MYCOBIOTA OF SPICES AND AROMATIC HERBS

Dana Tančinová, Michal Mokrý, Zuzana Barboráková, Zuzana Mašková

ABSTRACT

A total of 67 samples of spices and herbs were tested for mould contamination. From 50.7% of samples, moulds were not isolated. The most dominant genera were Aspergillus and Penicillium. Potential producers of mycotoxins Aspergillus spp. and Penicillium spp. were tested for the ability to produce some mycotoxins. Isolates of potentially toxigenic species were found to produce various mycotoxins, namely aflatoxin B₁ (Aspergillus flavus), cyclopiazonic acid (Mycetinophora sphingeoides), sterigmatocystin (Emericella nidulans), roquefortine C (Penicillium roqueforti, P. chrysogenum, P. crustosum, P. expansum), penitrein A (P. crustosum) and patulin (P. expansum). Some of the tested isolates produce two mycotoxins: A. flavus (aflatoxin B₁ and cyclopiazonic acid), P. crustosum (roquefortine C and patulin) and P. expansum (roquefortine C and patulin). None of the tested isolates of Aspergillus section Nigri screened, appeared to produce ochratoxin A. Totally 11 samples were analysed for the presence of aflatoxins and ochratoxin A. Aflatoxin B₁ was found in 5 (45.5%) out of 11 samples analysed with levels ranging from 0.14 to 2.9 µg.kg⁻¹. In one sample we detected aflatoxin G₁. Ochratoxin A was found in 3 samples (27.3%), with levels ranging from 2.2 to 5.19 µg.kg⁻¹. No sample was contaminated by aflatoxins or ochratoxin A above the maximum admitted threshold established by the European legislation.

Keywords: mycobiota; spices; aflatoxin; ochratoxin A

INTRODUCTION

Spices have been used for flavour, colours, aroma and preservation of food or beverages for thousands years (Ozbeý and Kabak, 2012). Because of their processing and environmental conditions, spices can be heavily contaminated with toxigenic fungi and mycotoxins. Mycotoxins are secondary metabolites produced naturally by filamentous fungi, which are considered toxic substances when present in food for human and food for animals (da Rocha et al., 2014). For spices there are two groups of mycotoxins of concern, aflatoxins and ochratoxin A (Ozbeý and Kabak, 2012). Aflatoxins are produced by fungi that belong to Aspergillus genus and especially by Aspergillus flavus. Aspergillus parasiticus and Aspergillus nomius (Cary and Ehrlich, 2006, Marín et al., 2009). Ochratoxin A is a secondary metabolite produced by filamentous fungi of the genera Aspergillus and Penicillium present in a wide range of foodstuffs. The most relevant ochratoxin A producing species are Penicillium verrucosum, Aspergillus ochraceus, Aspergillus niger and Aspergillus carbonarius due to their prevalence in foodstuffs (cereals, grapes, coffee, etc.) and the number of strains are able to produce ochratoxin A (Amézqueta et al., 2012, Luque et al., 2013, Rodríguez et al., 2011). Prevention of microbial contamination in dried herbs and spices lies in the application of good hygiene practices during growing, harvesting and processing from farm to fork (Sagoo et al., 2009).

The aim of the study was the determination of potentially toxigenic filamentous fungi from genera Aspergillus and Penicillium from spices and herbs. A special emphasis was laid on the ability of isolated Aspergillus and Penicillium species to produce some significant toxic extrolites - mycotoxins.

MATERIAL AND METHODOLOGY

Samples

Totally 67 samples of spices and herbs from different countries (Table 1) were analysed. The samples (approximately 100 g) were collected from the storage rooms of food factory.

Mycological analysis

Dilute plate technique was used for isolation of fungi from the samples according to Samson et al. (2002). Sample in weigh of 20 g was mixed with 180 ml of saline solution (0.85% sodium chloride) with 0.05% Tween 80 in homogenizer. Then 0.1 ml of appropriate dilution made up to 10⁻² was applied on DRBC (Dichloran Rose Bengal Chloramphenicol agar). After 5 to 7 days of incubation at 25 ± 1°C, in dark resulting colonies were transferred onto appropriate identification media.

The identification of Aspergillus species. Conidial suspensions were inoculated at three equidistant points both on Czapek-yeast Extract agar (CYA), Czapek-yeast with 20% Sucrose (CY20S) and malt extract agar (MEA) and incubated in the dark at 25 ± 1°C, 7 days. Species identification was done according to Klich (2002), Pitt and Hocking (2009), Samson et al. (2002, 2010) and Samson and Varga (2007).

The identification of Penicillium species. The penicillia were inoculated at three equidistant points both on Czapek-yeast Extract agar (CYA), Malt Extract agar (MEA) and Creatine Sucrose agar (CREA) and incubated in dark at 25 °C. Sub-cultivation on CYA at 37 °C was...
used as well. Species identification was done after 7 days according to Pitt a Hocking (2009), Samson et al., (2002, 2010) and Frisvad a Samson (2004).

The identification of Fusarium species. Potato Dextrose agar (PDA) was used for observation of colony characteristics. “Synthetischer Nährstoffermer agar” (SNA) was used for micromorphological features. Cultures were incubated at the room temperature and natural light. Species identification was done after 10 days according to Leslie a Summerell (2006), Nelson et al. (1983), Nirenberg (1981) Pitt a Hocking (2009) and Samson et al. (2002, 2010).

**Mycotoxins screening by a modified agar plug method**

The cultivation for screening of extracellular metabolites (aflatoxin B₁, aflatoxin G₁, citrinin, patulin, ochratoxin A) were carried out on YES (Yeast Sucrose agar) and for intracellular (cyclopiazonic acid, penitrem A, roquefortin C, sterigmatocystin) on CYA (Czapek–yeast Extract agar); conditions of cultivation in dark at 25 °C, 14 days. In each tested isolate, 3 pieces of mycelium together with cultivation medium of approximately 5 x 5 mm area were cut from colonies and extracted in 1000 ml of chloroform:methanol (2:1, v/v) on vortex for 2 minutes. Then 20 µl of liquid phase of extracts along with standards (Sigma, Germany) were applied on TLC plate (Marchey-Nagel, Germany) and consequently developed in solvent system toluene:ethylacetate:formic acid (5:4:1, v/v/v). The visualisation of extrotoxins was carried out as follows: cyclopiazonic acid directly in daylight after spraying with the Ehrlich reagent (violet-tailed spot); patulin by spraying with 0.5% methylbenzothiazolone hydrochloride in methanol, heated at 130 °C for 8 min and then detectable as a yellow-orange spot; penitrem A after spraying with 20% AlCl₃ in 60% ethanol, heated at 130 °C for 8 min and then detectable as a dark green to black spot on daylight; roquefortin C after spraying with Ce(SO₄)₂ x 4 H₂O visible as an orange spot. Directly under UV light (365 nm) were visualised following mycotoxins: aflatoxin B₁ (blue spot), aflatoxin G₁ (green), citrinin (yellow-green), ochratoxin A (bluish-green), sterigmatocystin (reddish).

**The determination of mycotoxins in sample**

In the 11 samples were determined following mycotoxins: aflatoxin B₁, B₂, G₁, G₂ and ochratoxin A. Analyses were performed by HPLC method (high-pressure liquid chromatography) in an external accredited laboratory.

**RESULTS AND DISCUSSION**

In the current study from 50.7% of the samples, moulds were not isolated (basil, crushed black pepper, granulated garlic, curry, cumin powder, salvia, crushed chillies, crushed bay leaves, paprika (spicy), dill, crushed green pepper, savory). These findings are similar to data reported by Witkowska et al. (2011), where in 50% of samples of commercial herbs and spices were detected moulds. The fungal species recovered from the samples are listed in Table 2. Species of 11 genera were isolated and identified. The Aspergillus and Penicillium were the most common genera. Hashem and Alamri (2010) from 15 spices isolated as the most common genera Aspergillus, Penicillium and Rhizopus. Rhizopus (Rhizopus stolonifer) was isolated from granulated onion, only. Hammami et al. (2014), Kong et al. (2014), Yogendrarajah et al. (2014) and other authors reported Aspergillus and Penicillium as predominant fungi in spices. With regard to Aspergillus genus, the following species were isolated: A. flavus, A. fumigatus and Aspergillus section Nigri. A. flavus is a very important producer of aflatoxins and is frequently occurring in food commodities (Luo et al., 2012). Species of Aspergillus section Nigri are important producers of ochratoxin A.

In the Aspergillus section Nigri, A. niger and A. carbonarius produce ochratoxin A (Almela et al., 2007). The isolates of this section were the most frequent in our study.
Kong et al. (2014) isolated Aspergillus section Nigri as the most frequent in spices in China markets. Isolated penicillia were P. allii, P. atramentosum, P. crustosum, P. chrysogenum, P. expansum, P. glabrum, P. solitum (in alphabetical order). Hammami et al. (2014) detected P. aurantiogriseum, P. charlesi, P. verruculosum, P. citrinum, P. commune, P. griseofulvum, P. melanoconidium. Yogendrarajah et al. (2014) in their study identified Penicillium only as genus.

Apart from the two regulated mycotoxins in European Union (aflatoxins and ochratoxin A), we determined the ability of the isolates obtained from the analysed samples, to produce other mycotoxins (cyclopiazonic acid, patulin, penitrem A, roquefortine C and sterigmatocystin).

Table 2 Mycobiota isolated from the samples of spices and aromatic herbs

| Sample            | Isolated species (group)                                                                 |
|-------------------|------------------------------------------------------------------------------------------|
| crushed white pepper | Aspergillus section Nigri, Emericella nidulans, Eurotium sp., Penicillium crustosum, Penicillium expansum, Penicillium chrysogenum |
| marjoram          | Aspergillus section Nigri, Penicillium expansum                                           |
| garlic powder     | Aspergillus section Nigri, Penicillium allii, Penicillium chrysogenum                    |
| onion powder      | Aspergillus flavus, Aspergillus section Nigri, Penicillium glabrum, Penicillium chrysogenum |
| granulated onion  | Aspergillus section Nigri, Penicillium sp., Rhizopus stolonifer                           |
| crushed marjoram  | Aspergillus section Nigri, Aspergillus fumigatus, Cladosporium sp., Penicillium atramentosum, Penicillium solitum |
| crushed ginger    | Aspergillus flavus, Aspergillus section Nigri, Paecilomyces sp.                          |
| nutmeg            | Paecilomyces sp.                                                                           |
| paprika           | Penicillium chrysogenum                                                                    |
| chive             | Fusarium proliferatum                                                                     |
| leaves of parsley | Alternaria sp., Geotrichum candidum                                                        |
| leaves of celery  | Cladosporium herbarum, Geotrichum candidum                                                 |

Table 3 Potential ability of moulds isolated from spices and aromatic herbs to produce relevant mycotoxins in in vitro conditions, tested by TLC method

| Tested isolates | Source of isolates | OTA | AFB1 | AFG1 | CPA | STER | RC | PA | PAT |
|-----------------|--------------------|-----|------|------|-----|------|----|----|-----|
| Aspergillus section Nigri | crushed white pepper | 0/1 | -    | -    | -   | -    | -  | -  | -   |
|                  | marjoram           | 0/1 | -    | -    | -   | -    | -  | -  | -   |
|                  | garlic powder      | 0/2 | -    | -    | -   | -    | -  | -  | -   |
|                  | granulated onion   | 0/1 | -    | -    | -   | -    | -  | -  | -   |
|                  | crushed ginger     | 0/1 | -    | -    | -   | -    | -  | -  | -   |
| Aspergillus flavus | granulated onion   | 1/1 | 0/1  | 1/1  | -   | -    | -  | -  | -   |
|                  | crushed ginger     | 0/1 | 0/1  | 1/1  | -   | -    | -  | -  | -   |
| Emericella nidulans | crushed white pepper | -  | -    | -    | -   | 1/1  | -  | -  | -   |
| Penicillium allii | garlic powder      | -   | -    | -    | -   | 2/2  | -  | -  | -   |
| Penicillium chrysogenum | crushed white pepper | -  | -    | -    | -   | 3/3  | -  | -  | -   |
|                  | garlic powder      | -   | -    | -    | -   | 2/2  | -  | -  | -   |
|                  | paprika            | -   | -    | -    | -   | 1/1  | -  | -  | -   |
| Penicillium crustosum | crushed white pepper | -  | -    | -    | -   | 1/1  | 1/1| -  | -   |
| Penicillium expansum | crushed white pepper | -  | -    | -    | -   | 1/1  | -  | 1/1| -   |
|                  | marjoram           | -   | -    | -    | -   | 1/1  | -  | -  | 1/1 |

** number of tested isolates, * number of isolates with ability to produce mycotoxin, OTA - ochratoxin A, AFB1 - aflatoxin B1, AFG1 - aflatoxin G1, CPA - cyclopiazonic acid, STER - sterigmatocystin, RC - roquefortine C, PA - penitrem A, PAT - patulin, TLC - thin layer chromatography

Kong et al. (2014) isolated Aspergillus section Nigri as the most frequent in spices in China markets. Isolated penicillia were P. allii, P. atramentosum, P. crustosum, P. chrysogenum, P. expansum, P. glabrum, P. solitum (in alphabetical order). Hammami et al. (2014) detected P. aurantiogriseum, P. charlesi, P. verruculosum, P. citrinum, P. commune, P. griseofulvum, P. melanoconidium. Yogendrarajah et al. (2014) in their study identified Penicillium only as genus.

Apart from the two regulated mycotoxins in European Union (aflatoxins and ochratoxin A), we determined the ability of the isolates obtained from the analysed samples, to produce other mycotoxins (cyclopiazonic acid, patulin, penitrem A, roquefortine C and sterigmatocystin).
The ability to produce relevant mycotoxins are shown in Table 3. The isolates of potentially toxigenic species were found to produce various mycotoxins, namely aflatoxin B1 (Aspergillus flavus), cyclopiazonic acid (Aspergillus flavus), sterigmatocystin (Emericella nidulans), roquefortine C (Penicillium allii, P. chrysogenum, P. crustosum, P. expansum), penitrem A (P. crustosum) and patulin (P. expansum). Some of the tested isolates produce two mycotoxins: A. flavus (aflatoxin B1 and cyclopiazonic acid), P. crustosum (roquefortine C and patulin) and P. expansum (roquefortine C and patulin). None of the tested isolates Aspergillus section Nigri screened appeared to produce ochratoxin A.

Totally 11 samples were analysed for the presence of aflatoxins and ochratoxin A (Table 4). Aflatoxin B1 was found in 5 (45.5%) out of 11 samples analysed with levels ranging from 0.14 to 2.9 µg.kg⁻¹. No sample was contaminated by aflatoxin B2 above the maximum admitted threshold established by the European legislation (Commission regulation, 2010b). In one sample we detected aflatoxin G1. Ochratoxin A was found in 3 of samples (27.3%), with levels ranging from 2.2 to 5.1 µg.kg⁻¹. No sample was contaminated by ochratoxin A above the maximum admitted threshold established by the European legislation (Commission regulation, 2010a).

Prelle et al. (2014) showed that 15.4% and 23.8% of samples were contaminated with aflatoxins and ochratoxin A, respectively. In our study, 2.3% of spice samples contaminated by ochratoxin A get over the threshold admitted by European Regulation. Zhao et al. (2013) presented that about 11% of the 480 Chinese spices samples tested contained detectible levels of aflatoxin B1, with the highest concentrations found in chili, prickly ash and pepper. Zinedine et al. (2006) reported the higher level of aflatoxin B1 contamination in red paprika (9.68 µg.kg⁻¹). The analysis of the spice samples contamination (in Morocco) with aflatoxin B1 revealed that paprika is frequently contaminated, since 95% were contaminated with mycotoxin and 40% of samples exceeded European regulation for that contaminant (Mahgubi et al., 2013). Co-occurrence of aflatoxin B1 and ochratoxin A in samples of crushed chillies and paprika was detected in our study. Ozbey a Kabak (2012) reported co-occurrence of these mycotoxins in 62.5% of red chilli flake, 40.9% of red chilli powder and 4.3% pepper of powder samples.

CONCLUSION

From 50.7% of samples, moulds were not isolated. The most dominant genera were Aspergillus and Penicillium. The isolates of potentially toxigenic species were found to produce various mycotoxins (aflatoxin B1, cyclopiazonic acid, sterigmatocystin, roquefortine C, penitrem A and patulin). None of the tested isolates Aspergillus section Nigri screened appeared to produce ochratoxin A. Totally 11 samples were analysed for the presence of aflatoxins and ochratoxin A. Aflatoxin B1 was found in 45.5% out of 11 samples analysed. Ochratoxin A was found in 27.3% of samples.

REFERENCES

Almela, L., Rabe, V., Sánchez, B., Torrella, F., López-Pérez, J. P. 2007. Ochratoxin A in red paprika: Relationship with the origin of the raw material. Food Microbiology, vol. 24, no. 4, p. 319-327. [http://dx.doi.org/10.1016/j.fm.2006.08.001] PMid:17189757

Amézqueta, S., Schorr-Galindo, S., Murillo-Arbizu, M., González-Peñas, E., López de Cerain, A., Guiraud, J. P. 2012. OTA-producing fungi in foodstuffs: A review. Food Control, vol. 26, no. 2, p. 259-268. [http://dx.doi.org/10.1016/j.foodcont.2012.01.042]

Cary, J. W., Ehrlich, K. C. 2006. Aflatoxinigenicity in Aspergillus: molecular genetics, phylogenetic relationships and evolutionary implications. Mycopathologia, vol. 162, no. 3, p. 167-177. [http://dx.doi.org/10.1007/s11046-006-0051-8] PMid:16944284

Commission regulation (a) (EU) No. 105/2010 of 5 February 2010 amending Regulation (EC) No 1881/2006 setting maximum levels for certain contaminants in foodstuffs as regards ochratoxin A. Official Journal of the European Union L 35, p. 7-8.

Commission regulation (b) (EU) No. 165/2010 of 26 February 2010 amending Regulation (EC) No 1881/2006 setting maximum levels for certain contaminants in foodstuffs

| Sample               | Mycotoxins (µg.kg⁻¹) |
|----------------------|----------------------|
|                      | AFB1 | AFB2 | AFG1 | AFG2 | OTA |
| crushed white pepper | <0.10 | <0.10 | <0.10 | <0.10 | <0.20 |
| crushed chillies     | 0.14  | 0.10  | <0.10 | <0.10 | 5.19  |
| nutmeg               | 0.14  | <0.10 | <0.10 | <0.10 | <0.20 |
| paprika (spicy)      | <0.10 | <0.10 | <0.10 | <0.10 | 2.2   |
| paprika              | 0.11  | <0.10 | <0.10 | <0.10 | 2.35  |
| crushed green pepper | <0.10 | <0.10 | <0.10 | <0.10 | <0.20 |
| crushed black pepper | 2.9   | <0.10 | 3.2   | <0.10 | <0.20 |
| crushed ginger       | <0.10 | <0.10 | <0.10 | <0.10 | <0.20 |
| nutmeg               | 0.55  | <0.10 | <0.10 | <0.10 | <0.20 |
| paprika (spicy)      | <0.10 | <0.10 | <0.10 | <0.10 | <0.20 |

AFB1 - aflatoxin B1, AFB2 - aflatoxin B2, AFG1 - aflatoxin G1, AFG2 - aflatoxin G2, OTA - ochratoxin A

Table 4 Contamination of spices with aflatoxins and ochratoxin A
as regards aflatoxin. Official Journal of the European Union L 50, p. 8-12.

da Rocha, M. E., da Chagas Oliveira Freire, F., Feitoza Maia, F. E., Florindo Guesed, M. I., Rondina, D. 2014. Mycotoxins and their effects on human and animal health. Food Control, vol. 36, no. 1, p. 159-169. http://dx.doi.org/10.1016/j.foodcont.2013.08.021

Hammani, W., Fiori, S., Thani, R., Kali, N. A., Balmas, V., Migheli, Q., Jauoua, S. 2014. Fungal and aflatoxin contamination of marketed spices. Food Control, vol. 37, p. 177-181. http://dx.doi.org/10.1016/j.foodcont.2013.09.027

Hashem, M., Alamri, S. 2010. Contamination of common spices in Saudi Arabia markets with potential mycotoxin-producing fungi. Saudi Journal of Biological Sciences, vol. 17, p. 167-175. http://dx.doi.org/10.1016/j.sjbs.2010.02.011 PMid:23961074

Klich, M. A. 2002. Identification of common Aspergillus species. Wageningen: Ponsen & Looijen, 116 p. ISBN 90-70351-46-3.

Kong, W., Wei, R., Logrieco, A., Wei, J., Wei, J., Wen, J., Xiao, X., Yang, M. 2014. Occurrence of toxigenic fungi and determination of mycotoxins by HPLC-FLD in functional foods and spices in China markets. Food Chemistry, vol. 146, p. 320-326. http://dx.doi.org/10.1016/j.foodchem.2013.09.005 PMid:24176349

Labuda, R., Tančinová, D. 2006. Fungi recovered from Slovakian poultry feed mixtures and their toxigenicity. Annals of Agricultural and Environmental Medicine, vol. 13, p. 193-200. PMid:17195991

Leslie, J. F., Summerell, B. A. 2006. The Fusarium Laboratory Manual. Australia: Blackwell Publishing, 388 p. ISBN 978-0-8138-1919-8.

Luque, M. I., Córdoba, J. J., Rodríquez, A., Núñez, Adrade, M. J. 2013. Development of a PCR protocol to detect ochratoxin A producing moulds in food products. Food Control, vol. 29, p. 270-278. http://dx.doi.org/10.1016/j.foodcont.2012.06.023

Luo, J., Vogel, R. F., Niessen, L. 2012. Development and application of a loop-mediated isothermal amplification assay for rapid identification of aflatoxicogenic molds and their detection in food samples. International Journal of Food Microbiology, vol. 159, p. 214-224. http://dx.doi.org/10.1016/j.ijfoodmicro.2012.08.018 PMid:23107500

Mahgubi, A. E., Puel, O., Bailly, S., Tadrist, S., Querin, A., Ouadia, A., Oswald, I. P., Bailly, J. D. 2013. Distribution and toxigenicity of Aspergillus section Flavi in spices marketed in Morocco. Food Control, vol. 32, p. 143-148. http://dx.doi.org/10.1016/j.foodcont.2012.11.013

Marin, S., Colom, C., Sanchis, V., Ramos, A. J. 2009. Modelling of growth of aflatoxicogenic A. flavus isolates from red chilli powder as a function of water availability. International Journal of Food Microbiology, vol. 128, p. 491-496. http://dx.doi.org/10.1016/j.ijfoodmicro.2008.10.020 PMid:19046614

Nelson, P. E., Toussoun, T. A., Marasas, W. F. O. 1983. Fusarium species. An illustrated Manual for Identification. USA: The Pennsylvania State University. 193 p. ISBN 0-271-00349-9

Ozbek, F., Kabak, B. 2012. Natural co-occurrence of aflatoxins and ochratoxin A in spices. Food Control, vol. 28, no. 2, p. 354-361. http://dx.doi.org/10.1016/j.foodcont.2012.05.039

Pitt, J. I., Hocking, A. D. 2009. Fungi and food spoilage. 3rd ed. London, New York: Springer Science + Business Media, LLC 2009, 519 p. ISBN 978 0-387-92206-5

Prell, A., Spadaro, D., Garibaldi, A., Gullino, M. L. 2014. Co-occurrence of aflatoxins and ochratoxin A in spices commercialized in Italy. Food Control, vol. 39, 192-197. http://dx.doi.org/10.1016/j.foodcont.2013.11.013

Rodriguez, A., Rodriguez, M., Luque, M. I., Justesenh, A. F., Córdoba, J. J. 2011. Quantification of ochratoxin A-producing molds in food products by SYBR Green and TaqMan real-time PCR methods. International Journal of Food Microbiology, vol. 149, p. 226-235. http://dx.doi.org/10.1016/j.ijfoodmicro.2011.06.019 PMid:21802757

Sahoo, S. K., Little, C. L., Greenwood, M., Mithani, V., Grant, K. A. McLachlin, J. 2009. Assessment of the microbiological safety of dried spices and herbs from production and retail premises in the United Kingdom. Food Microbiology, vol. 26, p. 39-43. http://dx.doi.org/10.1016/j.fm.2008.07.005 PMid:19028303

Samson, R. A., Frisvad, J. C. 2004. Polyphasic taxonomy of Penicillium subgenus Penicillus: new taxonomic schemes, mycotoxins and other exotoxins. Studies in Mycology 49, Utrecht, The Netherlands: Centraalbureau voor Schimmelcultures, 2004, 260 p. ISBN 90-70351-53-6

Samson, R. A., Van Reenen-Hoekstra, E. S., Frisvad, J. C., Filtenborg, O. 2002. Introduction to food-borne fungi. Utrecht: Centraalbureau voor Schimmelcultures, 389 p. ISBN 90-70351-42-0.

Samson, R. A., Houbraiken, U., Thrane, U., Frisvad, J. C., Andersen, B. 2010. Food and Indoor Fungi. Utrecht: CBS-KNAW Fungal Biodiversity Centre, 390 p. ISBN 978-90-70351-82-3

Samson, R. A., Varga, J. (eds.) 2007. Aspergillus systematics in the genomic era. Studies in Mycology, 59, Utrecht: CBS Fungal Biodiversity Centre, 206 p. ISBN 978-90-70351-69-4

Witkowska, A. M., Hickey, D. K., Alonso-Gomez, M., Wilkinson, M. C. 2011. The microbiological quality of commercial herb and spice preparations used in the formulation of a chicken supreme ready meal and microbial survival following a simulated industrial heating process. Food Control, vol. 22, no. 3-4, p. 616-625. http://dx.doi.org/10.1016/j.foodcont.2010.10.014

Yogendrarajah, P., Deschuyfleer, N., Jacksens, L., Sneyers, P., J., Maene, P., De Saeger, S., Devlieghere, F., De Meulenaer, B. 2014. Mycological quality and mycotoxin contamination of Sri Lankan peppers (Piper nigrum L.) and subsequent exposure assessment. Food Control, vol. 41, p. 219-230. http://dx.doi.org/10.1016/j.foodcont.2014.01.025

Zhao, X., Schaffner, D. W., Yue, T. 2013. Quantification of aflatoxin risk associated with Chinese spices: Point and probability risk assessments for aflatoxin B1. Food Control, vol. 33, no. 2, p. 366-377. http://dx.doi.org/10.1016/j.foodcont.2013.03.012

Zinedine, A., Brera, C., Elakhdari, S., Catano, C., Debegnach, F., Angelini, S., De Santis, B., Faid, M., Benelmihi, M., Minardi, V., Miraglia, M. 2006. Natural occurrence of mycotoxins in cereals and spices commercialized in Morocco. Food Control, vol. 17, p. 868-874. http://dx.doi.org/10.1016/j.foodcont.2005.06.001
Acknowledgments:
This work was co-funded by European Community under project no 26220220180: Building Research Centre “AgroBioTech”.

Contact address:
Dana Tančinová. Slovak University of Agriculture in Nitra, Faculty of Biotechnology and Food Sciences, Department of Microbiology, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, E-mail: dana.tancinova@uniag.sk.

Michal Mokrý. Ružičková 561/8, Kamenc pod Vtáčnikom, 972 44 Kamenc pod Vtáčnikom, Slovakia. E-mail: michal.mokry@sk.nestle.com.

Zuzana Barboráková. Černík č. 332, 941 05 Černík, Slovakia, E-mail: zuzana.barborakova@gmail.com.

Zuzana Mašková. Slovak University of Agriculture in Nitra, Faculty of Biotechnology and Food Sciences, Department of Microbiology, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, E-mail: zuzana.maskova@uniag.sk.