https://doi.org/10.15218/zjms.2026.036

Impacts of low dose gamma rays on hematological parameters in Wistar albino rats: In-vivo

Received: 19/05/2025 Accepted: 01/09/2025

Sardar Pirkhider Yaba [1*]

Abstract

Background and objective: The effects of gamma radiation dosages on the hematological parameters of albino rats were examined through in-vivo exposure methodologies.

Methods: Cesium-137 was utilized as a source of ionizing radiation, and various doses were administered via appropriate irradiation collimators. The subjects comprised 30 female albino rats, each with a mass of 200±10 grams, with the duration of exposure for each irradiation source calibrated individually. The principal hematological components (including white blood cells, red blood cells, and platelet counts) of the female rats were assessed employing direct exposure methodologies for low radiation doses.

Results: The results indicated that variations in the optimum time of exposure were 15 minutes. High doses of ionizing radiation have a considerable effect on the primary blood components. The radio-sensitivity and physiological properties of each kind of blood component determined the optimal irradiation dosages that resulted in high WBC, RBC, and PLT densities. Radiation doses had a substantial impact on PLT density, reduced with 42% compare to the control value (P-value < 0.05).

Conclusion: Ionizing radiation had a relatively small effect on the density of the main blood components after a limited amount of exposure. The type of blood components determined the optimal radiation doses with high efficiency on component density. Furthermore, high impacts (very significant) concentrated on PLT density.

Keywords: Rats, Ionizing radiation, Hematological parameters, Cs-137, Irradiation collimator.

[1] **Department of Physics, College of Education, Salahaddin University, Erbil, Kurdistan region, Iraq.**

Correspondence: Sardar.yaba@su.edu.krd

https://doi.org/10.15218/zjms.2026.036

Introduction

Gamma radiation is ionizing radiation and it creates free electrons in the irradiated life tissue, and this makes an ionizing for the exposed life cells within a limited time. Rate of ionizing depends on the time of exposure, the energy of the gamma, and the quantity of the absorbed dose. Health risk of ionizing comes from producing a high rate of free radicals (breaks down and destabilizes the molecules) in the exposed tissue, and then producing cancer cells, Thus, extended exposure to ionizing radiation poses a risk (1). On the other hand, ionizing radiation dose can be useful to sterilization of some liquids included the blood, it encompasses an important topic and rule in aspects of diagnostic (gamma camera) and therapy (sterilization of blood), and keeping the food for a long time (2-3).

Irradiation of blood products is undertaken using a dedicated blood irradiator with a long half-life gamma-emitting source. Generally, high linear energy transfer (LET) radiation is more efficient in inducing biological damage than low LET radiation (gamma-ray). Because most of the incident energy will be deposited within a short distance, causing dense ionization in the trajectory (3-4), and this is particularly true for bimolecular, including DNA. On the other hand, it can be altered resulting in mutations or can be damaged to the point that the cell dies (5). The effects of radiation on the human body ranged between mild suntan to massive organ failure, coma, and death.

Hematology studies in the field of radiation have played an active role to estimate exposure to ionizing radiation, as it increases the number of chromosomal aberrations in human blood lymphocytes (6). As well as, gamma-ray effects on the rheological properties of the blood (7) because of its high penetration, so it has a high ability to make dense ionization in the trajectory (8-9). Blood ionization means an increase of free radicals that refer to the increase of damage cells. Rate of damage depends on the time of exposure, the energy of the gamma, and the quantity of the absorbed dose. Thus, studies on the risks of radiation have been carried out for a long time and research on the techniques is novel (2, 10).

The high amount of white blood cells can be a sign of infection, and increases in certain types of leukemia. Low white blood cell counts can be a sign of bone marrow diseases or an enlarged spleen. High levels of hemoglobin (Hgb) can occur due to lung disease, living at high altitude, or excessive bone marrow production of blood cells. The decrease in the number of platelets in the blood due to thrombocytopenia can result in poor blood clotting (3). In the present

https://doi.org/10.15218/zjms.2026.036

research, optimum radiation dose and time of exposure of ionizing radiation (gamma radiation source (137Cs) that changeable of Rats' blood components will improve using a suitable irradiation collimator.

Recent in-vivo studies have demonstrated that even low-level ionizing radiation can significantly impair hematological health in Wistar albino rats. Abd El-Hady et al (11) reported notable declines across the full spectrum of blood parameters—including RBCs, WBCs, platelets, hemoglobin, hematocrit, and red cell indices—following γ-irradiation, with evidence of oxidative stress indicating hematopoietic suppression. Similarly, Vaishnav et al (12) showed that low-dose X-ray exposure induced dose-dependent drops in RBCs, hemoglobin, platelets, and WBCs, despite the radiation being in the lower dose range. Together, these findings underscore that even brief, low-dose irradiation can elicit marked hematological changes in Wistar rats—yet the impact of varying short-duration exposure times (e.g., 5–25 minutes) remains uncharted. This gap motivates the current study, which aims to systematically assess how incremental increases in gamma exposure duration affect hematological parameters in vivo.

Although the hematological consequences of gamma irradiation have been widely studied at moderate and high doses, there is still a lack of clarity regarding the biological impact of low-dose, short-duration exposures. Most investigations focus on chronic or acute high-dose exposures, whereas brief exposures in the range of minutes remain largely unexplored. In particular, the hematopoietic system, known for its radiosensitivity, may exhibit measurable changes even under short irradiation periods. However, the relationship between exposure duration (5–25 minutes) and alterations in hematological parameters in Wistar albino rats has not been systematically characterized. This gap highlights the need for in-vivo studies to determine whether incremental increases in exposure time at low doses can induce significant hematological changes.

Material and Methods

Materials and equipment

Albino Rats

Thirty Albino Rats (female; 200±10 grams) were used as cases (exposed to various levels of ionizing radiation) and controls (not exposed). The rats were maintained in proper environmental circumstances, including feeding and drinking (Rat's Feed), ventilation rate (air moving), light rate (12 light and 12 dark), and appropriate cages that were prepared for the albino rats.

Ketamine and xylazine

Ketamine and xylazine were used for anaesthesia; both have been mixed to

https://doi.org/10.15218/zjms.2026.036

anesthetize the rats (6mml with 1mml) (13).

Gamma radiation source

Cs-137 is perfect for regulated irradiation, particularly in biological studies, because it releases gamma rays with a noticeable energy peak. Rats were exposed to Cs-137 for a predetermined amount of time in order to evaluate the biological consequences of the radiation.

Survey Radiation Dosimeter

Survey dosimeters type used to measure an exposure dose rate (mR/hr). The principle of the detection of these dosimeters depended on ionizing radiation. Digital Dosimeter Inspector Ext., version 2.1, model: 2-0033-10, S/N: 8307-019. Made by RCTEM INDUSTRIES C€. It is a portable radiation survey meter with external probes for all kinds of radiation. The internal detector has a measuring range from 0.5 µSv/h to 1100 µSv/h. Background check (< 0.104 µSv/h).

Methods

Design Irradiation Collimators

Irradiation collimators are fabricated for the ionized radiation source, depending on the source–dosimeter distance method. The exposure dose rate of radioactive sources (137Cs) was obtained by variation of the collimator length (Figure 1).

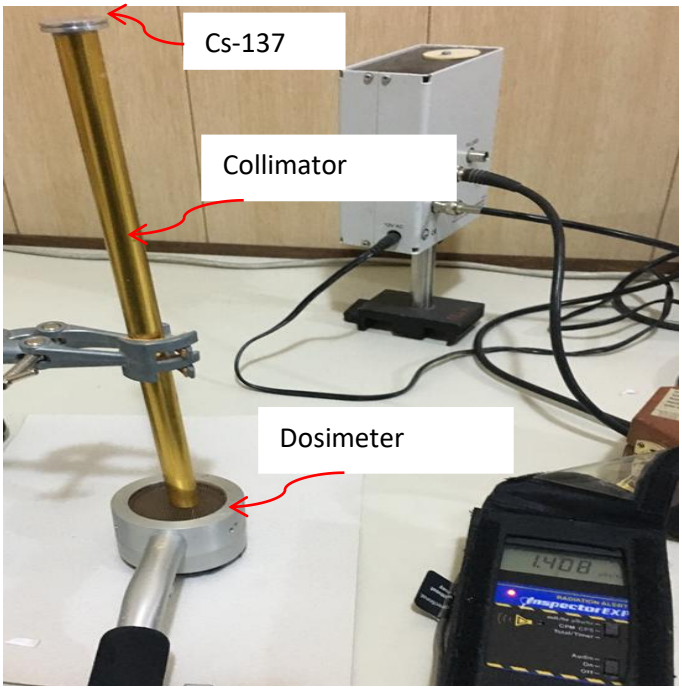

Figure 1. Irradiation collimator for the Cs-137 to get IRDs

https://doi.org/10.15218/zjms.2026.036

With an interior diameter of 2.5 cm and made of aluminum, the collimator should be able to secure the Cs-137 sources. The measured average background radiation dose was regarded as data in the irradiation process. Table 1 lists the collimators' calibration data to obtain the average dosage rate.

The 30 rats were divided into two groups: group A (15 rats) was exposed to the Cs-137 source for varying amounts of time, while group B (15 rats) was the control group, which was not exposed.Group A was split up into five exposed cases (A1, A2, A3, A4, and A5) at five different exposure times at a constant gamma radiation dose of 54 µSv/hr.Heart position (in-vivo) of the rats directly irradiated during irradiation collimators for 15min (Figure 2).

After the irradiation process, blood specimens were obtained directly from the cardiac region of each rat through dissection, as depicted in Figure 3. An estimated volume of 10 mL of blood was extracted from each individual subject. The collected samples were subsequently analysed for Complete Blood Count (CBC) using automated haematology analysers to assess the possible haematological impacts of gamma irradiation.

Table 1. Exposed dose rate of incident gamma ray for each source-detector distance

Source-Detector distance (cm)	Average exposure dose (µSv/hr)
1	529.766± 2.75
15	9.66± 0.1561
30	1.8120.043
50	0.5964 ± 0.053
70	0.239 ± 0.065

https://doi.org/10.15218/zjms.2026.036

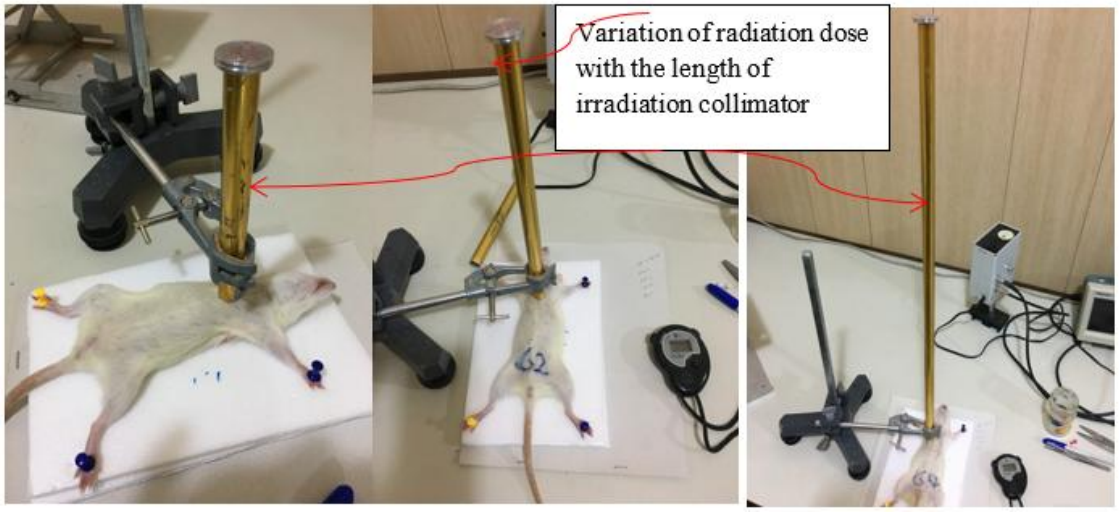

Figure 2. Irradiation exposure of by the ionizing radiation source (Cs-137) for different dosages

Figure 3. Rat dissection and cardiac blood collection

https://doi.org/10.15218/zjms.2026.036

Animal guideline

This study was approved by the Ethics Committee of [Salahaddin University-Erbil/Iraq] in accordance with institutional guidelines. All procedures involving animals complied with national and institutional ethical standards

Statistical analysis

The mean and standard deviation were taken. Student's t-test was used to assess the statistical significance of the differences between means. The level of significance was considered at $P < 0.05$.

Results and Discussion

Different dosages of ionized radiation were generated from Cs-137 by varying the length of the irradiation collimators. They are described using a logarithmic connection between source radiation and distance (Figure 4). The Fitting equation {dose rate (µSv/hr)=-131.1Ln(x) +482.52 (with R2= 0.89)} is experimentally considered as a main relationship between radiation doses and the source-distance.

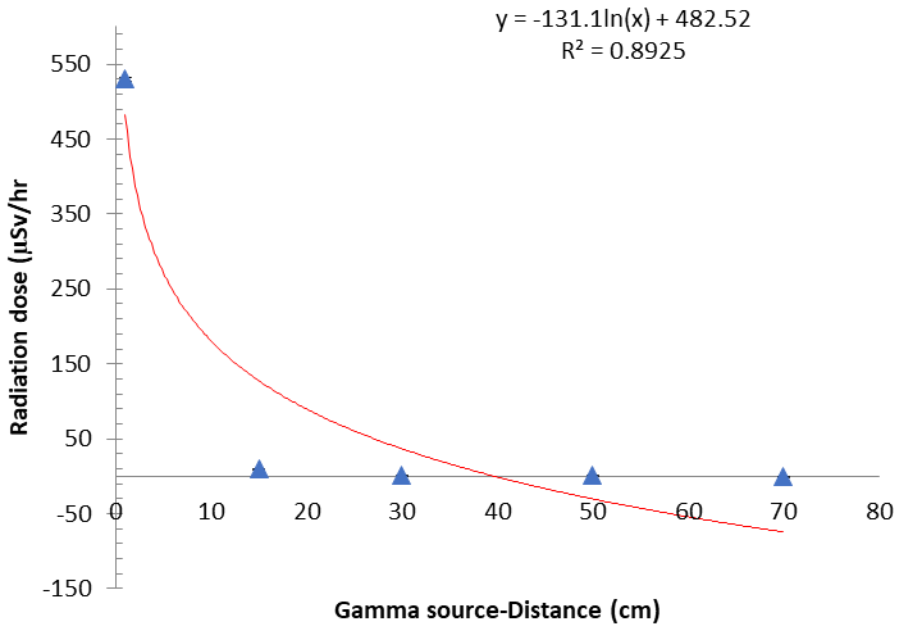

Figure 4. Logarithmic relationship between dose rate (µSv/hr) and the source-dosimeter distance (length of irradiation collimators)

https://doi.org/10.15218/zjms.2026.036

Table 2 illustrates that 15 minutes of exposure to the radioactive sources of Cs-137 has sufficiently changed the density of PLT, WBC, and RBC. That is considered an optimum time to irradiate the rats.

Impacts of ionization radiation doses on the blood component density were relatively different; it was high (P-value <0.05) impacts on PLT density compared with the density of WBC and RBC due to variation in the radiosensitivity and biological formation of the blood components. The density of PLT was more effective compared with other blood components (Figure 5) due to the structure and high radiosensitivity of PLT (8). At very low levels of ionized radiation dose (0.239 ± 0.065 µSv/hr), platelet density increases (Thrombocytosis) due to a disorder in the exposed rat body. In general, at high and very high incident exposure radiation doses, the density of PLT decreased (Thrombocytosis), relatively due to a blood and bone marrow disease.

Table 2. Impacts of time exposure of ionized radiation on the density of WBC, RBC, and PLT for the female Rats

Case groups	Time of exposure (minutes)	Average ratio of WBC (after/before irradiation)	Average ratio of RBC (after/before irradiation)	Average ratio of PLT (after/before irradiation)
A1	5	0.98 ±0.09	0.99 ±0.102	0.76 ±0.01
A2	10	0.77±0.101	0.89±0.21	0.66±0.201
A3	15	0.56±0.111	0.78±0.09	0.58±0.105
A4	20	0.69±0.107	0.88±0.103	0.77±0.098
A5	25	0.335±0.243	0.58±0.103	0.40±0.102

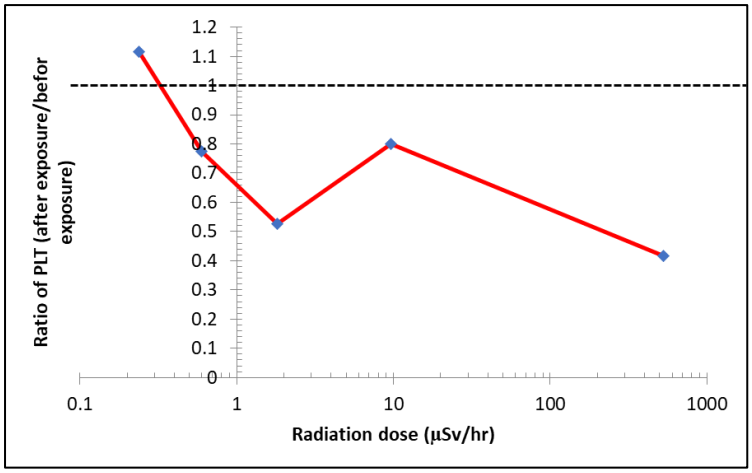

Figure 5. Impacts of ionized radiation doses on the density of PLT of the female rats

https://doi.org/10.15218/zjms.2026.036

The impact of ionizing radiation doses on white blood cell (WBC) density is illustrated in Figure 6. The data indicate that lower radiation doses had a more pronounced effect on WBC density. Specifically, exposure to 0.239 Â± 0.065 ÂµSv/hr resulted in an increase in WBC density, likely reflecting the activation of the rat's immune defense mechanisms in response to perceived physiological stress. This suggests that even low-dose radiation can trigger hematological changes, potentially leading to blood disorders in the exposed organisms (14). At a high rate of radiation doses (>1300µSv/hr), the density of WBC did not show sufficient effects due to a blood and bone marrow disease already done via its impacts on the PLT density, and this was in agreement with the previous study (4).

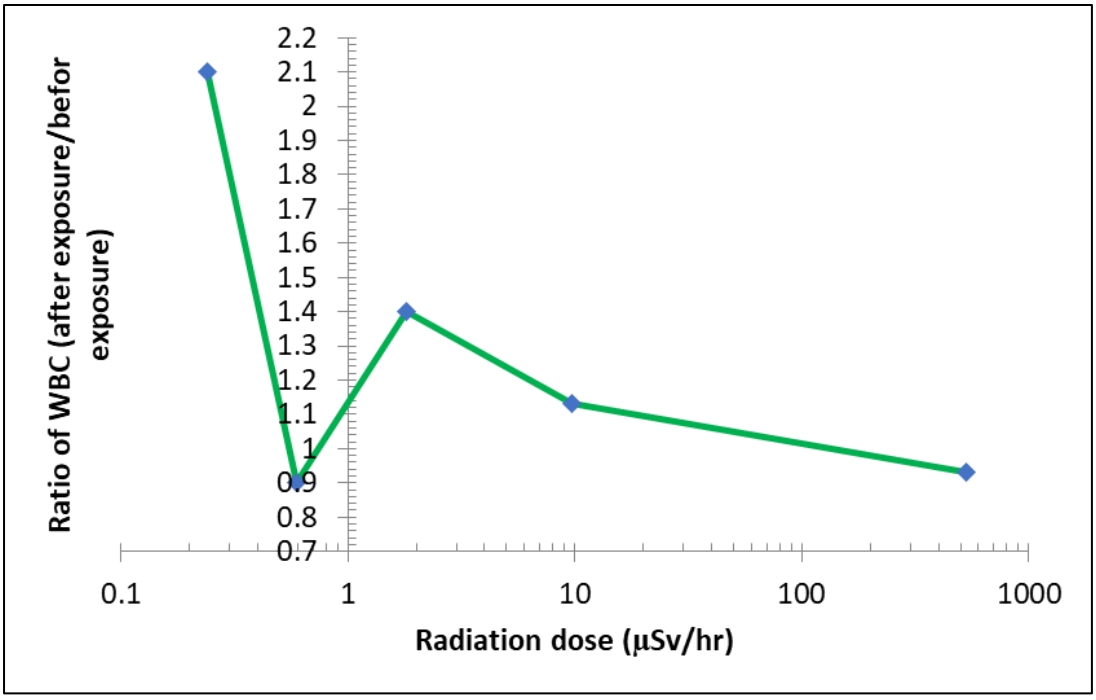

Figure 6. Impacts of ionized radiation doses on the density of WBC for the irradiated female rats

https://doi.org/10.15218/zjms.2026.036

The actions of RBCs directly contrasted those of PLTs as seen in Figure 7. For these very low IRDs, RBC density decreased while increasing with higher doses, directly opposed to the change in PLT density. Such an inverse correlation has previously been suggested using different radiation doses (1,15,16) and suggests different biological functions of the respective blood components. Bone marrow is at a significant risk even from this low dose of 0.239 ± 0.065 µSv/hr applied for 15 min as a result of the impairment in RBC density. Other ionization radiation, such as X-rays, did not influence blood cell counts. Research has been conducted on technicians who operate the X-ray devices in a local hospital, the result showed that the blood count is the same as the control samples (17).

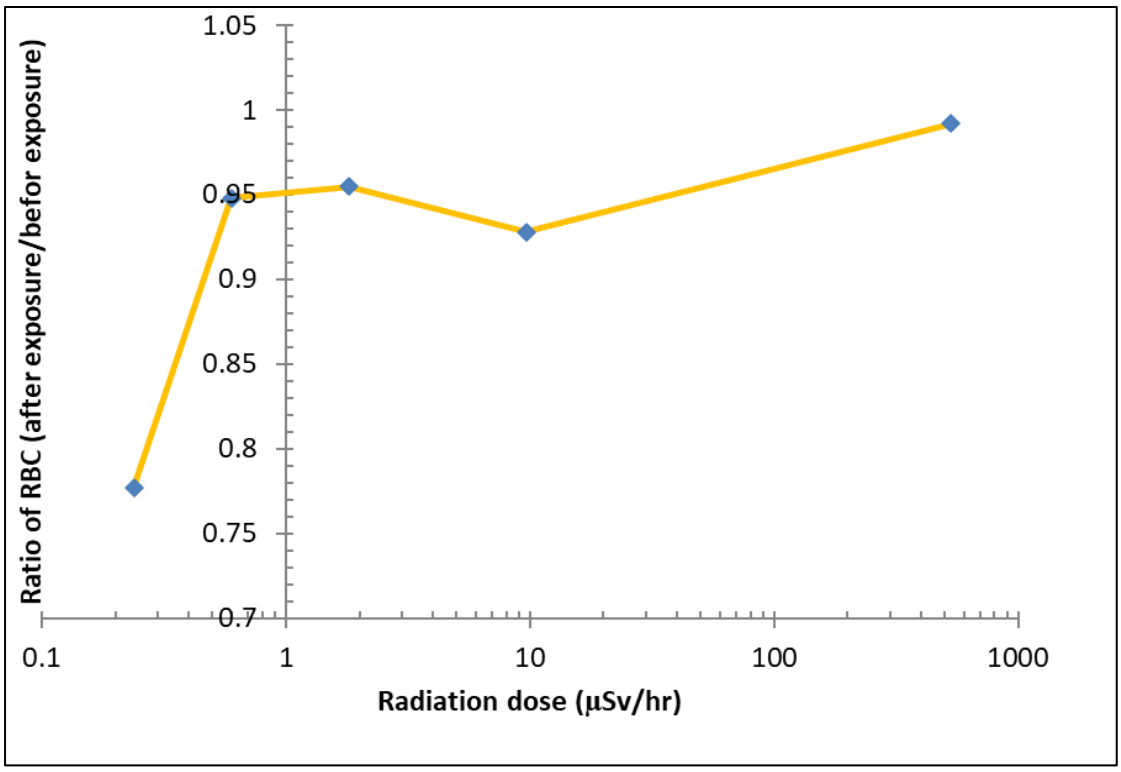

Figure 7. Impacts of ionized radiation doses on the average density of RBC for the irradiated female rats

https://doi.org/10.15218/zjms.2026.036

Conclusion

The main blood component densities were significantly affected by ionizing radiation exposures.- PLTs, WBCs, and RBCs-only for a limited period of exposure in the case of female rats. The present study experimentally calibrated the optimum exposure time and radiation doses. High doses of ionizing radiation brought about considerable changes in the density of all three blood components. The dose that inflicted the maximum influence was, however, variable with respect to the particular type of blood cells. Very significantly, the largest and most statistically significant effects were recorded for PLT density with both types of ionizing radiation examined.

The present study focused on evaluating the hematological responses of Wistar albino rats subjected to short-duration gamma irradiation (5–25 minutes). While the experiment provides valuable insights into the time-dependent sensitivity of blood parameters, the scope was limited to a single strain, age group, and sex of rats, which ensures consistency but does not capture potential inter-strain or sex-related variations. Hematological parameters were selected as primary endpoints due to their radiosensitivity and clinical relevance; however, future work could extend these findings by incorporating molecular and biochemical markers to better elucidate the underlying mechanisms. In addition, long-term follow-up studies would help to clarify whether the observed changes are transient or persistent. These considerations offer opportunities for further research building on the present findings.

Acknowledgment

I would extend my deepest thanks to Salahaddin University-Erbil for providing the opportunity and facilitating the necessary academic environment to conduct this research.

Competing interest

The author declares that he has no competing interests.

References

1. Ismail AH. Influence of radiation doses on the ratio of blast cells, lymphocytes and neutrophils inside blood samples of leukaemia patients: In vitro. Zanco J Pure Appl Sci. 2015;27(3):65-74.

2. Martin W, Wolfgang H, Enno R, Michael B. Biological effects of ionizing radiation on human blood compounds ex vivo. J Cancer Res Clin Oncol. 2000;126:584-8.
DOI: 10.1007/PL00008468

3. Jacobs GP. A review on the effects of ionizing radiation on blood and blood components. Radiat Phys Chem. 1998;53:511-23. DOI: 10.1016/S0969-806X(98)00185-6

https://doi.org/10.15218/zjms.2026.036

4. Ismail AH, Jaafar MS. Interaction of low-intensity nuclear radiation dose with human blood: Using the new technique of CR-39 NTDs for an in vitro study. Appl Radiat Isot. 2011;69(3):559-66.
DOI: 10.1016/j.apradiso.2010.11.004

5. Bauchinger M, Schmid E, Streng S, Dresp J. Quantitative analysis of chromosome damage at first division of human lymphocytes after 60Co γ-irradiation. Radiat Environ Biophys. 1983;22:225-9.
DOI: 10.1007/BF01323712

6. Anderson RM, Marsden SJ, Wright EG, Kadhim MA, Goodhead DT, Griffin CS. Complex chromosome aberrations in peripheral blood lymphocytes as a potential biomarker of exposure to high-LET alpha-particles. Int J Radiat Biol. 2000;76(1):31-42. DOI: 10.1080/095530000138989

7. Selim NS, Desouky OS, El-Marakby SM, Ibrahim IH, Ashry HA. Rheological properties of blood after whole-body gamma irradiation. Iran J Radiat Res. 2009;7(1):11-7.

8. Ismail AH, Mohamad AH, Edrees MH. Radiation exposure of leukaemia blood samples and its impacts on the density of RBC, WBC, and PLT: In vitro. Open J Biophys. 2012;2:130-6. DOI: 10.4236/ojbiphy.2012.24016

9. El-Dessouky MM, El-Dessouky YM. Effect of gamma radiation on CBC parameters of male guinea pigs. Int J Adv Sci Res Manag. 2018;3(2):71-5.

10. Ismail AH, Jaafar MS, Houssein HA, Mustafa FH. The impact of exposing human blood samples to radon gas on platelet count: Using a new exposure technique. Biophys Rev Lett. 2011;6(1-2):81-92.
DOI: 10.1142/S1793048011001270

11. Abd El-Hady AM, Azzoz RM, Soliman SM, Hamed EA, Elghazaly NA, Gado WA. Studies on the effect of curcumin and quercetin in the liver of male albino rats exposed to gamma irradiation. Histochem Cell Biol. 2024;162(4):299-309. DOI: 10.1007/s00418-024-02300-1

12. Vaishnav VAD, Bhat R, Suneetha N, Beulah DS, Shree GK. Effects of low-dose X-ray exposure on hematological parameters in Wistar albino rats. Angiotherapy. 2024;6(2):23-9. DOI: 10.25163/angiotherapy.899879

13. Xu Q, Ming Z, Dart AM, Du XJ, Van Pelt LF. Optimizing dosage of ketamine and xylazine in murine echocardiography. Clin Exp Pharmacol Physiol. 2007;34(5-6):499-507. DOI: 10.1111/j.1440-1681.2007.04601.x

14. El-Shanshoury H, El-Shanshoury G, Abaza A. Evaluation of low-dose ionizing radiation effects on some blood components in animal model. J Radiat Res Appl Sci. 2016;9:282-93. DOI: 10.1016/j.jrras.2016.01.001

15. Mohamed AKA, Mohamed SA, Sherif AM, Abd-Elhadi MA. The effects of

https://doi.org/10.15218/zjms.2026.036

gamma radiation on red blood cell corpuscles and dimensional properties in rats. Pak J Pharm Sci. 2015;28(5):1819-22. PMID: 26525021

16. Yousuf R, Mobin MH, Subramaniam T, Leong CF. Effects of gamma irradiation on red blood cells at different storage periods: A comparative study. Bangladesh J Med Sci. 2018;17(1):65-70. DOI: 10.3329/bjms.v17i1.35275

17. Tawfeeq G, Tawfeeq RD, Ommar A, Ali S. Hematological changes after Röntgen ray exposure in radiologic technologists. Zanco J Med Sci. 2021;25(2):526-31.
DOI: 10.15218/zjms.2021.016