Food Control 22 (2011) 426–429

Contents lists available at ScienceDirect

Food Control

journal homepage: www.elsevier.com/locate/foodcont

Studies on contamination level of aflatoxins in some dried fruits and nuts of Pakistan

Ghosia Luttfullah [a], Arshad Hussain [b,*]

[a] Centre of Biotechnology, University of Peshawar (NWFP), Pakistan
[b] Food Technology Center, PCSIR Laboratories Complex, Jamrud Road, University Town, Peshawar (NWFP), Pakistan

ARTICLE INFO

Article history:
Received 16 June 2010
Received in revised form
4 August 2010
Accepted 3 September 2010

Keywords:
Aflatoxins
Contamination
Dried fruits
Nuts
HPLC

ABSTRACT

The occurrence of aflatoxins in dried fruits and nuts was surveyed in this study. One hundred and eighty samples of dried fruits and nuts were purchased from retail shops and local markets of different locations of NWFP and Northern areas of Pakistan. The samples were analyzed for total aflatoxins by immune affinity (IAC) clean-up with liquid chromatography and fluorescence detection. The results showed the percentage of contamination for total aflatoxins in the samples such as in; dried apricot (20%), dates (10%), dried figs (50%), dried mulberries (26%) and raisins (20%), while in apricot kernels (26%), almonds without shell (30%), walnuts with shell (40%), walnuts without shell (70%), peanut with shell (40%), peanuts without shell (50%), pistachios with shell (20%), pistachios without shell (50%) and pine nuts with shell (20%). The highest contamination levels of aflatoxins were found in one peanut sample (14.5 μg/kg) and one pistachio sample (14 μg/kg). Among all the contaminated samples, one dried apricot, three dried fig, one raisins, one apricot kernels, two walnuts with shell, three walnuts without shell, one peanuts with shell, two peanuts without shell and two pistachios without shell samples were above the suggested limit for total aflatoxins (4 μg/kg), set by EU regulations.

© 2010 Elsevier Ltd. All rights reserved.

1. Introduction

Mycotoxins are secondary metabolites produced by filamentous micro fungi that can cause disease in vertebrate animals when introduced via a natural route: ingested, absorbed through the skin or inhaled (Frisvad, Thrane, & Samson, 2007). The species of *Aspergillus*, *Penicillium* and *Fusarium* produce mycotoxins, which invade crops in the field and may grow on foods during storage under favorable conditions of temperature and humidity. They are regularly implicated in toxic syndromes in animals and humans as resulting from the intake of mycotoxins are known as mycotoxicoses (Berry, 1998; Smith, Solomons, Lewis, & Anderson, 1995). Aflatoxins are difuranocoumarin derivatives produced by a polyketide pathway by many strains of *Aspergillus flavus, Aspergillus parasiticus* and the rare *Aspergillus nomius*, which contaminate plants and plant products. They have been detected in various food commodities from many parts of the world and are presently considered as one of the most dangerous contaminants of foods and feeds (Bennett & Klich, 2003).

The main mycotoxins currently considered of importance include the aflatoxins, tricothecenes, zearalenone, fumonisins and ochratoxin A. They can occur in various commodities, such as cereal grains, pulses, nuts, dried fruits, milk and dairy products, coffee and wines (Kritzinger, Aveling & Marasas, 2003; Stefanaki, Foufa, Tsatsou-Dritsa, & Photis, 2003). Although 20 aflatoxins have been identified, only 4 of them, that is, the aflatoxins B1, B2, G1 and G2 occur naturally in most kinds of foods in tropical countries. This species is very common on maize, peanuts, pistachios and cottonseed, and produces only B aflatoxins (Molyneux, Mahoney, Kim & Campbell, 2007).

A. parasiticus occurs rather commonly in peanuts, but is apparently quite rare in other foods and is more restricted geographically as compared to *A. flavus*. *A. parasiticus* produces both B and G aflatoxins, and virtually all known isolates are toxigenic (Frisvad et al., 2007). Pistachio nuts are among the commodities with the highest risk of aflatoxin contamination (Molyneux et al., 2007; Pittet, 1998).

Several epidemiological studies have shown that aflatoxins associated with human gastrointestinal disorders, hepatic neoplasms and liver cell carcinoma in Africa, Philippines and China (Goeger, Hsie, & Anderson, 1999). Recently, aflatoxins outbreaks affecting a large geographical area and causing over 123 deaths were reported in Kenya (CDC, 2004). Preliminary surveys from

* Corresponding author. Tel.: +92 091 9216240; fax: +92 091 9216232.
E-mail addresses: arshadpcsir@yahoo.com, arshadpcsir@hotmail.com (A. Hussain).

0956-7135/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.foodcont.2010.09.015

Morocco reported the contamination of some agricultural products with mycotoxins especially aflatoxins (Zinedine et al., 2006). Due to the significant health risks associated with the presence of aflatoxins in foods, it is important to establish a data collection on the occurrence of these toxins in Pakistani foods. Much attention has been paid recently in the country to monitor the presence of aflatoxins in agricultural products intended for national consumption and/or exportation. However, dried fruits and nuts have never been investigated for the presence of aflatoxins. The purpose of this work was to screen the content of aflatoxins in dried fruits and edible nuts available in Pakistan that are widely consumed in huge amounts. Therefore this study aimed to determine occurrence of aflatoxins in dried fruits and nuts intended for export.

2. Materials and methods

2.1. Sampling

One hundred and eighty ($n = 180$) samples of dried fruits and nuts (20 dried apricot, 20 dates, 10 dried figs, 15 mulberries, 10 dried raisins, 15 apricot kernels, 10 almonds with shells, 10 almonds without shells, 10 peanut with shells, 10 peanuts without shells, 10 pistachios with shells, 10 pistachios without shells, 10 walnuts with shells, 10 walnuts without shells and 10 pine nuts with shell) were purchased from retail shops and local markets of different locations of NWFP and Northern areas of Pakistan during the period from January to November 2009. The collected samples ranging from 2 to 3 Kg were transported to Mycotoxin Laboratory at PCSIR Laboratories Complex Peshawar Pakistan.

Mould contamination is by nature non homogeneous and hence the amount of mycotoxin is not uniformly distributed throughout the food stuff. Mycotoxin contamination particularly in grains and nuts is likely to occur in pockets of high concentration. To obtain maximum particle size reduction and thoroughness of mixing to achieve effective distribution of contaminated portions an attempt was made to implement an acceptable sampling procedure. The 500 g representative samples were taken from each collected sample after through mixing. Finally a 200 g subsample was subjected to fine grinding in a Grinding mill RAS Mill EQMMR 1017 Romer, Labs, Inc. (MO, USA), till it passed through a No. 20 sieve or becomes paste and immediately dispensed into plastic bags. These samples were kept at −4 °C until analyzed for aflatoxins.

2.2. Chemical and reagents

All reagents and solvents used were of LC grade supplied by Merck (Darmstadt, Germany). LC grade water was obtained by filtering deionized water through a 0.45μ filter with a Waters Millipore (Milford, MA, USA) system. Solvents and water were degassed for 20 min using ultrasonic bath (Model EIA CP104, Italy). Phosphate buffer saline (PBS) and trifluoroacetic acid (TFA) were purchased from Sigma (St. Louis, MO, USA).

Standards of aflatoxin B1 (2.02 μg/ml) and aflatoxin B2 (0.520 μg/ml) were purchased from Biopure (Tecknopark Tullin, Austria). Standard stock solutions of AFB_1 and AFB_2 of concentrations 1 μg/ml each were prepared by diluting in benzene/acetonitrile (98:2; v/v). These stock solutions were stored at −4 °C in refrigerator, wrapped in aluminum foil due to that aflatoxins gradually breakdown under UV light.

2.3. Apparatus

The LC system consisted of Hitachi model L-2000 equipped with two pumps L-2130, autoinjector L-2200 and fluorescence detector L-2458 (Macao, Japan). The guard column, Intersil ODS-3, 5 μm (GL sciences Inc. Tokyo, Japan) was placed between the autoinjector and the separative column, Intersil ODS-3 (25 cm × 4.6 m I.D., 5 μm, GL science, Tokyo, Japan) column. Photochemical reactor, UVE (LC Tech, Germany) for post column derivatization of Aflatoxin was equipped between separative column and fluorescence detector.

2.4. Extraction procedure

Aflatoxins were analyzed in dried fruits and nuts according to the method reported by Stroka, Anklam, Jorissen, and Gilbert (2000). Briefly, in 10 g of pistachio, peanut, and walnut, 1 g of NaCl added and blended with 40 ml of methanol/water (80:20) and 20 ml of cyclohexane for 3 min. After separation of the two phases, cyclohexane was eliminated. For figs and raisins, samples were extracted only with 40 ml of methanol/water (80:20). Extracts were filtrated by a Whatman filter paper No. 4.

2.5. Immunoaffinity column clean-up

An aliquot of 10 ml was diluted with 60 ml of PBS buffer (pH 7.4). An immune affinity column (IAC AflaTest®, Vicam, USA) was conditioned with 10 ml of PBS buffer by gentle syringe pressure at a flow rate of 5 ml/min. Then, the mixture of the filtrate diluted extract (70 ml) was applied to the IAC column (1–2 drops per second), followed by a washing with 20 ml of bi distilled water and then dried with air. Aflatoxins were then slowly eluted from the IAC with 2 ml methanol into a glass vial.

2.6. LC analysis

The mobile phase consisted of acetonitrile/methanol/water (8:27:65, v/v/v). The mobile phase was degassed by sonication. The Intersil ODS-3 (25 cm × 4.6 m I.D., 5 μm, GL science, Tokyo, Japan) column was connected as LC column. The column was maintained at 40 °C with a flow rate of 0.8 ml/min. The aflatoxins were detected at the excitation and emission wavelengths of 365 and 450 nm, respectively. The injection volume was 20 μl. For quantitation of aflatoxins in samples, a separate calibration curve was established for each aflatoxin. Triplicate samples were used for setting calibration curve, determining LODs and extraction recovery.

2.7. Method performance

The extraction procedure was optimized to facilitate the complete removal of the aflatoxins. Recovery studies were carried out by spiking uncontaminated samples with aflatoxins standard solution. Three replicated dried fruits and nuts samples were spiked with four concentration levels (0.5, 2.5, 5 and 25 μg/kg) with AFB1, AFG1, AFB2 and AFG2. The fortified samples were extracted and analyzed using the entire procedure. The limits of detection (LOD) was estimated using the signal-to-noise ratio as $S/N = 3$ and $S/N = 10$, respectively, for dried fruits samples containing 5 μg/kg AFB1, AFG1, AFB2 and AFG2. The LOD were 0.5 μg/kg for AFB1 and AFG1 and 1.0 μg/kg for AFB2 and AFG2.

3. Results and discussion

The performances of the employed analytical method were satisfactory for the purpose. Analysis gave clean chromatograms and recoveries were considered as valid for analyzing residues of aflatoxins in foods according to the Commission Directive (European Commission, 2002) being the recoveries at 2.5–5 μg/kg level for the four aflatoxins up to 70% (Table 1).

Table 1
Recoveries of aflatoxins in dried fruits and edible nuts.

Commodities	Mean recovery [a] ± RSD			
	AFB1	AFG1	AFB2	AFG2
Dried apricot	91.7 ± 2.7	84.5 ± 3.2	85.7 ± 2.1	88.3 ± 4.1
Dried fig	84.5 ± 2.1	86.7 ± 4.3	89.5 ± 1.9	85.7 ± 3.7
Dried mulberry	86.7 ± 2.5	87.3 ± 4.5	90.4 ± 1.6	89.5 ± 2.6
Dates	90.5 ± 1.6	90.4 ± 3.7	83.5 ± 1.8	92.5 ± 3.2
Raisins	83.5 ± 2.5	86.5 ± 2.7	92.4 ± 3.5	90.2 ± 2.5
Apricot kernels	83.5 ± 2.1	87.3 ± 3.4	88.5 ± 1.9	85.7 ± 2.5
Almonds with shell	87.5 ± 4.2	83.7 ± 2.6	85.7 ± 2.1	86.4 ± 1.6
Almonds without shell	85.7 ± 2.4	88.2 ± 1.7	89.5 ± 2.0	91.5 ± 1.9
Walnuts with shell	86.4 ± 1.9	89.6 ± 1.9	92.5 ± 1.9	84.5 ± 3.2
Walnuts without shell	91.5 ± 3.2	85.7 ± 2.0	90.2 ± 3.5	86.7 ± 2.1
Peanuts with shell	90.4 ± 4.2	91.7 ± 2.6	83.7 ± 3.2	87.3 ± 2.7
Peanuts without shell	83.5 ± 1.8	84.5 ± 3.3	87.5 ± 2.6	83.7 ± 3.4
Pistachios with shell	85.6 ± 1.5	86.7 ± 1.8	84.5 ± 2.6	88.2 ± 2.5
Pistachios without shell	89.5 ± 2.6	90.5 ± 2.3	88.6 ± 4.0	92.4 ± 1.8

RSD: relative standard deviation.
[a] Number of replicates: $N = 3$.

3.1. Occurrence of AFs in analyzed dried fruits samples

Results of 75 dried fruits samples analyzed for aflatoxins are summarized (Table 2). It is evident from the results that four samples of dried apricot, two samples of dates, five samples of dried fig, four samples of dried mulberries and two samples of raisins were found contaminated with aflatoxins. Among contaminated samples of dried apricot, one sample (10.1 μg/kg) was above the suggested limit (4 μg/kg) set by EU regulations for total aflatoxins (European Commission, 2006a), whereas three samples were ranging from 1.5 to 3.2 μg/kg had aflatoxins below the suggested limit.

In dates, only two samples were contaminated with aflatoxins having concentrations ranging from 2.1 to 3.2 μg/kg, were above the suggested limit. In dried fig, out of five contaminated samples, three samples were above the suggested limit had concentration ranging from 4.5 to 12.5 μg/kg and two samples were ranging from 0.8 to 3.7 μg/kg had aflatoxins below the suggested limit. More recently, dried figs from Turkey were found contaminated with aflatoxins ranging from 117.9 to 471.9 μg/kg (Karaca & Nas, 2006).

In dried mulberries, the contaminated samples had concentration ranging from 1.0 to 3.5 μg/kg were below the suggested limit. In raisins, out of two contaminated samples, one (7.5 μg/kg) was above and one (2.6 μg/kg) had aflatoxins below the suggested limit. It has been reported that 16% dried grapes from Brazil were found contaminated with AFB1 and AFB2 (Iamanaka, Menezes, Vicente, Leite, & Taniwaki, 2007).

3.2. Occurrence of AFs in analyzed nuts samples

Results of 105 nuts samples analyzed for aflatoxins are summarized (Table 3). It is evident from the results that four samples of apricot kernels, three of almonds with shell, four of walnuts with shell, seven of walnuts without shells, four of peanuts with shells, five of peanuts without shells, two of pistachios with shells, five of pistachios without shells and two of pine nuts with shells were found contaminated with aflatoxins.

Table 2
Total aflatoxins in dried fruits.

Commodities	Sample size/positive	Contamination (μg/kg)		Mean value (μg/kg)
		Below limit	Above limit	
Dried apricot	20/4	3 (1.5–3.2)[a]	1 (10.8)	4.55
Dates	20/2	2 (2.1–2.9)	–	2.5
Dried fig	10/5	2 (0.8–3.7)	3 (4.5–12.5)	5.81
Dried mulberries	15/4	4 (1.0–3.5)	–	2.22
Raisins	10/2	1 (2.6)	1 (7.5)	5.05

[a] total aflatoxin range.

Table 3
Total aflatoxins in edible nuts.

Commodities	Sample size/positive	Contamination (μg/kg)		Mean value (μg/kg)
		Below limit	Above limit	
Apricot kernels	15/4	3 (0.7–2.8)[a]	1 (5.6)	2.65
Almonds with shell	10/0	–	–	–
Almonds without shell	10/3	3 (1.2–3.4)	–	2.13
Walnuts with shell	10/4	2 (1.5–3.0)	2 (7.8–13.5)	6.45
Walnuts without shell	10/7	4 (0.8–3.6)	3 (6.0–10.8)	3.43
Peanuts with shell	10/4	3 (1.5–2.5)	1 (14.5)	5.10
Peanuts without shell	10/5	3 (0.7–3.8)	2 (6.4–12.8)	5.20
Pistachios with shell	10/2	2 (1.2–3.0)	–	2.10
Pistachios without shell	10/5	3 (2.0–3.6)	2 (9.5–14.0)	6.34
Pine nuts with shell	10/2	2 (2.6–3.9)	–	3.25

[a] total aflatoxin range.

In apricot kernels, out of four contaminated samples, one (5.6 μg/kg) was above the suggested limit and three showed aflatoxins ranging from 0.7 to 2.8 μg/kg were below the suggested limit. No contamination was found in samples of almond with shell, while three samples of almonds without shell had concentration ranging from 1.2 to 3.4 μg/kg were below the suggested limit.

In walnut with shell, two samples had concentration ranging from 1.5 to 3.0 μg/kg were below the suggested limit and two samples had contamination levels ranging from 7.8 to 13.5 μg/kg were above the suggested limit. Walnuts without shell showed maximum contamination levels among all the samples. Out of seven samples, four had concentration ranging from 0.8 to 3.6 μg/kg were below the suggested limit and three had concentration ranging from 6.0 to 10.8 μg/kg, above suggested limit fixed for aflatoxins by European legislations (European Commission, 2006a). Analysis of 40 in shell walnut samples in USA revealed that only 3 samples contained more than 1 μg/kg of total aflatoxins (AFT), several lots of walnut both in shell and shelled were unusually contaminated with AFB2 (Fuller, Spooncer, King, Schade, & Mackey, 1977). In peanuts with shell, one (14.5 μg/kg) out of 4 samples contaminated was above the permitted level and three samples had contamination levels ranging from 1.5 to 2.5 μg/kg were below the suggested limit, whereas peanuts without shell also showed high contamination level. Two samples had contamination levels ranging from 6.4 to 12.8 μg/kg were below; while three had concentration ranging from 0.7 to 3.8 μg/kg, above suggested limit fixed for aflatoxins. It has reported that 78% of raw peanut from Botswana contained aflatoxins at concentrations ranging from 12 to 329 μg/kg (Mphande, Siame, & Taylor, 2004). In China, peanut was found contaminated with aflatoxins, being the average level was 80.27 μg/kg and the highest level was 437.09 μg/kg (Wang & Liu, 2006).

Contamination by aflatoxins was also found in pistachios, two out of 10 samples of pistachio with shell had concentration ranging from 1.2 to 3.2 μg/kg were below suggested limit. Aflatoxins were found in five samples of pistachio without shell. Two out of 5 showed contamination ranging from 9.5 to 14.0 μg/kg, above permitted level, while three showed contamination ranging from 2.0 to 3.6 μg/kg were below the suggested limit. In pine nuts with shell, two out of 10 samples were found contaminated had concentration ranging from 2.6 to 3.9 μg/kg were below the suggested limit. Literature available on the occurrence of aflatoxins in pistachio from Morocco indicates higher levels of contamination (Cheraghali et al., 2007). According to a report published by Iranian Ministry of Health, 7926 pistachio samples were analyzed during

March 2001–March 2002, data indicated 761 samples contained AFB1 higher than 10 μg/kg (FDCL, 2002). In Qatar, it has been reported that in 37% pistachio kernels an incidence of total aflatoxins were found in the range of 0.53–289 μg/kg (Abdulkadar, Al-Ali, & Al-Jedah, 2000). Aflatoxins are regulated in more than 75 countries. The most common limits for AFB1 and total aflatoxins (B1, B2, G1 and G2) in food are 5 and 20 μg/kg respectively, and in countries belonging to the European Union (EU) are 2 and 4 μg/kg respectively (European Commission, 2006b; Van Egmond & Jonker, 2004;).

4. Conclusion

This study showed that among contaminated samples, dried apricot 5%, dried Fig. 30%, raisins 10% apricot kernels 6%, walnuts with shell 20%, walnuts without shell 30%, peanuts with shell 10%, peanuts without shell 20% and pistachios without shell 20% were above the permitted level for aflatoxins (4 μg/kg), which show the idea that "the percentage of contaminated samples merit continue with this kind of research". The absence of mycotoxin regulations should spur our national authorities to revise the proposed limits and also to introduce maximum limits especially for dried fruits and nuts since data reported in this work showed high aflatoxins content in some analyzed dried fruits and nut samples that are above European limits. A survey of a large kind of foodstuffs available in Pakistan for the occurrence of aflatoxins will be needed to completely assess the situation.

References

Abdulkadar, A. H. W., Al-Ali, A., & Al-Jedah, J. (2000). Aflatoxin contamination in edible nuts imported in Qatar. *Food Control, 11*, 157–160.

Bennett, J. W., & Klich, M. (2003). Mycotoxins. *Clinical Microbiology Reviews, 16*, 497–516.

Berry, C. L. (1998). The Pathology of mycotoxin. *Journal of Pathology, 154*, 301–311.

Centres for Disease Control and Prevention – CDC. (2004). Outbreak of aflatoxin poisoning-eastern and central provinces, Kenya, January–July 2004. *Morbidity and Mortality Weekly Report, 3*, 790–793.

Cheraghali, A. M., Yazdanpanah, H., Doraki, N., Abouhossain, G., Hassibi, M., Ali-Abadi, S., et al. (2007). Incidence of aflatoxins in Iran pistachio nuts. *Food and Chemical Toxicology, 45*, 812–816.

European Commission. (2002). Commission Directive No. 2002/27/EC of 13th March amending Directive No. 98/53/EC laying down the sampling methods and the method of analysis for the official control of the levels for certain contaminants in foodstuffs. *Official Journal of European Communities, L75*, 44–45.

European Commission. (2006a). Commission Regulation No. 1881/2006, Setting maximum levels of certain contaminants in foodstuffs. *Official Journal of the European Union* L364/5.

European Commission. (2006b). Commission Regulation (EC) No. 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs. *Official Journal of the European Union*. L364/5–L364/24.

Food and Drug Control Labs-FDCL. (2002). *The situation of aflatoxin contamination in pistachio during March 2001–March 2002*. Iranian Ministry of Health and Medical Education.

Frisvad, J. C., Thrane, U., & Samson, R. A. (2007). Mycotoxin producers. In J. Dijksterhuis, & R. A. Samson (Eds.), *Food mycology. A multifaceted approach to fungi and Food* (pp. 135–159). Boca Raton: CRC Press.

Fuller, G., Spooncer, W. W., King, A. D., Schade, J., & Mackey, B. (1977). Survey of aflatoxins in California tree nuts. *Journal of the American Oil Chemists' Society, 54*, 231–234.

Goeger, D. E., Hsie, A. W., & Anderson, K. E. (1999). Co-mutagenicity of Coumarin (1, 2-benzopyrone) with aflatoxin B1 and human liver S9 in Mammalian Cells. *Food and Chemical Toxicology, 37*, 581–589.

Iamanaka, B. T., Menezes, C. H., Vicente, E., Leite, R. S. F., & Taniwaki, M. H. (2007). Aflatoxigenic fungi and aflatoxins occurrence in sultanas and dried figs commercialized in Brazil. *Food Control, 18*, 454–457.

Karaca, H., & Nas, S. (2006). Aflatoxins, patulin and ergosterol contents of dried figs in Turkey. *Food Additives and Contaminants, 23*, 502–508.

Kritzinger, Q., Aveling, T. A. S., & Marasas, W. F. O. (2003). Myco.ora and fumonisin mycotoxins associated with cowpea [*Vigna unguiculata* (L.) Walp] seeds. *Journal of Agricultural and Food Chemistry, 51*, 2188–2192.

Molyneux, R. J., Mahoney, N., Kim, J. H., & Campbell, B. C. (2007). Mycotoxins in edible tree nuts. *International Journal of Food Microbiology, 119*, 72–78.

Mphande, F. A., Siame, B. A., & Taylor, J. E. (2004). Fungi, aflatoxins, and cyclopiazonic acid associated with peanut retailing in Botswana. *Journal of Food Protection, 67*, 96–102.

Pittet, A. (1998). Natural occurrence of mycotoxins in foods and feeds – An updated review. *Revue de Medicine Veterinaire, 149*, 479–492.

Smith, J. E., Solomons, G., Lewis, C., & Anderson, J. G. (1995). The role of mycotoxins in human and animal nutrition and health. *Natural Toxins, 3*, 187–192.

Stefanaki, I., Foufa, E., Tsatsou-Dritsa, A., & Photis, D. (2003). Ochratoxin A concentrations in Greek domestic wines and dried vine fruits. *Food Additives and Contaminants, 20*, 74–83.

Stroka, J., Anklam, E., Jorissen, U., & Gilbert, J. (2000). Immunoaffinity column cleanup with liquid chromatography using post-column bromination for determination of aflatoxins in peanut butter, pistachio paste, fig paste, and paprika powder: Collaborative study. *Journal of AOAC International, 83*, 320–340.

Van Egmond, H. P., & Jonker, M. A. (2004). Current situation on regulations for mycotoxins. In T. Yoshizawa, S. Kumagai, & T. Goto (Eds.), *New Horizon of Mycotoxicology for Assuring food Safety* (pp. 1–15). Tokyo: Japanese Association of Mycotoxicology.

Wang, J., & Liu, X. M. (2006). Surveillance on contamination of total aflatoxins in corn, peanut, rice, walnut and pine nut in several areas in China. *Chinese Journal of Preventive Veterinary Medicine, 4*, 33–37.

Zinedine, A., Brera, C., Elakhdari, S., Catano, C., Debegnach, F., Angelini, S., et al. (2006). Natural occurrence of mycotoxins in cereals and spices commercialized in Morocco. *Food Control, 17*, 868–874.