

Evaluation of Anti-Arthritic Activity of Bioactive Fractions of *Rumex hastatus* in Experimental Models of Rheumatoid Arthritis

Anu viral Patel^{1*}, Ishita Basera¹, Ravikumar R. Patel¹, Ketan Shantilal Rathod², Zalak Bhupendrakumar Patel³, Jahanviben Chandrakant Patel⁴, Rakeshkumar Pravinbhai Patel², Kalubha Shivubha Zala¹

¹Shree Swaminarayan College of Pharmacy, Swaminarayan University, Kalol, Gujarat, 382725, India

²A-One Pharmacy College, Ahmedabad, Gujarat – 382330, India.

³K. N. School of Pharmacy, Ahmedabad, Gujarat – 380481, India.

⁴SAL Institute of Pharmacy, Ahmedabad, Gujarat – 380060, India.

*Corresponding Author E-mail: anu.patel@sal.edu.in

Abstract:

The present study evaluated the acute oral toxicity and in vivo anti-inflammatory activity of the methanolic leaf extract of *Rumex hastatus* (RHLM). In the acute toxicity study, mice received RHLM at 250, 500, 1000 and 2000 mg/kg and were observed for 14 days. No mortality or notable adverse behavioural changes were reported up to 2000 mg/kg, and body-weight gain remained comparable with the control group. Hematological indices and biochemical markers of hepatic and renal function showed no notable treatment-related alterations. Anti-inflammatory activity was evaluated in carrageenan- and formalin-induced rat hind-paw edema models. In the carrageenan model, RHLM at 200 and 400 mg/kg reduced paw edema over 5 h; at 5 h, percentage inhibition was $36.12 \pm 1.75\%$ and $61.42 \pm 1.03\%$, respectively, compared with $61.58 \pm 1.34\%$ for indomethacin (10 mg/kg). In the formalin model, RHLM reduced edema across the six-day observation period, with the 400 mg/kg dose showing the greatest effect. On day 6 at 3 h, inhibition was $57.55 \pm 3.45\%$ with RHLM 400 mg/kg, compared with $55.21 \pm 3.05\%$ for diclofenac (5 mg/kg). These findings indicate that RHLM was well tolerated in the reported acute toxicity study and demonstrated marked anti-inflammatory activity, particularly at 400 mg/kg.

Keywords: *Rumex hastatus*; methanolic leaf extract; acute toxicity; anti-inflammatory activity; carrageenan; formalin

Received: July 12, 2026

Revised: August 09, 2026

Accepted: August 27, 2026

Published: September 25, 2026

DOI: <https://doi.org/10.64063/3049-1681.vol3.issue9.000301>

This is an Open Access article distributed under the terms of the Creative Commons Attribution (CC BY NC), which permits unrestricted use, distribution, and reproduction in any medium, as long as the original authors and source are cited. No permission is required from the authors or the publishers. (<https://creativecommons.org/licenses/by-nc/4.0/>)

1. Introduction

Inflammation is a protective response to pathogens or injurious agents and involves mediator release, vascular changes, cell migration, tissue breakdown and repair. Persistent inflammatory processes contribute to chronic disorders such as rheumatoid arthritis, in which synovial proliferation and progressive destruction of cartilage and bone may occur. Conventional anti-inflammatory and disease-modifying therapies are effective, but their long-term use may be limited by adverse effects and monitoring requirements. These considerations support continued investigation of medicinal plants traditionally used for inflammatory conditions¹⁻⁴.

Rumex hastatus D. Don belongs to the family Polygonaceae and has been described in the supplied study as a medicinal plant used in traditional practice⁵⁻⁷. Previous work cited in the source material reported antinociceptive, anti-inflammatory and antipyretic activity of *R. hastatus* stem and root extracts⁸, while other investigations described antioxidant, antimicrobial and related biological activities of the species⁹⁻¹⁶. The present article focuses exclusively on the acute toxicity and in vivo anti-inflammatory findings generated for the methanolic leaf extract of *R. hastatus* (RHLM).

The objective was to assess the acute toxicity profile of RHLM and to evaluate its anti-inflammatory activity using carrageenan-induced acute paw edema and formalin-induced subchronic paw edema models.

2. Materials and Methods

Study material

The test material was the methanolic extract of *R. hastatus* leaves, designated RHLM in the supplied experimental record. No additional extraction conditions, solvent-to-drug ratio, extraction duration, authentication number, or voucher-specimen details were stated in the supplied content; these details should be inserted from the original laboratory record before journal submission.

Acute toxicity study

Acute oral toxicity was assessed in mice using a control group and RHLM dose groups of 250, 500, 1000 and 2000 mg/kg (n=6 per group as reported with the tabulated data). Animals were observed at 30 min, 4 h, 12 h and 24 h and subsequently through day 14 for behavioural and clinical signs. Body weight was recorded from day 0 through day 14 at two-day intervals. Hematological variables included red blood cell count, white blood cell count, hemoglobin, differential leukocyte count, packed cell volume, mean corpuscular volume, mean corpuscular hemoglobin and mean corpuscular hemoglobin concentration. Biochemical evaluation included SGOT, SGPT, ALP, bilirubin, urea and creatinine. The supplied results describe the limit-test outcome as LD₅₀ >2000 mg/kg.

Carrageenan-induced hind-paw edema

The carrageenan model was used to assess acute anti-inflammatory activity in rats¹⁻³. The reported treatment groups were control, indomethacin 10 mg/kg, RHLM 200 mg/kg and RHLM 400 mg/kg (n=6 per group). Paw edema volume was recorded at 0, 1, 2, 3, 4 and 5 h, and percentage inhibition of paw volume was calculated and reported for each time point. The

supplied content identifies the experimental animals as Sprague-Dawley rats but does not state the carrageenan concentration, injection volume, or exact administration route; add these details from the original protocol before submission.

Formalin-induced hind-paw edema

Subchronic anti-inflammatory activity was evaluated using formalin-induced rat hind-paw edema^{2, 20}. The reported groups were control, diclofenac 5 mg/kg, RHLM 200 mg/kg and RHLM 400 mg/kg (n=6 per group). Paw edema volume and percentage inhibition were recorded at 0, 1 and 3 h on days 1 through 6. The supplied content does not provide the formalin concentration, injection volume or exact dosing schedule; these should be verified against the original experimental protocol before submission.

3. Statistical presentation

All tabulated results in the supplied content were expressed as mean $\pm$ SD with n=6. The supplied content did not describe the inferential statistical test, software, or significance threshold; therefore, we did not add any unreported statistical procedure to this manuscript¹⁶⁻²⁰.

4. Ethical statement

All experimental procedures involving animals were conducted after obtaining prior approval from the Institutional Animal Ethics Committee (IAEC) of Shree Narnajibhai Lalbhai Patel College of Pharmacy. The project proposal entitled "Evaluation of Anti-arthritic Activity of Various Fractions of *Rumex hastatus*" was reviewed and approved/recommended by the committee at its meeting held on 07 January 2025. The Animal Ethical Approval/Protocol No. is CCSEA/SNLP/CP/IAEC/25/01/163.

5. Results and Discussion

Acute toxicity and general observations

RHLM produced no reported mortality or notable adverse behavioural effects up to 2000 mg/kg during the 14-day observation period. Body weight increased in all groups. On day 14, mean body weights were 22.73 $\pm$ 1.01 g in controls and 22.75 $\pm$ 0.78, 22.85 $\pm$ 0.66, 23.32 $\pm$ 0.63 and 23.16 $\pm$ 0.94 g in the 250, 500, 1000 and 2000 mg/kg groups, respectively. The source therefore classified the extract in the lowest reported acute-toxicity category, with LD₅₀ >2000 mg/kg.

Table 1. Body weight of mice during acute toxicity evaluation of RHLM

Treat ment	Body Wt. of mice (g)	Body Wt. of mice (g)	Body Wt. of mice (g)	Body Wt. of mice (g)	Body Wt. of mice (g)	Body Wt. of mice (g)	Body Wt. of mice (g)	Body Wt. of mice (g)	Body Wt. of mice (g)
Treatm ent	Day 0	2nd Day	4th Day	6th Day	8th Day	10th Day	12th Day	14th Day	Weight gain on 14th Day
Control	20.38 $\pm$ 0.77	20.68 $\pm$ 0.81	21.03 $\pm$ 0.81	21.36 $\pm$ 0.85	21.68 $\pm$ 0.92	22.00 $\pm$ 0.95	22.36 $\pm$ 0.96	22.73 $\pm$ 1.01	02.31 $\pm$ 0.32
Group 1	20.40 $\pm$ 0.72	20.72 $\pm$ 0.75	21.04 $\pm$ 0.77	21.37 $\pm$ 0.79	21.72 $\pm$ 0.79	22.05 $\pm$ 0.82	22.40 $\pm$ 0.79	22.75 $\pm$ 0.78	02.32 $\pm$ 0.20

Group 2	20.35±0.61	20.62±0.64	21.02±0.60	21.34±0.60	21.69±0.64	22.05±0.61	22.45±0.61	22.85±0.66	02.47±0.25
Group 3	20.58±0.58	20.93±0.62	21.25±0.65	21.70±0.60	22.10±0.60	22.48±0.60	22.86±0.62	23.32±0.63	02.68±0.13
Group 4	20.51±0.81	20.85±0.85	21.21±0.81	21.59±0.88	22.00±0.85	22.40±0.84	22.78±0.87	23.16±0.94	02.63±0.16

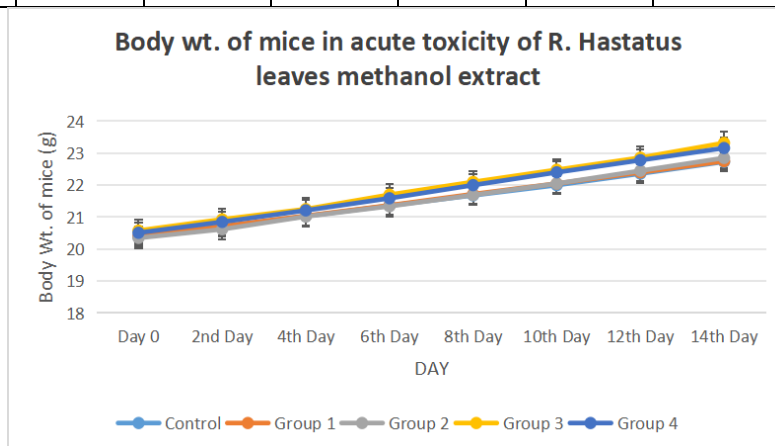


Figure 1. Body weight of mice during acute toxicity evaluation of *R. hastatus* leaf methanolic extract (source figure reproduced from the supplied study).

Hematological and biochemical findings

No notable treatment-related changes were reported for red blood cell count, hemoglobin, packed cell volume, mean corpuscular volume or mean corpuscular hemoglobin. The source described increases in lymphocyte, neutrophil and basophil counts across treated groups, while the principal hematological indices remained close to control values. Hepatic markers (SGOT, SGPT, ALP and bilirubin) and renal markers (urea and creatinine) likewise showed no notable changes across the tested dose range. These observations supported the reported absence of acute hepatic or renal toxicity under the study conditions.

Table 2. Biochemical parameters in control and RHLM-treated mice

Factors	Control	250 mg/Kg (G 1)	500 mg/Kg (G 2)	1000 mg/Kg (G 3)	2000 mg/Kg (G 4)
S.G.O.T (U/L)	107.32±03.63	108.53±04.21	108.32±04.85	107.45±05.86	108.31±04.35
S.G.P.T (U/L)	35.57±03.48	36.31±02.14	35.85±02.28	36.19±03.52	36.35±03.69
A.L.P (U/L)	76.15±03.77	77.65±02.64	77.19±03.59	76.86±04.42	77.32±03.59
Bilirubin (mg/dl)	00.61±00.15	00.61±00.23	00.61±00.20	00.61±00.17	00.61±00.25
Urea (mg/dl)	20.81±02.24	21.05±02.12	20.51±03.03	20.65±2.71	20.51±02.58
Creatinine (mg/dl)	00.27±00.16	00.27±00.11	00.27±00.11	00.27±00.07	00.27±00.13

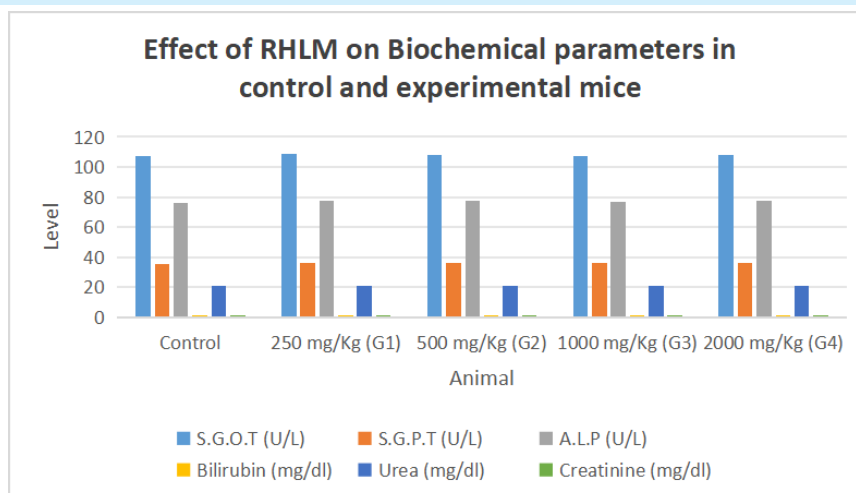


Figure 2. Biochemical parameters in control and RHLM-treated mice (source figure reproduced from the supplied study).

Carrageenan-induced paw edema

Carrageenan produced a progressive increase in paw edema in the control group, reaching 2.12 ± 0.04 ml at 5 h. Indomethacin reduced the 5-h edema value to 0.81 ± 0.01 ml. RHLM reduced paw edema to 1.35 ± 0.01 ml at 200 mg/kg and 0.82 ± 0.02 ml at 400 mg/kg at 5 h. Corresponding percentage inhibition at 5 h was $36.12 \pm 1.75\%$ for RHLM 200 mg/kg and $61.42 \pm 1.03\%$ for RHLM 400 mg/kg, compared with $61.58 \pm 1.34\%$ for indomethacin. Thus, the 400 mg/kg RHLM response at 5 h was numerically close to the standard treatment in the supplied dataset.

Table 3. Effect of RHLM on carrageenan-induced paw edema

Treatment	Body wt. of tested animals (g)	Mean increase in paw edema vol. (ml)	Mean increase in paw edema vol. (ml)	Mean increase in paw edema vol. (ml)	Mean increase in paw edema vol. (ml)	Mean increase in paw edema vol. (ml)	Mean increase in paw edema vol. (ml)
	Body wt. of tested animals (g)	0 Hr	1 Hr	2 Hrs	3 Hrs	4 Hrs	5 Hrs
Control	176.81 ± 03.68	00.85 ± 00.02	01.13 ± 00.02	01.46 ± 00.04	01.72 ± 00.06	01.88 ± 00.02	02.12 ± 00.04
Indomethacin (10mg/Kg)	176.31 ± 03.42	00.76 ± 00.04	00.84 ± 00.01	00.97 ± 00.03	00.92 ± 00.01	00.85 ± 00.01	00.81 ± 00.01
RHLM (200mg/kg)	176.65 ± 03.91	00.77 ± 00.03	01.04 ± 00.01	01.23 ± 00.02	01.38 ± 00.05	01.43 ± 00.03	01.35 ± 00.01
RHLM (400mg/kg)	176.65 ± 03.25	00.78 ± 00.02	00.96 ± 00.03	01.04 ± 00.01	01.05 ± 00.01	00.97 ± 00.01	00.82 ± 00.02

g)							
Table 4. Percentage inhibition of carrageenan-induced paw edema							
Treatment	Body Wt. of tested animals (g)	% Inhibition of paw vol. at various time interval	% Inhibition of paw vol. at various time interval	% Inhibition of paw vol. at various time interval	% Inhibition of paw vol. at various time interval	% Inhibition of paw vol. at various time interval	% Inhibition of paw vol. at various time interval
	Body Wt. of tested animals (g)	0 Hr	1 Hr	2 Hrs	3 Hrs	4 Hrs	5 Hrs
Control	176.81±03.69	--	--	--	--	--	--
Indomethacin (10mg/Kg)	176.31±03.42	09.10±02.91	24.10±02.88	34.72±03.41	48.10±02.02	53.18±00.52	61.58±01.34
RHLM (200mg/kg)	176.65±03.91	08.25±01.92	08.35±03.22	15.54±03.41	18.38±04.51	22.13±01.51	36.12±01.75
RHLM (400mg/kg)	176.65±03.25	06.93±01.33	14.12±05.47	28.24±02.82	37.52±02.83	46.54±01.95	61.42±01.03

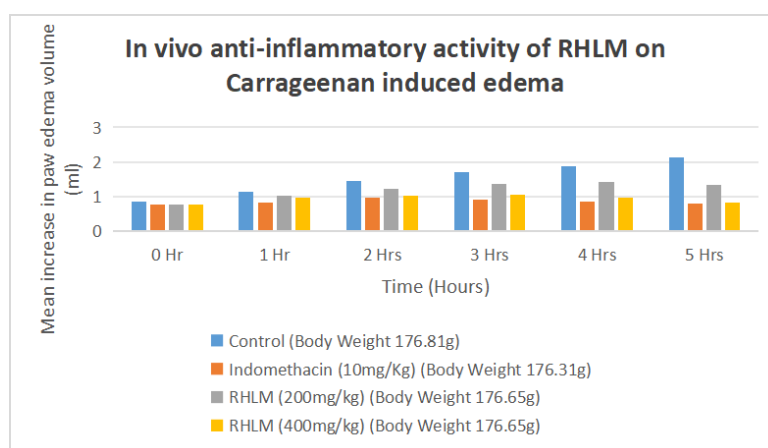


Figure 3. In vivo anti-inflammatory activity of RHLM in carrageenan-induced edema (source figure reproduced from the supplied study).

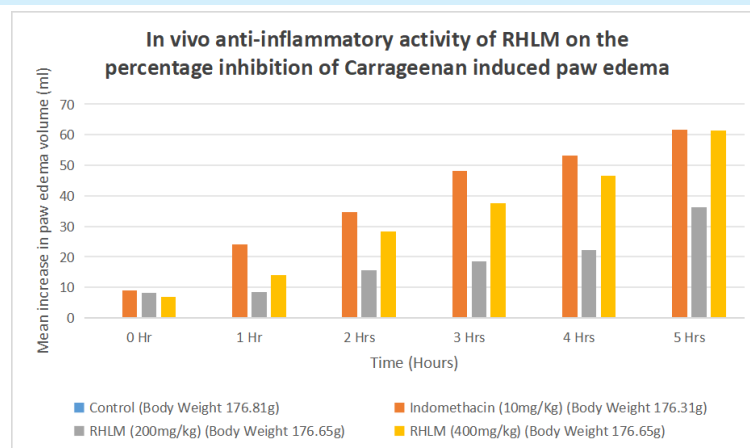


Figure 4. Percentage inhibition of carrageenan-induced paw edema (source figure reproduced from the supplied study).

The supplied discussion characterizes carrageenan inflammation as biphasic, with early mediator release followed by a later prostaglandin-dominant phase. The pronounced activity of RHLM 400 mg/kg at later time points is consistent with an effect on inflammatory mediator pathways; however, the present dataset does not directly measure cyclooxygenase, lipoxygenase or specific inflammatory mediators. Mechanistic statements should therefore remain interpretive rather than definitive. Comparable plant-derived anti-inflammatory effects in carrageenan models are described in references included in the source material.

Formalin-induced paw edema

In the formalin model, edema increased across the six-day observation period in control animals. Both RHLM doses reduced edema relative to control, with the 400 mg/kg dose consistently showing the stronger response. On day 6 at 3 h, paw edema was 2.61 ± 0.12 ml in the control group, 1.08 ± 0.02 ml with diclofenac 5 mg/kg, 1.82 ± 0.05 ml with RHLM 200 mg/kg and 1.06 ± 0.03 ml with RHLM 400 mg/kg. Percentage inhibition at the same time point was $55.21 \pm 3.05\%$ for diclofenac, $27.57 \pm 4.73\%$ for RHLM 200 mg/kg and $57.55 \pm 3.45\%$ for RHLM 400 mg/kg.

Table 5. Effect of RHLM on formalin-induced paw edema on days 4-6

Treat ment	Body wt. of tested animal s (g)	Mean incre ase in Paw Edem a Vol. (ml)	Mean incre ase in Paw Edem a Vol. (ml)	Mean incre ase in Paw Edem a Vol. (ml)	Mean incre ase in Paw Edem a Vol. (ml)	Mean incre ase in Paw Edem a Vol. (ml)	Mean incre ase in Paw Edem a Vol. (ml)	Mean incre ase in Paw Edem a Vol. (ml)	Mean incre ase in Paw Edem a Vol. (ml)	Mean incre ase in Paw Edem a Vol. (ml)
Treat ment	Body wt. of tested animals (g)	4th Day	4th Day	4th Day	5th Day	5th Day	5th Day	6th Day	6th Day	6th Day
Treat ment	Body wt. of	0 Hr	1 Hr	3 Hrs	0 Hr	1 Hr	3 Hrs	0 Hr	1 Hr	3 Hrs

	tested animals (g)									
Control	181.02 ±03.72	01.03 ±0.02	01.62 ±0.03	02.09 ±0.02	01.12 ±0.05	01.75 ±0.07	02.26 ±0.05	01.27 ±0.03	01.91 ±0.05	02.61 ±0.12
Diclofenac (5 mg/Kg)	181.18 ±02.49	00.91 ±0.05	01.12 ±0.04	01.33 ±0.04	00.81 ±0.04	01.06 ±0.05	01.18 ±0.07	00.81 ±0.11	01.02 ±0.03	01.08 ±0.02
RHLM (200mg/kg)	181.34 ±02.93	00.93 ±0.04	01.36 ±0.04	01.67 ±0.08	00.97 ±0.03	01.47 ±0.04	01.77 ±0.03	01.03 ±0.02	01.46 ±0.04	01.82 ±0.05
RHLM (400mg/kg)	181.82 ±03.38	00.88 ±0.04	01.13 ±0.03	01.33 ±0.06	00.83 ±0.02	01.08 ±0.02	01.15 ±0.03	00.82 ±0.02	01.03 ±0.02	01.06 ±0.03

Table 6. Percentage inhibition of formalin-induced paw edema on days 4-6

Treatment	Body weight of tested animals (g)	% Inhibition of Paw Vol. at various time interval	% Inhibition of Paw Vol. at various time interval	% Inhibition of Paw Vol. at various time interval	% Inhibition of Paw Vol. at various time interval	% Inhibition of Paw Vol. at various time interval	% Inhibition of Paw Vol. at various time interval	% Inhibition of Paw Vol. at various time interval	% Inhibition of Paw Vol. at various time interval	% Inhibition of Paw Vol. at various time interval
Treatment	Body weight of tested animals (g)	4th Day	4th Day	4th Day	5th Day	5th Day	5th Day	6th Day	6th Day	6th Day
Treatment	Body weight of tested animals (g)	0 Hr	1 Hr	3 Hrs	0 Hr	1 Hr	3 Hrs	0 Hr	1 Hr	3 Hrs

Contr ol	181.02 ±03.72	--	--	--	--	--	--	--	--	--
Diclo finac (5 mg/K g)	181.18 ±02.49	12.02 ±07.3 2	28.43 ±03.7 6	35.66 ±03.0 8	27.13 ±05.9 7	37.53 ±03.0 4	46.75 ±02.4 1	33.13 ±07.4 7	44.23 ±01.5 4	55.21 ±03.0 5
RHL M (200 mg/k g)	181.34 ±02.93	08.27 ±03.0 7	13.66 ±02.7 3	21.32 ±04.5 3	13.26 ±04.8 5	17.02 ±04.2 3	20.46 ±02.6 1	21.83 ±01.0 8	20.66 ±04.6 6	27.57 ±04.7 3
RHL M (400 mg/k g)	181.82 ±03.38	12.96 ±01.6 7	31.56 ±02.3 2	34.07 ±03.2 7	25.98 ±05.9 2	37.35 ±03.8 8	48.11 ±02.8 6	32.61 ±04.5 3	44.37 ±02.2 7	57.55 ±03.4 5

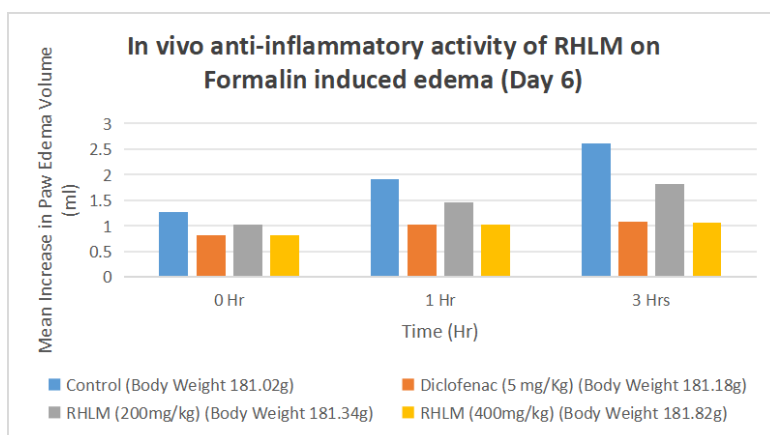


Figure 5. In vivo anti-inflammatory activity of RHLM in formalin-induced edema on day 6 (source figure reproduced from the supplied study).

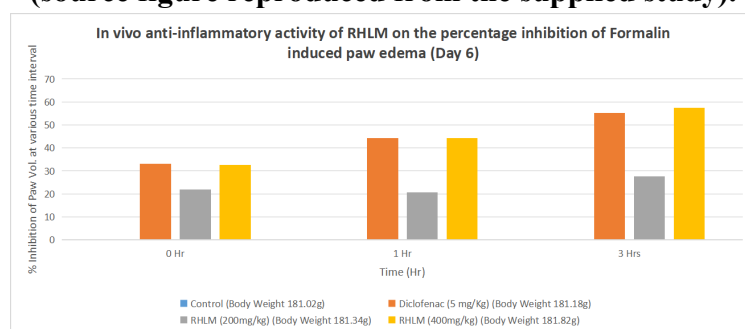


Figure 6. Percentage inhibition of formalin-induced paw edema on day 6 (source figure reproduced from the supplied study).

The formalin model was described in the source as a subchronic inflammatory model. The progressive reduction in edema and the strong day-6 response at 400 mg/kg support sustained anti-inflammatory activity of RHLM under the reported experimental conditions. The

source literature also includes reports of plant extracts reducing inflammatory responses in formaldehyde/formalin and carrageenan models.

6. Conclusion

Within the limits of the supplied experimental data, the methanolic leaf extract of *R. hastatus* was well tolerated in the acute toxicity study, with no mortality or notable adverse clinical, hematological, hepatic or renal effects reported up to 2000 mg/kg. RHLM demonstrated in vivo anti-inflammatory activity in both carrageenan- and formalin-induced paw edema models. The 400 mg/kg dose produced the strongest response, reaching $61.42 \pm 1.03\%$ inhibition at 5 h in the carrageenan model and $57.55 \pm 3.45\%$ inhibition on day 6 at 3 h in the formalin model. These findings support further investigation of the anti-inflammatory constituents of *R. hastatus*. Mechanistic studies and complete protocol reporting would strengthen future work.

7. Conflict of Interest

The authors declare that they have no conflicts of interest related to the publication of this article.

8. Acknowledgement

The authors sincerely acknowledge the management and administration of Shree Narnajibhai Lalbhai Patel College of Pharmacy and SAL Institute of Pharmacy for providing the necessary facilities, infrastructure, institutional support, and encouragement required for the successful completion of this research work.

The authors are grateful to the Institutional Animal Ethics Committee (IAEC), Shree Narnajibhai Lalbhai Patel College of Pharmacy, for reviewing and approving the animal experimental protocol. The authors also extend their sincere appreciation to the faculty members, laboratory staff, technical personnel, and supporting staff of both institutions for their valuable assistance and cooperation throughout the experimental work.

The authors gratefully acknowledge all individuals who directly or indirectly contributed to the successful completion of this study.

References

1. Akhtar, G., & Shabbir, A. (2019). *Urginea indica* attenuated rheumatoid arthritis and inflammatory paw edema in diverse animal models of acute and chronic inflammation. *Journal of Ethnopharmacology*, 238, 111864.
2. Akinawo, O. O., & Anyasor, G. N. (2017). Aqueous fraction of *Alstonia boonei* De Wild leaves suppressed inflammatory responses in carrageenan and formaldehyde induced arthritic rats. *Biomedicine & Pharmacotherapy*, 86, 95–101.
3. Arpitha, S., & Srinivasan, K. (2019). Anti-inflammatory effect of resin fraction of cardamom (*Elettaria cardamomum*) in carrageenan-induced rat paw edema. *PharmaNutrition*, 10, 100165.
4. Mengi, S. A., & Bakshi, V. J. (2009). Evaluation of the aqueous extract of *Rotula aquatica* roots in acute and chronic inflammatory conditions in rats. *Pharmaceutical Biology*, 47(6), 491–495.

5. Salehi, B., et al. (2022). The genus *Rumex* (Polygonaceae): An ethnobotanical, phytochemical and pharmacological review. *Plants*.
6. Vasas, A., Orbán-Gyapai, O., & Hohmann, J. (2015). The genus *Rumex*: Review of traditional uses, phytochemistry and pharmacology. *Journal of Ethnopharmacology*, 175, 198–228.
7. Sharma, P., Sehgal, A. K., et al. (2026). Phytochemical profiling and in vitro evaluation of antioxidant, antimicrobial, hypoglycemic, and antiulcer activities of aerial parts of *Rumex hastatus* D. Don. *Chemistry & Biodiversity*.
<https://doi.org/10.1002/cbdv.202502151>
8. Singh, S., Kaur, R., & Sharma, S. (2013). Antinociceptive, anti-inflammatory and antipyretic activities of *Rumex hastatus* D. Don stem and roots. *Der Pharmacia Sinica*, 4(3), 95–102.
9. Afzal, S., Tabassum, S., Gilani, M. A., Hussain, N., Farooq, R., Zahid, S., Shah, A. T., & Khan, A. (2014). Total phenolic content, in vitro radical scavenging and antimicrobial activities of whole plant *Rumex hastatus*. *Science International*, 26(2), 721–727.
10. Kamal, Z., Ullah, M., Ahmad, S., Ullah, F., Sadiq, A., Ayaz, M., Zeb, A., & Imran, M. (2015). Ex vivo antibacterial, phytotoxic and cytotoxic potential in the crude natural phytoconstituents of *Rumex hastatus* D. Don. *Pakistan Journal of Botany*, 47(SI), 293–299.
11. Ahmad, I., & Beg, A. Z. (2001). Antimicrobial and phytochemical studies on 45 Indian medicinal plants against multidrug resistant human pathogens. *Journal of Ethnopharmacology*, 74(2), 113–123.
12. Ahmad, S., Ullah, F., Ayaz, M., Sadiq, A., & Imran, M. (2015). Antioxidant and anticholinesterase investigations of *Rumex hastatus* D. Don: Potential effectiveness in oxidative stress and neurological disorders. *Biological Research*, 48, 20.
13. Ahmad, S., Ullah, F., Sadiq, A., Ayaz, M., Imran, M., Ali, I., Zeb, A., Ullah, F., & Shah, M. R. (2016). Chemical composition, antioxidant and anticholinesterase potentials of essential oil of *Rumex hastatus* D. Don collected from the North West of Pakistan. *BMC Complementary and Alternative Medicine*, 16, 29.
14. Sahreen, S., Khan, M. R., & Khan, R. A. (2014). Comprehensive assessment of phenolics and antiradical potential of *Rumex hastatus* D. Don roots. *BMC Complementary and Alternative Medicine*, 14, 47. <https://doi.org/10.1186/1472-6882-14-47>
15. Shafiq, N., Khan, M. R., Ali, A., & Rehman, M. U. (2020). Isolation of bioactive compounds from *Rumex hastatus* extract and their biological evaluation and docking study as potential antioxidant and anti-urease agents. *Journal of Food Biochemistry*, 44(8), e13320.
16. Verma, K. K., Choudhary, A., Gupta, G. D., Gautum, R. K., Singla, S., & Goyal, S. (2020). In-vitro evaluation of the total phenolic, flavonoid contents and free radical scavenging potential of *Rumex hastatus*. *International Journal of Pharmaceutical*

- Sciences and Research*, 11(10), 5104–5111. [https://doi.org/10.13040/IJPSR.0975-8232.11\(10\).5104-11](https://doi.org/10.13040/IJPSR.0975-8232.11(10).5104-11)
17. Sahreen, S., Khan, M. R., & Khan, R. A. (2013). Ameliorating effect of various fractions of *Rumex hastatus* roots against hepato- and testicular toxicity caused by CC14. *Oxidative Medicine and Cellular Longevity*, 2013.
 18. Sahreen, S., Khan, M. R., & Khan, R. A. (2017). Evaluation of *Rumex hastatus* leaves against hepatic fibrosis: A rat model. *BMC Complementary and Alternative Medicine*, 17(1), 435.
 19. Qazi, N. G., Khan, A.-u., Abbasi, S. W., Shah, F. A., Rasheed, F., Ali, F., Hassan, S. S. ul, & Bungau, S. (2022). Pharmacological basis of *Rumex hastatus* D. Don in gastrointestinal diseases with focusing effects on H⁺/K⁺-ATPase, calcium channels inhibition and PDE mediated signaling: Toxicological evaluation on vital organs. *Molecules*, 27(18), 5919. <https://doi.org/10.3390/molecules27185919>
 20. Saleem, A., & Saleem, M. (2020). Antioxidant, anti-inflammatory and antiarthritic potential of *Moringa oleifera* Lam: An ethnomedicinal plant of Moringaceae family. *South African Journal of Botany*, 128, 246–256.