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Effect of Gamma Radiation on Quality Attributes of Groundnut Oil in the Presence of Antioxidants

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Abstract: ***Exposure of groundnut oil to gamma radiation was investigated. The scope of the study elaborates the interactions taking place between antioxidants and gamma radiation when applied to edible oils. The objective is to assess the impact of gamma radiation on the quality attributes of groundnut oil in the presence of antioxidants. The groundnut oil was divided into three categories; namely, Category (1) that was (control1-untreated oil); Category (2) that was (control2 treated oil) which is exposed to different doses of gamma radiation in the absence of antioxidants and Category (3) was treated with different levels of antioxidants (Vitamins E and C) at levels of (50, 150 and 200 ppm) followed by exposure with different doses of gamma radiation (5, 10, 15 and 20 kGy). All samples were subjected to chemical analyses.. Groundnut oil samples treated with gamma radiation without antioxidants showed significant increases (P≤0.05) of 1.03 to 1.99, 11.22 to 23.77 and 1.60 to 13.20 forfree fatty acids (FFAs), peroxide value (PV) and anisidinevalue (AV) values respectively. On the other hand, the iodine value (IV) showed significant decreases (from 96.25 to 89.46 at P≤0.05) with increasing radiation doses. For Category 2 oils with vitamin C levels of (50, 150, 200ppm), the results showed significant increases (P≤0.05) in FFA, PV and AV with increasing radiation doses ranging,1.03 to1.87, 11.22 to 18.77 and 1.60 to 12.21 for FFA, PV and AV respectively. With the addition of vitamin E (50-150-200ppm) the results showed significant decrease (P≤0.05) from 1.99 to 1.10, from 23.77 to 14.45 and from 13.20 to 8.93 for FFA, PV and AV, respectively. According to the results, it was noted that exposing oil to gamma radiation (>10KGy) led to deterioration of oils quality. Presence of antioxidants in the oil reduced the effect of gamma radiation within limits. Vitamin E compared to vitamin C as an antioxidant showed better stability to radiation. Finally, it can be recommended that avoiding exposure of oils seeds, as a main source of edible oils, to gamma radiation are preferred, unless the latter is used for specific objectives (e.g. disinfestations from fungi or insect). The study suggests that exposure of fatty foods or food containing fats to radiation as a means for cold sterilization can further be investigated.***

Keyword: Food irradiation- Antioxidants- Gamma radiation- Groundnut oil

1. Introduction

Edible oils are a major dietary component and play an important nutritional role as a concentrated source of energy and a carrier of fat-soluble vitamins. They also impart flavor and taste on food, provide essential fatty acids and fats are generally required for normal functions of body (Tom et al. , 2006).In most developing countries of the world, seeds serve as the major source of the nutrient needs of human and animals. Oil seeds are important sources of vegetable oil needs. Groundnut and its products, such as oils and spreads play an important role in healthy balanced diet even though they are energy dense and contain a high proportion of fat, and are particularly important source of vitamins B and E as well as contributing to vitamin A intake. In addition, groundnut oil is very rich in polyunsaturated fatty acids (Pureseglove, 1968). In Sudan, groundnut is considered as one of the major oil sources, and the crop continues to play an important role in the Sudan foreign trade (Arab Agricultural Statistics Yearbook, 2000). Irradiation of edible oils could occur due to certain environmental factors, this prompted the study of the effect of irradiation on free radical and peroxide formation in groundnut oil in the presence or absence of antioxidants. A free radical is easily formed when a covalent bond between entities is broken and one electron remains with each newly formed atom (Karlsson, 1997). A major source of dietary free radicals are chemically altered fats from commercial vegetable oils, vegetable shortening and all oils heated to elevated temperatures (Stephen *et al.*, 1978). Antioxidants work to protect lipids from peroxidation by free radicals. Antioxidants are effective because they are willing to give up their own electrons to free radicals. When a free radical gains the electron it becomes non reactive and the chain of reaction of oxidation is broken (Dekkens*et al.*, 1996). This study was intended to investigate some chemical and quality changes induced in groundnut oil upon gamma radiation. The specific objectives of the study were toinvestigate effect of different doses of gamma radiation on quality attributes of groundnut oil andto investigate the effect of some selected antioxidants (vitamins E and C) to control or inhibit the effect of gamma radiation.

2. Material and Methods

Food materials

Refined,bleached and deodorized groundnut oil was donated by Bitar Oil Factory (Khartoum North-Sudan).

Chemicals and reagents

Chemicals and reagents used were all of analytical grade, and obtained from the Faculty of Agriculture, University of AlzaiemAlazahri.

Methods

Preparation of raw materials

The oil was divided into threecategories: The oil category (1) that was (control1) untreated oil.Category 2(control2) the oil exposed to different doses of gamma radiation in the absence of antioxidants. Category (3) oil was treated with different levels of antioxidant (Vitamins E and C) followed by exposure to different doses of gamma radiation. The general feature of the oil untreated (category1) reflects acceptable levels of acidity (FFA1.03), slightly high value of peroxide value (11.22), and anisidine value (1.60). The iodine value lied within reported limits (96.25).

Irradiation process

The groundnut oil with or without different levels of antioxidant (vitamins E and C) of 50, 150 and 200 ppm were irradiated at Ali Kaila irradiation processing unit, Sudanese Atomic Energy Commission (SAEC) using an experimental cobalt-60 gamma source (Nordion gamma cell 220-Excell) at the rate of 1.16 Gy /sec with doses 5, 10, 15 and 20 kGy. Non-irradiated oil samples (control1) were kept outside the irradiation chamber within the same environment and used as control.

Oil characteristics

The iodine value (IV) of the oilswas determined according to AOCS (1972)Method. Peroxide value (PV) of oils was determined according to the AOAC method (1984).The free fatty acids (F.F.A) were determined according to the (AOCS, 1972)Method. TheAnisidine value (AV) or the carbonyl value was measured in the oil according to (Teresa *et al*., 1995).

Statistical analysis

Data generated were subjected to Statistical Analysis System (SAS). Means were tested using Completely Randomized Design (CRD) according to Mead (1985), and then means separated using Duncan's Multiple Range Test [DMRT] according to Duncan (1997).

3. Results and Discussions

The study was conducted to investigate the effect of gamma radiation (5, 10, 15 and 20 KGys) on free fatty acid (FFA), peroxide value (PV), anisidine value (AV) and iodine value (IV) of groundnut oil as illustrated in Tables(1, 2, 3 and 4) and traced below. Table 1 indicates that applying radiation at the levels of 5, 10, 15 and 20 kGy to oil control (2), showed a consistent FFA indicated by the highest FFA peak being in the case of the 20 kGy treatment (FFA 1.99). FFAs of groundnuts decrease with increase antioxidant and increase with increasing doses of radiation. Maximum increase was observed again in 20KGy treatment for irradiated oil with 50ppm vitamin C i.g.1.03-1.87.This alerts the fact that applying vitamins (antioxidants) to limit the degree of FFA formation as required. Zeb and Ahmed (2004) reported that free fatty acids of sunflower and soybean oils increased with the high doses of irradiations. Nazia*et al*. (2010) found that gamma irradiation increase the acid value of sunflower and maize oils. . According to the figures shown in Table 2, vitamin E compared to vitamin C showed high resistance to FFA formation due to irradiation. Nazia*et al*. (2010) reported a small decrease in vitamin E of both sunflower and maize oils when irradiated up to 6 kGy. Thayer *et al.* (1993) noted that, there were small losses of vitamin E (alpha tocopherol) on exposure to ionizing radiation. Kilcast (1994) found that Vitamin C is one of the most sensitive to the effect of radiation. Similar indications of high resistance of vitamin E were shown in Tables (3, 4 and 5) with respect to peroxide value, anisidine value and iodine value, respectively. For the oil control (2) free of antioxidants presented in Table (2) remarkable consistent increases in peroxidation were recorded as a result of increased radiation doses ranging from PV 11.22to PV23.77. Peroxidation decreased with antioxidant addition while it was increasing with increased doses of irradiation ranging from11.22-18.77. This finding agreed with that of Zeb and Ahmed (2004) who found that the peroxide value of sunflower and soybean oils increased with high doses of irradiation.

Mahrous*et al*. (2003) found that gamma irradiation increase the peroxide value of grain oil. Hammer and Will (1979) concluded that, application of gamma irradiation to plant nut oils increased the peroxide value. On the other hand Santos-norris (2001) reported that there was no difference in peroxide value of almond oil due to gamma irradiation. Nazia*et al*. (2010) found that gamma irradiation increased the peroxide value of sunflower and maize oils. Increased PVs with increased gamma irradiation is possibly due to gamma irradiation triggering more radicals that allow the continuity of the peroxidation cycle and possibly due to other factors.

Table 3 showed that anisidine value decreased with increased antioxidant additions, while increased with increased doses of irradiation ranging from.1.60 to13.20. Zeb and Ahmed (2004) found that, anisidine value increased with high doses of irradiation. Nazia *et al*. (2010) found that, gamma irradiation increase the ansidine value of sunflower and maize oils. This is obviously due to less peroxidation Table 4 shows decreased iodine values in with increasing irradiation doses ranging from IV 96.25 to IV 89.46. Increased iodine values with increased antioxidant content of the oil, while decreased iodine value with increased irradiation doses. This is obvious since irradiation is coupled with the production of more oxygenated compounds which normally lead to lower IVs that normally increase in the presence of antioxidants reactivity against the oxygenated produces. Similar results were obtained by Zeb and Ahmed (2004) who reported that, the iodine value of sunflower and soybean oils were decreased significantly by high gamma irradiation. Nazia*et al*. (2010) reported that, gamma irradiation decrease the iodine value of sunflower and maize oils.and consequently less hydroperoxide and carbonyl compounds formation.

4. Conclusions

From the results of the effect of gamma radiation on quality attributes of groundnut oil in presence of antioxidants it can be concluded that, free fatty acids of groundnut oil decreased with increase of antioxidant level and increased with increasing dose of gamma radiation.Peroxidation of groundnut oil decreased with antioxidant addition while it increased with increased doses of gamma radiation.Anisidine value of groundnut oil decreased with increased antioxidant additions while increased with increased doses of gamma radiation. Increased iodine values with increased antioxidant content of the oil, while decreased iodine value with increased gamma radiation doses. Vitamin E compared to vitamin C as an antioxidant, shower better stability to irradiation. The acceptability of groundnut oil without antioxidant and treated with radiation is a better indication of deterioration of oils.

5. Recommendations

Recommendations may be considered: To avoid exposure of oils seeds, as main source of edible oils, to gamma radiation unless the latter is used for specific objectives (e.g. disinfestations from fungi or insect). Exposure of source fatty food or food containing fats to radiation source as a mean for cold sterilization should be taken into consideration for further research. Studies of the role of antioxidants in extending the use of food radiation.

Table 1: Free fatty acid (oleic acid %) of groundnut oil as influenced by radiation dose and antioxidants level and type

Sample and treatment	Doses of irradiation(kGy)*				
	0	5	10	15	20
Standard groundnut oil (control 1)**	1.03^{k} ±0.07	-	-	-	-
Groundnut oil (control 2)***	1.03^{k} ±0.07	1.68^{d} ±0.24	1.75^{c} ±0.16	1.89^{b} ±0.25	1.99^{a} ±0.26
Groundnut oil + 50 ppm Vitamin E	1.03^{k} ±0.07	1.23^{h} ±0.19	1.36^{g} ±0.11	1.49^{f} ±0.14	1.59^{e} ±0.19
Groundnut oil + 150 ppm Vitamin E	1.03^{k} ±0.07	1.09^{i} ±0.10	1.11^{i} ±0.15	1.18^{h} ±0.13	1.20^{h} ±0.17
Groundnut oil + 200 ppm Vitamin E	1.03^{k} ±0.07	1.04^{j} ±0.08	1.06^{j} ±0.09	1.08^{j} ±0.09	1.10^{i} ±0.09
Groundnut oil + 50 ppm Vitamin C	1.03^{k} ±0.07	1.57^{e} ±0.17	1.62^{de} ±0.22	1.73^{c} ±0.22	1.87^{b} ±0.21
Groundnut oil + 150 ppm Vitamin C	1.03^{k} ±0.07	1.41^{fe} ±0.18	1.54^{e} ±0.19	1.60^{de} ±0.19	1.77^{c} ±0.25
Groundnut oil + 200 ppm Vitamin C	1.03^{k} ±0.07	1.31^{g} ±0.21	1.41^{fe} ±0.13	1.50^{f} ±0.17	1.69^{d} ±0.24

* Mean±SD values having different superscript letters in each column and row differ significantly (P<0.05)
** Control 1=Non-irradiated groundnut oil
*** Control 2 = groundnut oil exposed to different doses of irradiation without antioxidants.

Table 2: Peroxide value (m.Eq/kg) of groundnut oil as influenced by radiation dose and antioxidants level and type

Sample and treatment		Doses of irradiation (kGy)*			
	0	5	10	15	20
Standard groundnut oil (control 1)**	11.22^{hi} ±0.58	-	-	-	-
Groundnut oil (control 2)***	11.22^{hi} ±0.58	18.64^{g} ±0.61	18.75^{b} ±0.63	19.39^{b} ±0.51	23.77^{a} ±0.62
Groundnut oil + 50 ppm Vitamin E	11.22^{hi} ±0.58	12.40^{g} ±0.39	13.32^{fg} ±0.51	14.52^{e} ±0.36	17.33^{c} ±0.71
Groundnut oil + 150 ppm Vitamin E	11.22^{hi} ±0.58	11.12^{hi} ±0.56	11.74^{h} ±0.32	12.36^{g} ±0.28	15.16^{de} ±0.64
Groundnut oil + 200 ppm Vitamin E	11.22^{hi} ±0.58	10.34^{ij} ±0.51	10.89^{i} ±0.51	11.39^{hi} ±0.39	14.45^{e} ±0.60
Groundnut oil+ 50 ppm Vitamin C	11.22^{hi} ±0.58	13.20^{fg} ±0.61	14.28^{ef} ±0.49	15.23^{de} ±0.54	18.77^{b} ±0.69
Groundnut oil + 150 ppm Vitamin C	11.22^{hi} ±0.58	11.76^{h} ±0.68	12.17^{g} ±0.54	13.85^{f} ±0.62	16.14^{d} ±0.57
Groundnut oil + 200 ppm Vitamin C	11.22^{hi} ±0.58	11.43^{hi} ±0.62	12.55^{g} ±0.61	13.38^{f} ±0.47	15.66^{d} ±0.65

* Mean values having different superscript letters in each column and row differ significantly (P<0.05)
** Control 1= Non-irradiated groundnut oil
*** Control 2 = groundnut oil exposed to different doses of irradiation without antioxidants.

Table 3: Anisidine value of groundnut oil as influenced by radiation dose and antioxidants level and type

Sample and treatment		**Doses of irradiation** (kGy)*			
	0	**5**	**10**	**15**	**20**
Standard groundnut oil (control 1)**	1.60^{j} ±0.08	-	-	-	-
Groundnut oil (control 2)***	1.60^{j} ±0.08	9.05^{de} ±0.39	9.19^{de} ±0.41	10.32^{c} ±0.45	13.20^{a} ±0.55
Groundnut oil + 50 ppm Vitamin E	1.60^{j} ±0.08	6.48^{g} ±0.32	7.85^{f} ±0.33	8.64^{e} ±0.35	9.41^{d} ±0.38
Groundnut oil + 150 ppm Vitamin E	1.60^{j} ±0.08	5.36^{h} ±0.30	5.77^{h} ±0.31	7.42^{f} ±0.39	9.10^{de} ±0.35
Groundnut oil + 200 ppm Vitamin E	1.60^{j} ±0.08	4.93^{i} ±0.29	5.15^{hi} ±0.32	6.70^{g} ±0.34	8.93^{e} ±0.28
Groundnut oil + 50 ppm Vitamin C	1.60^{j} ±0.08	7.19^{fg} ±0.31	8.39^{ef} ±0.27	10.82^{bc} ±0.41	12.21^{b} ±0.40
Groundnut oil + 150 ppm Vitamin C	1.60^{j} ±0.08	6.33^{g} ±0.32	7.73^{f} ±0.21	9.45^{d} ±0.38	10.13^{c} ±0.39
Groundnut oil + 200 ppm Vitamin C	1.60^{j} ±0.08	5.23^{hi} ±0.30	6.58^{g} ±0.34	8.81^{e} ±0.36	9.27^{d} ±0.38

* Mean values having different superscript letters in each column and row differ significantly (P<0.05)
** Control 1= Non-irradiated groundnut oil
*** Control 2 = groundnut oil exposed to different doses of irradiation without antioxidants.

Table 4: Iodine value of groundnut oil as influenced by radiation dose and antioxidants level and type

Sample and treatment		Doses of irradiation(kGy)*			
	0	5	10	15	20
Standard groundnut oil (control 1)**	96.25^{a} ±2.16	-	-	-	-
Groundnut oil (control 2)***	96.25^{a} ±2.16	94.15^{bc} ±2.11	92.25^{a} ±2.07	90.22^{h} ±2.36	89.46^{ij} ±1.77
Groundnut oil + 50 ppm Vitamin E	96.25^{a} ±2.16	93.91^{c} ±2.09	91.23^{fg} ±2.04	90.92^{h} ±2.14	86.74^{k} ±1.74
Groundnut oil + 150 ppm Vitamin E	96.25^{a} ±2.16	95.11^{ab} ±2.13	93.59^{cd} ±2.07	91.37^{fg} ±2.41	87.87^{j} ±1.75
Groundnut oil + 200 ppm Vitamin E	96.25^{a} ±2.16	96.45^{a} ±2.15	94.54^{b} ±2.09	92.32^{ef} ±2.33	90.73^{gh} ±1.95
Groundnut oil + 50 ppm Vitamin C	96.25^{a} ±2.16	91.43^{f} ±2.09	89.79^{i} ±1.98	87.37^{jk} ±1.99	85.66^{l} ±1.71
Groundnut oil + 150 ppm Vitamin C	96.25^{a} ±2.16	94.41^{b} ±2.14	92.36^{ef} ±2.11	90.92^{g} ±2.07	87.43^{jk} ±1.74
Groundnut oil + 200 ppm Vitamin C	96.25^{a} ±2.16	95.16^{ab} ±2.49	93.27^{cd} ±2.41	91.55^{f} ±2.09	89.53^{ij} ±1.76

* Mean values having different superscript letters in each column and row differ significantly (P<0.05)
** Control 1= Non-irradiated groundnut oil
*** Control 2 = groundnut oil exposed to different doses of irradiation without antioxidants.

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