Journal of Radiation Research and Applied Sciences

J. Rad. Res. Appl. Sci., Vol.3, No 4(A), pp.965 -986 (2010)

Physiological and Biochemical Impacts of Radiation Processed Full-Fat Linseed

Hikmat M.El-Shennaway, Hania F.G. El-Niely and R.G. Hamaza

Food Irradiation Department, Radiation Processing Division, National Center for Radiation Research and Technology, Atomic Energy Authority, P.O. Box 29, Nasr City, Cairo, Egypt, 11371

E-mail:

Received: 07/ 07 /2009. *Accepted: 04/01 /2010.*

ABSTRACT

The aim of the study was to investigate the effect of gamma radiation at dose levels of 2.5, 5, 7.5 and 10 kGy on chemical composition of full-fat linseeds especially fatty acids. Also, to explore the physiological and biochemical impacts of feeding irradiated full-fat linseeds to growing male Albino rats. The study indicated that there was no effects of irradiation treatment on chemical composition of full-fat linseeds. Meanwhile, irradiation treatment produced changes in fatty acids of processed seeds as a function of radiation of dose especially on linolenic acid and α-Linolenic which increase by irradiation at different doses but no effect on another fatty acid content. In the present feeding study, a thirty six male growing Albino rats were equally and randomly categorized into six groups. Animals were fed the experimental diets for 5 weeks. The results obtained revealed that feeding rats on processed seed at 10 kGy has exhibit higher body weight more than the experimental groups. Meanwhile, the internal organs (liver, spleen, kidneys, heart, lungs and testis) of rats fed raw or processed seeds up to 10 kGy were similar to these of rats casein diet. Same results were recorded for the hematological parameters (Hb, PCV and MCHC) and plasma proteins (TP, albumin and globulin). Feeding rat with raw and processed seed modulated the levels of liver enzymes activities AST and ALT and AST/ALT ratio. However, the feeding of raw and irradiated linseeds up to 10 kGy reduced the levels of total cholesterol, triglycerides and HDL more than those fed casein diet. Therefore, it could be concluded beside the irradiation treatments improve the nutritional quality and extended the shelf life of such seeds through protect them from insects and pathogens microorganism it dose not impaired their protective roles for consumer who are suffered from hypercholesterolaemic.

Keywords: linseed meal, Fatty acids, Radiation processing, Animal feeding, Growth, Plasma biochemistry.

INTRODUCTION

Linseed is belongs to the family Linaceae genera *Linum*. The genus *Linum* is further divided into various taxonomic sections such as *linum*, *Dasylinum, Linastrum, and Syllinum*, each containing well-identified species. Commercially, all cultivated linseed belongs to section *Linum*, and species usitatissimum. A proximate composition of linseed is: moisture 6.5-10%, proteins 20-24%, oil 37-42%, carbohydrates 15-29%, crude fiber 4.8-9% and ash 2.4-4% [(1-3)]. Linseed is among the richest sources of lignans. It support normal cell multiplication and reduce cancer risk. Linseed in healthy diet supports normal cell development and growth and minimizes carcinogenic influences on cellular activities [(4)]. Linseed meal in our diets has potential health benefits of omega-3 fatty acid-rich foods, of which flaxseed is a prominent source [(5)].

The consumption of dietary fats have been long associated to chronic diseases such as obesity, diabetes, cancer, arthritis, asthma, and cardiovascular disease; although some controversy still exists in the role of dietary fats in human health, certain fats have demonstrated their positive effect in the modulation of abnormal fatty acid and eicosanoid metabolism, both of them associated to chronic diseases. Among the different fats, some fatty acids can be used as functional ingredients such as alpha-linolenic acid, arachidonic acid, eicosapentaenoic acid, docosahexaenoic acid, γ-linolenic acid, stearidonic acid and conjugated linoleic acid, among others. Special attention is paid to *trans* fatty acids due its increasing interest for the food industry [(6)]. Linseed oil contains both omega-3 and omega-6 fatty acids. It is considered the nature's richest storehouse of omega-3 fatty acid which is necessary for a wide variety of biological processes [(7)]. A little more than half of the oil found in flaxseed is alpha linolenic acid which is converted by the body into eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). The benefits of EPA and DHA include protection frome fatal heart attack (thrombotic disease), decreased inflammation and pain in arthritis. DHA is one of the building blochs for brain growth and development and is noted for its effects on brain function, mood and behavior [(8)].

Alpha-linolenic acid (ALA) is one of the two essential fatty acids in humans. Epidemiological studies and dietary trials strongly suggest that this

fatty acid is important in relation with the pathogenesis (and prevention) of coronary heart disease. Like other n-3 fatty acids from marine origin, it may prevent cardiac arrhythmias and sudden cardiac death. The optimal dietary intake of alpha-linolenic acid seems to be about 2 g *per* day or 0.6 to 1% of total energy intake. Epidemiological studies and dietary trials in humans suggest that alpha-linolenic acid is a major cardioprotective nutrient [(9)]. α-Linolenic acid (18:3n-3) is essential in the human diet, probably because it is the substrate for the synthesis of longer-chain, more unsaturated n-3 fatty acids eicosapentaenoic acid (20:5n-3) and docosahexaenoic acid (22:6n-3) which are required for tissue function. Conversion to 18:3n-3 to 20:5n-3 and 22:6n-3 is greater in women compared to men, due possibly to a regulatory effect of oestrogen, while partitioning of 18:3n-3 towards β-oxidation and carbon recycling was lower than in men. These gender differences may be an important consideration in making dietary recommendations for n-3 PUFA intake [(10)]. The protected linseed oil PLO supplement was effective in significantly enriching lamb meat with longer chain n-3 polyunsaturated fatty acids (n-3 PUFA) in three weeks [(11)].

Blood levels of polyunsaturated fatty acids (PUFA) are considered biomarkers of status. Alpha-linolenic acid, the plant omega-3, is the dietary precursor for the long-chain omega-3 PUFA eicosapentaenoic acid (EPA), docosapentaenoic acid (DPA), and docosahexaenoic acid (DHA). Studies in normal healthy adults consuming western diets, which are rich in linoleic acid (LA), show that supplemental ALA raises EPA and DPA status in the blood and in breast milk [(12)]**.** The possibility of cooking and manufacturing typical French cooked meats enriched in n-3 PUFA with n-6/n-3 and LA/ALA ratios below 4 without deleterious effects. The high levels of n-3 PUFA incorporated in pig meat and cooked pork meats, obtained by feeding linseed supplemented diet to the pigs, can be of value in increasing the 3 PUFA intake[(13)].

Linseed meal is a valuable of protein source to poultry and ruminants. However, the meal cannot be directly used for feeding the animals. The linseed meal need to be proceed to remove mucilage, and inactivate compound such as mucilage, phytic acid, cyanogenic glucoside, an antipyridoxin factor and goitrogen which limit their utilization. The meal seed need to be processed to remove this antinutritional factor. The isolation

of the two new glycosides provides a probable explanation for the protective activity of linseed oil meal against selenium toxicity [14].

Utilization of linseed protein by broiler chicks was worse than that from soybean meal and it attributable in all probability to the presence in linseed of antinutritional factors, such as mucilage, which can depress the retention of protein in chicks [15]. Pulses contain a number of bioactive substances including enzyme inhibitors, lectins, phytates, oligosaccharides, and phenolic compounds. Enzyme inhibitors can diminish protein digestibility, and lectins can reduce nutrient absorption, but both have little effect after cooking. Phytic acid can diminish mineral bioavailability. Some phenolic compounds can reduce protein digestibility and mineral bioavailability, and galactooligosacc-harides may cause flatulence. On the other hand, these same compounds may have protective effects. Phytic acid exhibits antioxidant activity and protects DNA damage, phenolic compounds have antioxidant and other important physiological and biological properties, and galactooligosaccharides may elicit prebiotic activity [16]. Gamma irradiation has been recognized as a reliable and safe method for improving the nutritional value and inactivation or removal of certain anti-nutritional factors in foods and feeds [17, 18] . Gharaghani *et al* [19] reported that gamma irradiation seems to be a good procedure to improve the nutritional quality of canola meal for human and animals. Gamma-irradiation of full-fat soybean was effective in improving the nutritive value of its protein and increasing in vitro CP digestibility [20].

The present study was performed to investigate the changes in chemical compositions of full-fat linseeds up an irradiation treatment alongside the physiological and biochemical impacts of feeding irradiated of full- fat linseeds at dose levels of 2.5, 5, 7.5 and 10 kGy to growing male Albino rats for 5 weeks.

MATERIAL AND METHODS:

Full Fat Linseed

Linseeds samples were obtained from the Field Crops Research Institute, Ministry of Agriculture and Land Reclamation, Giza, Egypt, and stored in sealed plastic slaves at -20°C until exposed to gamma rays.

Processing treatments

In irradiation treatment, raw linseeds samples were packed in well-sealed polyethylene bags. Each bag contained about 2 kg. They were subjected at ambient temperature to gamma irradiation from a ^{60}Co source at the National Center for Radiation Research and Technology, Nasr City, Cairo, Egypt. The irradiation facility used was an Egypt's Mega Gamma-I, of the type J-6500 supplied by the Atomic Energy of Canada Limited. The applied doses were 2.5, 5, 7.5 and 10 kGy as monitored by radiochromic film **McLaughlin *et al.* [21].**

Analytical procedures

Samples of raw and processed linseeds were analyzed for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF) and ash content according to the **AOAC** method **[22].**

The free fatty acid of raw and processed linseeds samples were determined according to the method described in **AOAC [22]** on oil extracted by petroleum ether (BP 40-60ºC) at room temperature from raw and processed sample. Fatty acid profile was estimated on the oil extracted from all processed samples according to **AOAC [22].** Fatty acid methyl esters were prepared according to **Hamilton and Hamilton [23].** The fatty acid methyl esters of all samples were analyzed using gas liquid chromatography/ Pye Unicam PRO-GC equipped with a flame ionization detector.

Animals

Male Albino rats weight 50± 5g obtained from animal house at the National Center for Radiation Research and Technology, Nasr City, Cairo, Egypt. Animals were maintained under suitable ventilation, temperature, humidity and illumination condition and allowed to normal nutrition and fresh tap water. Male rats were divided into 6 equal groups of 7 animals each. Control group fed a casein diet, other groups were fed on diets containing raw, irradiated linseed meal at dose levels 2.5, 5, 7.5 or 10 kGy. During whole experiment period, rats were individually weighted every two weeks. At the end of the feeding period (5 weeks), the rats were sacrificed and various blood collected for analysis according to **Evans [24].**

Experimental diets

Raw and irradiated full- fat linseeds were freshly grinded and incorporated into the experimental diet at level 388.70 g kg^{-1} to represent 10% crud protein. The experimental diets contained adequate levels of nutrients as recommended by the **NRC** [25]**.** The experimental animals fed: control diet (casein diet), diets containing raw, irradiated linseed at dose levels 2.5, 5, 7.5 and 10 kGy. The composition of experimental diets (g kg^{-1}) is shown in Table (1).

Organs weights:

Internal organs (liver, spleen, kidney, heart, lung and testes) from each male Albino rat were immediately dissected out and weighted. The relative organs weights were calculated (g of organ / 100g of live body weight). Organs weighted to be used as early indices for the toxicity of raw and treated linseeds according to **Farag** [26, 27]**.**

Hematological parameters

Hematological parameters; Hemoglobin (Hb), Packed Cell Volume (PCV) were carried out according to the methods reported by **Dacie and Lewis** [28] and **Williams *et al.*** [29], respectively. Mean Corpuscular Hemoglobin Concentration (MCHC) was calculated from the result of Hb content and PCV according to **Dacie and Lewis** [28] **.**

$$MCHC\% = Hb / PCV \times 100$$

Biochemical assays

After 35 days, blood specimens were withdrawn by cardiac puncture ¾ inch, needle and collected from each rat in heparinised tubes and preserved in ice cold condition, the blood samples were then centrifuged at 5000 rpm for 15 min. After which blood plasma could be separated and collected using Pasteur's pipettes and frozen pending analyses were undertaken for total protein (TP) according to **Johnson et al.** [30], albumin by **Tielz** [31], globulin, AST and ALT described by **Reitman and Frankel** [32], total cholesterol (TC) performed was according to methods of **Allain *et al.*** [33], high density lipoprotein (HDL) was determined according to **Demacer *et al.*** [34], and triglyceride (TG) by **Fossati and Principle** [35].

Table (1): Composition of the experimental diets (g kg^{-1} diet).

Ingredient	Diet (g kg^{-1})	
	Casein	Linseeds
Linseeds[a]	--	388.70
Casein	115.0	--
Corn oil	80.0	--
Cellulose	10.0	--
Sucrose	125.0	143.83
Corn starch	560.0	394.71
Water	50.0	27.26
Vitamin mix.[b]	10.0	10.0
Mineral mix.[c]	50.0	35.5
Total	1000.0	1000.0
Crud protein	100.0	100.0

[a] Raw or irradiated full-fat linseeds at 2.5, 5, 7.5 or 10 KGy.

[b] The vitamin mixture provides the following (mg/100g): Vit. A, 2000 IU; Vit. D, 200 IU; Vit. E, 10 IU; Menadion, 0.5; Choline, 200; mg. Aminobenzoic Acid, 10; Inositol, 10; Niacin, 4; Ca D- Pantothenate, 4; Riboflavin, 0.8; Thiamine. HCI, 0.5; Pyridoxine- HCI, 0.5; Folic acid, 0.2; Biotin, 0.04; Vit. B_{12}, 0.003; Glucose, to make 1000.

[c] The mineral mixture provides the following: 139.3 g NaCI; 0.79 g KI; 389.0 g KH_2PO_4; 57.3g $MgSO_4$ anhydride; 381.4 g $CaCO_3$; 27.0 g $FeSO_4.7H_2O$; 4.01 g $MnSO_4.H_2O$; 0.548 g $ZnSO_4.7H_2O$; 0.477 g $CuSO_4.5H_2O$; and 0.023 g $CoCI_2.6H_2O$.

Statistical analyses of the data

Four determinations were made for all assays. Analysis of variance (ANOVA) was conducted for all data using the general linear model (GLM) **(SAS Institute [36])**. Duncan's multiple-range test were used for comparison of treatments **(Duncan [37])**. Data were reported as means with their standard error. A value of $P<0.05$ was taken as criterion of significant.

RESULTS AND DISCUSSION:

Chemical composition of full-fat linseed:

Proximate analyses of raw and irradiated full-fat linseed is shown in Table (2). The analysis of non-processed sample gave a mean crude protein concentration of 25.73%, ether extract of 26.24% crude fat, crude fiber was 6.93%, ash content 5.17% and moisture was 8.13%. In general, subjected full-fat linseeds to gamma irradiation at 2.5, 5, 7.5 and 10 kGy induced no any significant effects on their chemical composition. An exception to this

general observation was to the results recorded for the fiber content where a statistically significant with increasing of radiation dose up to 10 kGy where slightly reduction had been occurred from 6.93% to 6.47% however, the contents of crud fiber in the processed samples are closed to there of non processed sample. The aforementioned results may be due to that linseed contain limited amount of water (8.13%) which could not be easily influenced to be radiolyzed by irradiation to producing enough free radicals that could induced significant changes in chemical comparison. In addition, crude protein and fat are in a complex matrix of foodstuffs which take than more resistant to radiation processing than these in pure status [38, 39]. **El-Niely** [39] reported that the chemical composition of full- fat peanut kernels didn't affected by radiation processing at dose levels 5, 7.5 and 10 kGy. Also, **Abo El-Ella *et al.*** [40] reported that the chemical composition of raw lentil and cowpea did not affect by radiation processing up to 20 kGy.

Table (2): Effect of gamma irradiation on the chemical composition of full-fat linseeds.

Dose (kGy)	Protein %	Fat %	Fiber %	Ash %	Moisture %	Dry-matter %
0.0	25.73 ±0.175[a]	26.24 ±0.058[a]	6.93 ±0.088[a]	5.17 ±0.033[a]	8.13 ±0.007[a]	91.87 ±0.007[a]
2.5	25.65 ±0.158[a]	26.26 ±0.047[a]	6.93 ±0.208[a]	5.04 ±0.107[b]	8.00 ±0.054[a]	91.99 ±0.053[a]
5	25.78 ±0.191[a]	26.21 ±0.146[a]	6.67 ±0.167[b]	5.02 ±0.090[b]	8.01 ±0.196[a]	91.99 ±0.196[a]
7.5	25.64 ±0.098[a]	26.24 ±0.100[a]	6.71 0.049[b]	5.07 ±0.089[b]	8.15 ±0.247[a]	91.85 ±0.247[a]
10	25.64 ±0.127[a]	26.22 ±0.074[a]	6.47 ±0.088[c]	4.93 ±0.052[c]	8.00 ±0.041[a]	92.00 ±0.041[a]
Probability	0.9507	0.9970	0.1439	0.3942	0.8839	0.8839

a-c means with the same letter are not significantly different.

Effect of radiation processing on fatty acid contents of full-fat linseed:

Table (3) represented the effects of the applied radiation doses on fatty acids profile of irradiated full- fat linseeds compared to these of non-processed seeds. The results indicated that irradiated full-fat linseed at 2.5, 5, 7.5 and 10 kGy exhibited higher palmetic acid compared to raw linseed, but stearic acid showed some changes where it decreased by 2.63%, 7.7%, 37.8% and 9.6% at 2.5, 5, 7.5 and 10 kGy, respectively. Meanwhile, the

results indicated that oleic acid increased by 3.9%, 3.1%, and 3.7% at dose 2.5, 5 and 10 kGy, respectively while the oleic acid was decreased by 1% at dose 7.5kGy. Concentration of linoleic acid was significantly increased more than double by 124.3%, 122.1%, 122.2% and 119.5% at doses 2.5, 5, 7.5 and 10 kGy, respectively. α-Linolenic acid (omega 3) percentage in raw and irradiated linseed at doses levels 2.5, 5, 7.5 and 10 kGy were increased by 7.1%, 5%, 4.6% and 3 %, respectively. **Makoto *et al.*** [41] reported that hydrocarbons increases as the dose increases. **El-Niley** [39] on her works reported that peanuts contain 45-50% lipids, 80% of which are unsaturated fatty acids that are highly susceptible to oxidation [42]. However, some fatty acids were increased as compared with their concentration in roasted kernels at zero time, these fatty acids are stearic acid, olic, linolic and arachidic. Meanwhile, linolenic acid was appeared in concentration of 0.346% due to storage treatment. Moderate losses were observed for some fatty acid components of oil extracted from processed peanuts up to 10 kGy, but not sever, even after storage, as for oil extracted from roasted peanut. Also, she indicated that linoleic (18:2) and linolenic (18:3) acid contents decreased slightly with increased irradiation dose. The increased was more pronounced when peanuts had been stored for six months. This may due to, the effect of irradiation on such changes and their consequent influence on the fatty acids. Among changes induced by irradiation, free radicals formed by unsaturated fatty acids, which engage in chemical reactions with each other during storage, are of concern to those interested in sensory qualities of peanuts [42].

Tale (3): Fatty acid concentration (%) of raw and irradiated full-fat linseeds.

Treatments	Palmitic acid C16:0	Stearic acid C18:0	Oleic acid C18:1	Linoleic acid C18:2	α-Linolenic acid C18:3
Raw	5.79262	3.05827	12.75877	7.2300	53.81987
2.5 kGy	6.2487	2.97789	13.25487	16.21956	57.61395
5 kGy	5.89488	2.82288	13.15474	16.05978	56.49526
7.5 kGy	6.03087	1.90333	12.63653	16.06817	56.29573
10 kGy	6.05825	2.76498	13.23292	15.86663	55.45662

Effect of feeding radiation processed full-fat linseeds on body weight:

The effects of supplemental dietary raw and irradiated full-fat linseed up to 10 kGy for 5 weeks on rat body weight are presented in Table (4). The data indicated that the higher body weight was recorded with rats fed diet treated at 10 kGy during the experimental period (5 weeks). The data presented in Table (4) also, showed that the total and daily body weight gain of rats fed raw or irradiated full-fat linseeds at 2.5, 5, 7.5 and 10 kGy were lower than these fed to casein diet. However, rats fed irradiated seeds at 10 kGy exhibited some improve in their body weight gain than these received irradiated seeds at 2.5, 5 and 7.5 kGy in their diets. These results explain that the radiation processed at such higher radiation dose (10 kGy) improve the total and daily body weight gain (49.10 g and 1.40 g, respectively, Table 4). This may be due to that irradiation treatment inactivated the antinutritional factors, that may be present naturally in samples. Moreover, gamma irradiation has been recognized as a reliable and safe method for improving the nutritional value [17-19].

Table (4): Effect of feeding irradiated full-fat linseeds at 2.5, 5, 7.5 or 10 kGy on rats performance.

Diets	Body weight (g)			Total gain(g)	Daily gain(g)
	W1	W3	W5		
Casein diet	68.40 ±1.644 ^{d}	105.70 ±8.960 ^{e}	132.73 ±6.481^{d}	64.33 ±7.242 ^{a}	1.84 ±0.207 ^{a}
RL diet	111.80 ±11.342 ^{c}	122.30 ±8.602 ^{d}	157.13 ±7.921 ^{c}	45.33 ±9.084 ^{b}	1.30 ±0.545 ^{b}
IL (2.5kGy)	109.87 ±9.048 ^{c}	137.00 ±10.150 ^{c}	149.83 ±5.929 ^{c}	39.97 ±10.87 ^{b}	1.14 ±0.310 ^{b}
IL (5 kGy)	124.00 ±14.654 ^{b}	144.73 ±7.744 ^{bc}	174.87 ±25.529 ^{b}	50.87 ±32.800 ^{ab}	1.45 ±0.937 ^{ab}
IL (7.5 kGy)	144.07 ±3.688 ^{a}	153.67 ±9.207 ^{ab}	182.10 ±14.809 ^{ab}	38.03 ±12.377 ^{b}	1.09 ±0.354 ^{b}
IL (10 kGy)	139.97 ±2.454 ^{a}	158.67 ±23.491 ^{a}	189.07 ±5.745 ^{a}	49.10 ±5.016 ^{ab}	1.40 ±0.143 ^{ab}
Probability	0.0006	0.0881	0.0779	0. 0360	0. 0360

a-e, means with the same letter are not significantly different.
RL, raw linseeds diet.
IL irradiated linseed diet.

Effects of feeding raw and irradiated linseeds on relative organ weights:

Relative organ weights of rats fed the experimental diets for 5 weeks are summarized in Table (5). Results showed that there was no significant changes in relative liver, spleen, kidneys, heart, lungs and testis weight (g/100g body weight) of rats fed raw or irradiated full-fat linseeds at dose level of 2.5, 5, 7.5 or 10 kGy when compared with those fed casein diet (Table 5). **Orcheson** [4] reported that there was no effect of linseed diet on liver weights. In contrast**,** other studies [43,44] stated that the weight of kidney and spleen increased ($p<0.01$) linearly as prolonged the time of feeding linseeds diet.

Table (5): Average relative organ weights (g/100g body weight) of rats fed diets supplemented with raw and irradiated linseeds.

Diets	Liver	Spleen	Kidneys	Heart	Lungs	Testis
Casein diet	3.609 ±0.040[a]	0.368 ±0.022[a]	0.630 ±0.027[a]	0.363 ±0.007[a]	0.551 ±0.014[a]	1.463 ±0.035[a]
RL diet	3.513 ±0.041[a]	0.366 ±0.003[a]	0.644 ±0.051[a]	0.356 ±0.001[a]	0.557 ±0.012[a]	1.337 ±0.055[a]
IL (2.5kGy)	3.506 ±0.020[a]	0.364 ±0.003[a]	0.624 ±0.032[a]	0.365 ±0.014[a]	0.559 ±0.003[a]	1.413 ±0.129[a]
IL (5 kGy)	3.505 ±0.023[a]	0.360 ±0.016[a]	0.615 ±0.022[a]	0.363 ±0.006[a]	0.555 ±0.006[a]	1.332 ±0.056[a]
IL (7.5 kGy)	3.507 ±0.024[a]	0.356 ±0.005[a]	0.626 ±0.003[a]	0.359 ±0.038[a]	0.557 ±0.004[a]	1.312 ±0.157[a]
IL (10 kGy)	3.533 ±0.033[a]	0.363 ±0.004[a]	0.636 ±0.007[a]	0.371 ±0.012[a]	0.555 ±0.001[a]	1.310 ±0.086[a]
Probability	0.2128	0.9772	0.9802	0.9933	0.9917	0.8273

Means with the same letter are not significantly different.
Legend as Table 4

Influence of raw and irradiated full-fat linseeds on hematological parameters of male albino rats:

The result presented in Table (6) shows that the hemoglobin concentration and packed cell volume of male albino rats fed irradiated linseed for 5 weeks at dose 2.5, 5, 7.5 and 10 kGy were significantly not changes as compared with those fed non processed diet or with those fed casein diet. Irradiation treatment of linseeds did not reflect any adverse effect on the heamoglobi, packed cell value (PCV) and MCHC of groups of rats under the investigation as compared with these received casein diet for 5 weeks. Linseed, the richest known source of plant lignans, has been shown to have chemoprotective effects in animal and cell studies [45]. **Bourre** [46] stated that omega-3 polyunsaturated fatty acids play important role in the development and maintenance of different organs and hematological parameters**.**

Table (6): Effect of feeding male albino rats raw and irradiated linseed for five weeks on heamatological parameters .

Diets	Hb ($g\ dl^{-1}$)	PCV (%)	MCHC ($g\ dl^{-1}$)
Casein diet	12.90 ±0.058 [a]	34.33 ±0.333 [a]	0.376 ±0.002 [a]
RL diet	12.87 ±0.384[a]	35.33 ±0.882[a]	0.364 ±0.007[a]
IL (2.5kGy)	12.90 ±0.321[a]	35.00 ±1.00 [a]	0.369 ±0.007 [a]
IL (5 kGy)	13.03 ±0.186 [a]	34.00 ±0.00 [a]	0.383 ±0.005 [a]
IL (7.5 kGy)	12.80 ±0.152 [a]	34.67 ±0.333[a]	0.369 ±0.001[a]
IL (10 kGy)	12.87 ±0.201[a]	34.67 ±0.882[a]	0.371 ±0.004[a]
Probability	0.9900	0.7847	0.1666

Means with the same letter are not significantly different
Legend as Table 4

Effect of feeding raw and processed linseeds on plasma proteins of growing male albino rats.

The statistical analyses of the data presented in Table (7) indicated that feeding growing Albino rats on irradiated full-fat linseed at dose levels of 2.5, 5, 7.5 and 10 kGy for 5 weeks as compared with these kept on casein diet, did not exhibited any significant difference between plasma proteins (total protein, albumin, globulin) values. The above mentioned result confirmed that the radiation processing full-fat linseed up to 10 kGy did not impaired the nutritional value of linseed proteins. These results are agreement with Farag [27] who mentioned that irradiated different sorts animal feeds up to 50 kGy did not affect the levels of plasma proteins.

Table (7): Effect of feeding growing rats raw and irradiated full-fat linseed for five weeks on plasma proteins.

Diets	Tp ($g\ dl^{-1}$)	Albumin ($g\ dl^{-1}$)	Globulin ($g\ dl^{-1}$)
Casein diet	4.57 ±0.120 [a]	2.97 ±0.088[a]	1.60 ±0.200 [a]
RL diet	4.57 ±0.088[a]	2.93 ±0.176 [a]	1.63 ±0.120 [a]
IL (2.5kGy)	4.67 ±0.120 [a]	3.00 ±0.115 [a]	1.67 ±0.186 [a]
IL (5 kGy)	4.60 ±0.173[a]	2.97 ±0.088[a]	1.63 ±0.218 [a]
IL (7.5 kGy)	4.67 ±0.067 [a]	2.97 ±0.088[a]	1.70 ±0.058 [a]
IL (10 kGy)	4.67 ±0.033 [a]	3.00 ±0.115 [a]	1.67 ±0.088[a]
Probability	0.9521	0.9984	0.9981

Means with the same letter are not significantly different
Legend as Table 4

Influence of feeding raw or irradiated linseeds on biochemical parameters of growing male Albino rats.

Data obtained on the activity of the aspartic and the alanine

transaminases in the plasmas of growing male Albino rats fed raw or irradiated full-fat linseed at 2.5, 5, 7.5 and 10 kGy during the experimental period (5 weeks) are presented in Table (8). The result indicated that there are no significant difference in the activity of the plasma alanine transaminase between animals received raw and processed linseeds, while the data obviously indicated that the level of AST and ALT of animals fed casein diet were higher than the levels of those fed raw and processed linseed. Yearul and Takashi[47] reported that linseed are rich in α-18:3 acid which caused characteristic changes in the activity of hepatic enzymes (AST and ALT). However, AST/ALT ratio for rats fed casein diet was similar to those fed raw or irradiated full-fat linseeds at 2.5, 5, 7.5 and 10 kGy. On top of that, there are no significant differences between AST/ALT ratio for groups of rats fed raw or irradiated linseed and groups kept on casein diet.

Plasma total cholesterol (P=0.0001), high- density lipoprotein (P=0.0008) and triglyceride (P=0.0001) of growing male albino rats fed casein diet for 5 weeks were significantly higher (Table 8) more than these kept on diet containing raw or irradiated full-fat linseed (Table 1) for 5weeks. Meanwhile, there are certain significant differences between group of rats fed irradiated linseeds and as well between these fed raw and processed full-fat linseed up to 10 kGy. In general, as a function of radiation dose the TC, HDL and TG were decreased by increasing radiation dose for 5 to 10 kGy. This may be due to that irradiation treatment modified the fatty acids profile of linseed and subsequently could changed the levels of TC, HDL and TG of rats fed irradiated linseed for 5 weeks. High serum cholesterol levels are known to be one of the major risk factors for coronary heart diseases [48]. Both TG and cholesterol levels are largely food/feed dependent and the fatty acid composition seem to be one of the most important factors, that effect the level of TC, HDL and TG [49]. Many experiments have been performed to establish how particular fatty acids affect blood cholesterol levels [9,49,50]. Generally, it has been found that saturated fatty acids (SFA) are hypercholesterolaemic, and polyunsaturated fatty acids (PUFA) are hypocholesterolaemic [51]. Feeding of linseed oil or fish oil in the safflower oil diet resulted in lowering of the liver triacylglycerol levels [52].

Table (8): Comparison of plasma biochemical parameters of growing male Albino rats maintained on experimental diets containing raw and irradiated linseed for 5 weeks.

Diets	AST ($U L^{-1}$)	ALT ($U L^{-1}$)	AST/ALT ratio	TC (mg dl^{-1})	HDL (mg dl^{-1})	TG (mg dl^{-1})
Casein diet	23.43 ±0.472^{a}	7.43 ±0.120^{a}	3.156 ±0.108^{a}	138.90 ±0.600^{a}	88.33 ±0.882^{a}	100.39 ±0.314^{a}
RL diet	21.50 ±0.808^{b}	6.80 ±0.272^{b}	3.182 ±0.253^{a}	122.03 ±0.606^{c}	78.33 ±0.882^{d}	83.33 ±2.185^{b}
IL (2.5kGy)	21.92 ±0.877^{b}	6.93 ±0.176^{b}	3.162 ±0.112^{a}	122.13 ±0.612^{c}	79.00 ±2.082^{cd}	83.47 ±1.330^{b}
IL (5 kGy)	21.70 ±1.325^{b}	6.96 ±0.167^{b}	3.127 ±0.247^{a}	123.03 ±0.233^{b}	80.00 ±0.577^{bc}	84.53 ±0.291^{b}
IL (7.5 kGy)	21.92 ±0.133^{b}	6.99 ±0.319^{b}	3.152 ±0.163^{a}	123.60 ±0.819^{b}	80.00 ±1.00^{bc}	84.27 ±0.176^{b}
IL (10 kGy)	22.30 ±0.115^{b}	6.79 ±0.179^{b}	3.288 ±0.095^{a}	123.00 ±0.833^{b}	81.00 ±1.155^{b}	84.47 ±1.835^{b}
Probability	0.5466	0.3762	0.9893	0.0001	0.0008	0.0001

a-d, Means with the same letter are not significantly different.
Legend as Table 4

In conclusions, the present study indicated that there were no significant effects on chemical composition of full-fat linseed after exposure to gamma rays up to 10 kGy. Irradiation process improvemed fatty acids such as linoleic acid, oileic acid and α-Linolenic acid (omega 3). Feeding growing Albino rats for 5 weeks on diet containing irradiated full-fat linseed at 2.5, 5, 7.5 and 10 kGy at level (388.7g kg^{-1} diet) did not produced any adverse effect on the growth rate of rats fed the experimental diets for 5 weeks. Moreover, kept rats on the experimental diet induced no significant effect in total protein, albumin, globulin and transaminases enzymes. However, feeding both raw and irradiated full-fat linseeds induced significant in reduction in total cholesterol, triglycerides and HDL levels. In spite of, there are certain changes in fatty acid profile of linseed after irradiation (up to 10 kGy), the benefit effect of using full-fat linseed as a hypocholesterolaemic and modifying to the plasma lipid profile did not affected up on irradiation treatment therefore, it could be concluded that the

above mentioned applied radiation doses are safe for treated such seeds rich in fat.

Acknowlegement:

The authors wish to acknowledge the considerable time expended by Professor Dr. Farag, M. Diaa El-Din H. in performing the statistical analyses herein reported.

REFERENCE

1. Pryde, E. H. (1982): Nonfood uses of vegetable oils. In *Handbook of Processing andUtilization in Agriculture,* Vol.11. Part 2. Plant Products, ad. I. A. Wolff, pp.109 –142. Boca Raton, Fl: CRC Press.

2. Susheelamma, N. S. (1987): Isolation and properties of linseed mucilage. *J. Food Sci.Technol.* 24:103 – 6.

3.Susheelamma, N. S. (1989): Functional role of linseed (*Linum usitatissimum L.*) polysaccharides in steamed pudding (idli). *J. Food Sci. Technol*. 26: 16 – 20.

4. Orcheson, L. (1998): *Cancer Lett.,* 125 (1-2), 69. Transport from Ali, S. E., Osman, N.N. and Haggag, A. M.(2008). Linseed oil as a protective agent against toxicity of C Red No.40 dye in Albino rats. *Arab Journal of Nuc. Sci. and Appl*, 41(1) pp272- 280.

5- Neil M. R. O, Lardy G. P., Reynolds L. P., J. S. Caton J.S. and Vonnahme K. A. (2005): Effect of estradiol (E2) and linseed meal (LSM) on liver weight, protein concentration, and DNA in (OVX) ewes, proceedings, western section, *American Society of Animal Scienc* Vol. 56, 237-239.

6. Alejandro, R. R., Guillermo, R. and Elena, I. (2010): Recent trends in the advanced analysis of bioactive fatty acids. *Journal of Pharmaceutical and Biomedical Analysis*,*Volume51, Issue2*, *Pages305-326*.

7. Baylin, A., Kabagambe, E.K., Ascherio, A., Spiegelman, D. and Campos,H. (2003)*:Circulation.* 107 (12) 1586. Transport from Ali, S. E., Osman, N.N. and Haggag, A. M.(2008). Linseed oil as a protective agent against toxicity of C Red No.40 dye in Albino rats. *Arab Journal of Nuc. Sci. and Appl*, 41(1) pp272-280.

8. Burdge, G.C., Finnegan, Y.E., Minihane, A.M., Williams, C.M. and Wootton, S.A. (2003): Br *J Nutr*. 90 (2) 311. Transport from Ali, S. E., Osman, N.N. and Haggag, A. M.(2008). Linseed oil as a protective agent against toxicity of C Red No.40 dye in Albino rats. *Arab Journal of Nuc. Sci. and Appl*, 41(1) pp272-280.

9. Lorgeril, M. d.and Salen, P. (2004): Alpha-linolenic acid and coronary heart disease. *Nutrition, Metabolism and Cardiovascular Diseases*, *Volume 14, Issue 3*, *Pages 162-169*.

10. Burdge, G.C. (2006): Metabolism of α-linolenic acid in humans. *Prostaglandins,Leukotrienes and Essential Fatty Acids*, *Volume 75, Issue 3*, *Pages 161-168*.

11. Soressa M. K., Andrew, W., Suresh, G., Vivian, B., John, R. and Kelly, L. P. (2009): Influence of duration of supplementation with ruminally protected linseed oil on the fatty acid composition of feedlot lambs. *Animal Feed Science andTechnology*, *Volume151,Issues3-4,26MayPages228-239*.

12. Thomas, B.J., Norman, S. J., Andrew J. S., Stephen, C. C. (2009): α-Linolenic acid supplementation and conversion to n-3 long-chain polyunsaturated fatty acids in humans. *Prostaglandins, Leukotrienes and Essential Fatty Acids*, *Volume 80, Issues 2-3*, *Pages 85-91*.

13. Guillevic, Kouba, M. and Mourot, J.(2009): Effect of a linseed diet on lipid composition, lipid peroxidation and consumer evaluation of French fresh and cooked pork meats. Vol. 81, ISSUE 4, pp. 612–618.

14. Palmer, I. S. and Olson, O. E. (1979): Partial prevention by cynide of selenium poisoning in rats. *J. Nutr.* 110: 145-150.

15. Treviño, J., Rodríguez, M. L., Ortiz, L. T., Rebolé, A. and Alzueta, C.(2000): Protein quality of linseed for growing broiler chicks. *Animal Feed Science and Technology*, *Volume 84, Issues 3-4*, *5, Pages155-166*.

16. Rocio, C.V., Guadalupe, L.P.and Dave, B. O. (2009): Minor components of pulses and their potential impact on human health.

Food Research International, *In Press, Corrected Proof*, *Available online 10 September*

17. Siddhuraju, P., Makkar, H. P. and Becker, K. (2002): The effect of ionising radiation on antinutritional factors and the nutritional value of plant materials with reference to human and animal food. *Food Chem*. 78:187-205.

18. Farkas, J. (2006): Irradiation for better foods. Trends in Food Science and Technology 17:148-152.

19. Gharaghani, H. ; Zaghari, M. ; Shahhosseini, G. and Moravej, H. (2008): Article: Effect of gamma irradiation on anti nutritional factors and nutritional value of canola meal for broiler chickens.(Report) *J. Anim. Sci*., 21:1479-1485. http//www. ajas. Info / manuList-asps.

20. Shawrang, P., Nikkhah, A., Zare-Shahneh, A., Sadeghi, A. A., Raisali, G. and Moradi-Shahrebabak, M. (2007): Effects of gamma irradiation on protein degradation of soybean meal. *Anim. Feed Sci. Technol*. 134:140-151.

21. McLaughlin, W.L; Wenxia Cohen; Jia, H. and Humphreys, J. C. (1985): Response of radiochromic film dosimeter Gamma rays in different atmosphere. Radiate. *Phs. Chem.*, 25: 783-799.

22. A. O. A. C. (2003): Association of Official Analytical Chemists, International 17th ad., Arlington, Virginia, USA.

23. Hamilton, R. J. and Hamilton, S. (1993): Lipid Analysis a Practical Approach. IRL press, Oxford University Press, Oxford.

24. Evans, G.O. (2009): Animal Clinical Chemistry: A practical Handbook for Toxicologists and Biomedical Researchers. 2nd Ed. CRC press, Taylor and Francis Group.

25. NRC (National Research Council) (1994): Nutrient requirements of laboratory animals (3 rd.) *National Academy of Sciences, Washington, DC, USA.*

26. Farag, M. Diaa El-Din H. (1982): Nutritional evaluation of radiation induced biochemical changes in animal feed by products. M. Sc.

Thesis, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt.

27. Farag, M. Diaa El-Din H. (1987): Studies on protein turnover in poultry fed irradiated protein by- products Ph. D. Thesis Faculty of Agriculture, Al-Azhar University, Cairo, Egypt.

28. Dacie, J. V. and Lewis, S. M. (1975): Practical Haematology. Chuchil, Livivng-stone, Edinbugh, London and NY 5th –Ed.

29. Williams, R. R.; Beutler, E, A. and Rundless, R. W. (1972): Haematology. New York, Mc Graw-Hill Book Company.

30. Johonson, A.M., Rohlfts, E. M. and Silveman, L. (1999): Proteins. In: Burtis CA, Ashwood ER, editors. Tietz. Textbook of Clinical Chemistry. 3rd ad. Philadelphia: W.B. Saunders Company; 477.

31. Tielz, N. W. (1994): Textbook of Clinical Chemistry 2nd Ed., W. B. Saunders Company. Philadelphia, PA, p.36.

32. Reitman, S. and Frankel, A. (1957): A colorimetric method for the determination of serum glutamic oxaloacetic and glutamic pyruvic transaminase (GOT) and (GPT). Am.J. Clin. Path, 28: 56-63.

33. Allain , C. C., Poon, L. S., Chan, C. S. G., Richmonal, W. and Fu, P. C. (1974): Enzymatic determination of total serum cholesterol. *Clin. Chem*., 20 (4): 470.

34. Demacer, P. N. M., Nasjanssen, H. E., Hifmas, A.G. M., Vant,S., Lear, A. and Jansen, A. P. (1980): Measurement of gogh denseity lipoprotein cholesterol in serum, comparison of sex isolation methods combined with enzymatic cholesterol analysis. *Clin. Chem.,* 26 (13): 178.

35. Fossati, P. and Prencipe, L. (1982): Serum triglyceride determined colourimetrically with an enzyme that produce hydrogen peroxide. *Clin. Chem.,* 28, 2077.

36. SAS 'Statistical Analysis System', (2004): SAS / STAT User's guide. SAS Institute Inc Cary NC, USA.

37. Duncan, D. B. (1955): Multiple range and multiple F tests. Biomet. 11, 1.

38. Diehl, J.F. and Scherz, H. (1975): Estimation of radiolytic products as a basis for evaluation the wholesomeness of irradiated foods. Int. J. Appl. Rad. Isotopes ***26***:499.

39. El-Niely, H.F.G. (2001): Biochemical and Nutritional studies on radiationprocessed peanuts. PhD. Thesis, Department of Biochemistry and Nutrition. Women's College, Ain Shams University. Cairo, Egypt.

40. Abo El-Ella, W. M., Farag, M. Diaa El-Din H., AL-Shiwi, M. A., El-Niely, H. F., And Bayoumi, El-S. M. (2005): Nutritional and biochemical changes in irradiated lentil and cowpea. Zagazig J. Agric. Res. 32 (1) 133-46.

41. Makoto, M., Akiko, S., Tomomi, K., Taeko, N., Hitoshi, I. and Masatake, T. (2002): Hydrocabon produtions in hexane solutions of fatty acid methyl esters irradiated with gamma rays. *Jounal of Health Science,* 48 (5) 418-426.

42. Chiou R.Y.Y; Lin, C.M. and Siiyu S-L. (1990): Property char-acterization of peanut kernels subjected' to gamma irradiation and its effect on the outgrowth and aflatoxin production by *Aspergillus Parasuicus.* J. Food Sci., 55, 210-213.

43. Huang, F. R., Zhan, Z. P., Luo, J., Jiang, S. W. and Peng, J., (2008): Duration of feeding linseed diet influences peroxisome proliferator-activated receptor γ and tumor necrosis factor gene expression, and muscle mass of growing–finishing barrows. Livestock *Science, Volume 118, Issues 1-2, pp132-139.*

44. Ivan, S.P.; Oscar, E. O.; Andrew, W. H.; Roger, M. and Cecil, S. (1980): Isolation of factors in linseed oil meal protective against chronic selenosis in rats. Downloaded from *Jn nutrition.org* by on December 17, 2008.

45. Haggans, C.J., Hutchins, A.M. and Olson, B.A. (1999): *Nutr.Cancer*., 33 (2), 188. Transport from Ali, S. E., Osman, N.N. and Haggag, A. M. (2008). Linseed oil as a protective agent against toxicity of C Red No.40 dye in Albino rats. *Arab Journal of Nuc. Sci. and Appl*, 41(1) pp272-280.

46. Bourre, J. M. (2005): Effect of increasing the omega-3 fatty acid in the diets of animals on the animal products consumed by humans. *Med. Sci. (Paris)*. 21(8-9): 773-9.

47. Yearul, K. and Takashi, I.(1996): Activity of hepatic fatty acid oxidation enzymes in rats fed α-linolenic acid. *Biochimica et Biophysica Acta (BBA) - Lipids and Lipid Metabolism*, *Volume 1304, Issue 2*, *22*, *Pages 105-119*.

48. Flickinger B.D., and Huth P.J., (2004): Dietary fats and oils, technologies for improving cardiovascular health. *Curr. Atheroscler. Rep*. 6, 468-476.

49. Nagata J., Kasai M., Negishi S., and Saito M., (2004): Effects of structured lipids containing eicosapentaenoic or docosahexoenoic acid and caprylic acid on serum and liver lipid profiles in rats. *Biofactors* 22, 157-160.

50. Hanczakowski, P. and Szymczyk, B. (2006): The effect of olive or linseed oils supplemented with pure saturated fatty acids on serum cholesterol levels in the rat *Journal of Animal and Feed Sciences, 15, 287–294*.

51. Dorfman S.E., Wang S., Vega-Lopez S., Jauhiainen M., and Lichtenstein A.H. (2005): Dietary fatty acids and cholesterol differentially modulate HDL Cholesterol metabolism in Golden-Syrian hamsters. *J. Nutr*. 135, 492-498.

52. Manohar L. G., Alan, B. R., Thomson, M. and Thomas Clandinin. (1989): Hypotriglyceridemic effect of dietary $n - 3$ fatty acids in rats fed low versus high levels of linoleic acid. *Biochimica et Biophysica Acta (BBA) - Lipids and Lipid Metabolism*, *Volume 1006, Issue 1*, *6*, *Pages 127-130*.

مجلة البحوث الإشعاعية
والعلوم التطبيقية
مجلد 3 عدد 4 (أ) ص ص 965 – 986 (2010)

التأثيرات الفسيولوجية والكيموحيوية لبذور الكتان المعالجة بأشعة جاما

حكمت محمود الشناوى - هنية فتحى غريب النيلى – رفعت جلال حمزة

قسم بحوث تشعيع الاغذية ، المركز القومى لبحوث وتكنولوجيا الاشعاع ، ص.ب. 29 مدينة نصر ، القاهرة ، مصر

تهدف هذه الدراسة إلى دراسة تأثير التشعيع الجامى بالجرعات 2.5، 5، 7.5، 10 كيلو جراى على التركيب الكيميائى لبذور الكتان كاملة الدسم خاصة محتواها من بعض الأحماض الدهنية. وكذلك دراسة التأثيرات الفسيولوجيه والكيموحيويه نتيجة تغذية الجرذان على وجبة تحتوى على بذور الكتان كاملة الدسم بنسبة 38.87%. أظهرت النتائج المتحصل عليها انه ليس هناك تأثيرات للمعالجة الإشعاعية على التركيب الكيميائى لبذور الكتان ولكن المعالجة الإشعاعية بالجرعات المختلفة أدت الى زيادة نسب كل من حمض اللينوليك وحمض اللينولينك وهما من الأحماض الدهنية الضرورية ولكن ليس لها تأثير على محتوى الأحماض الدهنية الأخرى. فى تجربة التغذية استخدم 36 جرذ ذكر قسمت عشوائيا الى ست مجموعات واستمرت لمدة 5 أسابيع. أظهرت النتائج ان الجرذان المغذاة على عليقة تحتوى على بذور الكتان والمعالجة إشعاعيا بجرعة 10 كيلو جراى حققت زيادة فى وزن الجسم أعلى من المجموعات المغذاة على جرعات اخرى كما بينت النتائج انه لم يحدث أى اختلاف معنوى بين المجموعات المغذاة على بذور الكتان كاملة الدسم خام او مشعة أو المجموعة الضابطة فى أوزان الأعضاء (الكبد- الطحال- الكلى- القلب- الرئتين- الخصية) وقياسات الدم (المحتوى من الهيموجلوبين، حجم الكتلة الخلوية و تركيز الهيموجلوبين بكريات الدم الحمراء) كذلك البروتين الكلى والألبيومين والجلوبيولين. التغذية على البذور الخام أوالمعالجة إشعاعيا نظمت مستويات انزيمات الكبد AST ، ALT والنسبة بينهما. ايضا التغذية على البذور الخام والمشعة أدى إلى خفض مستويات الكوليستيرول الكلى والجليسريدات الثلاثية واللايبوبروتينات عالية الكثافة بالمقارنة بالمجموعة الضابطة. وبجانب أهمية المعالجة الإشعاعية فى تحسين القيمة الغذائية لبذور الكتان وزيادة فترة تخزينها وذلك بحمايتها من الحشرات والميكروبات المرضية فإن الدراسة القائمة توضح أن تلك المعالجات الإشعاعية لا تؤثر على الدور الذى تلعبه المحتويات الحيوية فى بذور الكتان لحماية الأشخاص الذين يعانون ارتفاع كوليستيرول الدم.