Effects of Low Dose γ Radiations on the Stability of Canola and Sunflower Oils

[1]F. K. BANGASH*, [1]S. AHMED, [2]T. AHMAD, [2]S. ATTA AND [1]S. ALAM.
[1]*Institute of Chemical Sciences, University of Peshawar, Peshawar 21250, Pakistan.*
[2]*Nuclear Institute for Food and Agriculture, Tarnab Peshawar, Pakistan.*

(Received 15th July 2006, Revised 31st October 2006)

Summary: Gamma rays at the dose rate of 5, 20, 40, 60, 80, and 100 krad were applied to irradiate canola and sunflower oils, and changes in their quality parameters were determined. The quality constants monitored were free fatty acid (FFA), iodine value (IV), peroxide value (POV), anisidine value (AV) and color (OD). Results revealed that a significant increase ($p < 0.05$) in FFA, POV, AV, and OD occurred after irradiation. However, IV decreased in both the oils as the radiation doses increased. Canola oil was found to be more stable than sunflower oil under the test conditions.

Introduction

Among the existing technologies for food preservation, irradiation is recognized as a safe and effective method for a range of specific applications. Ionizing radiation uses the high energy of gamma rays or accelerated electrons, thereby ionizing molecules. The use of this treatment on fresh food could extend shelf life of the food and protect the host against pathogenic bacteria [1]. On the other hand, irradiation treatment brings about some biochemical changes that could affect the nutritional adequacy of food [2]. The development of unpleasant flavors is the major difficulty associated with high dose irradiation of food [3]. Safety tests of irradiated foods has included over 1000 long and short-term toxicological effects that have been reviewed by international regulatory agencies [4].

The ionizing radiation might affect the quality of oils by increasing its oxidation rate. It may also produce active species like free radicals, which initiate certain chemical reactions that might also result in the rancidity of oils and fats [5]. Lipid oxidation and associated changes are the major causes of the quality deterioration of meat during storage. Irradiation of lipid induces the production of free radical, which reacts with oxygen, leading to the formation of carbonyls, responsible for the alteration in food's nutritional and sensorial characteristics. Various carbonyl compounds have been isolated and characterized, from irradiated meat fat [6]. Several investigators suspected the lipid fraction as a major contributor to the irradiation odor of complex fat containing foods [7]. Beef fats or pork fats, for example, if irradiated under vacuum, give rise to off-odors. The irradiated fat odor produced in beef and pork fat was detectable at 2 mrad and was more intense at higher doses. Alkanes, alkenes and alkadienes were the major radiolytic products in these samples [8].

Effects of temperature, light and gamma irradiation on the soybean, sunflower, corn and palm products have been investigated. Measurement of peroxides values after 5 months revealed that there was significant increase in peroxide values of the samples exposed to fluorescent light at room temperature than those refrigerated [9].

Radiation brings about changes in the compo-sition of oils and fats but the most volatile compo-nents, such as terpene hydrocarbons, were found resistant to irradiation [10]. Ionizing radiations effects the fatty acid composition of natural fats, and the lipid peroxide formation as a result indicates that the peroxide value of fats and oils would increase with radiation [11].

A study on the effect of irradiation with gamma rays of 0.5, 1.0, and 1.5 kGy, on the lipids present in different plant nuts revealed that the lipid extracted from the seeds have peroxide, anisidine and free fatty acid values higher than in their non-irradiated samples [12]. The objective of the present study was to determine the effect of ionizing

*To whom all correspondence should be addressed.

radiation of low doses on the quality parameter of the commonly utilized edible oils such as the sunflower oil and canola oil.

Results and Discussion

In order to evaluate the effect of low dose γ-irradiation on the quality constants of canola and sunflower oils, methods of AOCS [13] were used. The data were statistically analyzed in order to assess the significant effects of radiation on the oil. It was evident from the data that POV, OD, AV and IV were significantly affected by radiations.

Free fatty acids are produced by the hydrolysis of fats in the presence of water or enzymes lipase during storage. The fatty acids in SFO and CO are quantified in terms of percent oleic acid and for radiated and controlled samples are shown in Table-1. Results show that the free fatty acid contents of the samples increased with the increase in radiation doses. The triglycerides in the oils are not stable under ionizing radiation and convert into free fatty acids. Unsaturated fatty acids are also prone to auto-oxidation in the presence of oxygen [14]. The effects of irradiation on fatty acid, ester, triglycerol, natural fats and fat containing foods and cooking oils have been reported earlier [15-16]. The increase in peroxide value is a strong indicator of continuous deterioration of the oil [17]. Peroxides and their oxidative products are also associated with the off-odors [18]. Peroxide values of irradiated test oils are presented in Table-2. Where SFO has a greater change in values (from 4.3 to 13.14 meq/ kg) and a slight increase is observed in the values of CO (from 3.4 to 9.48 meq/ kg). Radiation increases lipid oxidation and the oxidation is initiated by radical reaction involving unsaturated fatty acids [12]. It has been reported [19] that the primary oxidative products formed are hydro-peroxide, which break down into a series of complex reactions. The secondary products of hydroperoxide include alcohols and cabonyles. These secondary products oxidize further to form carboxylic acids. The peroxide values however, increase with the increase in radiation doses.

The color of refined oil is a good indicator of its quality. The partial oxidation of vegetable oils is known to increase their red and yellow color as a result of formation of colored products like chromans and quinines [20]. The color of the oils determined in terms of optical density [OD] at 420nm (Table-3) is a marker of radiation. Radiolytic oxidation also produces colored products [21]. The ionizing radiations affect the color of canola oil more (changed OD from 0.154 to 0.327) than the sunflower oil (changed OD from 0.120 to 0.182) at the radiation dose of 100 krad. It is interesting to note that contrary to the results for sunflower and canola oils, the red palm oil color decreased with the increase of radiation doses [16].

The influence of irradiation on the formation of secondary products like peroxides and

Table-1: Effect of irradiation on the free fatty acid of sunflower and canola oils.

	Free fatty acid (%)	
Radiation dose (krad)	SFO	CO
Control	0.180[a]	0.130[a]
5	0.183[a]	0.132[a]
20	0.184[a]	0.133[a]
40	0.193[a]	0.150[ab]
60	0.210[a]	0.150[ab]
80	0.223[a]	0.160[b]
100	0.250[a]	0.170[b]
LSD, 5% Sample	0.641	0.027

Values sharing common letters are not significantly different ($p < 0.05$)

Table-2: Effect of irradiation on the peroxide value of sunflower and canola oils.

	POV (meq/ kg)	
Radiation dose (krad)	SFO	CO
Control	4.34[a]	3.493[a]
5	5.34[b]	4.200[b]
20	6.30[c]	5.500[c]
40	7.20[d]	6.450[d]
60	9.80[e]	7.353[e]
80	11.60[f]	8.080[f]
100	13.14[g]	9.483[g]
LSD, 5 % Sample	0.091	0.211

Values sharing common letters are not significantly different ($p < 0.05$)

Table-3: Effect of irradiation on the optical density of sunflower and canola oils.

	Color/Optical density	
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Radiation dose(krad)	SFO	CO
Control	0.128[a]	0.154[a]
5	0.139[b]	0.168[b]
20	0.156[c]	0.240[c]
40	0.168[d]	0.270[d]
60	0.169[e]	0.280[e]
80	0.178[f]	0.290[f]
100	0.182[g]	0.327[g]
LSD, 5% Sample	0.001	0.01

Values sharing common letters are not significantly different ($p < 0.05$)

hydro-peroxides can be measured by reacting them with anisidine. Anisidine values give a measure of the secondary oxidation products. It is shown in Table-4 that anisidine value for SFO changed from 2.320 to 3.08 and for CO from 3.059 to 3.85 as a result of irradiation. This increase is due to peroxides in the oils, which are unstable intermediates, and decompose into various carbonyls and other secondary oxidation products, principally 2-alkanals and 2,4-dienals [17-18].

The unsaturation of oil or fat can be determined by halogenation of the double bond present. The most important parameter for the oil and fat halogenation is the iodine value determination. Irradiation of SFO and CO has a decreasing effect on the iodine value. With the increase in radiation dose from 5 to 100 krad the iodine values decrease from 123.50 to 118.20 in case of SFO and from 110.77 to 105.10 for CO. Iodine value has been suggested a rather very stable quality parameter for oils and fats, little affected by oxidation, temperature and humidity, but the change in its value is quite significant with irradiation. Decrease in iodine value is an indication of cleavage of some double bonds [19].

Table-4: Effect of irradiation on the anisidine value of sunflower and canola oils.

	Anisidine Value	
Radiation dose(krad)	SFO	CO
Control	2.323^{a}	3.050^{a}
5	2.367^{ab}	3.160^{a}
20	2.433^{b}	3.280^{b}
40	2.620^{c}	3.410^{c}
60	2.800^{d}	3.513^{c}
80	2.960^{e}	3.710^{d}
100	3.080^{f}	3.850^{e}
LSD, 5% Sample	0.08	0.117

Values sharing common letters are not significantly different ($p < 0.05$)

Table-5: Effect of irradiation on the iodine value of sunflower and canola oils.

	Iodine Value(g/1 00 g)	
Radiation doses(krad)	SFO	CO
Control	123.50^{f}	110.770^{g}
5	122.90^{e}	109.100^{f}
20	121.86^{d}	108.120^{e}
40	121.36^{d}	107.643^{d}
60	120.30^{c}	107.217^{c}
80	119.85^{b}	106.500^{b}
100	118.20^{a}	105.100^{a}
LSD, 5 % Sample	0.179	0.161

Values sharing common letters are not significantly different ($p < 0.05$)

Experimental

Samples of canola and sunflower oils were purchased from the local market at Peshawar and irradiated with gamma rays, at 25 °C with dose rate of 5, 20, 40, 60, 80 and 100 krad, using Cobalt–60 source CISSLEDOVATEL, (CIS) at NIFA Tarnab, Peshawar. A non-irradiated oil sample was placed outside the irradiation chamber to have the same environmental temperature and used as control. The quality changes induced by different doses of gamma radiation were determine by analysis of the oils for the quality parameter such as POV, OD and IV using [13] AOCS method [22]. FFA was measured according to the method of AOAC [23]. The color of solution of oil in iso-octane (1: 1) was determined as absorbance (optical density) at 420 nm, using the Shimadzu UV-spectrophotometer. The AV was determined according to PORIM Test method [24].

Conclusions

It is concluded from the results that the canola oil was found to be more stable than sunflowers oil under test conditions.

Acknowledgements

The Institute of Chemical Sciences University of Peshawar, The Oil Chemistry Lab. of Nuclear Institute for Food and Agriculture (NIFA), Peshawar, are highly acknowledged for providing the research facilities cooperation.

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