

EFFECTS OF ETHANOL LEAF EXTRACT OF *Spondia mombin* ON SURGICALLY-
INDUCED DUODENAL ULCER IN ADULT MALE WISTAR-RATS

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ABSTRACT

Background: Duodenal ulcer (DU) is a common gastrointestinal disorder resulting from disruption of the balance between aggressive factors and mucosal protective mechanisms. Although *Spondias mombin* has demonstrated gastroprotective and ulcer-healing properties, limited information is available regarding its effects on surgically-induced DU and duodenal histoarchitecture. This study investigated the effects of ethanol leaf extract of *Spondias mombin* on surgically induced DU in adult male Wistar rats. **Methods:** Thirty Wistar rats were randomly divided into six groups of five rats each. DU was induced in Groups II–VI by submucosal injection of 0.02 mL of 20% acetic acid. Group I is the normal control which received only normal saline (1 mL/kg) orally for 15 days. Group II served as the ulcer control and was sacrificed 24 h after ulcer induction, while Group III received normal saline (1 mL/kg) orally for 14 days as the recovery group. Groups IV–VI received ethanol leaf extract of *S. mombin* at 200, 400, and 800 mg/kg body weight, respectively, for 14 days. Duodenal tissues were assessed using haematoxylin and eosin (H&E) and Masson's trichrome staining. **Results:** The normal control group showed relatively intact and well-developed villous architecture with preserved glandular and connective-tissue organization. The ulcer control group demonstrated marked mucosal disruption, characterized by irregular, shortened, blunted and eroded villi, with architectural disorganization. The recovery group showed partial restoration of the duodenal architecture. Treatment with ethanol leaf extract of *S. mombin* resulted in progressive improvement in villous tissue organization, with the 800 mg/kg group showing the most pronounced morphological restoration and features comparatively closer to the normal control. Masson's trichrome staining demonstrated differences in collagen distribution and organization, consistent with connective-tissue remodeling during mucosal repair. **Conclusion:** Ethanol leaf extract of *Spondias mombin* restored the injured duodenal tissue, providing a beneficial effect on the histoarchitecture of acetic-acid-induced duodenal ulcer in Wistar rats.

KEYWORDS: *Spondias mombin*; Duodenal ulcer; Acetic acid; Wistar rats.

INTRODUCTION

The gastrointestinal tract (GIT) is a continuous muscular tube responsible for digestion, absorption of nutrients, and elimination of waste products (McCoy *et al.*, 2024). Its wall consists mainly of four layers: the mucosa, submucosa, muscularis externa, and serosa or adventitia. The mucosa forms the innermost protective barrier and is therefore susceptible to injury when its defensive mechanisms are compromised. The stomach secretes hydrochloric acid and pepsin, which are essential for digestion but may cause mucosal injury when protective mechanisms are impaired (Vakil, 2024). The duodenum,

being the first part of the small intestine, receives acidic gastric contents and is protected by mucus and bicarbonate secretion, adequate blood flow, epithelial integrity, and rapid mucosal repair (Vakil, 2024; Wilson *et al.*, 2023). Disruption of the balance between aggressive factors, such as gastric acid, pepsin, *Helicobacter pylori* infection and non-steroidal anti-inflammatory drugs (NSAIDs), and mucosal protective mechanisms can result in gastrointestinal mucosal injury and ulcer formation. When this ulcerative lesion occurs in the proximal duodenum, it is referred to as a duodenal ulcer and constitutes an important form of peptic ulcer

disease (PUD) (Bailey, 2024; Ocasio Quinones & Woolf, 2023).

Peptic ulcer disease (PUD) is an important gastrointestinal disorder characterized by a mucosal defect resulting from an imbalance between damaging factors, such as gastric acid and pepsin, and protective mechanisms of the gastrointestinal mucosa (Zhang *et al.*, 2020). Depending on its location, an ulcer may occur in the stomach or duodenum. A duodenal ulcer (DU) is a localized break in the mucosal lining of the duodenum and occurs predominantly in the duodenal bulb (Hameed *et al.*, 2024; Amalia *et al.*, 2024). The development of duodenal ulcer involves disruption of mucosal defense and increased exposure of the duodenal mucosa to gastric acid and pepsin.

The major etiological factors implicated in duodenal ulcer formation are *Helicobacter pylori* infection and non-steroidal anti-inflammatory drug (NSAID) use. Other factors, including smoking, alcohol consumption, physiological stress, and hypersecretory conditions, may further increase susceptibility to mucosal injury (Hameed *et al.*, 2024). These factors can impair mucosal defense, promote inflammation and increase exposure of the duodenal mucosa to damaging gastric secretions, thereby contributing to ulcer formation. Clinically, duodenal ulcers commonly present with epigastric pain, particularly during fasting or at night, which may be temporarily relieved by food or antacids. Other manifestations include nausea, bloating, belching, and vomiting (Hameed *et al.*, 2024). Complications of untreated or inadequately managed ulcers include gastrointestinal bleeding, perforation, penetration into adjacent organs, and gastric outlet obstruction resulting from inflammation and scarring (Amalia *et al.*, 2024).

PUD remains an important public health problem because of its prevalence and associated morbidity and continues to be a major focus of clinical and experimental investigations (Zhang *et al.*, 2020). Globally, the prevalence and pattern of gastroduodenal ulcer disease vary across populations and geographic regions, partly due to differences in *H. pylori* infection, NSAID use, socioeconomic conditions, dietary practices, healthcare access, and other environmental and demographic factors (Amalia *et al.*, 2024). In Africa, a

2025 systematic review and meta-analysis reported a pooled prevalence of 15.2% for PUD, with duodenal ulcer accounting for 10.2%, compared with 5.8% for gastric ulcer and 0.6% for combined gastric and duodenal ulcers (Abdu *et al.*, 2025).

In Nigeria, recent endoscopic evidence from the Northern Savannah reported a PUD prevalence of 8.7% among patients undergoing upper gastrointestinal endoscopy. Among patients diagnosed with PUD, duodenal ulcers accounted for 31.6%, while gastric ulcers accounted for 59.6% and combined gastric and duodenal ulcers accounted for 8.8% (Yahya, 2023). In Southwest Nigeria, a retrospective endoscopic study conducted at the Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife, Osun State, reported a duodenal ulcer prevalence of 15.8% during the study period. The prevalence declined from 22.9% during 2000–2004 to 9.2% during 2005–2010, suggesting a changing epidemiological pattern of duodenal ulcer in the region (Ijarotimi *et al.*, 2017).

Although proton pump inhibitors and H₂-receptor antagonists remain important components of conventional ulcer therapy, limitations such as adverse effects, recurrence, and treatment costs have encouraged interest in alternative and complementary therapeutic approaches (Dalhoumi *et al.*, 2022; Ibrahim & Al-Qadhi, 2025). Medicinal plants are therefore receiving increasing attention as potential sources of affordable therapeutic agents, particularly in resource-limited settings where many plants have established ethnomedicinal applications. This has generated interest in investigating medicinal plants with potential anti-ulcer, antioxidant, anti-inflammatory, and mucosal protective properties.

Spondias mombin Linn. (yellow mombin) is a tropical tree widely distributed in Africa and South America. Various plant parts, including the leaves, flowers, fruits, seeds, stem bark, pulp, and roots, are ethnomedicinally important and have traditionally been used in the management of ailments such as leprosy, severe cough, diarrhea, dysentery, dyspepsia, gastralgia, colic, constipation, hemorrhoids, gonorrhea, leucorrhea, dystocia, postpartum hemorrhage, and inflammatory conditions (Ogunro *et al.*, 2023).



Spondias mombin Plant (Ogunro *et al.*, 2023)

In Nigeria, it is known locally as “Iyeye” (Yoruba), “Ichikara” (Igbo), and “Tsardarmasar” (Hausa) (Ogunro & Yakubu, 2026). The tree grows erectly, with a thick and rough bark, and can reach a height of 20–30 m, with a trunk diameter of approximately 60–75 cm (Ogunro *et al.*, 2023). The leaves are 20–45 cm long, hairy underneath, and consist of 5–11 pairs of petiolate leaflets, while the flowers are usually white and occur abundantly in small, fragrant panicles (Ogunro *et al.*, 2023).

Phytochemical investigations of its bark, leaves, and fruits have revealed tannins, flavonoids, phenolic compounds, saponins, and alkaloids, which have been associated with antioxidant, anti-inflammatory, antimicrobial, and other pharmacological activities (Ogunro *et al.*, 2023). Furthermore, *Spondias mombin* bark extract has demonstrated protective effects against ibuprofen-induced small intestinal injury in Wistar rats (Ogeyemhe & Odigie, 2025). Experimental evidence has demonstrated that ethanolic leaf extract of *S. mombin* possesses antiulcer activity, including stimulation of mucus production, antisecretory activity, and antioxidant effects (Brito *et al.*, 2018). Additionally, ethanol and hexane extracts of *S. mombin* fruit residues have demonstrated gastroprotective activity in experimental gastric ulceration (Cartaxo *et al.*, 2022).

However, available evidence has largely focused on gastric ulcer models, with limited information regarding the effect of ethanol leaf extract of *S. mombin* on surgically-induced duodenal ulcer and its ability to

restore duodenal histoarchitecture. Therefore, this study investigates the effects of ethanol leaf extract of *Spondias mombin* on surgically-induced duodenal ulcer in adult male Wistar rats.

MATERIALS AND METHODS

1. Plant Collection and Authentication

Fresh leaves of *Spondias mombin* were obtained from Old NEPA area of Modakeke, Osun state (7°50' N, 4°50'E). The plant leaves were authenticated by a taxonomist in the Department of Botany, Obafemi Awolowo University, Ile-Ife. A voucher specimen number IFE/18476 was assigned and deposited in the departmental herbarium for future references.

2. Preparation of Plant Extract

The *Spondias mombin* leaves were air-dried, weighed and pulverized. Thereafter, the powdered leaves were soaked in 70 % ethanol for 72 h at room temperature with intermittent agitation. The obtained extract was filtered using Whatman number 1 filter paper, and the filtrate was concentrated in a rotary evaporator and further freeze dried till a deep green extract was obtained.

3. Animal Care

Ethical clearance was obtained from the Health Research and Ethics Committee (HREC) of the Institute of Public Health, Obafemi Awolowo University, Ile-Ife (HREC/IPH/OAU). Thirty (30) male Wistar rats with weight range of 180g - 200g were used for this study. The rats were obtained from the Animal Holding of

College of Health Sciences, OAU, Ile-Ife, and housed and maintained under standard laboratory conditions. The rats were fed with standard rat pellets and provided water *ad libitum*.

4. Induction of Duodenal Ulcer

Following sub-mucosal injection method of Okabe and Amagase, (2005), the rats were fasted for 24 hours and anesthetized with ketamin and diazepam. The abdominal area of the rats were shaved and disinfected with 70% ethanol and povidone iodine, and midline laparotomy was performed to expose the duodenum. A micro syringe was used to inject 0.02 mL of 20% acetic acid into the sub-mucosal layer of the duodenal wall and the incision

was then sutured. The rats were allowed to recover and maintained under standard post-operative care.

5. Experimental Design

The study was carried out over a period of 15 days, during which the rats were randomly divided into five (5) groups (1-6) of five rats each. Group (1) (normal control) animals received of normal saline for 15 days, whereas duodenal ulcer was induced in groups (2–6) animals by administering 20% acetic acid sub-mucosally for 1 day. 24 hrs after induction, group (2) (ulcer control) were sacrifice, group (3) (recovery group) received normal saline for 14 days while group (4, 5 and 6) animals received ethanol extract at dose levels of 200, 400 and 800 mg/kg body weight respectively.

Group (N=5)	Dosage and treatment	Route of administration	Duration (Days)
1	Normal saline only (1 ml/kg)	Oral (P.O)	15
2	Acetic acid (0.02 ml)	S.M.	1
3	Acetic acid (0.02 ml) + 1 ml/kg	S.M. + P.O.	1 + 14
3	Acetic acid (0.02 ml) + ELESME 200 mg/kg	S.M. + P.O.	1 + 14
5	Acetic acid (0.02 ml) + ELESME 400 mg/kg	S.M. + P.O.	1 + 14
6	Acetic acid (0.02 ml) + ELESME 800 mg/kg	S.M. + P.O.	1 + 14

At the end of the experimental period, rats were fasted overnight then sacrificed by cervical dislocation and the duodenum were excised for further analysis.

6. Histological Studies

Duodenal tissues were processed using the paraffin-embedding method of Drury and Wallington (1980).

Section of 5 μ m thickness were obtained and stained with hematoxylin and eosin (H&E) and Masson's trichrome. H&E stained sections were used to assess the general histoarchitecture of the duodenum, while Masson's trichrome staining was used to demonstrate collagen fibers within the duodenal tissue.

HISTOLOGICAL EVALUATION

PLATE 1

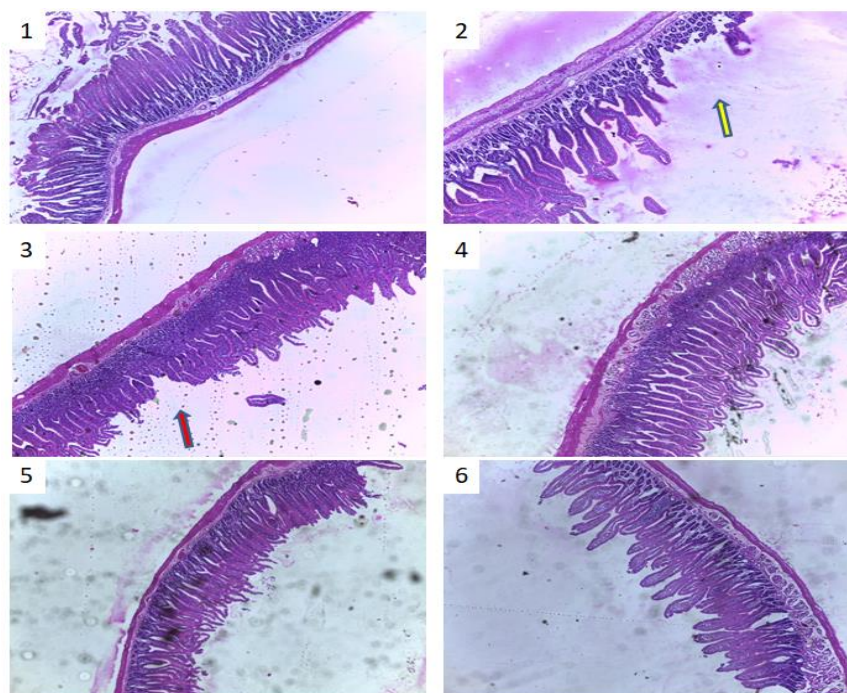


Figure 1: Representative photomicrograph showing the effect of ethanol leaf extract of *Spondia mombin* on acetic acid- induced duodenal ulcer in Wistar rats (H&E x40).

Group (1) showed relatively normal duodenal mucosal architecture, characterized by well-developed, closely arranged and intact villi. Marked disruption of the mucosal architecture (yellow arrow), with irregularity, apparent shortening/blunting and erosion of the villi was seen in group 2. Group (3) demonstrated partial restoration of the villous architecture (red arrow)

consistent with spontaneous mucosal healing. Group (4), (5) and (6) demonstrated progressive improvement in the integrity and organization of the villi, with (6) showing the most pronounced preservation of villous architecture and appeared comparatively similar to the control group.

PLATE 2

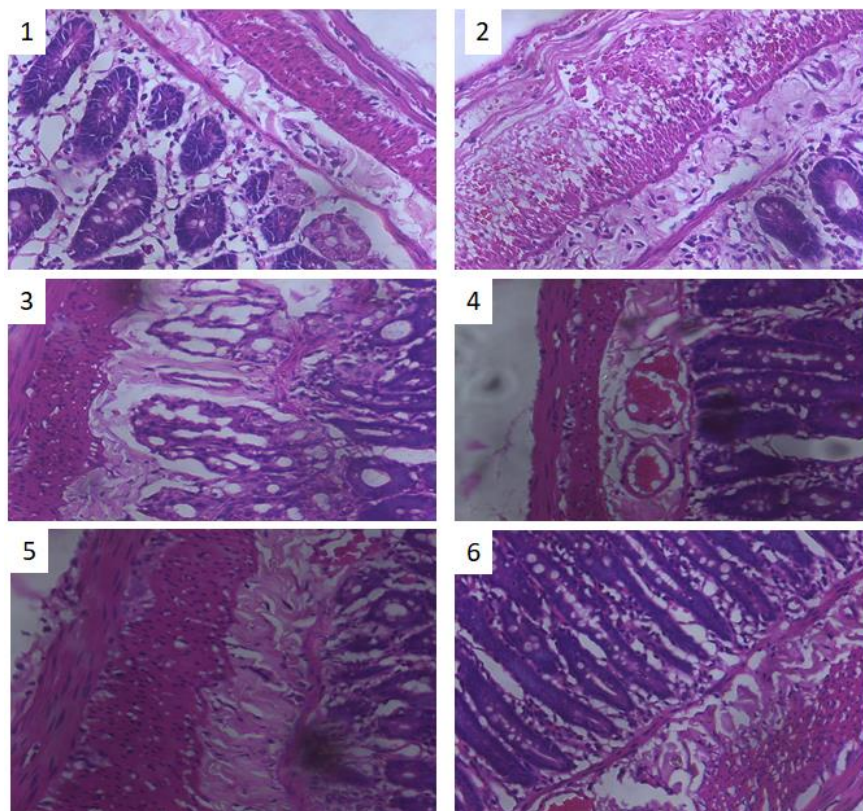
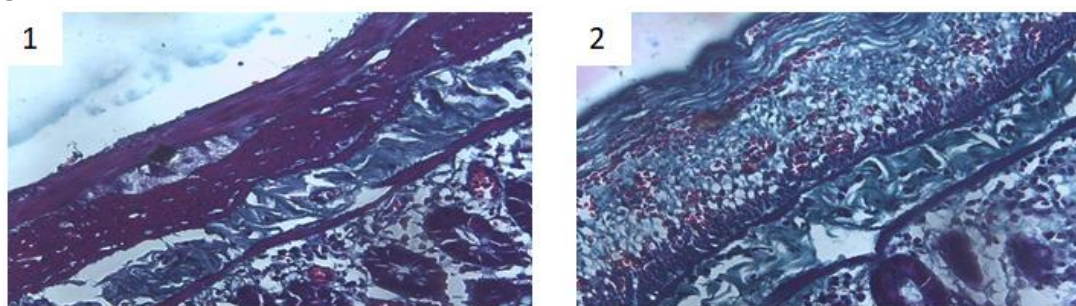


Figure 2: Representative photomicrographs showing the effects of ethanol leaf extract of *Spondias mombin* on the duodenal tissue of Wistar rats following acetic-acid-induced ulceration (H&E $\times 400$).

Group (1) showed relatively preserved tissue architecture, with organized intestinal crypts, preserved connective tissue and muscular components. Group (2) demonstrates greater tissue architectural disruption and increased cellularity compared with the normal control;

and group (3) shows relatively preserved glandular and connective-tissue architecture, suggesting morphological recovery. However, preservation of the intestinal architecture was observed in group (4), (5) and (6) respectively.

PLATE 3



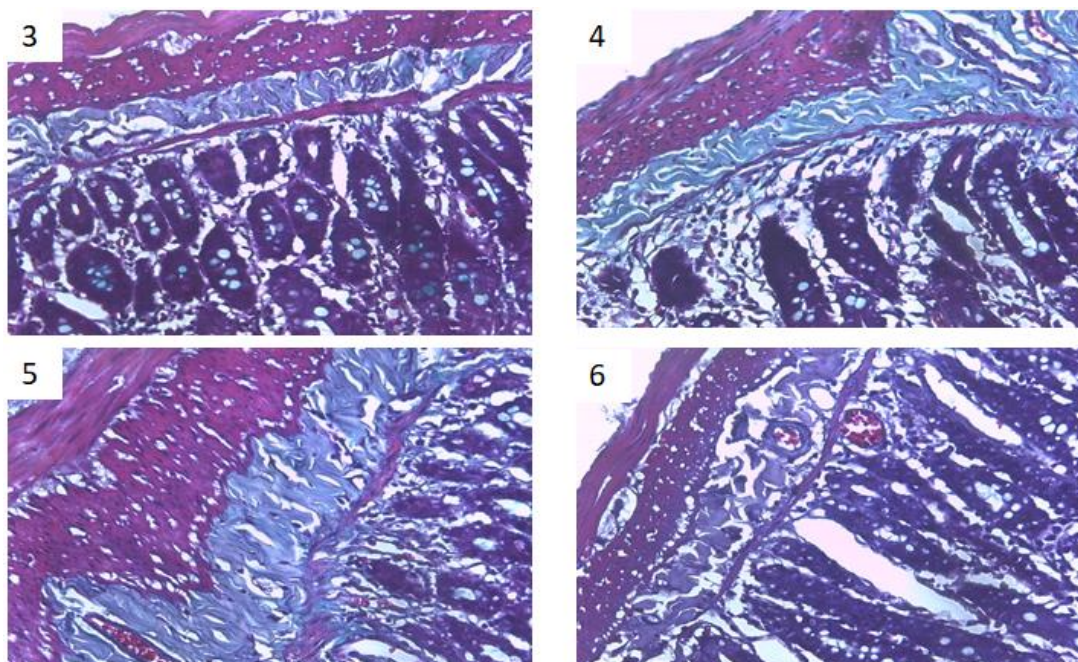


Figure 3: Representative photomicrographs showing collagen fiber distribution in the duodenal tissues of Wistar rats following acetic acid-induced ulceration (Masson's trichrome x400). Collagen fibers appeared blue to blue-green, while the muscle and other tissue components appeared reddish-purple.

Group (1) showed relatively preserved duodenal architecture with an organized distribution of collagen fibers. Altered organization of the collagen fibers was observed in group (2) which may indicate connective tissue remodeling in response to acetic acid-induced ulcer injury. Group (3), (4), (5) and (6) showed varying degrees of collagen fiber deposition and connective tissue organization, suggesting ongoing tissue repair and remodeling.

DISCUSSION

The present study demonstrated distinct histological differences between the normal control, ulcer control, recovery and *Spondias mombin*-treated groups. Examination of the duodenal tissues revealed marked mucosal disruption following acetic acid administration, whereas the recovery and *S. mombin*-treated groups showed varying degrees of morphological restoration.

The normal control group showed relatively intact, closely arranged and well-developed villi, reflecting preservation of the normal absorptive mucosal architecture. In contrast, the ulcer control group exhibited marked mucosal disruption, characterized by irregularity, shortening, blunting and erosion of the villi, indicating mucosal injury. Similar villous disruption and mucosal erosion have been reported following acetic-acid-induced intestinal injury (Bui *et al.*, 1993; Ilegbedion *et al.*, 2024). Bui *et al.* (1993), using a direct model of acetic-acid-induced duodenal ulcer, reported progressive disintegration of the villous tips, microvascular injury and necrosis of the duodenal wall.

At X 40 magnification, the recovery group demonstrated partial restoration of villous architecture compared with

the ulcer control group, suggesting ongoing spontaneous mucosal repair. This is consistent with the progressive healing described in experimental acetic-acid-induced duodenal ulcers (Bui *et al.*, 1993). The *S. mombin*-treated groups showed greater preservation and restoration of villous architecture, particularly at the higher doses, with morphology comparatively closer to that of the normal control. The greater improvement relative to the recovery group suggests that *S. mombin* treatment was associated with enhanced structural recovery.

At $\times 400$ magnification, the normal control group exhibited relatively preserved microscopic organization, including organized intestinal crypts and connective-tissue and muscular components. The ulcer control group showed greater architectural disruption and increased cellularity, which may reflect an inflammatory and reparative response to tissue injury. The recovery group showed improved organization compared with the ulcer control group, suggesting ongoing tissue repair. The *S. mombin*-treated groups demonstrated comparatively improved organization of the glandular and connective-tissue components, particularly at the higher doses, suggesting attenuation of acetic-acid-induced structural damage, which corroborated the work of Liu *et al.*, (2025) who similarly described intestinal mucosal healing as involving epithelial and vascular components together with inflammatory processes. Brito *et al.* (2018) also reported ulcer-healing and histological regenerative effects of ethanolic *S. mombin* leaf extract following 14 days of treatment.

At $\times 400$ magnification, Masson's trichrome staining provided additional information on the connective-tissue component of the duodenum. The normal control group

showed relatively organized collagen fibres, whereas the ulcer control group demonstrated alterations in collagen distribution and organization. These changes may be associated with extracellular-matrix remodeling during tissue repair. The recovery group showed features of ongoing connective-tissue reorganization, consistent with spontaneous repair following ulceration, while the *S. mombin*-treated groups showed varying degrees of collagen organization, suggesting continued extracellular-matrix remodeling during healing.

The histological improvement observed following *S. mombin* administration may be related to the biological activities of its phytochemical constituents. Ethanolic *S. mombin* leaf extract has been reported to possess antioxidant activity, with gallic acid and ellagic acid identified among its constituents (Brito *et al.*, 2018). More recently, *S. mombin* leaf extracts have also demonstrated antioxidant and anti-inflammatory effects in experimental animal models (Adetuyi *et al.*, 2025). These properties may contribute to the preservation of epithelial and connective-tissue integrity by limiting oxidative and inflammatory tissue damage.

Inflammation is an important component of intestinal injury and healing. Although a regulated inflammatory response contributes to removal of damaged tissue and initiation of repair, excessive or prolonged inflammation may sustain tissue injury and delay mucosal restoration (Liu *et al.*, 2025). Almeida *et al.* (2025) reported reduced tissue destruction and inflammation following administration of hydroethanolic *S. mombin* leaf extract in experimental periodontitis, while Adetuyi *et al.* (2025) demonstrated reduced oxidative and inflammatory disturbances following *S. mombin* administration in an experimental model of aluminium chloride-induced injury. Although these studies involved tissues other than the duodenum, they provide supporting evidence for the antioxidant and anti-inflammatory properties of the plant. More directly, Brito *et al.* (2018) demonstrated gastroprotective and ulcer-healing effects of ethanolic *S. mombin* leaf extract, including increased mucus production, reduced gastric acid secretion and histological regeneration of ulcerated tissue.

CONCLUSION

It can be concluded that this study provided experimental evidence that ethanol leaf extract of *Spondias mombin* has potential beneficial effects on acetic-acid-induced duodenal ulcer in adult male Wistar rats. The effects observed across the treatment groups suggested that *Spondias mombin* may have therapeutic potential in the management of duodenal mucosal injury.

Recommendation

Further studies involving biochemical, molecular and mechanistic assessments are recommended to establish the precise pathways through which the extract promotes ulcer healing and to determine its safety, optimal

therapeutic dose and potential applicability in clinical settings.

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