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Quality characteristics of cherry kernel as influenced by gamma irradiation and storage periods

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Abstract

The experiment was conducted on cherry kernels treated with gamma irradiation (with the dose of 0, 3 and 6 kGy) and stored up to 12 months at room temperature to estimate the effect on proximate, quality, and microbial changes of cherry seed kernel (ChSK). The results showed the abundance (%) of approximate parameters evaluated to be in fresh matter, crud fat (35.84%) > total sugar (30.34%) > crud protein (23.47%) > moisture (4.51%) %) > ash (3.51%) > total reducing sugar (2.11%) order. in general, there are no appreciable differences in proximate composition of ChSK samples irradiated with 0, 3, and 6 kGy and stored for 12 months. Gamma irradiation had no effect on acidity, pH and volatile basic nitrogen values of CHSK. The initial total viable count (TVC), total mould and yeast count (TMYC), and total coliform count (TCC) were 4.20 ±0.07, 4.52 ±0.20, and 2.56 ± 0.17 log CFU g-1. TVC, TCC, and TYMC was significantly ($P<0.05$) reduced with irradiation (from 0 to 6 kGy). Considering all traits it can be concluded that gamma irradiation treatments significantly reduced microbial population and maintain chemical composition and quality of ChSK.

Keywords: Gamma Irradiation, Cherry Kernel, Composition, Microbiology.

1. Introduction

Prunus species including sweet cherries (*Prunus avium*) are of prime economic importance fruit markets, and are also used as an ingredient in food [1].

Seeds including *prunus* seeds are waste product, industrial by-products and large amounts of these by-products are generated as waste after fruit processing. This not only wastes a potentially valuable resource, but also aggravates already serious disposal problems [2].

In recent years, seeds from the fruits of the *Prunus genus* can supply significant amounts of edible protein and oil. They are rich in macronutrients including carbohydrates, oils, and proteins as well as micronutrients including phenolic compounds, vitamins, and minerals etc. [3,4]. In future may constitute an important resource in the food, lubricants, fuels, additives for paint formulations and cosmetic fields [5].

The cherry seed connected with the flesh may constitute between 10% and 30% of the fruit weight. Seeds may serve as a secondary raw material, e.g. to obtain oil rich in unsaturated fatty acids [6]. According to Chow [7], the potential of lipid material from fruits and fruit by-products is enormous and should be investigated.

Micro organisms contaminating of dried food including seeds and kernel reside on the surface, and the inner areas are generally free [8]. Thus, there is a need to develop an innovative decontamination method to maintain their quality, and may help retain the original quality of cherry seeds [9].

Commonly, chemicals are used for disinfestations and decontamination purposes; however, chemicals used for controlling both pests and micro organisms negatively impacts on the environment and stored products [10].

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Irradiation has been recognized as an alternative to chemicals including methyl bromide for processing dried food products to overcome quarantine barriers in national and international trade, as a mode of disinfestations, decontamination, and for improving nutritional properties and extending shelf-life [11, 12]. The irradiation treatments can cause significant changes in physico-chemical properties of oil kernel and seed [13,14].

The literature survey also indicates that there hardly seems any information available till this date regarding the radiation processing of cherry seed of Syrian origin. Therefore, the present study was performed to investigate the influence of gamma irradiation and storage period on chemical composition, quality attributes, and microbial properties of cherry seeds.

2. Materials and methods

2.1. Treatments and analysis performed

Cherry seeds were obtained from local fruit processing factory in Damascus, Syria. The kernels of the seeds were manually separated from the seed by removing the outer shells to separate the kernels from the seeds. Physically damaged and immature seeds were sorted out and discarded. The cherry seed kernels (ChSK) were exposed to gamma radiation at doses of 0, 3 and 6 kGy. Multipurpose gamma irradiator with a Cobalt 60 source was used (compact-type semi commercial radiator) at the gamma irradiation facility. The samples of ChSK were irradiated at place with a dose rate of 7.775 kGy h^{-1}, at room temperature and atmospheric pressure [13]. The irradiated and non-irradiated seeds were placed in sealed bags. Sealed bags were stored at room temperature (20 °C) without exposure to direct sunlight.

2.2. Chemical analysis

Whole CHSK samples were analyzed for moisture (by drying for 6 h at 105 ^{o}C), ash (by ashing for 4 h at 550 ^{o}C), crud protein (using micro-Kjeldahl method), and crude lipid (as extractable component in Soxhlet apparatus) by AOAC procedures [15]. pH values of the ChSK solutions were measured using an HI 8521 pH meter (Hanna Instruments, Woonsocket, RI, USA). The total acidity was determined by a direct titration with (0.1 N) NaOH and indexed as ml of (0.1 N) NaOH = 0.0090 g lactic acid [15]. Total volatile basic nitrogen in the sample in terms of mg VBN kg^{-1} CHSK (ppm) was determined [14]. All reagents used in this study were of reagent grade.

2.3. Microbiological analysis

Microbial load was evaluated using the standard spread plate method [15]. The product of CHSK (10 g) was homogenized with 90 ml of sterile physiological water (9 g NaCl L-1). The suspension was then serially diluted and appropriate dilutions were plated on plat count agar (PCA) (Oxoid, CM 325, UK) (30 °C, 48 h) for total viable counts (TVC), Violet Red Bile Agar (VRBA) (Oxoid, CM 485, UK) (37 °C, 48 h) for total coliform count (TCC), and Dichloran Rose - Bengal Chloramphenicol Agar (DRBC) (Merck, 1.00466, Germany) (25 °C, 5 days) for total mould and yeast (TMY). Microbial counts were transformed to log 10 cfu g^{-1}.

2.4. Statistical analysis

The data were statistically evaluated by the one-way analysis of variance procedure (ANOVA). Data were expressed in the form of means ± standard deviation (SD) to compare mean values. All analyses were done in triplicate (n = 3). The difference was of statistical significance at $p < 0.05$.

3. Results and discussion

3.1. Effect of gamma irradiation on proximate composition of ChSK

Table 1 gives compositional characteristics of cherry seed kernels (ChSK). The CHSK were found to be rich in proteins (crud protein), lipids (oil), minerals (ash), carbohydrates (total sugar) with their corresponding concentrations of 23.47%, 35.84%, 3.51%, and 30.34%, respectively.

The amount of moisture (4.51%) was low in cherry kernels showing a very high amount of dry matter. Moisture content of plant materials determines their susceptibility to spoilage by micro organisms [16]. Food with moisture content higher than 13% is susceptible to decomposition by micro organisms [17].

The ChSK is a good source of protein (23.47%). Similar values for protein contents of other kernels and nuts including pistachio, almonds and peanut were reported [12,13,14]. The concentrations of protein in the kernels analyzed suggest that ChSK contribute to the daily protein need of 23.6 g for adults, as recommended by the National Research council [13].

The CHSK have importance from the point of dietary fibre content which is related to the intestinal regulation, the intestina labsorption of glucose and reduction of cholesterol levels [18]. Also, cherry seeds are to be used as a source of oil and protein for human consumption. The oil contents of the ChSK was found 35.84% (Table 1). It has been previously reported that cherry kernels comprise 32–36% of oil [19,20]. Doğantürk and Canbay [21] were determined 28.76% oil in cherry kernel. Total oil contents of mature cherry kernels from all 31 genotypes ranged from 38.2 – 46.7% [22]. Bak et al. [19] suggested that, the total ion chromatogram of the sour cherry seed kernel oil can be seen in comparison with that of sunflower oil. These cherry kernel oil may be used in food industry.

Relatively high oil content (35.84%) cherry kernel makes it a valuable source of edible oil when compared with oil content of other oil seeds and tree fruits such as soybean (18–20%), corn(3.1–5.7%), sunflower (35–45%), and olive (15–35%) [23]. In contrast, the analysed cherry kernel contained lower oil (35.84%) when compared with oil content of other nuts and kernels such as almond kernel (50.89%) [14], pistachio kernel (55.43%) [13], and peanut seeds (52.64%) [12].

The amount of ash (3.51%) in cherry kernels was the lowest in the approximate parameters evaluated. It is reveals the responding amount of mineral elements in cherry kernels. It has been noticed that environmental conditions, production practices, varieties or locations can affect seed or kernel composition in terms of such features as oil and protein content [24].

Changes in moisture, crude protein, oil, ash, total sugar, and reducing sugar, of ChSK due to irradiation dose are shown in Table 1. As shown in Table, in general, there are no appreciable differences in proximate composition of ChSK samples irradiated with 0, 3, and 6 kGy. However, the information on the chemical composition of ChSK exposed to gamma radiation was limited. These results are in general good agreement with those obtained by Al-Bachir and Khalil [25] who did not detect significant changes in the contents of crude fat, ash and total sugar of faba bean samples irradiated with 0, 1, 5 and 10 kGy. Also, In agreement with our results, it is reported that irradiation caused insignificant change on chemical composition of grape seeds f moisture and ash content ($p > 0.05$) [26].

Similar results were obtained by Hahm et al. [27], who reported no significant differences were found in proximate analysis of nutrient contents between cotton seed and gamma irradiated one. Moreover, extensive research showed that the contents of macronutrients of soy bean were relatively stable against irradiation doses up to 10 kGy [28]. Dixit et al. [29] determined that the nutritional features of soybean seeds, remained stable after gamma radiation. The nutritional value of micronutrients in food is little affected by radiation up to 10 kGy [17]. In contract with our result, some authors reported that gamma irradiation caused molecular changes include fragmentation, cross - linking, polymerization, aggregation, degradation, hydrogen - bonding distribution and oxidation by oxygen radicals that are generated in the radiolysis of water [24,30].

3.2. Effect of gamma irradiation on the chemical properties of ChSK

3.2.1. Total acidity and pH value: The acidity in term of free fatty acids (FFA) and pH value of the ChSK samples are shown in Table 2. Results showed that gamma irradiation decreased, but not significantly ($P>0.05$), FFA. While, only the higher dose (6kGy) increased, but not significantly ($P>0.05$), the pH value of ChSK. Immediately after irradiation, the overall observed value of FFA of ChSK samples treated at 0, 3 and 6 kGy were 0.45, 0.44 and 0.43%, respectively. While the overall observed pH value of ChSK samples treated at 0, 3 and 6 kGy were 5.81, 5.80 and 5.83, respectively.

During storage, both FFA and pH value of irradiated and non-irradiated ChSK increased significantly ($P>0.05$), After 12 months of storage, the overall observed value of FFA of CSK samples treated at 0, 3 and 6 kGy were 0.61, 0.61 and 0.61%, respectively. While the overall observed pH value of ChSK samples treated at 0, 3 and 6 kGy were 6.01, 6.02 and 6.00, respectively. Similar trend of acidity was reported by Parveen et al. [11] who found that during storage, acidity recorded an increasing trend for cherry seed in all the treatments.

The percentage of FFA of irradiated and non-irradiated, stored and un-stored samples of ChSK are very small, between 0.43 and 0.61%, and lie within the acceptable limits 0.1 – 3.0% [25]. These results are similar to the findings of Al-Bachir and Othman [25] in which irradiation increased peanut fatty acids compared with non-irradiated control sample of peanut seeds.

FFA of ChSK is also increased significantly with storage time and an overall observed value was 0.45 to 0.61 %. Similarly, Al-Bachir [31] found that percentage of saturated fatty acids of peanut, pistachio and almond seeds increased significantly with the irradiation dose and storage time and after irradiation. The not significant reduction on FFA content of ChSK might be due to lipase activity reduction in treated kernels, which result in dropping the FFA formation.

Free fatty acid is the products of enzymatic or microbial degradation of lipids [32]. Pankaj et al. [33] reported that the radiation process significantly decreased the lipase activity in seeds. Therefore, the results showed that gamma irradiation treatment is an effective process for stabilization and to extending the shelf life of seeds, since free fatty acids (FFAs) profile is an index of the rancidity and contributes to the development of off-flavor and off-odors in oil during storage.

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

Storage period/(Months)	**0**	**12**	**P-level**
Treatment	**Moisture (%)**		
Control	$4.51\pm^{Aa}0.05$	$4.62\pm^{Aa}0.26$	**0.5059**
3 KGY	$4.55\pm^{Aa}0.01$	$4.60\pm^{Aa}0.09$	**0.3677**
6 KGY	$4.49\pm^{Aa}0.03$	$4.54\pm^{Aa}0.23$	**0.7464**
P-level	**0.0918**	**0.8844**	
	Total protein (%)		
Control	$23.47\pm^{Aa}0.46$	$23.90\pm^{Ab}0.15$	**0.2005**
3 KGY	$23.44\pm^{Ba}0.00$	$24.22\pm^{Aab}0.03$	**0.0001**
6 KGY	$23.71\pm^{Ba}0.36$	$24.49\pm^{Aa}0.32$	**0.0481**
P-level	**0.5822**	**0.0331**	
	Total fat (%)		
Control	$35.84\pm^{Aa}0.12$	$32.63\pm^{Aa}2.97$	**0.1353**
3 KGY	$32.24\pm^{Ab}0.61$	$33.04\pm^{Aa}0.10$	**0.0903**
6 KGY	$^{A}29.89\pm^{c}0.17$	$^{A}30.76\pm^{a}3.52$	
P-level	**0.0001**	**0.5650**	
	Ash (%)		
Control	$3.51\pm^{Ab}0.01$	$3.38\pm^{Aa}0.14$	**0.1781**
3 KGY	$2.56\pm^{Aa}0.02$	$3.52\pm^{Ba}0.02$	**0.0749**
6 KGY	$3.50\pm^{Ab}0.01$	$3.48\pm^{Aa}0.07$	**0.6439**
P-level	**0.0089**	**0.2165**	
	Total sugar (%)		
Control	$30.34\pm^{Ab}1.34$	$32.14\pm^{Aa}2.55$	**0.3400**
3 KGY	$32.21\pm^{Aab}0.95$	$30.61\pm^{Ba}0.23$	**0.0478**
6 KGY	$32.74\pm^{Aa}0.70$	$32.05\pm^{Aa}3.12$	**0.7277**
P-level	**0.0642**	**0.6845**	
	Reducing sugar (%)		
Control	$2.11\pm^{Aa}0.07$	$2.11\pm^{Aa}0.14$	**.**
3 KGY	$2.12\pm^{Aa}0.06$	$2.05\pm^{Aa}0.08$	**0.2546**
6 KGY	$2.16\pm^{Aa}0.07$	$2.06\pm^{Aa}0.07$	**0.6914**
P-level	**0.7032**	**0.7039**	

^{abc} Means values in the same column not sharing a superscript are significantly different.
^{ABC} Means values in the same row not sharing a superscript are significantly different.

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 cherry kernel.

Storage period /(Months)	**0**	**12**	**P-level**
Treatment	**Total acidity (% Lactic acid)**		
Control	$0.45\pm^{Ba}0.03$	$0.61\pm^{Aa}0.03$	**0.0020**
3 KGY	$0.44\pm^{Ba}0.03$	$0.61\pm^{Aa}0.01$	**0.0003**
6 KGY	$0.43\pm^{Ba}0.02$	$0.61\pm^{Aa}0.01$	**0.0001**
P-level	**0.7127**	**0.8806**	
	PH value		
Control	$5.81\pm^{Ba}0.02$	$6.01\pm^{Aa}0.02$	**0.0001**
3 KGY	$5.80\pm^{Ba}0.01$	$6.02\pm^{Aa}0.03$	**0.0002**
6 KGY	$5.83\pm^{Ba}0.01$	$6.00\pm^{Aa}0.02$	**0.0001**
P-level	**0.1127**	**0.4851**	
	Volatile basic nitrogen (ppm)		
Control	$20.16\pm^{Aa}0.36$	$20.53\pm^{Aa}0.09$	**0.1581**
3 KGY	$19.51\pm^{Aa}2.35$	$20.16\pm^{Aa}2.45$	**0.7553**
6 KGY	$19.79\pm^{Ba}0.01$	$20.44\pm^{Aa}0.05$	**0.0001**
P-level	**0.8470**	**0.9472**	

^{abc} Means values in the same column not sharing a superscript are significantly different.
^{ABC} Means values in the same row not sharing a superscript are significantly different.

3.2.2. Total volatile basic nitrogen (TVBN): The results of the present study show that application of irradiation treatments (3 and 6 kGy), and storage up to 12 months causes no significant effect (P >.05) in the total volatile basic nitrogen (TVBN) content of ChSK (Table 2). As shown in table, the overall observed value of TVBN was in between 19.51 and 20.53 ppm.

Many studies on the effect of irradiation on volatile compounds of spices have been performed, but none have analyzed the effect of irradiation on total volatile basic nitrogen (TVBN) of CSK. Our results, related to the effect of gamma irradiation on TVBN of ChSK are consistent with the previous report which also demonstrated to no significant ($p > 0.05$) differences in TVBN between fababean kernel-irradiated and control ones [25].

Gyawali et al. [34] reported that the response of compounds to irradiation varied. The content of some volatile compounds increased after gamma irradiation, whereas the content of a few major compounds decreased after irradiation because of the high sensitivity of hydrocarbon molecular to irradiation treatment [35].

However, the TVBN is related to protein degradation, and the observed increases may be attributed to the formation of ammonia or other basic compounds due to microbial activity [36].

3.3. Effect of gamma irradiation and storage on microbial load of ChSK

In the present study, untreated ChSK had high levels of microbial contamination including total viable count (TVC), total mould and yeast count (TMYC), and total coliform count (TCC), which could have detrimental defects on the quality of the final product (Table 3). The initial TVC, TMYC, TCC were 4.20 ±0.07, 4.52 ±0.20, and 2.56 ± 0.17 log CFU g-1, respectively. It has been reported that both yeast and bacteria are present in fresh seeds and kernels [37].

Irradiation treatment at 3 kGy decreased TVC, TMYC and TCC significantly ($P<0.05$). After the application of irradiation process, the initial TVC, MYC and TC in CSK samples treated with 6 kGy were below the level of detection (>1 cfu g-1) [25]. Similarly, Al-Bachir [13]; Al-Bachir [14]; Al-Bachir and Othman [12]; showed that TVC, TMYC and TCC in irradiated samples of pistachio, almond and peanut were lower than the control.

Khalil and Al-Bachir [25] also reported that irradiation has a significant reduction in the microbial load in faba pean

Gamma irradiation can be used to inactivate bacteria, spores, yeast, and mold in both liquid and solid foods [8,38].

The mechanism of microbial inactivation by gamma irradiation is similar to that of other inactivation methods (DNA damage).

Irradiation inhibition of microorganisms growth in cherry kernel might be due to the destruction of their can damage DNA, RNA, ribosome, cell envelope, and proteins in microbial cell. [9,10].

Table 3. Total bacterial, fungal count and total coliform count (log10 cfu g) of cherry kernel.

Storage period /(Months)	**0**	**12**	**P-level**
Treatment	**Total bacterial count (log10 cfu g)**		
Control	$4.20\pm^{Aa}0.07$	$4.63\pm^{Aa}0.13$	**0.4881**
3 KGY	$2.56\pm^{Ab}0.13$	$2.98\pm^{Ab}0.07$	**0.7560**
6 KGY	>1	>1	
P-level	**0.0001**	**0.0001**	
	Fungal count (log10 spores g)		
Control	$4.52\pm^{Aa}0.20$	$4.16\pm^{Aa}0.05$	**0.4645**
3 KGY	$3.02\pm^{Ab}0.14$	$2.59\pm^{Ab}0.09$	**0.7120**
6 KGY	>1	>1	
P-level	**0.0001**	**0.0001**	
	Total coliform(log10 cfu g)		
Control	$2.56\pm^{A}0.17$	$2.50\pm^{A}0.18$	**0.7376**
3 KGY	>1	>1	
6 KGY	>1	>1	
P-level	**0.0001**	**0.0001**	

^{abc} Means values in the same column not sharing a superscript are significantly different.
^{ABC} Means values in the same row not sharing a superscript are significantly different.

4. Conclusions

The results clearly showed that gamma irradiation processing up to 6 KGy has reduced microbial load (TVC, TCC and TYMC), preserved, chemical composition and quality value of CSK. Among the treatments, the highest irradiation dose (6 KGy) showed best results in terms of overall chemical composition an quality acceptability and microorganisms control.

Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human or animal subjects (if exist) respect the specific regulation and standards.

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