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A Review of Ochratoxin Contamination Effects and Its Control

Ramesh, C. [1*] and Jayagoudar, S.[2]

[1]Department of Botany, Karnatak University, Dharwad;[2] Department of Botany, G.S.S. College, Belagavi.

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Abstract Mycotoxins are secondary metabolites produced by spectrum of fungi. Mycotoxin contamination of agricultural commodities is one of the major problem in agricultural trade and food industry, fungal contamination causes a considerable damage to quality and taste of the agricultural commodities. Fungal contamination occurs from field to fork level. In recent years, mycoflora and mycotoxin contamination of agricultural commodities had drawn the attention of the people; by their damage and harmful effects on humans and animals by the consumption of such contaminated food and food materials.
Among mycotoxins, aflatoxin and ochratoxins are the common most mycotoxins; aflatoxins produced by *Aspergillus flavus* and *Aspergillus parasiticus,* Ochratoxins are produced by mainly *Aspergillus ochraceous* and other related *Penicillium* species. Ochratoxins are classified into Ochratoxin-A, B, C among these Ochratoxins, Ochratoxin-A is the most common. OTA is classified as class-2B toxin, Ochratoxin–A contamination was recorded in various agricultural commodities, there are various influencing factors which contribute to the growth and development of the fungi, among those temperature and relative humidity plays very important role, Ochratoxins are having the several health effects on humans and animals. There are several efforts have been made to reduce Ochratoxin contamination in agricultural commodities and food materials. viz. good agricultural and hygienic practices, preservation, storage, transportation etc. leads to reduction in the level of Ochratoxin contamination along with these efforts, several International agencies trying their level are best to reduce OTA contamination in food and agricultural industry.

Keywords: Agricultural commodities, Mycoflora, Mycotoxins, Ochratoxins, OTA

Introduction

Mycotoxin contamination is common problem in agriculture and food industry. Fungal contamination of food agricultural commodities takes place at various level viz. during harvesting, processing and transportation, levels. When the fungi get suitable atmosphere for the growth and development, they grow and colonize. There are many fungal species which were isolated from various agricultural commodities. A spectrum of mycotoxins where screened by various analytical methods. (Garrido *et al.,* 2013 and Makun *et al.,* 2013). There are reports even OTA screened from

[*]**Coressponding author:** Ramesh. C.; **Email**: drchramesh@rediffmail.com

fruit juices (Al. Hazmi, 2010) and from chili and chili powder samples (Iqbal, *et al.,* 2013). Ochratoxin-A is one of the most important mycotoxin produced by some species of the genera *Aspergillus* and *Pencillium.* Ochraoxin-A is common contaminant food and food products, due to its range of its toxic effects, OTA problem is need to be addressed (Skarkova *et al.,* 2013).

Poor agricultural and storage conditions lead to mould contamination and mycotoxin production, (Keller *et al.,* 2013). OTA was also detected in several grains (Beheshti *et al.,* 2013).There are report which show co-occurrence of aflatoxins and ochratoxin contamination in spices (Ozbey *et al.,* 2012). Aflatoxins and ochratoxin-A was analyzed from retail cereal products from Turkey (Kabak, 2012). There are efforts have been done to reduce and eliminate and to nullify the effects of mycotoxins from the different food samples by different methods particularly by Gamma radiations from pepper samples (Jalali *et al.,* 2012). Aflatoxins and ochratoxin level in various food stuffs analyzed all over the world; from Chest nuts (Pietri *et al.,* 2012). Analysis OTA from cereal derived food products (Ozden *et al.,* 2012). Co-occurrence of analytical studies of various mycotoxins have been observed from rice (Almeida *et al.,* 2012).

Non sanitary practices during the harvesting, transportation and storage in the production of Chili could introduce mycotoxin contamination (Jalili *et al.,* 2012), almost 20 to 25% of the agricultural production may be contaminated with fungal toxins (Rubert *et al.,* 2010; Afsah-Hejri *et al.,* 2012). Ochratoxin A is one important mycotoxin produced by several species of *Penicillium* and *Aspergillus*, human exposure to OTA was mainly through intake of contaminated food (Munoz *et al.,* 2011). Mycotoxin contamination may occur during pre harvest, storage and transportation for the mycotoxin reduction there should be a strict implementation and follow of HACCP protocols (Hazard Analysis And Critical Control Point).Protocol and regulations and GAP's (Good Agricultural Practices) are very important (Ahn*et al.,* 2010). Many international organization and countries have set regulatory limits for Ochratoxin-A (Zaied *et al.,* 2010). Fungal growth mainly influenced by climatic conditions Viz, temperature and humidity; good storage and agricultural practices reduce the risk of contamination (Uysal *et al.,* 2009). Some of the studies revealed a significant yearly variations in crop years (Aksoy *et al.,* 2007). Mycotoxins toxic secondary metabolites produced by fungi these metabolites are highly toxic to humans and animals (Mortensen *et al.,* 2003) and Even air borne dust, fungal conidia can be a source of OTA (Skaug *et al.,* 2000). Ochrtacoxin–A is a nephrotoxic, nephro-carcinogenic mycotoxin which is produced by two fungal Genera *Aspergillus* and *Penicillium* (Studer-Rohr *et al.,* 1995).OTA common contaminant of various food including cereals, spices, beverages and other agricultural products (Jarmila *et al.,* 2013). The majority of the sample shows the various mycotoxins at relatively low levels and growth of

the mould favored by the weather conditions formation of mycotoxins may vary from year to year (Reinhold *et al.,* 2011). Mycotoxin analytical techniques should be universal and fast on the site screening (Goryacheva *et al.,* 2006), because of the persistence of OTA production in food chain leads to potential human health hazards (Monaci *et al.,* 2004).

Maximum Levels of Ochratoxin-A of Some Food Stuffs According To EU- Regulation **(**Commission Regulation (EC) No 1881/2006)

Table 1 Commission Regulation (EC) No 1881/2006

2.2	**Ochratoxin A**	**Maximum levels (µg/kg)**
2.2.1	Unprocessed cereals	5,0
2.2.2	All products derived from unprocessed cereals, including processed cereal products and cereals intended for direct human consumption with the exception of foodstuffs listed in 2.2.9 and 2.2.10	3,0
2.2.3	Dried vine fruit (currants, raisins and sultanas)	10,0
2.2.4	Roasted coffee beans and ground roasted coffee, excluding soluble coffee	5,0
2.2.5	Soluble coffee (instant coffee)	10,0
2.2.6	Wine (including sparkling wine, excluding liqueur wine and wine with an alcoholic strength of not less than 15 % vol) and fruit wine (11)	2,0 (12)
2.2.7	Aromatised wine, aromatised wine-based drinks and aromatized wine-product cocktails (13)	2,0 (12)
2.2.8	Grape juice, concentrated grape juice as reconstituted, grape nectar, grape must and concentrated grape must as reconstituted, intended for direct human consumption (14)	2,0 (12)
2.2.9	Processed cereal-based foods and baby foods for infants and young children (3) (7)	0,50
2.2.10	Dietary foods for special medical purposes (9) (10) intended specifically for infants	0,50
2.2.11	Green coffee, dried fruit other than dried vine fruit, beer, cocoa and cocoa products, liqueur wines, meat products, spices and liquorice	—

(3) Foodstuffs listed in this category as defined in Commission Directive 96/5/EC of 16 February 1996 on processed cereal-based foods and baby foods for infants and young children (OJ L 49, 28.2.1996, p. 17) as last amended by Directive 2003/13/EC (OJ L 41, 14.2.2003, p. 33).

(7) The maximum level refers to the dry matter. The dry matter is determined in accordance with Regulation (EC) No 401/2006.

(9) Foodstuffs listed in this category as defined in Commission Directive 1999/21/EC of 25 March 1999 on dietary foods for special medical purposes (OJ L 91, 7.4.1999, p. 29).

(10) The maximum level refers in the case of milk and milk products, to the products ready for use (marketed as such or reconstituted as instructed by the manufacturer) and in the case of products other than

milk and milk products, to the dry matter. The dry matter is determined in accordance with Regulation (EC) No 401/2006.

(11) Foodstuffs listed in this category as defined in Council Regulation (EC) No 1493/1999 of 17 May 1999 on the common organisation of the market in wine (OJ L 179, 14.7.1999, p. 1) as last amended by the Protocol concerning the conditions and arrangements for admission of the Republic of Bulgaria and Romania to the European Union (OJ L 157, 21.6.2005, p. 29).

(12) The maximum level applies to products produced from the 2005 harvest onwards.

(13) Foodstuffs listed in this category as defined in Council Regulation (EEC) No 1601/91 of 10 June 1991 laying down general rules on the definition, description and presentation of aromatised wines, aromatised wine-based drinks and aromatised wine-product cocktails
(OJ L 149, 14.6.1991, p. 1) as last amended by the Protocol concerning the conditions and arrangements for admission of the Republic of Bulgaria and Romania to the European Union. The maximum level for OTA applicable to these beverages is function of the proportion of wine and/or grape must present in the finished product.

(14) Foodstuffs listed in this category as defined in Council Directive 2001/112/EC of 20 December 2001 relating to fruit juices and certain similar products intended for human consumption (OJ L 10, 12.1.2002, p. 58).

The Annex to Regulation (EC) No 1881/2006 is amended as follows:

Table 2. Commission Regulation (EU) No 105/2010
1. Point 2.2.11 is replaced by the following points:

2.2.11.	Spices *Capsicum* spp. (dried fruits thereof, whole or ground, including chillies, chilli powder, cayenne and paprika) *Piper* spp. (fruits thereof, including white and black pepper) *Myristicafragrans*(nutmeg) *Zingiberofficinale*(ginger) *Curcuma longa* (turmeric) Mixtures of spices containing one or more of the abovementioned spices	30 µg/kg as from 1.7.2010 until 30.6.2012 15 µg/kg as from 1.7.2012
2.2.12.	Liquorice (*Glycyrrhizaglabra, Glycyrrhiza inflate* and other species	
2.2.12.1.	Liquorice root, ingredient for herbal infusion	20 µg/kg
2.2.12.2.	Liquorice extract (42), for use in food in particular beverages and confectionary	80 µg/kg’

(42) The maximum level applies to the pure and undiluted extract, obtained whereby 1 kg of extract is obtained from 3 to 4 kg liquorice root).’

OTA Contamination

OTA is one of the common contaminant of most food and food products, due to the wide range of its toxic effects, OTA problem is need to be addressed (Skarkova *et al.,* 2013). Fungal contamination of agricultural commodities takes place at various level viz. during harvesting, transportation, processing levels. When the fungi get suitable atmosphere for the growth, they grow and colonize. Fungal growth mainly favored by the climate conditions mainly temperature and humidity (Zaied *et al.,* 2010),

OTA common contaminant of various food including cereals, spices, beverages and other Agricultural Products (Skarkova *et al.,* 2013). The majority of the samples shows mycotoxins occurrence at relatively low levels and growth of the mould favored by the weather conditions, formation of the mycotoxins vary from year to year (Reinhold *et al.,* 2011). mycotoxin analytical techniques should be universal fast and on the site screening (Goryacheva *et al.,* 2006).

OTA contamination also transferred from food to animal production by consumption (Afsah-Hejri *et al.,* 2012). Human exposure to OTA was mainly through the intake of contaminated food (Munoz*et al.,* 2011).

Several authors across the world analyzed various agricultural commodities to check the OTA level of contamination. OTA is the one of the common mycotoxin found in grapes and grape juice it considered to be one of the harmful contaminant (Terra *et al.,* 2012). A few authors evaluated OTA contamination in non alcoholic beverages (Mahdavi *et al.,* 2007) OTA in the instant coffee samples (De Almeida *et al.,* 2007) assessment of mycotoxin contamination in staple cereals (Gwary *et al.,* 2012) study of aflatoxigenic and ochratoxigenic fungi and find their mycotoxins from five types of the spices by (Jeswal *et al.,* 2015). Ochratoxin- A in spices from Dharwad by High Performance Liquid Chromatography (Ramesh *et al.,* 2014) detection of fungal contamination and mycotoxins levels in peanut butter (Boli *et al.,* 2014) correlation of OTA levels in wine and vine environment (Rotaru *et al.,* 2011).Effect of roasting techniques the OTA reduction was reported by (Castellanos-Onorio *et al.,* 2011) presence of OTA in Grapes is dependent on the climatic conditions, during the maturation, ripening to reduce to the contamination sanitary practices are important (Belajova *et al.,* 2007).

OTA causes renal toxicity nephropathy and immune suppression in several species of animals (IARC monograph Vol.56). Ochratoxin-A: an antiinsectan metabolite from the sclerotia of *Aspergillus carbonarius* NRRL 369 (Wicklow *et al.,* 1996). OTA structurally consisting of chlorophenylic group containing dihydroisocoumarin moiety that is linked to L-phenylalanine and hypothetical (Khoury*et al.,* 2010).

(Reddy *et al.,* 2010) The major mycotoxin producing fungi *Aspergillus, Fusarium*and *Penicillium* important mycotoxins are aflatoxins, fuminosins, ochratoxins, cyclopiazonic acid petuline, zeralenone and nivanol. Mycotoxins are diverse group of fungal metabolites they have a wide variety of toxic effects (Kumar *et al.,* 2008). Regulatory limit of OTA varies with the type of Agricultural commodity (Commission Regulation (EC) No 1881/2006; Commission Regulation (EU) No 105/2010).

Effects

Ochratoxin-A is important mycotoxin produced by some of the genera *Pencillium* and *Aspergillus.* due to the wide range of its toxic effects OTA; OTA problem is need to be addressed (Skarkova, *et al.,* 2013). Poor agricultural and storage conditions lead to mould contamination and mycotoxin production, (Keller *et al.,*2013).

Mycotoxins are diverse group of fungal metabolites they have a variety of toxic effects (Kumar*et al* 2008) regulatory limit of OTA varies with the type of Agricultural commodity (Commission Regulation (EC) No 1881/2006; Commission Regulation (EU) No 105/2010), several attempts have been made to reduce, eliminate and to nullify the effects of mycotoxins from the different food samples by different methods (Jalali *et al.,* 2012). Human exposure to OTA was mainly through the intake of contaminated food (Munoz *et al.,* 2011). OTA contamination also transferred from food to animal production by consumption (Afsah-Hejri *et al.,* 2012). Many international organization and countries have set regulatory limits for OTA (Zaied *et al.,* 2010). OTA is an important common contaminant of various food including cereals, spices, beverages and other Agricultural Products (Skarkova *et al.,* 2013),because of the persistence of OTA production in food chain leads to human health hazards (Monaci *et al.,* 2004).

OTA has shown to be nephrotoxic, hepatotoxic, teratogenic, genotoxic compound by intake of the contaminated food and feed results into the impact on health and productivity (Denli *et al.,* 2010).

OTA is regarded as toxic member of fungal secondary metabolite ochratoxin mixtures or contamination with other mycotoxins my cause serious threat to humans and animals (Heussner*et al.,* 2015). OTA toxicity been found to involves; production of free radicals and oxidative stress (Domijan *et al.,* 2005), contamination mycotoxins in fodder makes the health problems of animals and people. Biological detoxification is one of the known strategy of mycotoxin Management (Slizewska *et al.,* 2014). OTA causes renal toxicity, nephropathy and immune suppression in several species of animals (IARC monograph Vol.56).

(Stoev *et al.,* 2010) studied carcinogenic and toxic effects of OTA in chicks. exposure to mycotoxins is mostly through injection, dermal and inhalation means (Peraica *et al.,* 1999).Thomas *et al.,* 2014 studied the quelling of OTA production by RNA interference. Toxico-pathlogical effects of in Vivo inoculation of OTA in chick embryo and hatched chicks was studied by (Hassan *et al.,* 2012).

Table 3. Commodity wise Ochratoxin-A analysis

Name of the commodity	Type	Author /reference
Soybean	Mycotoxins	Garrido *et al.,* 2013
Foods	Ochratoxin- A	Makun *et al.,* 2013
Apple juice	Patulin and Ochratoxin- A	N.A. Al-Hazmi, 2010
Red rice	Mycotoxigenic Fungi and mycotoxins	Samsudin *et al.,* 2013
Chilli and Chilli Sauce	Aflatoxins and Ochratoxin- A	Iqbal *et al.,* 2013
Food	Ochratoxin A	Skarkova *et al.,* 2013
Corn silage	Mycotoxins	Keller *et al.,* 2013
Grains	Ochratoxin- A	Beheshti *et al.,* 2013
Spices	Aflatoxins and Ochratoxin- A	Ozbey *et al.,*2012
	Ochratoxin- A	Ramesh *et al.,* 2014
Chestnuts and Chestnut flour	Aflatoxins and ochratoxin- A	Pietri *et al.,* 2012
Rice	Ochratoxin- A	Feizy *et al.,* 2011
Capsicum powder	Aflatoxins, Ochratoxin A and Zearalenone	Santos *et al.,* 2010
Foodstuffs	Ochratoxin- A	Chung *et al.,* 2009
Coffee	Ochratoxin- A	Rohr *et al.,* 1995
Cereals	Mycotoxins	Zinedine *et al.,* 2006
Feed	Citrinin and Ochratoxin A	Kononenko *et al.,* 2013
Tropical wine and grape juice	Ochratoxin A	Terra *et al* 2012
Staple Cereals	Total Aflatoxins and Ochratoxin-A	Gwary *et al.,* 2012
Peanut Butters	Fungal contamination and mycotoxins	Boli *et al.,* 2014
Wine with vine environment	ochratoxin A	Rotaru *et al.,* 2011
commercially important agricultural commodities	Mycotoxin and mycoflora	Kumar *et al.,* 2008

Control Measures

Ochratoxin contamination takes place from field to fork level hence there is a need to control OTA contamination at each level. To address this problem there should be good agricultural practices, storage practices, strong regulator measures in the form of HACCP protocols, regulations and code of practice are needed.

Control at cultivation level

1. By Crop rotation.
2. Selection of Resistant varieties.
3. Avoid temperature and drought stress during the Seedling growth.

Pre-harvest level

1. Minimize the insect and mechanical damage.
2. Control of weeds.
3. Harvest should be done on full maturity.

Harvest level

1. Hygienic and handling practices.
2. Proper drying and cleaning is required without the other matter.

Storage practices

1. Preservation of properly dried materials.
2. Storage is done in well ventilated structures.
3. Good housekeeping Home keeping procedures should be followed.
4. Transportation also done in good condition.

For the fungal contamination proper drying, aeration and the preservation temperature plays important role number (Codex alimentarius FAO-WHO CAC/RCP-51-2003 revised 2014) code of practice also goes with the type of agricultural commodity, post harvest practice, value addition and preservation practices, quality control by training programs (Codex alimentarius commission FAO-WHO CX/FAC 99/14November 1998).

An ideal method for the reducing the health risk of by reducing OTA contamination. There are several authors who stressed on biological control to prevent OTA Contamination or detoxify the foods (Ciconova *et al.,* 2010). Occurrence of citrinin and ochratoxin-A in different feed ingredients was screened by ELISA (Kononenko *et al.,* 2013).OTA is produced by *Aspergillus ochraceus* and *Penicillium verrucosum, Penicillium varidicatum.* OTA synthesis takes place in the variable conditions (Pohland*et al.,* 1992). OTA is fungal secondary metabolite, may cause serious threats to humans and animals (Heussner *et al.,* 2015) Their concentration is depends on climatic zone and Biological detoxification is one of the known strategy of mycotoxin management (Slizewska *et al.,* 2014) there are various methods to analyze the production in various matrices (IARC monograph Vol. 56).

Conclusion

Mycotoxins are secondary metabolites produced by *Aspergillus ochraceous* and other related *Penicillium* species. Mycotoxin contamination of agricultural commodities is one of the major problem in agricultural trade. Fungal contamination causes a considerable damage to quality and taste of the agricultural commodities. Fungal contamination occurs from field to fork level. In recent years mycotoxin contamination of agricultural commodities drawn the attention of the people and scientific community by

their degree of damage and harmful effects on humans and animals by the consumption of such contaminated food.

Ochratoxins are classified into ochratoxin-A, B, C among these ochratoxins, ochratoxin-A is the most common. OTA is classified as class-2B toxin. Ochratoxin–A contamination was recorded in various agricultural commodities, various factors which contribute to the growth and development of the fungi, among those temperature and relative humidity are playing important role, Ochratoxins are having the several health effects on humans and animals. There are efforts have been made to reduce ochratoxin contamination in agricultural commodities and food materials. Viz. good agricultural and hygienic practices, preservation, storage, transportation etc. leads to reduction in the level of ochratoxin contamination along with these efforts. Several international agencies trying their level are best to reduce OTA contamination in food and agricultural industry by the international food quality and contaminants regulations.

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