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Effect of Gamma Irradiation on the Physico-chemical Characterstics of Groundnut (*Arachis Hypogaea*)

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Abstract: The aim of this study was to evaluate the effect of gamma irradiation on physico-chemical properties of groundnut as well as to investigate its impact on quality attributes of groundnut oil. Seeds of two cultivars of ground nut (*Arachis hypogaea*) namely Sodari and Madani were gamma - irradiated at dose levels of 1, 1.5 and 2 kGys . Proximate composition, ash minerals, iodine value, acid value, peroxide value, saponification value, oil refractive index, oil relative viscosity, in-vitro protein digestibility, nitrogen solubility, water holding capacity, oil holding capacity, bulk density, emulsion activity, emulsion capacity, emulsion stability, foam capacity and foam stability were determined for raw and irradiated seeds. The results revealed that the effect of gamma irradiation on protein, oil, fiber, carbohydrates and minerals content of ground nut seeds was of no consistent pattern, however, for the quality attributes of groundnut oil, gamma irradiation caused significant decrease ($P \leq 0.05$) in iodine value and significant increase in acid and peroxide values for both cultivars, with exception of the acid value of Madani cultivar. While saponification value, refractive index and viscosity of groundnut oil for both cultivars were not affected significantly by gamma irradiation. Moreover, as compared with untreated groundnut flour, for both cultivars, water holding capacity, bulk density, emulsion activity and emulsion capacity of groundnut flour were not significantly affected by gamma irradiation. On the other hand, foaming stability was affected negatively with gamma irradiation. Generally, slight differences between the two cultivars studied were observed for the different properties tested.

Key words: Groundnut. gamma irradiation, groundnut oil, groundnut flour

INTRODUCTION

Groundnut (*Arachis hypogeae* L.) is a leguminous, annual herbaceous plant belonging to the suborder *Papillionacea* of the order *Leguminacea*, and grown mainly for their seeds. It is one of the leading agricultural crops of the world for the production of edible plant oil and protein (Adegoke *et al*., 2004). Sudan is one of the major groundnut producing countries in Africa, the area of production occupies about 13 % of the total cultivable land in the country (Ishag, 1986).

In most of the developing countries, groundnut is stored as dry seeds and forms an enormous serve of food; however, during storage, vast quantities of seeds are lost annually as a result of moulds and insects attacks (Tripathi and Kumar,2007) Losses of stored seeds, caused by insects' infestation, such as *Caryedon serratus*, Bruchids and Pyralids, are the most common storage pest, (Sembene,2006). On the other hand groundnut is among the major food commodities that can be affected by mycotoxins such as aflatoxins , which are the toxic chemical substances produced by toxigenic strain of fungi such as *Aspergillus flavus* (Smith and Ross,1991), under specific conditions. Aflatoxins and insect infestation are the most important quality problems in groundnut worldwide, with serous health and economic implications (IARC,1993).

Gamma radiation is a physical technique of food preservation that seems to have a potential to protect such commodity from insects infestation and microbial contamination during storage (Taub *et al.,* 1976; Rich; WHO, 1988). Therefore it has been proposed as a good alternative to methyl bromide and other fumigants for pest control (Gupta, 2001). However, development of this technique involve consideration that gamma might change the nutritive value of stored seeds. The absolute relationship of radiation application dose and possible changes must be known in order to comprehensively assess the acceptability of radiation – treated food seeds. This paper was intended to investigate some nutrition-related chemical changes induced in peanut seeds upon gamma irradiation.

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MATERIALS AND METHODS

Materials:

Two groundnuts ((*Arachis hypogaea*) cultivars seeds, Madani and Sodari were obtained from the plant breeding division, Hudieba Research Station, Agricultural Research Corporation (ARC), Sudan. The seeds were shelled by hand and all kernels samples were stored under ambient temperature during the study.

Methods:

Irradiation process:

About 200 g lots of the groundnut seeds were sealed in glass bottles prior and during irradiation process. The samples were irradiated at Kaila irradiation processing unit, Sudanese Atomic Energy Corporation (SAEC) using an experimental cobalt- 60 gamma source (Nordion gamma cell 220 - Excell), irradiation was carried out at room temperature, with the doses of 1.0, 1.5 and 2 KGry.

Non-irradiated seeds served as control. Irradiated and non- irradiated samples of groundnut seeds were ground to pass through 0.4 mm screen and kept in glass bottles at room temperature for analysis.

Proximate composition:

The level of moisture, ash, crude protein, oil, crude fiber and carbohydrates of the irradiated (1.0, 1.5 and 2.0 KGys) and non-irradiated groundnut seeds were determined by the use of manual methods as outlined by AOAC, (1990). Mineral extraction of the irradiated and non-irradiated groundnut seeds, was prepared according to the method described by Pearson (1981).

Oil Quality Attributes:

The Iodine value, peroxide value and saponification value of the irradiated and non-irradiated groundnut oil were determined according to the Amer. Oil Chem. Soc. (AOCS, 1972).

Functional properties:

The water retention capacity (WRC), oil absorption capacity (OAC) and emulsion capacity (EC) of the irradiated and non-irradiated groundnut flour was measured by a modified method of Beuchat (1977). The bulk density was determined by the method of Moreyra and Peleng (1981)

Statistical Analysis:

All analyses were performed in triplicate (n = 3). The analysis of variance was performed to examine the significant effect in all parameters measured. The level of significance used was 95 % (Gomez and Gomez,1984)

RESULTS AND DISCUSSION

Effect of Gamma Irradiation on Chemical Constituents:

The effect of gamma irradiation (0.0, 2.0 KGys) on moisture, protein, oil, fiber, carbohydrates ash and ash minerals content of groundnut seeds for both Sodari and Madani cultivars are presented in tables 1and 2, The moisture content was not substantially affected by gamma irradiation treatment for both Sodari and Madani cultivars. Similar findings were observed by Rady *et al*. (2002) who reported that gamma irradiation has no real effect on moisture content of oil seeds. Significant increase in protein and ash content ($P \leq 0.05$) was observed for Madani cultivar. While for Sodari cultivar the change was of no significant. However, opposite results were observed for that of oil content. Siddhuraji *et al*. (2002) and Seda *et al*. (2001) reported that gamma irradiation did not induce any change in protein and oil content of soybean and groundnut. On the other hand significant differences were observed in fiber and carbohydrates content as affected by irradiation. While data of minerals indicate that no apparent changes in both cultivars.

The diversity of the observed effects of gamma irradiation on different seeds chemical constituents, for the two cultivars, may be closely related to insects and microbial infestations as well as genetic factors, rather than direct effect of radiation. Positive values might result in part from insects and microbial protection offered by gamma irradiation. Ogbadu (1980) reported that aflatoxin B1 production decreased with increasing gamma irradiation dose in soy bean and groundnut. Many workers reported that there have been changes in chemical composition of seeds as affected by insect infestations (Jood and Kapoor, 1993; Modgil, 2002).

Table 1: Effect of gamma irradiation on proximate composition of groundnut seeds

Treated cultivars	Dose (Kgys)	Moisture (%)	Protein (%)	Oil (%)	Fiber (%)	Carbohydrates (%)	Ash (%)
Sodari	0.0	3.56[a]	25.80[c]	50.40[b]	2.66[a]	8.88[b]	2.54[b]
	2.0	3.67[a]	24.43[c]	52.50[a]	2.40[b]	19.08[a]	2.59[b]
Madani	0.0	3.40[b]	25.84[c]	53.00[a]	2.73[a]	15.40[c]	2.59[b]
	2.0	3.43[b]	29.75[a]	53.00[a]	2.49[b]	11.94[d]	2.82[a]
SEM		0.10	0.11	0.26	0.11	0.29	0.04

Means in the same column with different letter (s) are significantly different ($P \leq 0.05$) according to Least Significant Test (LSD)
SEM: standard error of means.

Table 2: Effect of gamma irradiation on ash minerals content of groundnut flour (mg/100g)

Treated cultivars	Minerals	Irradiation dose (0.0 Kgys)	(1.0 Kgys)	(1.5 Kgys)	(2.0 Kgys)	SEM
Sodari	Na	02.42 [d]	03.00 [b]	02.77 [c]	02.61 [cd]	0.020
	K	05.00[g]	15.00 [e]	17.85 [c]	16.25 [d]	0.044
	Ca	07.44 [a]	10.90 [a]	11.14 [a]	09.58 [a]	1.080
	Mg	11.36 [b]	13.18 [a]	13.26 [a]	13.50 [a]	1.029
	Zn	00.56 [c]	01.13 [a]	00.85 [bc]	00.88 [bc]	0.052
	Mn	00.41 [c]	00.77 [a]	00.77 [a]	00.77 [a]	0.050
	Cu	00.45[d]	00.44 [d]	00.53 [c]	00.54 [c]	0.015
	Fe	02.38[e]	03.33 [d]	03.93 [c]	05.70 [a]	0.090
Madani	Na	04.17 [a]	02.68 [cd]	02.77 [c]	02.47 [b]	0.020
	K	8.62 [b]	16.25 [d]	21.25 [a]	13.75 [f]	0.044
	Ca	10.81 [a]	11.46 [a]	09.75 [a]	10.92 [a]	1.080
	Mg	13.23 [a]	13.63 [a]	13.75 [a]	13.42 [a]	1.029
	Zn	00.85[bc]	00.91 [b]	00.34 [d]	00.73 [c]	0.052
	Mn	00.56 [b]	00.76 [a]	00.64 [ab]	00.58[b]	0.050
	Cu	00.93 [a]	00.40 [d]	00.66 [b]	00.52 [c]	0.015
	Fe	04.47 [b]	04.47 [b]	04.36 [b]	02.64 [e]	0.090

Means in the same row with different letter (s) are significantly different ($P \leq 0.05$) according to Least Significant Test (LSD)
SEM: standard error of means.

Effect of Gamma Irradiation on Oil Quality Attributes:

The effect of gamma irradiation (0.0, and 2.0 KGys) on iodine value, acid value, peroxide value, saponification value, refractive index and viscosity of groundnut seed oils for both cultivars are illustrated in table 3. The results indicate that, irradiation caused a decrease in iodine value for both cultivars; however change was significant for Madani cultivar. For acid and peroxide values, the irradiated samples were higher than that of non-irradiated ones for Sodari, while for Madani no change was observed. Similar findings were obtained by Zeb and Ahmed. (2004) who reported that, the iodine value of sunflower and soybean oil decreased significantly with high gamma radiation (1, 5 and20 KGys). while the acid values were increased. The decrease in iodine value may be attributed to the saturation of the double of unsaturated fatty acids bonds (Albashir, 2004). For saponification value, refractive index and relative viscosity, no change was observed between the irradiated and non-irradiated samples. This finding agreed with that reported by Zeb and Ahmed (2004).

Effect of Gamma Irradiation on Functional Properties:

The effect of gamma irradiation (0.0, and 2.0 KGys) on water and oil absorption capacity, bulk density, emulsion capacity and activity, foaming capacity and foaming stability of groundnut flour for both cultivars are shown in table 4. The results indicate that irradiation had no apparent effect on water absorption capacity. These findings were in accordance with that reported by Zayas (1997) who found that the water holding capacity was not affected by gamma irradiation. With regards of the results of oil absorption capacity, it is clear that, no change was observed in oil absorption capacity of Madani cultivar, however, significant increase for Sodari was observed, These results are in agreement with previous finding of Abu *et al*. (2005) who reported that at low dose irradiation (2 kGy), the oil absorption capacity of cow pea flour was not affected. However, an increase in oil absoption capacity was observed at higher doses (10 and 50 KGys), this may be due to exposure non-polar protein sites. Moreover, the results show that, the bulk density of ground nut flour of both cultivars was not affected significantly by gamma irradiation. However, It was observed that gamma irradiation decreases significantly ($P \leq 0.05$) the emulsion capacity of Sodari cultivar, while significant increase

was observed for Madani cultivar. On the other hand no significant change was observed in emulsion activity for both cultivars. It was reported that irradiation of cow pea at 2.0 KGys caused decrease in emulsion capacity (Abu *et al*.., 2005). The changes in emulsion properties may be attributed to protein aggregation as well as surface hydrophobicity and change the characteristics, which affect emulsifying properties in different ways (Cheftel *et al*., 1985). The results also indicate that gamma irradiation had no apparent affect on the emulation stability of ground nut flour of both cultivars. This result is in agreement of that reported by Abu *et al*. (2005) who concluded that at low dose of gamma irradiation emulsifying properties were not affected.

Table 3: Effect of gamma irradiation on oil quality attributes of groundnut seeds

Treated cultivars	Dose (Kgys)	IV (%)	AV (%)	PV (%)	SV (%)	RI	RV
Sodari	0.0	12.73^{a}	2.05^{b}	11.33^{d}	845.73^{a}	1.470^{b}	1.46^{b}
	2.0	12.63^{a}	4.67^{a}	23.00^{a}	820.63^{a}	1.470^{b}	1.45^{b}
Madani	0.0	2.90^{a}	2.24^{b}	12.67^{c}	868.90^{a}	1.469^{a}	1.51^{a}
	2.0	09.60^{b}	2.24^{b}	19.33^{b}	867.60^{a}	1.469^{a}	1.52^{a}
SEM^{-}	0.20	0.09	0.35	23.97	0.0001	0.001	

IV= iodine value AV= acid value PV= peroxide value SV= Saponification value RI= Refractive index RV= Relative viscosity

Means in the same column with different letter (s) are significantly different ($P \leq 0.05$) according to Least Significant Test (LSD)

SEM: standard error of means.

Table 4: Effect of gamma irradiation on functional properties of groundnut seeds

Treated cultivars	Dose (Kgys)	WAC (ml/100g)	OAC (ml/100g)	EC (%)	EA (Mg/g)	ES (%)	FC (%)	BD (g/m)
Sodari	0.0	180.73^{b}	320.470^{c}	0.35^{a}	154.73^{a}	47.360^{a}	05.35^{b}	08.00^{b}
	2.0	180.73^{b}	320.470^{c}	0.35^{a}	150.73^{b}	47.360^{a}	12.35^{a}	12.00^{a}
Madani	0.0	280.90^{a}	340.469^{b}	0.35^{a}	138.73^{d}	47.360^{a}	12.35^{a}	07.00^{c}
	2.0	280.60^{a}	340.469^{b}	0.35^{a}	148.73^{c}	47.360^{a}	12.35^{a}	08.00^{b}
SEM^{-}	0.001	0.001	0.00	0.39	0.00	0.75	0.002	

WAC = water absorption capacity OAC = oil absorption capacity EC = emulsion capacity EA= emulsion activity ES= emulsion stability FC= foam capacity BD= bulk density

Means in the same column with different letter (s) are significantly different ($P \leq 0.05$) according to Least Significant Test (LSD)

SEM: standard error of means.

Conclusion:

The irradiation applied to groundnut seeds indicated no substantial change in proximate and minerals composition; however, for the quality attributes of groundnut oil, gamma irradiation caused significant decrease ($P \leq 0.05$) in iodine value and significant increase in acid and peroxide values with exception of the acid value of Madani cultivar. While saponification value, refractive index and viscosity not affected significantly. Water holding capacity, bulk density, emulsion activity and emulsion capacity of groundnut flour were not significantly affected by gamma irradiation.

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