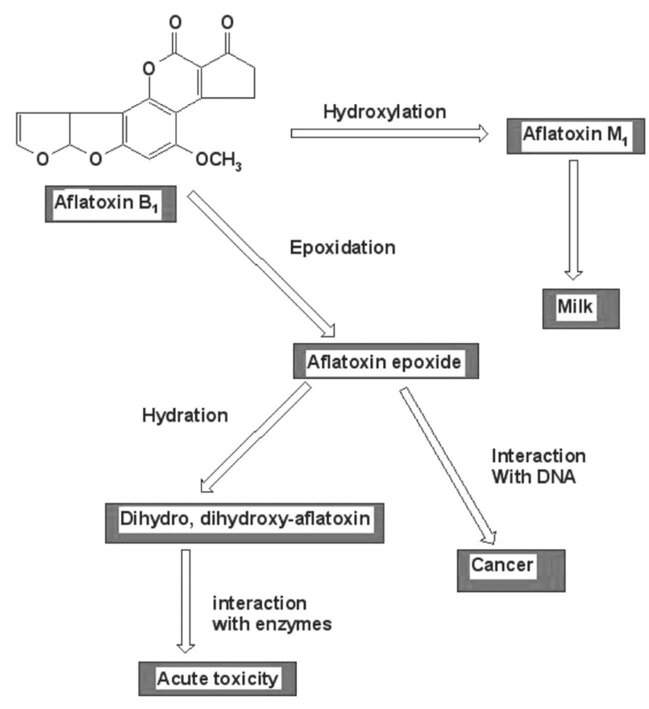

Figure 1. Some metabolic products from aflatoxin B_1.

daily press. Although susceptibility of humans to AFs is not well known, results of epidemiological studied carried out in Africa and Asia, where there is a high incidence of hepatoma, have revealed an association between cancer incidence and AF content of the diet (Jaimez et al., 2000). The largest reported outbreak of aflatoxicosis to date occurred in Kenya in 2004 where 317 cases and 125 recognized deaths were reported. Other documented fatal aflatoxicosis out breaks have been reported in India in 1974, with 397 cases and 108 reported deaths. Nigeria in 2005: more than 100 deaths; Kenya in 1981: 20 cases; Kenya in 2005: 80 cases and 30 reported deaths and 9 deaths in 2006 (Jaimez et al., 2000; Molyneux et al., 2007; Wagacha & Muthomi, 2008). The other studies demonstrated that foods containing AFs cause liver cancer in Qidong areas of the People's Republic of China (Wang et al., 1999).

Regulatory limits law AFM_1 in Iran and world dairy products

Presence of AFM_1 in milk and dairy products is a worldwide concern for human health, especially to children who are the major consumers of milk (Fallah, 2010b). Evidence of potential hazardous human exposure to AFM_1 through milk and milk derivatives has been shown by some authors in different countries. Accordingly, most of the developed countries have set or proposed legal regulations for AFM_1 levels in milk and dairy products to reduce this hazard. These regulations vary from one country to another depends on economic considerations (Fallah, 2010b; Nuryono et al., 2009; Oveisi et al., 2007; Rahimi et al., 2010; Unusan, 2006). At present time, some countries such as Indonesia and India have no legal maximum limit of AFM_1 in milk and dairy products (Nuryono et al., 2009; Rastogi et al., 2004). Table 1 shows the tolerance levels for AFM_1 levels in milk and dairy products for human consumption in various countries.

Current types of methods to measure AFM_1

Current AFM_1 analysis is done by various methods including thin-layer chromatography (TLC), high-performance liquid chromatography (HPLC) and enzyme-linked immunoassays (ELISA). The ELISA method is the most current in Iran by researchers because it is easy to use, fast and readily automated. Table 2 shows the characteristics of these procedures (Anklam et al., 2002; Chun Pei et al., 2009; Guan et al., 2011; Jaynes et al., 2007; Leszczynska et al., 2001; Moricz et al., 2007; Tavakoli et al., 2013).

Research conducted AFM_1 in dairy products in Iran

Several researches reported the presence of AFM_1 in milk and dairy products in Iran. However, this study undertaken reported about the presence of AFM_1 between 2005 and 2013 in Iran, and also not reported any study about AFM_1 in milk and dairy products between 2001 and 2004 in Iran. Table 3 shows the AFM_1 contamination in milk and dairy products produced in Iran between 2005 and 2013.

Prevention and detoxification methods of AFM_1

Several studies showed that AFM_1 is relatively stable to heat treatments such as pasteurization, sterilization (UHT techniques) and autoclaving, and other processes like freezing, fermentation and cold storage (Chun Pei et al., 2009; Godic Torkar & Vengust, 2008; Gurbay et al., 2006; Martins et al., 2005). Wiseman & Marth (1983) reported that frozen storage of contaminated milk and dairy products for a few months does not appear to affect the content of AFM_1. Heimbecher et al. (1988) reported that add amount of 0.5% formaldehyde to contaminated milk samples can reduce 1.1 μg AFM_1 to 0.05 μg. Nageswara Rao & Chopra (2001) suggested that absorbent substances should be utilized to decrease AFM_1 in milk of dairy species and reduce the hazardous exposure of humans to the toxin.

Soha & Borji (2007) demonstrated that milk AF was decreased >90% by bentonite B1, but decreasing of AFM_1 by hydrated sodium calcium alumino-silicate and bentonite X was about 77% and 71%, respectively. Milk composition did not affected by the absorbents, but a low level of silicium was left in the samples that were treated with chemisorption compounds. On the other hand, some techniques for reduction in AFs are more effective than other methods; such as solar radiation is more effective than Y-irradiation and microwave heating (Herzallah et al., 2008).

Suggestion

In order to promote health and sanitation in the society and to decrease toxic levels of AFM_1, the following suggestions seem necessary:

- Educating producers about planting, harvesting, new ways to store and transport, especially ships that are suitable for fungal growth;
- Extension of Industrial livestock husbandry and familiarity with the principles of proper livestock husbandry;
- Inspection of food products and animal feed by regular sampling;
- Equip the Laboratories at the national level as well as milk and dairy factories for testing some toxins;
- Prevent contamination of milk and dairy products during processing and packaging;
- Knowledge of state health officials and administrators about the dangers that AFs plays in health, especially in human carcinogenesis;
- Regular inspection of dairy plants by relevant experts;
- Try to implement further studies in the field of optimization techniques to reduce contamination of AFM_1.

Conclusion

Fungal toxins can be detected in agricultural products during harvesting, processing and storage. According to the results obtained in Iran and other countries, incidence and contamination levels of AFM_1 in Iran and some of the countries (especially Asian countries), seem to be a serious problem for the public health, since all the age groups including infants and children consume these products. So, to produce high-quality milk, it is essential to keep food free from

Table 1. Maximum tolerance levels of aflatoxin M_1 in milk and dairy products in various countries.

Country	Maximum limit (µg/kg or µg/l)	Food	Reference
Argentina	0.05	Raw milk	Kaniou-Grigoriadou et al. (2005)
	0.50	Milk products	Kaniou-Grigoriadou et al. (2005)
Austria	0.05	Raw milk	Kaniou-Grigoriadou et al. (2005)
	0.01	Pasteurized infant milk	Kaniou-Grigoriadou et al. (2005)
	0.02	Butter	Kaniou-Grigoriadou et al. (2005)
	0.25	Cheese	Kaniou-Grigoriadou et al. (2005)
	0.4	Powdered milk	Kaniou-Grigoriadou et al. (2005)
Belgium	0.050	Milk	Celik et al. (2005)
Brazil	0.50	Fluid milk	Kaniou-Grigoriadou et al. (2005)
	5.0	Powdered milk	Kaniou-Grigoriadou et al. (2005)
Bulgary	0.50	Raw milk	Kaniou-Grigoriadou et al. (2005)
	0.10	Powdered milk	Kaniou-Grigoriadou et al. (2005)
China	0.5	Milk products	Chun Pei et al. (2009)
Croatia	0.05	Milk and dairy products	Bilandzic et al. (2010)
	0.025	Milk-based baby food	Bilandzic et al. (2010)
Czech Republic	0.1	Children's milk	Celik et al. (2005)
	0.5	Adult's milk	Celik et al. (2005)
Egypt	0	Raw milk	Kaniou-Grigoriadou et al. (2005)
	0	Dairy products	Kaniou-Grigoriadou et al. (2005)
France	0.03	Children's milk	Kaniou-Grigoriadou et al. (2005)
	0.05	Adult's milk	Kaniou-Grigoriadou et al. (2005)
Germany	0.05	Milk	Chin Lin et al. (2004)
	0.01	Infant formula	Chin Lin et al. (2004)
Honduras	0.05	Raw milk	Kaniou-Grigoriadou et al. (2005)
	0.25	Cheese	Kaniou-Grigoriadou et al. (2005)
Iran	0.05	Yoghurt	Fallah (2010a)
	0.2	Cheese	Fallah (2010a)
	0.05	Raw milk	Fallah (2010a)
Italy	0.05	Milk	Chin Lin et al. (2004)
	0.05	Infant formula	Chin Lin et al. (2004)
	0.45	Cheese	Manetta et al. (2009)
Morocco	0.05	Liquid milk	Zinedine et al. (2007)
	0.5	Powdered milk	Zinedine et al. (2007)
Netherlands	0.020	Butter	Celik et al. (2005)
	0.200	Cheese	Celik et al. (2005)
Nigeria	1	Raw milk	Kaniou-Grigoriadou et al. (2005)
Portugal	0.01	Yoghurt	Martins & Martins (2004)
Rumania	0	Raw milk	Kaniou-Grigoriadou et al. (2005)
	0	Dairy products	Kaniou-Grigoriadou et al. (2005)
South Korea	0.5	Raw milk	Lee et al. (2009)
Sweden	0.050	Liquid milk products	Celik et al. (2005)
Switzerland	0.05	Raw milk	Kaniou-Grigoriadou et al. (2005)
	0.025	Milk whey and products	Kaniou-Grigoriadou et al. (2005)
	0.25	Cheese	Kaniou-Grigoriadou et al. (2005)
	0.02	Butter	Kaniou-Grigoriadou et al. (2005)
Syrian	0.2	Fluid milk	Ghanem & Orfi (2008)
	0.05	Powdered milk	Ghanem & Orfi (2008)
Taiwan	0.5	Milk	Chin Lin et al. (2004)
	5	Powdered milk	Chin Lin et al. (2004)
European Union	0.05	Raw milk	Kaniou-Grigoriadou et al. (2005)
	0.05	Dairy products	Kaniou-Grigoriadou et al. (2005)
	0.025	Infant formulae	Zinedine et al. (2007)
	0.5	Powdered milk	Zinedine et al. (2007)
USA	0.5	Liquid milk and dried or processed milk products	US FDA (1996)
Codex Alimentarius	0.5	Milk	Codex Alimentarius Commission (2001)

Table 2. The characteristics of common methods used for AFM1 analysis.

ELISA	HPLC	TLC	Criterion
Middle	High	Low	Reliability
High	High	Middle	Automated
High	High	Middle	Simple
High	High	Middle	Selective
High	High	Middle	Sensitive
High	Middle	Low	Speed
Middle	High	Low	Cost
Low	High	Middle	Importance
Quality control, examine an amount of sample, epidemiologic studies	Quality control, examine an amount of sample, epidemiologic studies	Quality control, examine an amount of sample	Usage

Table 3. Reports on the occurrence of aflatoxin M_1 contamination in milk and dairy products produced in Iran between 2005 and 2013.

Location	Samples	No. of samples	Season	Detection method	Positive samples (%)	Range (ng/kg)	Percent of contaminated milk sample <50 ng/kg	References
Tehran	White cheese	48	Winter, Spring	TLC	70.08	159–1047	75.6	Kamkar (2005a)
Sarab	Raw milk	111	Spring, Summer, Autumn, Winter	TLC	76.6	15–280	40	Kamkar (2005b)
Gonabad	Pasteurized milk	90	Spring, Summer, Autumn, Winter	ELISA	100	7.31–141.2	57.7	Mokhtarian Daloei & Mohsenzadeh (2005)
Mashhad	UHT milk	62	Spring, Summer, Autumn, Winter	ELISA	100	22–389	6.8	Mohsenzadeh & Bisjerdi (2005)
Shiraz	Traditional and UF cheese	96	*	ELISA	*	25–137	30	Alborzi et al. (2005)
Shiraz	Pasteurized milk	624	Spring, Summer	ELISA	100	<45→80	17.8	Alborzi et al. (2006)
Tehran	Feta cheese	80	Spring, Summer, Autumn, Winter	TLC	82.5	150–2410	60.6	Kamkar (2006)
Mashhad	Pasteurized milk	110	Spring	ELISA	100	8–89	5.4	Karimi et al. (2007)
Hamedan	Raw milk	196	Summer, Winter	ELISA	63.97	≤10–410	11.76	Ghiasian et al. (2007)
Babol	Pasteurized and UHT milk	72	Winter	ELISA	100	193–259	100	Gholampour Azizi et al. (2007)
Khoramabad	Pasteurized and raw milk	82	Summer, Winter	HPLC	100	13–117	5	Nazari et al. (2007)
Babol	Pasteurized milk	144	Winter, Summer	ELISA	100	110.4–229.64	100	Sefidgar et al. (2007)
Urmia	Pasteurized and raw milk	144	Spring, Summer, Autumn, Winter	ELISA	100	4.3–91.8	6.25	Tajik et al. (2007)
Tehran, Rasht, Gorgan, Shiraz and Hamedan	Raw milk	98	Spring, Summer, Autumn, Winter	HPLC	100	3–392	39	Tajkarimi et al. (2007)
Tehran	Infant milk products	328	Spring, Summer	ELISA	96.3	1–113	78	Oveisi et al. (2007)
Tehran and Sanandaj	Raw milk	84	Winter	ELISA	91.65	2.7–69.8	20.33	Hazhir et al. (2008)
Tehran	Powdered milk	42	Spring, Autumn, Winter	ELISA	100	32–914	80.7	Kamkar (2008a)
Tehran	UHT milk	52	Summer, Autumn	ELISA	100	19.40–93.60	79.92	Kamkar (2008b)
Chahar_Mahal_Bakhtiari	Raw milk	86	Spring, Summer	ELISA	47.7	2.868–176.192	18.6	Rahimi & Karim (2008)
Babol	Raw milk	120	Winter	ELISA	56.7	50–352.3	56.7	Sefidgar et al. (2008)
Tehran, Rasht, Gorgan, Shiraz and Hamedan	Raw milk	319	Summer, Winter	HPLC	54	5–30	77	Tajkarimi et al. (2008)
Yazd and Esfahan	White and cream cheese	210	Spring, Autumn, Winter	ELISA	76.6	52.1–785.4	24.2	Fallah et al. (2009)
Shiraz, Marvdasht and Sepidan	Raw milk, milk storage tank and pasteurized milk	180	*	ELISA	80	18.26–32.23	52.2	Hashemi (2009)
Chenaran	Raw milk	93	Spring, Summer	ELISA	100	3.86–140.1	76.34	Jampour et al. (2009)
Tabriz	Pasteurized milk	50	Summer, Autumn	ELISA	100	0–259	62	Movassagh Ghazani (2009)
Kerman	Pasteurized milk	76	Winter	HPLC	100	2–140	44.7	Pournour Mohammadi et al. (2009)
Ahwaz	Raw milk	90	Winter, Spring	ELISA	100	*	48	Maktabi et al. (2009)
Khorasan Razavi Province	Pasteurized milk	140	Spring, Summer	ELISA	100	*	91.43	Mohamadyan et al. (2009)
Esfahan	Traditional cheese	88	Spring, Summer, Autumn, Winter	ELISA	53.4	82–1254	31.8	Rahimi et al. (2009a)
Shahr_e kord and Esfahan	Raw milk, UHT and pasteurized milk	236	Spring, Summer, Autumn, Winter	ELISA	90.3	12–218	55.9	Rahimi et al. (2009c)
Shahr_e kord and Esfahan	Infant milk products	120	Spring, Summer, Autumn, Winter	ELISA	78.3	7–102	15.7	Rahimi et al. (2009b)
Babol	Pasteurized milk	100	Winter	ELISA	100	*	100	Sefidgar et al. (2009)
Tabriz	Raw milk	10	Spring	ELISA	30	2–250	30	Movassagh (2009)
Central part of Iran	Pasteurized and UHT milk	225	Winter, Summer	ELISA	67.1	5.6–528.5	22.05	Fallah (2010a)

(*continued*)

Location	Samples	No. of samples	Season	Detection method	Positive samples (%)	Range (ng/kg)	Percent of contaminated milk sample <50 ng/kg	References
Tehran, Esfahan, Shiraz and Yazd	Pasteurized milk, yoghurt, white cheese, butter and ice cream	298	Winter, Summer	TLC	63.14	13–1200	24.92	Fallah (2010b)
Tehran	UHT milk	210	Spring, Summer, Autumn, Winter	ELISA	55.2	<2→5	33.3	Heshmati & Milani (2010)
Khorasan Province	Pasteurized milk	196	Winter, Spring	ELISA	100	64.21–84.10	80.6	Mohamadi Sani et al. (2010)
Sanandaj	Pasteurized and raw milk	272	Spring, Summer, Autumn, Winter	ELISA	94.49	~0–116	4.4	Mohammadian et al. (2010)
Ardabil	Raw milk, UHT and pasteurized milk	90	Summer, Winter	ELISA	100	17.4–56.3	33	Nemati et al. (2010)
Ahvaz	Raw milk	311	Autumn	ELISA	42.1	<5→50	12.5	Rahimi et al. (2010)
Tehran	Pasteurized milk	50	Winter, Summer	ELISA	84	12.5–23.5	4	Riazipour et al. (2010)
Mazandaran Province	Pasteurized and local yoghurt	50	Autumn	ELISA	100	2.1–61.7	6	Barjesteh et al. (2010)
Guilan Province	Raw milk	100	*	HPLC	100	19–128	80	Tabari (2010)
Hamedan	White cheese	188	Summer, Winter	ELISA	70.7	67–1993	36.2	Heshmati (2010)
Urmia	Creamy and Feta cheese, UHT and pasteurized milk	160	Summer	ELISA	120	*	0	Mohamadi et al. (2010)
Tabriz	UHT milk	49	Spring, Summer, Autumn, Winter	ELISA	100	0–259	83.67	Movassagh (2011)
Shiraz, Yazd and Khuzestan	Pasteurized and UHT milk	149	Spring, Summer, Autumn, Winter	ELISA	95.3	>17–100	22.1	Rahimi et al. (2011)
Babol	Pasteurized milk	72	Winter	ELISA	100	178.8–253.5	100	Sefidgar et al. (2011)
Ardabil	Raw milk	122	Autumn, Winter	ELISA	100	4–112.4	14.75	Kamkar et al. (2011)
Tehran, Esfahan, Shiraz and Tabriz	Raw milk of cow, goat and sheep; Lighvan cheese, industrial and traditional yoghurt, Kashk and doogh	682	Spring, Summer, Autumn, Winter	TLC	46.3	13–394	13.1	Fallah et al. (2011)
Ahvaz	Pasteurized milk and cheese	121	Spring, Summer, Autumn, Winter	ELISA	50.4	11–209	5	Rahimi et al. (2012)
Gilan	Yoghurt	60	Autumn	ELISA	98.33	6.2–87	63.33	Issazadeh et al. (2012)
Babol	Ice cream	45	Autumn	ELISA	*	1.2–103	22.2	Khoshnevis et al. (2012)
Mazandaran Province	Pasteurized milk	75	Spring, Summer	ELISA	96	*	62.67	Gholipour et al. (2012)
Qom	Pasteurized milk and yoghurt	103	Winter, Summer	ELISA	100	5–64	57.4	Behnamipour et al. (2012)
Gilan	White cheese	90	Summer, Autumn	ELISA	86.66	7.2–413	23.33	AzizollahiAliabadi et al. (2012)
Tehran	White cheese	50	Summer, Winter	ELISA	60	40.9–374	6	Tavakoli et al. (2012)
Mashhad	Pasteurized milk	42	Autumn	ELISA	97.6	6–71	1.6	Mohammadi Sani et al. (2012)
Mashhad	Pasteurized milk	60	Spring	HPLC	100	2–64	1.6	Mohammadi Sani et al. (2013)
Gilan Province	Raw milk	90	Autumn, Winter	ELISA	65.55	2.1–131	31.11	Lalehrokhi et al. (2013)
Gilan Province	Ice cream	90	*	ELISA	68.88	8.4–147.7	12.22	Kazemi Darsanaki et al. (2013)
Qazvin	Raw milk	2160	Spring, Summer, Autumn, Winter	EIA	100	0.04–148.01	33.4	Khosravi et al. (2013)
Gilan Province	Commercial and traditional yoghurt	120	*	HPLC	100	4.2–78.9	13.33	Tabari et al. (2013)
Tehran	Yoghurt	50	Summer, Winter	ELISA	70	21.1–137.6	17.14	Tavakoli et al. (2013)
Rafsanjan	Lighvan and white cheese	82	Spring, Winter	ELISA	47.6	70.5–309	12.2	Akrami Mohajeri et al. (2013)
Ilam	Raw and pasteurized milk	144	Summer, Winter	ELISA	43.75	10.03–85.24	31.3	Vagef and Mahmoudi (2013)

*Not reported.

contamination to AFB_1. According to Iran's Ministry of Agriculture program, milk production will reach 12 million tons in the next few years, but they have not mentioned anything about health status indicators or change of this status. Chemical pollution such as, drug residues, pesticides in vegetable and mycotoxin are sensitive items in the world to check the quality of the milk. Some studies indicated seasonal effect influences AFM_1 occurrence in milk and dairy products. The higher incidence and levels of AFM_1 contamination in dairy products during cold seasons could be due to the fact that forage and compound-stored feeds used in cold seasons contain higher amount of AFB_1 comparing to the feeds such as fresh grass used in warm seasons. The most important factor in the amount of AFB_1 was temperature and moisture, since some molds like *Aspergillus flavus*, and *Aspergillus parasiticus* can easily grow in feeds having moisture between 13% and 18% and environmental moisture between 50% and 60%.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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Notice of Correction:
In the version of this article, published on 9 June 2014, a reference was missing from the manuscript (Mohammadi, 2011). The reference and appropriate citation has been included in this version.