Modulation of Radiation Injury by *Physalis Peruviana*

Nadia N. Osman[1,2], Madeha N. AL-seeni[1], Mayson H. Alkhatib [1] and Hanaa A. Al-shreef [1]

[1]Biochemistry Department, Faculty of Science, King Abdulaziz University, KSA
[2]Food Irradiation Research Dep. National Center for Radiation Research and Technology, Atomic Energy Authority, Cairo, Egypt
nmahmod@kau.edu.sa

Abstract: Radiation therapy is considered to be one of the most popular and important therapeutic modalities for the cure of cancer. During radiotherapy, ionizing irradiation interacts with biological systems to produce free radicals, which attacks various cellular components. The present study clarifies the efficacy of cape gooseberries (*Physalis peruviana*) in reducing gamma- irradiation- induced oxidative damage to the liver, lipid profile and antioxidant enzymes in adult male rats. Rats were exposed to whole body gamma radiation (2 Gy /week up to total dose of 6 Gy) and fed on basal diet supplemented with 15% of *Physalis powder* (Ph p.), one week before irradiation and during the period of radiation exposure. Animals were randomly divided into four groups as following: Normal control, Ph p, irradiated and Ph p + irradiated. The results demonstrated that irradiation of rats induced a significant increase in lipid peroxides level measured as thiobarbituric acid reactive substances (TBARS) and xanthine oxidase (XO) concomitant with a significant decrease in superoxide dismutase (SOD), catalase (CAT) activity, glutathione (GSH) and xanthine dehydrogenase (XDH) content in liver tissues. In parallel, significant increases in serum enzymes aspartate transferase (AST), alanine transferase (ALT), alkaline phosphatase (ALP) and gamma - glutamyl transpeptidase (γ-GT) as well as serum bilirubin were recorded. While serum total protein (T.P) and albumin (Alb) were decreased. Furthermore, alteration in lipid profile manifested by a significant increase in triglycerides (TG), total cholesterol (TC), and low density lipoprotein cholesterol (LDL-C), and a significant decrease in high density lipoprotein cholesterol (HDL-C), were observed. *Physalis powder* pretreatment has significantly improved the oxidant/antioxidant status, which was associated with reduced the severity of liver damage. It is concluded that Ph p has a protective effect against gamma-irradiation induced hepatotoxicity through antagonizing the free radicals generation beside enhancement of the antioxidant defense mechanisms.
[Nadia N. Osman, Madeha N. AL-seeni, Mayson, H. Alkhatib and Hanaa W. Al-shreef. **Modulation of Radiation Injury by *Physalis Peruviana*.** *Life Sci J* 2013;10(4):3403-3410] (ISSN: 1097-8135). http://www.lifesciencesite.com. 508

Keywords: radiation, *Physalis peruviana*, liver, liver function tests, lipid profils, oxidative stress

1.Introduction

The effective use of radiotherapy in cancer cure and palliation is compromised by the side-effects resulting from radiosensitivity of bordering normal tissues, which are invariably exposed to the cytotoxic effects of ionizing radiation during treatment **(Rahman and Parvin, 2014)**. Ionizing radiation inflicts its adverse effects through the generation of an abnormal increase in reactive oxygen species (ROS) levels that unleash large-scale destruction or damage of various biomolecules **(Moritake *et al*., 2003 and Yusuf *et al*., 2011).**These free radicals react with body tissues and generate lipid peroxidation, DNA lesions and enzyme inactivation, thus leading to the alteration and impairment of function of all cellular components leading to apoptosis **(Ciriolo, 2005).**

Protection of normal tissue and organs during radiotherapy is still a matter of special concern. Amelioration of the deleterious effects of ionizing radiations using synthetic compounds causes undesirable side effects. Therefore, intervention of plant extracts, herbal preparations and natural agents could be the most prudent strategy to develop nontoxic and the most effective drugs to protect the human beings against harmful effects of ionizing radiation. Recently, focus has shifted to test the radioprotective potential of plants and herbs **(Jajetia, 2007).**

Berries have been shown to provide health benefits because of their high antioxidants, vitamins, minerals and fiber **(Zhao, 2007).** Cape goose- berry (*Physalis peruviana*) is a fruit that belongs to the Solanaceae family has been grown in Egypt, South Africa, India, New Zealand, Australia and Great Britain **(Ramadan and Mörsel, 2003; 2004).** It has been used as a folk medicine with antiinflammatory, antitussive, antipyretic, diuretic, antidotal and antitumor effects in Taiwan **(Lee *et al.*, 2008).** Plant extracts show antioxidant activity (**Ramadan and Mörsel, 2009; Valdenegro *et al*., 2012; Ramadan, 2012; Puente *et al*., 2010; Ramadan and Mörsel, 2007**), anti-inflammatory activity (**Wu *et al*., 2006, Chang *et al*., 2008, Arun and Asha, 2007)** and anti-

hepatotoxic (**Chang *et al*., 2008)** and antiproliferative effects on hepatoma cells (**Wu *et al*., 2005)**. In addition, this fruit has excellent potential as a food-based strategy for anti-diabetic and anti-hypertensive products (**Pinto *et al*., 2009).**

Physalis peruviana contains biologically active components e.g. physalins, withanolides, phytosterols and polyunsaturated fatty acids e.g. linoleic acid and oleic acid. Among its major components are high amounts of vitamins A, B and C as well as the presence of essential minerals, magnesium, calcium, potassium, sodium and phosphorus which are classified as macronutrients, while the iron and zinc are considered as micronutrients **(Szefer and Nriagu, 2007).** Furthermore, **Ramadan (2011)** has been added that Cape gooseberry pulp, seed and pomace oils might serve as excellent dietary sources for vitamin K1, α-linoleic acid, essential fatty acids, tocopherols and carotenoids.

The present study aims to investigate the possible radioprotective effect of *Physalis peruviana* against Radiation -induced hepatotoxicity and oxidative stress.

2. Materials and Methods

2.1. Preparation of *Physalis* powder:

Fresh fruits of Goldenberries (*Physalis peruviana)* were purchased from local market. The fruits were washed with water, crushed and dried in air oven at 50ºc then grinded to powder form. *Physalis* powder was added in basal diet as 15 % in substitution of fiber.

2.2. Animal and Housing:

This study was carried out on twenty eight young male albino rats weighing 150 ± 20 g obtained from the animal house of the National organization for Drug Control and Research. Rats were housed under controlled climatic conditions (25°C, 40–70 RH), and 12 h/12 h light/dark cycle prior to subjection to experimental protocols. All rats were fed on a standard diet and water *ad libitum.* All animals were treated and handled according to the principles of laboratory animal care.

2. 3. Irradiation:

Gamma – irradiation was performed at the National Centre for Radiation Research and Technology (NCRRT), Cairo, Egypt, using a ^{137}Cesium biological irradiator source (γ-cell-40) Atomic Energy of Canada Limited. Rats were exposed to 6 Gy whole body γ-irradiation fractionated over 3 weeks (2 Gy/ week). The dose rate was 0.61 Gy/min.

2.4. Experimental Design:

The experimental animals were divided into four groups (n = 7) after adaptation period (7day), namely Group1 (control): Normal control, rats in this group were neither treated nor irradiated. Group 2(Ph p): animals fed on basal diet supplemented with 15% *Physalis* powder for 4 weeks. Group 3(IR): rats in this group were exposed to whole body gamma radiation with a fractionated dose (2 Gy / week up to 6 Gy total doses). Group 4 (Ph p + IR): animals received diet as group 2 for 7consecutive days before exposed to fractionated dose and within the period of fractionated irradiation (21 days).

2.5. Biochemical analysis*:*

Animals were sacrificed on the 7th day after the last gamma radiation. Blood samples were collected by heart puncture and serum `and stored frozen until the biochemical analysis. Liver was removed and homogenized with saline using Teflon homogenizer.

The activity of serum aspartate transaminase (AST) and alanine transaminase (ALT) were assayed by the method of **Reitman and frankel (1957)** while serum alkaline phosphatase (ALP) and gamma glutamyle transferase (γ GT) enzymes activity, were estimated according to **Kind and King (1954) and Henry (1974),** respectively.

Total bilirubin, total protein, and Albumin concentrations were measured using the methods of **Jendrassik, (1938)**, **Lowry *et al*., (1951)** and **Doumas *et al* (1977),** respectively.

Total Cholesterol (TC), triglycerides (TG) and high-density lipoprotein-cholesterol (HDL-C) were assayed according to the method of **Allain *et al*., (1974)**, **Fossati and Prencipe, (1982)** and **Demacker *et al*., (1980)**, respectively. Low-density lipoprotein-cholesterol was evaluated according to Friedwald's formula **(Friedewald *et al.,* 1972)** by the following equation: LDL-C (mg/dl) -TC-(TG/5+HDL-C). The extent of lipid peroxidation was assayed in hepatic tissue by the measurement of thiobarbituric acid reactive substances (TBARS) according to **Yoshioka *et al.,* (1979).** The content of reduced glutathione (GSH) was determined according to **Beutler *et al.,* (1963)**. Estimation of superoxide dismutase (SOD) as well as catalase activities was done in the hepatic tissue according to the methods of **Minami and Yoshikawa, (1979)** and **Bergmeyer *et al*., (1987)**, respectively. Hepatic xanthine oxidase (XO) and xanthine dehydrogenase (XDH) were determined according to **Kaminski and Jewezska (1979)**.

2.6. Statistical analysis:

The statistical package for social sciences SPSS/PC computer program was used for statistical analysis of the results. Data were analyzed using one-way analysis of variance (ANOVA) followed by Newman–Keuls post hoc test for multiple comparisons. The data were expressed as mean ±S.E.

Differences were considered statistically significant at ($P < 0.05$).

3. Results

Data demonstrated in (Table 1) showed that whole body exposure of male rats to 2 Gy /week during the three weeks induced a significant increase ($P<0.05$) in serum AST, ALT, ALP and GGT activity, compared to control rats. Treatment of irradiated rats with Ph p significantly ($p<0.05$) reduced the release of these diagnostic hepatic marker enzymes, compared to their corresponding values of irradiated rats.

Table 1: Effect of *Physalis* powder (Ph p) administration on hepatic serum markers levels in rats exposed to gamma radiation.

Parameters **Groups**	**ALT** **(IU/L)**	**AST** **(IU/L)**	**ALP** **(IU/L)**	**γ-GT** **(IU/L)**
control	31.71± 4.25[a]	73.20± 5.46[a]	69.77± 7.62[a]	2.07± 0.19[a]
Ph p	30.35± 3.14[a]	71.83± 4.68[a]	70.10± 4.10[a]	1.95± 0.12[a]
IR.	56.23± 3.41[b]	121.51±7.25[b]	102.12±5.40[b]	4.45±0.50[b]
Ph p + IR.	39.32± 3.49[c]	81.34±5.61 [c]	75.17± 4.18[a]	2.41±0.32[a]

Values are given as mean ±SE for 7 rats. Values not sharing a common superscript letter differ significantly at $P \leq 0.05$.

As shown in (Table 2), Gamma-radiation (6Gy) induced a marked increase in serum total bilirubin accompanied by a significant decrease in serum total protein and albumin levels compared to control values. Return to some normalized amelioration was observed in total bilirubin, total protein and albumin levels when the irradiated animals feeding on diet supplemented by Ph p.

Table (2): Effect of *Physalis* powder (Ph p) administration on serum total protein, albumin and bilrubin levels in irradiated rats.

Parameters Groups	T. P (g/dl)	Alb (g/dl)	Bilirubin (mg/dl)
Control	7.51±0.37[a]	3.01 ±0.18 [a]	0.43±0.06[a]
Php	7.69±0.23[a]	3.15±0.29 [a]	0.45±0.04[a]
IR.	5.95±0.25[b]	2.44±0.13 [b]	0.86±0.09[b]
Ph p + IR.	7.29±0.28[ac]	2.92±0.19 [a]	0.65±0.04[b]

Legand as in (Table 1).

Data in (Table 3) represented that rats exposed to γ - radiation showed a significant increase in serum TC, triglyceride and LDLc ($p< 0.05$), while the mean value of HDL-C was significantly decreased compared to control group.

On the other hand, treatment of irradiated rats with *Physalis* powder pre and during γ – radiation exposure showed significant amelioration in the above parameters compared to those of the irradiated rats (Table 3).

Table (3): Effect of *Physalis* powder (Ph p) administration on serum Lipid profile in rats exposed to gamma radiation.

Parameters Groups	TC (mg/dl)	TGs (mg/dl)	HDL-C (mg/dl)	LDL-C (mg/dl)
Control	127.55±3.35[a]	94.54±1.74 [a]	71.36 ±0.96 [a]	38.53±2.09 [a]
Php.	121.71±4.07 [a]	93.90±2.18 [a]	72.36±1.00[a]	35. 59±3.79 [a]
IR.	200.03±7.15 [b]	171.17±7.72[b]	35.57±0.59[b]	130.75±8.32 [b]
Ph p + IR.	148.00±4.23 [c]	119.91±4.04 [c]	47.03±0.80[c]	75.98±2.44 [c]

Legand as in (Table 1).

Whole-body gamma-irradiation increased the formation of hepatic lipid peroxides by 64 % compared to the control group (Table 4). In the present study, treatment with PhP produced a significant reduction in TBARS levels in irradiated-treated rats. Irradiated rats showed significant decreases ($P < 0.05$) in liver GSH content, SOD and CAT activities as compared to control group (Table 4). PhP supplementation before and during the period of radiation exposure showed a significant elevation in the GSH level as well as SOD and CAT activities when compared with the irradiated untreated rats.

Table 4: Effect of *Physalis* powder (Ph p) administration on hepatic TBARS, GSH, SOD and CAT in irradiated rats.

Parameters Groups	TBARS (µmol/g tissue)	GSH (mg/g tissue)	SOD (U/mg protein)	CAT (U/mg protein)
Control	112.26± 4.66[a]	36.37 ± 1.63[a]	29.10± 1.11[a]	9.49 ± 0.43[a]
Php.	105.18 ± 3.34[a]	34.52 ± 1.26[a]	30.33 ± 1.37[a]	10.02 ± 0.57[a]
IR.	175.20± 5.89[b]	20.53± 1.12[b]	18.43 ± 0.97[b]	5.19 ± 0.29[b]
Ph p + IR.	125.57± 4.93[aC]	29.24 ± 1.30[c]	23.45± 1.14[c]	9.09 ± 0.46[a]

Legand as in (Table 1).

Data in (Table 5) presented that exposure to gamma radiation (6 Gy) induced a significant increase in liver XO accompanied by a significant decrease in liver XDH compared to normal controls. Interestingly, treatment with Php in addition to radiation (group 4) lead to significant improvement in the levels of these enzymes relative to the irradiated untreated group (group 3).

Table (5): Effect of Php **supplementation to γ-irradiated rats on the level of xanthine oxidoreductase system (XO and XDH)**

Groups Parameters	Control	Php.	IR.	Ph p + IR.
XO(mU/mgprotein)	2.12±0.08[a]	2.09±0.07[a]	3.82±0.09[b]	2.73±0.06[c]
XDH(mU/mgprotein)	3.29±0.15[a]	3.25±0.14[a]	1.62±0.09[b]	2.87±0.12[c]

Legand as in Table 1.

4. Discussion

Search for effective and less toxic radioprotectors lead to increasing interest on natural compounds from dietary ingredients to medicinal herbs **(Yamini and Gopal, 2010).** The crude extracts of these plants and their preparation constitute several effective radioprotective drugs which can used for protecting patients from the side-effects of radiotherapy, as well as occupational workers in nuclear and radiation plants.

Whole body γ -radiation of rats with 2Gy / week up to a total dose of 6Gy induced a significant elevation of serum AST, ALT, ALP and γ- GT activities in rats, it indicate that radiation causes hepato-cellular damage which in turn alters the structure and function of liver cells (**Table 1**). These conclusions are in accordance with those of other studies **(Makhlouf and Makhlouf, 2012; Nwozo *et al*., 2012).** The increase in the activities of AST and ALT in the serum after exposure to γ-radiation can be attributed to the possible release of these enzymes from different tissues associated with the obstruction of the blood flow to the liver **(Park *et al.*, 2010).** Moreover, the increased in serum alkaline phosphatase may be related to the increased synthesis of it by cells lining bile canalliculi usually in response to cholestasis and increased biliary pressure **(Venkatachalam and Muthukrishnan, 2013).** The elevated γ- GT activity after radiation-exposure pointed to the destruction of cell membrane where the enzyme is attached. γ- GT, is a membrane-bound enzyme that initiates the degradation of extracellular glutathione (GSH) forming γ-glutamyl amino acid and cysteinylglycine **(El-Batal *et al*., 2008).**

Animals receiving diet supplemented with *Physalis* powder before whole body γ-radiation and during the period of radiation exposure showed a significant reduction in the severity of the liver damage by decreasing the activities of the above enzymes. These results are agreement with **(Arun and Asha, 2007 and El-Gengaihi *et al*., 2013). Chang *et al*., (2008)** who recorded that pre-treatment with *Physalis peruviana L.* (Solanaceae) aqueous extract at doses150, 300, and 600 mg/kg body weight significantly prevented the increase in serum ALT, AST and alkaline phosphatase enzymes, which are the major indicators of liver hepatitis. Moreover, **Rashwan (2012)** concluded that the decrease in serum enzymes may be due to the prevention of the leakage of intracellular enzymes by its membrane stabilizing activity.

Hypoalbuminemia is a symptom of hepatic damage. Results from the present study demonstrated that exposure to radiation led to a significant decrease in serum total protein and albumin level (**Table 2**). The obtained results were agreed with **Moulder *et al* (2004)** and **Osman (2013).** This decease may be related to significant pathology either in production of albumin by the liver or its leakage through damaged surface **(Mackiewiez *et al.*, 1992).** Moreover, the decrease in total protein of irradiated rats might be referred to either damage of vital biological processes or to changes in permeability of

liver, kidney and other tissue cells leading to leakage of proteins via the kidney **(Roushdy *et al.*, 1989).**

Data of the present study depicted that serum total bilirubin level increase post exposure to fractionated dose of gamma radiation which comes in agreement with **Osman and Hamza (2013).** Bilirubin is a waste product that results from the breakdown of hemoglobin molecules. The amount of bilirubin in blood circulation may be increased with reasons which induced destruction of red blood cells such as radiation, chemical agents and hemolytic anemia (or hemolytic disease of the newborn) **(Cavusoglu *et al.*,2010).**

Interestingly, administration of *Physalis* significantly improved the radiation-induced decline in total protein and albumin level in irradiated group. **Shariati and Zarei (2006),** observed that intraperitoneal prescription of *Physalis alkekengi* plant fruit extract induces increase in plasma proteins and albumin levels. Furthermore, Php return the level of bilirubin to be closed to control group indicated the effectiveness of the *physalis* in normalized functional status of the liver **(Yihui *et al.*, 2012).**

Exposure of animals to fractionated dose of 6Gy has induced alteration in lipid profile possibly as a result of liver injury (Table 3). These changes are in agreement with previous studies on rats **(Makhlouf and Makhlouf, 2012). Azab *et al.*, (2011a)** reported that radiation exposure is associated with induction of hyperlipidemic state which resulted from increased fat mobilization from adipose tissues due to radiation induced cellular biomembranes injury. Moreover, **Bodwen *et al.*, (1989)** stated that irradiation induces hyperlipidemia through cell membrane destruction, enhancement of lipid metabolism, cholesterol release and triglycerides synthesis.

In this study, rats fed diet supplemented with *physalis* powder caused reduction in the levels of serum cholesterol, LDL, but HDL statistically increased. This is probably due to the wealth of phytosterols in the *physalis* fruit which induce a decrease in lipoprotein cholesterol levels in total plasma **(Ramadan *et al.*, 2011).** Furthermore, **Wasan *et al.*, (2001)** has been hypothesized that these compounds provoke a decrease in cholesterol solubility and their absorption across the intestinal barrier, inducing consequently low plasma cholesterol levels. These findings are in agreement with previous studies suggested that cape gooseberry has effective in reducing cholesterol level **(Arun and Asha, 2007).**

Zarei *et al.*, (2011) concluded that the hypocholesterolemic effects of cape gooseberry are mainly due to the lycopene existing in the plant which is a strong antioxidant which inhibits the production of LDL and presumably increases the excretories through releasing cholesterol; therefore, it reduces blood cholesterol level and controls cholesterol synthesis. Recently, **Ramadan (2012)** suggested that consumption of goldenberry pomace has hypocholesterolemic activities in rats fed high cholesterol diet (HCD). In addition, goldenberry supplementation seems to protect the liver in response to oxidative stress as well as alleviate the magnitude of fatty liver development in response to HCD.

Results of the study demonstrated that exposure of rats to ionizing radiation has induced an increase in the levels of TBARS concomitant with a decrease in SOD and CAT activities and GSH content in liver tissues (Table4). These results are in agreement with **Mansour and Hafez (2012),** who recorded a significant depletion in the antioxidant system accompanied by enhancement of lipid peroxides after whole body gamma-radiation. The increase of TBARS is probably the consequence of interaction of the excess of $^{\bullet}OH$ generated in the cells after exposure to ionizing radiation with the polyunsaturated fatty acids in the phospholipids portion of cell membranes initiating the lipid peroxidation chain reaction **(Azab *et al.*, 2011b)**. The observed decrease in SOD activity suggests inactivation of the enzyme possibly due to increased superoxide radical production or an inhibition by the H2O2 as a result of corresponding decrease in the activity of CAT which selectively degrades H2O2 **(El shahat,2013).** Moreover, **Kregel and Zhang, (2007)** attributed the significant decrease in the activity of SOD and CAT might be due to the excess of ROS, which interacts with the enzyme molecules causing their denaturation and partial inactivation. The observed decrease in GSH content after irradiation may be due to the diminished activity of glutathione reductase (GR) and to the deficiency of NADPH (formed by G6PDH), which is necessary to change the oxidized glutathione to its reduced form **(Pulpanova *et al.*, 1982).** These alteration of SOD and GSH in liver tissues indicated disturbance of cellular antioxidants and increase in the production of oxygen free radicals which in turn causes lipid peroxidation that is indicated by increase in MDA level **(Kanimozhi and Prasad, 2009).**

On the other hand, rats receiving the *Physalis* powder before irradiation and within the period of radiation exposure showed a significant reduction in the level of lipid peroxides in parallel with a significant increase in antioxidant activities. This might be attributed to its high levels of polyphenols and other antioxidants like flavonoids **(Abdel Moneim and El-Deib ,2012)** ,which enhanced the process of regeneration by destruction of free radicals, supplying a competitive substrate for

unsaturated lipids in the membrane and/or accelerating the repair mechanism of damaged cell membrane (**Coskun *et al*., 2005)**. However, the administration of *physalis* to the irradiated rats were significantly reverted back TBARS levels to near normal values which show the anti-lipid peroxidative property of *physalis* in the experimental animals **(Hassan and Ghoneim, 2013).**

According to the data obtained, it appears that exposure rats to whole body gamma radiation resulted in alteration of XOR system and conversion of XDH into XO activity (Table 5). These results is consistent with the finding of **(Osman and Hamza, 2013)** who reported that, fractionated 8Gy of gamma-radiation induced a significant increase in XO activity paralleled with significant decrease in XDH activity. XOR system is shifted towards XO in case of cellular and tissue damages by radiation **(Srivastava and Kale, 1999).** In addition, **Saada et al., (2010)** reported that the significant increase in XO activity might be attributed to radiation-induced hypoxia where insufficient oxygen availability elevates calcium concentration, which activates protease capability of converting the dehydrogenase to oxidase form.

Administration of *physalis* in irradiated rats showed significant improvement in liver XOR system as compared to irradiated rats. This protective effect of *physalis* may be due to the presence of phyto-chemicals that protect the thiols from being oxidized.

In conclusion, the results of the present study indicate that the *Physalis peruviana* Linnaeus exhibited a potential hepatoprotective activity against γ-radiation induced hepatotoxicity via regulation of ROS generator in addition to direct antioxidant action of the mixture that protect the self antioxidant molecules.

References

Abdel Moneim, A. E. and El-Deib, K. M. (2012): The Possible protective effects of *Physalis peruviana* on carbon tetrachloride-induced nephrotoxicity in male albino rats. Life Science J.,9(3):1038-1052.

Allain, C.C., Poon, L.S., Chan, C.S., Richmond, W. and Fu, P.C. (1974): Enzymatic determination of total serum cholesterol. Clin. Chem., 20: 470–5.

Arun, M. and Asha, V.V. (2007): Preliminary studies on antihepatotoxic effect of *Physalis peruviana* Linn. (Solanaceae) against carbon tetrachloride induced acute liver injury in rats. J**.** Ethnopharm., 111: 110–114.

Azab, Kh. Sh., Bashandy, M. and Helal, H. (2011a): Royal jelly modulates oxidative stress and tissue injury in gamma irradiated male Wister Albino rats. N. Am. J. Med. Sci., 3(6):268-276.

Azab, Kh. Sh., Mostafa, A.H.A., Ali, E.M.M. and Abdel-Aziz, M.A.S. (2011b): Cinnamon extract ameliorates ionizing radiation-induced cellular injury in rats. Ecotoxicol Environ. Saf., 74: 2324-2329

Bergmeyer, H. U., Bergmeyer, J. and Grabi, M. (1987): In Methods of Enzymatic Analysis. 3rd ed. USA and Canada. P.273. VSH Publishers.

Beutler, E., Duron, O. and Kelly, M. B. (1963): Improved method for the determination of blood glutathione. J. Lab. Clin. Med., 61: 882-888.

Bodwen, D. A., McLea, P. and Steinmetz, A. (1989): Lipoprotein, apolipo-protein, and lipolytic enzyme changes following estrogen administration in postmenopausal women. Lipid Res., 30(12):1895-906.

Cavusoglu, K., Arica, S. C. and Kurtman, C. (2010): Alterations in serum biochemical parameters of patients with lung cancer exposed to radiotherapy. J. Enviro. Bio., 31(5): 841-844.

Chang, J.C., Lin, C.C., Wu, S.J., Lin, D.L., Wang, S.S., Miaw, C.L. and Ng, L.T. (2008): Antioxidative and hepatoprotective effects of *Physalis peruviana* extract against acetaminophen-induced liver injury in rats. Pharm. Biol., 46(10-11): 724-731.

Ciriolo, M. R. (2005): Redox control of apoptosis. Antioxid. Redox. Signal, 7: 432-5.

Coskun, O., Kanter, M., Korkmaz, A.and Quercetin, O.S. (2005): A flavonoid antioxidant, prevents and protects streptozotocin-induced oxidative stress and beta-cell damage in rat pancreas. Pharmacol. Res., 51(2): 117-123.

Demacker, P.N.M., Vos-Janssen, H.E., Hifman, A.G.M., Vant's Lear, A. and Jansen, A.P. (1980): Measurement of high-density lipoprotein cholesterol in serum: Comparison of sex isolation methods combined with enzymatic cholesterol analysis. Clin. Chem., 26: 1780–6.

Doumas, B.T.; Watson, W.A. and Biggs, H.G. (1977): Albumin standards and measurement of serum albumin with bromocresol green. Clinica. Chimica. Acta, 31: 87-96.

El shahat, A. N. (2013): Efficiency of Broccoli in Attenuating of Some Biochemical Disorders in Rats exposed to γ-irradiation. Arab J. Nuc. Sci. Applic., 46(4): 260-267.

El-Batal, A. I., Aazb, Kh. Sh., Saada, H.N., Rezk, R.G. and El-Tahawy, N.A. (2008): Ameliorating effect of yeast Glucan with zinc Bisglycinate in Histological and Biochemical changes in γ-irradiated rats. Int. J. Agri. Biol., 10:361–368.

El-Gengaihi, S. E., Hamed, M.A., Khalaf-Allah, A.M. and Mohammed, M. A. (2013): Golden Berry Juice Attenuates the Severity of Hepatorenal Injury. J. Diet. Suppl. 10(4): 357-369.

Fossati, P. and Prencipe, L. (1982): Serum triglycerides determined colorimetrically with an enzyme that produces hydrogen peroxide. Clin. Chem., 28: 2077–80.

Friedewald, W.T., Levy, R.I. and Fredrickson, D.S.

(1972): Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin. Chem., 18: 499–502.

Hassan, A. I. and Ghoneim, M. A.M. (2013): A Possible Inhibitory Effect of Physalis (Physalis pubescens L.)On Diabetes in Male Rats. World Appl. Sci. J., 21 (5): 681-688.

Henry, R. J., (1974): Clinical Chemistry, Principles and Techniques. 2nd Edition Harper and Row. P. 525.

Jajetia, G.C. (2007): Radioprotective potential of plants and herbs against the effects of ionizing radiation. J. Clin. Biochem. Nutr.,40(2): 74-81.

Jendrassik, L., (1938): Colorimetric determination of bilirubin. Biochem., 97:72-81.

Kaminski, Z.W. and Jewezska, M. M. (1979): Intermediate dehydrogenase oxidase form of xanthine oxidoreductase in rat liver. Biochem. J., 181: 177–182.

Kanimozhi, P. and Prasad, R.N. (2009): Antioxidant potential of sesamol and its role on radiation-induced DNA damage in whole-body irradiated Swiss albino mice. Environ. Toxicol. Pharmacol., 28 (2): 192–197.

Kind, P.R. and King, E.J. (1954): Estimation of alkaline phosphatase activity by determination of hydrolyzed phenol with aminoantipyrene. J. Clin. Path., 7: 322.

Kregel, K.C. and Zhang, H. J. (2007): An integrated view of oxidative stress in aging: basic mechanisms, functional effects, and pathological considerations. Am. J. Physiol. Regul. Integr. Comp. Physiol., 292: 18–36.

Lee, S.W., Pan, M.H., Chen, C.M. and Chen, Z.T. (2008): Withangulatin I, a new cytotoxic withanolide from Physalis angulata. Chem. Pharm. Bull. (Tokyo) 56, 234-236.

Lowry, O. H., Rosenbrough, N. J., Farr, A. I. and Randell, R. J. (1951): Protein measurement with the folin-phenol reagent. J. Biol. Chem., 193: 265–275.

Mackiewiez, A., Schooltink, H., Heinrich, P. and Rose-John, S. (1992): Complex of soluble human II-6 receptor/II-6 up-regulates expression of acute phase proteins", J. Immunol., 149: 2021-27.

Makhlouf, R. and Makhlouf, I. (2012): Evaluation of the effect of Spirulina against Gamma irradiation induced oxidative stress and tissue injury in rats. Int. J. App. Sci. Eng. Res., 1(1), 152-164.

Mansour, H. H. and Hafez, H. F. (2012): Protective effect of Withania somnifera against radiation-induced hepato-toxicity in rats .Ecotoxicol. Environ. Saf., 80: 14–19.

Minami, M. and Yoshikawa, H. (1979): A simplified assay method of superoxide dismutase, Clin. Chem. Acta., 92: 337.

Moritake, T., Tsuboi, K., Anzai, K., Ozawa, T., Ando. K. and Nose, T.(2003): ESR spin trapping of hydroxyl radicals in aqueous solution irradiated with high-LET carbon-ion beams. Radiat. Res., 159: 670–5.

Moulder, J.E., Fish, B.L. and Cohen, E.P. (2004): Impact of angiotensin II Type 2 receptor blockade on experimental radiation nephropathy. Rad. Res., 161: 312–7.

Nwozo, S.O., Okameme, P.E. and Oyinloye, B.E. (2012): Potential of Piper guineense and Aframomum longiscapum to reduce radiation induced hepatic damage in male Wistar rats. Radiats Biol. Radioecol., 28: 26-30.

Osman, N. N. (2013): The role of antioxidant properties of Celery against lead acetate induced hepatotoxicity and oxidative stress in irradiated rats. Arab J. Nuc. Sci. Appli., 46(1):339-346.

Osman, N. N. and Hamza, R. G. (2013): Protective Effect of Carica papaya Linn Against γ-Radiation-Induced Tissue Damage in Rats. Arab J. Nuclear Sci. Applic., 46(1): 305-312.

Park, S. H., Pradeep, K., Choi, M. H., Ko, K.and Park, H. (2010): Hesperidin and Curdlan treatment ameliorates γ-radiation induced cellular damage and oxidative stress in the liver of Sprague-Dawley rats. RJPBCS, 1 (3) : 165- 177.

Pinto, M. S., Ranilla, L.G., Apostolidis, E., Lajolo, F.M., Genovese, M.I. and et al. (2009): Evaluation of antihyperglycemia and antihypertension potential of native Peruvian fruits using *in vitro* models. J. Med. Food, 12: 278-291.

Puente, L. A., Pinto-Muñoz, C.A., Castro, E.S. and Cortes, M. (2010):*Physalis peruviana* Linnaeus, the multiple properties of a highly functional fruit: A review. Food Res. Int., 44: 1733-1740.

Pulpanova, J., Kovarova, H. and Ledvina, M. (1982): Changes of the reduced glutathione concentration and the activity of glutathione reductase in some tissue of rats gamma irradiated after the administration of cystamine. Radiobiol., 30 (3):413.

Rahman, S. and Parvin, R. (2014): Therapeutic potential of Aegle marmelos (L.)-An overview . Asian Pac. J. Trop. Dis., 4(1): 71-77.

Ramadan, M.F. (2011): Bioactive phytochemicals, nutritional value, and functi-onal properties of Cape gooseberry (*Physalis peruviana*): An overview. Food Res. Intern., 44: 1830-1836.

Ramadan, M.F. (2012): *Physalis peruviana* pomace suppresses high-cholesterol diet-induced hypercholesterolemia in rats. Grasasy. Aceites., 63 (4):411-422.

Ramadan, M.F. and Mörsel, J.T. (2003): Oil goldenberry (Physalis perviana L.). J. Agric. Food Chem., 51: 969-974.

Ramadan, M.F. and Mörsel, J.T. (2004): Goldenberry: a noval fruit source of fat soluble bioactives. Inform., 15:130-131.

Ramadan, M.F. and Mörsel, J.T. (2007): Impact of enzymatic treatment on chemical composition, physicochemical properties and radical scavenging

activity of goldenberry (*Physalis peruviana* L.) juice. J. Sci. Food Agric., 87: 452-460.

Ramadan, M.F. and Mörsel, J.T. (2009): Oil extractability from enzymatically treated goldenberry (*Physalis peruviana* L.) pomace: range of operational variables. Intern. J. Food Sci. Technol., 44: 435-444.

Ramadan, M.F., Zayed, R., Abozid, M. and Asker, M.M.S. (2011): Apricot and pumpkin oils reduce plasma cholesterol and triacylglycerol concentrations in rats fed a highfat diet. Grasas. Aceites., 62: 443-452.

Rashwan, N. M. (2012): Effect of Physalis and Choline on Lipid Profile and Antioxidant Activity in Hepatic Toxicity Rats. Aust. J. Basic App. Sci., 6(8): 654-660.

Reitmen, S. and Frankel, S. (1957): Determination of serum transaminases. Am. J. Clin. Path., 4th edition, 28: 56.

Roushdy, H. M., EI-Huseini, M. and Saleh, F. (1989): Effect of whole body gamma irradiation and/or dietary protein deficiency on the levels of plasma non-protein nitrogen and amino acids:plasma and urinary ammonia and urea in desert rodent and Albino rats. Egypt. J. Rad. Sci., Applic., 1(2): 157.

Saada, H.N., Rezk, R. G. and Eltahawy, N.A. (2010): Lycopene protects the structure of the small intestine against gamma-radiation-induced oxidative stress. Phytother. Res., 24: S204–S208.

Shariati, M. and Zarei, A. (2006): The study of physalis alkekengi extract on liver function] [dissertation]. Kazeron: Azad university of Kazeron.

Srivastava, M. and Kale, R.K. (1999): Effect of radiation on xanthine Oxido-reductase system in the liver of mice. Radiat. Res., 152: 169-175.

Szefer, P. and Nriagu, J. (2007): Mineral components in foods. CRC Press – Taylor & Francis, FL, 480 pp.

Valdenegro, M., Fuentes, L., Herrera, R. and Moya-Leon, M.A. (2012): Changes in antioxidant capacity during development and ripening of goldenberry (*Physalis peruviana* L.) fruit and in response to 1-methylcyclopropene treatment.Postharvest. Biol. Technol., 67: 110-117.

Venkatachalam, U. and Muthukrishnan, S. (2013): Hepatoprotective activity of *Desmodium gangeticum* in paracetamol induced liver damage in rats. Biomed. Prev. Nut., 3(3):273-277**.**

Wasan, K.M., Najafi, S., Wong, J., Kwong, M. and Pritchard, P.H.(2001): Assessing plasma lipid levels, body weight, and hepatic and renal toxicity following chronic oral administration of a water-soluble phytostanol compound, FM-VP4, to gerbils. J. Pharm. Sci., 4: 228–234.

Wu, S.J., Ng, L.T., Huang, Y.M., Lin, D.L., Wang, S.S. and et al. (2005): Antioxidant activities of Physalis peruviana. Biol. Pharm. Bull., 28: 963-966.

Wu, S.J., Tsai, J.Y., Chang, S.P., Lin, D.L., Wang, S.S. and et al. (2006): Supercritical carbon dioxide extract exhibits enhanced antioxidant and anti-inflammatory activities of Physalis peruviana. J. Ethnopharmacol., 108: 407-413.

Yamini, K. and Gopal, V. (2010): Natural Radioprotective Agents against Ionizing Radiation – An Overview. International Journal of PharmTech Research, CODEN (USA): IJPRIF, ISSN: 0974-4304, 2(2): 1421-1426.

Yihui, Y., Xianmei, P., Mingyu, Z., Xiaodan, W., Bing, X., Jiuxin, Z., Zhiwei, F., Yunlong, H., Yanjie, L. and Baofeng, Y. (2012): Bioactivity-guided fractionation of the triglyceride-lowering component and in vivo and in vitro evaluation of hypolipidemic effects of Calyx seu Fructus Physalis. Lipids Health Dis., 11: 38.

Yoshioka, T., Kawada, K., Shimada, T. and Mori, M. (1979): Lipid peroxidation in maternal and cord blood and protective mechanism against activated oxygen toxicity in the blood. Am. J. Obstet. Gynecol., 35: 372.

Yusuf, S.W., Sami, S. and Daher, I.N.v(2011): Radiation-induced heart disease: a clinical update. Cardiol. Res. Pract., 10.4061/ 2011/317659.

Zarei, A., Ashtiyani, S.C., Rasekh, F., Mohammadi, A. and Jabary, A. (2011): The effects of Physalis Alkekengi extract on lipids concentrations in rats. Arak. Medical University J. (AMUJ), 14(55): 36-42.

Zhao, Y. (2007): Berry fruit, value-added products for health promotion. Ed by Zhao Y, CRC press, NW (USA). ISBN-10: 0-8493-5802-7.

12/11/2013