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Fatty Acid Profile of Oil Extracted from Irradiated and Un-Irradiated Kernel of Cherry Seeds

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The aim of this work was to compare the fatty acid (FA) composition of oil from irradiated and un-irradiated cherry kernels (ChK). Cherry kernel were exposed to radiation doses of 0, 3 and 6 kGy of gamma irradiation covering the range for insect/pest disinfestations and for microbial load. The FA composition of cherry kernel oil (ChKO) was analyzed with using gas chromatography analysis. Oleic acid (C18:1) was consistently present in the highest quantity with averaged 51.07% of the total FA. The FA existing in second highest quantity was linoleic acid (C18:2) showing 38.03% on the average, followed by palmitic acid (C16:0) averaged 7.71%, stearic acid (C18:0) averaged 2.41%, palmitic acid (C16:1) averaged 0.42%, and linolenic acid (C:18:3) averaged 0.38%. indicating that it can be used for human consumption. In the present study, Palmitic, stearic, oleic, linoleic and linolenic acid, SFA and USFA were not affected by irradiation or storing. Conclusively, the ChKO may have sufficient oil volume potential to be used as edible (domestic) and industrial oil.

Key words: fatty acids, cherry kernel oil, gamma irradiation, storage, gas chromatography

Cherry seeds such other fruit seeds are industrial by-products and large amounts of these by-products are generated as waste after fruit processing. Some fruit seeds can be used as sources of oils or for production of biomasses and already used for several purposes (Yatnatti *et al.* 2014; Özyurt, 2019), but in future may constitute an important resource in the food and cosmetic field (Straccia *et al.* 2012).

In fact, the oil content of cherry seed varied between 32 and 36%, which was full with and the majority of the fatty acids (FA) present in cherry seed oil are polyunsaturated fatty acids (PUFA), with cherry accounting for about 68% of the PUFAs, with high content of oleic acid (C18:1) (50–53%) and linoleic acid (C18:2) (35–38%), which is essential for human metabolism, while, it has not been commercially utilized. (Bak *et al.* 2010; Apaydin *et al.* 2016). Fatty acid composition and stability of vegetable oils have taken more attention as an essential source of biologically active compounds in a good balanced diet (Doğantürk and Canbay, 2019; Mu *et al.* 2015)

Food that rich in edible vegetable oils supply most of the dietary intake of the lipids vitally needed for daily life that provide energy, essential FAs and that makes it a valuable source of oil for human nutrition (Yang *et al.* 2018; Dorni *et al.* 2018).

The property of a vegetable oil is defined by its FA composition. FA composition and stability of vegetable oils have taken more attention as an essential source of biologically active compounds in a good balanced diet (Konuskan *et al.* 2019). Oil with higher amount of saturated fatty acids (SFA) is one of the major reasons of coronary heart diseases. The rate of SFAs to USFAs is very important indicator for human nutrition, increasing intake of USFA mainly PUSFA instead of SFA decreases the risk of cardiovascular diseases (Al-Bachir and Koudsi, 2016). FA composition is one of the important parameters of nutritional quality. Therefore, particularly SFA/UFA ratio is a valuable parameter for human health, economic and efficient availability (Doğantürk and Canbay, 2019).

Irradiation is potentially useful technology ensuring the safety and extending the shelf life of food production worldwide (Al-Bachir and Othman, 2018). Advantages over other treatments include tolerance by most food commodities, ability to treat in the final packaging food products, and absence of pesticide residues (Al-Bachir, 2014; Al-Bachir, 2015a; 2015b). Several studies have investigated the effect of gamma irradiation treatment on quality of vegetable oils (Al-Bachir, 2017; Al-Bachir and Sahloul, 2017; Al-Bachir, and Koudsi, 2019). To the best of our knowledge, there is any no study about the effects of gamma irradiation on the FA composition of cherry kernel oil. For this reason, in the present study, changes in FA composition of cherry kernel oil (ChKO) due to radiation dose of oils extracted from irradiated at 3, and 6 kGy and un-irradiated cherry kernel oil were investigated.

MATERIALS AND METHODS

Cherry kernel preparation

Seeds of local cherry belong *Prunus avium* L. related to family *Rosaceae* was collected from cultivating place in Syria. The cherry seeds were manually separated from the pulp, and the outer shells of the cherry seeds were removed manually. Then kernels were cleaned, dried and transferred into polyethylene pouches for irradiation, storage and analyzing. Each pouch of cherry kernels (250 g) was considered as a replicate.

Irradiation treatment

The gamma radiation doses (3 and 6 kGy) were applied to the cherry kernels. Irradiation was performed in a Cobalt-60 gamma irradiator (ROBO, Russa) located at the radiation technology department in the Syrian Atomic Energy Commission (SAEC). The absorbed dose was monitored by alcoholic chlorobenzene dosimeter (Al-Bachir, 2014). Un-irradiated samples, kept under the same conditions, was used as a control. Irradiated and non-irradiated samples were stored at room temperature (20 °C).

Oil extraction

The control and irradiated cherry kernels were grinding and broken into paces smaller than 1 mm by using a domestic grinder. Oils from the ground cherry kernels were extracted by the manual Soxhlet apparatus (Scientific Apparatus Manufacturing Company, Glas-Col Combo Mantle, USA) for 16 h, using distilled AG

(analytical grade) n-hexane as the solvent (AOAC, 2010).

Fatty acids (FA) determination

ChKO was esterifited following the method described by Al-Bachir (2017) using gas chromatography machine and the identification of FA methyl esters was done through the comparison of the retention time for samples and standards. The samples were analyzed by the model of 17 Shimadzu gas chromatography apparatus (Shimadzu Corp., Koyoto, Japan) equipped with a capillary column (CBP20-S25- 050, Shimadzu, Australia). The results were expressed as g FA/100 g total FAs (%) by means of the CLASS – VP 4.3 program (Shimadzu Scientific Instruments, Inc., Columbia, MD). FA composition of oils extracted from irradiated and non-irradiated cherry kernel samples were performed immediately after irradiation, and after 12 months of storage. All chemicals and reagents were analytical grade and were purchased from Sigma Aldrich Chemical Co. (Steinheim, Germany) and Merck (Darmstadt, Germany).

Statistical analysis

All data were analyzed by analysis of variance test (ANOVA) using the SUPERANOVA computer package (Abacus Concepts Inc, Berkeley, CA, USA; 1998), and significant differences (p value of less than 0.05) among means was determined using Duncanm,s test.

RESULTS AND DISCUSSION

Fatty acids composition of ChKO

Gas chromatography analysis showed that the ChKOs under study were largely composed of USFAs. The FA composition of ChKO contains a healthy mixture of all the types of SFA, mono-unsaturated fatty acids (MUSFAs) and poly-unsaturated fatty acids PUSFAs (Table 1). Oleic acid (C18:1) was consistently present in the highest quantity with averaged 51.07% of the total FA. The FA existing in second highest quantity was linoleic acid (C18:2) showing 38.03% on the average, followed by palmitic acid (C16:0) averaged 7.71%, stearic acid (C18:0) averaged 2.41%, palmitic acid (C16:1) averaged 0.42%, and linolenic acid (C:18:3) averaged 0.38%. A review of the literature showed that, analysis of the shares of individual FAs in the oil extracted from cherry kernels showed that it contained significant amounts of C18:1 and C18:2 acids. Popa *et al.* (2011) reported that sour cherries kernel oil contain high levels of oleic acid (42.9 %), followed by linoleic acid (38.2 %), while the dominant SFAs were palmitic (11 %) and stearic acid (6.4%). The results from Doğantürk and Canbay (2019) also confirm the presented results for cherry seed oil with 10.93% palmitic acid, 55.26% oleic acid, and 23.26% linoleic acid. Viorica-Mirela *et al.* (2011) confirmed our results when reported that the seed oil from cherry pits contained only USFAs, 63.5% oleic and 31.5% linoleic acids, as compared to olive, safflower, sesame, soybean, peanut and sunflower oils. For instance, the high concentration of oleic acid found in ChKOs (51.7%) is in the same range as that found in high oleic sunflower, sesame and peanut, oil (Al-Bachir, 2017).

The particular FA composition of ChKOs opens up possibilities for application in the food industry. Since ChKO has a higher content of linoleic acid when compared to conventional edible nut oils, such as almond or pistachio oils (Al-Bachir, 2014, Al-Bachir, 2015). It can be nutritionally beneficial as an ingredient in food products (Pereira *et al.*, 2018).

Linoleic acid plays a very important role in nervous cell construction. It is also fundamental to the prevention of cardiovascular diseases (Santos *et al.*, 2017).

There is a great deal of scientific literature supporting the positive role of PUFAs for human health. Linoleic acid, classified as polyunsaturated FAs form an important part of human diet, because lack of them in the diet creates adverse effects on human health such as cardiovascular disease and skin lesion (Temelli *et al.*, 2007). The abundance of oleic and linoleic acids in these oils makes them good oils for reducing serum cholesterol and low density lipoprotein (LDL) and increasing high density lipoprotein (HDL) levels in human and animal blood; they could also be good oils for the fight against cardiovascular illnesses (Al-Bachir and Koudsi, 2016; Brufau *et al.*, 2008). The relatively low content of SFAs (palmitic acid and stearic acid) in ChKO is interesting from a nutritional point of view. It is well known fact that the oils of plant origin contain very small stearic acid fraction (Al-Bachir and Koudsi,2019).

The share of SFA in oils obtained from seeds and stones of fruits is relatively small, ranges from 6 to 10% (Mikołajczak, 2018). The sum of SFAs (stearic acid and palmitic acid) was less than11% in the ChKOs. Yılmaz and Gökmen (2013) reported that sour ChKO contained low levels of palmitic acid (6.23%) and stearic acid (1.33%). The relatively low content of SFAs such as palmitic acid with amounts of 10.9% to 13.3% and the content of stearic acid of the oils ranged from 3.7% to 4.0% is interesting from a nutritional point of view (Doğantürk and Canbay, 2019).

It is common knowledge that SFA have a negative impact on human health. First of all, they are attributed to the concentration of cholesterol (total and its LDL fraction) in the blood serum, hypercholesterolemic action, an activity promoting platelet aggregation, and thus increasing the risk of blood clots in vessels (Mikołajczak, 2018).

Lipids of the ChKO samples had high content of UFA (89.90%), and low content of SFA (10.12). Meanwhile, the values of USFA/SFA index is 8.9 (Table 5). Mikołajczak (2018) reported that, the cherry stones oil provides a significant amount of USFAs. The largest amounts are found for FAs such as C18:1 and C18:2, and their shares are similar to each other. The share of SFAs is estimated at almost 12%, and C16:0 is predominant.

In addition, ChKO was characterized by a high PUFA/SFA ratio was (3.8) (as defined in Table 2), which is highly favorable for the reduction of serum cholesterol and atherosclerosis, and the prevention of cardiovascular disease (Shen *et al.*, 2018). The higher the TUFA/TSFA ratio, the more nutritional potentials the oil has (Ogungbenle and Afolayan, 2015). Current nutritional recommendations are that the PUFA/SFA ratio in human diet should be above 0.45 (Al-Bachir, 2015b). The balanced diet ratio of PUSFA: MUSFA: SFA is 1:2:1, and the value of the seed oils of about 5:2:1 (Al-Bachir, 2018), while that of the ChKO is about 4:5:1.

Effect of storage period on fatty acids composition of ChKO

The effect of storage time on individual FA, SFA, USFA, PUSFA, USFA/SFA ratio, and PUSFA/SFA ratio of ChKO is shown in Tables, 1, and 2. Storage time caused no significant ($p > 0.05$) difference between the FA composition of the ChKO. Moreover, the palmitic, palmitoleic, stearic, oleic, linoleic, linolenic FA, SFA, USFA, PUSFA, USFA/SFA/ ratio, and PUSFA/ ratio of ChKO remained unaffected during storage. Therefore, such storage conditions are recommended for this oil producing kernels. Al-Bachir and Koudsi, (2019) demonstrated that the storage period up to 36 months applied to olive oil induce significant differences ($p<0.05$) in FA content, and it was always below the accepted limit for the extra virgin olive oil. However, it was found that, for all analyzed samples, the values of palmitic acid, stearic acid, palmitoleic acid, oleic acid, linoleic acid Linolenic acid fall within the recommended International Oil Council (IOOC, 2015).

In contrast to our results, Al-Bachir and Sahloul (2017) reported an increase in SFAs with parallel decrease in USFAs in olive oil during storage. Mexis *et al.* (2009) who reported an increase in SFAs with parallel decrease in USFAs in ground almonds during storage. Storage may cause the saturation of double bonds of palmitoleic (C16:1), linoleic (C18:2), and linolenic acid (C18:3). (Al-Bachir and Sahloul, 2017). The decrease in the USFA content and the concomitant increase in the SFA content are explained by De Camargo et al, (2012) who stated that the ratio of the oxidation rates of stearic, oleic, linoleic, and linolenic acids was 1: 10: 100: 200. However, the change in FA saturated during storage of oil is mainly due to a molecular structure change in FAs (Aric *et al.* 2007).

Effect of gamma irradiation on fatty acids composition of ChKO

Compositions and differences, related to irradiation exposure doses in terms of contents of palmitic, palmitoleic, stearic, oleic, linoleic, linolenic FA, SFA, USFA, PUSFA, the ratio of USFA/SFA and (PUSFA/SFA) were statically analyzed (Tables 1 and 2). As shown in Tables, at all used irradiation doses and at all extracted and stored times of ChKOs, small change were observed in palmitic, palmitoleic, stearic, oleic, linoleic, linolenic FA, SFA, USFA, and the ratio of USFA/SFA,and this small changes in FAs composition

were all times not significant (P>0.05).

In the present study, the results indicate that oil samples extracted from irradiated and non-irradiated ChKO contained the same FAs. In general, there were no significant (p > 0.05) differences in FAs compositions of both oil extracted from irradiated and un-irradiated ChKO. This can be due to the relative stability of olive oil's FAs against oxidation reaction during the irradiation processing (Al-Bachir and Sahloul, 2017). According to the published results in the literature, irradiation of high moisture content foods produces in high hydroxyl radical amounts, which trigger fat oxidation, leading to changes in FA composition of foodstuff. Such reactions are expected to be slower in low moisture foodstuff, such as seeds kernels or nuts (Al-Bachir, 2015b). Given the low moisture content of cherry kernels (4.51%) and it is most probable that no FA modifications were done through triglycerides hydrolysis.

Our results are in agreement with other studies which, observed that, at low irradiation doses (3 kGy), small change were observed in individuals, SFA and USFA components, but the changes in FA composition of oil extracted from irradiated pumpkinseeds (Abd El-Aziz and Abd El-Kalek, 2011) and olive fruits (Al-Bachir, 2018) were not significant (P<0.05). Minami et al (2012) did not find significant changes in FA composition of soybean irradiated at gamma irradiation doses up to 10 kGy. Apaydin *et al.* (2016) reported that, there was no change observed in C18:0 and C16:0 FA contents as irradiation dose increased. On the other hand, there is a significant (p < 0.05) decrease in C18:1, C18:2, and C18:3 content depending on the increase in irradiation dose.

In contrast to our results, SFA and USFA of sesame peanut and sunflower oils are considered to be affected one by gamma-radiation which was decreased the SFA and increased the USFA when irradiated at doses of 3, 6 and 9 kGy (Al-Bachir 2017).

Brewer (2009) reported that the lipids that are affected by irradiation are mainly the two or more double bonded of PUSFAs. It was estimated that, the reason for the increase in SFAs and decrease in USFA during the irradiation exposure was because of molecular structure change in FAS, the breaking of dual links and radicals and trans FA turning to free condition (Al-Bachir, 2018).

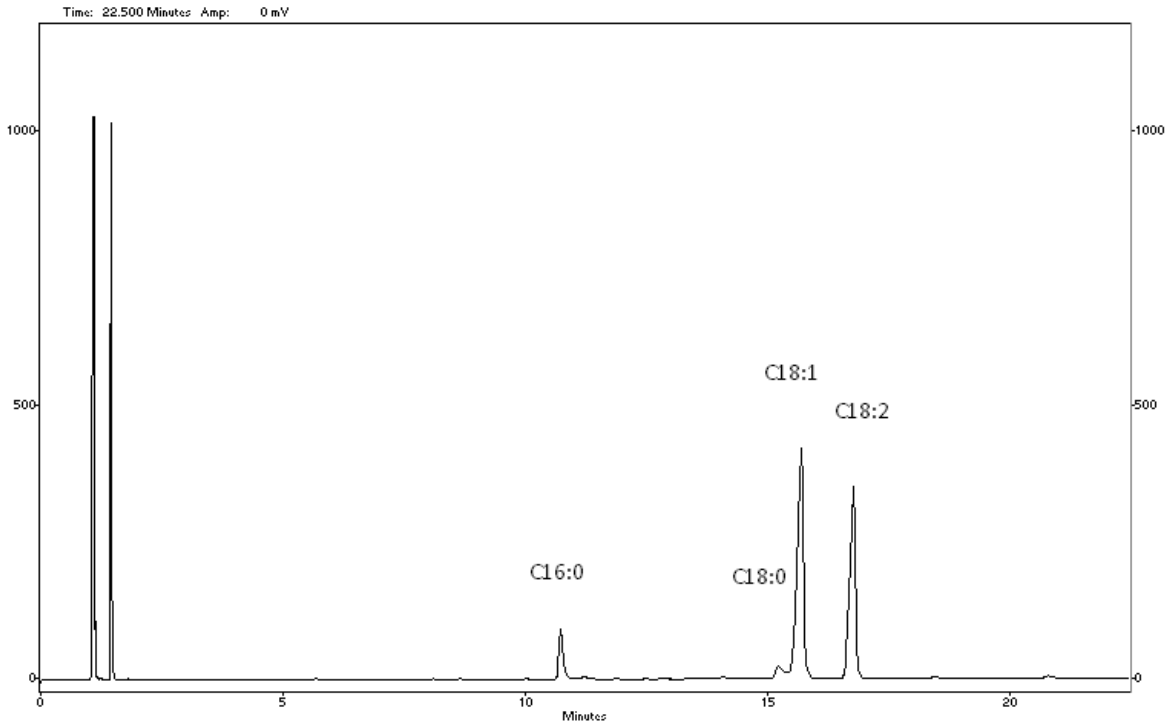

Figure 1: Fatty acid contents of cherry kernel oil.

Table 1. Effect of gamma irradiation and storage period on fatty acid content (%) of cherry seed oil.

Treatment	Control	3 KGY	6 KGY	P-level
Storage period/ (Months)		**C16:0**		
0	^{Aa}0.88±7.71	^{Aa}0.69±7.77	^{Aa}0.72±7.13	**0.5606**
12	^{Aa}0.27±7.55	^{Aa}0.43±8.50	^{Aa}0.94±7.32	**0.1189**
P-level	**0.7806**	**0.1939**	**0.7995**	
		C16:1		
0	^{Aa}0.03±0.42	^{Aa}0.06±0.43	^{Aa}0.06±0.41	**0.9232**
12	^{Aa}0.02±0.44	^{Aa}0.48±0.47	^{Aa}0.12±0.40	**0.9525**
P-level	**0.3621**	**0.8901**	**0.8600**	
		C18:0		
0	^{Aa}1.07±2.41	^{Aa}0.30±2.89	^{Aa}0.15±2.88	**0.6047**
12	^{Aab}0.44±2.78	^{Ab}0.25±2.00	^{Aa}0.46±2.85	**0.0686**
P-level	**0.6044**	**0.0166**	**0.9326**	
		C18:1		
0	^{Aa}2.85±51.07	^{Aa}2.33±52.24	^{Aa}4.02±52.81	**0.7961**
12	^{Aa}4.06±50.94	^{Aa}0.61±49.85	^{Aa}0.81±50.69	**0.8493**
P-level				
		C18:2		
0	^{Aa}2.99±38.03	^{Aa}2.12±36.28	^{Aa}3.65±36.11	**0.7006**
12	^{Ab}1.00±35.95	^{Aa}1.30±39.32	^{Aab}1.69±38.39	**0.0536**
P-level	**0.3162**	**0.1020**	**0.3745**	
		C18:3		
0	^{Aa}0.16±0.38	^{Aa}0.29±0.39	^{Aa}0.47±0.67	**0.5228**
12	^{Aa}0.10±0.36	^{Ab}0.00±0.00	^{Aa}0.27±0.35	**0.0610**
P-level	**0.8907**	**0.0801**	**0.8015**	

^{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.
NS: not significant. * Significant at p<0.05. ** Significant at p<0.01.

Table 2: Effect of gamma irradiation and storage period on total saturated fatty acids (SFA), unsaturated fatty acids (USFA) and (USFA/SFA) of thyme oil (%).

Treatment	Control	KGY3	KGY6	P-level
Storage period/(Months)		**SFA**		
0	^{Aa}0.4±10.12	^{Aa}0.49±10.66	^{Aa}0.79±10.01	**0.3994**
12	^{Aa}0.37±10.33	^{Aa}0.53±10.50	^{Aa}0.67±10.17	**0.7601**
P-level	**0.5305**	**0.7254**	**0.8015**	
		USFA		
0	^{Aa}0.39±89.90	^{Aa}0.49±89.34	^{Aa}0.79±90.00	**0.3894**
12	^{Aa}3.23±87.69	^{Aa}0.38±89.64	^{Aa}0.67±89.83	**0.3783**
P-level	**0.3049**	**0.4486**	**0.8002**	
		USFA/SFA		
0	^{Aa}0.39±8.90	^{Aa}0.44±8.40	^{Aa}0.77±9.04	**0.3932**
12	^{Aa}0.31±8.49	^{Aa}0.47±8.55	^{Aa} 0.66±8.87	**0.6367**
P-level	**0.2297**	**0.6930**	**0.7861**	

^{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.
NS: not significant. * Significant at p<0.05. ** Significant at p<0.01.

CONCLUSION

Cherry seeds are by product and generated as waste after fruit processing. The results showed that oils obtained from cherry seeds are a source of unsaturated fatty acids (more 89%), in particular C18:1 (51.07%) and C18:2 (38.03%). The share of saturated fatty acids in oils from cherry seeds is relatively low (less than 11%), the main acid of this group is C16:0 acid (7.71%). Fatty acid composition of tested ChKO is within the range as explained in the literature. So, the ChKO may be used as natural additive to improve the quality, stability of food products.

The present study demonstrated that the effect of gamma irradiation and storage on the FA profile of ChKO was minimized. Irradiation and storage of cherry kernel, however, had no significant effect on individual FA (palmitic, palmitoleic, stearic, oleic, linoleic, and linolenic fatty acid), SFA, USFA, SFA/USFA ratio, and SFA/PUSFA of ChKO.

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CONFLICTS OF INTEREST

All authors have declared that they do not have any conflict of interest for publishing this research.

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