Design and Development of an Anti-Inflammatory Hydrogel of *Acanthocereus tetragonus*

Dr. Swati Patil[1*], Nikita Aier[2], Ashish Mokashi[2], Ashwini Yamgar[2], Prathmesh Jadhav[2], Aadesh Patil[2], Vishvaraj Dethe[2], Dr. Pravin Honmane[1]

1 Associate Professor, Adarsh College of Pharmacy, Vita, Sangli, Maharashtra

2 Adarsh College of Pharmacy, Vita, Sangli, Maharashtra

Corresponding Author

Dr. Swati Patil

Associate Professor, Adarsh College of Pharmacy, Vita, Sangli, Maharashtra

devkar.swati98@gmail.com

Abstract

This study intended to formulate, develop, and pharmacologically investigate a unique herbal polyhydrogel made up of the methanol extract of the *Acanthocereus tetragonus* stem in order to achieve a specific anti-inflammatory effect. The obtained methanol extract contained bioactive secondary metabolites, such as flavonoids, phenols, alkaloids, saponins, and tannins. Moreover, the topical hydrogel was successfully formulated utilizing the Carbopol 940 as a gelling agent, which had good consistency, homogeneous yellowish-green color, complete homogeneity, physiological pH of 7.0, and optimal rheological properties, with a viscosity of 30,000 cP. In terms of evaluating the anti-inflammatory activity in vitro of this gel by the method of egg albumin protein denaturation within concentrations ranging from 200 µg/mL to 1000 µg/mL, the hydrogel was found to have a concentration-dependent anti-inflammatory effect, showing the increase in inhibition percentage values from 35.66% to 57.36% as opposed to the control substance Diclofenac sodium (72.87% to 85.27%).

Keywords: *Acanthocereus tetragonus*, Polyherbal Hydrogel, Carbopol 940, Anti-inflammatory, Protein Denaturation.

How to cite this article: Patil S, Aier N, Mokashi A, Yamgar A, Jadhav P, Patil A, Dethe V, Honmane P. Design and Development of an Anti-Inflammatory Hydrogel of Acanthocereus tetragonus. Int J Drug Deliv Technol. 2026;16(71s): 516-521. DOI: 10.25258/ijddt.16.71s.63

1. Introduction

Acanthocereus tetragonus is belonging to cactaceae family from the succulent cactus species. This plant found in dry and semi dry area of America, Mexico, Caribbean, and some southern parts of United States. It also identified as Triangle Cactus or Fairy Castle Cactus. Tropical and subtropical coastal areas are suitable for the growth of these plants. It contains the spine which protects it from losing moisture and also from herbivores and its succulent stem store water which helps it in drought condition.

Acanthocereus tetragonus consist morphology of columnar, upright steam with triangular ribs, spines that contain small areoles and large white flower. In favorable environmental condition it grows up to maximum 2 m to 7 m in height. It's also known as ornamental plants in garden and indoors due to its unique structure.

In recent dates because of its phytochemical constituent and health profit in research is mostly active. It's mainly contains alkaloids, flavonoids, phenolic compounds glycosides tannins, and saponins. This compound has anti-oxidant, anti-microbial, anti-inflammatory, anti-ulcer, anti-diabetic, anti-obesity, and anti-cancer, *Acanthocereus tetragonus* plant shows phenolic compounds it helps to nullify free radicals and prevent biological system. Oxidative stress responsible for various inflammatory disorders. More amounts of reactive oxygen species may affect the cellular compounds like proteins, lipids and DNA, which leads to tissue damage and inflammation. A medicinal plant contains natural antioxidants which help to remove the free radicals and reduces the oxidative degradation, and modulating inflammation.

Hydro-methanolic and ethylacetate extracts of *Acanthocereus tetragonus* shows antioxidant activity in tests like DPPH and FRAP. The phenolic and flavonoid compounds provide antioxidant property which is responsible for inhibition of enzyme that causes inflammation for ex, cyclooxygenase (COX) and lipoxygenase (LOX) pathways. For these actions the plant shows anti-inflammatory, analgesic, and anti-lesion activity.

In addition to these properties it shows larvicidal activity against mosquito larvae and anticancer activity against Hela cancer cell lines in lab studies. This suggests all possible uses in pest control and cancer research. The *Acanthocereus tetragonus* is studied for ecological uses. The plant has also been studied for environmental purposes. Its extracts may work as natural coagulants for treating textile wastewater, effectively removing dyes like Congo Red and Direct Blue with less sludge compared to traditional chemical coagulants.

Hidradenitis suppurativa (HS) is a chronic inflammatory skin disease characterized by painful

lesions and immune system dysfunction. While previous research has focused mainly on innate immunity, the role of antibodies—especially immunoglobulin A (IgA)—is not well understood. This study investigates how IgA antibodies are produced within skin lesions and how they contribute to inflammation, immune activation, and fibrosis. The findings suggest that IgA plays a key role in driving disease progression by interacting with multiple immune cells and promoting chronic inflammatory responses.

The current state of hydrogel-based drug delivery systems shows rapid growth fueled by the need for safer, targeted, and more effective treatment methods. Hydrogels are crosslinked networks of hydrophilic polymers. They have attracted significant interest due to their ability to absorb large amounts of water and imitate biological tissues.

2. Materials and Methods

2.1 Materials

Methanol, Carbopol 940, Methyl paraben, Propyl paraben, Glycerin, Triethanolamine, Distilled water was obtained from S.D Lab Mumbai, Research Lab Industries.

2.2 Methods

2.2.1 Collection of Plant Material

The plant material *Acanthocereus tetragonus* (L.) Hummelinck belonging to the family Cactaceae was collected for the present study. The collected plant material was cleaned properly to remove dust and other foreign particles.

2.2.2 Preparation of Plant Material

The collected plant material was washed with water to remove soil and impurities. The plant material was then shade dried at room temperature for several days until complete drying was achieved. After drying, the plant material was coarsely powdered using a mechanical grinder. The powdered plant material was stored in an airtight container for further experimental studies.

2.2.3 Extraction of Plant Material (Soxhlet Extraction)

The powdered plant material was subjected to **Soxhlet extraction** using **methanol** as the solvent.

2.2.4 Extraction Procedure

The dried powdered plant material was placed in a thimble.

↓

The thimble was placed in the Soxhlet apparatus.

↓

Methanol was used as the extraction solvent.

↓

The extraction process was carried out for several cycles until complete extraction of phytoconstituents.

↓

The methanolic extract obtained was concentrated by evaporating the solvent.

↓

The concentrated extract was stored in a suitable container for further phytochemical analysis.

2.3 Formulation of the Herbal Hydrogel

Table 1. Composition of the Herbal Hydrogel Formulation

Sr. No.	Ingredients	Quantity Taken	Role
1.	Extract (*Acanthocereus tetragonus*)	0.5 g	Anti-inflammatory

Sr. No.	Ingredients	Quantity Taken	Role
2.	Carbopol 940	0.5 g	Gelling Agent
3.	Methyl Paraben	0.08 g	Preservative
4.	Propyl Paraben	0.02 g	Preservative
5.	Glycerin	2.5 mL	Plasticizer and Humectant
6.	Triethanolamine	2-3 drops	pH Adjuster
7.	Distilled water	Quantity sufficient	Solvent

2.4 Evaluation of the Herbal Hydrogel Formulation

2.4.1 Visual Assessment

The visual assessment test examined parameters such as color, odor, state, consistency, and texture effectively.

2.4.2 Homogeneity

The gel formulation was placed in a suitable container. The homogeneity of the prepared gel was checked by visual inspection for any aggregates.

2.4.3 pH

The pH of the gel was measured using a digital pH meter. One gram of antifungal herbal gel was dissolved in 100 ml of distilled water. The glass electrode was fully immersed in the gel to ensure good contact.

2.4.4 Viscosity

The viscosity of the herbal gel was measured with a Brookfield rotational viscometer using spindle number 7. Measurements were taken at rotational speeds of 10 rpm. After allowing each sample to reach equilibrium for 2 minutes, the readings were recorded. The viscosity was measured in triplicate to ensure consistency and reliability.

2.4.5 Spreadability

The spreadability of the formulation was evaluated by determining how easily it spread on a glass surface.

2.4.6 UV-Visible Spectrophotometry

One gram of gel was dissolved in methanol, filtered, and then analyzed using a spectrophotometer.

2.4.7 Irritancy

The sample was applied to the skin and it was left for 5 minutes to check for any irritation effects.

2.4.8 Stability Study

Stability studies of the gel were conducted according to the International Conference on Harmonization (ICH) guidelines. The stability of all selected formulations was studied for three months at 40°C ± 2°C, following ICH guidelines. All selected formulations were checked for changes in appearance and pH as mentioned above.

2.4.9 In Vitro Anti-Inflammatory Activity

Reaction Setup and Incubation

In separate test tubes, mix 0.5 mL of the test sample or standard drug solution with 0.5 mL of the 1% BSA solution. For the control, mix 0.5 mL of phosphate buffer with 0.5 mL of the 1% BSA solution. Once mixed, incubate all the tubes at 37°C for 15 to 20 minutes to allow the protein and sample interaction to occur.

Denaturation and Measurement

Transfer the incubated tubes into a water bath and heat them at 70°C for 5 to 10 minutes to cause protein denaturation. After heating, remove the tubes and let them cool to room temperature.

Finally, measure the absorbance of the solutions at 660 nm using a UV-Vis spectrophotometer.

3. Results

3.1 Preliminary Phytochemical Screening

3.1.1 Extract Screening Results

Table 2. Preliminary Phytochemical Screening of *Acanthocereus tetragonus* Extract

Sr. No.	Test	Inference
1.	Alkaloids	Positive
2.	Flavonoids	Positive
3.	Saponin	Positive
4.	Tannins	Positive
5.	Glycoside	Positive
6.	Phenol	Positive
7.	Steroid	Positive
8.	Quinone	Positive
9.	Carbohydrates	Positive

3.2 Physical Evaluation

Table 3. Physical Evaluation of the Herbal Hydrogel

Sr. No.	Parameter	Result
1.	Colour	Yellowish green
2.	Odour	Odourless
3.	State	Slightly viscous
4.	Consistency	Semisolid
5.	Texture	Smooth

3.3 Homogeneity Test

Table 4. Homogeneity Test of the Herbal Hydrogel

Experiment	Result
Clarity Test	Absence of white spot and black spot

3.4 Determination of pH

Table 5. pH Determination of the Herbal Hydrogel

Experiment	Result
Digital pH Meter	7

3.5 Viscosity Measurement

Using the **Brookfield Viscometer** the viscosity of hydrogel was measured and found as per below:

Table 6. Viscosity Measurement of the Herbal Hydrogel

Sr. No.	Parameter	Value
1.	Viscosity	30,000 cP
2.	Spindle used	RV-07
3.	Speed	10 rpm
4.	Temperature	32.0 °C

3.6 Spreadability Test

The hydrogel was found easily spreadable and shows optimum spreadability.

3.7 UV-Visible Analysis

After analyzing the extract solvent on UV instrument at 400-800 nm, the absorbance of *Acanthocereus tetragonus* was found to be 0.45 AU.

This shows moderate concentration and absorbance as compared to standard range. The graph obtained in UV Instrument is as follows:

3.8 In Vitro Anti-Inflammatory Activity

The anti-inflammatory activity of the hydrogel formula was determined using the protein denaturation technique. It displayed a concentration-dependent inhibitory effect on protein denaturation, where the percentage inhibition increased from 35.66% to 57.36% for 200 µg/mL and 1000 µg/mL concentrations, respectively. The standard drug used, Diclofenac sodium, revealed greater percentage inhibition between 72.87% and 85.27%. Thus, the hydrogel

formula appears to have moderate anti-inflammatory activity and can serve as a natural anti-inflammatory agent. The formulated hydrogel exhibited satisfactory physicochemical properties including good homogeneity, smooth texture, acceptable viscosity, optimum spreadability, and skin-compatible pH, indicating its suitability for topical administration. Stability studies further confirmed that the formulation remained stable without significant changes in physical characteristics during the study period.

4. Discussion

This polyherbal formulation offers an efficient way to develop the herbal products based on the drug delivery system. The findings show that the extraction of constituents from the plant material was effective, that the formulation was stable and suitable for application on the skin and exhibited good anti-inflammatory properties with an excellent spreadability, and reasonable viscosity. The developed formulation showed sustained release of the formulation, which would reduce frequency of application and helps in efficient delivery of potent herbal actives like flavonoids and phenolic compounds to the target site. It can be concluded from the present study that it is a safe and effective topical preparation with good anti-inflammatory potential.

5. Conclusion

The in vitro anti-inflammatory activity evaluated by the protein denaturation method demonstrated that the prepared formulation possesses moderate anti-inflammatory activity in a concentration-dependent manner. The observed activity may be attributed to the presence of phenolic and flavonoid compounds, which help inhibit protein denaturation and reduce oxidative stress associated with inflammation. Although the activity was lower compared to the standard drug, the formulation showed appreciable therapeutic potential with sustained and localized drug release through the hydrogel system.

Overall, the developed polyherbal hydrogel can be considered a promising topical herbal formulation with moderate anti-inflammatory potential and good formulation characteristics. Further pharmacological, toxicological, and clinical studies are required to enhance its therapeutic efficacy and establish its applicability in advanced topical drug delivery systems.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the research, authorship, and/or publication of this article.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sector

Acknowledgements

The authors express their gratitude to all the participants who volunteered for this study, Appreciation also granted to the college administrative Adarsh College of Pharmacy, Vita, for their support.

References

1. Méndez-Figueroa HG, Ossandón S, Ramírez-Fernández JA, Galván-Martínez R, Espinoza-Vázquez A, Orozco-Cruz R. Electrochemical evaluation of an *Acanthocereus tetragonus* aqueous extract on aluminum in NaCl (0.6 M) and HCl (1 M) and its modelling using forward and inverse artificial neural networks. J Electroanal Chem. 2022;918:116444. doi:10.1016/j.jelechem.2022.116444.
2. Gómez-Hinostrosa C, Durán R, Tapia JL. *Acanthocereus tetragonus*. The IUCN Red List of Threatened Species 2017: e.T152925A119232727 [Internet]. 2017 [cited 2026 Jul 22]. Available from: https://www.iucnredlist.org/species/152925/119232727
3. Sharma P, Modi N. Investigating the qualitative and quantitative phytochemical analysis of *Acanthocereus tetragonus* (Cactaceae family) along with the antioxidant activity. Vidya J Gujarat Univ. 2023;2(1):176-182. doi:10.47413/vidya.v2i1.169.
4. Nellen W. Moment mal! Biol Unserer Zeit. 2015;45. doi:10.1002/biuz.201590026.
5. Parasuraman S, Thing GS, Dhanaraj SA. Polyherbal formulation: concept of Ayurveda. Pharmacogn Rev. 2014;8(16):73-80. doi:10.4103/0973-7847.134229.
6. Chamkouri H, Chamkouri M. A review of hydrogels, their properties and applications in medicine. Am J Biomed Sci Res. 2021;11(6):485-493. doi:10.34297/AJBSR.2021.11.001682.
7. Sakthivel M, Mohamed Halith S, Rajesh D, Ramachandiran S, Ranjani M, Rishima Riyeem M, et al. Review of hydrogel. Int J Pharm Sci Rev Res. 2024;84(11):117-120. doi:10.47583/ijpsrr.2024.v84i11.016.
8. Elsevier. Bulk polymerization: an overview [Internet]. ScienceDirect Topics; [cited 2026 Jul 22]. Available from: https://www.sciencedirect.com/topics/engineering/bulk-polymerization
9. Kumary JP. Hydrogels: synthesis and applications. J Res Med Dent Sci. 2022;10(S1):52-55.
10. Abdo JM, Sopko NA, Milner SM. The applied anatomy of human skin: a model for regeneration. Wound Med. 2020;28:100179. doi:10.1016/j.wndm.2020.100179.
11. Carmona-Rivera C, O'Neil LJ, Patino-Martinez E, Ambler WG, Mallela T, Hanata N, et al.

IgA autoantibodies promote inflammation, Th17 polarization and fibrotic responses in hidradenitis suppurativa. Nat Commun. 2026;17:4469. doi:10.1038/s41467-026-70883-5.

12. Lin X, Zhang X, Wang Y, Chen W, Zhu Z, Wang S. Hydrogels and hydrogel-based drug delivery systems for promoting refractory wound healing: applications and prospects. Int J Biol Macromol. 2025;285:138098. doi:10.1016/j.ijbiomac.2024.138098.
13. Ho TC, Chang CC, Chan HP, Chung TW, Shu CW, Chuang KP, et al. Hydrogels: properties and applications in biomedicine. Molecules. 2022;27(9):2902. doi:10.3390/molecules27092902.
14. Elsevier. Protein denaturation: an overview [Internet]. ScienceDirect Topics; [cited 2026 Jul 22]. Available from: https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/protein-denaturation
15. Tian Y, Guo J, Sun J, Zhang X, Zhou G, Ye L, et al. CD73high fibroblasts orchestrate keratinocyte inflammation in the psoriasis-associated epithelial immune microenvironment. Nat Commun. 2026;17:6932. doi:10.1038/s41467-026-71323-0.
16. Abbas K, Amin A, Mudassir J, Alzahrani AYA, Saher T, Manzoor R, et al. Preparation, characterization and evaluation of hydrogels from different fractions of diverse medicinal plants for management of pain and inflammation. Int J Food Prop. 2023;26(1):2532-2552. doi:10.1080/10942912.2023.2250572.
17. Vigata M, Meinert C, Hutmacher DW, Bock N. Hydrogels as drug delivery systems: a review of current characterization and evaluation techniques. Pharmaceutics. 2020;12(12):1188. doi:10.3390/pharmaceutics12121188.
18. Benicia MP, Bamia A. Hydrogels in drug delivery: past developments, current innovations, and future directions. J Biomed Sci Eng. 2026;19(1):30-54. doi:10.4236/jbise.2026.191005.