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CHEMICAL, ORGANOLEPTIC AND MICROBIOLOGICAL EVALUATION OF IRRADIATED CUMIN SEEDS

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ABSTRACT

The purpose of this study is to improve the quality of cumin seeds increase the storage period by using gamma irradiation. Irradiated cumin seeds with different doses of gamma rays (5.0, 8.0 and 10.0 kGy) and storage for six months were carried out in order to improve its quality. The effectiveness of different gamma irradiation doses (without pesticides) on the inhibition of bacteria, fungi and yeasts contaminating cumin seeds were carried out. Also, evaluation the major chemical composition, and sensory properties for irradiated cumin seeds were achieved. Identification the optimum irradiation dose for microbial decontamination without affecting spices properties was studied.

The obtained data indicated that irradiation doses at 5.0, 8.0 and 10.0 kGy had no significant effects on the chemical constituents of cumin sseds seeds i.e. crude protein and total lipids. But, they were sufficiently decrease *Enterobacteriaces* and total bacterial count and completely inhibited the fungal flora.

Statistical analysis of data showed that irradiation had no significant effect on sensory properties of cumin seeds.

INTRODUCTION

Spices are an important group of agricultural commodities. It can be used in various forms such as ripe, fresh, dried and powdered. Spices and herbs are widely used in most food preparation such as meat or meat products; fish or fish products; bakery products; pizza and other food stuffs (Rtmictchell, 2003).

Spices whole, ground, powdered are known to be highly contaminated with microorganisms. The majority of microbial flora of spices consists of aerobic sporeforming bacteria, heat resistant bacteria and mold spores. The total counts may be reach to 107-108 cfu/g. When contaminated spices added to foods that support out growth of the microflora, then microflora can shorten market life of the products through spoilage and/or conceivably contribute to consumer illness (Munasiri *et al.*, 1987).

Spices after harvesting are often sun-dried by spreading them on open field or tarfelt road and then sold without any treatment in order to reduce the microbial load as reported by Andress *et al.* (2001) and Fennell *et al.* (2004).

Subbulakshmi *et al.* (1991) found that cumin seeds exposed to an absorbed dose of 10 kGy of gamma irradiation had no significant differentiation in their sensory qualities as compared with unirradiated samples.

Emam (2001) found that, the chemical constituents of cumin seeds (Cuminum *cyminium* L.), i.e. moisture contents was 12.8%, total lipids 20.8%, crude protein 18.7% and total volatile oils 5.53%. Chemical constituents of cumin seeds treated with gamma irradiation (2.5, 5.0 and 7.5 kGy) had no significant effect as the result of irradiation. Also, studied the effect of gamma irradiation on microorganisms of cumin seeds. The obtained results showed that, total bacterial counts, sporeforming bacteria and total moulds and yeasts were decreased as the level of irradiation dose increased. The percentages of reductions were 85.14%, 97.71% and 99.9%, respectively. The data revealed that, irradiation dose of 7.5 kGy was sufficient to decrease sporeforming bacteria with the percentage of 91.11% and completely inhibitted the fungal flora contaminating the examined samples.

Cumin is one of the commonly used spices of food industries and preservation. Many authors reported that, essential oils of cumin had antioxidants and antibacterial effects (Lee, 2005; Singh *et al.*, 2005 and Ani *et al.*, 2007).

Phianphak *et al.* (2007) examinated the microbial quality of seventeen species of herbs in Thailand. The levels of microbial load of herbs were ($>10^5$-10^{11} cfu.g^{-1}) of total aerobic bacteria, ($>10^3$-10^7 cfu.g^{-1}) of *Staphylococcus. sp.* ($>10^4$-10^7 cfu.g^{-1}) of *Salmonella,* sp., ($>10^3$-10^7 cfu.g^{-1}) of coliform bacteria and ($>10^3$-10^6 cfu.g^{-1}) fungi.

Abdel-Khalek (2008) studied the effect of γ-irradiation doses (2.5, 5.0, 7.5 and 10 kGy) on the chemical changes of cumin seeds, caraway seeds and mixture of spices powder (MSP) during storage for one year. She found that γ-radiation doses had significantly decrease moisture content and elevated the peroxide value of all tested spices. On the other hand, total lipid content showed insignificant effect. The storage period for one year of studied spices resulted in a decrease in all studied chemical properties except, peroxide value showed a progressive increase by extending the storage of unirradiated and irradiated samples. Also, the obtained results found that total aerobic count ranged from <106 to 107 cfu/g. The average of the mesophilic sporeforming ranged from 101 to less than 104 cfu/g. The total molds and yeasts were generally lower than 105 cfu/g.

The purpose of this study is to improve the quality to increase the storage period by using gamma irradiation.

MATERIALS AND METHODS

Cumin seeds (*Cuminum cyminum* L.) used in this research were obtained from the (local market in Cairo Governorate, Egypt). Samples (100 g) packed in polyethylene bags and were kept at refrigerator at 0°C.

Irradiation process:

Cumin seed samples were divided into four groups. The first group was left without irradiations to serve as control. The second, third and fourth groups were exposed to 5.0, 8.0 and 10 kGy, respectively. Irradiation process was performed at the National Center for Radiation Research and Technology (NCRRT), Nasr City, Cairo, Egypt using Russian gamma cell, Model Issledovatel utilizing cobalt 60 as an irradiation source. The dose rate of time source was 2.5 KGy.h^{-1}. All samples were stored at room temperature (25-27°C) for 6 months, then chemical, microbiological and sensory analysis were carried out (Atomic Energy Authority).

Chemical analysis:

Moisture, crude protein, total lipid, ash and total carbohydrate content of cumin seeds was determined according to the method described by A.O.A.C. (2000). Total phenol content of the untreated and treated samples was measured by the method of Amerine and Ough (1980), the absorbance was measured at 765 nm using Spectrophotometer, UVD-3500, Labomed, USA and the results were expressed as milligram of galic acid as standard equivalent per gram. Minerals (Ca, Fe, Mg, Ni and Co) of cumin seeds were determined by using Spectrophotometric analysis according to the method described by Anon (1982).

Microbiological examinations:

Total bacterial count (TBC) was counted was carried out according to the method described by APHA (1992).

Enterobacteriacea was counted according to the method described by ICMSF (1986).

Total molds and yeasts were counted on Czapek's Dox Yeast Extract Agar (CDYEA) medium according to Koburger and Marth (1984).

Sensory evaluation:

Sensory evaluation of color, texture, taste, odor, and overall acceptability of cumin seed was estimate by 10 panelists of staff members of National Center for Radiation Research and Technology, Dokky, Cairo Governorate, Egypt according to the method described by Subbulakashmi *et al.* (1991).

Statistical analysis was applied on the results for complete randomization design. Least significant difference (L.S.D.) was calculated at 0.05 level of significance according to the method described by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

1. Chemical composition:

1.1. Moisture content:

Results of moisture content of cumin seeds treated with gamma rays are summarized in Table (1). The moisture content ranged between 12.30 and 12.85%. The moisture content of cumin seeds decreased as the result of irradiation doses. These results were in agreement with those found by Abdullah (1989). Ragab (1994) and Abdel Khalek (2008).

1.2. Crude protein content:

Results in Table (1) show the effect of irradiation doses (5.0, 8.0 and 10 kGy) and storage periods (six months) on crude protein of cumin seeds. Crude protein of unirradiated cumin seeds was 18.71%.

Slight decrease of crude protein during subsequent storage period. At the end of storage (after six months), crude protein of unirradiated samples decreased from 18.71 to 18.53%. There was no significant effect in crude protein as a result of irradiation and storage period. These results were in agreement with those reported by Al-Jassir, (1992), Emam, (2001) and Abdel Khalek, (2008).

1.3. Total lipid content:

Data in Table (1) showed the influence of different γ-irradiation doses (5.0, 8.0 and 10 kGy) and storage periods for 6 months on total lipids of cumin seeds. The percentage of total lipids in unirradiated sample was 21.11%, while, the irradiated samples by 5.0, 8.0 and 10.0 kGy were 20.96, 20.65 and 20.45%, respectively. There was no significant effect of all irradiation doses on total lipids of cumin seeds. These results were in agreements with those found by Emam (2001).

During subsequent storage at room temperature, a slightly decrease in the total lipids either in unirradiated or irradiated samples was found. The current results indicated that treated samples with elevated irradiation doses 10 kGy tended to have the lowest value of lipids, as compared to untreated samples, even after storage for 6 months. At the beginning of storage, total lipids of unirradiated decreased from 21.11 to 20.66% at the end of storage (six months). This trend of results was found by El-Khawas (1995).

1.4. Ash content:

Data in Table (1) showed the change of ash content of cumin seeds as a result of irradiation doses and storage period (for six months). The highest value was found in the unirradiated sample (4.68%), while, the lowest value was detected for irradiated samples with the elevated dose of 10 kGy (4.35%). These results were in agreement with those found by Weber (1983), Abdullah, (1989) and Emam, (2001).

During storage, ash content of cumin seeds either in unirradiated or irradiated samples was insignificantly decreased. The percentage of control samples decreased from

4.68% to 4.66% after six months of storage. The lower value of ash content was observed for the higher irradiation dose.

1.5. Total carbohydrates content:

Data in Table (1) showed the influence of irradiation treatments and storage periods for six months on total carbohydrates of cumin seeds. The highest value was found in control sample (48.16%) while, the lowest one was detected in irradiated samples with a high dose (10 kGy) (46.8%). This results were in agreement with those found by Farahath *et al.* (2001) who found that carbohydrate content of cumin seeds was 48.01% on dry weight basis. Total carbohydrates of cumin seeds was insignificantly affected in response to the applied doses (5.0, 8.0 and 10 kGy) of gamma irradiation.

During storage, a slightly decreased in carbohydrates of cumin seeds was observed. The percentage of carbohydrates of control samples was decreased from 48.16 to 47.47% during storage period.

1.6. Total phenols content:

Data in Table (1) illustrated the total phenols of cumin seeds as affected by irradiation doses and storage period for six months. Unirradiated cumin seeds contained 1.5% phenols. While, the Irradiated samples with doses of 5.0, 8.0 and 10 kGy contained 1.4%, 1.3 and 1.3%, respectively. Results shown in the same table revealed that, at zero time of storage, the content of phenols of cumin seeds were no significantly changed in response to gamma irradiation doses used in the present investigation.

During storage, a slightly decrease in phenols of cumin seeds was observed with the increasing irradiation doses. The lower value of phenols was observed with the higher irradiation dose. Also, there was no significant effect due to irradiation treatments.

Finally, it could be stated that gamma irradiation doses and storage periods for six months had no significant effects on the content of total phenols of cumin seeds.

1.7. Minerals content:

Results of minerals content of cumin seeds treated with irradiation doses (5.0, 8.0 and 10.0 kGy) and storage period for six months were summarized in Table (2). It was found that, cumin seeds contained, Ca 1135 mg/100 g, Fe 3.75 ppm, Mn 3.61 ppm, Ni 0.72 ppm and Co 2.32 ppm on dry weight basis. These results were nearly to results obtained by Joseph *et al.* (1999).

Irradiation doses of 5.0, 8.0 and 10.0 kGy doses had no significant effects on Ca, Fe, Mn, Ni and Co of cumin seeds. These results were noticed by Al-Jassir (1992).

During storage period, a slightly decreased in all minerals content of cumin seeds was noticed. The decrease of these minerals of unirradiated samples reached from 1135 to 1120 mg/100 g on dry weight basis of Ca; followed by Fe (3.75 to 3.71 ppm); Mn (3.61 to 3.57 ppm) and Ni (0.72 to 0.68 ppm). The lower value of minerals was observed with the higher irradiation doses. There were no significant difference of minerals content of cumin seeds as a result of exposure to gamma irradiation doses.

Finally, it could be noticed that gamma irradiation dose, (5.0, 8.0 and 10.0 kGy) and storage periods for six months had no significant effects as regards the content of minerals (Ca, Fe, Mn, Ni and Co) of cumin seeds.

3. Microbiological examination:

3.1. Total bacterial count:

Total bacterial counts of treated seeds with gamma irradiation doses (5.0, 8.0 and 10.0 kGy) and stored at ambient temperature for six months are summarized in Table (3). It is evident that the total aerobic mesophilic bacterial counts of cumin seeds was 1.42×10^5 cfu/g. Is this count principle according to Egyptian Standards or American Standards or Egyptian Standards. These results were in agreement with those found by Al-Bachir and Lahham (2003) and Phianphak *et al.* (2007).

Table (1): Effect of both irradiation and storage period on chemical composition of cumin seeds (%).

Treatments / Storage period	Irradiation doses (kGy)			
	0.0	5.0	8.0	10.0
	Moisture content			
Zero time	12.85	12.65	12.50	12.30
3 months	11.75	11.60	11.45	11.30
6 months	11.55	11.45	11.35	11.20
L.S.D. for storage periods (A)	0.56			
L.S.D. for treatments (B)	0.59			
L.S.D. for AxB	1.68			
	Crude protein content			
Zero time	18.71	18.50	18.44	18.35
3 months	18.55	18.50	18.40	18.34
6 months	18.53	18.49	18.35	18.29
L.S.D. for storage periods (A)	0.44			
L.S.D. for treatments (B)	0.50			
L.S.D. for AxB	0.75			
	Total lipid content			
Zero time	21.11	20.96	20.65	20.45
3 months	20.89	20.78	20.70	20.48
6 months	20.66	20.57	20.45	20.32
L.S.D. for storage periods (A)	0.70			
L.S.D. for treatments (B)	0.86			
L.S.D. for AxB	1.17			
	Ash content			
Zero time	4.68	4.55	4.48	4.35
3 months	4.67	4.53	4.46	4.32
6 months	4.66	4.48	4.26	4.10
L.S.D. for storage periods (A)	0.36			
L.S.D. for treatments (B)	0.49			
L.S.D. for AxB	0.66			
	Total carbohydrate content			
Zero time	48.16	47.75	47.30	46.80
3 months	47.65	46.95	46.39	46.20
6 months	47.47	46.86	46.15	45.35
L.S.D. for storage periods (A)	1.41			
L.S.D. for treatments (B)	1.65			
L.S.D. for AxB	2.90			
	Total phenol content			
Zero time	1.50	1.40	1.30	1.30
3 months	1.31	1.29	1.26	1.23
6 months	1.30	1.20	1.20	1.20
L.S.D. for storage periods (A)	0.24			
L.S.D. for treatments (B)	0.26			
L.S.D. for AxB	0.41			

L.S.D. at $P < 0.05$

Table (2): The influence of irradiation and storage on minerals content of cumin seeds.

Treatments \ Periods	Ca (mg/100 g)		
	1st	2nd	3rd
Control	1135	1130	1120
5 kGy	1105	1115	1105
8 kGy	1095	1105	1095
10 kGy	1085	1095	1090
L.S.D. for storage period (A)	15.11		
L.S.D. for treatments (B)	58.35		
L.S.D. for AxB	64.45		
	Fe (ppm)		
Control	3.75	3.73	3.71
5 kGy	3.64	3.61	3.50
8 kGy	3.55	3.48	3.29
10 kGy	3.53	3.36	3.22
L.S.D. for storage period (A)	0.07		
L.S.D. for treatments (B)	0.15		
L.S.D. for AxB	0.66		
	Mn (ppm)		
Control	3.61	3.58	3.57
5 kGy	3.35	3.32	3.28
8 kGy	3.25	3.23	3.16
10 kGy	3.18	3.15	3.09
L.S.D. for storage period (A)	0.15		
L.S.D. for treatments (B)	0.53		
L.S.D. for AxB	0.64		
	Ni (ppm)		
Control	0.72	0.68	0.68
5 kGy	0.61	0.50	0.50
8 kGy	0.47	0.40	0.37
10 kGy	0.39	0.29	0.28
L.S.D. for storage period (A)	0.12		
L.S.D. for treatments (B)	0.43		
L.S.D. for AxB	0.56		
	Co (ppm)		
Control	2.32	2.31	2.30
5 kGy	1.92	1.89	1.87
8 kGy	1.76	1.72	1.67
10 kGy	1.66	1.60	1.51
L.S.D. for storage period (A)	0.53		
L.S.D. for treatments (B)	0.90		
L.S.D. for AxB	0.98		

L.S.D. at ($P<0.05$)

Table (3): Effect of both gamma irradiation and storage period on total bacterial counts of cumin seeds (cfu/g).

Storage period \ Treatments	Irradiation doses (kGy)			
	0.0	5.0	8.0	10.0
Zero time	$1.42x10^5$	$2.2x10^3$	$2.2x10^2$	< 10
3 months	$5.0x10^4$	$1.0x10^3$	2.0x10	< 10
6 months	$8.0x10^3$	$2.0x10^2$	$1.0x10^2$	< 10

Data in the same table showed that irradiation with gamma rays at doses of 5.0, 8.0 and 10.0 kGy reduced total aerobic bacterial counts, the percentages of reduction were 98.5, 99.8 and 99.9%, respectively. As it was observed, samples treated with a highest dose of gamma irradiation had the lowest total bacterial counts. Also, my be due to the radiolytic effect on the chemical compounds and hence the production of free radicals which had been occurred during storage. The obtained results are in conscience with that reported by Singh and Tak (1997) and Lee *et al.* (2005).

During storage, total aerobic bacterial counts gradually decreased as the time of storage period. The percentages decrement of unirradiated samples were 64.8% after 3 months of storage and 94.4% at the end of storage period (after six months).

This decrease of total bacterial counts during storage may be due to the loss of moisture content of cumin seeds. At radiation dose of 10 kGy, the growth of bacteria was completely inhibited. At the end of storage period (after six months) the total bacterial counts of cumin seeds were $8.0x10^3$, $2.0x10^2$, $1.0x10^2$ and <10 cfu/g for gamma irradiation doses of 0.0, 5.0, 8.0 and 10.0 kGy, respectively. These results were in agreement with those found by (Abdullah 1989 and Abdel Khalek 2008).

3.2. *Enterobacteriaceae* count:

Table (4) illustrates the counts of *Enterobacteriaceae* of cumin seeds as affected by gamma irradiation doses (5.0, 8.0 and 10.0 kGy) and storage period. It is evident from the results of cumin seeds contained *Enterobacteriaceae* counts of $3.4x10^3$ cfu/g. These results were in conscidence with those obtained by Mousumi and Sarkar (2003).

Table (4): Effect of gamma irradiation and storage periods on total *Enterobacteriaceae* counts of cumin seeds (cfu/g).

Treatments / Storage period	Irradiation doses (kGy)			
	0.0	**5.0**	**8.0**	**10.0**
Zero time	$3.4x10^3$	< 10	< 10	< 10
3 months	$1.1x10^2$	< 10	< 10	< 10
6 months	6.5x10	< 10	< 10	< 10

Data in the same table revealed that, irradiation of 5.0 kGy was sufficient to decrease *Enterobacteriaceae* count to undetectable level. These results were in agreement with those found by Hammad *et al.* (1987).

During storage period, total *Enterobacteriaceae* of unirradiated cumin seeds gradually decreased during storage periods. The counts of *Enterobacteriaceae* of unirradiated cumin seeds at zero time was $3.4x10^3$ cfu/g then decreased till reached to $1.1x10^2$ and 6.1x10 cfu/g after three and six months of storage, respectively.

3.3. Total molds and yeasts count:

Table (5) illustrated that the effect of both irradiation doses (5.0, 8.0 and 10.0 kGy) and storage period for six months on total molds and yeasts of cumin seeds. The unirradiated (control) cumin seeds contained $1.2x10^3$ cfu/g of molds and yeasts. These results were in conscidence with that obtained by Mousumi and Sarkar (2003). While, the current for total of fungi and yeast results were disagree with those obtained with Phianphak *et al.* (2007) noticed that total molds was ranged between 10^3 and 10^6 cfu/g of spices and herbs.

Irradiation doses of 5.0, 8.0 and 10.0 kGy showed complete elimination of molds and yeasts of cumin seeds. As it is shown into Table (5) the dose of 5.0 kGy was enough to cause great reduction of molds and yeasts. These results were in agreement with those found by Abdel Khalek (2008).

During storage period, total fungi and yeast in unirradiated cumin seeds gradually decreased during storage periods. The percentages decreased by about 89.2 and 97.5% after three and six months of storage period, respectively. This decrease may be due to the loss of moisture content of cumin seeds during storage at room temperature (25±2°C) as shown in the previous Table (3). These results were in agreement with those found by Abdel Khalek, (2008).

Table (5): The influence of gamma irradiation and storage period on molds and yeasts of cumin seeds (cfu/g).

Treatments / Storage period	Irradiation doses (kGy)			
	0.0	**5.0**	**8.0**	**10.0**
Zero time	$1.2x10^3$	< 10	< 10	< 10
3 months	$1.3x10^2$	< 10	< 10	< 10
6 months	3.0x10	< 10	< 10	< 10

4. Sensory evaluation:

It is known that organoleptic properties test is a reliable index for color, texture, taste, odor and overall acceptability. The sensory properties is considered of great importance for consumer. Spices are known for their own characteristics flavors to food as well as enhance their natural value, also, spices can be used in various food processing.

Table (6) shows sensory scores of color of cumin seeds as affected by both irradiation doses (5.0, 8.0 and 10.0 kGy) and storage period (for six months). Both unirradiated and irradiated cumin samples recorded high score (8.4-8.9 degree). Irradiation doses had no significant differentiation in the color of cumin seeds if compared with control samples. These results were in agreement with those mentioned by Emam (2001).

During storage period, color scores of unirradiated and irradiated cumin seeds were acceptable for the panelist, the score of color was ranged from 8.5 to 8.6 degree after six months of storage. It is worthy to mention that analysis of variance showed that, there were no significant effect as a result of irradiation or during storage at room temperature after six months of storage. The same trend of results was found by Bahari *et al.* (1983).

Sensory evaluation of texture of cumin seeds as affected by irradiation and storage period was illustrated in Table (6). The score of texture of cumin seed samples was ranged from 8.6 to 8.7. Irradiation doses up to 10 kGy had no significant effect on the sensory quality of cumin. This trend of results was in agreement with those found by Subbulakshmi *et al.* (1991); Piggott and Othman (1993); Andrews *et al.* (1995).

During subsequent storage period, also texture of unirradiated and irradiated cumin seeds recorded higher score which was ranged between 8.4 and 8.6 and all samples accepted for the panelists.

Sensory evaluation of taste of cumin seeds as affected by irradiation and storage period (Table 6). It is evident that taste of cumin was recorded higher score of all treatments and ranged between 9-9.2 degree. Irradiation doses up to 10 kGy had no significant change in taste of cumin. These results were in agreement with those obtained by Anrdrews *et al.* (1995).

During storage period, these were no any significant effect due to either irradiation doses or during subsequent storage period of all samples. At the end of storage period, both unirradiated and irradiated cumin seeds were accepted for the panelists. The same trend of Bahari *et al.* (1983).

Table (6) sensory evaluation of odor of cumin seeds as affected by both irradiation and storage period. Sensory of odor score of cumin seeds was the higher value and ranged between 8.6 and 8.87 degree. Irradiation doses of 5.0, 8.0 and 10.0 kGy had no significantly change of flavor. The same trend of results was in agreement with those found by Subbulakshmi *et al.* (1991).

It is evident from results in Table (6) unirradiated and irradiated cumin seeds were recorded the high score of odòr and ranged from 8.4 to 8.6 degree at the end storage period. Also, all samples either irradiated or during storage period were accepted by the panelists. The same trend of results were noticed by Andrews *et al.* (1995) and Sharabash *et al.* (1999). Moreover, the storage period had no significant differentiation in their sensory qualities as compared with unirradiated samples.

Data in Table (5) observed that differentiation in the overall acceptability of different treatments were slightly affected and achieved a high score in overall acceptability. Also, the different storage periods had slightly effects in overall acceptability for different treatments. Finally, it could be noticed that high score in unirradiated cumin seeds ranged from 8.9 to 8.4 degrees in zero time, while decreased in irradiated cumin seeds with 10 kGy from 8.4 to 8.2 degrees during storage periods.

Table (6): Sensory evaluation of cumin seeds as affected by both irradiation and storage period.

Storage period \ Treatments	Irradiation doses (kGy) 0.0	5.0	8.0	10.0
	Colour			
Zero time	8.9	8.4	8.7	8.4
3 months	8.9	8.5	8.7	8.5
6 months	8.6	8.6	8.5	8.5
L.S.D. for storage periods (A)	**0.6**			
L.S.D. for treatments (B)	**0.5**			
L.S.D. for AxB	**0.7**			
	Texture			
Zero time	8.9	8.5	8.6	8.6
3 months	8.5	8.9	8.8	8.5
6 months	8.6	8.6	8.5	8.4
L.S.D. for storage periods (A)	**0.4**			
L.S.D. for treatments (B)	**0.5**			
L.S.D. for AxB	**0.6**			
	Taste			
Zero time	9.1	9.2	9.0	9.1
3 months	9.0	9.1	9.0	9.1
6 months	8.0	8.1	8.2	8.0
L.S.D. for storage periods (A)	**0.5**			
L.S.D. for treatments (B)	**1.2**			
L.S.D. for AxB	**1.4**			
	Odour			
Zero time	8.8	8.5	8.7	7.5
3 months	8.7	8.3	8.5	7.6
6 months	8.6	8.4	8.3	7.9
L.S.D. for storage periods (A)	**1.6**			
L.S.D. for treatments (B)	**1.5**			
L.S.D. for AxB	**1.7**			
	Overall acceptability			
Zero time	8.9	8.7	8.5	8.4
3 months	8.9	8.7	8.8	8.4
6 months	8.5	8.4	8.4	8.2
L.S.D. for storage periods (A)	**0.6**			
L.S.D. for treatments (B)	**0.5**			
L.S.D. for AxB	**0.7**			

L.S.D. at $P < 0.05$.

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التقييم الكيماوى والحسى والميكروبيولوجى لبذور الكمون المشععة

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استهدفت الدراسة استخدام طريقة حديثة آمنة صديقة للبيئة وذات كفاءة عالية فى التخلص من الميكروبات التى تصيب التوابل دون حدوث تغيرات تذكر فى صفات وخصائص التوابل وفى نكهتها ورائحتها. ولذا تم استخدام أشعة جاما كطريقة طبيعية وآمنة لما لها من قدرة فائقة على التخلص من الميكروبات دون حدوث أى تغيرات فى صفاتها. وقد تمت معاملة بذور الكمون بأشعة جاما بجرعات قدرها ٥، ٨، ١٠ كيلو جراى ثم تم دراسة التقييم الكيميائى والميكروبيولوجى والحسى لبذور الكمون المعاملة بالإشعاع والمخزنة على درجة حرارة الغرفة (٢٥±٢°م) لمدة ستة أشهر.

وقد أوضحت النتائج المتحصل عليها عدم وجود فروق معنوية تذكر بين المعاملات المختلفة سواء على الخواص الكيميائية أو الحسية مقارنة بالكنترول ولكن أعطت نتائج إيجابية من حيث التخلص من الكائنات الحية الدقيقة مقارنة بالكنترول ولذا نوصى بمعاملة التوابل بجرعات من الإشعاع خاصة أشعة جاما وذلك للقضاء على الكائنات الحية الدقيقة سواء البكتريا بأجناسها المختلفة أو الفطريات.