# Changes in the Quality of Sunflower and Soybean Oils Induced by High Doses of Gamma Radiations

[1]G. LUTFULLAH, [2]A. ZEB, [3]T. AHMAD, [3]S. ATTA AND [2]F. K. BANGASH*
[1]*Center of Biotechnology University of Peshawar, Pakistan*
[2]*Department of Chemistry University of Peshawar, Pakistan*
[3]*Nuclear Institute for Food and Agriculture Research (NIFA) Peshawar, Pakistan*

(Received 4th January, 2003, revised 25th June, 2003)

**Summary**: The effect of gamma radiations of different doses on the quality of edible oils such as Sunflower and Soybean oils were studied w. r. t. the changes in the Peroxide Value, Free Fatty Acid, Iodine Value, β-Carotene, Anisidine Value, Refractive Index and Color. The oil samples were radiated with gamma rays using Cobalt-60 source at the rate of 0.9234 kGy/h, with doses of 1, 5, 10, 15 and 20 kGy. The non-radiated Sunflower and Soybean oils were used as a control. The results show that the Peroxide, Free Fatty Acids, Anisidine values and Optical Density levels increase and Iodine, β-Carotene levels decrease with the high doses of radiation. It was found that the Soybean oil is more resistant to radiations as compared to the Sunflower oil.

## Introduction

Gamma radiations being Ionizing radiations have strong penetrating power and are usually obtained from Cobalt-60 sources, measured in the units of Gray or Rad. Gamma irradiation have wide range of applications in food technology. Therefore it can be used to slows the rate of ripening in fruits and vegetables and as an alternative to chemical fumigants for disinfestations of grains, spices, fruits and vegetables. With the banning of certain chemical fumigants, food irradiation thus facilitate the international shipment of food products.

Microorganisms from undercooked or improperly handled meat, poultry and seafood cause many cases of food borne illness each year. Of particular concern are the illnesses caused by the pathogenic organisms such as salmonella, campylobacter, listeria and toxoplasma. At medium doses, irradiation can be used to prevent food borne diseases by eliminating these organisms.

The major difficulty in the application of high-energy radiation of food is the development of unpleasant flavors. The ionizing radiation (gamma radiation) especially affects the quality of oils by increasing its oxidation rate. Ionizing radiation may also produce active species like free radicals, which initiate certain chemical reactions, and thus result in the rancidity of the oils or fats. It is because the lipid fraction as a major contributor to the irradiation odor of complex fat containing foods [1]. The organic peroxides in irradiated and un-irradiated pork were found to increase. The increase was of 7.4 times greater than background in 1 kGy irradiated minced meat of pork [2]. The pectoral major muscles were treated with gamma radiation, for pH, total nitrogen content and solubility of amino nitrogen and sulfa hydroxyl contents as well as water holding capacity just after irradiation and during storage [3]. The effect of irradiation on the hygienic quality of meat and meat products is considered as related to the control of meat-borne parasites of humans; elimination of pathogens from fresh meat and poultry; and elimination of pathogens from processed meat [4].

The increase in free fatty acid and total acidity, concomitant with pH decrease was observed in beans starch irradiated in the range of 2.5-20 kGy. ESR spectra of irradiated beans starch after 9 and 11th months storage (-40°C) showed the presence of long life radicals [5].

The effect of temperature, light and gamma irradiation on the Soybean, Sunflower, Corn and Palm products was observed. Determination of peroxide and cholesterol values after 5 months revealed there was significant increase in peroxide values of the samples exposed to fluorescent light at room temperature than those in refrigerator. Antioxidants added to Canola and rapeseed oils and stability test of 6 weeks showed a lower oxidation rate [6]. The effect of ionizing radiation and antioxidants (BHA, BHT etc) was observed on the Rapeseed, Canola, Palm oil and Palm oil products [7]. The biological effect of irradiated fats was also observed [8]. Radiation produces changes in the composition of oils and fats [9] and it was found that most volatile components such terpene hydrocarbons are resistant to irradiation [10].

The gamma radiation has been successfully used against fungal spoilage of oil seed during storage and the storage stability of oil seed was improved [1]. The effect of ionizing radiation on fatty acid composition of natural fats and on lipid peroxide formation revealed that peroxide value of fats and oils increase with radiation [11]. Butter, Butterfat and Corn, Cóconut, Rapeseed and Soybean oils were exposed to fluorescent light irradiation at varying time-temperature conditions and their stability was evaluated [12]. Different plant nuts were radiated with gamma rays of 0.5, 1.0 and 1.5 kGy. The lipids were extracted from the seed and were analyzed for various parameters. It was found that peroxide, anisidine and FFA values were higher in the irradiated samples [13].

Keeping in view the interest in the importance of irradiation, the present work was aimed at the study of the effects of gamma radiation (Radiolytic stability) of high doses (up to 20 kGy) on the quality and stability of Soybean and Sunflower oils.

## Results and Discussion

The influence of gamma (ionizing) radiations at the rate of 0.945 kGy/hour with different doses on the changes of physico-chemical constants of edible oils such as Sunflower and Soybean oils were investigated as a function of Color, Refractive Index, Free Fatty Acid, Peroxide Value, Anisidine Value, Iodine Value and β-Carotene. The Control Quality Parameters of Sunflower and Soybean oils are given in the table # 1.

The color of fats & oil is of considerable practical importance and figures prominently in the trading rules for these materials. Pure fats, fatty acids, esters and the other usual lipid derivatives are color less and essentially transparent to visible light (400-700 mμ). All natural fats & oils however, contain pigments that partially absorb transmitted light. The color of most of the oils and fats are due to presence of carotene pigments. Color of oils increase with increase in the pigments content. Color of oils determined in terms of the optical density (O.D), are given in fig. (1). The results show increasing trend for both oils, it is being in the range of (0.120 to 0.170) for Sunflower oil and for Soybean oil the increasing trend is (0.091 to 0.097) for the control to 20 kGy radiation doses. It is clear from the finding that by increasing the radiation doses the color of both Sunflower and Soybean oils increases. The color change of Sunflower oil is much more significant than Soybean oil. This means that the Sunflower oil is less resistant to radiation doses than Soybean oil. So for the commercial purposes it would not be suitable to radiate these oils into so much high radiation doses.

Table-1: Quality Control Parameters of Sunflower and Soybean oils

| S.No | Quality Parameters | Sunflower Oil | Soybean Oil |
|---|---|---|---|
| 1. | Optical Density | 0.091 | 0.12 |
| 2. | Refractive Index | 1.4713 | 1.4708 |
| 3. | Free Fatty Acid (%) | 0.2102 | 0.198 |
| 4. | Peroxide Value (meq/Kg) | 4.50 | 6.49 |
| 5. | Anisidine Value | 4.96 | 3.65 |
| 6. | Iodine Value (g/100g) | 123.47 | 127.23 |
| 7. | β-Carotene Value (ppm) | 24.65 | 22.13 |

The refractive index of fats and fatty acids is an important characteristic for determining the purity or quality of substances. Refractive index values of Sunflower and Soybean oils are presented in the fig. (2). As can be seen from the figure, that increase in the radiation doses do not have significant effects on the refractive index of Soybean oil, its value however change slightly by 0.0001 for Sunflower oil. Earlier researcher [14] had found out the value of refractive index for butter fat in the range of 1.453 to 1.456.

Fatty acid being a significant constituent of lipids, plants, animals, and microorganisms, normally consists of a straight chain of an even number of carbon atoms, with hydrogen atoms along the length of the chain and a carboxyl group (-COOH) at the end. The fatty acids occur in saturated (e.g. palmitic acid etc) and un-saturated. (e.g. linolenic acid etc) forms and commonly exist as tri-glyceride in nature. The most widely distributed fatty acid is Oleic acid, which is abundant in some vegetable oils (e.g., Olive, Palm, Peanut and Sunflower seed) and which makes up about 46 percent of human fat. The free fatty acids value (FFA) of both the oils samples were

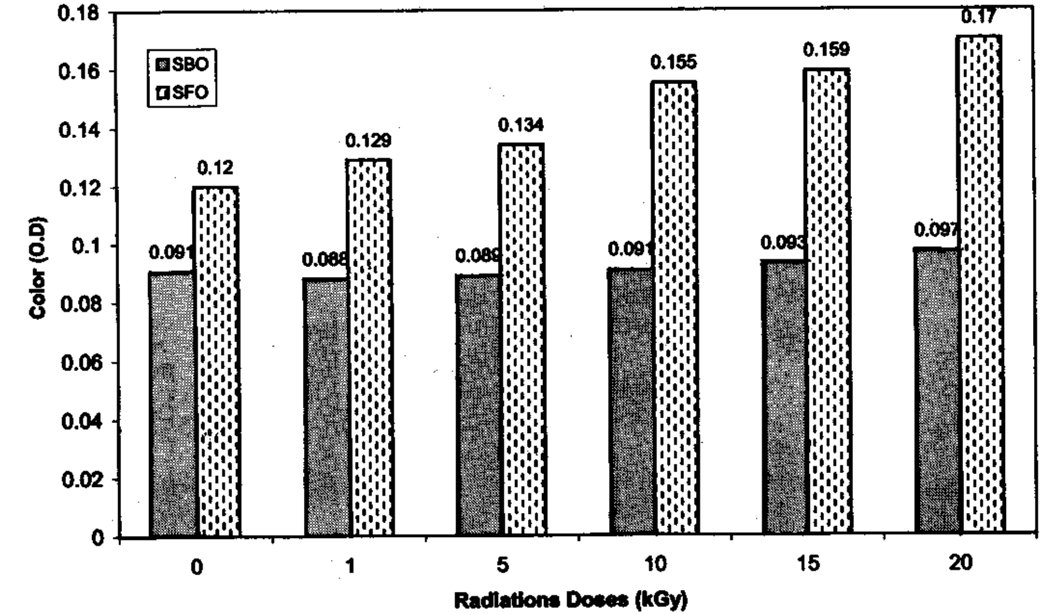


Fig. 1: Changes in color (O.D) of Sunflower and Soybean Oils induced by High Doses of Gamma Radiation.

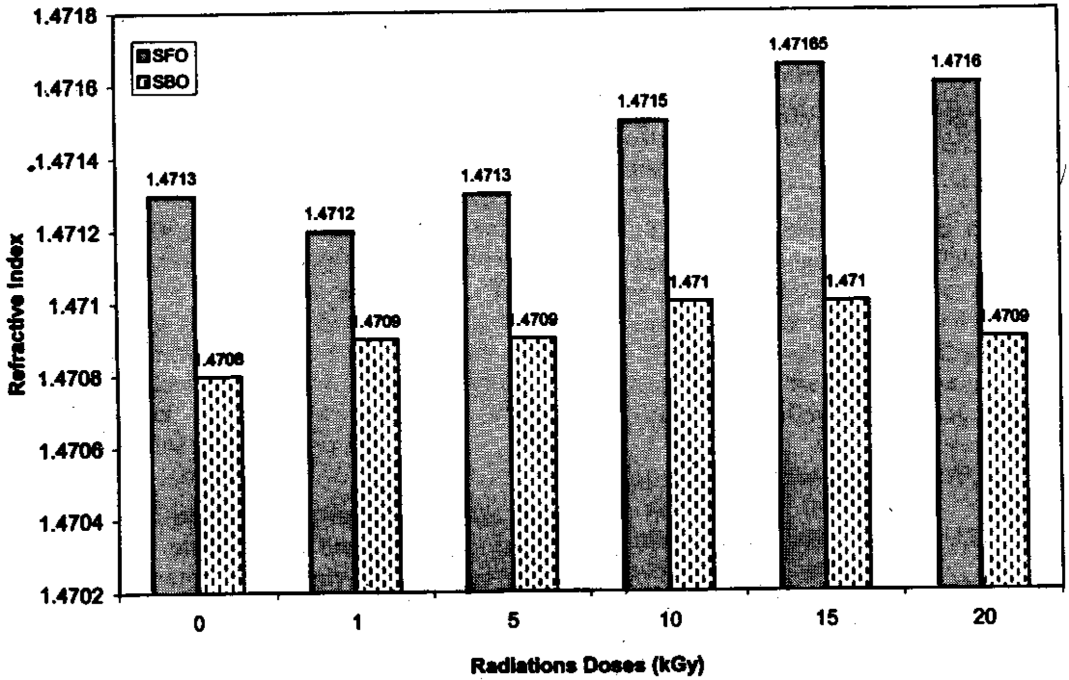


Fig. 2: Changes in Refractive Index of Sunflower and Soybean Oils induced by High Doses of Gamma Radiation.

determined before its exposure to the gamma radiations, which were considered as control values for the irradiated oil samples The results are plotted in fig. (3). The values of free fatty acids in Sunflower and Soybean oils are in the range of 0.2 – 0.5 %, as produced by the different doses of gamma radiations. It is thus found that high doses of radiations increases the amount of free fatty acids, which is due to the conversion of triglycerides to free fatty acids, as reported by earlier workers [1,15-17]. This shows that the oils under investigation are not stable towards ionizing radiations, which results into high rancidity.

The free fatty acids and the triglycerides are oxidizable by auto oxidation or by enzymes called lipoxygenases. The oxidation is concerned primarily with the unsaturated fatty acids, of which oleic,

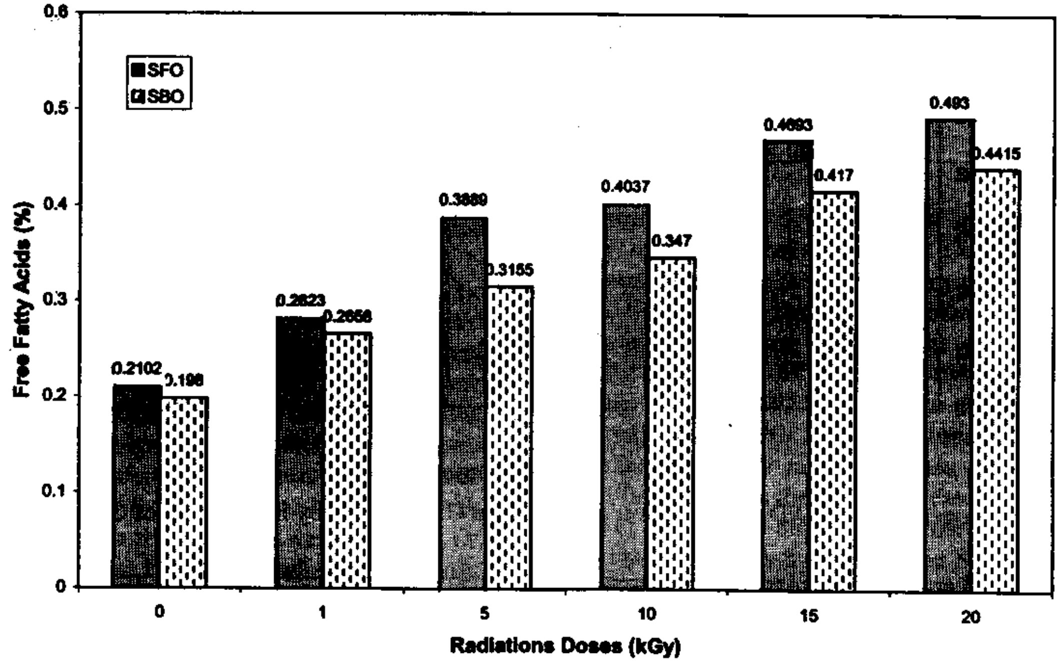


Fig. 3: Changes in Free Fatty Acids of Sunflower and Soybean Oils Induced by high doses of Gamma Radiation.

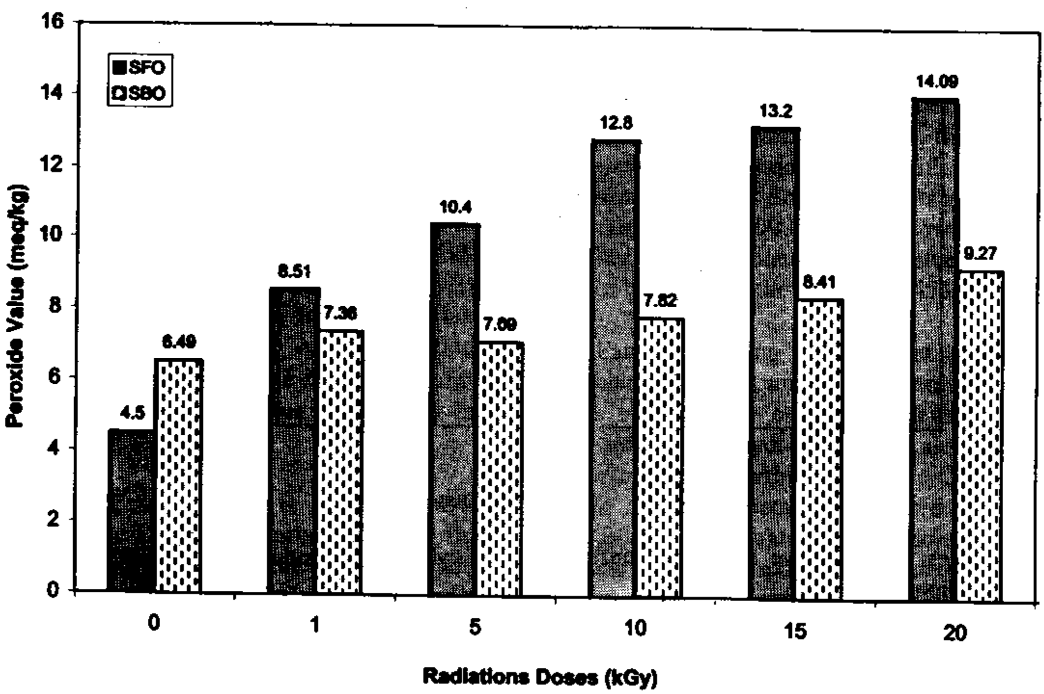


Fig. 4: Changes in Peroxide Value of Sunflower and Soybean Oils Induced by high doses of Gamma Radiation.

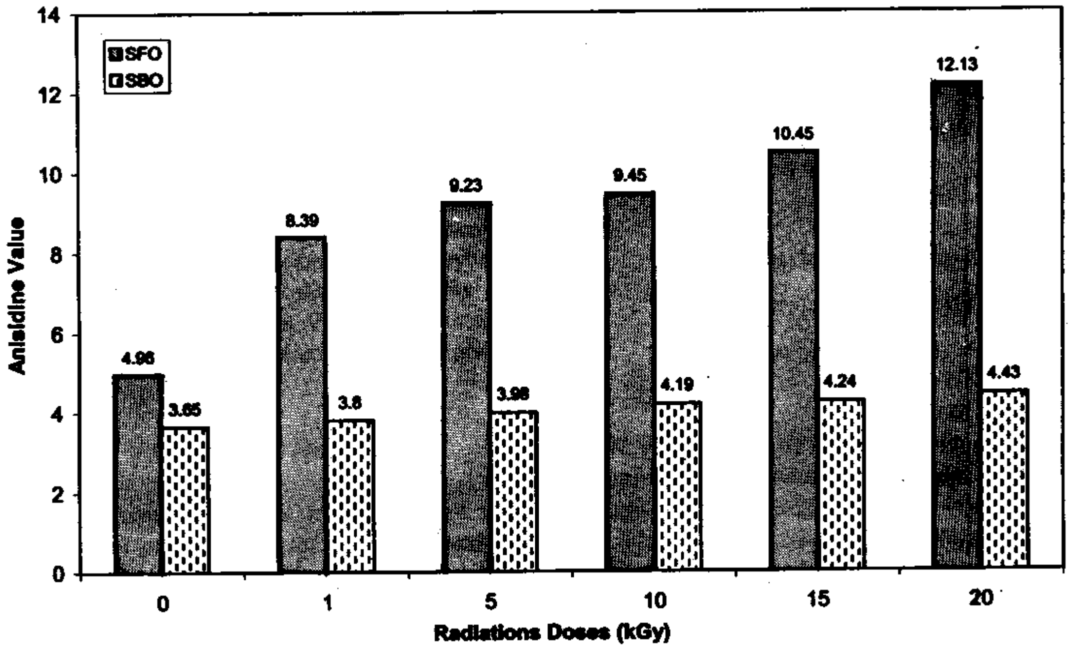


Fig. 5: Changes in Anisidine Value of Sunflower and Soybean Oils Induced by high doses of Gamma Radiation.

linoleic and linolenic acids are the most important. The oxidation of oils produces peroxides or hydro-peroxide which results in the rancidity of oils and fats determined as peroxide value (POV). The peroxide values of Sunflower and Soybean oils are shown by the fig. (4). It is clear from fig. that peroxide value increases with increasing radiation doses. Sunflower oil shows greater oxidation than Soybean oil. The increasing trend in the peroxide value of the oils indicates its deterioration towards high doses of radiation and Sunflower oil is oxidized more than the Soybean oil. Other investigators [6,18] have also reported the anisidine value of oils and fats.

Lipid hydro-peroxides formed as a result of oxidation are very unstable and break down to free radical, which decomposes mainly by cleavage on either side of the carbon bearing the oxygen atom. Aldehydes are among the secondary reaction products, which give rise to flavors, which are described as ranging from sweet, pungent to oxidized milk. The results regarding anisidine values are shown by the fig. 5. It is clear from the graph that Anisidine value of both oils increases with increasing radiation doses. The increase in Sunflower oil is in the range of 4 to 13 and for Soybean oil from 3 to 5 for control to 20 kGy radiation doses respectively. The results for Sunflower oil shows that it is more rancid because of the high level of Anisidine, while the Soybean oil is more resistant to oxidation induced by radiation.

The unsaturation of oil or fat can be determined by halogenation of the double bond present in the fatty acids. The most important halogenation method for the oil and fat is the Iodine value. The iodine values obtained are given in fig. (6). According to the figure, the decrease in the iodine value of Sunflower oil in the range of 123 to 82 g / 100 g oil, while Soybean oil shows a decreasing trend in the range of 127 to 60 g / 100 g from the control to 20 kGy radiation doses respectively. Other investigators [19,20] also found that iodine value of fats.

Beta– Carotene is the precursor of vitamin A and is mostly present in all natural fats and oils. It acts as a strong natural antioxidant. High level of β-carotene offer greater stability to the oil toward rancidity. Data regarding the β- carotene values are presented by the fig. (7). The results show that β-Carotene content of Sunflower and Soybean oils decrease with increase in radiation doses. The gamma radiation split up the molecule of β-carotene and thus

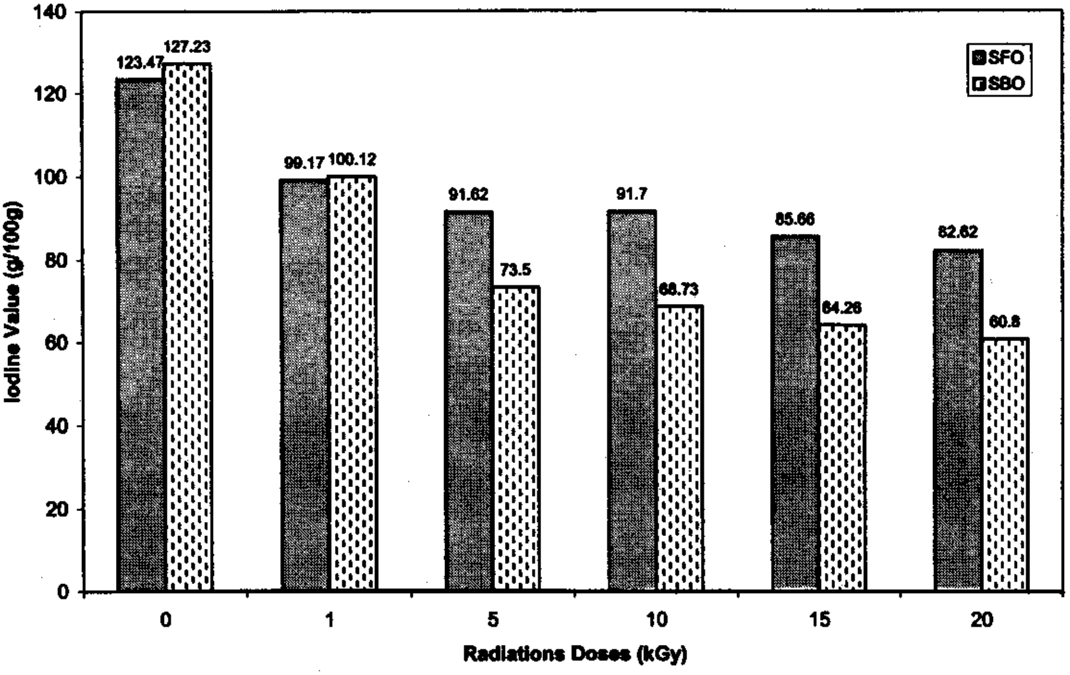


Fig. 6: Changes in Iodine Value of Sunflower and Soybean Oils Induced by high doses of Gamma Radiation.

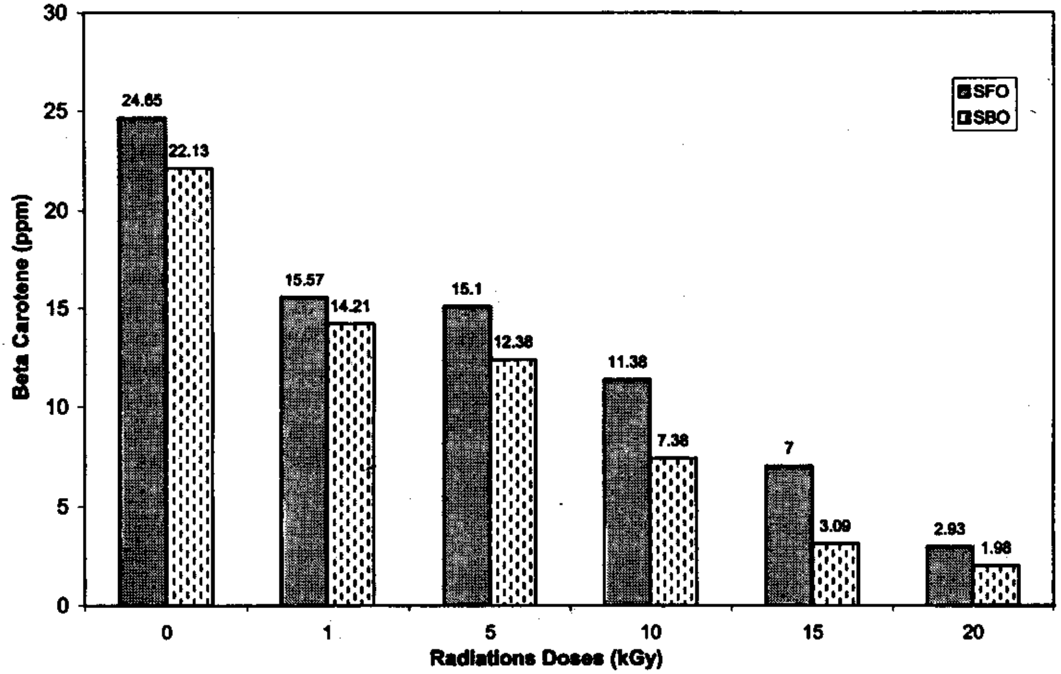


Fig. 7: Changes in Beta-Carotene Value of Sunflower and Soybean Oils Induced by high doses of Gamma Radiation.

the level of Carotene decrease. Increasing the radiation doses thus decrease in the carotene level, which result in lowering the stability of oil and fat and occurrence of rancidity. Carotene is oxidized to vitamin A and its stability in milk was found [21].

It is clear from the results of this investigation that the Sunflower oil is less resistant to the exposure of high radiation doses as compared to the Soybean oil. It is therefore recommended that for preservation or other stability purposes both the Sunflower and Soybean oils should not be irradiated by doses above 10 kGy.

## Experimental

The common edible oils i.e. Sunflower and Soybean oil were purchased from the local market. The oil samples were kept in the 50ml caped test tubes and radiated with gamma rays using cobalt-60 source (ISSLEDOVATEL, CIS) with the doses of 1, 5, 10, 15 and 20kGy. The non-radiated samples of both oils were used as control.

The quality changes induced by different doses of gamma radiation are determine by analysis of quality parameters such as Color (O.D), Refractive Index (RI), Free Fatty Acid (FFA), Peroxide Value (POV), Anisidine Value (AV), Iodine Value (IV) which were determined by the AOCS methods [22].

## Acknowledgements

The Department of Chemistry, University of Peshawar, Nuclear Institute for Food & Agriculture Research (NIFA) Peshawar (research facilities), and Mr. Shamshad Laboratory Assistant for their help, are highly acknowledged.

*Nomenclature*

| | | |
|---|---|---|
| β | = | Beta. |
| SFO | = | Sunflower Oil. |
| SBO | = | Soybean Oil. |
| POV | = | Peroxide Value. |
| FFA | = | Free Fatty Acid. |
| AV | = | Anisidine value. |
| IV | = | Iodine Value. |
| O. D | = | Optical Density. |
| NIFA | = | Nuclear Institute for Food & Agriculture. |
| PORIM | = | Palm Oil Research Institute of Malaysia. |
| meq. | = | milli equivalents. |
| kGy | = | kilo Gray. |
| BHA | = | Butylated Hydroxy Anisole. |
| BHT | = | Butylated Hydroxy Toluene. |
| ppm | = | part per million |

## References

1. W.W. Nawar. The effect of ionizing radiation on lipids. In: Progress in the chemistry of fats & lipids. **13**, 91 (1972).
2. Qi Shengchu, W. Jialn and Zhu-yan,. *Phy. Chem*, **42**, 370 (1993).
3. I.M Hassan, A. Mohammad & R.A Hegazy, *J. Rad, Sci. application*, **4**, 179 (1989).
4. M.S. Brito, A.L.C.H. Villavicencio and J Mancini, *Radiation Physics and Chemistry*, **63**, (3-6), 337 (2002).
5. P.D. Rayas and J.H. Rupnow, *J. Food. Sci.*, 59: 839 (1994).
6. Taufiq Ahmad, A. Sattar, Shaheen Atta, Proc., 2nd All pak. Sci. Conf. (Lah) **26** (1993).
7. Taufiq Ahmad, S. Atta & A. Sattar, Sci. Intern (Lah), proc; 2nd All Pak, Sci. Conf. (1993).
8. K. Lang and K.H. Bassler. Biological effect of irradiated fats, In: Food Irradiation IAEA Vienna pp: 147 (1966).
9. E.C. Maxie, N.F. Somer, Proc. IAEA. Vienna, 39 (1968).
10. S. Bachman, S. Witkowski and A. Zegota, IAEA. Vienna. 435 (1978).
11. C.T. Hammer, C.D. Will, *Int. J. Radiat. Biol. Related stud. Physic. Chemistry. Med.*, **35**(4): 323 (1979).
12. Sattar and J.M. Deman. Stability of edible oils and fats to fluorescent light irradiation. *JAOCS.*, **63**, 473 (1976)
13. Anwar Ahmad, A. Sattar, A. Hussain and M. Zafar Iqbal., *Sains Hayat. Life Science.*, **26**(2): 43 (1997).
14. A.G. Woodman. Food Analysis. McGraw Hill Book Co. Inc. London. 4th ed. 607 (1941).
15. M.F. Dubravic and W.W. Nawar, *JAOCS.* **45**, 656 (1968).
16. W.W. Nawar, *J. Agric. food. Chem.* **26, 21** (1978).