JAP&T
TPA-Timisoara

Available online at http://journal-of-agroalimentary.ro

Journal of Agroalimentary Processes and Technologies 2019, *25* (1), 24-30

Journal of Agroalimentary Processes and Technologies

Some characteristics of oil extracted from gamma irradiated apricot (*Prunus Armeniaca* L.) kernels

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Abstract

Recently, more attention has been focused on utilization of food processing by irradiation. This investigation aims to evaluate the effects of gamma irradiation on the physical and chemical properties of apricot kernel oil. Apricot kernel samples were irradiated by 60Co gamma source at absorbed dose of 0, 6 and 9 kGy. The chemical properties of oil obtained from non-irradiated samples of apricot kernel were determined as acid value (AV) (10.95 mg KOH g^{-1} oil), peroxide value (PV) (2.91 meq kg^{-1} oil), iodine value (IV) (102.53 g I_2 100 g^{-1} oil), (SV) (188.60m g KOH g^{-1} oil), refractive index (RI) index (25 ºC) (1.4690), TBA number (Thiobarbituric acid) (0.06 mg MDA kg^{-1}) and color (L*= 30.18, a*=15.60, b*= 40.91 and ΔE= 92.83). PV, TBA, IV, SV, refractive index L* and b* values of apricot kernel oil were not significantly affect by different gamma irradiation doses. While, an increase ($p<0.05$) in AV, and ΔE were observed in oil extracted from apricot kernel exposed to doses of 9 kGy. Physical and chemical characteristics of apricot kernel oil indicated that it is edible and therefore recommended as cooking oil.

Keywords: Apricot kernel oil, Irradiation, Physico-chemical properties, Storage, Syria.

1. Introduction

Plants contain a significant amounts of biologically active substances able to lower the risk of population diseases [1]. Antioxidant contents exist in fruits and vegetables have been reported to play a major role in disease prevention due to their ability to scavenge free radicals in the biological system [2].

Following food processing from fruits, vegetables or oilseeds, high amounts of waste materials such as seeds, stones and peels are produced, and there is an increasing demand for their conversion into useful by-products [3]. Obviously, such utilization of food processing wastes could provide extra income and at the same time help reduce a waste disposal problem. Generally, some waste materials are used as animal feeds or fertilizers [4], but most of them are left as waste. Fruit stone/pits thrown as a waste after processing are currently used for the production of biomasses, but in the future they may constitute an important raw materials in the food and cosmetic industry [5]. This waste, otherwise, is a good source of edible oil and considered to be a good source of polyunsaturated fatty acids like linoieic acid and oleic acid as monounsaturated with a good nutritional, healthful and pharmaceutical importance [6]. The stone seed oil has been called a specialty oil, which is small volume but high value [5]. The ability of some unsaturated fatty acids percents in vegetable oils to reduce the serum low density lipoprotein (LDL) cholesterol level may focus attention on the apricot kernel oil due to its high unsaturated fatty acid content [7].

Apricot kernels have been utilized for oil. The oil that are manufactured from the kernels are used in leather, pharmacology, cosmetics and food

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industry [8, 9]. Their oils have a high percentage of unsaturated fatty acids with oleic (60.07-70.6 %) and linoleic (20.5-27.76 %) being the dominants [6].

Food safety is a concern for the general public health when almost everybody for the past period has ever suffered from food borne diseases at least once [10]. Treatment with ionizing radiation is an preservation method. Although the safety of irradiation food is well documented [11]. Then, in addition to investigating the effective ionizing radiation doses needed for a proposed objective, the effects of irradiation on product chemical, nutritional value and organoleptic quality must also been determined [12,13,14]. Brewer [15] reported that the fat contents that are affected by ionizing irradiation treatments are majorly the two or more double bonded polyunsaturated fatty acids. Until now, there have been no previous studies reported on irradiated or non irradiated Syrian apricot kernel oil. As ionizing irradiation is investigated to affect the physical and chemical properties of several foods. In this regard, the present research was undertaken to investigate the physical and chemical properties of oils extracted from irradiated and non-irradiated apricot kernels of locally available cultivar.

2. Materials and methods

2.1. Treatments and analysis performed

Apricot fruits were purchased from local markets in Damascus, Syria. The seeds of the fruit were manually separated from the pulp. Outer shells of the seeds were removed manually from kernel of apricot. Then kernels were cleaned and dried, they were broken into paces smaller than 1 mm by using a domestic grinder and then sieved. Apricot kernels were exposed to gamma radiation at doses of 0, 6 and 9 kGy in a ^{60}CO package irradiator. The apricot kernel samples were irradiated at place with a dose rate of 7.775 kGy h^{-1}, at ambient temperature and normal atmospheric pressure [16]. The oils from control and irradiated apricot kernels after grinding were extracted by the manual Soxhlet apparatus (Scientific Apparatus Manufacturing Company, Glas-Col Combo Mantle, USA) for 16 h, using distilled AR (analytical grade) n-hexane as the solvent [17]. Physical and chemical characteristics of oils extracted from irradiated and non-irradiated apricot kernels samples were performed immediately after irradiation, and after 12 months of storage.

2.2. Chemical analysis of oils

Standard analytical procedures were followed for estimation of acid value (AV) (Oleic acid %) in term of mg KOH g^{-1} oil, peroxide value (PV) in term of meq O_2 kg^{-1} oil, iodine value (IV) in term of g I_2 100 g^{-1}, specification value (SV) in term of mg KOH g^{-1} oil sample and the refractive index (RI) at 40 °C of apricot kernel oils were determined according to standard methods [17]. TBA number (Thiobarbituric acid) in mg MDA kg^{-1} sample was measured according to IUPAC direct method [12]. The color of apricot kernel oil was measured using AvaSpec Spectrometer Version 1, 2 June 2003 (Avantes, Holland) and expressed as color L* (lightness), a* (redness), and b* (yellowness) values. Reflectance values were obtained at wave length of 568 nm by exposing the samples to the illuminant [13]. The reported results (L*, a*, b*) are the mean of 9 determination.

2.3. Statistical analysis

Experimental data were evaluated by using analysis of variance test (ANOVA) and the significant differences among the means of the three replicates were determined by Duncan's multiple range test, using the SUPERANOVA computer package (Abacus Concepts Inc, Berkeley, CA, USA; 1998).

3. Results and discussion

3.1. Physico-chemical properties of apricot kernel oil.

Some properties of the apricot kernel oil are given in tables 1 and 2. The oil from apricot kernel exhibited AV (10.95 mg KOH g^{-1} oil); PV (2.91 meq O_2 kg^{-1} oil); TBA value (0.06 mg MDA kg^{-1}); IV (102.53 g I_2 100 g^{-1} oil); SV (188.60m g KOH g^{-1} oil); and RI (25 °C) (1.4690). The results reported here are in accordance with those of Gupta et al. [6]; Kaya et al. [8]; Lazos, [18], Ozcan et al. [7], Birnin-Yauri and Garba, [19] on apricot seed oil, Al-Bachir and Koudsi, [20] on olive oil, Al-Bachir, [14] on peanut oil, Al-Bachir, [12] on almond oil. Kaya et al. [8] reported that, AV, PV, IV, RI (at 20 °C) of the wild apricot kernel oil were, 0.223%, 4.901 meq O_2 kg^{-1}, 90.91 g I_2 100 g^{-1}, 1.4686 respectively. Earlier, the oil from apricot kernels exhibited low AV (2.27-2,78 mg KOH g^{-1} oil); PV (5.12-5.27 meq O_2 kg^{-1} oil), IV (100.2-100.4 g I_2 100 g^{-1} oil) and SV of 189.8-191.3 mg KOH g^{-1} oil) [6].

Acid value is an indicator of the level of hydrolytic rancidity and contributes to the developed of off-flavors and off-odor in the oil [21]. The AVs of apricot seeds ranged between 0.28% and 0.9% [7,8,18].

The PV is a measure of the content of hydroperoxides, which are primary oxidation products. The PV is an indicator of deterioration of fat. As oxidation takes place the double bonds in the unsaturated fatty acids are attacked forming peroxides [21]. The lipid oxidation was attributed to the combination of free radicals with O_2 to the form of hydroperoxides [22]. The PVs of apricot kernel oils changed between 0.834 and 8.294 meq kg^{-1} [6,7]. It is also determined that the PV of the wild apricot kernel oil is ≤ 5 meq O_2 kg^{-1} oil [8]. The PV of 2.91 meq O_2 kg^{-1} oil detected in this analysis is a good property which gives more resistant to oxidation, with better shelf-life.

The TBARS (2-thiobarbituric acid-reactive substance) are commonly used to estimate the level of oxidative stability of the oils. TBARS test is based on measurements color intensity of the reaction between TBA (2-thiobarbituric acid) and secondary oxidation products of polyunsaturated fatty acids [23].

Apricot kernel oil has been found to have high IV (Table 2), indicating that it is high unsaturated oil. Thus, it may be found in liquid form at ambient temperature [19].

The IV is a measure of the degree of un-saturation in oil; it gives valuable information about the drying property of the oil as well as the extent of adulteration of the oil [24]. In confirmation to our result, the IV of apricot seed oil was reported as 100.3-105.0 g I_2 $100g^{-1}$ oil [6,18]. It is also determined that the IV of the wild apricot kernel oil is 92.3 g I_2 100 g^{-1} oil [8]. The IV of (102 g I_2 100 g^{-1} oil) of apricot kernel oil is comparable to that of virgin olive oil (89.68 g I_2 100 g^{-1} oil) [20], peanut oil (107.24 g I_2 100 g^{-1} oil) [14], almond oil (98.49 g I_2 100 g^{-1} oil) [12].

Earlier, the SV of apricot kernel oil was reported in range of 189.8-195.0 mg KOH g^{-1} oil [6,18]. SV of (188.60 mg KOH g^{-1} oil) of apricot kernel oil is close to peanut oil (191.21 mg KOH g^{-1} oil) [14], almond oil (194.4 mg KOH g^{-1} oil) [12], pistachio oil (193.50 mg KOH g^{-1} oil) [13], and olive oil (195.48 mg KOH g^{-1} oil) [25]. Science SV is inversely proportional to the molecular weight and, hence, chain length of the fatty acid present in oil, it can be concluded that apricot kernel oil contains glycerides with the highest molecular weight [19].

In agreement with our results, RI of apricot kernel oil was determined between 1.4645 and 1.549 [6,8,18]. RI is used by most processors to measure the change in un-saturation as the fat or oil is hydrogenated [26]. The refractive index of oils depends on their molecular weight, fatty acid chain length, degree of un-saturation, degradation and percentage of polar compounds formed during oxidation an hydrolytic reactions [27].

Table 1. Effect of gamma irradiation and storage period on acid, peroxide and TBA values of apricot kernel oil

Treatment	Control	6 KGY	9 KGY	P level
Storage period/(Months)	**Acid value (mg KOH g-1 oil)**			
0	$10.95\pm^{Ab}0.65$	$8.50\pm^{Ac}0.94$	$15.14\pm^{Aa}0.86$	**0.0002**
12	$10.01\pm^{Bb}015$	$9.44\pm^{Ab}0.40$	$16.22\pm^{Ba}0.51$	**0.0001**
P-level	**0.074**	**0.190**	**0.132**	
	Peroxide Value (meqO2 kg-1 Oil)			
0	$2.91\pm^{Aa}0.12$	$2.71\pm^{Aa}0.50$	$2.72\pm^{Aa}0.50$	**0.815**
12	$2.78\pm^{Aa}0.21$	$2.73\pm^{Aa}0.31$	$2.73\pm^{Aa}0.30$	**0.965**
P-level	**0.410**	**0.970**	**0.983**	
	TBA value (mg MDA kg-1 oil)			
0	$0.06\pm^{Ba}0.001$	$0.06\pm^{Ba}0.001$	$0.07\pm^{Ba}0.004$	**0.0414**
12	$0.09\pm^{Aa}0.001$	$0.09\pm^{Aa}0.001$	$0.09\pm^{Aa}0.001$	**0.0202**
P-level	**0.0001**	**0.0001**	**0.0003**	

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

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

Table 2. Effect of gamma irradiation and storage period on iodine and saponification value and refractive index of apricot kernel oil.

Treatment	Control	6 KGY	9 KGY	P- level
Storage period/(Months)	**Iodine number (g I_2 100g^{-1} oil)**			
0	$102.53\pm^{Aa}1.06$	$102.81\pm^{Aa}0.92$	$102.81\pm^{Aa}0.90$	**0.946**
12	$103.54\pm^{Aa}0.68$	$102.69\pm^{Aa}1.31$	$98.93\pm^{Bb}0.48$	**0.012**
P-level	**0.238**	**0.898**	**0.028**	
	Saponification value (mg KOH g^{-1} oil)			
0	$188.60\pm^{Ba}0.65$	$189.36\pm^{Ba}1.74$	$187.42\pm^{Ba}0.74$	**0.199**
12	$199.63\pm^{Aa}0.21$	$199.82\pm^{Aa}0.38$	$198.90\pm^{Ab}0.32$	**0.024**
P-level	**<0.0001**	**0.0005**	**<0.0001**	
	Refractive Index (nD 25 °C)			
0	$1.4690\pm^{Aa}0.001$	$1.4694\pm^{Aa}0.001$	$1.4700\pm^{Aa}0.001$	**0.0002**
12	$1.4690\pm^{Aa}0.001$	$1.4698\pm^{Aa}0.001$	$1.4700\pm^{Aa}0.001$	**0.0034**
P-level	**0.001**	**0.119**	**0.643**	

[abc] Means values in the same row not sharing a superscript are significantly different.
[ABC] Means values in the same column row not sharing a superscript are significantly different

Table 3. Effect of gamma irradiation and storage period on color change of apricot kernel oil.

Treatment	Control	6 KGY	9 KGY	P- level
Storage period/(Months)		**L**		
0	$30.18\pm^{Aa}1.86$	$30.17\pm^{Ba}1.75$	$32.22\pm^{Ba}2.13$	**0.381**
12	$70.91\pm^{Aa}0.75$	$70.57\pm^{Aab}1.10$	$69.06\pm^{Ab}0.37$	**0.061**
P-level	**<0.0001**	**<0.0001**	**<0.0001**	
		a		
0	$15.60\pm^{Bab}0.83$	$13.69\pm^{Bb}1.08$	$16.64\pm^{Ba}1.15$	**0.033**
12	$23.27\pm^{Aa}3.30$	$25.66\pm^{Aa}1.32$	$21.96\pm^{Aa}5.02$	**0.478**
P-level	**0.018**	**0.0003**	**0.149**	
		b		
0	$40.91\pm^{Ba}4.31$	$45.33\pm^{Aa}5.36$	$39.61\pm^{Aa}5.81$	**0.422**
12	$24.35\pm^{Aa}4.45$	$16.61\pm^{Ba}3.72$	$19.54\pm^{Ba}8.17$	**0.323**
P-level	**0.010**	**0.002**	**0.026**	
		ΔE		
0	$92.83\pm^{Aab}3.19$	$89.84\pm^{Ab}2.13$	$94.94\pm^{Aa}1.18$	**0.091**
12	$84.37\pm^{Aa}4.33$	$92.11\pm^{Aa}3.25$	$89.03\pm^{Aa}8.59$	**0.334**
P-level	**0.053**	**0.369**	**0.304**	

[abc] Means values in the same row not sharing a superscript are significantly different.
[ABC] Means values in the same column row not sharing a superscript are significantly different

3.2. Effect of gamma irradiation on properties of apricot kernel oil

The results in tables 1 and 2, show the effect of different doses of gamma irradiation (6 and 9 kGy) on the AV, PV, TBA, IV, SV and RI of apricot kernel oil. Regarding the effects of gamma radiation on the AV, an increase ($p<0.05$) in AV (10.95%) was observed in oil extracted from apricot kernel exposed to doses of 9 kGy (15.14%). In turn, a small but statistically significant ($p<0.05$) decrease was reported in AV of oil extracted from apricot kernel exposed to doses of 6 kGy (8.50 %). Our results are in agreement with the previously reported findings of Aric et al. [22] who also reported that the free fatty acid of black cumin increased with increasing the doses of irradiation treatment (up to 10 kGy). Bhatti et al., [28] observed an increase in free fatty acids for oil extracted from gamma irradiated almond kernels, might be attributed to slight random hydrolysis of triglycerol components to free fatty acids and diacylglycerols [16]. Similar findings were reported for the acid values of sunflower and soy bean oil [29] and pumpkin seed oil [30] which increased significantly with high gamma irradiation doses (5 and 20 kGy). Many research study have reported the irradiation induced fatty acid compositional changes [13,14,31].

Analysis of variance showed that parameters such as PV, TBA, IV, SV and RI of apricot kernel oil were not significantly affected by different gamma irradiation doses (Tables 1 and 2). Our results agree with Al-Bachir [14] who also observed that irradiation process had no effect on the chemical and physical qualities such as, PV, IV, SV and TBA value of oil extracted from peanut seeds. Gamma irradiation caused an alteration of properties of pistachio oil which showed a decrease in AV, PV and IV, and increased SV, with no effect on TBA value

[13]. Irradiation reduced AV, PV, IV and SV of almond oil. Whereas, the TBA value was almost unaffected [12]. Wen et al. [32] found that no significant change in AV following 4, 8 and 14 kGy gamma irradiation in lyceum fruit. Bhatti et al. [33] and Bhatti et al. [28] who also did not observed any significant change in RIs between the control and irradiated peanut and almond oils.

3.3. Effect of storage period on properties of apricot kernel oil

Tables 1 and 2 show the effect of storage time on AV, PV, TBA, IV, SV and RI of apricot kernel oils. The results indicated that, during storage, the chemical properties such as PV and RI of the oil extracted from non–irradiated and irradiated samples were almost unaffected, while, the TBA and SV decreased ($p<0.05$) during storage. AV of oil extracted from non-irradiated apricot kernel decreased ($p<0.05$) during storage, while AV of oil extracted from irradiated ones increased ($p<0.05$). The increase in AV of oil extracted from irradiated apricot kernel throughout storage period might be attribute to slight and random hydrolysis of triglycerol molecules to free fatty acids and diacylglycerols [16]. AV represents free fatty acid content due to enzymatic activity and is usually indicative of spoilage [34].

During storage, the IV of oil extracted from apricot kernel treated with higher dose (9 kGy) was decreased. This decrease in IV of oil might indicate a saturation of the oil as a result of the breakdown of double bonds due to oxidative deterioration in the fatty acids [28]. In other words, as a result of storage, saturated oils increased and unsaturated oils decreased [22]. These results are in agreement with the results reported by some investigators. Afify et al. [35] indicated that a marked decreased in IV was noticed in soy bean seeds treated with gamma irradiation.

The decrease in IV may be attributed to the saturation of the double of un-saturated fatty acids bonds [16].

During storage, the SV of the oil extracted from both irradiated and non-irradiated apricot samples increased ($p<0.05$). Our results agree with Al-Bachir [12] who also observed an increase in the SV in oil extracted from both irradiated and non-irradiated almond kernels after 12 months of storage, which indicated that large original molecules of oils containing long-chain fatty acids degraded to smaller molecules as a result of oxidation and cleavage of bonds [14].

Storage significantly increased the TVBN in irradiated and non-irradiated apricot kernel oil samples. These results are somehow in agreement with those of Al-Bachir (2014) who reported that TBA values of irradiated and non irradiated almonds increased significantly ($p < 0.05$) during storage up to 12 months. While the peroxide, acidity and TBA values of the peanut oil were decreased due to storage time [14].

3.4. Effect of gamma irradiation and storage on color of apricot kernel oil

The color of apricot kernel oil samples was evaluated from the chromatic coordinates a* corresponding to the green zone, b* corresponding to the yellow zone, L* corresponding to the Lightness, and ΔE values of the absorption spectrum. The color in term of L*, a*, b* and ΔE values of oils extracted from apricot kernel treated at 0, 6, and 9 kGy of gamma irradiation and stored at ambient temperature for 12 months are presented in Table 3. As shown in the table, the initial L*, a*, b* and ΔE values of apricot kernel oil obtained from non-irradiated apricot kernel were 30.18, 15.60, 40.91 and 92.83 respectively. Gamma irradiation had no effect on the redness (a*-value) and yellowness (b-value), but the lightness (L*-value) and yellowness (b*-value) were less intense of apricot kernel oil. Gamma irradiation dose of 9 kGy increases significantly ($p>0.05$) the ΔE values of apricot kernel oil obtained from kernel immediately after irradiation.

During storage, the lightness (L*-value) and redness (a*-value) value of oil obtained from irradiated and non-irradiated apricot kernels were significantly ($p<0.05$) increased, while the yellowness (b-value) was significantly ($p<0.05$) decreased. Also, during storage, The ΔE values of apricot kernel oil obtained from control sample and from sample treated with higher dose (9 kGy) decreased significantly ($p<0.05$). While the ΔE values of apricot kernel oil obtained from sample treated with lower dose (6 kGy) inccreased significantly ($p<0.05$).

There is no information available in the literature on the effect of gamma irradiation and storage on the Hunter's color values of apricot kernel oil. However, for the other oil seeds or kernels, diverse effects of irradiation on the color of its extract have been reported. Color parameters L*, a* and b* showed a small but statistically significant ($p<0.05$) increase in all irradiated almond samples [12]. Irradiation had a significant effect on colour values (L*, a*, and b* values) of pistachio oil [13]. Irradiation of peanut seed reduced L*, a* and b* values reflecting that the oil became darker or less light [14]. Gölge and Ova [36] reported statistically significant change in L* and b* values for pine nuts at dose of 5 kGy. Mexis and Kontominas [37] reported a statistically significant change in a* values for cashew nuts at dose 3 kGy. Mexis et al. [38] reported that, the color parameters a* and b* remained unaffected after irradiation of almonds kernels at doses up to 7 kGy. According to previous work of De Camargo et al. [39] the color of peanut was not affected by the short term effects of gamma radiation at doses up to 15 kGy.

4. Conclusion

The analytical parameters studied of apricot kernel oil including acid value (10.95 mg KOH g-1 oil); peroxide value (2.91 meq kg^{-1} oil); TBA value (0.06 mg MDA kg^{-1}); iodine value (102.53 g I_2 100 g^{-1} oil); saponification value (188.60 mg KOH g^{-1} oil); refractive index were close and comparable to that of olive oil, peanut oil, pistachio oil and almond oil. Physic-chemical properties indicated that it is edible and therefore recommended as cooking oil. It is clear that this waste is a source of goods and upon utilization could provide extra income.

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.

Acknowledgements: The authors would like to thank the Director General of the Atomic Energy Commission of Syria (AECS) and the staff of the division of food irradiation.

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