



## ***Foeniculum vulgare* Mill. Essential Oil Attenuates some Biochemical Disorders Induced by $\gamma$ -irradiation in Male Rats**

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Received:05/09/2010.

Accepted:28/10/2010.

### **ABSTRACT**

This study was conducted to evaluate the modulating efficacy of prolonged oral administration of *Foeniculum vulgare* Mill. essential oil (FEO) against  $\gamma$ -rays-induced biochemical changes in rats. To achieve the ultimate goal of this study, 32 rats were used, divided into 4 groups. Control group, Irradiated group with a single dose (6.5 Gy), and sacrificed after 7 days of irradiation, group 3 received FEO (250 mg/kg b.wt) for 28 successive days by gavages and group 4 received treatment of FEO for 21 days, then was exposed to  $\gamma$ -rays (6.5Gy), followed by treatment with FEO 7 days later to be 28 days. Animals were sacrificed at the end of the experiment. Transaminases (AST, ALT), alkaline phosphatase (ALP) and total bilirubin, lipids (cholesterol, triglycerides), proteins profile (total protein, albumin, globulin, and A/G ratio) as well as levels of urea, creatinine and testosterone were determined in serum. Rats exposed to  $\gamma$ -rays exhibited a profound elevation of AST, ALP, bilirubin, urea and creatinine levels and lipid abnormalities. Noticeable drop in serum total protein, albumin and testosterone levels were recorded. Rats treated with FEO before and after whole body  $\gamma$ -rays showed significant modulation in AST & ALT, ALP, bilirubin, urea, creatinine and lipids and noticeable improvement in the protein profile levels. It could be concluded that FEO has a beneficial protective potentials against radiation-induced some oxidative stress and biochemical perturbations.

**Keywords:** *Fennel, antioxidant enzymes, rats,  $\gamma$ -rays.*

### **INTRODUCTION**

Exposure to ionizing radiation causes many health hazardous effects. Such exposure produces biochemical lesions that initiate a series of

physiological symptoms. Reactive oxygen species (ROS) such as superoxide ( $O_2^-$ ), hydroxyl radical ( $OH^\cdot$ ) and hydrogen peroxide ( $H_2O_2$ ) created in the aqueous medium of living cells during irradiation cause lipid peroxidation in cell membrane and damage to cellular activities leading to a number of physiological disorders situation and dysfunction of cells and tissues<sup>(1, 2)</sup>. Ionizing radiation passing through living tissues generates free radical that can induce DNA damage. The damaging effects of ionizing radiation on DNA lead to cell death and are associated with an increased risk of cancer<sup>(3)</sup>.

Many plants sources, natural occurring antioxidant compounds have been identified as free radical or reactive oxygen scavengers<sup>(4)</sup>. Recently, interest has increased considerably in natural occurring antioxidant for use in foods or medicinal materials to replace synthetic antioxidants, which are being restricted due to their side effects such as carcinogenicity<sup>(5)</sup>. Natural antioxidants can protect the human body from free radicals and retard the progress of many chronic diseases as well as retard lipid oxidative rancidity in foods<sup>(6, 7)</sup>. Plant tissue is the main source of  $\alpha$ -tocopherol, ascorbic acid, carotenoids and phenolic compounds<sup>(8)</sup>. Flavonoids and other plant phenols have been reported to have multiple biological effects such as antioxidant activity, anti-inflammatory action, inhibition of platelet aggregation and antimicrobial activity<sup>(9, 10)</sup>.

Fennel (*Foeniculum vulgare* Mill. family *umbelliferae*) is an annual, biennial or perennial aromatic herb, depending on the variety, which has been known since antiquity in Europe and Asia Minor. The dried, aromatic fruits are widely employed in culinary preparations for flavoring bread and pastry, in candies and in alcoholic liqueurs as well as in cosmetic and medicinal preparations<sup>(11)</sup>. Trans-anethole (1-methoxy-4-(1-propenyl) benzene or para-propenylanisole), fenchone and estragole are the most important volatile components of *Foeniculum vulgare* volatile oil<sup>(12, 13)</sup>. In traditional medicine fennel and its herbal drug preparations are used for dyspeptic complaints such as mild, spasmodic gastric intestinal complaints, bloating and flatulence<sup>(14)</sup>. The medicinal use of fennel is largely due to antispasmodic, secretolytic, secretomotor and antibacterial effects of its essential oil. Many investigators have shown *Foeniculum vulgare* Mill. extracts and essential oil induced hepatoprotective effects<sup>(15)</sup>; exhibited inhibitory effects against acute and subacute inflammatory diseases, allergic reactions and showed a central analgesic effect<sup>(16)</sup>, produced antioxidant activities including the radical scavenging effects, inhibition of hydrogen peroxides  $H_2O_2$  and  $Fe^{2+}$  chelating

activities<sup>(17)</sup>, have estrogenic activities, increase milk secretion, promote menstruation, facilitate birth, alleviate the symptoms of the male climacteric, and increase libido<sup>(18)</sup>. It also have properties for the prevention and therapy of cancer<sup>(19,20)</sup>, antitumor activities in human prostate cancer<sup>(21)</sup>, and antimicrobial properties<sup>(22)</sup>. Furthermore, fennel has a bronchodilatory effect<sup>(23)</sup> as well as immunomodulatory activities by enhancing natural killer cell functions, the effectors of the innate immune response<sup>(24, 25)</sup>. Another study showed that the essential oil of *Foeniculum vulgare* beside other compounds has been used to reduce oxidative stress in cardiovascular disease<sup>(26)</sup>. Singh *et al.*<sup>(27)</sup> showed that both volatile oil and extract showed strong antioxidant activity. Toda<sup>(28)</sup> revealed that several aromatic herbs including *Foeniculi fructus* have inhibitory effects on lipid peroxidation or protein oxidative modification by copper. Tognolini *et al.*<sup>(29)</sup> stated that *Foeniculum vulgare* essential oil and its main component anethole, demonstrate a safe antithrombotic activity that seems due to their broad spectrum antiplatelets activity, clot destabilizing effect and vaso-relaxant action.

In view of these considerations, the present study was carried out to evaluate the possible protective effect of *Foeniculum vulgare* Mill. against gamma irradiation induced some biochemical disorders.

## **MATERIALS AND METHODS**

### ***Experimental animals***

Male Swiss albino rats (Sprague Dawely Strain), weighting 120-150 g, were obtained from the Egyptian Organization for Biological Products and Vaccines. They were kept for about 15 days, before the onset of the experiment, under observation to exclude any intercurrent infection and to acclimatize the laboratory conditions. The animals were kept in metal cages with good aerated covers at normal atmospheric temperature (25±5°C) and at normal daily 12 hrs dark/light cycles. They were fed commercial food pellets and provided with tap water *ad libitum*.

### ***Radiation processing***

Whole body gamma irradiation performed with a Canadian gamma cell 40-Cesium-137 biological sources, belonging to the National Center for Radiation Research and Technology (NCRRT), at Cairo, Egypt. The radiation dose level was 6.5 Gy.

### ***Treatment***

Fennel oil was purchased from local market (EL CAPTAIN pharmaceutical Co.) it was supplied to certain groups of animals as a single dose (250 mg/kg b.w.) according to Özbek *et al.*<sup>(14)</sup> by intragastric gavages.

### ***Experimental design***

After an adaptation period of one week, the animals were divided into four groups, each of 8 rats. Group 1: normal control group. Group 2: the animals were subjected to a single dose of whole body gamma irradiation (6.5 Gy), and were sacrificed after 7 days of irradiation. Group 3: the animals were received *Foeniculum vulgare Mill.* essential oil (FEO) (250 mg/kg b. wt) for 28 consecutive days, through oral administration by intra-gastric gavages. Group 4: the animals were received treatment of FEO for 21 days, then were exposed to gamma radiation (6.5Gy), followed by treatment with FEO for 7 days later to be 28 days as group 3. Rats were sacrificed after 7 days post-gamma irradiation.

### ***Biochemical analysis***

Serum AST & ALT were determined according to Reitman and Frankel<sup>(30)</sup> and serum ALP detected according to Belfield and Goldberg<sup>(31)</sup>. Serum urea and creatinine were measured according to Fawcett and Scott<sup>(32)</sup> and Schirmeister *et al.*<sup>(33)</sup>, respectively. Serum cholesterol and triglyceride were estimated following the method of Richmond<sup>(34)</sup>, Allian *et al.*<sup>(35)</sup> and Fossati and Principe<sup>(36)</sup>, respectively. Total protein, albumin and globulin were determined according to Doumas *et al.*<sup>(37)</sup>, total billirubin were estimated according to Balistreri and Shaw<sup>(38)</sup> and testosterone was measured using enzyme immunoassay kit (Meddix Bioech Inc, 420 Lincoln Centre Drive, Foster City, CA 94404, USA, Catalog Number: KEF4057).

### ***Statistical analysis***

Data were analyzed using one-way analysis of variance (ANOVA) followed by LSD test to compare various groups with each others using PC-STAT program (University of Georgia) coded followed method of Rao *et al.*<sup>(39)</sup>. Results were expressed as mean± S.E. and values of P<0.05 and P<0.01 were considered significant and highly significant, respectively. F probability expresses the general effect between groups.

## **RESULTS**

The results represented in Table 1 revealed that, whole body gamma

irradiation, at single dose (6.5 Gy), resulted in significant elevation in AST, ALP, cholesterol and triglycerides recording percentage changes of 50.64%, 38.22%, 124.27% and 163.67% from the control level, respectively. However, gamma irradiation produced no significant effect in ALT (5.17%) in comparison with normal control. Administration of fennel oil showed insignificant changes in these parameters when compared with control rats, recording a percentage change of 1.01%, 3.58%, 2.57%, 6.53% and -3.16% from control level, respectively. The supplementation of rats with fennel oil (250 mg/kg b.wt.) for 21 successive days before irradiation and 7 successive days after whole body gamma irradiation induced significant amelioration in the levels of the above mentioned parameters as compared with irradiated rats. These improvements were manifested by modulating the increase in activities of AST, ALP, cholesterol and triglycerides and recoded 2.53%, 3.96%, 71.17% and 39.29%, when compared with irradiated group, respectively.

**Table (1): Effect of *Foeniculum vulgare* essential oil (FEO) on serum AST, ALT, ALP, cholesterol and triglycerides activities in different animal groups.**

Groups	AST U/l	ALT U/l	ALP U/l	Cholesterol mg/dl	Triglycerides mg/dl
Control	50.5± 1.63	27.1± 0.49	167.4± 3.59	41.7± 1.27	44.9± 1.72
Irradiated	76.1± 1.34*	28.5± 0.50	231.4± 4.60*	93.4± 1.38*	118.3± 1.8*
% Change	50.64	5.17	38.22	124.27	163.67
Treated	51.0± 1.35	28.0± 0.52	172.0± 3.34	44.4± 1.4	43.5± 1.43
% Change	1.01	3.58	2.75	6.53	-3.16
IRR+ FEO	51.8±1.10#	25.7± 0.95#	174.0± 4.06#	71.3± 1.13*#	62.5± 1.32*#
% Change	1.53	-4.73	3.96	71.17	39.29

The % change of control.

Values are expressed as mean ± S.E of 8 observations.

\*Significant difference when comparing with the corresponding value of control rats.

#Significant difference when comparing with the corresponding value of irradiated rats.

The results represented in Table 2 revealed that whole body gamma irradiation at single dose (6.5 Gy), resulted in a significant decrease in total protein and albumin ( $P < 0.001$ ) recording percentage changes of -9.98%, -16.76% of the control level respectively. However, gamma irradiation produced no significant ( $P > 0.05$ ) effect in globulin (0.93%) and A/G ratio (-4.79%) in comparison with normal control. The prolonged administration of fennel oil for 28 consecutive days showed significant increase in total protein,

globulin, significant decrease in A/G ratio and non-significant change in albumin, when compared with control rats recording a percentage change of 10.16%, 31.16%, -26.35% and -3.18% of control level, respectively. Group irradiated and treated with FEO induced significant amelioration in the levels of total protein and albumin as compared with irradiated rats. These improvements were manifested by modulating the decrease in activities of total protein and albumin from -9.98% and -16.76% to 2.85 and -9.83% respectively. Moreover, there was an increase in globulin level with a percentage change of 23.25% of the control level.

**Table (2): Effect of *Foeniculum vulgare* essential oil (FEO) on protein profile activities in different animal groups.**

Groups	A/G ratio	Globulin (g/dl)	Albumin (g/dl)	T-proteins (g/dl)
<b>Control</b>	1.67± 0.03	2.15± 0.07	3.46± 0.06	5.61± 0.15
<b>Irradiated</b>	1.59± 0.05	2.17± 0.08	2.88± 0.11*	5.05± 0.19*
% Change	-4.79	0.93	-16.76	9.98-
<b>Treated</b>	1.23± 0.03*	2.82± 0.12*	3.35± 0.073	6.18± 0.20*
% Change	-26.35	31.16	3.18-	10.16
<b>IRR+ FEO</b>	1.22± 0.21*#	2.65± 0.10*#	3.12± 0.05*#	5.77± 0.14#
% Change	-26.95	23.25	-9.83	2.85

Legends are as in Table 1.

A highly significant ( $P<0.01$ ) increase in urea, creatinine, bilirubin and a decrease in testosterone concentrations were observed after exposure to whole body  $\gamma$ - irradiation (6.5 Gy), recording percentage changes of 46.01%, 57.86%, 23.38% and -23.25%, respectively. No appreciable changes were recorded in serum urea (-6.47%), creatinine (6.45%) and bilirubin (1.41%) activities in rats treated with FEO (250 mg/kg b.wt), while a highly significant ( $P<0.01$ ) increase in serum testosterone (66.75%) was observed. On the other hand, irradiated animals which treated with FEO exhibited significant modulation in the levels of urea, creatinine and total bilirubin and significant increases in the diminished level of testosterone due to irradiation when compared with irradiated group. It turned the value of urea, creatinine and bilirubin levels almost to their normal values with percentage change of -2.10, 28.30% and -5.35% from control, respectively, in addition to enhancement of testosterone level by 65%.

**Table (3): Effect of *Foeniculum vulgare* essential oil (FEO) on serum urea, creatinine, bilirubin and testosterone activities in different animal groups.**

Groups	Urea (mg/dl)	Creatinine (mg/dl)	Bilirubin (mg/dl)	Testosterone (ng/ml)
<b>Control</b>	35.69± 0.89	0.636± 0.02	1.77± 0.07	4.00± 0.09
<b>Irradiated</b>	52.11± 1.46*	1.00± 0.06*	2.19± 0.07*	3.07± 0.30*
% Change	46.01	57.86	23.38	-23.25
<b>Treated</b>	33.38± 1.01	0.68± 0.57	1.80± 0.06	6.67± 0.25*
% Change	6.47-	6.45	1.41	66.75
<b>IRR+ FEO</b>	34.94± 1.14#	0.82± 1.60*#	1.68± 0.044#	6.60± 0.09*#
% Change	-2.10	28.30	-5.35	65

Legends are as in Table 1.

## DISCUSSION

In the present study, gamma irradiation (6.5 Gy) induced a significant increase in the activities of AST and ALP and bilirubin concentration. This increase is in agreement with the previous finding of Kafafy<sup>(40)</sup> and Nada<sup>(41)</sup>. The increase in serum aminotransferase activities by radiation may be due to the damage of cellular membranes of hepatocytes, which in turn leads to an increase in the permeability of cell membranes and facilitates the passage of cytoplasmic enzymes outside the cells leading to the increase in the aminotransferase activities in blood serum<sup>(42)</sup>. Also, ionizing radiation enhanced lipid peroxidation in cell membrane which contains fatty acids and excessive production of free radicals; this in turn increases the cytoplasmic membrane permeability to organic substances and causes leakage of cytosolic enzymes such as AST and ALT<sup>(43)</sup>.

Free radical impairs liver functions and can be a major reason of hormonal imbalance. This imbalance induces hyperlipidemia through its multiple effects on lipid metabolism, including increased synthesis of cholesterol, triglyceride<sup>(44)</sup>. In the present study, marked significant elevation was observed in lipid (cholesterol, triglyceride) in irradiated rats. Our results are in agreement with those of Markevich and Kolomiitseva<sup>(45)</sup>, Zahran *et al.*<sup>(46)</sup>, Abbady *et al.*<sup>(47)</sup> and Nada<sup>(41)</sup> who reported an increase of lipids in plasma level of rats post irradiation. They attributed the hypercholesterolemia conditions to the stimulation of cholesterol synthesis in the liver after gamma-irradiation.

Moreover, Bok *et al.*<sup>(48)</sup> contributed the irradiation-induced hypercholesterolemia to the increase of activation of HMG-CoA reductase enzyme, the key regulatory enzyme in the reduction of the overall process of cholesterol synthesis. The increase in cholesterol and triglycerides levels after exposure to irradiation compared to control confirms previous reports which revealed that whole body exposure to gamma radiation induces hyperlipidemia<sup>(49, 50)</sup>. They reported that increased level of serum cholesterol fractions was probably due to its release from tissues, destruction of cell membranes and increase rate of cholesterol biosynthesis in the liver and other tissues. Also, the hyperlipidemic state observed after irradiation could be attributed to the mobilization of fats from the adipose tissues to the blood stream<sup>(51)</sup> in addition to mitochondrial dysfunction<sup>(52)</sup>.

The results obtained in this work showed that, there is significant decrease in serum total proteins and albumin and non-significant effect for globulin and albumin/globulin ratio. Saada<sup>(53)</sup> and Srinivasan *et al.*<sup>(54)</sup> suggested that, the decrease in serum protein in irradiated rats might be the result of damage of vital biological processes or due to changes in the permeability of liver, kidney and other tissues resulting in leakage of protein especially albumin via the kidney. This decrease coincides with the decrease in serum T-protein reported by other workers in irradiated rats, which may be due to radiation damage to the liver<sup>(55)</sup>. Roushdy *et al.*<sup>(56)</sup> and El-Kafif *et al.*<sup>(49)</sup> suggested that the decrease in protein in irradiated rats might be the result of either damage of biological membranes or to changes in the permeability of the liver. Several investigations indicated that exposure to radiation increases free radical activity. The generation of free radicals is considered to be the primary cause of damaging effects. Radiation induced lipid peroxidation reduce protein synthesis and cause disturbances in the enzyme activity of the liver<sup>(57)</sup>. Albumin is the most abundant circulatory protein and its synthesis is atypical function of normal liver cells. Low levels of albumin have been reported in the serum of patients and animals with hepatocellular cancer<sup>(58)</sup>. The fall in albumin levels could probably contribute to the damage in the liver cells induced by irradiation. In the present study, there were a decrease in contents of total proteins, albumin, and total globulins in serum of rats irradiated with gamma-irradiation, indicating liver injury<sup>(59,60)</sup>. These results are in accordance with other studies (Bhatia and Manda<sup>(61)</sup> who suggested that oxidative stress as a result of gamma-irradiation is linked to the organ damage following exposure to ionizing radiation.



Kempner<sup>(62)</sup> explained that this decrease in proteins level may be due to gamma-irradiation which can damage or inactivate proteins by two different mechanisms. First, it can rupture the covalent bonds in target protein molecules as a direct result of a photon depositing energy into the molecule. Second, it can act indirectly, link with a water molecule, producing free radicals and other non-radical reactive oxygen species that are in turn responsible for most (99.9%) of the protein damage.

In the present study, plasma urea and creatinine levels, which are considered as a markers of kidneys function were significantly elevated after exposure the animals to  $\gamma$ -irradiation indicating renal impairment<sup>(63-65)</sup>. They attributed the increase in urea and creatinine concentrations after exposure of rats to  $\gamma$ -radiation to the interaction of irradiation with their sites of biosynthesis. The significant increment in the concentration of serum urea in rats by gamma-irradiation could be due to radiation-induced changes in amino acids metabolism. The present results are in accordance with Abou-Safi and Ashry<sup>(66)</sup> who suggested that the significant increase in serum urea was attributed to the increase in glutamate dehydrogenase enzyme levels, which might increase carbamyl phosphate synthetase activity leading to an increase in urea concentration. Also, Kafafy<sup>(67)</sup> concluded that the increase in urea could be an indication for the elevation of protein catabolic rate.

In this study, a marked significant decrease in serum testosterone was observed in irradiated rats. This result is in agreement with those of El-Dawy and Ali<sup>(68)</sup> and SivaKumar *et al.*<sup>(69)</sup> who reported a decrease in testosterone in serum of irradiated rats. The testis consists of seminiferous tubules, which form the sperm and the interstitial leydig cells, which secret testosterone. The function of the testis is controlled by the hypothalamic pituitary mechanism. In the present study, the disturbed testosterone level might be attributed to hypothalamic and pituitary gland dysfunction, which interferes with hormone production. The decrease in male sex hormone (testosterone) might also be attributed to the production of free radicals and increase of LPO in testis tissue which attack the testicular parenchyma causing damage to the seminiferous tubules and leydig cells<sup>(70)</sup>.

On the other hand, the present study revealed that long term pretreatment of *Foeniculum vulgare Mill.* Essential oil (FEO) for 28 days to irradiated animals; induced significant amelioration effects on the tested parameters. It means that FEO has a physiologic antioxidant role. Essential oils,

as natural sources of phenolic component attract investigators to evaluate their activity as antioxidants or free radical scavengers. The essential oils of many plants have proven radical-scavenging and antioxidant properties in the 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical assay at room temperature <sup>(71)</sup>. The phenolic compounds are very important plant constituents because of their scavenging ability due to their hydroxyl groups <sup>(72)</sup>.

Fennel essential oil has physiologic antioxidant activities including the radical scavenging effect, inhibition of hydrogen peroxides  $H_2O_2$  and Fe chelating activities where it can minimize free radical which initiate the chain reactions of lipid peroxidation as mentioned <sup>(73, 17, 27)</sup>. The volatile oil contain trans-anethole and cis-anethole. Anethole is the principal active component of fennel seeds which exhibited anticancer activity <sup>(74)</sup>. The *anethole* in fennel has repeatedly been shown to reduce inflammation and prevent the occurrence of cancer. Researchers have also proposed a biological mechanism that may explain these anti-inflammatory and anticancer effects. This mechanism involves the shutting down of an intercellular signaling system called *tumor necrosis factor* or *(TNF)-mediated signaling*. By shutting down this signaling process, the *anethole* in fennel prevents activation of a potentially strong gene-altering and inflammation-triggering molecule called *NF-kappaB*, also the volatile oil has been shown to be able to protect the liver of experimental animals from toxic chemical injury <sup>(75)</sup>, and these may explain the ameliorating effect of FEO on transaminases and ALP induced by irradiation. Administration of *Foeniculum vulgare* essential oil for 28 days attenuated the effect of gamma radiation induced increase in transaminases (AST and ALT) and ALP as well as cholesterol and triglyceride. These findings are in accordance with results of Özbek *et al.* <sup>(14)</sup>, Kaneez *et al.* <sup>(76)</sup>, Özbek *et al.* <sup>(77)</sup> and Tognolini *et al.* <sup>(29)</sup> who have reported that FEO has a potent hepatoprotective effect and antithrombotic activity, clot destabilizing effect and vaso-relaxant action. Volatile components of fennel seed extracts contain trans-anethole, fenchone, methylchavicol, limonene,  $\alpha$ -pinene, camphene,  $\beta$ -pinene,  $\beta$ -myrcene,  $\alpha$ -phellandrene, 3-carene, camphore and cis-anethole <sup>(78)</sup>. In accordance with our results, Ibrahim <sup>(79)</sup> stated that there were significant increases over the control in testosterone level in the serum of rats treated with fennel oil. Also, Ibrahim <sup>(25)</sup> found that fennel oil administration could ameliorate the destructive effect of cigarette smoke in rat testis. The improvement effect of fennel oil on testicular function as indicated by the testosterone may be attributed to the powerful active components of the fennel oil <sup>(12, 13)</sup>.

On the basis of the present observation it could be suggested that *Foeniculum vulgare* Mill. essential oil which contains a mixture of bioactive compounds could be of value to stimulate the body self defense mechanisms against oxidative stress imply scavenging or neutralizing of free radicals, oxygen quenching and making it less available for oxidative enzymes, enhancement of antioxidant as well as radioactive properties in addition to hepatoprotective, renoprotective and genital protective properties.

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## زيت نبات الشمر يخفف بعض الاختلالات البيوكيميائية التي يحدثها الإشعاع فى ذكور الجرذان

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تهدف هذه الدراسة إلى تقييم الدور الوقائي لزيت نبات الشمر ضد التغيرات البيوكيميائية التي تحدث نتيجة للتعرض للإشعاع. ولتحقيق ذلك تضمنت هذه الدراسة استخدام عدد (32) من ذكور الجرذان البيضاء التي يتراوح وزنها من 120-150 جرام وقسمت إلى أربع مجموعات وتحتوى كل مجموعة على (8 جرذان): المجموعة الأولى/ جرذان المجموعة الضابطة ، المجموعة الثانية / جرذان تم تعرضها إلى جرعة مفردة من أشعة جاما (6.5 جراى) وتم ذبحها بعد 7 أيام من التشعيع ، المجموعة الثالثة / جرذان تمت معالجتها بزيت نبات الشمر (250 مللي جرام/كجم) لمدة 28 يوما متتالى عن طريق الفم ، المجموعة الرابعة / جرذان تمت معالجتها بزيت نبات الشمر (250 مللي جرام/كجم) لمدة 21 يوما ثم تم تعرضها لأشعة جاما (6.5 جراى) واستمر علاجها بزيت نبات الشمر لمدة 7 أيام لتكتمل 28 يوما (كما في المجموعة الثالثة). وفى نهاية التجربة تم ذبح الجرذان وقد تم قياس مستوى إنزيمات الناقل الأمينى الانين واسبرتيت (ALT, AST), إنزيم الفوسفاتيز القلوي (ALP) ، البيليروبين الكلى ، البروتين الكلى ، الالبومين ، الجلوبيولين ، نسبة الألبومين إلى الجلوبيولين وكذلك مستوى الكوليستيرول، الدهون الثلاثية ، البولينا ، الكرياتينين وهرمون التستوستيرون في مصل الدم. وتشير النتائج إلى أن الجرذان التى تعرضت للإشعاع (6.5 جراى) قد أظهرت ارتفاعا في نشاط إنزيمات الكبد (الناقل الأمينى AST, إنزيم الفوسفاتيز القلوي ALP ، البيليروبين الكلى) وتركيز كل من البولينا والكرياتينين والجلسريدات الثلاثية والكوليستيرول التي تمت دراستها ماعدا البروتين الكلى والالبومين ومستوى التستوستيرون الذى إنخفض انخفاضاً ملحوظاً وأسفرت هذه الدراسة إلى أن المعالجة بزيت نبات الشمر (250 مللي جرام /كيلو جرام من وزن الجرذ) قبل وبعد التعرض للإشعاع أدى إلى تحسن في القياسات الكيميائية الحيوية المختلفة السابق ذكرها. خلصت الدراسة إلى أن المعالجة بزيت الشمر له دور وقائي ضد الإشعاع المحفز لبعض التغيرات البيوكيميائية والإجهاد التأكسدى.