INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES
[ISSN: 0975-4725; CODEN(USA): IJPS00]
Journal Homepage: https://www.ijpsjournal.com

OPEN ACCESS

Research Study

Formulation and Evaluation of a Polyherbal Topical Gel Containing *Camellia sinensis*, *Boswellia serrata*, and *Glycyrrhiza glabra* for Anti-inflammatory Activity

Shivangi Gupta*, Megha Parashar

Sagar Institute of Research and Technology – Pharmacy, Sanjeev Agrawal Global Educational University, Bhopal, Madhya Pradesh, India

ARTICLE INFO

Published: 18 May 2025
Keywords:
Polyherbal gel, Camellia sinensis, Boswellia serrata, Glycyrrhiza glabra, anti-inflammatory, topical formulation
DOI:
10.5281/zenodo.15453475

ABSTRACT

The present study focuses on the formulation and evaluation of a polyherbal topical gel incorporating extracts of Camellia sinensis, Boswellia serrata, and Glycyrrhiza glabra, known for their anti-inflammatory and antioxidant properties. Phytochemical analysis confirmed the presence of key bioactive compounds such as flavonoids, tannins, saponins, terpenoids, and polyphenols. Six formulations (CSBSGG-1 to CSBSGG-6) were prepared and evaluated for physicochemical parameters including pH, spreadability, viscosity, and extrudability. Among them, CSBSGG-6 demonstrated optimal characteristics with a pH of 6.17, spreadability of 55 mm, extrudability of 89%, and viscosity of 4500 cp. In-vitro drug diffusion studies showed enhanced release for CSBSGG-6, comparable to marketed Diclofenac sodium gel. Rheological analysis confirmed thixotropic and thermoresponsive behavior, supporting its suitability for topical application. The formulation exhibited significant in-vitro anti-inflammatory activity with 86.27% inhibition of protein denaturation, closely matching the 88.63% inhibition shown by Diclofenac. In vivo studies using the carrageenan-induced rat paw edema model further validated its efficacy. Chronic dermal toxicity evaluation revealed only mild, transient erythema with a Primary Dermal Irritation Index (PDII) of 1.0, indicating the formulation is safe for prolonged dermal use. These findings suggest that CSBSGG-6 is a stable, effective, and safe natural alternative to conventional topical anti-inflammatory agents.

INTRODUCTION

Inflammation is a complex and essential physiological response to tissue injury, infection,

***Corresponding Author:** Shivangi Gupta
Address: *Sagar Institute of Research and Technology – Pharmacy, Sanjeev Agrawal Global Educational University, Bhopal, Madhya Pradesh, India*
Email ✉: sakshigupta3747@gmail.com
Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

or irritation. While acute inflammation serves a protective role, chronic inflammation is implicated in a wide array of diseases, including arthritis, dermatitis, and various musculoskeletal disorders. Standard pharmaceutical anti-inflammatory treatments, although effective, often come with undesirable side effects when used long-term. This concern has driven significant interest in herbal alternatives that are both effective and safer for prolonged use. [1, 2, 3] Polyherbal formulations, which combine multiple plant-based extracts, are gaining popularity for their synergistic therapeutic effects and lower side effect profiles. In this context, the present research aims to formulate and evaluate a polyherbal topical gel incorporating *Camellia sinensis* (green tea), *Boswellia serrata* (Indian frankincense), and *Glycyrrhiza glabra* (licorice)—each known for their distinct yet complementary anti-inflammatory properties.[20] *Camellia sinensis* is rich in epigallocatechin-3-gallate (EGCG), a powerful antioxidant that inhibits pro-inflammatory cytokines and downregulates COX-2 expression and NF-κB activation. *Boswellia serrata* contains boswellic acids, which are known inhibitors of 5-lipoxygenase, reducing leukotriene-mediated inflammation. *Glycyrrhiza glabra* possesses glycyrrhizin and liquiritin, compounds with corticosteroid-like effects that help in reducing skin irritation and supporting wound healing. [4, 5, 6] The formulation of these herbs into a topical gel is advantageous due to its ability to deliver active constituents directly to the site of inflammation, ensuring localized action with minimal systemic exposure. The gel form enhances bioavailability, ease of application, and patient compliance, making it a suitable alternative to conventional treatments.[7] This study is therefore designed with the following objectives: to screen the phytochemical constituents of the selected herbal extracts, formulate a stable gel using suitable excipients, evaluate its physicochemical and rheological properties, and assess its in vitro anti-inflammatory efficacy in comparison with a standard drug. By combining traditional knowledge with modern pharmaceutical techniques, this research aims to offer a natural, effective, and patient-friendly alternative for managing inflammatory conditions.[8]

MATERIALS AND METHODS:

Collection of Plant Material and Chemicals

The leaves of *Camellia sinensis* and *Boswellia serrata* were collected from the tea gardens of Palampur, Kangra, Himachal Pradesh, and the local market of Bhopal, respectively. The aerial parts of *Glycyrrhiza glabra* were also sourced from Bhopal's local market. All plant materials were authenticated prior to use. Chemicals and reagents, including Carbopol 940, Propylene glycol, Ethanol, Methyl paraben, Propyl paraben, EDTA, and other analytical grade reagents were procured from Central Drug House (P) Ltd., Alpha Chemika, Changshu Hongsheng Fine Chemical Co. Ltd., and other certified suppliers.

Preparation of Plant Extracts

Dried plant materials were coarsely powdered and defatted using petroleum ether (60–80°C) in a Soxhlet apparatus. The defatted residues were then extracted with methanol. The extracts were concentrated via distillation and stored in desiccators until use.

Formulation of Polyherbal Gel

Polyherbal gels (CSBSGG-1 to CSBSGG-6) were prepared using Carbopol-940 as the gelling agent, along with Propylene glycol, Ethanol, Methyl and Propyl parabens, and EDTA. Extract concentrations ranged from 1% to 10%. A gel of Diclofenac sodium (0.5%) was used as the standard. Composition details are listed in Table 1. [9-15]

TABLE 1: Composition Of Polyherbal Gel

Formulation Batch	Extract (%)	Carbapol-940 (%)	Propylene glycol (%)	Ethanol (%)	Methyl paraben (%)	Propyl paraben (%)	EDTA (%)
CSBSGG-1	1	1	4	3	0.2	0.02	0.03
CSBSGG-2	2	2	4	3	0.2	0.02	0.03
CSBSGG-3	4	3	4	3	0.2	0.02	0.03
CSBSGG-4	6	1	3	3	0.2	0.02	0.03
CSBSGG-5	8	2	3	3	0.2	0.02	0.03
CSBSGG-6	10	3	3	3	0.2	0.02	0.03

***CSBSGG: Combination of methanolic extract of Boswellia serrata, Camellia sinensis and Glycyrrhiza glabra**

Evaluation of Gel Formulations

pH: Measured using a digital pH meter.[16]

Appearance & Homogeneity: Assessed visually. [17]

Spreadability: Measured by the diameter of gel spread under a standard weight. [18]
Extrudability: Evaluated by extruding gel from aluminium tubes and calculating percentage output. [19, 20]

Viscosity: Measured using a Brookfield viscometer (Model RVTDV II) with spindle no. 6 at 100 rpm. [21]

In-vitro Diffusion Study: Conducted using a cellophane membrane diffusion setup in phosphate buffer (pH 6.8) at 37 ± 0.5°C. Samples were analysed using UV-VIS spectrophotometry. [22, 23]

In-vitro Anti-inflammatory Activity

Protein denaturation inhibition method was used to evaluate anti-inflammatory activity. Egg albumin was mixed with phosphate buffer and various concentrations of gel, and absorbance was recorded at 660 nm post incubation and heating. [24, 25]

In-vivo Anti-inflammatory Activity

Animals: Wistar rats (150–200 g) were maintained under standard laboratory conditions. Ethical approval was obtained from the Institutional Animal Ethics Committee (Approval No. 648/02/6/CPCSEA). Carrageenan-induced Paw Edema: Inflammation was induced via subplantar injection of 0.1 mL carrageenan (1% w/v). Gels were applied topically 1 hour before induction. Paw thickness was measured at 0, 30, 60, 120, 180, 240, and 300 minutes using a digital vernier caliper. [26, 27]

RESULT AND DISCUSSION

Evaluation of Polyherbal Gel

All gel formulations demonstrated satisfactory physical properties, as summarized in Tables 2 and 8. Among all, CSBSGG-6 emerged as the optimal formulation with a favourable pH (6.17), excellent homogeneity, light green colour, and high spreadability (55 mm), indicating ease of application. Its extrudability (89%) and viscosity (4500 cp) were within ideal ranges for topical delivery. The formulation showed performance metrics closely matching the standard Diclofenac gel (0.5%), which had a pH of 6.15, spreadability of 59 mm, extrudability of 92%, and viscosity of 4600 cp.

Table 2: Evaluation Parameters of Prepared Polyherbal Gels

Formulation Batch	pH	Appearance	Homogeneity	Spreading diameter after 1 min (mm) V	Extrudability %	Viscosity (cp)
CSBSGG-1	6.14	Light Green	Good	38	83	4800
CSBSGG-2	6.38	Light Green	Good	41	81	4500
CSBSGG-3	6.21	Light Green	Good	43	79	4600
CSBSGG-4	6.39	Light Green	Good	49	74	4700
CSBSGG-5	6.19	Light Green	Good	47	83	4900
CSBSGG-6	6.17	Light Green	Good	55	89	4500
Diclofenac gel	6.15	White	Good	59	92	4600

In-vitro Diffusion Study

The in-vitro diffusion studies revealed that drug release was inversely proportional to the concentration of Carbopol-940 used as the gelling agent. CSBSGG-6 exhibited the highest drug release among the test formulations, comparable to the marketed Diclofenac gel. This suggests optimized release characteristics likely due to balanced viscosity and excipient composition.

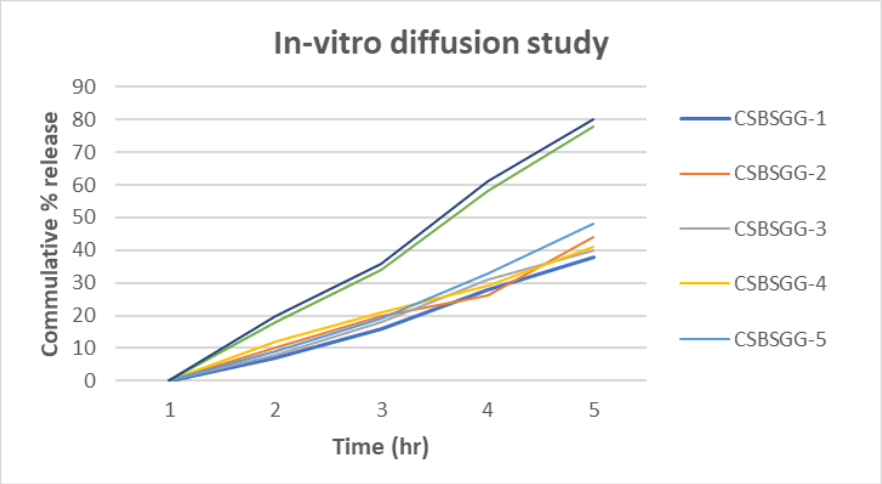


Fig 1: In-vitro diffusion study of polyherbal gel (CSBSGG-1 to CSBSGG-6) compared with marketed formulation

In-vitro Anti-inflammatory Activity

The CSBSGG-6 formulation exhibited a concentration-dependent inhibition of protein denaturation. At 50 µg/mL, it achieved an 86.27% inhibition rate, closely approaching that of Diclofenac sodium (88.63%). This confirms the gel's strong potential to counteract inflammatory protein denaturation pathways in vitro.

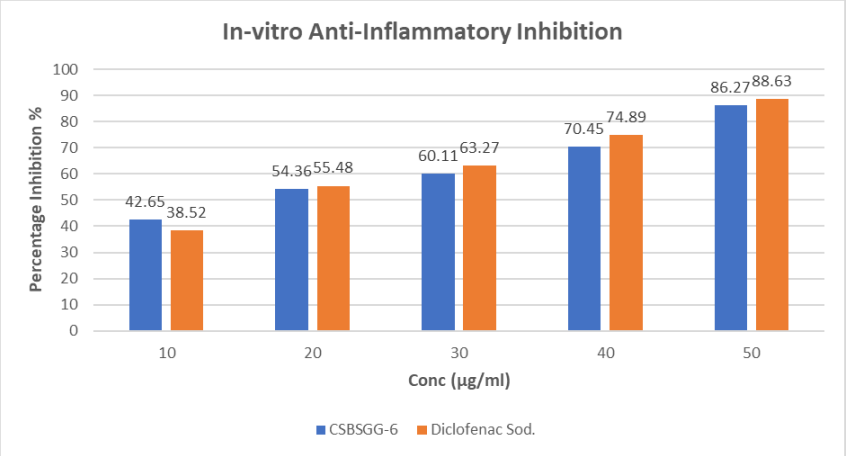


Fig 2: Effect of polyherbal formulation (CSBSGG-6) on heat induced protein denaturation

Chronic Dermal Toxicity Study

In vivo irritation testing in rats indicated that the herbal gel was well-tolerated. Only minor erythema was observed in two animals at early time points (PDII = 1.0), which resolved within 48 hours. No edema or severe irritation was recorded. This suggests the polyherbal gel is safe for chronic dermal application with negligible irritation.

In-vivo Anti-inflammatory Activity (Carrageenan-Induced Paw Edema)

Topical application of CSBSGG-6 significantly reduced carrageenan-induced paw edema in rats. The gel demonstrated anti-inflammatory effects comparable to the standard Diclofenac formulation across both early and late inflammatory phases. These results validate the polyherbal gel's efficacy in modulating inflammation mediated by histamine, bradykinin, and prostaglandins.

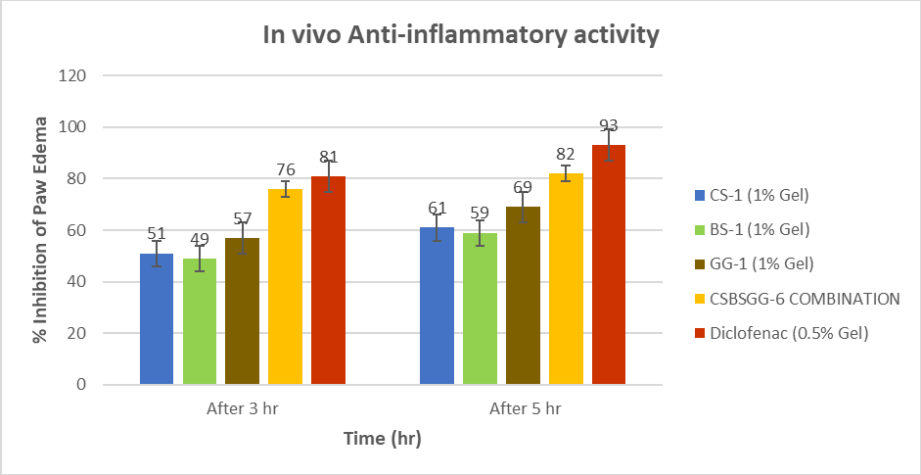


Fig 3: Anti-inflammatory effect of topical application of single extract gels and polyherbal gels in combination on the first phase and late phase of carrageenan-induced paw edema in rat.

The results showed that the anti-inflammatory effect of the combination formulation CSBSGG-6

applied showed equivalent to the effect of standard gel formulation**.**

CONCLUSION

The polyherbal gel formulation CSBSGG-6, developed using extracts of *Camellia sinensis*, *Boswellia serrata*, and *Glycyrrhiza glabra*, demonstrated optimal physicochemical characteristics including suitable pH, good homogeneity, high spreadability, and acceptable viscosity. It showed superior in-vitro drug release compared to other formulations and exhibited rheological behavior favorable for topical application. Pharmacological evaluations confirmed significant anti-inflammatory activity, comparable to Diclofenac sodium gel, in both in-vitro and in-vivo models. Additionally, chronic toxicity studies indicated minimal irritation, supporting its safety for dermal use. Overall, CSBSGG-6 presents a promising natural alternative to conventional topical anti-inflammatory agents.

REFERENCES

1. Abdulkhaleq LA, Assi MA, Abdullah R, Zamri-Saad M, Taufiq-Yap YH, Hezmee MN. The crucial roles of inflammatory mediators in inflammation: A review. Veterinary world. 2018 May;11(5):627.
2. Mack M. Inflammation and fibrosis. Matrix Biology. 2018 Aug 1;68:106-21.
3. Chen L, Deng H, Cui H, Fang J, Zuo Z, Deng J, Li Y, Wang X, Zhao L. Inflammatory responses and inflammation-associated diseases in organs. Oncotarget. 2018 Jan 23;9(6):7204-7218
4. Yang F et al. Green tea polyphenols block endotoxin-induced tumor necrosis factor-alpha production. J Nutr Biochem. 1998;9(10):595–603.
5. Singh BN et al. Green tea catechin, epigallocatechin-3-gallate (EGCG): mechanisms, perspectives and clinical applications. Biochem Pharmacol. 2011;82(12):1807–1821.
6. Yamada K et al. Topical application of green tea extract enhances skin barrier function. J Dermatol Sci. 2006;42(2):150–152.
7. Yuan H et al. Synergistic effects of herbal extracts: mechanisms and clinical applications. Evid Based Complement Alternat Med. 2016;2016:5283459.
8. Benson HA. Transdermal drug delivery: penetration enhancement techniques. Curr Drug Deliv. 2005;2(1):23–33.
9. Kaur LP, Garg R, Gupta GD.: Development and evaluation of topical gel of minoxidil from different polymer bases in application of alopecia. Int J Pharmacy and Pharm Sci 2010; 2(3): 43-47.
10. Bele AA, Jadhav VM, Kadam VJ.: Formulation and evaluation of Herbal Drug. Drug Invention Today 2010; 2(7): 369-372.
11. Gupta A, Mishra AK, Singh AK, Gupta V, Bansal P.: Formulation and evaluation of topical gel of diclofenac sodium using different polymers. Drug Invention Today 2010; 2(5): 250-253.
12. Shivhare UD, Jain KB, Mathur VB, Bhusari KP, Roy AA, Formulation development and evaluation of diclofenac sodium gel using water soluble polyacrylamide polymer. Digest J. of Nanomaterials and Biostructures 2009; 4(2): 285-290.
13. Das MK, Ahmed AB.: Formulation and ex-vivo evaluation of Rofecoxib gel for topical application. Acta Poloniae Pharmaceutica. Drug Research 2007; 63: 5: 461-467.
14. Osborne DW, Amann AH.: Topical Drug Delivery Formulation. Marcel Dekker Inc. New York vol-42 381-388.

15. Queiroz, M.B.R.; Marcelino, N.B.; Ribeiro, M.V.; Espindola, L.S.; Cunha, F.; Silva, M.V. (2009).Development of gel with Matricaria recutita L. extract for topic application and evaluation of physical-chemical stability and toxicity. Lat. Am. J. Pharm.; 28(4): 574-579.
16. Rajan R., Vasudevan D. (2012). Effect of permeation enhancers on the penetration mechanism of transfersomal gel of ketoconazole. J. Adv. Pharma. Tech. Res.;3(7):112-116.
17. Cui H, Quan P, Zhou Z, Fang L. (2016). Development of a drug-in-adhesive patch combining ion pair and chemical enhancer strategy for topical delivery of zaltoprofen: pharmacokinetic, pharmacodynamic and in vitro/in vivo correlation evaluation. Drug Deliv. ; 23(9):3461-3470.
18. Sudipta D, Haldar PK, Pramanik G. (2011). Formulation and evaluation of herbal gel containing Clerodendrum infortunatum leaves extract. Int J Pharmtech Res. 3:140-3.
19. Giri MA, Bhalke RD.(2019). Formulation and Evaluation of Topical Anti-Inflammatory Herbal Gel. Asian J Pharm Clin Res. 12(7): 252-255
20. Mulani H., Bhise K. (2017).QbD Approach in the formulation and evaluation of Miconazole nitrate loaded ethosomal cream -o-gel. Int. Res. J. Pharm. Sci.8:1-37.
21. Rajasekaran Aiyalu, Arulkumaran Govindarjan, Arivukkarasu Ramasamy. (2016). Formulation and evaluation of topical herbal gel for the treatment of arthritis in animal model. Brazilian Journal of Pharmaceutical Sciences.52(3): 493-507.
22. Susheel Thakur, Nisha Thakur, Niladry Shekar Ghosh. (2016). Formulation and in-vitro evaluation of Polyherbal Micro-emulgel containing Tinospora cordifolia and Curcumin for treatment of Arthritis. International Journal of Pharmaceutical Sciences and Drug Research. 8(5): 259-264.
23. Priscilla R. Varges, Camila M. Costa, Bruno S. Fonseca, Mônica F. Naccache and Paulo R. de Souza Mendes. (2019). Rheological Characterization of Carbopol® Dispersions in Water and in Water/Glycerol Solutions. Fluids. 4, 3.
24. Sakat S, Juvekar AR, Gambhire MN. (2010). In vitro antioxidant and anti-inflammatory activity of methanol extract of Oxalis corniculata Linn. Int J Pharma and Pharmacol Sci. 2(1): 146-155.
25. Gautam RK, Sharma S and Sharma K: (2013). Comparative evaluation of anti-arthritic activity of Pongamia pinnata (Linn.) Pierre and Punica granatum An in-vitro study. International Journal of Pharmacy and Pharmaceutical Sciences. 5(4): 721-724.
26. Mahaveer, G. Bronchoprotective, bronchodialatory and antiinflammatory activity of ethanolic extract of Woodfordia fruticosa (Kurz) flowers. IJPE, 2012, 46, 161-178.
27. Chen, Y.; Yang, L.; Lee, T.J.F. Oroxylin A inhibition of lipopolysaccharide-induced iNOS and COX-2 gene expression via suppression of nuclear factor-κB activation. Biochem. Pharmacol., 2000, 59, 144-1457.

HOW TO CITE: Shivangi Gupta*, Megha Parashar, Formulation and Evaluation of a Polyherbal Topical Gel Containing Camellia sinensis, Boswellia serrata, and Glycyrrhiza glabra for Anti-inflammatory Activity, Int. J. of Pharm. Sci., 2025, Vol 3, Issue 5, 2960-2966. https://doi.org/10.5281/zenodo.15453475