Effect of Gamma Irradiation on Peanut (*Arachis Hypogaea*.L)

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Chemical analysis, Gamma irradiation, Microbial load, Peanut seeds, Sensory evaluation

ABSTRACT

This work report the effect of irradiation with gamma rays (1, 2 and 3 kGy) on the chemical composition, microbial loads, chemical characteristics and sensorial properties of the peanut seeds. The data obtained from the experiments showed that gamma irradiation process has no effect on the proximate composition (water content, proteins, sugars, lipids, and ash), and chemical attributes (free fatty acids, pH value and based nitrogen value (BVN)) of peanut seeds. Irradiation was found to cause significant reduction in microbial load and no fungal colonies were detected in irradiated samples with 2 and 3 kGy. Bacterial and fungal load of irradiated peanut seeds and there comparison with control samples suggest that gamma irradiation treatment at low doses is an effective post-harvest treatment and quarantine control for fungal load. However, non-irradiated and irradiated peanut seeds did not show significant differences in the sensorial test (texture, odor, color and test).

دراسة تأثير أشعة غاما في معالجة الفول السوداني (*Arachis Hypogaea*.L)

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الكلمات الدالة

التحاليل الكيميائية، أشعة غاما، حمولة ميكروبية، بذور فول سوداني، تقويم حسي

المُستلخص

درس فـــي هذا العمل تأثير أشـــعة غاما (1 و 2 و 3 كيلو غري) فـــي التركيب التقريبي و الحمولة الميكروبية والخصائص الكيميائية والمواصفات الحســية لبذور الفول الســودان. أشـــارت البيانات المتحصل عليها من هــذه التجارب إلى عدم وجود تأثير للمعالجة بأشـــعة غاما في التركيب التقريبي (محتـــوى الماء و البروتين و الســكر و الدهــن و الرماد) والخصائص الكيميائيـــة (الأحماض الدهنية الحرة وقيـــم الحموضة الـ pH و الازوت القاعــدي الطيــار) عنــد بذور الفول الســوداني. ونتج عن المعالجة بالأشـــعة خفــض معنوي في الحمولة لميكروبية ولم يلاحظ أي وجود لمســتعمرات فطرية قابلة للكشــف عند العينــات المعالجة بالجرع 2 و 3 كيلو غري. وبالتالي فحمولة بذور الفول الســوداني المعالجة بالأشـــعة مـــن البكتريا والفطور مقارنة مع عينات الشـــاهد قد أوحـــى بأن المعالجة بجرع منخفضة من أشـــعة غاما هي معالجـــة فعالة في التطبيق بعــد الحصاد وفي الحجــر الزراعي لضبط الحمولـــة الفطرية. ومع ذلــك فلم يتبين وجود فـــروق معنوية بين العينات المعالجة بالأشـــعة وعينات الشـــاهد في الخصائص الحســـية (القوام والرائح و اللون ة والطعم) عند بذور الفول الســـوداني

Introduction

Crude peanuts (Arachis hypogaea L.) are of great importance in foods worldwide. Peanut are relatively high-value products used primarily for snack foods or as confectionary ingredients, and their successful marketing requires strict attention to quality control (Johnsoon, 2004). Recently, peanuts have gained much attention as functional food (Fransico and Resurrection, 2008). However, according to Dorner (2008) the contamination of peanuts with mycotoxins, is a worldwide problem that affects both food safety and agricultural economies. The ability of salmonella to survive in high fat content, low water activity foods like peanut butter has been demonstrated by large food borne illness outbreaks in recent years (D,Souza et al., 2012).

Consequently, various intervention technologies have been assessed, including propylene oxide fumigation (Danyluk et al., 2005), moist heating (Jeong et al., 2009), steam pasteurization (Chang et al., 2010), water pressure (Willford et al., 2008), sanitizers, dry heat, hot water, and gas catalytic infrared heat (Latiful Bari et al., 2009), and irradiation (Mexis et al., 2009; Prakash et al 2010).

Worldwide, a number of studies have reported that gamma irradiated food items such as tree nuts (Evern and Gulden, 2008; Mexis and Kontominas, 2009; Prakash et al., 2010; Al-Bachir, 3004), oil seeds (De Camargo et al., 2012), and other seeds (Aziz & Mahrous, 2004; Hajare et al, 2007) showed better physico-chemical statues as well as biological characteristics verses non-irradiated samples.

There is inadequate information about the nutrient statues, microbial, chemical and sensorial properties, and the effect of irradiation on these properties of peanut seeds produced in Syria. The present study therefore reports the proximate composition, and the microbial, chemical and sensorial properties of irradiated and non-irradiated Syrian peanut seeds.

Materials and Methods

Samples of peeled peanut seeds cv. Baladi (crop year 2010/2011) were purchased from local shops in Damascus, Syria. About 250 g of peanut seeds in form of single layer was packed in small polyethylene bag for irradiation. Each bags of peanut seed is considered as a replicate. Irradiated and non-irradiated samples were stored for 12 months at room temperature.

Treatments and analysis performed during storage

Samples from peanut seeds were exposed to gamma radiation at doses of 1, 2 and 3 kGy in a 60CO package irradiator (dose rate 8.488 kGy h-1). The irradiation was performed at room temperature (15–20 oC). The absorbed dose was determined using alcoholic chlorobenzene dosimeter (Al-Bachir, 2004). For each treatment, 12 bags of peanut seed were allocated and all were stored at room temperature. Microbiological, proximate and chemical analyses were performed on controls and treated samples immediately after irradiation, and after 12 month of storage. Sensory evaluation was done within two days of irradiation.

Microbiological evaluation

Three replicates from each treatment, un-irradiated and irradiated, were aseptically opened, and 10 g of whole peanut seed were transferred to a sterilized glass bottle containing 90 ml of sterile physiological water (9 g kg-1 NaCl). The bottle was shaken to homogenize the sample. Further dilutions were made as far as 10-6 (AOAC, 2010). The media used for the microbiological study were nutrient agar for the total bacterial plate counts (TBPCs), agar plate counts (APCs) (Oxoid, CM 325, UK) (48 h incubation at 30 oC). Fungus were enumerated on Dichloran Rose-Bengal Chloramphenicol Agar (DRBC) (Merck, 1.00466, Germany) after incubation at 25 oC for 5 days.

Chemical analysis

Approximately 150 g of peanut seeds were blended for 15 s in a laboratory blender, and was used in all the chemical analysis. Each sample was homogenized and analyzed in triplicates, to determine moisture and ash (drying for 6 h at 105 oC, and ashing for 4 h at 550 oC), crude fat (as extractable component in Soxhlet apparatus), and crude protein (as Kjeldahl nitrogen) using standard methods (AOAC, 2010). pH values of the solutions of peanut seeds were determined using an HI 8521 pH meter (Hanna Instruments, Woonsocket, RI, USA). The total acidity was obtained by a direct titration with (0.1 N) NaOH and phenolphthalein as an indicator. The total acidity was calculated as ml of (0.1 N) NaOH = 0.0090 g lactic acid (AOAC, 2010).. Total volatile basic nitrogen in the sample in term of mg VBN kg-1 peanut seed (ppm) was determined (Al-Bachir, 2004).

Sensory evaluation

Sensory evaluation (consumer analysis) was carried out by 30 member untrained panel. Approximately 20 g of whole peanut seeds were placed in small glasses coded containers. Panelists were served a set of four treated samples (0, 1, 2, and 3 kGy) and they were instructed to consume the whole sample and rinse mouth with sparkling water (room temperature), in between sample evaluation. Sensory attributes evaluated included color, texture, odor and taste. Scoring was carried out on paper ballots using a 5 point hedonic scale where:1 = extremely poor, 2 = poor, 3 = acceptable, 4 = good, 5: excellent) (Al-Bachir, 2004).

Statistical analysis

The four treatments were distributed in a completely randomized design with three replicates. Data were subjected to the analysis of variance test (ANOVA) using the SUPERANOVA computer package (Abacus Concepts Inc, Berkeley, CA, USA; 1998). A separation test on treatment means was conducted using Fisher's least significant differences (LSD) methods at 95% confidence level (Snedecor & Cochran, 1988).

Results and Discussion

Effect of irradiation and storage on proximate composition of peanut

Table 1 shows the proximate composition of peanut seeds samples. It can be seen that the proximate chemical contents of non-irradiated (control) samples of peanut seeds were: moisture (6.27 ± 0.88 %), crude protein (23.83 ± 0.20 %), crude fat (52.64 ± 0.88 %), ash (2.42 ± 0.05 %), total sugar (13.03 ± 0.03 %) and reducing sugar (0.46 ± 0.02 %). The current results are in accordance with the proximate composition of blanched peanut samples already reported in the literature. Protein, lipid and ash contents were: 22.92, 46.92 and 2.11% respectively (De-Camargo et al., 2012). The high protein and mineral content in peanut seeds emphasizes their value as a vital source of nutrients. The quantity of ash in any seed sample assumes importance, as it determines the nutritionally important minerals (Vadivel and Janardhanan, 2004). As seen in Table 1; storage period affected the proximate composition parameters of peanut seeds significantly ($p<0.05$). After 12 months of storage the percentage of moisture (4.43%), crude fat (51.97%) and total sugar (11. 96%) was lower than those of non stored samples (6.27, 52.64 and 13.03% respectively). Whereas, the crude protein were increased during the storage period (Table 1) from 23.83 to 24.18%. There are no appreciable differences in proximate composition of samples irradiated to 0, 1, 2 and 3 kGy (Table 1). The Moisture, protein, lipid, ash, total sugar, and reducing sugar content were not significantly changed. This results is in agreement with other study, which reported that gamma irradiation did not induce any change in other seeds like wheat and bean (Aziz and Mahrous, 2004). No significant differences between irradiated and un-irradiated walnuts in moisture, ash and protein contents were found (Al-Bachir, 2004). Data obtained by others also showed that gamma treatment with up to 10 kGy, did not induce significant loss in water soluble components such as minerals, nitrogenous constituents, sugars and proteins (Stajner et al., 2007). On the other hand, based on previous research reports, the total carbohydrate contents decreased with increasingly higher dosage of gamma irradiation caused by higher metabolic activities and hydrolyzing enzyme activity in seed (Barros et al., 2002; Maity et al., 2009). However, electron beam irradiation increased the crude carbohydrates of lotus seeds, which was significant ($p<0.05$) only at 30 kGy. The increase in carbohydrates might be attributed to radiation-induced breakdown of complex sugar (polysaccharides) into simple extractable forms (e.g., free sugars) (Bhati and Sridhar, 2008).

Table 1. Effect of gamma irradiation and storage period on moisture, ash, protein, total sugar, reducing sugar and fat contents (%) of peanut.

Treatment	Control	1 KGY	2 KGY	3 KGY	LSD 5%
Storage period (months)					
Moisture (%)					
0	6.27±0.88	5.84±0.78	6.27±1.20	5.42±0.12	**1.58**
12	4.43±0.07	4.58±0.21	4.76±0.13	4.63±0.22	**0.32**
LSD 5%	**1.41**	**1.29**	**1.93**	**0.40**	
Crude protein (%)					
0	23.83±0.20	23.70±0.23	23.98±0.30	23.48±0.08	**0.41**
12	24.18±0.52	22.85±1.08	24.43±0.26	24.16±1.92	**2.51**
LSD 5%	**0.89**	**1.76**	**0.64**	**3.09**	
Crude fat (%)					
0	52.64±0.88	52.14±0.67	50.96±2.05	52.25±2.64	**3.32**
12	51.97±1.13	52.11±1.08	52.82±0.96	52.70±1.12	**2.02**
LSD 5%	**2.30**	**2.03**	**3.63**	**4.60**	
Ash (%)					
0	2.42±0.05	2.52±0.21	2.34±0.03	2.38±0.04	**0.20**
12	2.34±0.07	2.32±0.09	2.33±0.12	2.35±0.02	**0.16**
LSD 5%	**0.14**	**0.36**	**0.19**	**0.08**	
Total sugar (%)					
0	13.03±0.24	10.71±0.64	10.86±0.82	10.51±0.92	**1.32**
12	11.96±0.12	11.98±0.16	12.58±0.14	12.67±0.07	**0.24**
LSD 5%	**0.42**	**1.05**	**1.33**	**1.49**	
Reducing sugar (%)					
0	0.46±0.02	0.49±0.01	0.46±0.01	0.46±0.02	**0.03**
12	0.55±0.01	0.54±0.01	0.55±0.01	0.54±0.00	**0.01**
LSD 5%	**0.04**	**0.02**	**0.02**	**0.03**	

LSD: Least significant difference

Effect of gamma irradiation and storage time on chemical properties

Total acidity and pH value: The control sample of peanut seeds had low acidity as compared to the samples stored for 12 months or treated with gamma irradiation (1, 2 and 3 kGy) (Table 2). The acidity values of the peanut seed increased from 0.36 % to 0.54 % during the storage period. The behavior of the total acidity during storage in peanut seeds, reported in our study, was found to be in harmony with Jubeen et al. (2012) and Sanchez-Bel et al. (2008). Similarly, Faruk Gamli and Hayoglu, (2007) reported that the total acidity (%) and free fatty acids (%) of the pistachio past increased during the storage. The total acidity of the peanut seeds irradiated with 1, 2 and 3 kGy was higher as compared to the control samples. The increase in acidity of the oil seeds might be due to slight and random hydrolysis of triglycerol molecules to free fatty acids and diacylglycerols (Al-Bachir, 2004; Anjum et al., 2006). Immediately after irradiation, low doses of gamma irradiation (1 and 2 kGy) decreased ($p<0.05$) the pH values of peanut seeds. The pH values of the peanut seeds dropped gradually during the storage period from 6.72 to 6.62 at room temperature. The decrease of pH values of peanut seeds were associated with increasing the total acidity (Table 3)

Total volatile basic nitrogen (TVBN)

Total volatile basic nitrogen (TVBN) content of non-irradiated and 1, 2 and 3 kGy irradiated peanut seeds stored at room temperature for 12 months are shown in Table 2. At the beginning of storage, the TVBN value was 401.92 mg kg-1 peanut seeds for control samples. TVBN values increased according to irradiation doses. Immediately after irradiation, TVBN values reached 401.92, 428.20, 450.89 and 562.17 mg kg-1 for non-irradiated, and 1, 2 and 3 kGy irradiated peanut samples, respectively. TVBN values decreased according to time of storage. At the end of the storage period of 12 months, TVBN values reached 296.26, 297.46, 300.80 and 312.89 mg kg-1 for non-irradiated, and 1, 2 and 3 kGy irradiated peanut seeds, respectively. The TVBN is related to protein breakdown (Egan et al., 1981), and the observed increases may be attributed to the formation of ammonia or other basic compounds due to microbial activity (Banwart, 1981). Increasing the applied dose decreased the rate of TVBN formation during storage by reducing the initial levels of the common spoilage bacteria (Table 3).

Table 2 .Effect of gamma irradiation and storage period on total acidity (%Lactic acid), PH value and volatile basic nitrogen (VBN)(P.P.M) of peanut.

Treatment	Control	1 KGY	2 KGY	3 KGY	LSD 5%
Storage period (months)					
Total acidity (Lactic acid %)					
0	0.36±0.02	0.38±0.02	0.39±0.01	0.40±0.01	0.03
12	0.54±0.01	0.50±0.01	0.50±0.01	0.49±0.02	0.03
LSD 5%	0.03	0.03	0.03	0.04	
PH value					
0	6.72±0.01	6.62±0.03	6.67±0.02	6.72±0.04	0.05
12	6.62±0.17	6.72±0.06	6.69±0.05	6.65±0.04	0.17
LSD 5%	0.27	0.10	0.08	0.09	
Volatile basic nitrogen (P.P.M)					
0	401.92±26.27	428.20±26.77	450.89±11.67	562.17±31.51	47.41
12	296.26±2.02	297.46±2.95	300.80±7.41	312.89±6.62	9.95
LSD 5%	42.23	43.18	22.17	51.62	

LSD: Least significant difference

Effect of irradiation and storage time on microbial load

The spread plate method and direct observation were used to evaluate the total bacterial and fungal loads. Our results revealed significant variation in the bacterial and fungal load of peanuts throughout storage and after irradiation (Table 3). The total bacterial and fungal counts of control samples of peanut seed were 2.97 and 2.55 log cfu/g respectively. After 12 months of storage at room temperature, the total bacterial and fungal count increased to 3.97 and 2.87 log cfu/g respectively. Irradiation was found to cause significant reduction in microbial load proportionate to the dose delivered. One kGy of gamma irradiation reduced the bacterial load from 2.97 to 2.53 log cfu/g, on day 0. While 2 and 3 kGy doses reduced the initial bacterial load to below detection level when analysis was carried out immediately after irradiation treatment. Throughout storage, the bacterial load of peanut seeds increased in both irradiated and non-irradiated samples. On month 12, the microbial load in 0, 1, 2 and 3 kGy irradiated samples were 3.97, 3.20, 2.81 and 2.43 log cfu/g respectively. Regarding total fungal load, immediately after irradiation treatment and after 12 months of storage, no fungal colonies were detected in irradiated samples with 2 and 3 kGy. The total fungal counts (log cfu/g) of control samples increased from 2.55 to 2.87 log cfu/g after 12 months of storage. It was noted that the number of contaminant colonies increased with storage periods for sample irradiated at 1 kGy, similar to non-irradiated controls. Our found was found to be in agreement with Chun et al. (2007) and Jubeen et al. (2012) who report that the level of fugal count was found to be very high in all nut samples at the end of storage. Recently, Aziz and Mahrous (2004) Aziz et al. (2007) fond that irradiation of different kinds of seeds at a dose of 4 kGy reduced mould growth greatly relative to un-irradiated controls. Among the most sensitive microorganisms to radiation are gram-negative rods, followed by gram-positive cocci and rods, yeast, molds, fungal spores, aerobic and anaerobic spore formers (Diehl, 1995).

Table 3. Total bacterial (log10 cfu/g) and fungal (log10 spores /g) count of peanut

Treatment	Control	1 KGY	2 KGY	3 KGY	LSD 5%
Storage period (months)					
Total bacterial count (log10 cfu/g)					
0	2.97±0.06	2.53±0.03	>1	>1	**0.07**
12	3.97±0.04	3.20±0.05	2.81±0.06	2.43±0.06	**0.10**
LSD 5%	**0.12**	**0.10**	**0.10**	**0.10**	
Fungal count (log10 spores /g)					
0	2.55±0.03	2.21±0.13	>1	>1	**0.13**
12	2.87±0.05	2.38±0.04	>1	>1	**0.05**
LSD 5%	**0.08**	**0.22**			

LSD: Least significant difference

Effect of irradiation and storage time on sensory quality

The data on sensory evaluation presented in Table 4. showed that all the peanut seed samples of got high scores for taste, flavor, color and texture with mean values range between 3.54 and 3.96. As shown in table 4. the taste, flavor, color and texture score for control and irradiated sampled were found to be the same ($p<0.05$). Thus our results demonstrated that no off-flavor was generated because of irradiation. Likewise Chaudry et al. (2004) reported that a dose of 2 kGy is sufficient to maintain the textural and sensorial quality of carrots. While, Hajare and co-workers (2007) found that low doses irradiation had no significant effect on the rating of any of the sensory attributes in green gram as well as garden pea sprouts. Finally Khattak et al. (2009) indicated that the irradiated samples of lotus were acceptable sensorically. Peanuts are high oil content foods. Oil content has important effect on the sensory characteristics of foods because it contributes mouth feel and carries flavors and aromas. (Ng et al., 2008; De Camergo et al., 2012).

Table 4. Effect of gamma irradiation and storage period on the taste, texture, color and flavor of peanut.

Treatment	Control	1 KGY	2 KGY	3 KGY	LSD 5%
Taste	3.96±0.91	3.75±1.23	3.75±1.23	3.79±1.41	0.69
Flavor	3.71±1.12	3.63±1.17	3.67±1.13	3.54±1.41	0.70
Color	3.83±1.24	3.83±0.92	3.63±1.28	3.71±1.27	0.68
Texture	3.75±1.07	3.63±1.31	3.71±1.16	3.67±1.17	0.68

LSD: Least significant difference

Conclusion

The reported results show that gamma irradiation can be effect to improve the quality of peanut seeds in terms of reduction of microbial contamination. The results also revealed that, there were no adverse effects in proximate composition, chemical and sensory characteristics of peanut seeds due to irradiation.

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