Beneficial use of continuous administration of *crataegus oxycantha* in irradiated male albino rats

M. I. Michael

*Biological Application Department, Nuclear Research Center, Atomic Energy Authority, Egypt.*  
E-mail: dr_mick2005@hotmail.com  
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**ABSTRACT**

Exposure to ionizing radiation has become frequent with its vast applications in diagnosis, treatment and industry rather than possible environmental pollution with radiation. The animals of this study were allocated into three groups, control group, irradiated group (5 Gy one shot) and hawthorn treated post-irradiation group. Exposure to radiation was implicated with hematological suppression in all hematological parameters tested red blood cells count (RBCs), hemoglobin content (Hb), hematocrit percentage (HCT) and white blood cells count (WBCs). Radiation exposure caused alteration of lipid metabolism leading to increased total lipids, triglycerides, total cholesterol, and low density lipoprotein (LDL) and decreased high density lipoprotein (HDL). In addition, liver enzymes were also elevated, while serum albumin was diminished referring to liver dysfunction. The male reproductive hormone (testosterone) was severely inhibited along with glutathione. Administration of extraction of *Crategous oxinatha* (hawthorn) with a dose of 500 g/kg b.w. orally for consecutive 15 days post-irradiation showed significant ameliorating effects on both hematological and biochemical parameters leading to the suggestion of using hawthorn as food additive in relatively high amount.

**Keywords:** Radiation, Hawthorn, Hematology, Lipid profile, Liver enzymes, Testosterone, Glutathione.

**INTRODUCTION**

Oxidative stress is implicated in the etiology of many diseases, results from an imbalance in the production of reactive oxygen species (ROS) and antioxidant defenses. ROS deregulate the redox homeostasis by initiating an aberrant induction of signaling networks that cause oxidative damage. Gamma-radiation and other environmental pollutants like certain chemicals, or local
tissue inflammation generate ROS in the cells, which can exert apoptosis \(^1\). Evidences have shown that overproduction of ROS creates an imbalance between pro-oxidants and anti-oxidants, once this imbalance occurred, ROS can damage cellular macromolecules such as nucleic acids, proteins, structural carbohydrates and lipids and lead to cellular dysfunction or death \(^2\).

Several phytochemicals, derived from vegetables, fruits, herbs and spices, have demonstrated excellent chemo-preventive properties by regulating the redox status of the cells during oxidative stress \(^3,4\). Hawthorn has a long history of use as a medicinal plant contains phenolic and flavonoid compounds that have highly antioxidant effects \(^5\). It has many pharmacological properties, such as reducing blood pressure and total plasma cholesterol, treatment of congestive heart failure that led to significant decrease in mortality after ischemia reperfusion in animals. It has antiviral effects and it can protect mouse and human blood lymphocytes from \(\gamma\)-rays hazards \(^4,6\). Moreover, Egea et al. \(^7\) reported that there is a possibility of using medicinal plants posses high antioxidant activity, including hawthorn, as natural antioxidants to as alternatives to replace the synthetic additives which used as dietary supplements to protect biological system against oxidative stress.

Agents delivered to ameliorate the well attained hazards of radiation are considered radiation modifiers or protectors. *Crataegus oxycaynthia* (hawthorn) extract was introduced, as an alternative phytomedicine, shortly after radiation exposure was the endeavor of this research.

**MATERIAL AND METHODS**

**Animals and treatments:**

This study was carried out on thirty male albino rats (120-140 g). Rats were obtained from the animal house of the Nuclear Research Center, Inshas, Egypt. Animals were kept under normal conditions, standard diet and tap water. Hawthorn extract used in this study was purchased from Nature’s Way Products, USA, packed in gelatin capsule, each capsule contains 500 mg hawthorn dried extract and it was dissolved in distilled water before oral supplementation using stomach tube at daily dose of 500 mg/kg body weight for 15 days.

**Irradiation source:**

The radiation dose was five Gray (5Gy) delivered from Cobalt-60 gamma cell 3500. The dose rate was 3.1 Gy/min as calibrated at the time of
irradiation. This source is located at The Middle East Regional Radioisotopes Center for The Arab Countries, Dokki, Cairo, Egypt.

**Experimental design:**

The animals were classified into three equal groups as follows:

**Group I (control group):** rats of this group were fed standard rodent diet and watered tap water *ad libitum*.

**Group II (irradiated group):** the animals of this group were subjected to whole body $\gamma$-radiation with a dose of 5 Gy.

**Group II (irradiated-treated group):** the rats of this group were orally supplemented with hawthorn (*Crataegus oxycantha*) extract (500 mg/kg b.w.) after 2 hours of radiation exposure. Supplementation with hawthorn extract was continued for 14 successive days post-irradiation.

After the experimental period of 15 days, all animals were fasted for approximately 14 hours and decapitated for collecting blood samples. Samples were collected into two tubes, the first with anticoagulant for the hematological and glutathione analysis and in the other tube, blood was set to clot then sera were obtained by centrifugation at 1500 rpm for 15 minutes.

**Hematological analysis:**

The red blood cells count (RBCs), hemoglobin content (Hb), hematocrit percentage (HCT) and white blood cells count (WBCs) were evaluated as described by Dacie and Lewis \(^8\).

**Biochemical analysis:**

Serum total lipids, triglycerides, total cholesterol and high density lipoprotein (HDL) were colorimetrically determined using Randox kits (U.K.). The values of low density lipoprotein cholesterol (LDL) were calculated according to the equation: $\text{LDL} = \text{total cholesterol} - (\text{HDL} + \text{serum triglycerides}/5)$. The liver enzymes alanine aminotransferase (ALT) and aspartate transaminase (AST) were calorimetrically determined using commercial kits (Randox, UK) and albumin was estimated using kit from Diamond Diagnostic. Testosterone hormone was determined by RIA kits from Diagnostic Product Corporation, LA, U.S.A. Glutathione (GSH) concentration were determined in plasma by Eliza (Sandwich Immunoassay Technique) using commercial kits (IBL-Hamburg Co. Germany).
Statistical analysis:

ANOVA (one-way classification F-test) followed by Duncan (Multiple Range-test) were carried out for the statistical analysis studies as described by Lind and Masson (9) and data were represented in tables as mean ± standard error.

RESULTS AND DISCUSSION

The precise mechanisms involved in the pathogenesis of radiation-induced injury have not been fully elucidated. It has been recently proposed that the radiation-induced late effects are caused, in part, by chronic oxidative stress and inflammation. Increased production of reactive oxygen species, which leads to lipid peroxidation, oxidation of DNA and proteins, as well as activation of pro-inflammatory factors has been observed in vitro and in vivo (10). This study revealed direct and indirect evidences supporting this hypothesis.

Blood picture can give novel insight to determine stress due to environmental, nutritional and physiological factors as well as irradiation. The blood picture figured in this study asserted the decrement of hematopoiesis induced after radiation exposure. RBCs count, Hb content, HCT percent and WBCs count, all of them significantly decreased (p < 0.05) when investigated after 15 days of irradiation (Table 1). The excess formation of reactive oxygen species and the ionization of water molecules induced by gamma rays may cause drastic changes in RBCs membrane structure and permeability that consequently led to increased penetration of ROS inside the red blood cells inducing destruction in the cytoskeleton of the cells. Moreover, the phospholipids of the cell membrane are a major target of ROS as described by Prasad et al. (11).

Table (1): Effect of radiation and hawthorn supplementation on blood pictures in male albino rats

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group I n=10</th>
<th>Group II n=10</th>
<th>Group III n=10</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBCs (x10^6/mm³)</td>
<td>7.11±0.34 A</td>
<td>5.71±0.39 B</td>
<td>6.95±0.36 A</td>
</tr>
<tr>
<td>Hb (g/dl)</td>
<td>14.1±0.36 A</td>
<td>12.4±0.38 B</td>
<td>13.6±0.34 A</td>
</tr>
<tr>
<td>HCT%</td>
<td>43.4±2.29 A</td>
<td>35.8±2.25 B</td>
<td>42.9±2.11 A</td>
</tr>
<tr>
<td>WBCs (x10³/mm³)</td>
<td>6.89±0.41 A</td>
<td>4.89±0.29 B</td>
<td>6.11±0.49 A</td>
</tr>
</tbody>
</table>

Values with different superscripts in the same row differ significantly (P<0.05). Difference between capital and small letters = p<0.01.

As the number of Red cells decreased, the suppression of Hb content and HCT percentage noticed in this research was a subsequent consequence and may also be attributed to the injury of the red cell membrane that led to libration.
of intracellular hemoglobin out of the cell. Moreover, the destruction of these injured cells and the radiation-induced hemodilution resulted in decreased its packed volume (HCT %). Zhirnov et al. (12) and Amer (4) established these outcomes and explanations.

The whole body gamma-irradiation induced cytopenia in this study was observed and manifested by significant \( p < 0.01 \) drop in total WBCs count 15 days post-irradiation (Table 1). These data evoked that the highly damage of irradiation impaired the cell precursors and progenitors in the bone marrow; therefore, irradiation may depress the ability of bone marrow to produce and differentiate the white cells. In this sequence, Amer (4) reported that late-stage bone marrow precursors appear to be extremely sensitive targets of irradiation, particularly at 14 days in concomitant with Okazaki et al. (13) who recorded that the number of lymphocytes in bone marrow decreased in irradiated mice. In this point, the suppressed leukocytes resulted herein granted with Amer (4), Hossenimehr et al. (6) and Akleyev et al. (14).

Lipids are major target of oxidative damage. In the present study, \( \gamma \)-rays exposure (5Gy) induced a dramatic rise in lipid profile as an incidence of lipid peroxidation. These alterations may be assembled in Table (2), in the form of significant \( p < 0.01 \) increase in total lipids, triglycerides, total cholesterol and LDL-cholesterol and significant decrease \( p < 0.01 \) in HDL-cholesterol after 15 days of 5 Gy whole body irradiation. These findings confirmed previous reports of Zhao and Robbins (10) and Michael and Amer (15); they reported that ionizing radiation induced hyperlipidemia. The blood levels of lipids are controlled primarily by their production and utilization by liver, consequently, alteration of lipids was secondary to radiation induced liver dysfunction occurred in this study. However, Gupta (16) reported that irradiation of animals resulted in triglycerides build up which increase hepatic lipid accumulation. Moreover, the radical chain reactions induced by ionizing radiation may resulted in the production of hydroperoxides residues that changed the hydrophobic interactions allowing easier penetration of water molecules; the altered gradient of water concentrations throughout the membrane, changes the membrane substructure directly and indirectly leading to the degradation of lipids and proteins as hypothesized by Zhao et al. (17).
Table (2): Effect of radiation and hawthorn supplementation on lipid profile and testosterone hormone in male albino rats

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group I n=10</th>
<th>Group II n=10</th>
<th>Group III n=10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total lipids (mg/dl)</td>
<td>355.8±7.59</td>
<td>405.7±8.53 A</td>
<td>361.1±7.61 b</td>
</tr>
<tr>
<td>Triglycerides (mg/dl)</td>
<td>118.1±3.65 b</td>
<td>147.5±4.88 A</td>
<td>124.4±3.84 b</td>
</tr>
<tr>
<td>Cholesterol (mg/dl)</td>
<td>104.7±3.58 b</td>
<td>137.9±4.28 A</td>
<td>112.9±3.33 b</td>
</tr>
<tr>
<td>HDL (mg/dl)</td>
<td>29.8±1.26 a</td>
<td>21.3±1.39 B</td>
<td>27.8±1.31 a</td>
</tr>
<tr>
<td>LDL (mg/dl)</td>
<td>48.4±2.18 b</td>
<td>61.3±2.29 A</td>
<td>46.6±2.14 b</td>
</tr>
<tr>
<td>Testosterone (ng/dl)</td>
<td>73.8±3.47 A</td>
<td>55.7±3.35 b</td>
<td>70.9±3.22 A</td>
</tr>
</tbody>
</table>

Values with different superscripts in the same row differ significantly. Difference between capital and small letters = p<0.01.

Ionizing radiation is one of the environmental factors that may contribute to reproductive dysfunction by a mechanism involving oxidative stress. Data in Table (2) approved this state since testosterone in irradiated male rats significantly decreased (p<0.01) when measured after 14 days of gamma-irradiation. Oxidative stress induced post irradiation may alter Leydig cell function leading to decreased production of testosterone hormone. This explanation came in harmony with Adaramoye et al. (18) statement that γ-irradiation causes reproductive dysfunction by depleting the antioxidant defense system in the rats, increase testicular lipid peroxidation and promote testicular degeneration. The defect of testosterone production in this study agreed with the previous results obtained by Bang et al. (19), Michael and Amer (15) and Zhou et al. (20).

Damaging effects of ionizing radiation implies oxidative attack of ROS to vital cell constituents. Several enzymes when extra released from cells to blood are considered as indicators of tissue damage. Alanine aminotransferase (ALT) and aspartate transaminase (AST) are liver enzymes; their levels in serum are the most reliable marker of hepatic cellular injury. In the present study, the significant (p<0.01) increase in the activity of ALT and AST in serum indicated hepatic cell injury accompanied radiation exposure. In harmony with enzymatic discharge from hepatic cells, significant (p<0.05) inhibition of albumin synthesis came to confirm the oxidative impact of ionizing radiation on liver cells (Table 3). These results coincided with those of Sezar et al. (21), Zhao et al. (17) and Amer (4) who postulated that radiation exposure resulting in chronic inflammation, organ dysfunction, and ultimate fibrosis and/or necrosis. The liver response to oxidative damage is always the same nevertheless this
oxidation originated. Several investigations concerned oxidative damage of different origins on liver tissues have come to the same conclusion that reactive oxygen spices is the promoter of hepatic injury \(^{22-25}\).

Glutathione (GSH) plays a unique role in the cellular defense system against toxicity of endogenous and exogenous origin. In addition, GSH has been reported to play an important role in a multitude of cellular processes, including cell differentiation, proliferation, and apoptosis, and as a result, disturbances in GSH homeostasis are implicated in the etiology and/or progression of a number of diseases \(^{26}\). GSH levels, turnover rates and/or oxidation state can be compromised by inherited or acquired defects, transcription factors or from exposure to ionizing radiation. This is the case attained in this study, where GSH exhibited a sharp significant (\(p < 0.01\)) decrease after 15 days of exposing rats to ionizing radiation (Table 3). GSH deficiency through an increased susceptibility to oxidative stress that affected the synthesis and catabolism of GSH occurred by regulated series of enzymatic and plasma membrane transport steps that were distorted due to increased production of ROS. This explanation is concurred with Amer \(^4\) and Galván et al. \(^27\), they reported that exposure to ionizing radiation produced free radicals and depleted antioxidant resources and GSH is particularly susceptible to radiation effect due to oxidant-antioxidant disequilibrium. The glutathione depletion recorded in this study came in accordance with the previous results of Adaramoye et al. \(^{18, 28}\).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Groups</th>
<th>Group I (n=10)</th>
<th>Group II (n=10)</th>
<th>Group III (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALT (U/I)</td>
<td>95.7±4.37 (^b)</td>
<td>129.4±5.61 (^A)</td>
<td>103.2±4.74 (^b)</td>
<td></td>
</tr>
<tr>
<td>AST (U/I)</td>
<td>36.4±3.25 (^b)</td>
<td>59.7±3.59 (^A)</td>
<td>40.8±3.53 (^b)</td>
<td></td>
</tr>
<tr>
<td>Albumin (g/dl)</td>
<td>3.74±0.34 (^a)</td>
<td>2.35±0.35 (^b)</td>
<td>3.46±0.31 (^a)</td>
<td></td>
</tr>
<tr>
<td>GSH (mg/dl)</td>
<td>47.9±3.53 (^A)</td>
<td>30.8±2.47 (^b)</td>
<td>44.6±3.25 (^A)</td>
<td></td>
</tr>
</tbody>
</table>

Values with different superscripts in the same row differ significantly \((p<0.05)\). Difference between capital and small letters = \(p<0.01\).

Efforts to reduce the toxicities associated with radiation have focused on both technological improvements in radiation delivery and chemical modifiers of radiation injury. An alternative mechanism was proposed to reduce normal tissue toxicity is the use of radiation modifier/protector. They are agents that when present prior to or shortly after radiation exposure can alter the response of normal tissues to irradiation. To obtain the ideal benefits from
radio-protector, they should have several characteristics relative to their ability to improve the therapeutic ratio. First, the agent should be selective in protecting normal tissues from radiation. Second, the agent should be delivered with relative ease and with minimal toxicity. Finally, the agent should protect normal tissues that are considered sensitive such that acute or late toxicities in these tissues are either dose limiting or responsible for a significant reduction in quality of life (29).

Although a number of compounds have been described, that meets the most or all of these criteria in preclinical studies or in early clinical trials, the natural or phytomedicinal compounds are currently the most in clinical use. In this research, the extract of *Crataegus Oxyacantha*, commonly named hawthorn, is carefully selected as a radiation modifier to ameliorate the established radiation injury occurred.

Hawthorn contains high amounts of phenolic, flavonoid and epicatichin compounds that may be the main tools, by which hawthorn can exhibit its radio-protective action. These compounds characterized by their ability to scavenge OH• and other free radicals (6). In the same line, Bahri-Sahloul et al. (5) identified eight antioxidants of phenolic type in hawthorn extract that possess a strong radical-scavenging activity. In addition, antioxidants agents, including phenols, are hydrogen atom-donating (reducing agents); in this condition the oxidants are neutralized by hydrogen atom donation, resulting in a less reactive or nonreactive product apart from the original oxidant and a radical product from the antioxidant, which no longer can exert detrimental effects (7). The mechanism of free radical scavenger suggests that these agents are oxidized by free radicals, forming stable compounds incapable of reacting with other cellular components. This mechanism prevents the free radicals from reacting with the cell vital components and cut the free radical chain reaction. In radiation work, Ye et al. (30) authorized the antioxidant and the radio-protective effects of hawthorn and its potent capacity of scavenging free radical induced by gamma irradiation.

The results of this study focused on the valuable protective effect of hawthorn extract against toxicity induced by γ-irradiation on hematopoietic system. It is obvious that hemopoiesis retained its vitality in relative short time post-irradiation due to hawthorn treatment (Table 1). This observation may indicate that hawthorn extract, which is rich in phenolic and flavonoids, exhibited its powerful affinity to scavenge the free radicals developed by
gamma-irradiation and this property helped in recovery of cells of blood constituents and even extended to the stem cells and the bone marrow leading to regeneration of normal cells with normal rate of production. These results came in the same line with Amer\(^{(4)}\) Hosseinimehr et al.\(^{(6)}\), and Bing et al.\(^{(31)}\).

Lipid profile is always acquiring the most attention for its close association with chronic heart diseases and brain stroke. From this point, the return back of the serious values of lipids and its fractions to its normal values using hawthorn extract and testing its potentiality as a natural radio-modifier hypolipidemic agent was interesting and gave promising results in this study as figured in Table (2). All lipid profile tested values came around control values after 15 days of *Crataegus* administration post-irradiation. Hawthorn extract has the property of depressing the concentration of blood-lipids in a mechanism involving regulation of the LDL receptors on cell surfaces, or/and inhibit cholesterol and bile acid absorption or increase excretion of these neutral and acidic sterols. The same explanation was declared by Xie et al.,\(^{(32)}\) pronouncing that hawthorn extract has the function of depressing the concentration of blood-fat.

Our results agreed with Hong\(^{(33)}\) and Luo et al.\(^{(34)}\) who reported that a diet included hawthorn could be useful for the treatment of hyperlipidemia and used to prevent atherosclerosis, and Michael and Amer\(^{(15)}\) who concluded that a mixture of antioxidants including hawthorn extract could ameliorate the oxidative effect of radiation and hyperlipidemia.

The testosterone level in serum was recovered by administration of hawthorn (*Crataegus Oxycantha*) to irradiated male rats for the same experimental period (15 days) as seen in Table (2). This may be due to the potent antioxidant effects of hawthorn that may promote the normal vital activity of Leydig cells, and restored its membrane to normal permeability that prevent the liberation of testosterone hormone to interatesticular spaces. The work in this line of hormonal relationship to hawthorn still needs further efforts. This explanation could be logic putting in consideration the findings of Samarth and Samarth\(^{(35)}\) that the amount of phenolic compounds, the content of flavonoids and flavonols may be responsible for radio-protective effect on testis of rats due to their antioxidant and radical scavenging activity.

Although the liver is the organ responsible for detoxifying the biological system; hence, it is susceptible to toxification and injury due to irradiation, so, its protection or at least recovering its function is necessary,
using a natural component instead of chemical drugs to recover an already injured organ is more preferable. From this point, using hawthorn extract was influential. The data of Table (3) spotlight on the ameliorating efficiency of hawthorn extract on liver enzymes activity and albumin level. The increased levels of liver enzymes and albumin were almost recovered around control values pointing to the positive role of hawthorn extract as a radio-modifier agent. Hawthorn extract have a potent antioxidant activity by trapping free radicals (hydroxyl, lipid free radicals, free iron molecules and lipid peroxides), delaying fat oxidation, inhibiting the major substance responsible for generating oxygen derived free radicals. In addition, it may reduce the concentration of H\textsubscript{2}O\textsubscript{2} produced by oxidative stress. Du \textit{et al.} \cite{36} reported that proanthocyanins (of hawthorn) can protect hepatocytes against oxidative stress by increasing superoxide dismutase activity inhibiting the lipid peroxidation, cell membrane damage and controlling related oxidative DNA damage. Pittler \textit{et al.}, \cite{37} reported that proanthocyanidin improves the oxygen carrying capacity of blood, and increases the strength and elasticity of blood vessel wall by binding with collagen. This may increase the blood flow to liver for permitting normal function of hepatocytes. Moreover, Srinivasan \textit{et al.} \cite{38} revealed that flavonoids might achieve its protective capacity through stabilizing cell membrane and influencing certain metabolic processes including RNA function in gamma-irradiated rats, in addition, falvonoids can protect DNA damage, lipid peroxidation and antioxidant status in isolated rat hepatocytes exposed to gamma irradiation. In this connection, flavonoid can protect against lipid peroxidation toxicity and alterations induced in liver membrane by modifying the phospholipids content of plasma membrane, thereby, preventing changes in membrane permeability.

Bahri-Sahloul \textit{et al.} \cite{5} identified the active ingredients found in hawthorn, this include tannins, flavonoids (such as vitexin, rutin, quercetin, and hyperoside), oligomeric proanthocyanidins (OPCs, such as epicatechin, procyanidin, and particularly procyanidin B-2), flavone-C, triterpene acids (such ursolic acid, oleanolic acid, and crataegolic acid), and phenolic acids (such as caffeic acid, chlorogenic acid, and related phenolcarboxylic acids). Qi \textit{et al.}, \cite{39} reported that the radioprotective effect of flavonoids depend on each of these ingredients that can act as a potent antioxidant; therefore, the endogenous antioxidant GSH drop due to oxidative stress damage following radiation exposure was reasonable to recover after minimizing this stress with all these strong antioxidative agents. Recently, Bing \textit{et al.} \cite{31} summarized the properties
of hawthorn that it has been found to possess vasodilatory, antiinflammatory, antiviral, antiendotoxin, hepatoprotective, neuroprotective, antiangiogenic and hematopoietic activities, beside its antioxidant property; that collectively approve the results obtained in this study.

Finally, the outcome of this work underline the magnificent values of the hawthorn extract (*Crataegus Oxycantha*) as a simple, natural and side less effect radio-modifier that can convalesce the radio-damaged tissues, organs or systems.

ACKNOWLEDGEMENT

The author is appreciative to Mr. Ibrahim Abo Zied, the technician at the Biological Applications Department, for his cooperative assistance in animals housing, treatment administration throughout experimental period and collecting samples at all time intervals.

REFERENCES


الإستخدام المفيد للتعاطى المستمر لنبات كراتيجيس/ أوكسيكانثا في ذكور الجرذان البيضاء المشعات

ميخائيل إبراهيم ميخائيل
قسم التطبيقيات البيولوجية - مركز البحوث النووية - هيئة الطاقة الذرية - مصر

أجرت هذه الدراسة على ثلاثين من الجرذان البيضاء (130±20 جم) تم تقسيمها إلى ثلاث مجموعات متساوية. المجموعة الأولى عولمت كمجموعة ضابطة، المجموعة الثانية تم تبريدها لجرعة إشعاعية مقدارها 5 جرائ أما المجموعة الثالثة فقد تم تبريدها لنفس الجرعة الإشعاعية ثم تم تغريدها بعد ساعتين من التشغيل بجرعة من مستخلص نبات الزعور (كراتيجيس/ أوكسيكانثا) مقدارها 500 ملجم/كل مجم من وزن الجسم لمدة أربعة عشر يوما متتالية بعد التشغيل. تم أخذ العينات بعد فترة أطعام عن الطعام لمدة 14 ساعة وذلك لتقييم كل من عدد كرات الدم الحمراء، نسبة الهيموجلوبين، نسبة كرات الدم الحمراء المكدسة، عدد كرات الدم البيضاء، الكولسترول الكلوي، الدهون عالية ومنخفضة الكثافة بالإضافة إلى إنزيمات الكبد والألبومين وهرمون التستيرويد ومستوي الجلوكوز بالدم.

وقد أظهرت نتائج هذه الدراسة أن تعرض ذكور الجرذان للإشعاع يحدث تغيرات سلبية ذات دلالة إحصائية في المعايير محل الدراسة وقد أدت المعالمة بمستخلص نبات الزعور بعد التعرض للإشعاع إلى تحسن ملحوظ في معظم هذه المعايير مما يشير إلى أهمية الدور الفعال لهذا النبات في تحسين الآثار السلبية للإشعاع الجامى.