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Research Article

Effect of Kiwi Fruit (Actinidia deliciosa) Extract on Histological Structure and Testicular Weight in Monosodium Glutamate-Induced Male Rats

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Abstract: Monosodium glutamate (MSG) is a widely consumed food additive that has been reported to increase the production of reactive oxygen species (ROS), potentially inducing damage to various organs, including the testes. Oxidative stress in the testes may impair histological structure and disrupt the process of spermatogenesis. Antioxidants have been shown to attenuate the harmful effects of free radicals, and kiwifruit (Actinidia deliciosa) is recognized as a rich source of natural antioxidants. This study aimed to evaluate the effect of kiwifruit extract on testicular weight and histopathological characteristics in male Sprague Dawley rats exposed to MSG for 30 days. This experimental study used 25 male Sprague Dawley rats randomly assigned into five groups (n = 5 per group): negative control (K−), positive control receiving MSG at 4.8 g/kg body weight/day (K+), MSG plus vitamin C at 0.2 g/kg body weight/day (P1), MSG plus kiwifruit extract at 0.2 g/kg body weight/day (P2), and MSG plus kiwifruit extract at 0.4 g/kg body weight/day (P3). All treatments were administered for 30 consecutive days. Histopathological evaluation of the testes was performed on hematoxylin and eosin (H&E)-stained sections to assess the seminiferous tubule germinal epithelium, while testicular weight was measured at the end of the experiment. Data were presented descriptively as mean ± standard deviation. Histopathological examination demonstrated improved seminiferous tubule germinal epithelium in the P2 and P3 groups compared with the MSG-treated group (K+). The lowest mean testicular weight was observed in the P3 group (0.66 ± 0.31 g), compared with the K+ group (1.07 ± 0.28 g) and the negative control group (0.95 ± 0.30 g). Administration of kiwifruit extract tended to improve the histopathological appearance of the testes in male rats exposed to MSG, particularly in the P3 group, suggesting a potential protective effect against oxidative stress-induced testicular damage. However, the findings regarding changes in testicular weight remain descriptive and require confirmation through inferential statistical analysis.

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1. Introduction

Monosodium glutamate (MSG) is a widely used food additive that enhances the umami flavor of foods. However, excessive and chronic exposure to MSG has raised concerns because of its potential toxic effects, particularly on the male reproductive system. Experimental studies have demonstrated that MSG may induce reproductive toxicity by damaging gonadotropin-releasing hormone (GnRH) neurons in the hypothalamus, thereby disrupting the hormonal regulation of reproduction in a persistent manner without spontaneous recovery (Wang et al., 2021; Jubaidi et al., 2019).

Animal studies have shown that MSG exposure can induce structural and functional alterations in the testes, including impaired spermatogenesis, damage to Sertoli and Leydig cells, and histomorphological changes in the seminiferous tubules. These pathological alterations are associated with impaired steroidogenesis, enhanced inflammatory responses, oxidative stress, and activation of apoptotic pathways, all of which contribute to the deterioration of male reproductive function (Askar et al., 2025; Kianifard et al., 2021).

Oxidative stress is considered one of the primary mechanisms underlying MSG-induced testicular toxicity. Excessive MSG exposure increases the production of reactive oxygen species (ROS), leading to lipid peroxidation, protein oxidation, and disruption of germ cell DNA integrity. These events may result in reduced testicular weight and histopathological alterations. Similar oxidative damage has also been reported in other organs, including the pancreas and liver, where antioxidant administration has been shown to alleviate tissue injury caused by oxidative stress (El Kotb et al., 2020; Rasyid et al., 2025).

Antioxidants play an essential role in neutralizing ROS and protecting tissues against oxidative damage. Exogenous antioxidants, such as vitamins C and E, have been reported to exert protective effects on testicular tissue. Vitamin C supplementation has been shown to improve sperm quality, including sperm motility and morphology, in animals chronically exposed to toxic agents (Shabanian et al., 2017). Furthermore, the combined administration of vitamins C and E has demonstrated greater protective effects by improving testicular histological architecture and reducing biomarkers of oxidative stress (Zare et al., 2019).

At the molecular level, oxidative stress also disrupts the regulation of genes involved in spermatogenesis. Reduced expression of the *Deleted in Azoospermia-Like* (*DAZL*) and *boule* genes has been associated with spermatogenic failure in infertile men, indicating that testicular damage involves not only structural abnormalities but also complex molecular mechanisms (Suryandari et al., 2019). In addition, cellular adaptation to oxidative stress involves alterations in energy metabolism, including the regulatory role of pyruvate kinase M2 (PKM2) in the cellular response to metabolic stress (Zulfa et al., 2025).

Kiwifruit (*Actinidia deliciosa*) is recognized as a rich natural source of antioxidants, including vitamin C, polyphenols, and flavonoids. Previous studies have demonstrated that kiwifruit possesses high antioxidant capacity compared with many other fruits, although its bioactive compound content varies among genotypes (Leontowicz et al., 2016; Saeed et al., 2019). The protective effects of kiwifruit extract on the reproductive system have also been reported, including its ability to ameliorate inflammation, inhibit apoptosis, and preserve testicular histological architecture through the suppression of oxidative stress (El-Demerdash et al., 2024). Similar findings have been observed in both animal and insect models, in which kiwifruit extract improved reproductive organ morphology following exposure to environmental stressors (Kusumawati & Sudaryadi, 2022).

Considering the high susceptibility of Sprague Dawley rat testes to oxidative stress (Hancı et al., 2018) and the importance of dietary antioxidants derived from fruits and vegetables (Rahimi Anbarkeh et al., 2019; Handayani et al., 2022), this study aimed to evaluate the effects of kiwifruit (Actinidia deliciosa) extract on testicular weight and histopathological characteristics in male Sprague Dawley rats exposed to MSG for 30 days.

2. Materials and Method

This laboratory-based experimental study employed a descriptive analytical approach using 25 male Sprague Dawley rats aged 4–5 weeks and weighing approximately 50 g. The sample size was determined using the Federer (Mead) formula, and five rats were allocated to each group to compensate for potential sample loss during the experiment. Following a four-day acclimatization period, the animals were randomly assigned into five groups (n = 5 per group): a negative control group receiving no treatment, a positive control group receiving MSG at 4.8 g/kg body weight/day, an MSG + vitamin C group receiving vitamin C at 0.2 g/kg body weight/day, an MSG + kiwifruit extract group receiving 0.2 g/kg body weight/day, and an MSG + kiwifruit extract group receiving 0.4 g/kg body weight/day. All treatments were administered orally by gavage for 30 consecutive days.

Kiwifruit extract was prepared from fresh kiwifruits, which were processed using a juicer, dried, and ground into a fine powder. The powdered extract was subsequently dissolved in distilled water before oral administration. Kiwifruit extract was administered in the afternoon following MSG administration. On day 31, all rats were anesthetized using inhalation anesthesia and subsequently euthanized for testicular tissue collection. The testes were excised, weighed, and fixed in 10% neutral buffered formalin for histopathological

examination. The observed variables included testicular weight and the histopathological characteristics of the seminiferous tubule germinal epithelium, which were examined under a light microscope at magnifications of ×10, ×20, and ×40. The experimental workflow is presented in Figure 1.

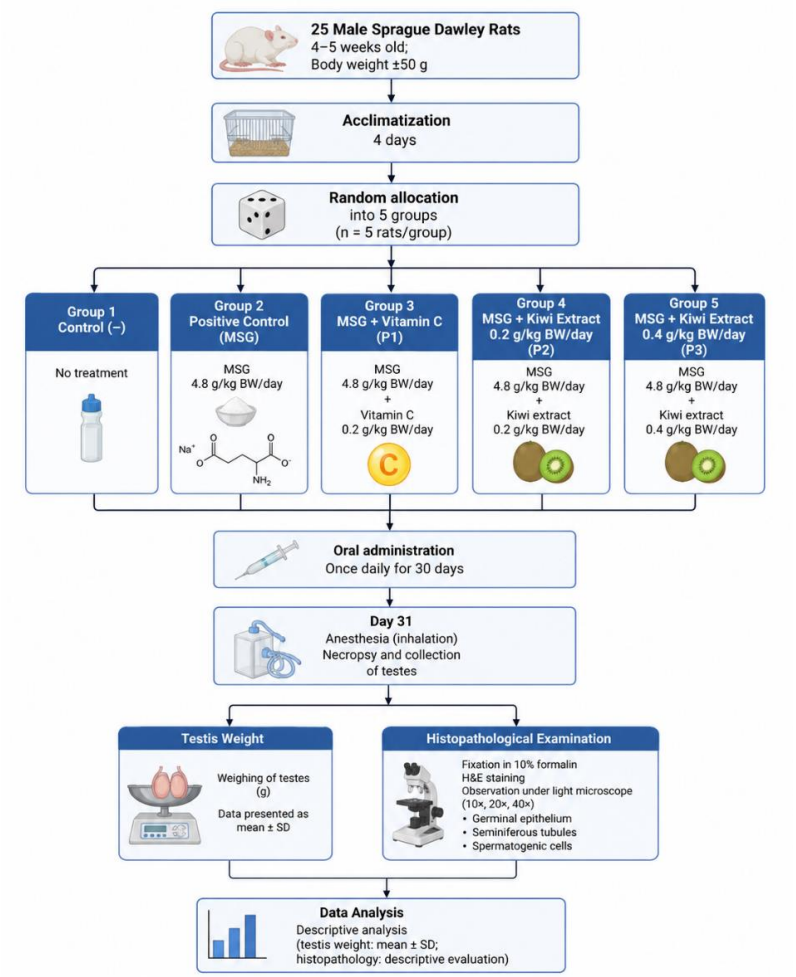

Figure 1. Flow diagram of the experimental design.

Testicular weight data were presented descriptively as mean ± standard deviation, whereas histopathological findings were evaluated descriptively based on changes in the structure of the seminiferous tubule germinal epithelium among the treatment groups. This study was approved by the Health Research Ethics Committee of the Faculty of Medicine and Health Sciences, UIN Syarif Hidayatullah Jakarta (Approval No. Un.01/FI/KP.01.1/KE.SP/06.16.009/017).

3. Results

Testicular Weight

Testicular weight was evaluated as one of the indicators of the effects of monosodium glutamate (MSG) exposure and antioxidant administration on the testes of male Sprague Dawley rats. Measurements were performed after 30 days of treatment, and the results are presented in Table 1.

Table 1. Testicular Weight of Male Sprague Dawley Rats.

Treatment Group	Testicular Weight (Mean ± SD) (g)
K(–) Negative control	0,95 ± 0,30
K(+) MSG 4.8 g/kg body weight/day	1,07 ± 0,28
P1: MSG + Vitamin C (0.2 g/kg body weight/day)	1,06 ± 0,26
P2: MSG + Kiwifruit extract (0.2 g/kg body weight/day)	1,06 ± 0,50
P3: MSG + Kiwifruit extract (0.4 g/kg body weight/day)	0,66 ± 0,31

As shown in Table 1, the negative control group had a mean testicular weight of 0.95 ± 0.30 g, whereas the positive control group exposed to MSG had a mean testicular weight of 1.07 ± 0.28 g. The P1 and P2 groups exhibited comparable mean testicular weights of 1.06 ± 0.26 g and 1.06 ± 0.50 g, respectively. The lowest mean testicular weight was observed in the P3 group, with a value of 0.66 ± 0.31 g.

Histopathological Findings of the Testes

Histopathological examination of hematoxylin and eosin (H&E)-stained testicular sections revealed differences in the morphology of the seminiferous tubules among the treatment groups. Histopathological evaluation was performed descriptively by assessing the integrity of the germinal epithelium, the arrangement of spermatogenic cells, and the morphology of the seminiferous tubules. Representative photomicrographs are presented in Figure 2.

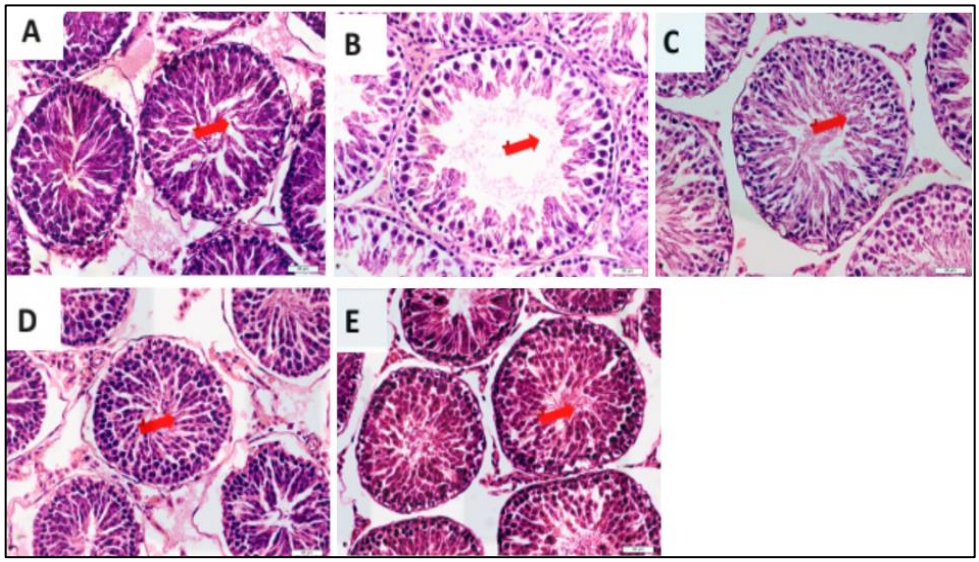

Figure 2. Representative histopathological appearance of the testes in male Sprague Dawley rats stained with hematoxylin and eosin (H&E; ×40). (A) Negative control; (B) Positive control (MSG); (C) MSG + vitamin C; (D) MSG + kiwifruit extract (0.2 g/kg body weight/day); and (E) MSG + kiwifruit extract (0.4 g/kg body weight/day).

The negative control group showed normal seminiferous tubule architecture with an intact germinal epithelium and regularly arranged spermatogenic cells. In contrast, the positive control group exposed to MSG exhibited a thinner germinal epithelium, disorganization of spermatogenic cells, and a reduced number of spermatogenic cells in several seminiferous tubules. The P1 and P2 groups demonstrated a more organized germinal epithelium and spermatogenic cell arrangement than the positive control group. Similar observations were found in the P3 group, in which the germinal epithelium and spermatogenic cells appeared more regularly organized. However, histomorphometric parameters, including seminiferous tubule diameter, germinal epithelial thickness, and histopathological scoring, were not evaluated. Therefore, the histopathological findings were limited to descriptive observations.

4. Discussion

The present study demonstrated that 30 days of monosodium glutamate (MSG) exposure was associated with morphological alterations in the testes of male Sprague Dawley rats, as reflected by changes in both testicular weight and histopathological characteristics. The negative control group exhibited normal seminiferous tubule architecture and a mean testicular weight of 0.95 ± 0.30 g, representing the physiological condition of healthy testicular tissue. These findings are consistent with previous studies reporting that MSG induces germ cell apoptosis through oxidative stress, resulting in structural alterations in testicular tissue (Rahimi Anbarkeh et al., 2019). Excessive production of reactive oxygen species (ROS) following MSG exposure has also been implicated in cellular damage that may subsequently affect testicular morphology and organ weight.

The higher mean testicular weight observed in the positive control group may be associated with inflammatory responses and disruption of tissue homeostasis induced by oxidative stress. Previous studies have shown that MSG-induced testicular injury is accompanied by blood–testis barrier dysfunction and elevated oxidative stress, which may promote tissue edema and alterations in organ weight (Acikel-Elmas et al., 2023). In addition, MSG has been reported to exacerbate reproductive toxicity by enhancing inflammatory processes and inducing structural damage to testicular tissue (Ogunro et al., 2025). Therefore, the increased testicular weight observed following MSG exposure should not necessarily be interpreted as an improvement in testicular function but may instead reflect pathological changes within the tissue.

The vitamin C-treated group and the group receiving kiwifruit extract at 0.2 g/kg body weight/day exhibited comparable mean testicular weights, whereas the lowest mean testicular weight was observed in the group receiving kiwifruit extract at 0.4 g/kg body weight/day. However, because inferential statistical analysis was not performed, differences among treatment groups cannot be considered statistically significant and should be interpreted only as descriptive observations. Consequently, changes in testicular weight alone cannot be regarded as definitive evidence of the protective effects of kiwifruit extract on testicular tissue.

Despite these findings, histopathological examination demonstrated that administration of kiwifruit extract, particularly at a dose of 0.4 g/kg body weight/day, was associated with better preservation of the seminiferous tubule germinal epithelium compared with the positive control group. This observation suggests a potential protective effect of kiwifruit extract against MSG-induced testicular injury. Kiwifruit is a rich source of vitamin C as well as several bioactive compounds, including polyphenols, flavonoids, and ellagic acid, all of which possess potent antioxidant and anti-inflammatory properties. These compounds are known to attenuate oxidative stress and inflammatory responses through modulation of multiple molecular pathways involved in cellular defense against free radicals (Leontowicz et al., 2016; Park et al., 2012; Wang et al., 2021; Uy et al., 2026). Furthermore, kiwifruit polyphenols have been reported to exhibit strong antioxidant activity, suppress inflammatory responses, and enhance cellular antioxidant capacity (Yang et al., 2024). Similar findings have also been reported for kiwiberry (Actinidia arguta), which contains abundant polyphenols with high antioxidant capacity and has demonstrated protective effects against oxidative stress-induced tissue injury (Qiao et al., 2025). Collectively, these bioactive constituents may contribute synergistically to maintaining testicular integrity by reducing oxidative damage and preserving tissue homeostasis.

Although the histopathological findings suggested improved testicular architecture in the group receiving the higher dose of kiwifruit extract, the lower mean testicular weight observed in this group compared with the negative control indicates that the relationship between organ weight and histological improvement remains unclear. Other factors, including adaptive tissue responses or dose-related effects of the extract on organ mass, cannot be excluded. Therefore, the present findings should be interpreted with caution.

Several limitations of this study should be acknowledged. First, the analysis was limited to descriptive observations without inferential statistical testing. Second, histomorphometric parameters, including seminiferous tubule diameter, germinal epithelial thickness, and histopathological scoring, were not evaluated. Consequently, although the present findings suggest that kiwifruit extract may attenuate MSG-induced testicular injury, further studies incorporating quantitative histomorphometric analysis, oxidative stress biomarkers, and inferential statistical approaches are required to confirm these protective effects.

5. Conclusion

This study demonstrated that 30 days of monosodium glutamate (MSG) exposure was associated with morphological alterations in the testes of male Sprague Dawley rats, including changes in testicular weight and seminiferous tubule architecture. Histopathological observations suggested that antioxidant treatment, particularly kiwifruit (Actinidia deliciosa) extract at a dose of 0.4 g/kg body weight/day, was associated with better preservation of the germinal epithelium and spermatogenic cell organization compared with the MSG-treated group. However, because the present study was limited to descriptive observations without inferential statistical analysis or histomorphometric measurements, these findings should be interpreted with caution. Nevertheless, the results suggest that kiwifruit extract may have potential as a natural protective agent against MSG-induced testicular injury. Further studies incorporating quantitative histomorphometric evaluation, oxidative stress biomarkers, and inferential statistical analyses are warranted to confirm these findings and elucidate the underlying mechanisms.

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