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The Nutritive and Functional Properties of Dry Bean (*Phaseolus vulgaris*) as Affected by Gamma Irradiation

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Abstract: The research was carried out to study the effect of gamma irradiation on chemical composition as well as to investigate its effect on protein quality. Seeds of Giza cultivar of dry bean *phaseolus vulgaris* were treated with gamma irradiation at dose levels of 1, 1.5 and 2 k Gys. The results indicate that slight change was observed in proximate Composition and ash minerals of dry bean flour as affected by gamma irradiation. However for protein fraction gamma irradiation caused Significant decrease ($p \leq 0.05$) in albumins while no significant change was observed for globulins, gliadins, glutenins and residue fractions. On the other hand the *in vitro* protein digestibility was not significantly changed while protein solubility was significantly ($p \leq 0.05$) decreased. The results also revealed that gamma irradiation caused no significant change for water holding capacity, bulk density, emulsion activity, emulsion capacity and foaming capacity however oil absorption capacity and foaming stability slightly decreased by application of gamma irradiation

Key words: Gamma irradiation, functional properties, protein fractionsm, dry bean

INTRODUCTION

Common dry bean (*Phaseolus vulgairs*) is the most important food legume for direct consumption in the world. Nutritionally dry bean is a nearly, perfect and rich food. It is an excellent source of protein, carbohydrates and fairly good source of minerals, vitamins, folic acid and dietary fiber (Rehman *et al*., 2001). The wide growth and consumption of dry bean throughout the world, is mostly due to the fact that, this product is a relatively inexpensive food (Pachico, 1993). In Sudan, dry bean is one of the most widely consumed legume seeds, cultivated mainly in Northern part of the country with the few centers of cultivation in other parts of the country (Hassan and Mubarak, 1978).

Many species of insect pests attack dry bean both before and after harvest, post harvest pests of dry bean cause both qualitative and quantitative losses. Indirectly these insects force the rapid sale of post-harvest grain and short storage period, thus causing post-harvest price collapse and market seasonal price fluctuation; there have been effort to use protective methods to reduce the attack and contamination of insects and micro organism.

Ionizing radiation technology is a physical technique in food processing. Its purpose is the same as that of freezing, high temperature and chemical treatment, for killing insects and removal of microorganism causing food spoilage (Grolichova *et al*., 2004). The advantage of this process compared to chemical treatments, is that no residues are formed in food stuff (Moy, 1985), but on the other hands it may causes physical, chemical and biological changes that may affect the nutritional value and sensory properties of irradiated foods.

The present study was carried out with the aim of assessing change in chemical composition, protein fractions and functional properties of dry bean due to gamma irradiation.

MATERIALS AND METHODS

Dry bean seeds cultivar (Giza) were obtained from the Plant Breeding Division, Hudieba Research Station, Agricultural Research Corporation (ARC), Sudan. The seeds were carefully cleaned and freed from foreign materials and debris. Some of these seeds were mottled to pass through-mesh sieve to obtain bean seed flour and stored in tightly sealed containers at 4°C for further analysis.

Irradiation process: The dry bean seeds were sealed in glass bottles before and during irradiation process. The samples were irradiated at Kaila Irradiation Processing Unit, Sudanese Atomic Energy cobalt 60 gamma source (Nordion gamma cell 220-Exell) with the doses 1, 1.5 and 2 k Gry.

Non irradiated seeds served as control. Irradiated and non-irradiated samples of dry bean seeds were ground to pass through 20 mesh hammer mill. Screen and kept in tightly sealed containers at 4°C for further analysis.

Proximate composition: The moisture, ash, crude protein, crude fiber and carbohydrates were determined according to (AOAC, 1990) methods.

Mineral content: Mineral solution was prepared according to the method described by Pearson (1981). Minerals were estimated in mg/1000 ml by atomic absorption spectrometer, Perkins Elmer model 3110.

Table 1: Effect of gamma irradiation on proximate composition

Irradiation dose (KGys)	Moisture (%)	Protein (%)	Oil (%)	Fiber (%)	Ash (%)	Carbohydrates (%)
0.0	7.04[a]	23.80[a]	1.40[b]	4.04[a]	5.58[a]	58.14[a]
1.0	8.89[a]	21.05[c]	2.40[a]	5.89[a]	5.29[a]	56.48[b]
1.5	8.82[a]	21.37[b]	2.53[a]	7.89[a]	5.31[a]	54.48[b]
2.0	6.74[a]	21.95[b]	3.60[a]	4.74[a]	5.52[a]	57.45[b]

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

Protein fractions: The protein was fractionated according to the technique of Marquez and Lajolo (1981) using distilled water, IN NaCl, 70% ethanol and 0.2% NaOH solution for albumins, globulins, gliadins and glutenin respectively. The nitrogen content of each fraction was determined using the micro-kjeldahl procedure. The residue left after extraction was also analyzed for nitrogen content. Each fraction was expressed as a percent of the total nitrogen.

***In vitro* protein digestibility:** The *in Vitro* protein digestibility of the sample was measured according to the methods, described by Manjula and John (1991) with minor modification.

Functional properties

Nitrogen solubility: Nitrogen solubility in distilled water was estimated by the method described by Hagenmaier (1972) with minor modification. The water soluble nitrogen was extracted by rotary shaking with distilled water at 1:50 solute to solvent ratio for 1h at room temperature, the slurry was centrifuged at 3000 rpm for 30 min. at room temperature. The nitrogen value of the supernatant obtained was determined according to the micro-kjeldahl procedure and expressed as percentage with reference to total amount of protein in the sample.

Water Absorption Capacity (WAC): Water absorption capacity was determined according to the method described by Beuchat (1977). 10% suspensions of the sample were mixed with glass rod in centrifuge tube for 2 min at room temperature (26°C). After 20 min of shaking the suspension was centrifuged for 30 min at 4000 rpm at room temperature. The freed water was decanted into a 10 ml graduated cylinder and the volume was recorded. (WAC) was estimated as the amount of water retained by 100 grams materials.

Fat Absorption Capacity (FAC): The fat absorption capacity was estimated by the method of Beuchat (1977) and was expressed as the amount of oil bound by 100 grams dry matter.

Bulk Density (BD): The bulk density was measured according to the method described by Moreyra and Peleg (1981).

Emulsion Capacity (EC): The Emulsion Capacity (EC) of the irradiated and raw dry bean flour was estimated according to the method described by Beuchat (1977).

Emulsion Activity (EA): The EA was determined by the method described by Yasumatsu *et al.* (1972).

Emulsion Stability (ES): ES was quantified by the procedure described by Yasumatsu *et al.* (1972).

Statistical analysis: Each determination was carried out on three samples and analyzed in triplicate and figures were then averaged. Data was assessed by the analysis of variance ANOVA (Snedecor and Cochran, 1987). Duncan's multiple rang test was used to separate means.

RESULTS AND DISCUSSION

Proximate composition: The effect of various doses of gamma irradiation (0.0, 1.0, 1.5 and 2.0 k Gys) on proximate composition of dry bean seeds are illustrated in Table 1. The results showed that no significant change ($p \leq 0.05$) was observed in moisture, ash and fiber content of dry bean seeds as affected by gamma irradiation treatment and there was a significant decreased in protein content and a significant ($p \leq 0.05$) increased in oil and carbohydrates content.

Minerals content: Table 2 summarizes the data of the level of sodium, potassium, calcium, magnesium, zinc, manganese, copper and iron of dry bean seeds as affected by gamma irradiation. The result indicates that no apparent changes were observed in sodium and copper and there was slight insignificant increase in the level of zinc and decrease in potassium, calcium, magnesium, manganese and iron.

Protein fractions: The effects of gamma irradiation (0, 2.0 k Gys) on protein fraction and *in vitro* protein digestibility are illustrated in (Table 3) the result revealed that the level of albumin decreased significantly ($p \leq 0.05$) as affected by gamma irradiation. However, insignificant changes were observed for globulins, gliadins, glutenins and residual protein as compared to non irradiated dry bean. Changes in protein fractions may be related to some cross linking or aggregation of proteins as a result of gamma irradiation which could affect nitrogen solubility (Ciesta *et al.*, 2000).

***In vitro* protein digestibility:** As shown in Table 3, the results of the *in vitro* protein digestibility of dry bean as affected by gamma radiation revealed that insignificant changes as compared to non irradiated one, similar

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

Minerals	Irradiation dose (KGys) 0.0	1.0	1.5	2.0
Na	04.70[a]	06.70[a]	04.50[a]	04.70[a]
K	42.23[a]	26.25[a]	40.09[a]	10.00[a]
Ca	24.19[a]	20.58[a]	24.96[a]	22.90[a]
Mg	20.93[a]	20.45[a]	22.25[a]	15.50[a]
Zn	00.65[a]	00.99[a]	00.78[a]	01.09[a]
Mn	00.48[a]	00.41[a]	00.61[a]	00.27[a]
Cu	04.70[a]	06.70[a]	04.50[a]	04.70[a]
Fe	00.48[a]	00.69[a]	00.55[a]	00.21[a]

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

Table 3: Effect of gamma irradiation on protein fractions and digestibility (%) of dry bean flour

Fractions	Irradiation dose (KGys) 0.0	2.0
Albumins	56.65[a]	46.92[b]
Globulins	11.77[a]	16.29[a]
Gliadins	4.52[a]	4.99[a]
Glutenins	6.15[a]	4.60[a]
Residue	23.89[a]	22.20[a]
Protein digestibility	87.87a	87.82[a]

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

finding was observed by (Fombang *et al.*, 2005) who found that the *in vitro* protein digestibility of maize porridge was not affect by gamma irradiation compared to that prepared from the non irradiated flour.

Nitrogen solubility: Table 4 summarizes the results of the effect of gamma irradiation treatment on nitrogen solubility the results show that gamma irradiation caused significant decrease ($p \leq 0.05$) in nitrogen solubility. Decrease in nitrogen solubility was reported by Hafez *et al.* (1985) for irradiated soy bean seeds and EL-Din and Farag (1999) for sunflower meal. Decrease in nitrogen solubility might be attributed to protein denaturation, exposure of hydrophobic groups and the aggregation of the unfolded protein molecules. (Cheftel *et al.*, 1985). In addition, protein may react with other components in Millard type reactions during irritation, leading to less soluble reaction products (Abu *et al.*, 2005).

Functional properties of dry bean

Water absorption capacity (WAC): As shown in Table 5 water absorption capacity of dry bean flour indicate

Table 4: Effect of gamma irradiation on nitrogen solubility (%) of dry bean flour

Irradiation dose (KGys)	Nitrogen solubility
0.0	65.95[a]
1.0	48.12[b]
1.5	46.07[b]
2.0	42.17[c]
SEM	0.00

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

that gamma irradiation had insignificant change in ($p<0.05$) WAC compared to untreated one-the same result obtained by Zayas (1997) and Abu *et al.* (2005). This may be due to the counter acting effects of irradiation on protein and starch components present on beans. These components both have affinity for water (Narayana and Rao, 1982).

Fat Absorption Capacity (FAC): Table 5 shows that dry bean has a FAC of 200 ml/100 g of flour. Irradiation was significantly ($p<0.05$) reduced the FAC of dry bean to 160 ml/100 g. The mechanism of oil absorption involves the physical entrapment of oil by food components and the affinity of non-polar protein side chains for lipids (Kinsella, 1979; Sathe *et al.*, 1982) Reduction of FAC may be due to masking of non polar protein residues as result of irritation.

Bulk Density (BD): From the result presented in Table 5, it is clear that gamma irradiation causes no change in bulk density of dry bean. This result is in agreement with that reported by Abu *et al.* (2005).

Emulsion activity, capacity and stability: With regarded to the result illustrated in Table 5. It is clear that gamma irradiation had no significant change on emulsion capacity and activity and stability of dry bean flour. Similar finding was observed by (Abu *et al.*, 2005) who found that a 2.0 k Gys dose had no real effect on emulsifying properties.

Foaming capacity and stability: As shown in Table 5, the foam capacity of dry bean flour was not affected by irradiation technique. The same result was observed by Abu *et al.* (2005) for irradiated cow pea flour. Foam stability was decrease with an increase in time or period and it was slightly better in non irradiated bean. This may be attributed to protein denaturation as indicated by

Table 5: Effect of gamma irradiation on functional properties

Irradiation dose (KGys)	WAC (ml/100 g)	FAC (ml/100 g)	BD (ml/100 g)	EC (ml/g)	EA (%)	ES (%)	FC (%)
0.0	220[a]	200[a]	0.79[a]	138.66[a]	52.94[a]	05.55[a]	48.00[a]
2.0	220[a]	160[b]	0.79[a]	140.66[a]	39.76[a]	05.55[a]	48.33[a]

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

Table 6: Effect of gamma irradiation on Foaming Stability (FS) of dry bean flour (%)

Time (min)	0.0	2.0
00	100.0	100.0
15	70.80	66.00
30	51.30	52.00
45	50.00	41.60
60	45.80	33.33
75	39.58	29.16
90	37.50	25.00
105	35.40	20.66
120	29.16	18.66
135	27.08	16.66
150	25.00	16.66

Yasumatsu *et al.* (1972) foaming properties are negatively related to protein denaturation.

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