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# Influence of Irradiated *Moringa oleifera* Leaf Meal as Dietary Supplement on some Serum Biochemical Parameters of Growing Rabbits

**A. M. AbdulAzeem [1*], Safaa, A.E. ,AbdElWahab [1], Amal , A. Mansour [1] and U. M. Abdel-Monem[2]**

*(1) Food Irradiation Research Department, National Centre for Radiation Research and Technology (NCRRT), Egyptian Atomic Energy Authority (EAEA), Cairo, Egypt.*

*(2)Department of Animal Production, Faculty of Agriculture, Zagazig University, Zagazig, Egypt.*

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ABSTRACT

**The present study evaluates the influence of gamma (γ) irradiation on anti-nutritional factors, total phenolic compounds of Moringa leaf meal (MLM) at different doses of 0, 10, 15, and 20 kGy, the effect of feeding rabbits on irradiated MLM, and their impacts on rabbit's performance, apparent digestibility, carcass traits, and certain blood constituents. 60 male rabbits (New Zealand White weaned, 35 days age) were assigned randomly to 4 groups (15 rabbits/group).The1st group was kept on a basal diet supplemented with 10% MLM (non-irradiated) (control), the 2nd, 3rd, and 4th groups were kept on the control diet (10% MLM ) subjected to γ irradiation at 10, 15, and 20 kGy, respectively. The results showed diminishing in the anti-nutritional factors (phytic acid, tannins, trypsin inhibitors, and saponins. On the other hand, the total phenolic compound was increased. The gradual increases were correlated by linear regression with the escalating irradiation dose. The supplemented 10% MLM irradiated for up to 20 kGy in the diet of rabbits resulted in a significant enhancement of rabbits performance(body weight, gain weight, feed conversion, the digestibility of dry matter, crude fiber, crude protein, carcass body traits (carcass weight, dressing (%) and prime cuts (%)), and the enhancement was proportional to the escalating radiation dose. On the other hand, no significant change in feed consumed, water consumed, rectum temperature, respiration rate, ether extracts digestibility, biochemical parameters such as; GPT, GOT, total lipids, total cholesterol, total protein, albumin, globulin, and blood urea, and hematological aspects (RBCs, WBCs and HB %) among the treatments. In general, γ- irradiation sounds to be a useful procedure to enhance nutrition quality of MLM without any negative effect on rabbits' biochemical constituents.**

## INTRODUTION

*Moringa oleifera* is a top advantageous plant found in numerous equatorial and subequatorial regions. It has a high nutritional amount and a large scope of pharmacological attributes (controls diabetes mellitus Type 2, controls blood pressure, reduces cholesterol levels, improves strength and immunity) [1].

Moringa leaves and pods are used as food products in human nutrition. Leaf extract has a very high antioxidants activity (flavonoids, phenolics and carotenoids) and anti-inflammatory compounds and shows a high safety degree in various safety studies in human and different animals species [2] ; [3].

Moringa is rich in its nutrition value due to the presence of a wide range of essential phytochemicals in its leaves, pods and seeds. The leaves and pods are used as rich sources of vitamins A, B compounds, C, D, E, P, Ca, K, Fe and Zn with a good source of amino acids, crude protein (45 and 29%, respectively), α-Tocopherol, and *β*-Carotene [4].

Anti-nutritional factors (chemical compounds) are naturalistic compounds occurring in plant parts that reduce palatability and their food value by diminution of absorption or digestive enzyme when consumed [5]. These compounds may not necessarily be poisonous [6] but give solicitude for human and animal health as their impediment with digestion and absorption could trigger nutrient lack [7].

Corresponding author: alyncrrt@yahoo.com

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With negative/ harmful effect on health and productivity. In this concern, Moringa contains anti-nutritional factors including phytic acid, tannins, saponins, trypsin inhibitors, oxalates and cyanide, which affect protein and mineral metabolism and availability to the animal [8,9,10].

Several treatments or process such as fermentation, heating, boiling in water and other solvents have been used to inactivate or minimize the anti-nutritional substances found in food and feed materials [11]. However, none of these processes is fit to completely remove all the detected anti-nutrients found in most of the food or feed materials currently, the use of gamma irradiation processing show potential alternative and further processing technique for decreasing anti-nutrients and enhancing the nutritive quality of food or feed[12,13].

Using γ- rays has been approved as an effective and noteworthy process for growth prohibition of microorganisms and for disinfestations of insects to have unharmed food/feed as well as facilitate international trade across the borders. This process can help to guarantee food safety to healthy and vulnerable consumers, phytosanitary requirements and controlling significant damages through commercialization and transportation. Gamma irradiation was used for decontamination of foods/feed and is a hopeful technique that could be used to the end product. This mechanization has the feature that it can be applied to frozen, fresh, or stewed products to extended shelf life. It is an environmentally clean, safe, and effective method [14].

Therefore, the present study aims at investigating the effectiveness of γ- irradiation processing at different doses on anti-nutritional factors and total phenolic compounds of MLM. The main target is to investigate the effect of irradiated MLM as a supplemented diet on male rabbit's performance, and the assessment of some biochemical blood serum aspects at the end of the experimental period.

## MATERIALS AND METHODS

### Radiation processing

Moringa leaves were air-dried on a floor, after being purchased from a local market, in a shed to avoid denaturation of the leaves. After drying, leaves were grinded to produce Moringa leaf meal (MLM), then packed in well-sealed polyethylene bags (6 kg per bag). The bags were exposed, at room temperature, to gamma radiation (doses were 0, 10, 15, and 20 kGy) at NCRRT, EAEA. All Moringa samples were stored at 4ºC until being used. The radiation dose rate was 2.60kGy/ hr.

### Determination of Phytic acid, Tannins,Trypsin inhibitor and Saponin

Wheeler and El Ferrel [15], mention the method for phytic acid determination. The tannin contents were determined using Folin Denis Reagent according to Makkar et al., [16]. While, Trypsin- inhibitor activity is measured indirectly by inhibiting the activity of trypsin. Benzyl-DL- arginine-para-nitroanailide (BAPNA) is used as synthetic substrate. The results of trypsin inhibitor activity were expressed as milligrams of pure trypsin inhibited. Meanwhile, the double solvent extraction gravimetric method was used for the Saponin content determination Harborne [17] and Obadoni and Ochuko[18].

### Determination of total phenolic content

Singleton et al. [19] have determined the total phenolic content (TPC) of extracts as GAE (mg gallic acid equivalent per gram dry weight) by the Folin-Ciocalteu reagent. The results were expressed using spectrophotometer UV/vis (AnalytikjenaSpectro D250 Germany).

### Experimental animals

Sixty weaned male rabbits (35 days age) were randomly distributed into 4 treatment groups (15 rabbits in each group) of approximately similar average weight (825 g), New Zealand White (NZW).

### Experimental design and diets

Table (1) shows the chemical analysis of MLM according to AOAC [20].

Group 1: control basal diet + 10 % non irradiated MLM

Group 2: control basal diet + 10 % irradiated MLM (10 kGy)

Group 3: control basal diet + 10 % irradiated MLM (15 kGy)

Group 4: control basal diet + 10 % irradiated MLM (20 kGy)

The relative humidity and ambient temperature average within rabbitry building at the middle of the day were 70.3% and 19.9 ºC during the autumn experimental period and 75.3% and 27.4 ºC in the summer period, respectively. The ingredients and nutrient content of the basal diet were presented in Table (2).

**Table (1): Chemical analysis of MLM (As % Dry Matter basis)**

| Chemical analysis | Dry-Matter (D.M) | Ash | Ether-Extract (E.E) | Crude-Protein (C.P) | Crude-Fiber (C.F) | Calcium (Ca) | Total Phosphorus (P) | Digestible Energy (kcal/ kg) |
|---|---|---|---|---|---|---|---|---|
| | 90.03 | 11.06 | 8.13 | 27.44 | 13.90 | 3.65 | 0.30 | 3468 |

**Table (2): Formulation of experimental basal diet**

| ingredients | % |
|---|---|
| alfalfa hay | 17.705 |
| molasses | 2 |
| Barley | 11.247 |
| Soybean meal (44%) | 15.171 |
| wheat bran | 10.47 |
| yellow corn | 30.907 |
| Moringa leaves meal (MLM) | 10 |
| limestone | 0.7 |
| sodium chloride | 0.3 |
| vitamin and minerals premix* | 0.3 |
| Di-calcium Phosphate (DCP) | 1.2 |
| Total | 100 |
| Calculated analysis** | --- |
| Crude protein | 17.90 % |
| Crude fiber | 9.06% |
| Ether extract | 2.92% |
| Digestible energy (kcal/kg) | 2800.00 |

*** Vit. A (10.000 IU), Vit.D3 (900 IU ), Vit.K (2mg ), Vit.E (50 mg ), Vit.B1(2mg ), Vit.B2 (6 mg), Vit.B6 (2 mg ), Vit. B12 (0.01 mg ), Panathonic acid (20 mg ), Niacin (50 mg ), Folic acid (5mg ), Biotin (1.2 mg ), Choline (12000 mg), Copper (3 mg ), Iodine (0.2 mg ), Iron (75 mg ), Manganese (30 mg ), Zinc (70 mg ), Selenium (0.1 mg ), Cobalt (0.1 mg ) and Magnesium (0.04 mg ). The basal diet contained of 18.18 % crude protein, 13.43% crude fiber, 2.29% ether extract, 2656.00 digestible energy (kcal/kg), **Calculated according to NRC [21] and Cheeke [22]**.

## Management and housing

In the experiment, rabbits were used in good health and free of parasites and kept in an exemplary healthy environment, and were cared for and treated according to accepted standards for humane handling of animals. The rabbits' groups were placed in well-ventilated wire cages, and the total artificial light was 16 hr/day. Stainless steel nipples were installed in each cage as a source of fresh water at all times as was the addition of food. The feed consumed was recorded weekly during the trial period, as well as the weight of rabbits was taken at the end of the experimental duration and the beginning. Body weight (g), weight gain (g), feed amount, and feed conversion ratio (g feed/ g gain) were recorded and calculated.

Once every two weeks, both respiratory rate and rectal temperature were measured in rabbits. After the end of the experiment time, three animals were randomly slaughtered from every group and blood samples were collected, then weighed carcass after removing the guts, skin, and tail. Hemoglobin concentration, red blood cells count and white blood cell count was examined immediately (Red blood cells (RBC's) and white blood cells (WBC's) were counted using a hemocytometer. Hemoglobin concentration (Hb) was determined calorimetrically in fresh blood samples using readymade kits (Diamond Diagnostics, Egypt). Then the serum were separated after centrifugation (3000 rpm / 20 min) and reserved at -20 ºC till analyses. Total cholesterol, total lipids, GPT, GOT, total protein, albumin, and blood concentration of urea in serum were determined by the procedure of commercial kits (Bio Merieux, France). The globulin concentration = Total protein - Albumin value.

## Digestibility

Three rabbits were randomly selected from each treatment at the end of the trial period (8 weeks) and were fasted for 24 hours. Each rabbit was placed in a metabolism cage for three days, with feed and water being given to determine experimental feeding values and nutrient digestibility factors. The amount of feed consumed was calculated, the feces was collected on a tray every 24 hours, then dried and weighed. Feces from each rabbit were placed in a screw-bottle container for analysis. The dry matter, crude proteins, ether extract and ash were determined according to [20]. The nutritional value of the various components and the digestibility parameters of the nutrients were calculated. Water was given to determine

experimental feeding values and nutrient digestibility factors. The amount of feed consumed was calculated, the excrement was collected on a tray every 24 hours, then dried and weighed. Dried feces from each rabbit were placed in a screw-bottle container for analysis. The nutritional value of various components and the digestibility parameters of the nutrients were calculated.

**Statistical analysis**

The data were statistically analyzed through the SPSS Program [23].A simple one-way analysis was used. Mean differences between treatments were examined through Duncan's multiple range test Duncan [24].

## RESULTS AND DISCUSSION

### Influence of γ- radiation on anti-nutritional factors and total phenolic compound of MLM

Table (3) demonstrates a significant diminution in the anti-nutritional factors (phytic acid, tannins, trypsin-inhibitor and saponin) content of MLM as a result of exposing to γ- irradiation treatments. The decrease was proportional to the rising of radiation doses (A negative correlation was found between γ-irradiation doses and anti-nutritional factors). The highest diminished on anti-nutritional factors was observed in irradiated MLM at 20 kGy.

Similar results were noticed by other authors [25,26], who mentioned that γ-irradiation is fit to diminish anti-nutritional substances particularly phytic acid as well as trypsin inhibitor. Since phytic acid is associated with minerals and protein, forming insoluble compounds, which results in diminishing protein digestibility in the small intestine and the bioavailability of trace minerals [11]; [12], its removal with radiation may boost the nutritional value of canola seeds. This decrease of phytic acid by radiation is probably due to chemical declination of phytate to lower inositol phosphates and inositol by the action of free radicals, which have lower chelating power or cleavage of the phytate ring itself [27].

Gaber (2005)[28] found that γ-irradiation changed the ordered structure of proteins to the denature form. Mallikarjunan et al.[29] reported that irradiation at doses up to 100 kGy in a dry state exhibited a loss in trypsin inhibitor activity through a diminished intensity band of the protein and without the appearance of any fragmented or cross-linked products. Furthermore, the diminished trypsin-inhibitor activity in irradiated rice bran might be attributed to the breakdown of disulfide bonds [30].

Rousta *et al.* [31] found that radiation processing at 10, 20 and 30 kGy caused considerable ($P<0.05$) diminution in tannins and phytic acid content of sorghum grain. Besides, γ-irradiation has significantly diminished the tannins content of sorghum and maize grains [32]. On the other hand, [33] reported that the reduction mechanism of tannin contents increase by dose increasing and may be related to the chemical degradation of the free radicals which formed by irradiation. Gao et al.[34] treated fresh ginseng with both gamma and electron beam irradiation at 2 and 4 kGy, they found that the total saponin content declined with an escalating in the irradiation dose. Shiddhuraju et al.[11] found that γ-irradiation at 6 kGy caused a significant diminishing in saponin of that different species of unconventional legume such as Sesbania and Vigna. A potential mechanism for the diminished is the breakdown of the glycosidic linkages in oligosaccharides by gamma irradiation which increase free monosaccharides and the level of free sugars in mung bean. The total soluble carbohydrates were increase about 5 times in irradiated samples particularly at high dose as the result of increasing total reducing sugars after irradiation[35].

Table (3) also shows the results of total phenolic content (TPC). Total phenolic content means of irradiated MLM were significantly ($p < 0.01$) better than that for non-irradiated MLM. TPC tended to increase ($p < 0.01$) with an escalating in -irradiation doses (A positive correlation was found between irradiation doses and TPC). The highest amount of TPC was observed in irradiated MLM at 20 kGy as compared to the lowest in the control (non-irradiated) sample. Abolhasani et al.[36] studied the impact of gamma irradiation on the TPC extract of Pistachio green hull and found that gamma irradiation at 30 kGy significantly increased TPC as its value were more than a non-irradiated sample. An increase in - irradiation, might be attributed to a rise in the availability of TPC prompt by of TPC due to their release from glycosidic components and the declination of great phenolic compounds into tiny ones by irradiation [37].

**Table (3): Effect of γ- irradiation on anti-nutritional factors and total phenolic compound of MLM**

| Dose / Item | Control MLM (non-irradiated) | Irradiated MLM (kGy) | | | Sig |
|---|---|---|---|---|---|
| | | 10 | 15 | 20 | |
| **Anti-nutritional factors:** | | | | | |
| Phytic acid % | 7.028[a] ±0.008 | 5.80[b] ±0.084 | 4.82[c] ±0.041 | 3.79[d] ±0.054 | ** |
| Tannins % | 2.33[a] ±0.060 | 2.03[b] ±0.033 | 1.81[c] ±0.049 | 1.69[c] ±0.087 | ** |
| Trypsin-inhibitor % | 0.94[a] ±0.003 | 0.89[b] ±0.015 | 0.76[c] ±0.025 | 0.31[d] ±0.006 | ** |
| Saponin % | 6.10[a] ±0.208 | 5.40[b] ±0.057 | 4.87c ±0.185 | 3.67[d] ±0.120 | ** |
| **Total phenolic compound (mg/100g-gallicacid equivalent)** | 82.48[d] ±0.289 | 99. 5[c] ±0.293 | 105.76[b] ±0.220 | 120.73 [a] ±0.312 | ** |

**Means within the same row bearing different letters differ significantly (P≤0.05). ** = P<0.01, sig: significance**

**Table (4): Animal weight and gain weight (0-8 weeks; ±SE) of rabbits as impacted by dietary supplemented with irradiated MLM**

| Dose / Item | Basal diet supplemented with MLM (non-irradiated) | Basal diet supplemented with irradiated MLM (kGy) | | | Sig |
|---|---|---|---|---|---|
| | | 10 | 15 | 20 | |
| $W_0$ | 832.1[a]±8.3 | 824.6[a]±8.0 | 829.1[a]±7.9 | 828.9[a]±7.2 | N.S |
| $W_4$ | 1429.5[c] ±10.1 | 1504.9[b]±10.8 | 1543.6 [a] ±11.0 | 1556.6 [a]±10.1 | * |
| $W_8$ | 1865.9[c] ±21.3 | 1962.5[b]±19.8 | 1997.9 [b]±23.1 | 2053.7 [a] ±11.1 | ** |
| $G_{0-4}$ | 598.4 [c]±0.9 | 680.3 [b]±0.6 | 714.5[ab]±0.8 | 727.7 [a] ±0.5 | ** |
| $G_{4-8}$ | 436.46[c]±0.7 | 457.6[b]±0.9 | 454.3 [b]±0.8 | 497.1 [a]±0.7 | ** |
| $G_{0-8}$ | 1033.8[c]±0.9 | 1139.9 [b]±1.2 | 1168.8 [b]±0.8 | 1224.8 [a] ±1.1 | ** |

**Means within the same row bearing different letters differ significantly (P≤0.05). ** = P<0.01, * = P<0.05, W: week, $w_0$: initial animal weight , $w_4$ animal weight at 4th week , $w_8$: animal weight at 8th week ,G: gain, $G_0$-$G_4$ : body weight gain from the beginning of experimental until the 4 th week, $G_{4-8}$ body weight gain from 4th week of the experiment till week 8, $G_0$-8 the overall body weight gain (body weight gain from starting of experimental until the end of the experiment), Sig: Significance, N.S. = Non-significant**

**Impact of experimental treatments on rabbit's performance**

**1-Live body weight and gain weight (g)**

Data in Table (4) indicate that there was a significant (P<0.05) growing in the mean live body weight of rabbits kept on diets supplemented with irradiated 10 % MLM for 4 weeks. Whereas, a highly significant (P<0.01) growing in live body weight of rabbits kept on diets supplemented with irradiated 10% MLM was observed at the end of the experimental period (week 8), and the increase was parallel with the escalating radiation dose. Meanwhile, diets containing 10 % irradiated MLM significantly (P<0.01) enhanced the weight gain of rabbits in comparison with those kept on a control diet supplemented with non-irradiated MLM at 4 and 8 weeks, and the improvement was parallel to the -irradiation dose. The negative effects of non-irradiated MLM on rabbit's performance were associated with the presence of phytic acid, tannin, and trypsin-inhibitor. These indicate that the irradiation process could ameliorate the nutritional value of feed through

depreciation or elimination of the toxins and anti-nutritional compounds and subsequently, increase the rabbit's growth performance. [38] reported that anti-nutritional factors like phytic acid, non-starch poly-saccharides, and trypsin-inhibitor in rice bran attenuate broiler chicks growth performance. Phytate is an ionic reactant that can depress mineral availability through minerals integrating and hence degrades their solubility and reduce the digestibility of amino acid [39]. This effect indicated that γ-irradiation is efficient to hydrolyze the anti-nutritional bonds and indigestible compounds to a more simple form within MLM which seems to lead to better digestion in the rabbit's gastrointestinal tract. [40].

**2- Feed consumed, feed conversion, water consumed, rectal heat and respiration rate**

Data in Table (5) reveled that no considerable ($P < 0.05$) variations in water consumed and feed consumed of rabbits kept on diet supplemented with irradiated MLM compared to control group kept on diet supplemented with control (non-irradiated) MLM. But, feed conversion ratio of rabbits kept on diet supplemented with 10% irradiated MLM has a significant ($P<0.05$) difference in comparison to their control counterpart.

Feed conversion enhancement was observed for γ-irradiation groups', and the enchantment was parallel diets supplemented with MLM subjected to symmetric with the escalating radiation dose. The better feed conversion was recorded for a rabbit kept on diets supplemented with irradiated MLM at 20 kGy. This is attributed to the observed lower feed intake or consumed and higher weight gain in rabbits kept on diets supplemented with irradiated MLM. Moreover, there were no significant differences in rectum temperature and respiration rate among all studied groups. These findings are in harmony with those of other investigators [41] who found that no considerable variation in water consumption, feed consumption, rectal heat, and respiration rate of growing rabbits kept on a diet supplemented with gamma-irradiated (10,20 and 30 kGy) Distillers Dried Grains (DDGS) compared to those groups fed diet supplemented with non-irradiated DDGS. Besides, they added an improvement in the feed conversion ratio of animals that kept on a regimen complemented with irradiated DDGS up to 30 kGy compared to their control counterpart, and the amelioration was a function of the radiation dose.

**Apparent digestibility**

Table (6) shows a significant enhancement for the digestibility of dry matter, crude protein and crude fiber of rabbits kept on diets supplemented with irradiated MLM, while no remarkable effect on ether extracts. While no notable effect on ether extracts. Rabbits supplemented with MLM (20 kGy) have the highest significant ($P < 0.05$) increase in digestibility

**Table (5): Feed consumed, feed conversion, water consumed and water/ feed ratio, rectal heat and respiration rate of rabbits as impacted by dietary supplemented with irradiated MLM**

| Item \ Dose | Basal diet supplemented with MLM (non-irradiated) | Basal diet supplemented with irradiated MLM(kGy) | | | Sig |
|---|---|---|---|---|---|
| | | 10 | 15 | 20 | |
| Feed consumption (g/day) | $78.0^{a} \pm 4.6$ | $74.2^{a} \pm 3.1$ | $79.0^{a} \pm 3.9$ | $72.5^{a} \pm 3.7$ | N.S |
| Feed conversion(g feed /gain) | $4.2^{a} \pm 0.03$ | $3.7^{b} \pm 0.04$ | $3.8^{ab} \pm 0.02$ | $3.3^{c} \pm 0.02$ | * |
| water consumption (ml /day) | 130.6±5.4 | 125.7±4.2 | 128.4±4.1 | 133.5±5.1 | N.S |
| Water/ feed ratio | 1.08 | 1.03 | 1.15 | 1.13 | - |
| Rectal heat (RH) (°C)\| | $39.8^{a} \pm 0.08$ | $39.6^{a} \pm 0.05$ | $39.5^{a} \pm 0.07$ | $39.5^{a} \pm 0.08$ | N.S |
| Respiration rate (RR)(Respirations/minute) | $99^{a} \pm 1.6$ | $98^{a} \pm 1.3$ | $99^{a} \pm 1.7$ | $98^{a} \pm 1.6$ | N.S |

**Means within the same row bearing different letters differ significantly (P≤0.05) * = P<0.05 and Sig: Significance, N.S = Not significant**

**Table (6): Apparent digestibility of rabbits as impacted by dietary supplemented with irradiated MLM.**

| Dose / Item | Basal diet supplemented with MLM (non-irradiated) | Basal diet supplemented with irradiated MLM (kGy) | | | Sig |
|---|---|---|---|---|---|
| | | 10 | 15 | 20 | |
| Dry matter (DM) | 72.9 $^{c}$±5.2 | 75.5 $^{bc}$±6.4 | 77.6 $^{b}$±4.8 | 81.1 $^{a}$ ±5.7 | * |
| Crude protein (CP) | 69.6 $^{c}$±8.3 | 73.7 $^{c}$±8.1 | 79.0 $^{b}$±7.1 | 83.2$^{ab}$ ±8.7 | * |
| Crude fiber (CF) | 58.1 $^{b}$±2.1 | 61.0 $^{b}$±2.6 | 63.2 $^{ab}$±2.9 | 64.7 $^{a}$ ±3.2 | * |
| Ether Extract (EE) | 71.3$^{a}$±10.9 | 72.7$^{a}$±12.0 | 73.2$^{a}$±11.6 | 74.1$^{a}$ ±13.1 | N.S |

**Means within the same row bearing different letters differ significantly (P≤0.05). * = P<0.05 and Sig: Significance, N.S = Not significant**

Regarding dry matter and crude fiber digestibility, this research was in contrast with the results of [42] who showed that broilers fed a diet containing 10% or 20 % with gamma -irradiated (20 kGy) flaxseed significantly (P < 0.05) improved dry matter and organic matter digestibility compared to birds kept on a diet containing raw flaxseed which had lower digestibility. Each glucose unit in the cellulose cell has two hydrogenic bonds. These bonds were stabilized and parallel chains. Gamma radiation affected these bonds and the formation of carbonyl groups of cellulose in the existence of oxygen that helps break down of cellulose and spiking digestibility by a breakdown of hydrogen bonds and free radicals [41]. Gamma rays lead to the hydrolysis of the glycosidic bond.

Concerning apparent crude protein digestibility, a study on fava bean seeds [43] found a significant increase in in-vitro protein digestibility than the non-irradiated one. This could be referred to the inactivation of anti-nutritional factors like phytic acid, tannin, and trypsin-inhibitor [44]. The amelioration in digestibility of protein after exposure to irradiation might be referred to the diminished activity of protein inhibitors [45]. The non-covalent bonds, hydrogen, and disulfide play an important role in stabilizing protein structure. Gamma radiation generates free radicals that attack protein molecules and may cause breaking of some bonds in protein polypeptide chains which lead to enhancing proteolysis and improving digestibility [46].

## Carcass body traits

Table (7) shows the results of carcass body traits (carcass weight, dressing %, and prime cuts %). There was a significant (P<0.01) rising in carcass traits of rabbits kept on a diet supplemented with gamma -irradiated MLM at 10, 15, and 20 kGy compared to those kept on a diet supplemented with non-irradiated MLM. they increased gradually with the escalating radiation dose. This is attributed to the observed enhancing of apparent digestibility of crude protein, crude fiber, and dry matter of irradiated MLM and the consequent enhancement of growth performance.

**Table (7): Carcass body traits of rabbits as impacted by dietary supplemented with irradiated MLM**

| dose / Item | Basal diet supplemented with MLM (non-irradiated) | Basal diet supplemented with irradiated MLM(kGy) | | | Sig |
|---|---|---|---|---|---|
| | | 10 | 15 | 20 | |
| Carcass weight (g) | 990.8 | 1119.1 | 1182.6 | 1192.2 | ** |
| Dressing (%) | 53.1 | 57.02 | 59.2 | 58.1 | - |
| Prime cuts (%) | 49.4 | 51.1 | 54.3 | 55.7 | - |

**Means within the same row bearing different letters differ significantly (P≤0.05) ** = P<0.01, Sig: Significance, N.S = Not significant**

## Biochemical parameters and hematological of rabbits blood

Blood attributes mirror the physiological responsiveness of the animal to its inner and exterior environments which provides beneficial data for an estimate of the health condition of animals. According to the blood chemistry presented in Table (8), GPT, GOT as liver enzymes did not show any significant change between those rabbits kept on a control diet contains 10% MLM and those kept on a diet supplemented with

10% irradiated MLM up to 20 kGy. Moreover, Table (8) shows that total protein, albumin, globulin, total lipids, total cholesterol, blood urea were also not significantly affected (P>0.05) by the dietary supplement of Moringa leaf meal (MLM) across the treatment either non treated or subjected to γ- radiation up to 20 kGy.

Hematological constituents are useful in control food and feed toxicity particularly with feed ingredients that affect the formalization of blood [47]. As shown in Table (8), all the hematological blood parameters(RBCs, WBCs, and HB %) were not significantly affected by the dietary treatments of rabbits kept on a control diet (10% non-irradiated MLM), and those kept on the diet - irradiation at 10, 15 and supplemented with MLM treated with 20kGy.

In conclusion, the results of the present work showed that gamma irradiation can be used safely for the increment of the digestibility and absorption of nutrients through diminished tannins, phytic acid and trypsin inhibitor content of MLM could interact with proteins. Therefore, enhanced feed conversion and weight gain in growing rabbits occurred without any deleterious impact on biochemical parameters.

**Table (8): Serum biochemical parameters (±SE) of growing rabbits as impacted by dietary supplemented with irradiated MLM**

| Item \ Dose | Basal diet supplemented with MLM (non-irradiated) | Basal diet supplemented with irradiated MLM (kGy) | | | Sig |
|---|---|---|---|---|---|
| | | 10 | 15 | 20 | |
| **Serum enzymes** | | | | | |
| GPT (U/L) | 3.8$^{a}$±0.3 | 4.1$^{a}$±0.7 | 4.0$^{a}$±0.3 | 4.0$^{a}$±0.2 | N.S |
| GOT (U/L) | 4.2$^{a}$±0.1 | 4.1$^{a}$±0.5 | 3.7$^{a}$±0.4 | 3.9$^{a}$±0.3 | N.S |
| **Serum analysis** | | | | | |
| Total protein (g/100ml) | 6.8$^{a}$±0.2 | 6.2$^{a}$±0.3 | 6.7$^{a}$±0.2 | 6.9$^{a}$±0.5 | N.S |
| Albumin (g/100ml) | 3.8$^{a}$±0.3 | 4.2$^{a}$±0.7 | 3.9$^{a}$±0.3 | 4.1$^{a}$±0.2 | N.S |
| Globulin (g/100ml) | 3.2$^{a}$±0.2 | 4.1$^{a}$±0.5 | 2.7$^{a}$±0.4 | 2.9$^{a}$±0.3 | N.S |
| Total lipids (mg/100ml) | 659.1$^{a}$±75.1 | 640.2$^{a}$±49.2 | 635.3$^{a}$ ±59.1 | 655.7$^{a}$±32.2 | N.S |
| Total cholesterol (mg/100ml) | 165.2$^{a}$±18.7 | 158.6$^{a}$±39.9 | 164.1$^{a}$±35.0 | 169.9$^{a}$±27.6 | N.S |
| Blood Urea (mg/100ml) | 18.7$^{a}$±1.8 | 19.6$^{a}$±2.7 | 17.8$^{a}$±4.2 | 19.9$^{a}$±7.0 | N.S |
| **Blood hematology** | | | | | |
| RBCs | 5.6$^{a}$±0.4 | 5.7$^{a}$±0.9 | 6.0$^{a}$±0.7 | 5.8$^{a}$±0.3 | N.S |
| WBCs | 7.1$^{a}$±1.3 | 7.4$^{a}$±1.6 | 6.9$^{a}$±01.5 | 6.4$^{a}$±1.1 | N.S |
| HB % | 12.1$^{a}$±1.6 | 10.9$^{a}$±1.8 | 11.1$^{a}$±0.9 | 11.6$^{a}$±1.0 | N.S |

**Means within the same row bearing different letters differ significantly Sig: Significance, N.S = Not significant**

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