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Assessment of aflatoxin level in stored wheat of godowns of hyderabad division and decontamination by UV radiation

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Abstract

Cereals and their products play crucial role as supplier of energy globally and among cereals wheat is the most important cereals in this regard and is known to be the Pakistan's 4th major crop. Wheat at all stages of growth and storage subject to numerous problem of deterioration due to the mycotoxin colonization which not only contaminate wheat but also hazardous to human and animal when consumed as food or feed therefore in present study efforts were made to reduce the aflatoxin contamination load from wheat, for this purpose UV radiation of time dependent dose (0, 5, 10, 20, 40, 80 and 160 minutes) was used to decontaminate aflatoxin and results observe that 80-90% and 65-73% decrease in the aflatoxin in both wheat samples exposed that is wheat exposed as open grain and the grain packed in sacks. After UV treatment the residues examination showed that residues was become within the MRLs set by FDA except wheat samples packed in the sack, Bolhari and Sehwan that were at the borderline of risk with 20 ng/g concentration and Aarazi showed residue (21 ng/g) which was found above the limit after the 5 minutes exposure time. UV was found to be most effective method in reduction level of aflatoxin from wheat and protect grain from deterioration during storage, provide safe food or feed consumption and minimize the annual wheat loss.

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Introduction

Approximately 20-40% of agricultural products were contaminated with mycotoxin and become a sever agricultural problem (Pittet, 1998), resulting in food and feed contamination this outcome was due to poor harvesting and indecorous storage which help to increase the fungal growth (Wagacha & Muthomi, 2008) and Fungal growth lessen the food quality and become a major concern in human toxication because these moulds are carcinogenic, teratogenic, hepatotoxic and mutagenic (Chu, 1991; Pariza, 1996). Fungal genera such as *Aspergillus, Penicillum, Fusarium, Altenaria* and *Claviceps* produced mycotoxin over variety of food (Adebajo & Diyaolu, 2003). Among all mycotoxin Aflatoxin are the potent mycotoxin and Agency for Research on Cancer has classified naturally-occurring mixtures of aflatoxins as carcinogenic to humans in group 1 (Salem and Ahmad, 2010) produced by *A. parasiticus and A. flavus*. Aflatoxin can contaminate variety of food including figs, nuts (peanut, walnut, almond and pistachio), cereals (wheat, maize, barley and rice), cottonseed and oil products (FAO/WHO). Environmentally hot and humid areas favour mycotoxin production in cereals, Pakistan is located in south East Asia and having the environment most likely favourable for the mycotoxin colonization (Paterson & Lima, 2011; Alam *et al.*, 2012).

Wheat is leading grain crop and staple food for the people of Pakistan (Anonymous, 2010). Large part of wheat milled into flour (atta, a high extraction flour) and used for the chapaties, naans, pastas and various bakery goods (Anjum *et al.*, 1991) whereas milling has little effect in whole meal flour against decontamination of metabolically active aflatoxin and if this active aflatoxin present can cause DNA modification (Eaton & Gallagher, 1994). Grain protection during storage is major issue globally (Gras *et al.,* 2000) and situation getting worse with each increasing day where there is no regulation for these toxins (Van Egmond *et al.,* 2007). Uncontrolled moisture content and thermal changes found to be the major factor for mycotoxin production (Styriak *et al.*, 1998). It is very difficult to remove them from food commodities and the best method of control is prevention because these toxins are environmentally stable as resistant towards thermal changes (Scudamore, 2005).

Therefore it is intense need of today to develop appropriate methods to control as well as to eliminate these deadly toxins, and many methods such as roasting, gamma rays exposure, sunlight, and microwave heating was studied as decontaminant for aflatoxin (Hussain *et al.,* 2011; Herzallah, 2008) and Overview of some scientific studies shown that mycotoxin production can be affected with light sources without effecting nutritional qualities of food (Samarajeewa *et al.,* 1990). Bennett *et al.* (1981) found no growth of aflatoxin under light at temperature 35 and 40°C, whereas growth was found good at this temperature. It was reported that aflatoxin B1 was degraded under UV radiation (Lillard & Lantin, 1970).

The use of ultraviolet-C (UV-C) radiation having germicidal effect has widely been reported for destroying the pathogenic fungi including aflatoxins & other fungal metabolites that may contaminate food products. A number of in-vitro studies have revealed the efficiency of UV–C radiation on microbial inhibition (Gardner & Sharma, 2000; Ribiero & Alvarenga, 2012). Aziz and Smyk (2002) assessed that near-UV radiation and nitrosamines had a mutagenic effect on the induction of aflatoxins and ochratoxin A synthesis by nontoxigenic moulds. Toxins was lost under UV radiations of 365nm wavelength (Yousef & Marth, 1987).

The research has been conceptualized by Visualizing scenario of the seriousness of aflatoxin production problem during storage and their stability towards environmental conditions and many processing methods, therefor in present work appropriate method of UV radiations and exposure time has found to decontaminate aflatoxin from wheat during storage without affecting protein value of wheat. Study may helpful for Pakistan to compete in export and at the national and regional markets.

Materials and methods

Wheat samples was collected from all government godowns of Hyderabad division namely Bolhari, Hali road, Fatah chowk, Hala city, Matiyaari, Thatta, Tandpallhyaar, Dadu, K.N shah, Sehwan and Aarazi. Wheat in godowns were stored in sacks and stacked over one another, which is found to be major factor of change of temperature and moisture and creates favourable environment for aflatoxin growth. Sampling was done form upper, central and bottom sacks of one selected stack. During sampling temperature was recorded 37-52°C and moisture of all godowns were in the range of 37-52%

Mycological Study

Agar plate method was used for determination of mycoflora described by Mathur *et al.* (2003) and relative isolation frequency (Fq.) of aflatoxin producing fungi (*Aspergillus parasiticus and Aspargillus flavus*) was calculated (Fatma Bensassi *et al.*, 2011).

Sample Extraction and analysis

For quantitative analysis 25ml of 70% methanol was added in ground wheat samples and filtered through wahtman no. 1 filter paper, and filtrate was used for the analysis by Enzyme linked immunosorbent assay (ELISA) technique and commercially immunoassay kit i-e Neogen ELISA Kit (Veratox , Product no. 8030) was used, the kit was based on competitive direct enzyme linked immunosorbent assay format. Concentration was calculated by ELISA 'state fax 2100' (Awareness technology).

Decontamination methods

In present study the UV irradiation method was employed for the decontamination of aflatoxin by choosing wheat from godown, a common wheat storage form using in Pakistan and method was pertained to be useful for the bulk quantity of wheat stored and can be easily applied at godown for aflatoxin level reduction and extend wheat storage time duration with minimizing aflatoxin colonozitation. To compete in national and international market Pakistan has to establish quality control system of wheat at the time of storage and the method used in this study will help in this regard. The wheat was irradiated under UV as open grain and wheat grain packed in sacks (a common packing material using in the godowns).

Wheat under the UV were exposed at the intensity 0.1mW cm−2 at 254nm UV-C, at the 15cm away from UV tube. Exposure time was divided in different time durations of 0, 5, 10, 20, 40, 80 and 160 minutes on both open and as well as on the grain packed in sack. 1kg of wheat sample were taken moreover open grain was layered about 3cm in a tray.

Protein analysis

Protein contents was analysed according to standard method (AACC, 2000).

Data analysis

All the experiments had three replicates. Data was analyzed for one-way analysis of variance followed by Student-Newman-Keuls multiple test at 0.05 level using compare means procedure of SPSS 16.

Results and discussion

The results of aflatoxin reduction percentage after treatment showed in table. 1 that revealed the high rate of decontamination were noted among the samples of 160 minutes exposure in the grain that openly exposed under UV as well as the grain packed in Sacks i-e 80 to 90% in open grain and 65 to 73% in wheat closed in sacks and minimum reduction percentage was observed after five minutes exposure time, open grain were showed 18- 27% reduction and 17-23 % reduction was observed in wheat grain packed in sacks.

Present results are in consistent with Attal *et al.* (2004) reported that short and long wavelength of UV were found useful in complete elimination of aflatoxin and ochratoxin in wheat grain. UV radiation were used in time dependent manner for mycotoxin the zearalenone (ZEN) and deoxynivalenol (DON) decontamination in solid and moist forms (Murata *et al.*, 2008). Aflatoxin contaminated nuts were exposed

to UV-C radiation at 265nm for 15, 30 and 45 minutes and was found proportional decrease in aflatoxin with increase in exposure duration. Poultry feed samples containing 500 µg kg−1 ochratoxin were 100 % decontaminated in 180 minutes with UV-C at 254nm and at distance of 25 cm (sumbal *et al.,* 2015). The results were further supported by Garge *et al.* (2013) Maximum reduction of aflatoxin concentration was observed after 10 hour of exposure in the nuts samples at two distances i-e 15 and 30 cm, at 15 cm aflatoxin concentration reduced to 99.1 % and at a distance of 30 cm, reduction of 97.4% was observed. Under UV irradiation (intensity: 1.5mW/cm² at 254 nm UV-C wavelength) deoxynivalenol was reduced significantly (p> 0.05) 13ug/g (22%) after 30 minutes exposure on corn silage (Murata *et al.*, 2011).

Table 1. Reduction percentage (%) of open wheat grain and grain in sack under UV.

Godowns	Minute (0)	Minutes (5)	Minutes (10)	Minutes (20)	Minutes (40)	Minutes (80)	Minutes (160)
Open Grain							
Bolhari	0	18^{a}	31^{a}	40^{a}	54^{ab}	72^{a}	86^{a}
Hali road	0	21^{a}	36^{a}	42^{a}	57	68^{a}	89^{a}
Fatah Chowk	0	27^{a}	38^{a}	44^{a}	61^{abc}	72^{a}	83^{a}
Hala city	0	22^{a}	38^{a}	44^{a}	66^{c}	77^{a}	88^{a}
Matiyaari	0	20^{a}	33^{a}	46^{a}	53	86^{a}	80^{a}
Thatta	0	25^{a}	31^{a}	43^{a}	62^{abc}	68^{a}	87^{a}
Tando allahyaar	0	23^{a}	38^{a}	46^{a}	76^{c}	69^{a}	84^{a}
Dadu	0	27^{a}	36^{a}	40^{a}	63^{abc}	72^{a}	90^{a}
K.N Shah	0	26^{a}	34^{a}	47^{a}	56	69^{a}	86^{a}
Sehwan	0	26^{a}	34^{a}	43^{a}	60^{abc}	73^{a}	82^{a}
Aarazi	0	22^{a}	36^{a}	47^{a}	63^{abc}	77^{a}	86^{a}
F-Statistics at df = 32		2.0	1.9	0.9	3.9	1.6	0.8
Grain In Sack							
Bolhari	0	9^{a}	27^{a}	36^{a}	50^{a}	54^{a}	72^{ab}
Hali road	0	15^{a}	31^{a}	36^{a}	52^{a}	57^{a}	68^{ab}
Fatah Chowk	0	22^{a}	33^{a}	33^{a}	55^{a}	55^{a}	72^{ab}
Hala city	0	11^{a}	27^{a}	38^{a}	50^{a}	55^{a}	66^{ab}
Matiyaari	0	20^{a}	33^{a}	33^{a}	53^{a}	53^{a}	66^{a}
Thatta	0	18^{a}	31^{a}	37^{a}	50^{a}	56^{a}	68^{ab}
Tando allahyaar	0	23^{a}	30^{a}	38^{a}	53^{a}	61^{a}	69^{ab}
Dadu	0	22^{a}	31^{a}	40^{a}	54^{a}	59^{a}	72^{ab}
K.N Shah	0	21^{a}	26^{a}	39^{a}	52^{a}	60^{a}	69^{ab}
Sehwan	0	17^{a}	34^{a}	43^{a}	52^{a}	66^{a}	73^{b}
Aarazi	0	22^{a}	31^{a}	31^{a}	54^{a}	63^{a}	68^{ab}
F-Statistics at df = 32		1.5	1.7	1.4	1.6	1.8	2.9

*Values followed by the same letter are not significantly different at 0.05 level Student-Newman-Keuls test.

Figure 1 and 2 shows positive correlation of aflatoxin reduction percent with exposure time Under UV as the time of exposure increase the reduction will also be increased in both samples i-e open and as well as packed wheat grain.

Data in table 2 shows the residues remaining after UV treatment and the residues was observed within the permissible range of aflatoxin i-e 20 ng/ g set by FDA in the wheat that openly exposed under UV light but the residues was reduced more after 160 minutes exposure time (2 t 3 ng/g). UV exposure upon wheat grain packed in sack were also found useful in residues reduction except three wheat samples Bolhari, Sehwan and Aarzi showed residues near to risk line an above the maximum residue limit that is 20 and 21 ng/g under 5 minutes exposure time. High residues reduction was observed from 4-7ng/g in the

packed wheat samples after 160 minutes exposure time. Results are in consistent with Trombete *et al.* (2014) assessed highest contamination of aflatoxin were found in whole wheat grain whereas the overall average was 0.69 µg/kg which was under the limit of Brazilian legislation (5 µg/kg) only one sample exceeding this limit. Summer and winter wheat was contaminated with aflatoxin but concentration were under permissible limits (Taheri *et al.,* 2012) and Out of 83 wheat samples 1.2% of samples were positive for *AFB1* with concentration of 25.6 µg/Kg (Abdullah *et al.*, 1998).

Table 2. Residues remaining after UV treatment (ng/g).

Godowns	Minutes (0)	Minutes (5)	Minutes (10)	Minutes (20)	Minutes (40)	Minutes (80)	Minutes (160)
			Open Grain				
Bolhari	22[a]	18[a]	15[a]	13[a]	10[a]	6[a]	3[a]
Hali road	19[a]	15[a]	12[a]	11[a]	8[a]	6[a]	2[a]
Fatah Chowk	18[a]	13[a]	11[a]	10[a]	7[a]	5[a]	3[a]
Hala city	18[a]	14[a]	11[a]	10[a]	6[a]	4[a]	2[a]
Matiyaari	15[a]	12[a]	10[a]	8[a]	7[a]	2[a]	3[a]
Thatta	16[a]	12[a]	11[a]	9[a]	6[a]	5[a]	2[a]
Tando allahyaar	13[a]	10[a]	8[a]	7[a]	3[a]	4[a]	2[a]
Dadu	22[a]	16[a]	14[a]	13[a]	8[a]	6[a]	2[a]
K.N Shah	23[a]	17[a]	15[a]	12[a]	10[a]	7[a]	3[a]
Sehwan	23[a]	17[a]	15[a]	13	9[a]	6[a]	4[a]
Aarazi	22[a]	17[a]	14[a]	11.5	8[a]	5[a]	3[a]
F-Statistics at df = 32	0.8	0.6	0.7	0.8	0.8	0.5	0.4
			Grain in Sack				
Bolhari	22	20[a]	16[a]	14[a]	11[a]	10[a]	6[a]
Hali road	19	16[a]	13[a]	12[a]	9[a]	8[ab]	6[a]
Fatah Chowk	18	15[a]	12[a]	12[a]	8[a]	8[ab]	5[a]
Hala city	18	16[a]	13[a]	11[a]	9[a]	8[ab]	6[a]
Matiyaari	15	12[a]	10[a]	10[a]	7[a]	7[ab]	5[a]
Thatta	16	13[a]	11[a]	10[a]	8[a]	7[ab]	5[a]
Tando allahyaar	13	11[a]	9[a]	8[a]	6[a]	5[a]	4[a]
Dadu	22	18[a]	15[a]	13[a]	10[a]	9[ab]	6[a]
K.N Shah	23	19[a]	12[a]	14[a]	11[a]	9[ab]	7[a]
Sehwan	23	20[a]	22[a]	13[a]	11[a]	7.8[ab]	6[a]
Aarazi	22	21[a]	17[a]	15[a]	10[a]	8[ab]	7[a]
F-Statistics at df = 32	1.2	1.0	1.5	0.9	1.3	1.9	1.4

*Values followed by the same letter are not significantly different at 0.05 level Student-Newman-Keuls test.

Effect of UV radiation on Crude Protein

Wheat are known to be the rich source of protein and protein are sensitive against irradiation and become denatured under long exposure, due to aflatoxin attack proteins was noted altered from their standard value and found average 11.9%. results are in agreement with previously reported data that Concentration of proteins in samples contaminated with *A. Flavus* were noted 12.04% (Embaby *et al.,* 2012). It was observed from the results that no effect was found on protein after UV treatment. Garg *et al.* (2013) reported no effect were seen in the nutritional values of peanuts when treated with UV irradiation for decontamination of aflatoxin.

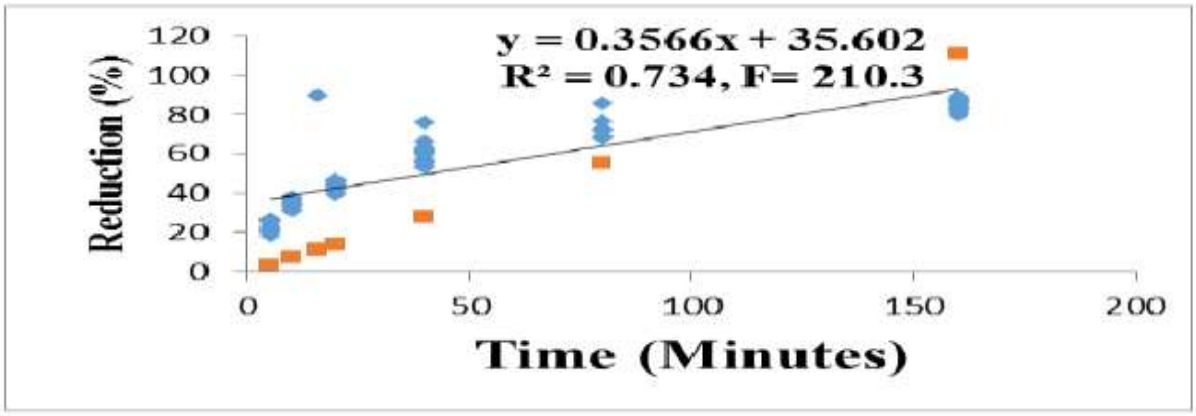

Fig. 1. Regression curve of Aflatoxin reduction (%) in relation with UV exposure time of open wheat grain.

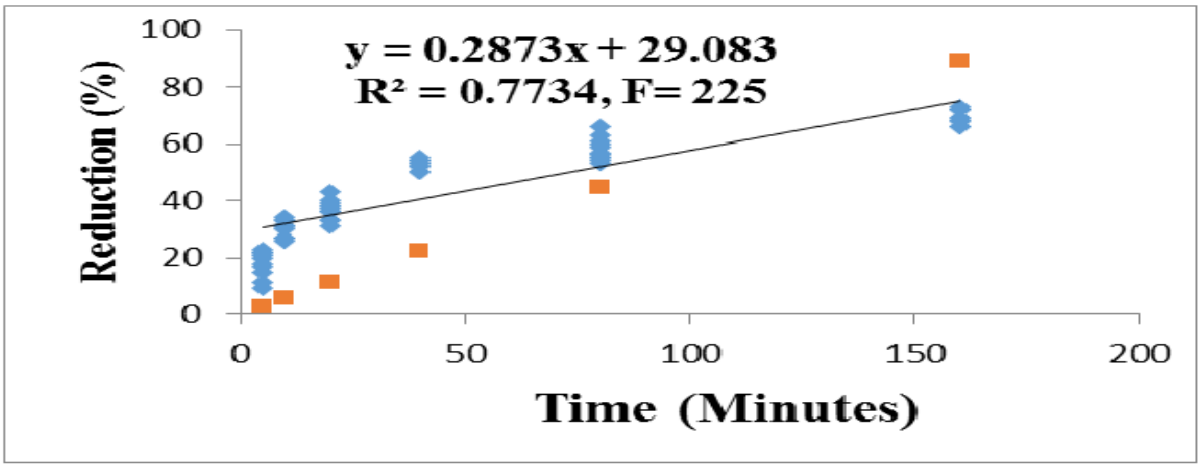

Fig. 2. Regression curve of Aflatoxin reduction (%) in relation with UV exposure time of wheat grain packed in sacks.

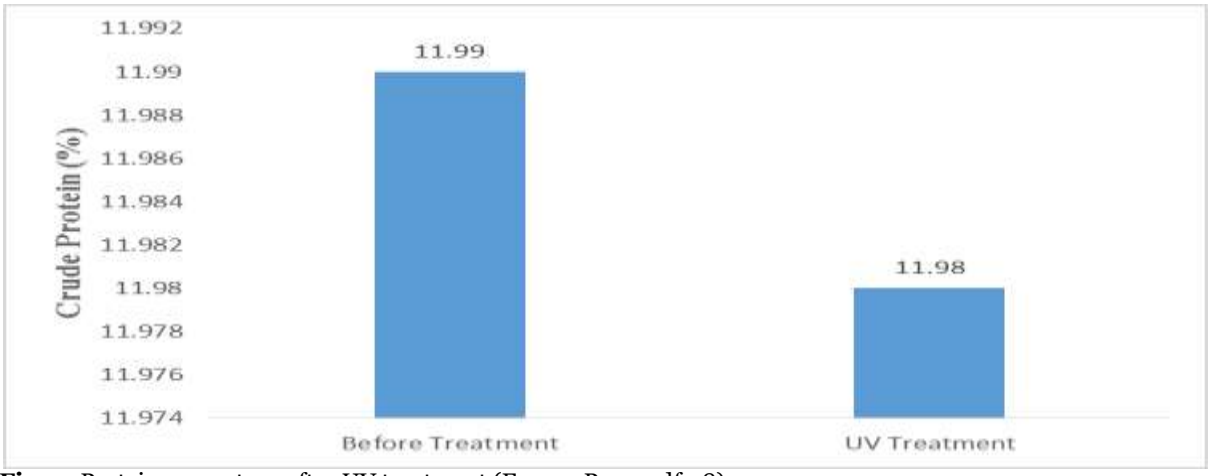

Fig. 3. Protein percentage after UV treatment (F= 0.3, P=0.7, df =8).

Conclusion

It was concluded that UV was found appropriate method in regard with aflatoxin reduction. Exposure time showed positive correlation with aflatoxin decontamination as the exposure time increases the aflatoxin was reduced more and concentration of aflatoxin was noted to highly decreases after exposure time of 160 minutes i-e 82-90% and residues level was 2-4ng/g in open grain, 65-73% reduction with 4-7ng/g residues was observed in the grain closed in sacks.

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References

AACC. 2000. Approved Methods of the American Association of Cereal Chemists,
10th edn.St. Paul, Minnesota , USA.

Abdullah N, Nawawi A, Othman I. 1998. Survey of fungal counts and natural occurrence of aflatoxins in Malaysian starch-based foods. Journal of Mycopathology **143,** 53-8.

Adebajo LO and Diyaolu SA. 2003. Mycology and spoilage of retail cashew nuts. African Journal of Biotechnology **2,** 369-373.

Alam S, Shah HU, Khan H, Magan N. 2012. The Effect of Substrate, Season, and Agroecological Zone on Mycoflora and Aflatoxin Contamination of Poultry Feed from Khyber Pakhtunkhwa, Pakistan Mycopathologia **174,** 341-349.
http://dx.doi.org/10.1007/s11046-012-9545-8. Epub 2012 Apr 29.

Anjum FM, Ali A, Chaudhry NM. 1991. Fatty acid, mineral composition and functional (bread and chapati) properties of high protein and high lysine barley line. Journal of Scienceof Food and Agriculture **55,** 511-519.
http://dx.doi.org/10.1002/jsfa.2740550403

Atalla MM, Hassanein NM, El-Beih AA, Youssef YA. 2004. Effect of Fluorescent and UV Light on Mycotoxin Production under Different Relative Humidities in Wheat Grains. International Journal of Agriculture Biology **6,** 1006-1012.

Aziz NH, Smyk B. 2002. Influence of UV radiation and nitrosamines on the induction of mycotoxins synthesis by nontoxigenic moulds isolated from feed samples. Nahrung **46,** 118–21.
http://dx.doi.org/10.1002/15213803(20020301)46:2<118::AID-FOOD118>3.0.CO;2-#

Bennett JW, Dunn JJ, Goldsman CI. 1981. Influence of white light on production of aflatoxins and anthraquinones in Aspergillus parasiticus. Journal Applied and Environmental Microbiology **41,** 488–91

Chu FS. 1991. Mycotoxins: food contamination, mechanism, carcinogenic potential and preventive measures. Journal of Mutation Research **259,** 291–296.
http://dx.doi.org/10.1016/0165-1218(91)90124-5

Embaby EM, Nahed M, Ayaat NH, El-Hamid ABD, Mona M, Abdel-Galil AA, Yaseen M, Younos A. 2012. Detection of Fungi and Mycotoxin Affected Wheat Quality. Journal of Applied Science Research **8,** 3382-3392.

FAO/WHO. 2007. First Session of the Joint FAO/WHO Food Standards Programme Codex Committee on Contaminants in Foods, Discussion Paper on Aflatoxin Contamination in Brazil Nuts. World Health Organization, Beijing.

Fatma B, Chennaoui M, Hassen B, Mohamed RH. 2011. Survey of the mycobiota of freshly harvested wheat grains in the main production areas of Tunisia. African Journal of Food Science **5,** 292-298.

Felipe MT, Douglas de ÁM, Yuri DP, Thaís BS, Glória MD, Marcelo EF, Tatiana S. 2014. Determination of Aflatoxins in Wheat and Wheat by products Intended for Human Consumption, Marketed in Rio de Janeiro, Brazil. Journal of Food & Nutrition Research **10,** 671-674.

Gras PW, Kaur S, Lewis DA, Riordan BO, Suter DAI, Thomson WKT. 2000. How and why to keep wheat quality constant. In: Australian Post Harvest Conference 195-198.

Garg N, Manjeet A, Saleem J, Rakesh K. 2013. Studies for optimization of conditions for reducing Aflatoxin Contamination in Peanuts using Ultraviolet Radiations. Internationa Journal of Drug Development and research **5,** 408-424.

Gardner DW, Sharma G. 2000. Modeling UV induced inactivation ofmicroorganisms on surfaces. Journal of Food Protection **63,** 63–70.

Herzallah SK, Alshawabekh, Fatafath A. 2008. Aflatoxin Decontamination of Artificially Contaminated Feeds by Sunlight, γ-Radiation and Microwave Heating. Journal of Poultry Science Association **17,** 515-521. http://dx.doi.org/10.3382/japr.2007-00107

Hussain A, Ali J, Akther S, Shafqat U. 2011.Degradation of aflatoxins by roasting in contaminated peanuts. Pakistan Journal of Biochemistry and Molecular Biology **44,** 56-59.

Lillard DA, Lantin RS. 1970. Some chemical characteristics and biological effects of photomodified aflatoxins. Journal of Association in Analytical Chemistry **53,** 1060–1063

Mathur SB, Olga K. 2003. Common Laboratory seed healthy testing methods for detecting Fungi ,Danish Government Institute of Seed Pathology for Developing Countries Thorvaldsensvey 57, DK-1871 Frederiksberg C, Copenhagen, Denmark. Page no. 399.

Pariza WM. 1996. Toxic substances. In O. R. Fennema (Ed.), Food chemistry, New York: Marcel Dekker Ed. 3rd, 825–841.

Paterson R, Lima N. 2011. Further mycotoxin effects from climate change. Food Research International journal **44,** 2555-2566. http://dx.doi.org/10.1016/j.foodres.2011.05.038

Pittet A. 1998. Natural occurrence of mycotoxins in foods and feeds an update review. Review Medical and Veterinary **149,** 479-492. http://dx.doi.org/10.1111/1541-4337.12122

Ribiero C, Canada J, Alvarenga B. 2012. Prospects of UV radiation for application in postharvest technology. Journal of Food and Agriculture **24,** 586-597. http://dx.doi.org/10.9755/ejfa.v24i6.14677

Salem NM, Ahmad R. 2010. Mycotoxins in food from Jordan: Preliminary survey. Journal of Food Control **21,** 1099– 1103. http://dx.doi.org/10.1016/j.foodcont.2010.01.002

Samarajeewa U, Sen AC, Cohen MD, Wei CIA.1990. Detoxification of aflatoxins in foods and feeds by physical and chemical methods. Journal of Food Protection **53,** 489–501

Scudamore KA. 2005. Identifying Mycotoxins is Paramount in the fight against their spread. Journal of Word Grain **23,** 36-39.

SPSS. Base16.0 User's Guide, SPSS Inc. 2007.

Styriak I, Conkova E, Laciakova A, Buhm J. 1998. Prevention of fumonisin production by microorganism. Czeeh Journal of Animal Scinces **43,** 449-452.

Sumbal GA, Shar ZH, Sherazi STH, Siraj U, Nizamani SM, Mahesar SA. 2015. Decontamination of poultry feed from ochratoxin A by UV and sunlight radiations. Journal of science and agriculture 23, [Epub ahead of print] http://dx.doi.org/10.1002/jsfa.7384.

Taheri N, Semnan S, Roshandel G, Namjoo M, keshavarzian H, Chogan AG, Ghasemi KF, Joshaghani H. 2012. Aflatoxin Contamination in Wheat Flour Samples from Golestan Province, Northeast of Iran. Iran Journal of Public Health **41,** 42–47.

Van Egmond HP, Schothorst RC, Jonker MA. 2007. Regulations relating to mycotoxins in food: perspectives in a global and European context. Journal of Analytical and bioanalytical chemistry **389,** 147-157**.** Epub ahead of print http://dx.doi.org/10.1007/s00216-007-1317-9

Wagacha JM, Muthomi JW. 2008. Mycotoxin problem in Africa: Current status, implications to food safety and health and possible management strategies. International Journal of Food Microbiology **124,** 1 –12. http://dx.doi.org/10.1016/j.ijfoodmicro.2008.01.008

Yousef AE, Marth EH. 1987. Kinetics of interaction of aflatoxin M1 in aqueous solutions irradiated with ultraviolet energy. Journal of Agriculture and Food Chemistry **35,** 785–789. http://dx.doi.org/10.1021/jf00077a035