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THE EFFECT OF GAMMA IRRADIATION OR ROASTING PROCESS ON THE FUNGAL FLORA AND ANTINUTRIONAL FACTORS OF PEANUT KERNELS *(Arachis hypogaea)*

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ABSTRACT

The Peanut kernels *(Arachis hypogaea)* variety Giza-5 were roasted by heat at 160°C for 30 min or subjected to gamma irradiation at dose levels of 5,7.5 and 10kGy. Samples were packed in kraft paper and another were packed in muslin bags. Then all samples were stored for six months at ambient temperature. The inhibition of fungal flora and their toxins plus inactivation the antinutrional factors were studied.

The data reflected that, 13 species of fungi from peanut kernels belonging to 7 genera were isolated and identified. The greater number of species held to *A. flavus, A. parasiticus, A. niger and A. fumigatus.* Whereas observed as the predominated *Aspergillus* spp recorvered from both the non surface – sterilized and surface – sterilized kernels containing fungi were more than the surface – sterilized. The results indicated that only 43 isolate from 211 were able to produce aflatoxin. The higher amounts of aflatoxins B_1 (285.12 ug. g^{K-1}) and B_2 (216. 63 ug g^{K-1}) were recorded by peanut kernels infested with *A. flavus.* Therefore, gamma irradiation (5-10 KGy) are suitable to insure the preventation of aflatoxin production in peanut kernels packed in kraft paper for extending shelf life to six months.

Gamma irradiation or roasting process exhibited significant reduction ($p < 0.001$) of antinutrional factors i.e vicine, tyrpsin inhibitors and hemagglutinating activity before and after storage. Whereas, the higher inactivation was occurred in the hemagglutinin than other factors. Whereas, the reduction rate was reached 96.88% of hemagglutinin after immediately peanut kernels roasted or irradiated at 10kGy.

INTRODUCTION

The peanut kernels are good source of diearty protein, vitamins and minerals. Major peanut product is processed into variety of food products such as peanut product, protein concentrates and protein rich peanut-meals *(Chiou et al., 1990)*. All commercial varieties of peanut grown through the world are cultivars of *Arachis hypogaea*.

During storage, the peanut is subjected to insect, fungal and microbial spoilage that produce their toxins. Species of *Aspergillus, Penicillium, Fusarium, Alternaria, cladosporium, Helminthosporium, Mucor* and *Rhizopus* were common and widespread in peanut kernels varieties in different countries *(Aziz et al., 1994and Chiou et al. , 1997)*.

Growth of *A. flavus* and *A. parasiticus* and subsequence aflatoxin production represent a serious public health concern to the industry and regulatory agencies. Since peanuts are good substance for aflatoxin producing molds and the conidia of these fungi are ubiquitous in field before

harvest and after harvest during drying in the windrow *(Diener et al., 1982)*. Aflatoxin have been found in oil seeds, pulses in various parts of the world.

The mold *A. flavus* usually produce four types of aflatoxin B_1, B_2 G_1 and G_2. Among the four isomers found, aflatoxin B_1 is much more toxic and carcinogenic than the others *(Chiou et al., 1990 and chiou 1996)* .

Many investigators attributed the poor nutrilive value of legumes or digestibility to the presence of some forms of protein such as trypsin, chemotrypsin inhibitors, vicine, convicine and hemagglutinin (Savelkoul *et al.,* 1994 and Saikia *el al*.,1999).

Food irradiation is reconized as a safe and effective process for a range of specific application, including cereal grains, legumes, fresh and dried fruits, nuts, dried vegetables *(WHO 1994 and Diehl 1995)*. Radiation treatment has been suggested to inactivate or reduce antinutrional factors *(Joseph & Dikshit 1993 and Farag 1998)*. Moreover, radiation process has a beneficial effect on the reduction of fungal growth and their aflatoxin. *(Patel et al., 1989 and Kheiralla et al., 1992)*

Heat treatment of legumes improved the protein quality by inactivating antiphysological factors *(Sharm & sehgal 1995)*. In naturally contaminated peanut kernels, both oven – and microwave -roasting were equally effective for destroying 48-61% of aflatoxin B_1 and 32-40% of aflatoxin G_1 *(Pluyer et al., 1987)*.

The present investigation aimed to isolate and identify natural fungal growth from the Egyptian peanut kernel (Giza-5). Also screening their mycotoxin content by qnantitive and qualitative analyses of aflatoxin. In addition to the effect of applied both roasting process and gamma irradiation up to 10kGy for elimination of fungal growth and aflatoxin as well as antinutrional factors (vicine, Trypsin inhibitors and Hemagglutinating activitywhich are present naturally in peanut kernels.

MATERIALS AND METHODS

Materials

Peanut kernels *(Arachis hypogaea)* variety Giza-5 were obtained from the Field Crops Resarch Institute, Ministry of Agriculture and Land Reclamation, Giza, Egypt. Peanut were manualy decorticated, and broken kernels were eliminated.

Methods

Roasting treatment: Peanut kernels were roasted by heat at 160°C for 30min and were left for half an hour to cool at room temperature. Some of the roasted samples were packed in kraft paper bags and another in muslin bags under aspectic condition. Each bag contained about 2kg.

Radiation treatment: The peanut kernels were packed in kraft paper or muslin bags. They were subjected at ambient temperature to gamma irradiation from Co^{60} source at National Centre for Radiation Research and Technology at Nasr City, Cairo. The applied doses were 5,7.5 and 10kGy

delivered at a dose of rate of 1.91 kGy/h. all samples were stored at ambient temperature for six months.

Analytical methods:

a- Mold and toxin assy: The isolation and identification of natural fungal strains from peanut kernels using procedure reported by Chiou *et al*(1997). The identified fungi (13species) were examined for their capability to produce mycotoxins (aflatoxin B_1, B_2 G_1 and G_2) in both liquid medium and peanut kernels were carried out according to the method of A.O.A.C (1995). Quantitative and qualitative analyses of aflatoxin on silica gel TLC plates were determined according to the method of A.O. A.C (1995).

b-Antinutrional factors*:* Determination of tyrpsin inhibitors was carried out by using the method reported by Hamerstrand *et al.* (1981), hemagglutinin was determined according to Liener and Hill (1953) and vicine content was carried out according to Collier (1976).

c-Statistical Analysis: All analysis were conducted using the general linear model procedure (SAS 1989). Where appropriate treatment means were separated using the Duncan's Multiple Range Test (Duncan 1995). The level for significance was $p \leq 0.5$.

RESULTS AND DISCUSSION

The fungal flora isolated from non-sterilized and surface sterilized peanut kernels were listed in Table (1). In this study 13 species of fungi belonging to 7 genera species were isolated and identified. The greater number of species related to genus *A. flavus, A. parasiticus, A. niger* and *A. fumigatus* were observed as the predominated Apspergillii reconvened from both the non-surface sterilized and surface sterilized peanut kernels. Also Table (1) was showed that *Penicillium chrysogenum, P. cyclopuim, Alternaria alternata, Fusarium moniliforme, F. solani, Trichoderma viride, Rhizopus.Sp* and *Mucor sp* were isolated only from the non-surface sterilized peanut kernels. The percentage of non-Sterilized kernels containing fungi were more than that of surface sterilized kernels. Only *Aspergillus* Spp were isolated from all surface of disinfected kernels indicating that *Aspergillus spp* were able to penetrate into kernels. *(Aziz et al., 1994 and Chiou et al.,1997)*.

Data from Table (2) indicated that only 43 isolates from 211 were able to produce aflatoxin. The data revealed that only *Aspergillus* Spp(43 isolates) are considered as an aflatoxin producers. As shown in Table (2), *A. flavus* (25isolates), *A. parasiticus (12 iolates)* and *A. fumigatus* (6 isolates) produced aflatoxin in the synthetic medium with different quantities. Whereas 11,7 and 4 isolates of *A. flavus, A. parasiticus* and *A. fumigatus* produced aflatoxin B_1, while 6 , 3and 2 isolates of *A. flavus*, *A. fumigatus* and *A. parasiticus* ,respectively were found to produce aflatoxin B_1 and B_2. Also, it was noticed that4 isolates of *A. flavus* and 2 isolates of *A. parasiticus* produced alfatoxin B_1 and G_1. Furthermore, only 2 isolates of *A. flavus* produced trace amount of B_1, B_2, G_1 and G_2.

Table (1): Occurrence of fungal flora isolated from the Egyptian peanut kernels,Giza-5.

Fungal Flora	Percentage of occurrence	
	Non surface-sterilized kernels	Surface-sterilized kernels
Aspergillus flavus	80	60
Aspergillus parasiticus	75	60
Aspergillus niger	80	60
Aspergillus fumigatus	40	20
Penicilluim chrysogenum	25	0
Penicilluim expanseum	15	0
Penicilluim cyclopium	25	0
Alternata alternata	25	0
Fusaruim moniliforme	20	0
Fusaruim solani	20	0
Trichoderma virde	20	0
Rhizopus sp.	60	0
Mucor sp.	20	0

Table (2): Screening for aflatoxins by moulds isolated from disinfected peanut kernels in semi –synthetic medium

Mold species	No. of Isolates Tested	No. of Positive isolates	Type of aflatoxins production				
			B1	B1 B2	B1G1	B1B2G1	B1B2G1G2
A. flavus	44	25	11(+++)	6(+++)	4(+)	2(+)	2(+)
A. parasiticus	28	12	7(+++)	3(++)	2(+)	-	-
A. niger	35	0					
A. fumigatus	20	6	4(++)	2(+)	-	-	-
P.chrysogenum	14	0					
P.expanseum	9	0					
P.cyclopium	16	0					
Alternata	12	0					
F.moniliforme	8	0					
F.solani	5	0					
T.viride	11	0					
Rhizopus sp.	6	0					
Mucor sp.	3	0					
Total	**211**	**43**	**22**	**11**	**6**	**2**	**2**

(+++) Very high ,(++) moderate, (+) low, (+) trace amount of aflatoxins and (-) not detected aflatoxins.

It was previously reported that to verify the possible production of aflatoxin in peanut kernels, the most active *Aspergillus* spp isolates that were recorded to produce aflatoxin B_1 and B_2 in broth medium *(Kheiralla et al.,1992 and Hilmly&Chosdu 1995)*.

The results from Table (3) reflected that all isolates under investigation were able to produce aflatoxins with variable concentrates in

peanut kernels. Very high amount of aflatoxin B_1 (285.21 ug kg^{-1}) and B_2 (216.63 ug kg^{-1}) were recorded in peanut kernels infested with *A. flavus* (isolate No. 8) followed by *A. flavus* (isolate No.19) which produced B1 (206.74 ug kg^{-1}) and B_2 (135.41 ug kg^{-1}) when grown in peanut kernels.

Table (3): Production of aflatoxins B1 and B2 by high aflatoxigenic producer mould isolated from peanut kernels.

Mold species	Isolatednumbers	Aflatoxins production (µg Kg^{-1})	
		B1	B2
A.flavus	2	140.66	172.50
	8	285.12	216.63
	16	174.3	148.22
	19	206.74	135.41
A.Parasiticus	3	154.2	102.64
	7	127.65	83.72
A. fumigatus	2	108.46	41.50

The effect of gamma irradiation on the occurrence of fungi in non surface sterilized and surface-sterilized stored for 6 months in kraft paper and muslin bags are presented in Tables (4), (5).Roasted peanut stored for six months are presented in table (6). Exposing of peanut kernels to increasing doses of gamma rays (5-10 kGy) led to complete inhibition of fungal flora naturally contaminating these kernels.Storing the treated peanut kernels in kraft paper gave better results than that in muslin bags. This may be due to that muslin bags failed to keep beneficial effect of radiation treatment to free kernels from molds because muslin bags allow fungal flora to attack the kernels through their bores. *(Chiou et al., 1990 and Chiou 1996)*.

The effect of roasting or irradiation process on the antinutrional factors of peanut kernels*(Arachis hypogaea)* were presented in Table (7). The results revealed that a significant reduction ($P < 0.05$) occurred in vicine, trypsin inhibitors and hemagglutinating activity. Meanwhile, the reduction increased significantly after storing samples for six months in some treatments.The higher inactivation rate due to process methods was recorded to hemagglutinin was 96.88 % when peanut kernels roasted or irradiated at 10Kgy. However, the more pronounced reduction have been observed due to effect of storage period with 5 and 7.5 kGy radiation dose only. On the other hand, when raw, roasted and irradiated peanut kernels at 10 kGy were stored for six months at ambient temperature, no significant effect was observed in the hemagglutinating activity *(Saikia et al., 1999)*.

Table (7) : The levels ' and destruction response² due to the effect of roasting or radiation processing on anti-nutritional factors of peanut kernels before and after six months of storage at ambient temperature.

Treatment	Vicine		TI		HA	
	Mg g-¹	% of destruction	TIU g-¹	% of destruction	HU g-¹	% of destruction
Zero time						
Raw	3.69[a]	00.00	8.07[a]	00.00	640[a]	00.00
Roasting	0.71[c]	80.76	5.83[d]	27.76	20[d]	96.88
Irradiation						
5 KGy	2.60[b]	29.54	7.10[b]	12.02	320[b]	50.00
7.5KGy	1.93[c]	47.70	6.50[c]	19.45	80[c]	87.50
10 KGy	0.89	75.88	5.50[c]	31.85	20[d]	96.88
Storage						
Raw	2.62[a]	29.00	7.53[a]	6.69	640[a]	00.00
Roasting	0.49[c]	86.72	4.17[c]	48.32	20[b]	96.88
Irradiation						
5KGy	1.90[b]	48.51	6.17[b]	23.54	160[b]	75.00
7.5KGy	0.86[c]	76.69	5.53[c]	31.47	40[c]	93.75
10 KGy	0.74[d]	79.95	4.57[d]	43.37	20[d]	96.88
Pooled SEM	0.033		0.083		0.00	
Factorial effects:				***Probabilities***		
Treatment (T)	0.001		0.001		0.001	
Storage (S)	0.001		0.001		0.001	
T by S	0.001		0.001		0.001	
Types of response due to radiation dose (kGy):						
Zero time						
Linear	0.001		0.001		0.001	
Quadratic	0.001		0.001		0.001	
Cubic	0.001		0.001		0.001	
Storage						
Linear	0.001		0.001		0.001	
Quadratic	0.001		0.001		0.001	
Cubic	0.001		0.001		0.001	

1- Values are means of triplicate analysis ,on dry matter basis
2- destruction rate compared with the corresponding values before storage
TI, trypsin inhibitor activity; HA, haemagglutinating activity.
a-e Means within a column , within classification ,with no common superscript differ significantly(P<0.05).

The reduction rate of vicine due to process methods was higher than tyrpsin inhibitors. While the reduction of vicine was 29.54%, 47.70%, and 75.88% at dose levels 5,7.5 and 10 kGy repectively. Meanwhile, the reduction increased significantly for irradiated samples (P < .001) stored for six months. The reduction in vicine content in response to storage period for raw kernels was 29.00% , wherase of roasted kernels was86.72% and to irradiation treatments at dose 5 , 705, and 10 KGy was46.51%,67.69% and 79.95% respectively. The marked reduction in vicine content in response to roasting and irradiation before and after storgemight be due to the

degradation and inter – conversion of vicine as a pyrimidin derivative (Pusztai 1991).

Trypsin inhibitors was the least affected by the process methods applied in this study(Table 7). Roasting and gamma irradiation induced marked reduction in trypsin inhibitors by27.76% 12.2%, 19.45%, 31.85% at dose levels of 5, 7.5 and 10kGy respectively. Also stroge for six months increased significanlty the reduction rate of trypsin inhibitors for all samples *(Bishoni et al., 1994 and Diehl 1995).*

Regression analysis of vicine content, trypsin inhibitors and Hemagglutinin in relation to the applied radiation dose indicated that there were significant effect of radiation process or antinutrional factors (P< 0.001). The linear (P < 0.001), quadratic (P< 0.001) and /or cubic (P < 0.001) effect were significant for irradiation before and after storage for six months at ambient temperature.

Correlation and different types of regnession analysis were used for testing any relationship between the applied radiation dose and the evoked response. Correlation analysis, at zero time indicated that radiation was significantly negative (P<0.01) associated with vicine (-0.981). trypsin inhibitors (-0.971) and Hemagglutinin (- 0.988). Also there are positive inter-relationship between vicine, trypsin inhibitors and Hemagglutinin (Table8) . Same correlation coefficeint (r) were observed for the effect of post – irradiation storage for six months.

Regression analysis of the bioactive antinutrional factors of peanut kernels data represented the slop(Table9), which is interpreted as the estimated mean change in the studied parameters (The dependent variable), for a unit change in the independent variable (radiation dose).

Table (8) :The pearson correlation coefficient(r) between radiation dose، (KGy) and vicine ,trypsin inhibitor activity ; hemagglutinating activity

	Vicine	TI	HA
Zero time.			
Dose	-0.981**	-0.971**	-0.988**
Vicine		0.987**	0.950**
TI			0.949**
Storage			
Dose	-0.967**	-0.898**	-0.846**
Vicine		0.945**	0.727**
TI			0.822**

TI, trypsin inhibitor activitY;HA, hemagglutinating activity*p< 0.05. **p < 0.01

The regression equation for the estimated bioactive antinutritional factors of peanut kernels (Table9) could be used to compute the radiation dose needed for almost complete inactivation of estimated bioactive antinutritional factors present naturally in peanut kernels.

Table (9) :Linear response equation for the bio active antinutritional factors of peanut kernels with increased radiation – processing dose (KGy).

Anti-Nutritional Factors	Linear equation	R^2	Probabilities	
			A	B
Zero time				
Vicine	Y= 7.72 (0.11)- 0.26 (0.02) X	0.962	0.001	0.001
TI	Y= 8.18(0.11)- 0.25 (0.02) X	0.959	0.001	0.008
HA	Y= 631.43 (21.98)-65.14 (3.27) X	0.976	0.001	0.001
Storage				
Vicine	Y= 2.67 (0.11) –0.20 (0.02) X	0.935	0.001	0.001
TI	Y = 7.58 (0.09) – 0.29 (0.01) X	0.980	0.001	0.001
HA	Y = 537.71 (77.4) – 57.37 (11.5) X	0.950	0.001	0.001

General Equation	Y = A (± SE) + B (± SE) X

TI, trypsin inhibitor activity ; HA , hemagglutinating activity.
The values Y = predicted constituent ;X = the radiation dose (KGy);
A = intercept of the line ; B = the slop of the line ;
SE = standerd error of estimated parameter

Generally, the present work demonsthtrated that, the applied irradiation or roasting process lead to inactivate antinutritional factors before and after storage. In addition to irradiated peanut kernels (5-10kGy) is suitable to insure the preventation of aflatoxin production packed in kraft paper for exteding the shelflife to six months.

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تـأثير أشـعة جامـا أو المعالجـه الحراريـه علـى الفطريـات ومعيقـات الاسـتفاده مـن العناصر الغذائية للفول السودانى

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*** قسم الكمياء الحيويه والتغذيه – كلية البنات جامعة عين شمس**

**** مركز تكنولوجيا الاشعاع بمدينة نصر – القاهره**

الفول السودانى صنف جيزة ٥ و الذى تم تقشيرة يدويا ثم معالجتة حراريا على ١٦٠ درجة مئوية لمدة نصف ساعة او تعرض للاشعاع بجرعات ٥، ٥ز٧، ١٠كيلو جرابو ذلك بعد ان تم تعبئتة فى نوعين من الأكياس اما اكياس تل او ورق تغليف و تم تخزين جميع العينات لمدة ستة شهور على درجة حرارة الغرفة وتهدف هذه الدراسه الى عزل الفطريات الموجوده على الفول السودانى والتعرف على ألأنواع المنتجه للسموم منها ثم تطبيق المعاملأت المشار اليها لأزالة هذة الفطريات وسمومها بالأضافة الى اتلآف معيقات الأستفادة من العناصر الغذائية فى الفول .

وقد أوضحت النتائج أنه تم عزل ١٣ غزلة تنمو على الفول السودانى وكانت معظمها تنتمى لجنس *Aspergillus spp*. والانواع السائده منها , *A. flavus , A.parasiticus* *A.fumigatus* ,*A. niger* بالاضافه الى ان نسبة الفطريات الموجوده على السطح الخارجى غير المعقم للفول أكبر من السطح الخارجى المعقم . كما أتضح أن ٤٣ عزله من ٢١٢ عزله منتجه للسموم هى عباره عن ٢٥ عزله من *A. . flavus* ١٢، عزله من *A . parasiticus* ، ٦ عزله من *A. fumigatus* . كما أن عدد الفطريات فى عينات الفول المعالجه حراريا أو إشعاعيا والمعبأه فى أكياس التل إزدادت بدرجه كبيره أثناء الخزين . لهذا تعتبر الجرعه ٥-١٠ كيلوجراى والمعبأه فى أكياس ورقيه هى المناسبه وأطالت فترة التخزين لمدة ٦شهورعلى درجة حرارة الغرفه. كما دلت النتائج على أن كل معيقات الاستفاده من العناصر الغذائيه (مثبط التربسين، الفيسين ، الهيماجلوتينين) إنخفضت بتأثير كل من المعالجه الحراريه والاشعاع قبل وبعد التخزين . بينما كان أعلى معدل إنخفاض لوحظ بالنسبه للهيماجلوتينين عن العناصر الاخرى . حيث وصل معدل الانخفاض الى ٩٦,٨٨% بعد المعالجه الحراريه أو التعرض للاشعاع بأستخدام الجرعه ١٠ كيلوجراى

Table (4): Percent of fungal species in disinfected (Y) and non disinfected(X) peanut kernels treated by various gamma- doses and stored in kraft paper bags at ambient temperature for 6 months

Storage period (month)	Dose Kgy	Fungal species																									
		A. f.		*A. p.*		*A. n.*		A. g.		*P1*		*P2*		*P3*		*Alt.*		*Fu1*		*Fu2*		*Trich*		*Rhi*		*Mucar*	
		X	*Y*	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
0	0	80	60	75	60	80	60	40	20	25	0	15	0	25	0	25	0	20	0	20	0	20	0				
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	
	7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			0	
																								0			
																								0	0	0	
																										0	0
1	0	85	65	80	60	60	85	45	20	30	0	20	0	30	0	30	0	25	0	25	0	25	0	65	0		
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
																										0	
																										0	0
2	0	85	70	85	65	90	65	50	20	30	0	25	0	35	5	30	5			25	0	25	0	70	0		
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	5		0	0	0	0	0	0	0	
	7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
																		0	0							0	0
3	0	90	70	85	65	90	70	50	30	35	5	25	0	35	5	35	5	30	5	30	0	30	0			30	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	10	0	5	0	5	0	0	0	0	0	0		0	0
	7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
																								0	0		
4	0	100	75	95	70	100	70	55	30	35	5	30	5	40	10	35	5	35	5	30	0	30	0	75	0	30	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	10	0	10	0	5	0	0	0	0	0	0	0	0	0
	7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	100	75	100	75	100	75	60	30	40	10	40	10	45	15	40	10	40	5	35	5	35	5	80	0	35	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	15	0	10	0	10	0	0	0	0	0	0	0	0	0
	7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	100	80	100	80	100	85	60	35	40	10	40	10	50	15	40	10	40	10	40	5	40	5	80	0	35	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	15	0	15	0	10	0	0	0	0	0	0	0	0	0
	7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

f. Aspergillus flavus ;A.p.Aspergillus parasiticus;A.n.Aspergillus niger ;A.g.Aspergillus fumigatus ;P1 Penicilium chrysogenium ; P2 Penicilium expansum ;P3 Penicilium cyclopsum ;Alt.Alternaria SP:Fu1,Fusarium solani:Trich.trichoderma viride:Rhi.Rhizopus sp:Muc.Mucor sp.X,Non surface disinfected accurrance % Y,Surface disinfected accurrance %

Table (5): Percent of fungal species in disinfected (Y) and non disinfected (X) peanut kernels treated by various gamma-doses and stored in muslin bags at ambient temperature for 6 months

Storage period (month)	Dose Kgy	Fungal species																													
		A. f.		*A. p.*		*A. n.*		A. g.		*P1*		*P2*		*P3*		*Alt.*		*Fu1*		*Fu2*		*Trich*		*Rhi*		*Mucar*	
		X	*Y*	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
0	0	80	65	75	60	80	60	45	25	20	0	20	0	15	0	35	5	30	5	25	0	25	0	70	0	25	0				
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
	7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
	10	0	0			0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
1	0	95	80	80	65	65	85	60	25	25	0	25	0			40	0			30	5	30	0	70	0	30	0				
	5	5	0	0	0	0		0		0	0	0	0	0		0	0	0		0	0	5		0		0					
	7.5	5	0	0		5		5		0		0		0	0	0		0	0	0		0		0		0					
	10	0	0			15		0						0	0	0		0	0			0		0							
														0	0			0	0												
2	0	100	85	90	70	90	70	70	40	30	10	35	15	25	5	45	10	35	5	35	0	30	0	75	0	30	0				
	5	0	0	5	0	30	0	0	0	5	0	0	0	5	0	5	0			0	0	5	0	0	5	0	0				
	7.5	0	0	10	0	25	0	5	0	0	0	0	0	0	0	0	0	0		0	0	5	0	5	0	0	0				
	10	0	0	15	0	30	0	0	0	0	0	0	0	0	0	5	0	0	0			5	0			0	0				
																		0	0												
3	0	100	95	100	95	80	100	75		80	45	10	35	10	35	20	0	30	5	55	15	5	45	10	35	10	30	5	75	0	10	35	0
	5	0	100	0	5	0	10	0	0	10	0	0	0	0	0	0	5	0	0	0	5	0	0	0	0	10	0	0	5	0	0	0	0
	7.5	0	5	20	0	25	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	10	0	10	0	0	0				
	10	0				35	0			0	0			0	0			0	0	0	0	5	0			0	0				
4	0	100	95	100	85	100	90	85	60	40	15	40	20	30	10	60	15	45	10	40	10	35	5	80	0	35	0				
	5	0	20	0	0	10	0	35	0	0	20	5	0	0	0	5	0	10	0	5	0	0	0	10	0	15	0				
	7.5	10	0	20	0	30	0	0		10	0	0	0	10	0	10	0	0	0	0	0	15	5	15	0	0	0				
	10					35	0	5	0	0	0	0	0	0	0	10	0	0	0	0	0	10	0	10	0	0	0				
5	0	100	100	100	90	100	100	90	75	50	25	45	25	40	15	60	20	50	10	40	10	35	5	80	5	35	0				
	5	20	5	0	20	0	35	10	20	0	5	0	0	0	0	10	0	10	0	0	0	20	0	20	0	0	0				
	7.5	30	5	25	0	30	5	20	5	10	0	0	0	0	0	15	0	5	0	0	0	20	0	15	0	5	0				
	10	20	0			40	5	10	0	0	0	0	0	0	0	15	0	0	0	0	0	20	0	15	0	0	0				
6	0	100	100	100	100	100	100	100	90	25	50	25	50	30	45	15	65	20	50	15	45	15	40	5	85	5	40	5			
	5	30	5	25	5	40	10	5	25	5	10	0	0	0	15	0	15	5	10	0	0	0	25	0	20	0	5	0			
	7.5	30	10	25	5	35	10	15	0	5	0	0	0	0	0	20	0	5	0	0	0	25	0	25	0	5	0				
	10	25	5	30	5	40	10			5	0	0	0	0	0	15	0	5	0	0	0	20	0	15	0	0	0				

A. f. Aspergillus flavus ;A.p.Aspergillus parasiticus;A.n.Aspergillus niger ;A.g.Aspergillus fumigatus ;P1 Penicilium chrysogenium ;

B. *P2 Penicilium expansum* ;P3 Penicilium cyclopsum ;Alt.Alternaria SP:Fu1,Fusarium solani:Trich.trichoderma viride:Rhi.Rhizopus

C. sp:Muc.Mucor sp.X,Non surface disinfected accurrance % Y,Surface disinfected accurrance %

Table (6): Percent of fungal species in disinfected (Y) and non disinfected(X) peanut kernels roasted by radiant heat at 160 °C for 30 min and stored in kraft paper (K) and muslin (M) bags at ambiant temperature for 6 months.

Storage period (month)	Bag Type	Fungal species																									
		A. f.		*A. p.*		*A. n.*		A. g.		*P1*		*P2*		*P3*		*Alt.*		*Fu1*		*Fu2*		*Trich*		*Rhi*		*Mucar*	
		X	*Y*	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
0	K	0	0	5	0	0	0	5	0	0	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	0	0
	M	0	0	5	0	0	0	5	0	0	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	0	0
1	K	0	0	5	0	0	0	5	0	0	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	0	0
	M	10	0	5	0	10	0	10	0	0	0	0	0	0	0	5	0	0	0	0	0	5	0	5	0	0	0
2	K	0	0	5	0	0	0	5	0	0	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	0	0
	M	10	0	10	0	15	0	10	0	0	0	0	0	0	0	10	0	0	0	0	0	10	0	10	0	0	0
3	K	0	0	5	0	0	0	5	0	0	0	0	0	0	0	5	0	0	0	0	0	10	0	0	0	0	0
	M	15	0	15	0	15	0	15	0	0	0	0	0	0	0	10	0	0	0	0	0	15	0	15	0	0	0
4	K	0	0	10	0	0	0	10	0	0	0	0	0	0	0	10	0	0	0	0	0	10	0	0	0	0	0
	M	20	5	15	0	20	0	20	5	0	0	5	0	0	0	15	0	5	0	0	0	15	0	15	0	0	0
5	K	0	0	10	0	0	0	10	0	0	0	0	0	0	0	10	0	0	0	0	0	10	0	0	0	0	0
	M	20	10	20	5	20	0	25	10	5	0	5	0	0	0	15	5	5	0	0	0	20	5	20	0	5	0
6	K	0	0	10	0	0	0	15	0	0	0	0	0	0	0	10	0	0	0	0	0	15	0	0	0	0	0
	M	30	10	25	5	25	5	30	10	10	0	10	0	0	0	25	5	10	0	0	0	30	10	25	0	5	0

D. f. Aspergillus flavus ;A.p.Aspergillus parasiticus;A.n.Aspergillus niger ;A.g.Aspergillus fumigatus ;P1 Penicilium chrysogenium ;
E. P2 Penicilium expansum ;P3 Penicilium cyclopsum ;Alt.Alternaria SP:Fu1,Fusarium solani:Trich.trichoderma viride:Rhi.Rhizopus sp:
F. Muc.Mucor sp.
G. X,Non surface disinfected accurrance % Y,Surface disinfected accurrance %