Journal of Genetic and Environment Conservation (JOGEC)
www.jogec.com
Print ISSN: 3007-4509 Online ISSN: 3007-4517

Histological study about testicular tissue damage induced by monosodium glutamate and the ameliorative effect of curcumin in male albino rats

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Received: May 25th 2025
Accepted: July 9th 2025
Published: July 20th 2025
DOI:
https://doi.org/10.63799/jgec.13.2.1

ABSTRACT

Monosodium glutamate (MSG) is a sodium and glutamic acid salt. It is most often used in food processing as a flavoring enhancer. Due to its distinct flavor, monosodium glutamate, a non-essential amino acid in the human body, has been used extensively as a food additive since 1909. The purpose of the study was to explore the toxic and detrimental effects of monosodium glutamate as well as the protective function of curcumin in male albino rats. The evaluation criteria are determined by histological measurements and relative testes organ weight. Forty male rats (Rattus norvegicus) were utilized, and they were divided into four groups, with ten rats in each group. The first group received distilled water as a control, followed by group that received 100 mg of curcumin per kilogram of body weight, 20 mg of monosodium glutamate per kilogram of body weight, and monosodium glutamate plus curcumin group for 30 days. This study detected damages in testes tissues of monosodium glutamate treated group and monosodium glutamate plus curcumin group compared with controls. The study also displayed slightly histopathological damages in testes tissue in group was administrated monosodium glutamate plus curcumin compared with group which was administrated monosodium glutamate only. The results reported significant decrement ($p \leq 0.05$) of relative testes weight in animal group that was treated by monosodium glutamate, monosodium glutamate plus curcumin in comparison with controls. Additionally, the results identified the positive role of curcumin in significantly ($p \leq 0.05$) enhancing monosodium glutamate adverse effects on relative testes weight.

Keywords: Monosodium glutamate, Curcumin, Testicular damage.

Introduction

A common food additive in both domestic and industrial settings, monosodium glutamate (MSG) improves the palatability of food. while MSG is generally regarded as safe at low doses, high doses and repeated exposure to MSG are linked to teratogenicity and embryotoxicity, obesity, cardiotoxicity, hepatotoxicity, kidney toxicity, neurotoxicity, endothelial dysfunction, and reproductive toxicities (Udom et al., 2025). Monosodium glutamate (MSG), one of the most widely used flavor enhancers in the world, has been linked to notable pathophysiological events in a number of bodily tissues and organs (Oluwole et al., 2024). Human health problems caused by monosodium glutamate include metabolic syndrome, immunological dysfunction, cancer, cardiovascular disease, neurotoxicity, renal toxicity, infertility, and fetal underdevelopment (Yang et al., 2023) Reactive oxygen species (ROS) are produced when monosodium glutamate is present, which changes redox equilibrium and damages the system (Banerjee et al., 2021). In both people and experimental animals, increasing the daily dosage of monosodium

glutamate causes a variety of metabolic problems. These include alterations in blood and urine biochemical markers, obesity, and an increase in body weight in specific population groups. These alterations are frequently linked to harm to the liver and kidney tubules (Kochmar et al., 2022) possible negative impact on human health in spite of its extensive use, excessive use of MSG has been associated with negative physiological effects on the immune system, cardiovascular system, brain system, and reproductive system as well as an increased risk of obesity and metabolic illnesses, oxidative stress, inflammation, and damage to liver and renal (Kumari et al., 2023). Monosodium glutamate is a well-known food additive that has been shown to be effective in causing male reproductive abnormalities, it can cause a number of reproductive dysfunctions, such as oxidative damage, histological alteration (blood hemorrhage, distorted germ and Sertoli cells), and spermatogenic alteration (low sperm count, high sperm abnormality, reduced live sperm, and decreased sperm pH) (Kayode et al., 2020).

Through a variety of modes of action, curcumin, a naturally occurring lipophilic polyphenol, demonstrates notable pharmacological effects both in vitro and in vivo. Curcumin's pharmacokinetic, pharmacodynamic, and clinical characteristics have been identified and described in a number of research. Curcumin possesses antioxidant and anti-inflammatory properties (Urosevic et al., 2022).

Curcuma longa, a member of the zingiberaceae family, contains curcumin, a naturally occurring polyphenolic substance, in its rhizome. Increasing experimental data showed that curcumin has multitarget biological effects, indicating its critical function in both health and disease (Patel et al., 2020).

Turmeric, or Curcuma longa, is a common and extensively used rhizomatous medicinal plant in India that belongs to the Zingiberaceae family, its components, curcumin, demethoxycurcumin and bisdemethoxycurcumin, are commonly referred to as curcuminoids (Rathore et al., 2020). It has hypoglycemic, anti-inflammatory, antibacterial, neuroprotective, and immunomodulatory properties. It also enhances the effectiveness of these treatments against a number of chronic conditions, such as osteoporosis, cancer, and arthritis (Prasad et al., 2021). In a variety of human disease disorders, curcumin is clearly active. Generally speaking, curcumin is good for human health since it has pharmacological anti-inflammatory and antioxidative properties in addition to anticancer and immune-regulating properties (Liu et al., 2022). This study evaluated curcumin's possible therapeutic and preventive benefits in lowering cytotoxicity and preventing testicular injury in male albino rats given monosodium glutamate.

Materials and Methods

The treatments and animals grouping: This study was performed out in the animal house and histological laboratory of the biology department of the Faculty of Science at the University of Kufa between February 1 and April 15, 2024. Forty male rats (Rattus norvegicus) weighing between 111 and 165 grams were used in the experiment; they were housed in the animal house with a regular light-dark cycle and fed and water-supplied for at least two weeks prior to the experiment. The University of Mosul's Ethical Approval No. um.VET.2021.5 granted approval for the study.

Ethics statement: Every animal experiment was carried out in accordance with the criteria for the use and care of laboratory animals, having been approved by Kufa University's Central Committee for Bioethics.

Experimental Design: Four equal groups were used. There were ten animals in each group. The animals in the first group were given distilled water instead of medication, while the animals in the second group were given 100 mg of curcumin per kilogram of body weight. The fourth group was given monosodium glutamate plus curcumin for 30 days, while the third group was given monosodium glutamate at a dose of roughly 20 mg/kg body weight.

Chemicals:

1-Monosodium glutamate solution is a chemical that is purchased from a supermarket in Najaf, Iraq, and is used as a food ingredient. Since the substance is crystallized, it is ground into a powder and dissolved in distilled water.

2. Curcumin solution: Curcumin food ingredient purchased from a Najaf, Iraq, store. To aid in its absorption by the animal intestine, it is utilized in powdered form and dissolved in olive oil.

Histopathological study: In order to examine histological changes in the testes tissue of experimental rats, tissue specimens were prepared, embedded in paraffin, and sectioned using a rotary microtome into 6 mm-thick slices in accordance with (Bancroft and Stevens 1999). Testes tissues were fixed in 10% formalin for at least 24 hours. The slices were stained with hematoxylin and eosin dyes, and the histopathological changes in the testes were viewed under a light microscope.

The relative testes organ weight: A sensitive scale was used to weigh the testes after all of the fat had

been removed. The relative testis weight, which was expressed as the testis weight to total body weight ratio, was determined using the (Gornall *et al*, 1949) method.

Analytical statistics: SPSS (statistical software for social sciences) was used to statistically evaluate the data. t-test for independent samples and analysis of variance (ANOVA). The findings are displayed using the mean ± standard deviation. A p-value of less than 0.05 was considered statistically significant for treatment differences.

Results and Discussion

Histopathological test: The testes tissue of male albino rats given monosodium glutamate at a dose of 20 mg/kg body weight for 30 days demonstrated the presence of histopathological alterations brought on by monosodium glutamate treatment in the current investigation. The findings also demonstrated curcumin's protective effects at a level of 100 mg/kg and its ability to lessen testicular damage (Figures 1–11).

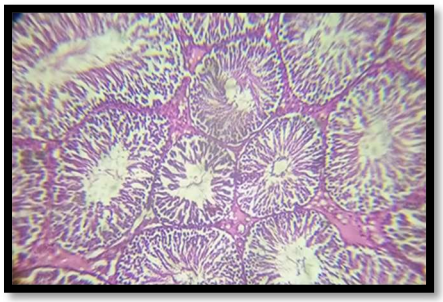

Figure (1). Male albino rat's testes tissue transvers section, showing normal architecture with normal spermatogonia stacked in several layers on seminiferous tubule and normal spermatogenesis from control ve- group (H&E X 100).

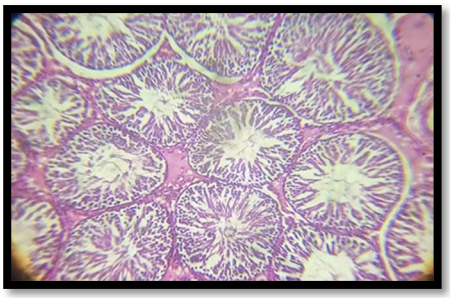

Figure (2): Male albino rat's testes tissue transvers section, showing normal architecture showing normal architecture with normal spermatogonia stacked in several layers on seminiferous tubule and normal spermatogenesis from control ve- group (H&E X 100).

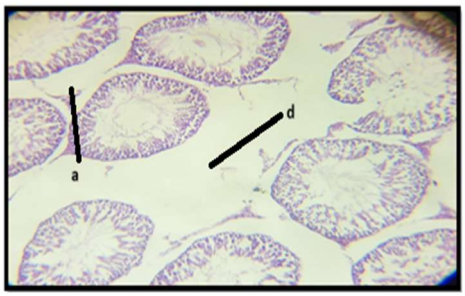

Figure (3): Male albino rat's testes tissue transvers section, showing abnormal architecture with changes represented by degenerated seminiferous tubules (d) and absence of leydig cells (a) from monosodium glutamate group (H&E X 100).

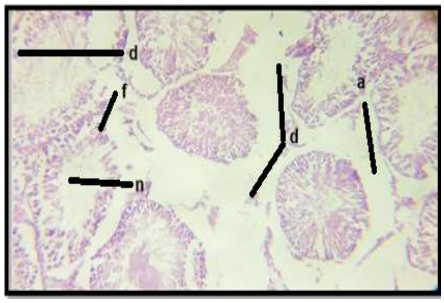

Figure (4): Male albino rat's testes tissue transvers section, showing degradation seminiferous tubules and spermatogonial cells (d), absence leydig cells (a), few number of spermatids (f) and no spermatogenesis from monosodium glutamate group (H&E X 100).

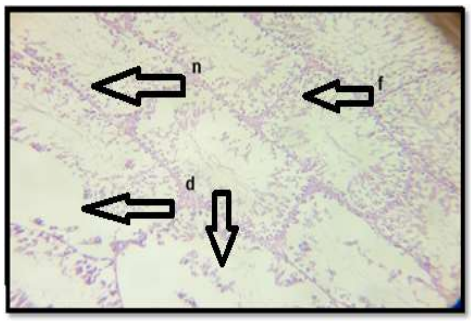

Figure (5): Male albino rat's testes tissue transvers section, showing few layers of spermatogonial cells (f) , no spermatogenesis (n) and depletion in seminiferous tubules and disorganized germinal epithelium with no sperm aggregations from monosodium glutamate group (H&E X 100).

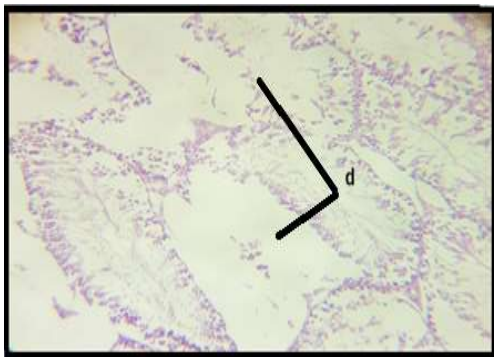

Figure (6): Male albino rat's testes tissue transvers section, showing represented by degradation in seminiferous tubules and lose the normal testes tissue architecture and disorganized germinal epithelium with no sperm aggregations (d) from monosodium glutamate group (H&E X 100).

Figure (7): Male albino rat's testes tissue transvers section, showing degradation in most seminiferous tubules (d) and absence of leydig cells from monosodium glutamate group (H&E X 100).

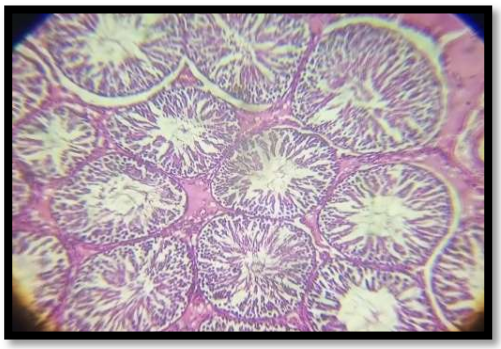

Figure (8): Male albino rat's testes tissue transvers section, showing normal architecture without changes from curcumin (control +) group (H&E X 100).

Figure (9): Male albino rat's testes tissue transvers section, showing semi normal architecture with too little changes from monosodium glutamate + curcumin group (H&E X 100).

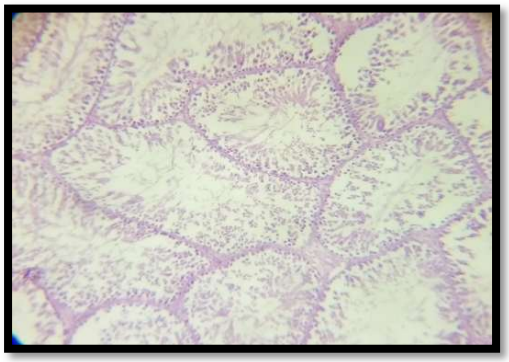

Figure (10): Male albino rat's testes tissue transvers section, showing semi normal architecture with mild changes in spermatogonial cells layers from monosodium glutamate + curcumin group (H&E X 100).

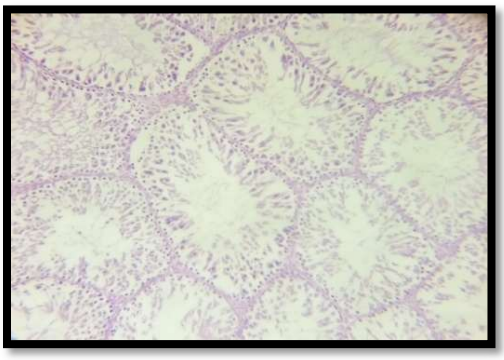

Figure (11): Male albino rat's testes tissue transvers section, showing semi normal architecture with very few changes in seminiferous tubules from monosodium glutamate + curcumin group (H&E X 100).

Relative testis organ weight: The present investigation revealed a significant P≤0.05 reduction in the weight of the associated testes in male albino rats administered monosodium glutamate at a dose of 20 mg/kg body weight during the experimental period, in comparison to the control groups. Furthermore, compared to the control group, the animal group administered monosodium glutamate + curcumin at a dose of 100 mg/kg during the experimental period showed a significant P≤0.05 increase in relative testes weight.

Table (1): Monosodium glutamate and curcumin affect the relative testes weight in male albino rats.

Treatment	Relative testes weight (gm) %
Control negative (distilled water)	**1.97±0.03**
Control positive (curcumin)	**2.3±0.20**
Monosodium glutamate	**0.77±0.09 abc**
Monosodium glutamate + curcumin	**1.18±0.01 abc**

Notes: Tiny letters and the mean ± standard deviation indicate significant differences, which are denoted by P≤0.05. a: significant change in comparison to the negative control. Significant differences are shown between two treatments (c) and between treatments and the positive control (b).

Histopathological test: According to the results in figure 1-7, the current study showed that experimental animals given monosodium glutamate at a level of 20 mg/kg of body weight for 30 days had histological abnormalities in their testes tissue, the results were similar to (Oluwole et al., 2024) who reported histopathological changes in the testicular tissues caused by monosodium glutamate, including distended seminiferous tubules by some spermatogenic cell stages, a small number of spermatids, Leydig cells, disorganized germinal epithelium, no sperm aggregations, and some degenerated parts. In addition, these results were similar to (Abd-Elkareem et al., 2021) who explained that monosodium glutamate caused atrophic seminiferous tubules with degeneration of their lining cells, damaged Leydig cells, and a decrease in the number of germ cells, as well as other significant abnormalities in the testis histological test. Furthermore, these results supported by (El Kotb et al., 2020) They found that monosodium glutamate induced a number of histological alterations in the testis, such as the absence of sperm in the lumina of tubules and the degradation of the germinal epithelium.

Furthermore, these results in agreement with (Kianifard et al., 2021) They observed several changes in the testicular tissue of adult rats treated with MSG, such as disrupted cellular organization, a decrease in the number of germ cells, and a loss of tubular architecture. Furthermore, these results according to (Abdou et al., 2020) Both low and high doses of MSG caused testicular degeneration in rats which had been demonstrated by detrimental impacts on histology and immunohistochemical data. Furthermore, the findings concurred with those of (Taha et al., 2025) who revealed that MSG marked rat's testicular degeneration. In addition, the results similar to (Kianifard et al., 2021) who said that most noticeable changes seen in the MSG-treated group of rats were the loss of tubular architecture and atrophy caused by MSG, the reduction in the number of germ cells, the disruption of cellular organization, and the growth of interstitial connective tissue.

The current study determined that rats given monosodium glutamate at a dose of 20 mg/kg and curcumin at a dose of 100 mg/kg showed only minor histological changes in testes tissue, and that curcumin had a protective effect by reducing testicular damage. Figures (8–11). Based on the findings in figures 9–11 the findings in agreement with (Feng *et al*., 2022). They reached the conclusion that giving rats curcumin significantly decreased the amount of apoptosis in their testicular cells and improved the testis' histological appearance. Moreover, the results were in agreement with (Shahedi *et al*., 2021). They noticed that curcumin reduces oxidative stress and free radical levels in a variety of tissues. This means that curcumin's antioxidant ability triggers antioxidant responses in cells, which lessens the negative effects on testicular tissue.

Additionally, these results were similar to (Ranjbar *et al*., 2023) They asserted that curcumin, a possible antioxidant, would be a useful attenuative treatment for testicular oxidative injury. Furthermore, these findings demonstrated curcumin's protective function and were supported by (Ndufeiya *et al*., 2022). They ultimately reached the conclusion that curcumin may repair testicular damage by elevating reproductive hormone levels, normalizing testicular biochemical parameters, and strengthening the testes' histological characteristics in Wistar rats. Moreover, these results were in similarity with (Balcioglu *et al*., 2023) They concluded that the rat's

testicular tissue had less histopathological damage after receiving curcumin.

Related testes organ weight: The current study indicated significant (P≤0.05) decrease in related testes weight after male albino rat's monosodium glutamate administration at dose of 20 mg/kilogram of body weight throughout experimental period compared with control groups. In addition, the results noticed significantly (P≤0.05) increment in relative testes weight in animal group which was administrated by monosodium glutamate + curcumin at dose 100mg/kg throughout experimental period in comparison with monosodium glutamate group, the study elucidated the protective effect of curcumin to reduce the toxic impact of monosodium glutamate on testes organ weight table 1. According to these data, the results in agreement with (Jubaidi *et al*., 2019) They showed that monosodium glutamate significantly reduced the weight of reproductive organs and prompted an evaluation of the testis' oxidative condition. In addition, these outcomes in agreement with (Wang *et al*., 2021) who discovered that monosodium glutamate can harm male mice's reproductive organs and alter testicular weight, causing reproductive toxicity. Furthermore, the result was similar to (Kayode *et al*., 2020) who established that, in comparison to the control, MSG reduced the rat's testis-to-body weight ratio. Additionally, these results supported by (Askar *et al*., 2025) They identified that MSG caused testicular tissues to undergo oxidative stress, inflammation, and apoptosis, which disturbed steroidogenesis, hindered spermatogenesis, and dramatically reduced teste weight. Moreover, the results in table 1 supported by (Taba *et al*., 2019) They discovered that supplementing with curcumin improved sperm parameters and biochemical indicators while also lowering apoptosis in the testicular tissue of the aged mouse model. Furthermore, the results are similar to (Belhan *et al*.,2020) They found curcumin may have a preventive impact indirectly, as evidenced by its ability to improve testicular injury and regulate reproductive hormones. Lastly, the findings concur with (Ara *et al*., 2021), who propose that curcumin enhances testicular morphology and reduces testicular weight.

Conclusion

The data summarized that curcumin had a strong protective effect against monosodium glutamate-induced testicular damage and changes in testes organ weight in male albino rats, indicating that supplements containing curcumin can be used as antioxidants due to their many beneficial culinary applications.

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