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Research Article

Antiulcer Activity of *Trianthema portulacastrum* Leaves in Rats Using an Experimental Ulcer Model

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ABSTRACT

Gastric ulcer conditions can lead to severe complications, including bleeding, perforation, and an increased risk of gastric carcinoma. Natural remedies such as Trianthema portulacastrum may help alleviate these issues by boosting antioxidant defenses and reducing inflammation. In this experiment, 30 wistar Albino rats were assigned to different groups and observed for 16 days. The study design included several treatment approaches for gastric ulcers. The normal control (Untreated) group received normal saline for 15 days, while the disease control group also received normal saline for the same period. The standard treatment group received omeprazole (20 mg/kg) over the 15-day duration. The first test drug group received a daily dose of 250 mg/kg of T. portulacastrum extract for 15 days, while the second test group received 500 mg/kg of the extract for the same period. All groups, except the normal control, were administered ethanol (1-mL/200 g, p.o.) on the 16th day. Multiple variables, including ulcer index, percentage inhibition of ulceration, antioxidant markers (SOD and CAT), and histopathological analysis of the stomachs of treated rats, were assessed. The methanolic extract of T. portulacastrum (METP) demonstrated potential in treating ulcers. In an ethanol-induced ulcer model, the METP increased SOD and CAT levels, essential antioxidant enzymes that neutralize reactive oxygen species, indicating its capacity to alleviate oxidative stress and inflammation. Notably, the higher METP dose (500 mg/kg) significantly elevated SOD levels, approaching those observed in the normal control group. Both the standard drug omeprazole and METP markedly reduced ulcer severity, count, and index while also increasing the percentage of inhibition. The METP exhibited dose-dependent antiulcer effects, with the 500 mg/kg dose providing substantial protection against ethanol-induced ulcers. Histopathological studies further supported that T. portulacastrum extracts improve mucosal integrity and reduce lesions. Overall, T. portulacastrum shows promising potential for treating gastric ulcers and enhancing overall health.

INTRODUCTION

Ulcers are open sores or lesions that occur on the skin or mucous membranes due to the breakdown of tissue. These painful lesions can develop in various parts of the body, such as the stomach, intestines, mouth, and skin. Gastric ulcers, for instance, form in the stomach lining and are often linked to factors like *Helicobacter pylori* infection, long-term use of NSAIDs, and excessive alcohol intake. In contrast, intestinal ulcers can occur in the small or large intestine, commonly associated with conditions like inflammatory bowel disease. Mouth ulcers, also known as

canker sores, can arise from stress, hormonal changes, or certain food sensitivities, while skin ulcers may develop as a result of pressure, poor circulation, or infections. A combination of factors, including inflammation, infection, reduced blood flow, and tissue damage, often influences the development of ulcers. Treatment typically focuses on addressing the underlying cause, relieving pain, promoting healing, and preventing complications. Infections, prolonged pressure, inflammation, or impaired blood circulation can cause ulcers. There are several types of ulcers: peptic ulcers, pressure ulcers, vein ulcers, arterial

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ulcers, and diabetic ulcers. Pressure ulcers result from prolonged pressure on the skin, often over bony areas, leading to impaired blood flow and tissue damage. Venous ulcers result from improper functioning of valves in the veins, often in the legs, leading to poor circulation and chronic wounds. Arterial ulcers result from insufficient blood supply due to arterial blockages, often seen in patients with peripheral artery disease. Diabetic ulcers occur in people with diabetes, particularly on the feet, due to poor circulation, neuropathy, and impaired healing. Gastric duodenal ulcers^[1] are some of the most widespread health problems worldwide, with hyperchlorhydria being a condition characterized by excessive and unregulated release of hydrochloric acid from the parietal cells of the stomach lining, predominantly driven by the proton pump. To manage gastric ulcers, various therapeutic interventions are available, including PPIs, anticholinergics, histamine H₂ receptor antagonists, and antacids. While these treatments can be effective in alleviating symptoms and promoting healing, However, these treatments are not free from potential side effects. Some patients may encounter negative reactions, including allergic responses, arrhythmias, and gynecomastia, highlighting the need for careful consideration of treatment options and monitoring of patients undergoing therapy. Peptic ulcer disease (PUD) affects approximately 500,000 patients^[2] annually in the United States, with 70% of cases occurring in patients aged 25 to 64 years. The estimated prevalence of peptic ulcers in India ranges from 6 to 15%, depending on the region and population studied. H. pylori infection, [3-5] a leading cause of peptic ulcers, has a high prevalence in India, with rates ranging from 60 to 90%.

Ulcer studies are crucial in improving patient outcomes, addressing complications, reducing healthcare burden, and advancing wound healing therapies. Herbal medicine has been utilized for centuries as a remedy for numerous conditions, including peptic ulcers. Herbal remedies address multiple aspects of the disease, such as reducing gastric acid secretion, protecting the gastric mucosa, and eradicating H. pylori, a common cause of ulcers. Gastroprotective effects of herbs include bioactive compounds that protect the gastric mucosa from damage and enhance mucus production. The anti-inflammatory properties of herbs like turmeric can help reduce inflammation and promote healing. Garlic and goldenseal have demonstrated antimicrobial activity against H. pylori growth. Reducing gastric acid secretion is another reason for using herbal remedies, as overproduction of gastric acid can contribute to ulcer formation. Some herbs, like slippery elm and chamomile, are believed to help reduce gastric acid secretion or neutralize it. Herbal medicine is often part of a broader holistic approach to health, addressing not only physical symptoms but also underlying factors like stress and diet. It generally has fewer side effects than conventional ulcer treatments and is more accessible and affordable, especially in regions where traditional medicine is deeply rooted in culture and history.

Trianthema portulacastrum L. is a small perennial weed native to various regions around the world, including the Americas, Africa, and India. This plant is widely recognized for its medicinal and nutritional applications, as it is utilized in traditional medicine and as a vegetable due to its diverse health benefits, which include analgesic, antipyretic, lipidlowering, and microbicidal properties. Additionally, T. portulacastrum offers protective effects for the liver and kidneys against carcinogens, inflammation, and oxidative damage. The plant serves as a host for the beet leafhopper, a significant pest that can transmit plant pathogens. T. portulacastrum has developed a versatile seed dispersal mechanism, contributing to its resilience and ability to thrive in a variety of environmental conditions. Its distinctive leaves are small, fleshy, smooth, and compact, measuring up to 4 cm in length. These adaptations allow the plant to store water, which is particularly beneficial in arid and semi-arid environments, while also playing a crucial role in photosynthesis. Phytochemical analyses of T. portulacastrum have identified several bioactive compounds, including phytosterols, alkaloids, polyphenols, flavonoids, terpenoids, and saponins. These constituents contribute to the plant's essential health benefits, which encompass anti-inflammatory properties, antioxidant activity, antimicrobial effects, diuretic properties, and wound-healing capabilities. This makes T. portulacastrum a valuable candidate for further research in both traditional and modern medicine. [6-10]

In the current scenario, the use of *T. portulacastrum* plant extract in ulcer studies is highly rational due to its rich phytochemical composition and known therapeutic properties. Herbal remedies are often favored due to their multifaceted approach in addressing not only the symptoms but also the underlying causes of ulcers. The use of *T. portulacastrum* may also be more accessible, affordable, and culturally accepted, especially in regions where traditional medicine plays a crucial role in healthcare.

MATERIALS AND METHODS

Collection of leaves of *T. portulacastrum* and Authentication

The leaves of *T. portulacastrum L.* were collected in April 2024 from Bhabua, Bihar-821101. Dr. V. Rama Rao authenticated the specimen, Research Officer in the Department of Botany at the Central Ayurveda Research Institute in Bengaluru (560109), under the reference number Authentication/SMPU/CARI/BNG/2024-25/974 (RRCBI-19627).

Extraction process

The leaves of *T. portulacastrum* L. were carefully cleaned with tap water to remove any impurities. They were then

shade-dried for a duration of 7 days to ensure proper moisture removal. Once dried, the leaves were coarsely powdered and prepared for methanolic extraction. The extraction process was conducted using the soxhlet extractor technique, wherein the coarsely powdered leaves were subjected to methanol extraction for three cycles over a period of 7 to 8 hours at 40°C. At the end, the resulting mixture was filtered through Whatman filter paper to separate the solid residue from the liquid extract. The filtered extract was weighed and stored in airtight containers for subsequent pharmacological studies.^[11,12]

Experimental Design

Experimental groups and protocol^[13,14]

All experimental procedures adhered to the protocols approved by the IAEC (KCP-IAEC/14/23-24/09/28/03/24). We maintained the rats according to the guidelines set forth by the CPCSEA. In this study, Wistar rats (male, weighing 150-200 g) were used, with 30 animals divided in the following manner: Group I, the normal control (Untreated) group, received normal saline (2 mL/kg, p.o.) daily for 15 days. Group II, the disease Control group, was administered ethanol (1-mL/200 g, p.o.) on day 16 to induce gastric ulcers, following a fasting period before ethanol administration. Group III, the standard drug group, was given omeprazole (20 mg/kg, 2 mL/kg, p.o.) for 15 days, followed by ethanol (1-mL/200 g, orally) on day 16 to induce ulcers. Group IV, test group 1, was treated with T. portulacastrum extract at 250 mg/kg, p.o., for 15 days, with ethanol administered on day 16. Group V, test group 2, received the same plant extract at a higher dose of 500 mg/kg p.o. for 15 days, followed by ethanol on day 16 to induce ulcers.

On the final day of the study, gastric ulcers were induced in all animals, except those in the normal control group, through ethanol administration (1-mL/200 g, orally) 1-hour before sacrifice. All animals were fasted overnight prior to ethanol administration to ensure ulcer induction. Afterward, the experimental animals were euthanized using phenobarbitone sodium, and gastric tissues were collected for further analysis.

Ulcer score, ulcer index and %inhibition

Following euthanasia, the rats were dissected along the convex border of the stomach, which were then thoroughly washed with running tap water and placed on slides for examination under 10X magnification to evaluate the presence of ulcers. The ulcer scoring system was as follows: a score of 0 for a stomach with normal coloration, 0.5 for red discoloration, 1 for spot ulcers, 1.5 for hemorrhagic streaks, 2 for 3–5 ulcers, and 3 for more than five ulcers. The total number of ulcers (Ulcer Number) was determined by counting all ulcers in each individual rat or group. The

ulcer score quantified the severity of ulcers based on their depth and appearance, with a score of 0 for a normal stomach, 1 for superficial ulcers, 2 for deep ulcers, and 3 for perforated ulcers. The total ulcer score for each rat was obtained by summing the individual scores. Finally, the ulcer index was calculated to reflect both the severity and the number of ulcers, offering a comprehensive assessment of the ulcer burden in each experimental animal. Ulcer index was assessed by ulcer number plus ulcer score divided by number of animals. The ulcer index is calculated to evaluate the effectiveness of a treatment by comparing the ulcer index of treated and untreated groups. A higher percentage of ulcer inhibition indicates a more effective treatment. The %inhibition of ulcer = Ulcer index control minus Ulcer index test divided by Ulcer Index control × 100

Antioxidant enzymes studies

To determine the activity of catalase, 1.9 mL of PBS at pH 7.0 was prepared in a test tube. To this solution, 100 μL of the supernatant were incorporated. Following that, 1-mL of hydrogen peroxide was introduced into the mixture. The absorbance values were taken at 240 nm over a period of 3 minutes and the activity was reported in μM of H_2O_2 per minute per milligram of protein

To measure the activity of superoxide dismutase (SOD), A test tube was set up using 2.78 mL of 0.05 mM Na2CO3 buffer at pH 10.2. Following this, 100 μL of 1 mM EDTA and 20 μL of tissue supernatant were introduced into the buffer. The incubation was carried out at 30°C for 45 minutes. The reaction was triggered by pouring in 100 μL of adrenaline, and the variation in absorbance was recorded at 480 nm for a duration of 3 minutes. Sucrose was utilized as a blank control. SOD activity was determined and presented as units per milligram of protein. $^{[15]}$

Histopathological evaluation

Samples of gastric tissue were fixed using neutral 10% buffered formalin for a duration of 24 hours. After the fixation period, the stomach sections were examined to assess the ulcerogenic or anti-ulcerogenic effects of *T. portulacastrum*. The fixed tissues were processed using a tissue processor, followed by incorporating them into paraffin blocks. These sections were subsequently stained with H&E according to standard protocols. The prepared slides were observed under a microscope to see pathomorphological changes, including congestion, hemorrhage, edema, and erosions, using an arbitrary scale to evaluate the severity of these alterations. ^[16]

Statistical Interpretation

Data are reported as Mean \pm SEM, where n = 6. Data analysis was conducted using GraphPad Prism statistical software. Statistics were assessed using ANOVA, followed by Tukey's test to compare all groups with their respective control group. A p > 0.05 was deemed statistically significant.



RESULTS AND DISCUSSION

There is growing recognition of the potential of medicinal plants, which has led to an increase in research aimed at identifying, isolating, and characterizing active components that can be used in pharmaceuticals.^[17,18] These bioactive compounds hold significant promise for developing novel therapies, particularly for conditions where conventional treatments are either insufficient or cause undesirable side effects. Among the various classes of compounds, alkaloids, saponins, tannins, and flavonoids have garnered attention for their role in gastroprotection and ulcer healing. Alkaloids are widely present in many herbal plants acknowledged for their diverse therapeutic activities, including antiulcer effects.^[19] Their mechanisms for preventing ulcers may involve various pathways linked to ulcer development, including the reduction of gastric acid secretion, the enhancement of mucosal defenses, and the promotion of tissue repair. Recent studies suggest that alkaloids could modulate neurotransmitters, reduce oxidative stress, and inhibit the activity of pepsin, an enzyme that degrades proteins in the stomach, all of which contribute to their therapeutic potential in ulcer management. Saponins are another important class of compounds with promising antiulcer properties. These glycosides are known to reduce the incidence of ulcers primarily by lowering gastric acid secretion and neutralizing the acidity of gastric juices, thus preventing the corrosive damage that stomach acid can inflict on the gastric mucosa. By stabilizing the mucous barrier and enhancing the secretion of bicarbonate, saponins also protect the stomach lining from irritants. [20] Furthermore, their role in reducing oxidative stress and promoting the production of prostaglandins, which help maintain the integrity of the stomach lining, adds to their protective effect. Tannins are polyphenolic compounds that contribute to gastroprotection by precipitating proteins in the mucosal layer, forming a protective barrier. This barrier prevents the penetration of harmful substances, such as irritants or enzymes that can cause gastric damage. Additionally, tannins exhibit strong antioxidant properties,^[21] which help mitigate oxidative stress and are a crucial contributor to the development of ulcers. Their ability to reduce inflammation and promote tissue regeneration further supports their role in preventing and treating gastric ulcers. Flavonoids are another group of phenolic compounds that possess significant gastroprotective properties. They enhance mucosal defense mechanisms by stimulating the secretion of mucous and bicarbonate, which neutralizes stomach acid. Flavonoids also promote the healing of ulcers by improving blood flow to the gastric mucosa and exerting anti-inflammatory and antioxidant effects. Moreover, Flavonoids restrain the proliferation of *H. pylori*, which is linked to disease, which further enhances their therapeutic potential in ulcer management.[22]

In contrast to these protective compounds, ethanol is a well-known risk factor for ulcer development. Ethanol can severely damage the gastric mucosa by increasing its permeability to hydrogen ions, which leads to excessive acid influx and erosion of the stomach lining. [23] This damage promotes inflammatory processes that further aggravate gastric injuries. Chronic ethanol consumption can disrupt the balance of harmful factors, such as acid and pepsin, and defensive factors, which results in ulcer formation. Given its harmful effects, ethanol is often used in experimental models to study ulcer pathogenesis and to assess the protective effectiveness of medicinal compounds.

The METP, reflecting its effectiveness against chemically induced ulcers. The test drug increases the levels of SOD and CAT, indicating its ability to mitigate oxidative stress and inflammation, which are pivotal in ulcer pathogenesis. The Fig. 1 shows the levels of SOD activity in an experimental ulcer rat model. SOD is an essential enzyme that neutralizes ROS, and its levels indicate oxidative stress and the protective effects of treatments. In the absence of ulcer induction, the antioxidant defense system is intact. However, ethanol-induced ulceration significantly diminishes antioxidant defenses, indicating high oxidative stress and significant damage to the gastric mucosa.

The omeprazole moderately restores SOD levels, suggesting that it helps in mitigating oxidative stress by enhancing the antioxidant response. The METP at 250 mg/kg also moderately increases SOD activity, showing a protective effect against ethanol-induced oxidative damage. The METP (500 mg/kg) significantly improves SOD levels, nearing the levels seen in the normal saline group. The ethanol-induced group exhibits the lowest SOD activity, indicating high oxidative stress due to ulcer formation. Both the standard drug omeprazole and the methanolic extract of T. portulacastrum significantly improve SOD levels, indicating a protective antioxidant effect. METP's 500 mg/kg dose is particularly effective, showing a strong ability to restore antioxidant defenses, suggesting its dose-dependent gastroprotective and antioxidant properties. The Fig. 2 shows the CAT activity of different treatment groups in an ulcer rat model. Catalase is an

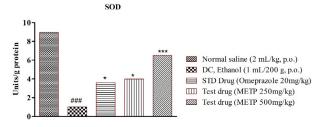


Fig. 1: Data are presented as Mean \pm SEM (n = 6); ****p < 0.001 in comparison to Normal control (Untreated group), *p < 0.05 and ****p < 0.001 relative to disease control (Ethanol induced), assessed via one-way ANOVA followed by Tukey's multiple comparison test.

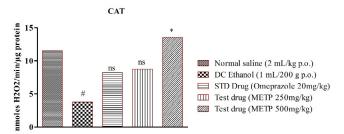


Fig. 2: Data are presented as Mean \pm SEM (n=6); $^{\#}p < 0.05$ in comparison to Normal control (Untreated group), $^{*}p < 0.05$, $^{ns}p > 0.05$ relative to Disease control (Ethanol induced), assessed via one-way ANOVA followed by Tukey's multiple comparison test.

antioxidant enzyme that neutralizes hydrogen peroxide, a reactive oxygen species, and acts as a significant factor in preventing oxidative damage to cells. The normal control group showed the highest CAT activity, indicating a healthy oxidative balance without stress or injury. The ethanol-induced group showed a drastic reduction in CAT activity, indicating substantial oxidative stress. The standard drug omeprazole moderately restored CAT activity but did not fully restore CAT levels to normal. The METP at 250 mg/kg showed similar results to the omeprazole group, suggesting some protective antioxidant effects. The METP (500 mg/kg) significantly improved CAT activity, approaching the levels of the normal saline group, suggesting that the higher dose of METP provides strong protection against oxidative damage, comparable to or even better than the standard drug omeprazole, in this ulcer model.

The image shows four Figs 3-6 comparing different treatments for ulcers. The ethanol treatment showed a high ulcer score (Fig. 3), while the omeprazole 20 mg/kg markedly decreased it. Both the standard drug and the test drug (METP 250 and 500 mg/kg) also substantially diminished the score, with higher doses being more effective. The ethanol treatment showed the highest number of ulcers (Fig. 4), with both doses of the test drug (METP 250 and 500 mg/kg) also significantly reducing ulcer numbers. The standard drug showed the highest ulcer index (Fig. 5), while the test drugs (METP 250 and 500 mg/kg) also showed ulcer inhibition (Fig. 6), with 500 mg/kg having a higher %inhibition. The key takeaway is that both the standard drug and the test drugs reduce ulcer severity, number, and index while increasing %inhibition, with better results observed at higher doses of the test drug.

The pictorial image (Fig. 7) depicts the effect of *T. portulacastrum* (METP) methanolic extract on ulcer inhibition in a rat model. The negative control group had a healthy stomach with no ulcer formation. The positive control group was exposed to ethanol, causing significant ulceration and inflammation. Omeprazole, a standard antiulcer drug, reduced ulceration compared to the DC group, indicating its protective effect. The lower dose of METP reduced ulceration, but the effect seemed mild

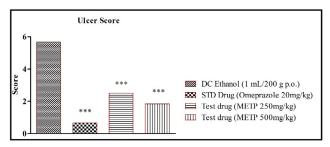


Fig. 3: Data are presented as Mean ± SEM (n=6); ***p<0.001 relative to Disease control (Ethanol induced), assessed via one-way ANOVA followed by Tukey's multiple comparison test.

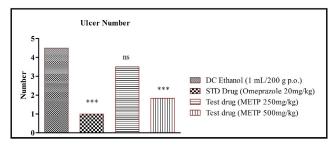


Fig. 4: Data are presented as Mean ± SEM (n=6); ^{ns}P<0.05 and ****P<0.001 relative to Disease control (Ethanol induced), assessed via one-way ANOVA followed by Tukey's multiple comparison test.

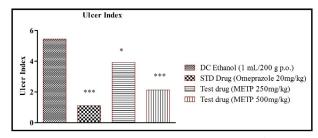


Fig. 5: Data are presented as Mean ± SEM (n=6); *P>0.05 and ****P<0.001 relative to Disease control (Ethanol induced), assessed via one-way ANOVA followed by Tukey's multiple comparison test.

Effect of METP on % Inhibition Ulcer

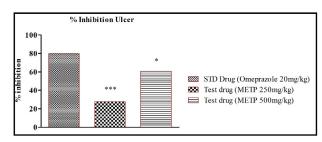


Fig. 6: Data are presented as Mean ± SEM (n=6); *P>0.05 and ****P<0.001 relative to Disease control (Ethanol induced), assessed via one-way ANOVA followed by Tukey's multiple comparison test.

compared to the standard drug. The higher dose of METP showed a significant reduction in ulceration, with almost no visible ulcers. This suggests that *T. portulacastrum* has dose-dependent antiulcer properties, with a higher dose (500 mg/kg) showing significant protection against ethanol-induced ulcers, comparable to the standard drug omeprazole.





Normal saline (Untreated, 2 mL/kg, p.o.)



DC, Ethanol (1 mL/200 g, p.o.)



STD Drug (Omeprazole 20mg/kg)



Test drug (METP 250mg/kg)



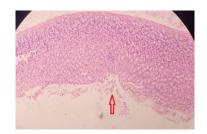
Test drug (METP 500mg/kg)

The image illustrates the impact of the methanolic extract of Trianthema portulacastrum (METP) on ulcer inhibition in a rat model. The observation from the study reveal that the ethanol control group exhibited severe ulceration and considerable mucosal damage, indicating a high degree of injury caused by ethanol. In contrast, the group treated with omeprazole demonstrated significant protection against ulcer formation, highlighting its effectiveness as an antiulcer agent. The lower dose of METP (250 mg/kg) showed moderate inhibition of ulcer development, suggesting a partial protective effect on the gastric mucosa. However, the higher dose of METP (500 mg/kg) provided strong ulcer inhibition, with results comparable to those seen with the standard drug, omeprazole. This indicates the potential of METP as an effective treatment for gastric ulcers. This suggests that the methanolic extract of Trianthema portulacastrum has dose-dependent antiulcer properties, with a higher dose (500 mg/kg) showing significant protection against ethanol-induced ulcers, comparable to the standard drug Omeprazole

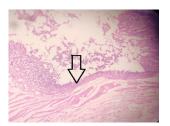
Fig. 7: Pictorial Image of Effect of Methanolic extract of Trianthema portulacastrum (METP) on % inhibition of ulcer



Normal saline (2 mL/kg, p.o.)



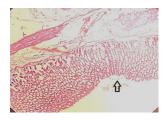
DC, Ethanol (1 mL/200 g, p.o.)



STD Drug (Omeprazole 20 mg/kg)



Test drug (METP 250 mg/kg)



Test drug (METP 500 mg/kg)

Histopathological evaluation of the normal control group treated with Normal Saline (2 mL/kg, p.o.) shows normal stomach architecture. In the disease control group (DC) treated with ethanol (1-mL/200 g, p.o.), sections reveal flattening of the surface mucosa with hemorrhage in the mucosal membrane (red arrow), acute nonspecific inflammatory reactions beneath the mucosal membrane, destruction of chief cells, and separation and exfoliation of the mucous membrane. The standard drug group treated with omeprazole (20 mg/kg) shows a few disarranged gastric pits, with mild separation of the mucous membrane and congestion (black arrow), suggesting mild mucosal disruption. The test drug group treated with METP (250 mg/kg) exhibits desquamation of the superficial mucosal layer, with mucosal cells removed (round yellow mark), along with congestion in the superficial mucosal membrane. In the higher dose test group treated with METP (500 mg/kg), there is less hemorrhage in the mucosa, and a loss of a few gastric pits and the surface layer is observed (black arrow) (transversal section, H&E stain, 10x magnification).

Fig. 8: The effect of methanolic extract of Trianthema portulacastrum (METP) on Tissue Histology

Histopathological Studies

These studies support that *T. portulacastrum* extracts enhance mucosal integrity, reducing mucosal lesions, as evidenced by improved structural integrity in treated rats (Fig. 8).

The detailed mechanisms through which these extracts operate suggest potential therapeutic applications not just for ulcer treatment but also for broader anti-inflammatory and antioxidant purposes. The findings emphasize the importance of identifying, isolating, and characterizing active components within these plants, aiding in the transition from traditional use to clinical applications in modern medicine. This understanding could contribute significantly to pharmaceutical research and development, offering new avenues for natural, effective, and potentially safer therapeutic alternatives to synthetic drugs, particularly in treating conditions like gastric ulcers where conventional therapies may have significant side effects.

CONCLUSION

The findings from the investigation on *T. portulacastrum* methanolic extract demonstrate its promising antiulcer activity, attributed to key bioactive compounds such as alkaloids, saponins, tannins, and flavonoids. The significant enhancement of superoxide dismutase and catalase, along with the protective effects on gastric mucosal integrity and the reduction of inflammation, clearly indicate the extract's potential to mitigate oxidative stress and promote gastric healing. This positions it as a valuable natural alternative for treating gastric ulcers, addressing the growing need for safer, plant-based therapeutic options.

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