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ORIGINAL ARTICLE

Physicochemical properties of Syrian dried kishk as affected by gamma irradiation

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Syrian dried kishk (SDK) was irradiated at 5, 10 and 15 kGy doses. The effect of gamma irradiation on microbial, physicochemical and sensorial properties of SDK samples was investigated. The results showed that the proximate composition of SDK did not change with dosage. However, physicochemical properties showed a significant ($p < 0.05$) decrease in total acidity, and a significant ($p < 0.05$) increase in total volatile basic nitrogen (TVBN) of SDK with increase in dosage. Irradiation treatment increased the Hunter color L* and b* values, whereas, as a* and ΔE values were decreased with increase in irradiation dose. Sensory panelist found no significant differences ($p<0.05$) between the non irradiated and irradiated samples of SDK for color and texture. While, the highest used dose (15 kGy), decreased the score values of flavor and taste. Based on the results, irradiation resulted in reduction of the number of total viable count (TVC), total mould and yeast count (TMYC), and total coliform count (TCC) of SDK. TVC, TMYC and TCC growth were not observed in any of the irradiated SDK samples with 10 or 15 kGy. It can be concluded that gamma irradiation may improve the storability of SDK and thus can be recommended to be used as an effective alternative method for preserving and extending the shelf life of SDK.

Key words: Syrian kishk, gamma irradiation, chemical properties, microbial load, sensory

The microbiological contamination of food products can occur throughout the food chain (Rahmani et al., 2021). Hence, in the agri-food industry, the infected operator, who does not sufficiently respect the basic hygiene measures, can contaminate handled food products during the chain of food production including; processing, packaging, storage (Rajwar et al., 2016).

Food preservation can be achieved by controlling water activity, pH and nutritional components factors, which limits the microbial growth and avoids enzymatic degradation (Rodrigo et al., 2015). Shelf-life extension of food and food products is one of the main objectives of the food, especially about the perishable foods. Several methods have been used as treatment measures to aid in the preservation of the perishable foods (Aghdam et al., 2018). The preservation is done by eliminating microorganisms, and inactivating the enzymes in the food (Stoforos, 2015).

Traditional methods such as thermal processing, fumigation, chemical, and drying are the most widely used ways for maintaining quality, extending shelf life, and to minimize health risks associated with collective food (Rodrigo et al., 2015). Chemicals besides having adverse environmental issues, pose serious health hazards, and limit the export capabilities of foods (Sarver et al., 2019). To overcome these environmental and health barriers induced by chemical and thermal preservatives, alternate treatments are needed. Several new food treating technologies have been studied and developed to replace traditional food treating techniques for better food quality, and consumer acceptance (Boekel et al., 2010). It is recommended to reduce the risk of food spoiling and extend food shelf life without side effect on health and with minimal effects on nutritional and sensory quality (Barkai-golan, 2017). One of the most important ways for extending of shelf-life is gamma irradiation. Food irradiation is a processing method that is used to improve the microbiological quality of several food types, which will ultimately improve food health (Al-Bachir and Khalil, 2018). A number of investigators have shown that gamma irradiation is very effective in controlling the growth of microorganisms in food (Al-Bachir, 2014; Al-Bachir, 2019; Al-Bachir, 2021).

Kishk is typically formulated from fermented milk (yoghurt) and parboiled wheat (burghul) (Gadallah, and Hassan, 2019). It is rich in nutritive components and source for many vitamins, elements, growth factors and other nutrients (Anon, 2007). Traditional dried Kishk is a preparation food, and can be consumed as fresh or used as a raw material for the production of liquid Kishk (Gocmen et al., 2004).

Prepared food is categorized as a food product which without prior preparation or cooking, is often packed and ready for consumption. Therefore, a vast food processing technology is important in the production of ready-to-eat food that is safe for consumption (Al-Bachir, 2019). There is no information available in the literature regarding proximate composition, chemical properties, and nutrition value of SDK, Moreover, there is a lack of knowledge about the effect of gamma irradiation treatment on the characteristics of Syrian dried kishk (SDK). In view of this, a study was carried out to examine the effect of gamma irradiation on the shelf life of SDK on the Syrian market. The objective of the study was to determine the impact of gamma irradiation on the proximate composition, physico-chemical and sensory characteristics of the SDK.

MATERIALS AND METHODS

Kishk meal preparation

Kishk as local (Syrian) ethnic prepared meals (foods) is considered as one of integral, important and commercial light prepared meal in Syria, and the food industry is traditionally dominated by kishk. It is a meal found almost in all Syria markets due to its commercial value as a resource for poor farmers and to its importance as food in rural and urban communities. Kishk typically formulated from fermented milk (yoghurt) and parboiled wheat (burghul). A study was conducted in radiation technology department, Syrian Atomic Energy Commission (SAEC). Syrian dried kishk (SDK) produced in 2019 was obtained from Haran Al-awamid village, near Damascus, Syria. SDK were prepared and weighed as in the sampling plan and transferred into special polyethylene pouches for irradiation treatment.

Each pouch of SDK (500 g) was considered as a replicate. The determinations were made in triplicate for each treatment.

Irradiation treatment

The packed whole SDK was subjected to three different doses of gamma irradiation viz, 5, 10, and 15 kGy using cobalt-60 as source irradiator (ROBO, Russa) at room temperature 18-25 ^{o}C, and relative humidity (RH) of 50-70%. The absorbed dose was monitored by alcoholic chlorobenzene dosimeter (Al-Bachir, 2014). The non-treated sample was taken as control.

Chemical and physical analysis of SDK

For proximate analysis, the parameters such as moisture (by drying for 6 h at 105 ^{o}C), ash (by ashing for 4 h at 550 ^{o}C), crude protein (using micro-Kjeldahl method), and crude lipid (as extractable component in Soxhlet apparatus), in the different SDK samples were carried out according to the methods described in the Association of Official Analytical Chemists AOAC (AOAC. 2010). Acidity in term of pH values of the SDK solutions was determined using an HI 8521 pH meter (Hanna Instruments, Woonsocket, RI, USA). The total acidity as (lactic acid %) 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 (AOAC, 2010). Total volatile basic nitrogen was determined in the sample in terms of mg VBN kg^{-1} SDK (ppm) (Al-Bachir, 2015). Samples were analyzed in triplicates.

Color analysis was performed by using AvaSpec Spectrometer Version 1, 2 June 2003 (Avantes, Holland) and expressed as color L* is lightness (black point L*=0, white point L*=100), a* is characteristics to red-green color, and b* is the blue-yellow color (sign; +a* red, -a* green, +b* yellow, -b* blue), and overall color difference (ΔE). Reflectance values were obtained at wavelength of 568 nm by exposing the samples to the illuminant (Al-Bachir, 2017). The equipment was calibrated each time the irradiation dosage changed using white color standard tile.

Microbiological analysis

The microbiological examination was carried out by using the spread plate technique and pour plate method as proposed by (AOAC, 2010). Total viable counts (TVC) were determined by using plate count agar (PCA) (Oxoid, CM 325, UK) (30 °C, 48 h). Total coliform counts (TCC) were determined using Violet Red Bile Agar (VRBA) (Oxoid, CM 485, UK) (37 °C, 48 h). Total mould and yeast (TMY) were determined using Dichloran Rose-Bengal Chloramphenicol Agar (DRBC) (Merck, 1.00466, Germany) (25 °C, 5 days). Microbial counts were transformed to log 10 cfu g-1 SDK.

Sensory evaluation

Sensory evaluation of SDK samples was carried out by a group of 30 workers (from Rad. tech. Dept.), who did not undergo professional training, in order to imitate consumer behavior. The quality of the cocked kishk samples prepared from treated samples (0, 5, 10 and 15 kGy) were determined after a thorough assessment of their sensory characteristics, including the overall appearance, color, smell, taste and texture of the SDK. Kishk samples were evaluated for color, texture, odor and taste using a 5-point balanced semantic scale according to the method described by Al-Bachir, (2014). Sensory scores were 5 for excellent, 4 for very good, 3 for good, 2 for fair and 1 for poor.

Statistical analysis

Values were expressed as means ± standard deviation (SD). Data were analyzed using one-way variance procedure (ANOVA). Differences were measured and considered to be statically significant at $p<0.05$. All statically analyses were conducted using SPSS for windows, version 16.9 (SPSS, Inc, Chicago, IL, USA).

RESULTS AND DISCUSSION

Effect of gamma irradiation in proximate composition of SKD

The proximate chemical composition of the irradiated and non-irradiated SDK is given in Table 1. The moisture, crude protein, crude fat, ash, total sugar and reducing sugar content of SKD was reported as 7.77%, 15.23%, 6.67%, 6.61%, 61.08%, and 1.22%, respectively. The low amount of moisture content (7.77%) in SKD indicates that this product is much easily preserved and is not highly susceptible to microorganism’s attack (Al-Bachir, 2019). The proximate composition of the SDK samples, including moisture, ash, total sugar, and reducing sugar, did not change significantly upon irradiation. In the current study, the crude protein and crude fat content of SDK were slightly, but significantly ($p<0.05$) increased by irradiation. There is little information on the influence of gamma irradiation on the composition of SDK. However, there is abundant literature on the effects of irradiation treatment on other prepared meals (food). In general, irradiation treatment has no significant effect on a number of food products (Al-Bachir and Othman, 2018). Similar results were showed by Bashir and Aggarwal (2016), Bhat et al. (2016), who found that gamma irradiation, does not alter the proximate composition percentage of the wheat flour. A previous study conducted by Al-Bachir (2019) indicated that used doses of gamma irradiation (10, 20 and 30 kGy) did not have a significant influence on crude protein, crude fat and total sugar contents of SDK as Syrian ethnic prepared meal. The differences in the nutritive value by gamma irradiation treatment up to 10kGy have been found to be very small (Bashir and Aggarwal, 2016).

Effect of gamma irradiation in chemical and physical properties of SDK

Total acidity and pH value. Table 2 shows the influence of gamma irradiation at different dose levels on the total acidity content (as % lactic acid) of SDK. As shown in the Table 2, irradiation process significantly ($p < 0.05$) reduced the total acidity in SDK compared to untreated one. The total acidity of SDK was found to be 1.19%, 1.19%, 1.03%, and 1.00 % in samples treated at dose levels of 0.0, 5, 10, and 15 kGy, respectively. The reduction of total acidity after irradiation treatment may be attributed to the reduction of lipase in treated SDK, which result in dropping the acidity formation. Pankaj et al. (2013) found that ionizing irradiation induces a reduction in the lipase activity in wheat germ, and such reduction of the total acidity in radiated samples may be improving its storability. During food irradiation, loss of acids occurs via indirect effect of irradiations, i.e. through products of water radiolysis namely the OH radicals rather than the direct effect of irradiations (Wong and Kitts, 2001). The slight decrease in total acidity in SDK samples irradiated at doses of 5, 10 and 15 kGy as observed in this work is similar to those reported for irradiated sesame pearl millet (Mahmoud et al., 2016), and irradiated almond kernels (Al-Bachir, 2015). However, Al-Bachir and Othman, (2018), (Al-Bachir (2016a), and Hassan et al. (2019) reported that the free fatty acid (FFA) contents in sesame and peanut seeds decreased with increasing irradiation doses. On the other hand, Al-Bachir, (2014) Al-Bachir (2016b) and Bashir and Aggarwal (2016) reported that gamma irradiation had no significant effect on the total acidity in pistachio kernels, peanut seed, and chickpea flour, respectively.

Total volatile basic nitrogen (TVBN). Total volatile basic nitrogen (TVBN) contents for non-irradiated and irradiated SDK are shown in Table 2. TVBN values of SDK increased according to irradiation doses. Immediately after irradiation, TVBN values of non-irradiated control sample and of samples treated with lower dose of gamma irradiated SDK (2.17 mg kg-1) were significantly ($p>0.05$) lower than those of irradiated ones (3.25 and 3.26 mg kg-1 for sample irradiated with 10 and 15 kGy respectively). These results could be explained by the relationship between protein content and TVBN, since the TVBN is related to protein breakdown (Al-Bachir and Othman 2018). The increase in TVBN concentration in SDK samples treated with gamma irradiation may be due to the formation of oxidation or radiation-induced degradation products (Al-Bachir, 2015). Oxidation and degradation of protein have been reported to be the main sources of volatile compounds formed as a result of irradiation treatment (Al-Bachir, Khalil, 2018). Many studies on the effect of irradiation on TVBN of other food products have been done, but none have analyzed the effect of irradiation on volatile compounds of SDK. Recent results are in agreement with previous report which also indicated that the TVBN increased due to irradiation doses in almonds (Al-Bachir, 2015), peanut seeds (Al-Bachir, 2016b), sesame seeds (Al-Bachir, 2016a), faba bean (Al-Bachir and Khalil, 2018). In contrast to our results, TVBN values decreased according to irradiation doses in pistachio (Al-Bachir, 2014), and thyme meal (Al-Bachir, 2019).

Color of SDK. Hunter color values of SDK samples are shown in Table 3. L*, a*, b* and ΔE values of the irradiated and non- irradiated SDK samples were found in the range of 93.48 to 98.81, 16.23 to 19.49, -33.21 to. -28.56, and 120.18 to 124.93, respectively. L* and b* value of the SDK samples was found to increase, while the a* and ΔE values decrease upon irradiation. The differences were significant ($p < 0.05$) and independent of the dose received. This change in color due to irradiation treatment could be due to the caramelization of the mono-saccharides during the irradiation. Color development depends on certain compound known as melanoidin compounds formed via Millard browning products that correspond directly to change the color in foods (Jittrepotch et al., 2010). However, the above-mentioned changes in SDK color parameters would not have any negative impact on the consumer acceptance (Al-Bachir, 2017). The results are in agreement with Falade and Kolawole (2012) who reported similar significant changes in wheat flour and pearl millet cultivars color due to irradiation. The color of the dairy products depends on the amount of reducing sugars that the product contains, and on the formation of brown colored pigments, such as melanoidins and pyralysins due to Maillard reactions. This increases with the irradiation process (Popov-Raljić, et al., 2008).

Effect of gamma irradiation in microorganisms' properties of SDK

The influence of different doses (5, 10 and 15 kGy) of gamma irradiation in the microbial load infection of SDK by total viable count (TVC), mould and yeast count (MYC), and total coliform counts (TCC) are shown in Table 4. The hygienic quality of non-irradiated (control samples) of SDK as estimated by TVC, TCC and MYC, exhibited rather a high microbiological contamination. The TVC, TCC, and MYC were for the non-irradiated SDK 4.51±0.07 log cfu. g^{-1}, 2.51±0.06 log cfu. g^{-1}, and 2.39±0.03 log cfu. g^{-1}, respectively (Table 4). As it is seen from Table 4 gamma irradiation in doses of 5 kGy on day 1 reduces the total bacterial count by 2.2 lg (cfu) g^{-1}, a further increase in the absorbed dose to 10 or 15 kGy leads to almost complete inhibition of the TVC, TMYC, and TCC. According to the results obtained in this research, none of the irradiated samples with 10 and 15 kGy show microorganism (TVC, TMYC, TCC) growth in SDK. It has been demonstrated that only a 10 kGy dose of SDK irradiation was enough to control the growth or removal of the all kinds of microorganisms. Several authors have indicated the influence of gamma irradiation on the inactivation of pathogenic organisms associated with the food as well as spices (Al-Bachir, 2021; Al-Bachir, 2019). Song et al. (2014) and Deng et al. (2015) had reported that there is a dose-dependent influence on the inhibition or inactivation of microorganisms when they are exposed to gamma irradiation.

The main benefit of good food irradiation application is the reduction of food borne risk and extension the shelf-life of the irradiated product. Irradiation caused the significant reduction in the microorganism count in food sample. These results correspond with the results of studies conducted by the Munir et al., (2021). Spores of microorganisms were considered more resistant to irradiation on low moisture present than in vegetative types spores (Barkai-Golan and Follett, 2017). Therefore, moisture control through food preservation method indicated a preservative effect of irradiation because of lower production of free radicals which are decreased due to low water activity (Sharma et al., 2020). Desirable effect of radiation processing on decreasing or elimination of the microorganism cells in dried foods is attributed to the direct effect of radiations by hitting the DNA molecule in the cells (Swailam et al., 2007). Indirect effects of irradiation are also very limited if the moisture content is less than 12% (Bashir and Aggarwal., 2016).

Effect of gamma irradiation in sensorial properties of SDK

The data on sensory evaluation presented in Table 5 showed that SDK samples got high scores for flavor (3.49), taste (3.69), color (3.94) and texture (3.97) with mean values range between 3.49 and 3.97. Similar observations on different types of Kishk prepared in Egypt were reported by Gadallah and Hassan, (2019) who reported a range in appear score extended from 3.4 to 4.4, the color score ranged from 3.6 to 4.4, the aroma score ranged from 3.7 to 4.3, and the test score ranged from 3.5 to 4.5 for Egyptian Kishk. However, according to the overall assessment of sensory properties, the samples irradiated at a dose of 5 kGy differ slightly from the control ones. Whereas, the samples treated at a dose of 10 and 15 kGy differ significantly (p < 0.05) from the control ones. According to our results of sensory evaluation, the sensory properties of irradiated and irradiated SDK were acceptable by panelists. The change in the flavor and taste of irradiated products can be explained by the oxidation of unsaturated fatty acids, a large amount of which was in SDK preserves. Bashir and Aggarwal (2016) showed that the composition of the wheat flour was not changed considerably was reduced significantly (p < 0.05) with increasing the dosage. Furthermore, the desirability of sensory properties decreased by increasing irradiation dose, but this reduction was not enough to have a significant (p < 0.05) effect on product rejection (Ansari et al., 2019). The release of several quality-degrading enzymes, produces serious sensory alteres, such as discoloration and off flavors and off odors (Yildiz, 2017; Temiz and Ayhan, 2017).

There was no significant (p > 0.05) change observed in the smell, texture and color of control and irradiated samples of wheat flour products (Munir et al., 2021). Development and decline of aroma test, and flavor due to cleavage of the sulfhydryl group from amino acids at higher dose (more than10 kGy) of irradiation processing altered the sensory properties in food. Reduction of the processing dose would also result in changed organoleptic quality as sensory degradation by irradiation dose-dependent (Lacroix et al., 2009). Park et al., (2010) stated that the use of gamma irradiation treatment up to 10 kGy should be useful in reducing or eliminating microorganisms' populations with no adverse effect on quality and most of sensory characteristics (color, chewiness, and taste). Similar results also found by Al-Bachir (2014), Al-Bachir (2015), Al-Bachir (2016a) and Al-Bachir (2016b) that flavor, color, taste and texture values of irradiated pistachio, almond, sesame and peanut were similar to non-irradiated samples.

Table 1. Effect of gamma irradiation on moisture, ash, protein, total sugar, reducing sugar and fat contents (%) of Syrian dried Kishk**.**

Treatments	Control	5 KGY	10 KGY	15 KGY	P-level
Moisture (%)	ab0.1±7.77	b0.10±7.73	b0.10±7.74	a0.02±7.88	NS
Total protein (%)	b0.12±15.23	b0.05±15.20	b0.03±15.27	a0.04±15.45	**
Total fat (%)	c0.03±6.67	a0.27±7.55	bc0.11±6.84	ab0.38±7.12	**
Ash (%)	a0.03±6.61	a0.04±6.63	a0.02±6.66	a0.03±6.64	NS
Total sugar (%)	a0.23±61.08	a0.10±61.31	a0.22±61.31	a0.13±61.02	NS
Reducing sugar (%)	a0.01±1.22	a0.04±1.22	a0.02±1.24	a0.01±1.24	NS

[abc] Means values in the same oow not sharing a superscript are significantly different.
NS: not significant.
* Significant at p<0.05.
** Significant at p<0.01.

Table.2 Effect of gamma irradiation on total acidity (% Lactic acid), PH value and volatile basic nitrogen (VBN) (P.P.M) of Syrian dried Kishk**.**

Treatments	Control	5 KGY	10 KGY	15 KGY	P-level
Total acidity (% Lactic acid)	a0.13±1.19	a0.20±1.19	b0.03±1.03	b0.04±1.0	*
PH value	b0.00±4.04	ab0.02±4.05	ab0.01±4.05	b0.03±4.07	NS
Volatile basic nitrogen (ppm)	c0.00±2.17	c0.00±2.17	b0.00±3.25	a0.00±3.26	**

[abc] Means values in the same row not sharing a superscript are significantly different.
NS: not significant.
* Significant at p<0.05.
** Significant at p<0.01.

Table 3. Effect of gamma irradiation on color change of Syrian dried Kishk**.**

Treatments	Control	5 KGY	10 KGY	15 KGY	P-level
Color changes					
L(Lightness)	b0.5±93.58	b0.66±93.48	a0.23±98.16	a0.12±98.81	**
a (redness/greenness)	a0.61±19.49	b0.61±17.67	bc0.7±16.95	c0.07±16.23	**
b (yellowness/blueness)	a0.47±33.21-	a0.50±33.43-	b1.07±29.04-	b0.58±28.56-	**
ΔE (Total color difference)	a0.48±124.79	a0.39±124.93	b1.01±120.61	b0.56±120.18	**

abc Means values in the same row not sharing a superscript are significantly different.
NS: not significant.
* Significant at p<0.05.
** Significant at p<0.01.

Table.4 Total bacterial (log10cfu.g) and fungal (log10spores.g) count of Syrian dried Kishk**.**

Treatments	Control	5 KGY	10 KGY	15 KGY	P-level
Total count (log^{10}cfu.g)	0.07±4.51	0.03±2.31	≥1	≥1	**
Fungal count (log^{10}spores.g)	0.06±2.51	≥1	≥1	≥1	**
Total coliform (log^{10}cfu.g)	0.03±2.39	≥1	≥1	≥1	**

abc Means values in the same row not sharing a superscript are significantly different.
NS: not significant.
* Significant at p<0.05.
** Significant at p<0.01.

Table.5 Effect of gamma irradiation on the taste, texture, color and flavor of Syrian dried Kishk**.**

Treatments	Control	5 KGY	10 KGY	15 KGY	P-level
Flavor	a1.04±3.49	ab0.95±3.17	b0.94±3.00	b1.07±2.83	*
Taste	a1.05±3.69	ab1.06±3.34	b1.04±3.03	b0.97±2.86	**
Color	a0.94±3.94	a0.92±3.83	a0.99±3.83	a0.91±3.86	NS
Texture	a0.92±3.97	a1.02±3.80	a0.99±3.89	a1.04±3.83	NS

abc Means values in the same row not sharing a superscript are significantly different.
NS: not significant.
* Significant at p<0.05.
** Significant at p<0.01.

CONCLUSIONS

The application of gamma irradiation treatment to SDK induced significant reduction in microbial counts (TVC, TMYC, and TCC) in a dose dependent manner. The use of gamma irradiation doses (5, 10, and 15 kGy) could be the most appropriate tool to minimize the microbiological load in SDK. The irradiated SDK was microbiologically safe and physico-chemically and sensorially acceptable in the room temperature conditions.

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CONFLICTS OF INTEREST

The authors declare that they have no potential conflicts of interest.

REFERENCES

Aghdam MS, Jannatizadeh A, and Luo Z, Paliyath G. (2018). Ensuring sufficient intracellular ATP supplying and friendly extracellular ATP signaling attenuates stresses, delays senescence and maintains quality in horticultural crops during postharvest life. *Trends in Food Science & Technology*, 76: 67–81.

Al-Bachir M. (2014). Microbiological, sensorial and chemical quality of gamma irradiated pistachio nut (*Pistachia vera* L.) *The Annals of the University Dunarea de Jos of Galati - Food Technology* 38(2): 57-68.

Al-Bachir M. (2015). Assessing the effects of gamma irradiation and storage time in quality properties of almond (*Prunus amygdalus* L.). *Innovative Romanian Food Biotechnology* Vol. 16, Issu of March: 1-8.

Al-Bachir M. (2016a). Some microbial, chemical and sensorial properties of gamma irradiated sesame (*Sesamum indicum* L.) seeds. *Food Chemistry* 197: 191-197.

Al-Bachir M. (2016b). Evaluation the effect of gamma irradiation on microbial, chemical and sensorial properties of peanut (*Arachis hypogaea* L.) seeds. *Acta Sci. Pol. Technol. Aliment.*, 15(2): 171-180.

Al-Bachir M. (2017). Comparison of fruit characteristics, oil properties and fatty acid composition of native Syrian Kaissy cv olive (*Olea europaea*). *Journal of Food Measurement and Characterization*, 11: 1011-1018.

Al-Bachir M. (2019). Microbial profile of gamma irradiated thyme; cold prepared meal. *Journal of Agroalimentary Processes and Technologies*, 25 (1): 1-9.

Al-Bachir M, and Khalil A. (2018). Analysis of the microbial and biochemical profile of gamma irradiated green faba bean (*Vicia Faba* L.) kernels. *Current Topics in Biotechnology*, 9: 55-61.

Al-Bachir M, and Othman Y. (2018). Effect of gamma irradiation on peanut (Arachis hypogaea L.). *Arab Gulf Journal of Scientific Research* 34(1/2): 17-25.

Al-Bachir M. (2021). Microbial, Chemical and Sensorial Properties of Irradiated Sunflower (*Helianthus annuus* L.) Seeds. *Journal of Stress Physiology & Biochemistry*, 17 (2): 88-97 ISSN 1997-0838.

Anon, (2007). European Research on Traditional Foods. European Commission, Directorate General for Research, Brussels, Belgium, pp 4–14.

Ansari F, Homayouni A, Mohsennezhad P, Alivand AM, and Pourjafar H. (2019). Extending the Shelf-life of Whole-Wheat Flour by Gamma Irradiation and Organoleptic Characteristics of Cakes Made with Irradiated Flour. *Current Nutrition & Food Science*, 15: 1-6.

AOAC (2010). Official Methods of Analysis. 15th edn. Association of Official Analytical Chemists," Washington, D.C.

Barkai-golan. (2017). Safety of Fresh and Fresh-Cut Fruits and Vegetables Following: Irradiation for Quality Improvement, Microbial Safety and Phytosanitation of Fresh Produce Irradiation. Editors. In: Barkai golan V, Follet P. Elsevier. 2017; 129-156.

Bashir K, and Aggarwal M. (2016). Effects of gamma irradiation on cereals and pulses- A Review. *International Journal of Recent Scientific Research* 7 (12): 14680-14686.

Bhat NA, Wani IA, Hamdani AM, Gani A, and Masoodi FA. (2016). Physicochemical properties of whole wheat flour as affected by gamma irradiation. *LWT-Food Science and Technology*, 71: 175-183.

Boekel V, Martinus VF, Pellegrini N, Stanton C, Scholz G, Lalljie S, Somoza V, Knorr D, Jasti PR, and Eisenbrand G. (2010). A review on the beneficial aspects of food processing Mol. *Nutr. Food Res*., 54: 1215-1247.

Deng W, Wu G, Guo L, Long M, Li B, Liu S, Cheng L, Pan X, and Zou L. (2015). Effect of gamma irradiation on Escherichia coli, Salmonella Enterica typhimurium and Aspergillus niger in peppers. *Food Sci Technol Res*. 21(2): 241–245.

Falade KO, and Kolawole TA. (2012). Physical, functional, and pasting properties of different maize (*Zea mays*) cultivars as modified by an increase in g-irradiation doses. *International Journal of Food Science and Techn*ology, 47: 801- 807.

Barkai-Golan R, and Follett PA. (2017). Irradiation for Quality Improvement, Microbial Safety and Phytosanitation of Fresh Produce. Academic Press, San Diego, CA, volum 25(10) pp: 302. DOI: https://doi.org/10.21273/HORTSCI5210bkrev-17

Gadallah MGE, and Hassan MFY. (2019). Quality properties of Kishk (a dried fermented cereal-milk mixture) prepared from different raw materials. *Journal of the Saudi Society of Agricultural Sciences* 18: 95–101

Gocmen D, Gurbuz O, Rouseff RL, Smoot JM, and Dagdelen AF. (2004). Gas Chromatographic-Olfactometric Characterization of Aroma Active Compound in Sun-Dried and Vacuum-Dried Tarhana. *European Food Research and Technology*, 218: 573–578. DOI: 10.1007/s00217-004-0913-6.

Hassan AB. Mohamed Ahmed IA, Sir Elkhatim KA, Elagib RAA. Mahmoud NS, Mohamed MM, Salih AM, and Fadimu GJ. (2019). Controlling fungal growth in sesame (*Sesamum indicum* L.) seeds with f-irradiation: impacts on some properties of sesame oil. *Grasas Aceites* 70 (2), e308. ISSN-L: 0017-3495 https://doi.org/10.3989/gya.0933182.

Jittrepotch N, Kongbangkerd T, and Rojsuntornkitti K. (2010). Influence of microwave irradiation on lipid oxidation and acceptance in peanut (*Arachis hypogaea* L.) seeds. *International Food Research Journal* 17: 173-179.

Lacroix M, Caillet S, and Shareck F. (2009). Bacterial radiosensitization by using radiation processing in combination with essential oil: Mechanism of action. *Radiat. Phys. Chem.,* 78(7-8): 567-570.

Mahmoud NS, Awad SH, Madani RMA, Osman FA, Elmamoun K, and Hassan AB. (2016). Effect of γ-radiation processing on fungal growth and quality characteristics of millet grains. *Food Sci. Nutr.* 4: 342-347. https://doi.org/10.1002/fsn3.295

Munir N, Riaz A, Mehmood E, Mustafa SG, Haq R, Ilyas S, and Naz S. (2021). Effect of different treatments on nutritional, microbiological and rheological properties of flours. *Progress in Nutrition*, 23(2): e2021113 DOI: 10.23751/pn. v23i2.9217.

Pankaj KJ, Kudachikar VB, and Sourav K. (2013). Lipase inactivation in wheat germ by gamma irradiation. *Radiation Physics and Chemistry*, 86: 136–139.

Popov-Raljić J, Lakić N, Laličić-Petronijević J, Barać M, and Sikimić V. (2008). Color Changes of UHT Milk During Storage. Sensors, 8(9): 5961–5974. https://doi.org/10.3390/s8095961.

Park JG, Yoon Y, Park JN, Han IJ, Song BS, Kim JH, and Lee JW. (2010). Effects of gamma irradiation and electron beam irradiation on quality, sensory, and bacterial populations in beef sausage patties. *Meat Sci.* 85(2): 368–372. doi: 10.1016/j.meatsci.2010.01.014. [PubMed] [CrossRef]

Rahmani F, Yahya M, Jebri S, Amri I, Mejri A, Hamdi M, and Hmaied F. (2021). Effect of Gamma Irradiation on Microbial Quality of Minimally Processed Product in Tunisia: A Case of Ready to Eat Salad. *J Bacteriol Mycol*., 8(2): 1167.

Rajwar A, Srivastava P, and Sahgal M. (2016). Microbiology of Fresh Produce: Route of Contamination, Detection Methods, and Remedy. *Critical Reviews in Food Science and Nutrition.* 14: 2383-2890.

Rodrigo D, Tejedor W, and Martínez A. (2015). Heat Treatment: Effect on Microbiological Changes and Shelf Life. *In Encyclopedia of Food and Health* (pp. 311–315). Elsevier Inc. https://doi.org/10.1016/B978-0-12-384947-2.00372-X.

Sarver A, Rather, Peerzada R. Hussain, Prashant P. Suradkar, Omeera Ayob, Bhaskar Sanyal, Abhijit Tillu, Nishant Chaudhary, R. B. Chavan & Sunil K. Ghosh (2019). Comparison of gamma and electron beam irradiation for using phyto-sanitary treatment and improving physico-chemical quality of dried apricot and quince, *Journal of Radiation Research and Applied Sciences*, 12(1): 245-259, DOI: 10.1080/16878507.2019.1650223.

Sharma P, Sharma SR, and. Mittal TC. (2020). Effects and Application of Ionizing Radiation on Fruits and Vegetables: A Review. *Journal of Agricultural Engineering*, 57 (2): April-June. http://www.isae.in / journal_jae.aspx

Song WJ, Sung HJ, Kim SY, Kim KP, Ryu S, and Kang DH. (2014). Inactivation of Escherichia coli O157:H7 and Salmonella Typhimurium in black pepper and red pepper by gamma irradiation. International Journal of Food Microbiology, 172: 125–9.

Stoforos NG. (2015). Thermal Processing. In T. Varzakas & C. Tzia (Eds.), Handbook of Food Processing: Food Preservation (pp. 27–56). *Boca Raton*: CRC Press.

Swailam HM, Hammad AA, Serag MS, Mansoar FA, and Abuel-Nour SA. (2007). Shelf-life extension and quality improvement of minimally processed pear by combination treatments with irradiation. *International Journal of Agriculture and Biology*, 9: 575–583.

Temiz A, and Ayhan DK. (2017). Enzymes in Minimally Processed Fruits and Vegetables. In Minimally Processed Refrigerated Fruits and Vegetables; Yildiz, F.,Wiley, R.C., Eds.; Springer: New York, NY, USA, 2017; pp. 93–153.

Wong PYY, and Kitts, DD. (2001). Factors influencing ultraviolet and electron beam irradiation-induced free radical damage of ascorbic acid. *Food Chemistry*, 74: 75–84.

Yildiz F. (2017). Initial Preparation, Handling, and Distribution of Minimally Processed Refrigerated Fruits and Vegetables. In Minimally Processed Refrigerated Fruits and Vegetables; Yildiz, F.,Wiley, R.C., Eds.; Springer: New York, NY, USA, 2017; pp. 53–93.