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Mycobiota and Mycotoxins Associated with Wheat Grains and some of its Products in Upper Egypt

Hamdy, Rania, M.[1]; M.N. El- Rify [2]; A.A. Zohri [3] and W.S.M. Ragab [4, 5]

[1, 2, 4]Department of Food Science & Technology, College of Agric., Assiut university, Egypt
[3]Dept. of Botany and Microbiology, College of Science, Assiut University, Egypt
[5]Dept. of Biology, College of Sci., Univ. of Hafr Al Batin, P.O. Box 1803, Saudi Arabia

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Abstract

Mycobiota and mycotoxins associated with wheat grains and some of its products intended for human consumption in Upper Egypt, such as wheat flour, kishk, shamsy bread, Burghol and biscuits have been investigated. The obtained results indicated that all the studied products showed various levels of fungal contamination specially wheat flour, which was highly contaminated, followed by wheat burghol. Many species belonging to several genera of fungi were isolated from all the studied products. *Aspergillus* was the most predominant genus followed by *Penicillium*. Aflatoxin B_1 detected in 40% of burghol samples and 20% of wheat grains and kishk samples. Sterigmatocystin detected in 40 % of wheat grain samples, meanwhile zearalinone occurred in 20% of wheat flour samples.

Keywords*: Fungi, Mycotoxins, Wheat grains, Wheat grain products, Contamination.*

Introduction

Wheat is the most important grain crops and the main source of grain-based foods in most of the world's countries. Egypt considered one of the largest importers of wheat in the world. According to The Food and Agriculture Organization (FAO), wheat imports represent approximately 20% of all agricultural imports and about 10% of the agricultural production in Egypt (FAO, 2015). In recent years, there is a big growth in the human consumption of wheat bran as a direct source of dietary fiber, because of its cheap price and high dietary fibers content (Vidal *et al.*, 2013). Therefore, wheat grains should be free from molds and mycotoxins contamination.

Kishk is one of the whole-wheat products, which widely used in the region between the eastern Mediterranean and the Indian sub-continent. It is made by mixing parboiled `cracked' wheat (Burghol) with fermented milk and sun drying to 8-12% moisture content **(**El-gendy, 1983; Tamime *et al.,* 1997a).

Shamsy (sunny) bread is a type of bread used in Upper Egypt. It is made from flour, water, fermented starter dough and left in a sunny place for at least one or two hours before baking (El-gendy, 1983). There are many factors affecting the wheat grains safety, the most important one is fungal contamination. Many conditions are influencing fungal growth; the most important one of them is environmental factors such as temperature and humidity. The optimum temperature for fungal growth is ranging from 25 to 30^{o}C and the optimum moisture content is 13–18%. Many species of fungi are known to produce mycotoxins (Doohan *et al*.,

2003; Novošinskas *et al*., 2005; Zain, 2011 and Kirincic, 2014).

Wheat grains are highly susceptible to mycotoxins contamination before and during harvesting, handling and storage (Pleadin *et al*., 2014a). Mycotoxins are fungal secondary metabolites mainly produced by several species of the genera *Aspergillus, Penicillium, Fusarium, Claviceps* and *Alternaria.* More than 400 types of mycotoxins have been described. Due to the variable molecular structure of these mycotoxins, these metabolites exhibit a wide range of effects on human health, such as immune suppressive disorders, hormonal teratogenicity and mutagenic effects as well as carcinogenic effects on liver and kidney tissues (Pitt, 2013; Rychlik, 2017; Asam *et al.,* 2017).

Aflatoxins (AF) are the most potent mycotoxins in all food products with aflatoxin B_1 (AFB_1) being the highest carcinogenic natural compound known. It exhibits hepatotoxicity and hepatocarcinogenicity. Acute aflatoxicosis occurs when moderate to high levels of aflatoxin B_1 ingested as food contaminants. The disease symptoms may include hemorrhage, acute liver damage, oedema, alternation of digestion, absorption and/or metabolism of nutrients and may result in death. The International Agency for Research on Cancer (IARC) has classified AFB_1 as group I carcinogens (Varga *et al.,* 2015). These mycotoxins are produced predominantly by *A. flavus* and *A. parasitic* (Paterson and Lima, 2010 a&b; Paterson *et al.,* 2014).

The present research aimed to evaluate the extent of fungal and mycotoxins contamination in wheat grains and some of its products intended for human consumption in Assiut Governorate, Egypt, such as Wheat flour, Shamsy bread, Kishk and Biscuits, which are widely differ in their processing technique.

Materials and Methods

Collection of samples

One hundred and twenty samples of Wheat grains, Wheat flour, Kishk, Burghol, Shamsy bread and Biscuits (twenty samples of each) collected from five different regions (centers) called Al-Qusiyah, Manfalut, Al-Wasta, Abnob and Assiut in Assiut Governorate, Egypt. Each sample (500 g weight) put in a sterilized polyethylene bag, sealed and put in another bag, which also sealed to minimize the loss of water content. All samples transferred immediately to the laboratory and kept in a refrigerator (3 - 5ºC) until mycology and mycotoxins analysis.

Sampling for analysis:

For each type of the studied products, the four samples collected from the same region thoroughly mixed to make a compound sample. Then one representative sample was taken for analysis from this compound sample. Therefore, each of the numbered samples 1,2,3,4 and 5 is a representative samples of four samples collected from the same source.

Isolation of fungi

Fungi were isolated using the dilution plate method as described by Tournas *et al*., (2006) using 20% sucrose-Czapek's agar medium containing chloramphenicol (20 µg/ml) as bacteriostatic agent. Ten grams homogenized sample suspended in 90 ml sterilized distilled water using a

rotating shaker to homogenate the obtained suspension. Then, serial tenfold dilutions were prepared and one ml of the appropriate dilution pipetted into a sterilized Petri dish, then a 15-20 ml- portion of melted and cooled medium was poured, mixed well and left to solidify. Five plates used for each sample. The plates incubated at 28±2°C for 5-7 days and the developing colonies counted and isolated for the identification.

Identification of the isolated fungi

Identification of the isolated fungi was carried out on the bases of their macro and microscopic characteristics using the taxonomic methods of Reper and Fennell (1965); Ainsworth (1971); Ellis (1976); Booth (1977) Pitt (1979); Klich and Pitt (1992); Moubasher (1993); Pitt and Hocking (2009).

Mycotoxins extraction

Fifty grams of each of the studied samples transferred into a blender jar, 100 ml of chloroform were added and the contents were homogenized for 5 minutes at low speed and 3 minutes at high speed. The extract filtered through flouted Whatman No.1 filter paper. The extraction procedure was repeated twice with the same volume of chloroform. The combined chloroform extracts washed with equal volume of distilled water dried over anhydrous sodium sulphate and then evaporated to near dryness on steam bath. The residue was transferred quantitatively to a small vial with 1ml chloroform.

Mycotoxins determination

The extracted mycotoxins were determined by thin layer chromatographic technique on pre-coated silica gel plate 60 F254 (Merck) as described by El-Kady and Moubasher (1982). Mycotoxins were identified by comparison with appropriate reference standards of mycotoxins using solvent system of chloroform: acetone (90:10, v/v) for Aflatoxins; toluene: ethylacetate: 90% formic acid (60:30:10, v/v/v) for Ochratoxins; toluene: acetone (20:10, v/v) for Sterigmatocystin and ethyl acetate: n-hexane (1:1, v/v) for Zearalenone.

Chemical confirmatory tests for mycotoxins

Additional confirmatory tests are require to differentiate unambiguously between the mycotoxins and other fluoresces compounds that may be present in an extract. Chemical confirmatory tests for positive samples were carried out using various treatments on TLC plates according to the method described by Golinski and Grabarkiewica-szczesna (1984).

Results and Discussion

Fungi isolated from samples

Fungal genera and species isolated from the studied samples listed in Table (1). In general, 14 species of fungi belonging to eight genera were isolated and identified from samples of wheat grains, Wheat Flour, Kishk, Burghol, Shamsy bread and Biscuits. Six species of Aspergilli (*A. flavus, A. fumigates, A. niger, A. sydawi, A. terreus* and *A. versicolor*) and two species of Penicillia (*P. chrysiogenum and P. ducluxii*) were isolated. Besides, one species of each of *Alternaria* (A. *alternata*); *Cladosporium* (*C. cladospoides*); *Curvularia* (*C. spicifera*); *Epiococcum* (*E. nigrum*); *Rhizopus (R. nigricans*) and *Scopulariopsis (S. brevicaulis*) were also isolated and identified.

In case of wheat grain samples, nine species belonging to six genera were identified as follows: *Aspergillus,*(4 species), *Alternaria alternata*, *Cladosporium cladospoioides, Epiococcum nigrum, Penicillium chrysiogenum* and *Rhizopus nigricans.* The total fungal count recordedon different wheat grain samples was 64, 58, 12, 73 and 31CFUs/10 g of samples number 1,2,3,4 and 5, respectively. These results indicated that wheat grains collected from Abnob region (sample no. 4) was the highly contaminated (73 CFUs/ 10g) while, wheat grains collected from Al-Wasta region (sample no.3) was the least contaminated one (12 CFUs/ 10g). Similar results were recorded by many investigators such as Lohar and Sonawane (2013) who isolated *Aspergillus terreus, Aspergillus oryzae, Aspergillus glaucus,* and *Syncephalastrum racemosum* from stored cereals, pulses, rice and wheat grains on Sabouraud dextrose agar medium. In addition, Mokhtar and Dehimat (2013) isolated 39 isolates of *Alternaria alternata* from three stored samples of local hard wheat seeds on potato-dextrose-agar (PDA) medium.

In case of wheat flour samples, data in Table (1) showed that, five species belonging to three genera were identified from the samples as follows: *Aspergillus flavus, A. niger, A. versicolor*, *Penicillium ducluxi* and *Rhizopus nigricans.* The total counts of fungi isolated were 281, 94, 148, 166 and 22 CFUs/ 10g for samples number 1, 2, 3, 4 and 5, respectively. The results indicated that, sample number 1 -collected from Al-Qusiyah region- was the most contaminated sample (281 CFUs/ 10 g) while, commercial wheat flour sample "Al-Salam" (sample no. 5) was the least contaminated one (22 CFUs/ 10 g). Al-Defiery and Merjan (2015) studied the extent of molds contamination on three types of wheat flour in Babylon province using spread plate technique on PDA medium and found that the major genera of molds isolated according to decreasing frequency were *Aspergillus, Penicillium, Fusarium, Cladosporium, Alternaria, Mucor, Rhizoctonia, Trichoderma, Rhizopus, Nigrospora, Bipolaris* and *Macrophomina*.

Data in Table (1) also revealed that nine species belonging to five genera were isolated and identified from kishk samples. *Aspergillus* was the most predominant genus representing by five species namely *A. flavus, A. fumigatus, A. niger, A. sydawi* and *A. terreus.* The other four genera detected as single species such as *Alternaria alternata, Curvularia spicifera, Epiococcum nigrum* and *Penicillium ducluxi.* The total count of fungi isolated from the Kishk samples was 73, 18, 118, 57 and 125 CFUs/ 10 g of samples number 1, 2, 3, 4 and 5, respectively. The results indicated that, sample No. 5 which collected from Assiut city was the most contaminated sample (125 CFUs/ 10 g) while, Kishk sample No. 2 which collected from Manfalut City was the least contaminated one (12 CFUs/10 g). These results arein agreement with that obtained by Ismail (1993) who found that, the most common fungal genera contaminating the Egyptian foodstuff kishk are *Aspergillus, Penicillium, Emericella and Rhizopus*.

Concerning the mycological analysis of wheat burghol samples, data in Table (1) showed that four species of *Aspergillus* namely *A. flavus, A. niger, A. terreus* and *A. versicolor* in addition to *Cladosporium cladospoioides, Penicillium chrysiogenum* and *Rhizopus nigricans* were isolated and identified. The total fungal count in the analyzed samples was 97, 134, 134, 123 and 134 CFUs/ 10 g of samples numbers 1, 2, 3, 4 and 5, respectively. The results indicated that, wheat burghol sample of Manfalut, Al-Wasta and Assiut City (No. 2, 3 and 5) were highly contaminated by fungi (134 CFUs/ 10 g of each one) while, wheat burghol sample collected from Al-Qusiyah City (No. 1) was the least contaminated one (97 CFUs/10 g). These results were consistent with that recorded by Faria *et al*., (2017) who studied the presence of aflatoxigenic *Aspergillus* in 30 samples of commercial Burghol wheat in the city of Maringá, Paraná, Brazil and found that 42% of the fungal isolates identified as *Aspergillus flavus*.

Results in Table (1) also indicated that seven species belonging to five genera were identified from Shamsy bread samples as follows: *Aspergillus flavus, A. niger, A. versicolor*, *Alternaria alternata, Curvularia specifera*, *Penicillium ducluxi* and *Scopulariopsis brevicaulis.* The total count of fungi isolated from the samples was 28, 17 and 10 CFUs/ 10g of samples numbers 1, 2, and 5, respectively. While each of samples 3 and 4 didn't give any fungal isolates. The results indicated that, sample number (1) collected from Al-Qusiyah city was the most contaminated sample (28 CFUs/ 10g).

In case of Biscuits samples, three *Aspergillus* species *(A. fumigatus, A. niger* and *A. versicolor*) in addition to *Penicillium ducluxi*were identified. The total count of fungi isolated from Biscuits samples was 63, 40, 44, 46 and 73 CFUs/ 10 g of samples numbers 1, 2, 3, 4 and 5, respectively. The results indicated that, sample no. 5 (commercial tea biscuits called "FAIRY") was the most contaminated sample (73 CFUs/ 10 g) while, "LUXE" biscuits sample was the least contaminated one (40 CFUs/ 10 g).

Table 1. Fungal genera and species isolated from wheat grains and its products.

Genera and species	Sample number																																	
	Wheat Grains						Wheat Flour						Kishk						Burghol						Shamsy Bread						Biscuits					
	1	2	3	4	5	TC	1	2	3	4	5	TC	1	2	3	4	5	TC	1	2	3	4	5	TC	1	2	3	4	5	TC	1	2	3	4	5	TC
Aspergillus	60	39	7	49	18	173	243	62	118	159	19	601	20	18	83	5	100	226	78	134	134	120	134	600	4	10			10	24	19	14	4	5	2	44
Aspergillus flavus	3	7		2	5	17	7	32	13	135	2	189			3		2	5	43	117	117	53	117	447	2					2						
Aspergillus fumigatus													12	9	78	2	93	194															3		3
Aspergillus niger	7	7	7	17	8	46	3	12	5	22	2	44	8		2	3	5	18	27	17	17	37	17	115		3				3		1		2	2	5
Aspergillus sydawi														2				2																		
Aspergillus terreus	48	23		30	5	106								7				7	3			22		25												
Aspergillus versicolor	2	2				4	233	18	100	2	15	368							5			8		13	2	7			10	19	19	13	4			36
Alternaria alternata		5				5							23			2		25							2	2				4						
Cladosporium cladospoioides		2		2	5	9													2					2												
Curvularia spicifera													8					8							3					3						
Epiococcum nigrum		3		2		5							2					2																		
Penicillium	2	2	3	2	5	14	38	25	28		3	94	20		35	50	25	130	10					10	17	2				19	44	26	40	41	71	222
Penicillium chrysiogenum	2	2	3	2	5	14													10					10												
Penicillium ducluxi							38	25	28		3	94	20		35	50	25	130							17	2				19	44	26	40	41	71	222
Rhizopus nigricans	2	7	2	18	3	32		7	2	7		16							7			3		10												
Scopulariopsis brevicaulis																									2	3				5						
Total Count (TC)	64	58	12	73	31	238	281	94	148	166	22	711	73	18	118	57	125	391	97	134	134	123	134	622	28	17			10	55	63	40	44	46	73	266
No. of genera	3	5	3	5	4	6	2	3	3	2	3	3	5	1	2	3	2	5	4	1	1	2	1	4	4	4			1	5	2	2	2	2	2	2
No. of species	6	9	3	6	6	9	4	5	5	4	4	5	6	3	4	4	4	9	6	2	2	5	2	7	6	5			1	7	2	3	2	3	2	4

Counting of isolated fungi

The mycological analysis (total count, density, number of cases of isolation and frequency percentage) of the samples are shown in Table (2). The results showed that, wheat flour samples were the most contaminated samples with total count of 711CFUs/ 10 g, which may be due to its highly spreadable surface area in comparison with the other types of the studied samples or to improper moisture content in the flour. *Aspergillus* was the most predominant genus encountered in wheat grains as well as in all wheat-based products except biscuits samples. In wheat grain samples, it comprised 72.69% of the total fungi and represented by four species. The highest values of frequency (100%) with highest number of cases of isolation (5) recorded for *Aspergillus niger,* while the highest density (44.54%) and counts (106 CFUs/10g) were recorded for *Aspergillus terreus*. In wheat flour samples, the genus *Aspergillus* encountered for 84.53% of the total isolated fungi and represented by three species. All of them have 100% frequency value with number of case of isolation 5. The highest density (51.76%) and counts (368 CFUs/10 g.) observed with *Aspergillus versicolor*.

Data in Table (2) also indicated that *Aspergillus* was the predominant genus in Kishk samples comprising 57.80% of the total fungi and represented by five species. The highest values of frequency (100 %) with number of case of isolation 5achieved by *Aspergillus niger.* The highest account (194CFUs/10 g) achieved by *Aspergillus fumigates* with density 49.62%. Concerning burghol samples, the predominant genus *Aspergillus* genus accounted for 96.46% of the total count of the isolated fungi and represented by four species. Each of *Aspergillus flavus* and *Aspergillus niger* has 100% frequency value with number of isolating cases of five. The highest density (%) and counts (CFUs/10 g) were 71.86 and 447, respectively for *Aspergillus flavus*.

Three species of *Aspergillus* namely *A. flavus, A. niger* and *A. versicolor* were isolated from Shamsy bread samples at percentage of 43.64% of the total fungi. *Aspergillus versicolor* has the maximum value of frequency percentage and number of case of isolation, which were 60 and 3.0, respectively. Meanwhile, the highest density percentage and counts (CFUs/10 gm.) recorded for *Aspergillus versicolor* were 34.55 and 19.00, respectively.

On the other hand, the predominant genus observed in Biscuits samples was *Penicillium* genus, which comprised 83.46% of the total fungi. *Penicillium ducluxi* was the single representative, which has 100% frequency value and 5 number of case of isolation. The density (%) and counts (CFUs/10 g) value of the fungus were estimated as 83.46 and 222, respectively.

Table 2. Total count (TC), density (D%), number of cases of isolation (NCI) and frequency (F%) for fungal genera and species isolated from wheat grains and its products.

Sample / Fungal isolated	Wheat Grains				Wheat Flour				Kishk				Burghol				Shamsy Bread				Biscuits			
	TC	D%	NCI	F%	TC	D%	NCI	F%	TC	D%	NCI	F%	TC	D%	NCI	F%	TC	D%	NCI	F%	TC	D%	NCI	F%
Aspergillus	173	72.69	5	100	601	84.53	5	100	226	57.80	5	100	600	96.46	5	100	24	43.64	3	60	44	16.54	5	100
Aspergillus flavus	17	7.14	3	60	189	26.58	5	100	5	1.28	2	40	447	71.86	5	100	2	3.64	1	20				
Aspergillus fumigatus									194	49.62	4	80									3	1.13	1	20
Aspergillus niger	46	19.33	5	100	44	6.19	5	100	18	4.60	5	100	115	18.49	5	100	3	5.45	1	20	5	1.88	3	60
Aspergillus sydawi									2	0.51	1	20												
Aspergillus terreus	106	44.54	4	80					7	1.79	1	20	25	4.02	2	40								
Aspergillus Versicolor	4	1.68	2	40	368	51.76	5	100					13	2.09	2	40	19	34.55	3	60	36	13.53	3	60
Alternaria alternata	5	2.10	3	60					25	6.39	2	40					4	7.27	1	20				
Cladosporium cladospoioides	9	3.78	1	20									2	0.32	1	20								
Curvularia spicifera									8	2.05	1	20					3	5.45						
Epiococcum nigrum	5	2.10	2	40					2	0.51	1	20												
Penicillium	14	5.88	5	100	94	13.22	4	80	130	33.25	4	80	10	1.61	1	20	19	34.55	2	40	222	83.46	5	100
Penicillium chrysiogenum	14	5.88	5	100									10	1.61	1	20								
Penicillium ducluxi					94	13.22			130	33.25	4	80					19	34.55	2	40	222	83.46	5	100
Rhizopus nigricans	32	13.45	5	100	16	2.25	3	60					10	1.61	2	40								
Scopulariopsis brevicaulis																	5	9.09	2	40				

Natural occurrence of mycotoxins in the studied samples

Thirty representative samples belonging to six kinds of wheat and wheat-based products (five samples of each kind) were analyzes for the presence of mycotoxins. Data illustrated in Table (3) indicated that, 40% of wheat grain samples proved to be contaminate by mycotoxins. Wheat grain sample no. 3 contained a moderate concentration (300-500 µg/kg) of both sterigmatocystin and aflatoxin B_1. Meanwhile, sample no. 4 showed contamination by a moderate concentration (300 - 500 µg/kg) of sterigmatocystin only. The obtained results are in consistence with that recorded by Trombete *et al*. (2014), who determined aflatoxins B_1, B_2, G_1 and G_2 in 108 samples of whole-wheat grains in Brazil and found that 30.6% of the tested samples were positive for at least one aflatoxin and the B_1 form had the highest prevalence in the samples. The mycotoxins that commonly occur in cereal grains and other products are aflatoxins, ochratoxin A, fumonisins, deoxynivalenol and zearalenone. Most of these mycotoxins may survive during food processing operations and can contaminate finished processed foods (Bullerman, 2007).

Regarding wheat flour samples, the obtained results indicated that 20% of the analyzed samples showed contamination by low concentration (less than 300 µg/Kg) of zearalinone. Although this mycotoxin produced mainly by some species of *Fusarium* genus, which does not detected among the contaminant fungi. The occurrence of fungi on the foodstuff does not necessarily accompanied with the presence of mycotoxins, as not all fungal strains are able to excrete toxins. At the same time, the presence of a mycotoxin is not always accompanying by the presence of the fungus produced of it, as the mycotoxigenic fungi may exist and excrete the toxin at an early stage of food production chain, and then the fungus disappears or kills while the secreted mycotoxin remains survive

on the foodstuff. The obtained results are in agreement with those reported by MacDonald *et al*. (2005) who found that barley, wheat and maize flour naturally contaminated by very low levels of zearalenone.

Data presented in Table (3) also showed that one sample of Kishk out of five samples contained a moderate concentration (300 - 500 µg/Kg) of aflatoxin B_1. These results agree with Colak *et al*. (2012) who found that 23.2% of tarhana samples (turkish cereal-based fermented food product like kishk) collected from Istanbul were contaminated by aflatoxins in the range of 0.7–16.8 µg/kg. However, Eighty percent of Kishk samples were negative for mycotoxin. This may be due to the effect of manufacturing steps such as washing wheat grains, pre-cooking of the grains, sun drying of the cooked grains, addition of sour milk and fermentation process by lactic acid bacteria. Several studies indicated that many species of Lactic acid bacteria have potential as natural food - grade bio-control agents of molds and mycotoxins contamination of foods. Chelkowski (1989) demonstrated that some lactic acid bacteria have promising ability as natural food-grade bio-control agents of mold growth and mycotoxin production. Nanis *et al.* (2009) studied the antifungal effect of *Lactobacillus plantarum, L. paracasei* subsp. *paracasei* and *L. rhamnosus against A. parasiticus* NRRL2999*, A. flavus, A. versicolor, Penicillium roqueforti* and *P. communi*. All the studied *Lactobacillus* strains exhibited various degrees of growth inhibition against some but not all the studied molds. Production of Aflatoxin B_1 by *A. parasiticus* and *A. flavus* almost completely inhibited by all the tested lactobacilli.

For wheat burghol, 40% of the examined samples showed contamination by moderate concentrations (300 - 500 µg/Kg) of aflatoxin B_1. These results were agree with Faria *et al.* (2017) who isolated 42 monosporic isolates of aflatoxigenic *Aspergillus flavus* and Some of the isolates were confirmed to be aflatoxin producers and several of them presented a genetic profile of aflatoxin synthesis.

Data in Table (3) also showed that, Shamsy bread and biscuits samples were negative for the presence of mycotoxin. These results are normal and expected, and it should be so if these products were produced under quality control and healthier conditions.

Table 3. Natural occurrence of mycotoxins in wheat grains and wheat-based products.

Type of sample	% Contamination of Samples	sample no.	Level of Mycotoxin detected							isolated fungi
			Aflatoxins				Ochr. A	Sterig.	Zearlin.	
			B1	B2	G1	G2				
Wheat Grains	40%	1	-	-	-	-	-	-	-	*A. flavus, A.niger, A. terreus, A.Versicolor, P. chrysiogenum, R. nigricans*
		2	-	-	-	-	-	-	-	*A. flavus, A.niger, A. terreus, A.Versicolor, A. alternata, C. cladospoioides, E. nigrum, P. chrysiogenum, R. nigricans*
		3	1+	-	-	-	-	3+	-	*A. niger, P. chrysiogenum, R. nigricans*
		4	-	-	-	-	-	2+	-	*A. flavus, A.niger, A. terreus, C. cladospoioides, E. nigrum, P. chrysiogenum, R. nigricans*
		5	-	-	-	-	-	-	-	*A. flavus, A.niger, A. terreus, A.Versicolor, A. alternata, C. cladospoioides, E. nigrum, P. chrysiogenum, R. nigricans*
Wheat flour	20%	1	-	-	-	-	-	-	-	*A. flavus, A.niger, A.Versicolor, p. ducluxi*
		2	-	-	-	-	-	-	-	*A. flavus, A.niger, A.Versicolor, p. ducluxi, R. nigricans*
		3	-	-	-	-	-	-	1+	*A. flavus, A.niger, A.Versicolor, p. ducluxi, R. nigricans*
		4	-	-	-	-	-	-	-	*A. flavus, A.niger, A.Versicolor, R. nigricans*
		5	-	-	-	-	-	-	-	*A. flavus, A.niger, A.Versicolor, p. ducluxi*
Kishk	20%	1	-	-	-	-	-	-	-	*A. fumigatus, A.niger, A. alternata, C. spicifera, E. nigrum, P. ducluxi*
		2	-	-	-	-	-	-	-	*A. fumigatus, A. sydawi, A. terreus*
		3	-	-	-	-	-	-	-	*A. flavus, A. fumigatus, A. niger, p. ducluxi*
		4	2+	-	-	-	-	-	-	*A. fumigatus, A. niger, A. alternata, p. ducluxi*
		5	-	-	-	-	-	-	-	*A. flavus, A. fumigatus, A. niger, p. ducluxi*
Burghol	40%	1	3+	-	-	-	-	-	-	*A. flavus, A.niger, A. terreus, A.Versicolor, C. cladospoioides, P. chrysiogenum, R. nigricans*
		2	-	-	-	-	-	-	-	*A. flavus, A. niger*
		3	-	-	-	-	-	-	-	*A. flavus, A. niger*
		4	2+	-	-	-	-	-	-	*A. flavus, A. niger, A. terreus, A.Versicolor, R. nigricans*
		5	-	-	-	-	-	-	-	*A. flavus, A. niger*
Shamsy bread	0%	1	-	-	-	-	-	-	-	*A. flavus, A.Versicolor, A. alternata, C. spicifera, P. ducluxi, S. brevicaulis*
		2	-	-	-	-	-	-	-	*A. niger, A.Versicolor, A. alternata, P. ducluxi, S. brevicaulis*
		3	-	-	-	-	-	-	-	ND
		4	-	-	-	-	-	-	-	ND
		5	-	-	-	-	-	-	-	*A.Versicolor*
Biscuits	0%	1	-	-	-	-	-	-	-	*A.Versicolor, P. ducluxi*
		2	-	-	-	-	-	-	-	*A. niger, A.Versicolor, P. ducluxi*
		3	-	-	-	-	-	-	-	*A.Versicolor, P. ducluxi*
		4	-	-	-	-	-	-	-	*A. fumigatus, A. niger, p. ducluxi*
		5	-	-	-	-	-	-	-	*A. niger, p. ducluxi*

* 1+ : (low concentration less than 300 µg/Kg), * 2+ / 3+ : (moderate concentration 300 - 500 µg/Kg),
* ND: not detected.

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Website:www.aun.edu.eg/faculty_agriculture/journals_issues_form.php ***E-mail: ajas@aun.edu.eg***

الفطريات والسموم الفطرية المصاحبة لحبوب القمح وبعض منتجاتها في صعيد مصر

رانيا مصطفى حمدي[١]، محمد نجيب احمد الريفي[٢]، عبد الناصر احمد زهري[٣] و وفيق سند رجب[٤،٥]

[١،٢،٤] قسم علوم وتكنولوجيا الأغذية – كلية الزراعة – جامعة أسيوط –مصر

[٣] قسم النبات والميكروبيولوجي– كلية العلوم – جامعة أسيوط –مصر

[٤،٥] قسم الأحياء – كلية العلوم – جامعة حفر الباطن – ص ب ١٨٠٣ – المملكة العربية السعودية

الملخص

تناول البحث دراسة أنواع الفطريات وسموم الفطريات المرتبطة بحبوب القمح وبعض منتجاتها المخصصة للاستهلاك البشري في صعيد مصر مثل دقيق القمح والخبز الشمسي والكشك والبرغل وأنواع مختلفة من البسكويت التجاري. أوضحت النتائج التي تم الحصول عليها أن جميع المنتجات التي تمت دراستها ظهرت بها مستويات مختلفة من التلوث بالفطريات خاصة دقيق القمح الذي كان الأكثر تلوثاويليه برغل القمح. تم عزل وتعريف العديد من الأنواع الفطرية التي تنتمي إلى عدة أجناس من الفطريات وكان جنس الأسبرجيلس هو الأكثر انتشارا في جميع أنواع المنتجات المدروسة ويليه جنس البنسليوم.

أظهرت نتائج تحليل السموم الفطرية تواجد سم الأفلاتوكسين ب ١ في ٤٠% من عينات برغل القمح، ٢٠% في كل من عينات حبوب القمح وعينات الكشك، بينما تواجد سم الاسترجماتوسيستين في ٤٠% من عينات حبوب القمح وسم الزيرالينون في ٢٠% من عينات دقيق القمح.