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PHARMACOLOGICAL ASSESSMENT OF HERBAL SYRUP CONTAINING HYDRO-ALCOHOLIC EXTRACT OF *TERMINALIA CATAPPA* FOR ANTI-ULCER ACTIVITY

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ABSTRACT

This study explores the phytochemical composition, physicochemical properties, and gastroprotective potential of a hydro-alcoholic extract of *Terminalia catappa* (HATC) in leaf and bark parts, with particular emphasis on its formulated herbal syrup (HATCHS). The extract yield was 10.7% w/w, with dark brown semi-liquid characteristics. Phytochemical screening confirmed the presence of several bioactive compounds, including alkaloids, phenols, flavonoids, tannins, and glycosides. Pharmacological evaluations, including ulcer index, pH of gastric contents, total acidity, gastric volume, antioxidant parameters (SOD, CAT, GSH), and histopathological analysis were performed. Results indicate significant gastroprotective and antioxidant effects, especially with higher doses and syrup formulation, showing near comparable efficacy to standard omeprazole treatment.

KEYWORDS: *Terminalia catappa*, Herbal Syrup, Antiulcer, Antioxidant, Phytochemical Screening, Gastroprotection, Antioxidant Enzymes, Histopathology

1. INTRODUCTION

An ulcer is a localized erosion or open sore on the surface of an organ or tissue, most commonly found in the gastrointestinal tract. The most prevalent types are gastric ulcers (occurring in the stomach lining) and duodenal ulcers (in the upper part of the small intestine). Collectively, these are referred to as peptic ulcers. Ulcers develop when the balance between aggressive factors (like gastric acid and pepsin) and defensive mechanisms (such as mucus and bicarbonate secretion, mucosal blood flow, and cell regeneration) is disrupted.

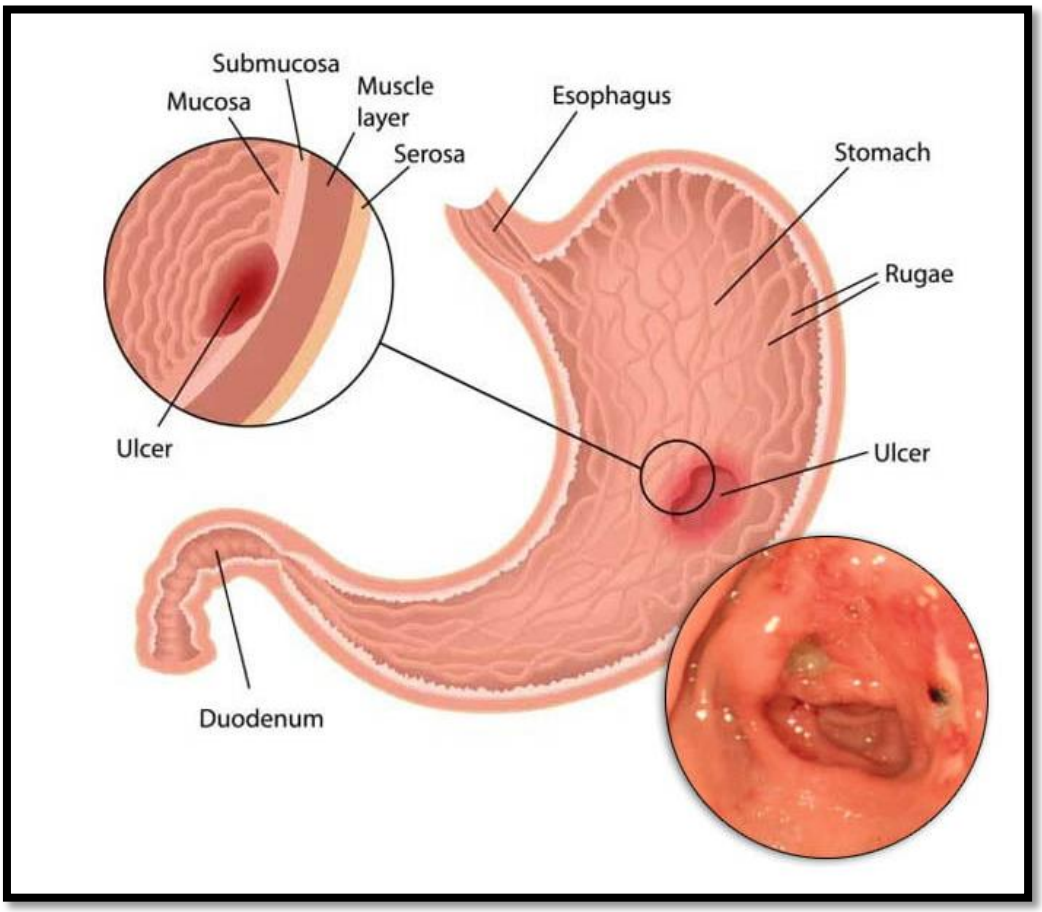

Fig: 1 Stomach Ulcer.

The primary etiological factors contributing to ulcer formation include infection with Helicobacter pylori, chronic use of nonsteroidal anti-inflammatory drugs (NSAIDs), excessive alcohol consumption, smoking, stress, and certain dietary habits. H. pylori is a gram-negative bacterium that colonizes the gastric mucosa and disrupts mucosal defenses, while NSAIDs reduce prostaglandin synthesis, impairing mucus and bicarbonate production. Ulcers can lead to various complications if left untreated, including bleeding, perforation,

penetration into adjacent organs, and gastric outlet obstruction. Clinical manifestations typically include epigastric pain, bloating, nausea, and in severe cases, hematemesis or melena.

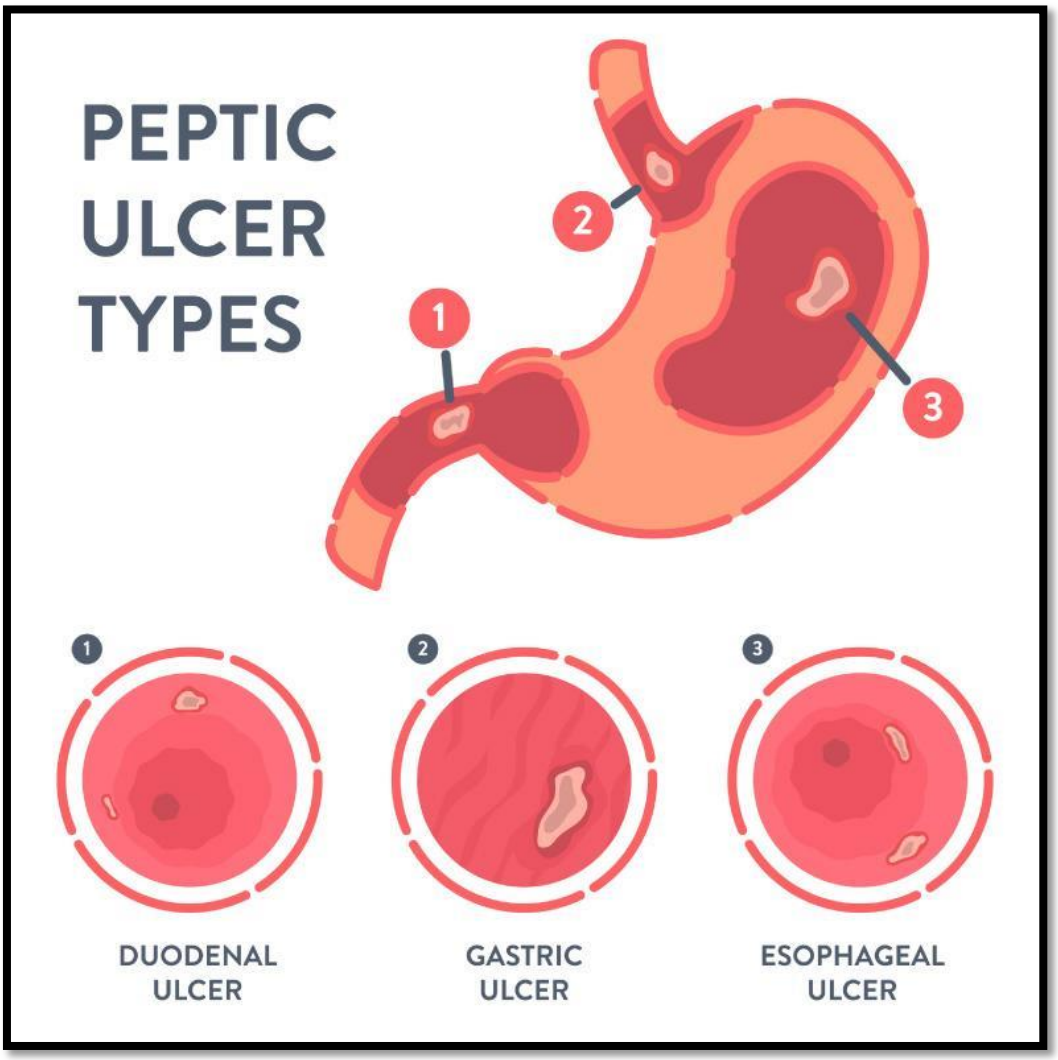

Fig. 2: Types Of Peptic Ulcer.

Advancements in diagnostic techniques like endoscopy and the discovery of H. pylori have transformed the understanding and treatment of ulcers. Current therapeutic strategies involve proton pump inhibitors (PPIs), H2-receptor antagonists, antibiotics for H. pylori eradication, and lifestyle modifications. Despite this, recurrence remains a concern, particularly in patients with persistent risk factors or antibiotic resistance. Ongoing research is exploring the role of novel synthetic compounds, herbal medicines, and drug delivery systems in ulcer management, with the aim of improving therapeutic efficacy and reducing side effects. Let me know if you'd like this tailored for a specific type of ulcer (e.g., gastric, duodenal, stress-induced), or expanded to include molecular mechanisms or treatment details.

2. PLANT PROFILE

Terminalia catappa Linn. is known for its nutritional fruit and possesses medicinal benefits as well. T. catappa has been recognized for its medicinally essential phyto- constituents, such as phenol, flavonoid, and carotenoid. Numerous pharmacological investigations have confirmed by this plant's ability to exhibit antimicrobial, anti-inflammatory, anti-diabetic, antioxidant, hepato-protective, and anticancer activities, all of which support its traditional uses.

Terminalia catappa is a large tropical tree in the lead wood tree, family- Combretaceae, native to Asia, Australia, the Pacific, Madagascarand Seychelles. Common names in English include country almond, Indian almond, Malabar almond, sea almond, tropical almond, beach almond and false kamani.

Fig. 3: Leaf & Bark (*Terminalia catappa Linn*).

2.1 CHEMICAL CONSTITUENTS

Terminalia catappa Linn. contains a rich variety of chemical constituents distributed across its different parts (leaves, bark, seeds, and fruit). These constituents are responsible for its diverse pharmacological activities. Here's a breakdown by plant part:

1. Leaves

The leaves are particularly rich in polyphenols**,** flavonoids**,** tannins**,** and triterpenoids**.**

- **Flavonoids:**
  - Kaempferol

- Quercetin
- Isovitexin
- Rutin

- **Tannins (hydrolyzable tannins):**
- Punicalagin
- Geraniin
- Ellagic acid
- Gallic acid

- **Other Compounds:**
- Saponins
- Phytosterols
- Triterpenoids **(**e.g., ursolic acid**,** asiatic acid**)**
- Chlorogenic acid

2. Bark

- Tannins (especially condensed tannins)
- Flavonoids
- Steroids
- Alkaloids

3. MATERIALS AND METHODS

3.1 PREPARATION OF EXTRACT

The Freshly collected Bark of *Terminalia Catappa*are dried in shade. About 500 grams of dry powder obtained from *Terminalia Catappa* Bark& Leaf are taken. The powdered Bark & Leaf are extracted with acetone to remove chlorophyll and then continuous hot solvent Hydro – alcoholic extraction was done using a Soxhlet apparatus for 24 h at 50 °C using solvent: drug ratio of 10:1 (mL/g). The extract is concentrated by vacuum distillation, cooled and placed in desiccators to remove the excessive moisture.

3.2 PHYTOCHEMICAL TEST

The Hydro – alcoholic extracts of *Terminalia Catappa*. were subjected to the preliminary phytochemical analysis.

3.3 PREPARATION OF *TERMINALIA CATAPPA L* CONTAINING HERBAL SYRUP

Table 1: Herbal Syrup.

S. NO	INGREDIENTS	HATCHS
1	**PLANT EXTRACT**	10ml
2	**HYDROXY ETHYL CELLULOSE**	1.2gm
3	**GLYCERIN**	15ml
4	**PROPYLENE GLYCOL**	3ml
5	**PIPPERMINT OIL**	0.5ml
6	**SODIUM BENZOATE**	1gm
7	**SIMPLE SYRUP**	Up to 100ml

Dispersed Hydroxy ethyl cellulose in 5 ml purified water and allowed to swell at room temperature for 15 minutes. Added Sodium benzoate. Heated the solution to 80 degree Centigrade under stirring for 1 hour. Allowed the solution to cool to room temperature and added 10ml of plant Extract under stirring. Peppermint Oil in additional propylene glycol was prepared separately. Add 15ml glycerol to mixing vessel under stirring, rinsed the container with 50 ml simple syrup and added it to mixing vessel under stirring. Added herbal extract to mixing vessel under stirring. Rinsed the containers with 5 ml simple syrup and added the rinsing to the mixing vessel under stirring. Cooled the solution to 35-40 C. Added solution of peppermint Oil to mixing vessel under stirring, rinsed each container separately with 5 ml sorbitol each and added to the mixing vessel. And finally make up to 100ml with simple syrup.

3.4 EVALUATION OF HERBAL SYRUP

Physicochemical Parameters: The herbal syrup was evaluated for various physicochemical parameters such as physical appearance (colour, odour, taste), pH, Wt/ml, viscosity.

Glucose Diffusion: It was performed according to the method. A total of 25 ml of glucose solution (20m mol / L) and the samples of plant extract (1%) were dialyzed in dialysis bags against 200ml of distilled water at 37 degree centigrade in a shaker water bath. The glucose content in the dialysis was determined using UV Spectrophotometer. A control test was carried out without sample.

3.5 ACUTE TOXICITYSTUDY

Organisation for Economic co-operation and Development (OECD) regulates guidelines for oral acute toxicity study. It is an international organisation which works with the aim of reducing both the number of animals and the level of pain associated with acute toxicity

testing. To determine the acute oral toxicity OECD frames the following guideline methods. Acute toxicity studies were performed according to OECD-423 (Organization of Economic and Cooperation Development) guidelines. Wistar albino Rat selected by random sampling technique were employed in this study. The animals were fasted for 4h with free access to water. The Hydro-Alcoholic Extract of *Terminalia Catappa* (HATC) was administered orally at a dose of 5 mg/kg initially and mortality if any was observed for first 24 hrs and after 72 hrs.

If mortality was observed in two out of three animals, then the dose administered was considered as toxic dose. However, if the mortality was observed in only one animal out of three animals then the same dose was repeated againt confirm the toxic effect. If nomortal it was observed then higher (50, 300, 2000 mg/kg) doses of the plant extracts were employed for further toxicity studies.

3.6 EXPERIMENTAL DESIGN

The experimental design involved 36 male Wistar albino rats, divided into six groups with six animals each (n=6). Group I received Tween-20 (10% w/v) for 21 days as a control. Groups II to VI were treated with NSAIDs (Aspirin, 150 mg/kg/day body weight) for 21 days. Group II served as the negative control and received no additional treatment.

Group III received omeprazole (40 mg/kg/body weight) orally as a standard treatment for 21 days along with the NSAID treatment. Groups IV and V received low dose (HATC) (200 mg/kg/body weight) and high dose (HATC) (400 mg/kg/body weight) of the experimental compound orally for 21 days along with the NSAID treatment. Group VI received Herbal Syrup of (HATCHS) (Hydro-Alcoholic extract of Terminalia catappa) for 21 days along with the NSAID treatment. At the end of the experiment, the animals were euthanized with isopentane, and their organs were isolated for assessment of parameters.

1. Group I: This group served as the control and consisted of animals treated with Tween-20 (10% w/v) for 21 days.

2. Group II: Animals in this group were treated with aspirin 150 mg/kg/ body weight for 21 days and did not receive any additional treatment beyond the standard diet and housing conditions.

3. Group III: Animals in this group received omeprazole (40 mg/kg/body weight) orally for 21 days, serving as the standard treatment group along with the NSAID treatment(inducing agent).

4. Group IV: Animals in this group received a low dose (HATC) (200 mg/kg/body weight) of the experimental compound orally for 21 days, concurrently with NSAID treatment.

5. Group V: Animals in this group received a high dose (HATC) (400 mg/kg/body weight) of the experimental compound orally for 21 days, concurrently with NSAID treatment.

6. Group VI: Animals in this group received a nanosuspension of (HATCHS) (Hydro-Alcoholic extract of Terminalia catappa) orally for 21 days, alongside NSAID treatment.

After the 21-day treatment period, all animals were euthanized with isopentane, and their organs were isolated for further assessment of parameters relevant to the study.

3.7 PHARMACOLOGICAL STUDY

- **The PH Of Stomach Acid**
- **Gastric Volume**
- **Ulcerative Index**
- **Percentage Of Ulcer Protection**
- **Total Acidity Content**
- **Superoxide Dimutase**
- **Catalase**
- **Glutathione**

4.RESULTS AND DISCUSSION

4.1 EXTRACTION APPEARANCE AND PERCENTAGE YIELD

Table 1: Appearance and Percentage.

S. No	Drug	*Leaf &Bark Part of Terminalia Catappa*
1	Solvent	Hydro – Alcoholic
2	Colour	Dark Brown
3	Consistency	Semi Liquid
4	Percentage yield	10.7 % w/w

Fig. 4: Extraction.

4.2 PRELIMINARY PHYTOCHEMICAL SCREENING:

Results of the Preliminary Phytochemical Constituents present in Hydro – Alcoholic extract of *Terminalia Catappa*

+ = Present

– = Absent

Table: 2 Phytochemical Screening

S. No	Constituents	Hydro-Alcoholic Extract Of Terminalia Catappa	Hydro-Alcoholic Extract Of Terminalia Catappa Herbal Syrup
1.	Alkaloids	+	+
2.	Carbohydrates	_	+
3.	Protein	_	+
4.	Terpinoids	_	_
5.	Phenols	+	+
6.	Tannins	+	+
7.	Flavanoids	+	+
9.	Glycosides	+	+
10.	Saponins	_	_

4.3 HYDRO-ALCOHOLIC EXTRACT OF TERMINALIA CATAPPA HERBAL SYRUP

Fig. 5: Herbal Syrup.

Table: 3 Evaluation Of Herbal Syrup

S. NO	PARAMETERS	HATCHS
1	COLOUR	Yellow
2	ODOUR	Aromatic
3	TASTE	Sweet
4	PH	5.25
5	VISCOSITY	24.58 Centipoise
6	GLUCOSE DIFFUSION 50 (µg/mL)	0.135

4.4 PHARMACOLOGICAL ACTIVITY

4.4.1 Effect Of HATC On The PH Of Stomach Acid, Ulcerative Index, Percentage Of Protection & Total Acidity Content

Table: 4 Effect Of HATC On The PH Of Stomach Acid, Ulcerative Index, Percentage Of Protection & Total Acidity Content

S. No	Groups	PH value	Ulcerative Index	% Of Protection	Total Acidity Content Total Acidity (MEQ/L/4H)
1	Control	3.008 ± 0.05	0.000 ± 0.00	0.000 ±0.0	134.6 ± 0.3444
2	Negative Control	1.790 ± 0.02 a^{****}	13.66 ± 0.21 a^{****}	0.000 ± 0.0a^{ns}	245.0 ± 0.3427 a^{****}
3	Positive Control	5.035 ± 0.02	2.931 ± 0.17	85.54 ± 0.31	145.7± 0.2865 a^{****} b^{****}

		a^{****} b^{****}	a^{****} b^{****}	a^{****} b^{****}	
4	HATC 200 mg/kg (Low dose)	3.291 ± 0.02 a^{***} b^{****} c^{****}	8.255 ± 0.06 a^{****} b^{****} c^{****}	54.11 ± 0.38 a^{****} b^{****} c^{****}	196.1 ± 0.6245 a^{****} b^{****} c^{****}
5	HATC 400 mg/kg (High dose)	4.031 ± 0.02 a^{****} b^{****} c^{****}	6.188 ± 0.04 a^{****} b^{****} c^{****}	63.65 ± 0.33 a^{****} b^{****} c^{****}	163.4 ± 0.2005 a^{****} b^{****} c^{****}
6	HATCHS	4.893 ± 0.02 a^{****} b^{****} c^{*}	3.310 ± 0.05 a^{****} b^{****} c^{ns}	75.31 ± 0.75 a^{****} b^{****} c^{****}	135.6 ± 0.8623 a^{*} b^{****} c^{****}

Values are represented in Mean ± SEM, n=5 ns- Non significant,*p<0.05,

**p<0.01, ***p<0.001, ***p<0.0001, ****p<0.00001

Comparison:

a - Group I vs Group II, Group III, Group IV, Group V, Group VI

b - Group II vs Group III, Group IV, Group V, Group VI

c - Group III vs Group IV, Group V, Group VI (one way ANOVA followed by Turkey test).

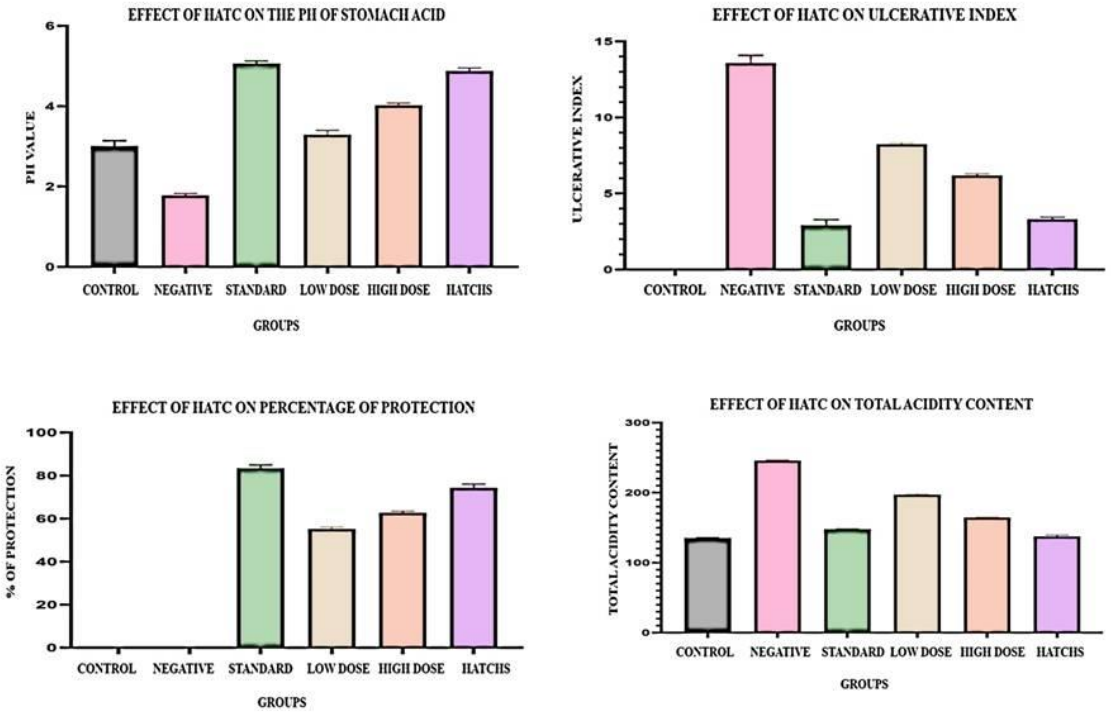

Fig. 6: Effect Of HATC On The PH Of Stomach Acid, Ulcerative Index, Percentage Of Protection & Total Acidity Content.

4.4.2 Effect Of HATC On Gastric Volume, Superoxide Dimutase, Catalase & Glutathione

Table: 5 Effect Of HATC On Gastric Volume, Superoxide Dimutase, Catalase & Glutathione

S.No	Groups	Gastric volume (in ml)	SOD (U/mg issue)	µmole H_2O_2 /mg of protein/minute	GSH (mmole/mg protein)
1	Control	3.175 ± 0.01722	270.2 ± 3.992	363.0 ± 5.323	57.67 ± 0.20
2	Negative Control	5.945 ± 0.02135a^{****}	100.0 ± 1.703 a^{****}	174 ± 3.319 a^{****} b^{****} c^{****}	20.11 ± 0.07 a^{****} b^{****} c^{****}
3	Positive Control	3.363 ± 0.03679a^{**}	221.4 ± 3.501 a^{****} b^{****}	290 ± 2.902 a^{****} b^{****} c^{****}	45.55 ± 0.17 a^{****} b^{****} c^{****}
4	HATC 200mg/kg (Low dose)	5.531 ± 0.03579 a^{****} b^{****} c^{****}	146.0 ± 0.8367 a^{****} b^{****} c^{****}	205 ± 2.289 a^{****} b^{****} c^{****}	28.33 ± 0.16 a^{****} b^{****} c^{****}
5	HATC 400mg/kg (High dose)	5.148 ± 0.02711 a^{****} b^{****} c^{****}	178.0 ± 2.214 a^{****} b^{****} c^{****}	262 ± 2.183 a^{****} b^{****} c^{****}	35.35 ± 0.06 a^{****} b^{****} c^{****}
6	HATCHS	3.730 ± 0.02988 a^{****} b^{****} c^{****}	208.2 ± 2.223 a^{****} b^{****} c^{*}	302 ± 2.735 a^{****} b^{****} c^{ns}	38.11 ± 1.65 a^{****} b^{****} c^{****}

Values are represented in Mean ± SEM, n=5 ns- Non significant,*p<0.05,

**p<0.01, ***p<0.001, ***p<0.0001, ****p<0.00001

Comparison:

a - Group I vs Group II, Group III, Group IV, Group V, Group VI

b - Group II vs Group III, Group IV, Group V, Group VI

c - Group III vs Group IV, Group V, Group VI (one way ANOVA followed by Turkey test).

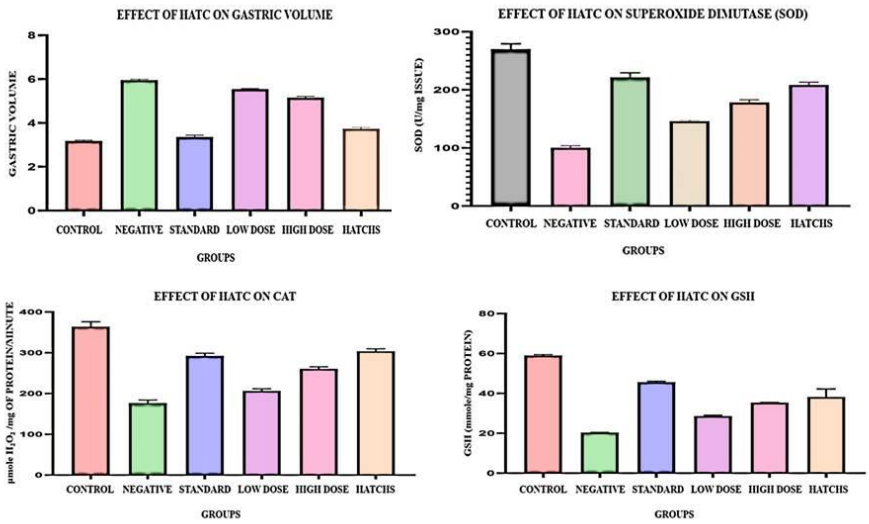

Fig: 7. Effect Of HATC On Gastric Volume, Superoxide Dimutase, Catalase & Glutathione.

4.5 HISTOPATHOLOGY

Group I: The stomach histology of control normal rats reveals typical microscopic architecture with intact glands, exhibiting no abnormalities. Parietal cells, situated in the upper portion of gastric glands, display eccentric nuclei and faint eosinophilic vacuoles within the cytoplasm, indicative of normal cellular activity.

Group II: The Aspirin-treated negative control group exhibits a pronounced inflammatory response, characterized by marked submucosal edema and infiltration of mononuclear leukocytes, observed throughout the lamina propria, muscularis mucosa, and submucosal layers of the stomach tissue.

Group III: Treatment with omeprazole at a dose of 20 mg/kg resulted in mitigated damage to the gastric mucosa when contrasted with the notably severe injuries witnessed in the ulcer control rat. This suggests a protective effect of omeprazole against gastric mucosal damage.

Group IV: In this group, HATC low dose (200 mg/kg),the examination revealed moderate levels of leucocytic inflammatory cell infiltration within the submucosal layer and muscularis mucosa.,

Group V: The HATC high dose (400 mg/kg) treatment resulted in minimal disruption to the surface epithelium with an absence of edema and no infiltration of leukocytes into the submucosal layer. This suggests a protective effect of the treatment of HATC.

Group VI: In this Herbal syrup of HATCHS group receives 50 mg/kg exhibited a consistent epithelial and glandular structure with well-maintained tissue architecture. Minor infiltration of leucocytic inflammatory cells was observed in tissue sections, indicating a mild immune response. Overall, the absence of significant abnormalities suggests the preservation of tissue integrity and function.

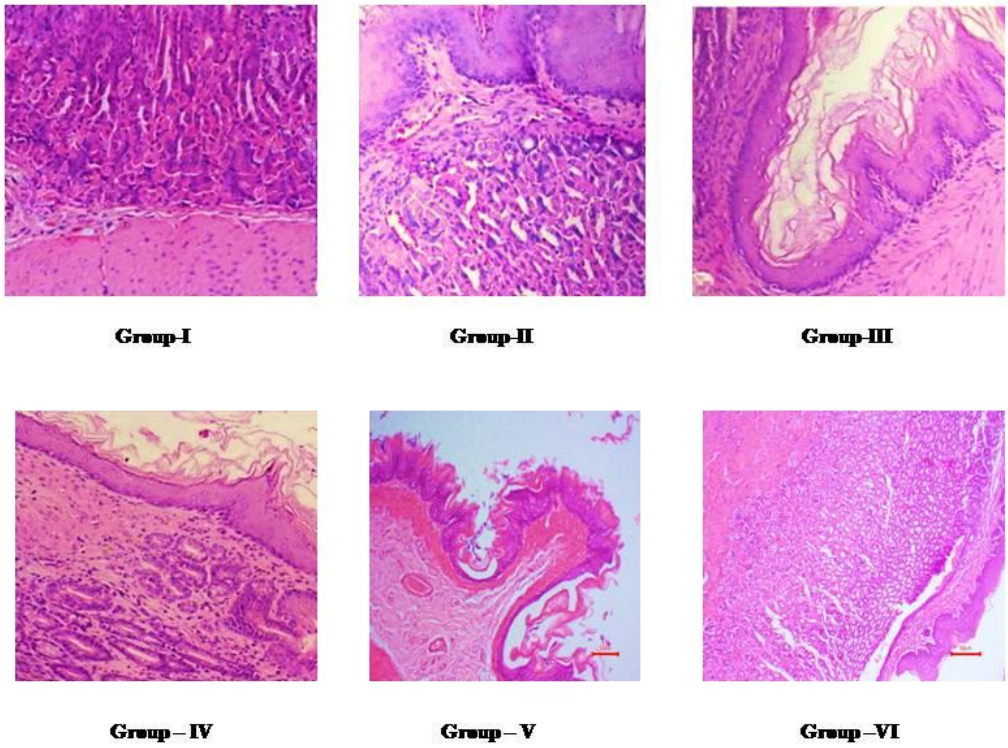

Fig. 8: Histopathology.

DISCUSSION

Extraction and Phytochemistry:

The hydro-alcoholic extract of *Terminalia catappa* yielded 10.7% w/w. Phytochemical analysis revealed a robust presence of alkaloids, phenols, flavonoids, tannins, and glycosides—compounds known for antioxidant and anti-inflammatory properties. The herbal syrup formulation retained these bioactives and showed improved solubility and acceptability parameters such as pH, viscosity, taste, and glucose diffusion.

Pharmacological Activities

The antiulcer potential was significant across multiple parameters:

- **pH of Gastric Contents:** HATCHS and HATC (400 mg/kg) showed marked pH elevation (4.89 and 4.03 respectively), suggesting reduced gastric acidity.
- **Ulcer Index & % Protection:** The highest dose of HATC and HATCHS significantly lowered ulcer indices and provided up to 75.31% protection, nearly matching or surpassing the positive control (omeprazole).

- **Gastric Volume & Total Acidity:** Both parameters were significantly reduced in the treatment groups, especially with HATCHS.
- **Antioxidant Activity:** HATC enhanced antioxidant defense by increasing SOD, CAT, and GSH levels in a dose-dependent manner, indicating protection against oxidative gastric damage.

Histopathology

Control groups maintained normal gastric histology, while aspirin-induced ulcers showed massive epithelial erosion and inflammation. HATCHS and high-dose HATC preserved tissue integrity and reduced leukocytic infiltration, closely mimicking omeprazole's protective effect.

5. CONCLUSION

The hydro-alcoholic extract of *Terminalia catappa*, particularly in its syrup form (HATCHS), demonstrates potent gastroprotective and antioxidant activity. The results confirm its efficacy in reducing gastric ulcers, modulating gastric pH and acidity, and enhancing enzymatic antioxidant defenses. With comparable effectiveness to omeprazole, this herbal formulation holds promise as a natural antiulcer therapeutic agent. Further clinical studies are warranted to support its application in human models.

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