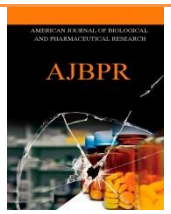
e- ISSN - 2348-2184
Print ISSN - 2348-2176

AMERICAN JOURNAL OF BIOLOGICAL AND PHARMACEUTICAL RESEARCH

Journal homepage: www.mcmed.us/journal/ajbpr



FORMULATION AND EVALUATION OF A HERBAL TOPICAL GEL CONTAINING ANTI-INFLAMMATORY PLANT EXTRACTS

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Article Info

Received 25/04/2026
Revised 19/05/2026
Accepted 12/06/2026

Key words: -
Herbal gel; anti-inflammatory; Carbopol; HPMC; topical drug delivery; phytochemicals

ABSTRACT

Background: Topical herbal formulations offer a safe, patient-acceptable route for managing localised inflammation while avoiding the gastrointestinal toxicity of systemic non-steroidal agents. This study aimed to formulate and evaluate a polyherbal topical gel combining the anti-inflammatory extracts of Aloe vera, turmeric, neem, tulsi and hibiscus. Methods: Plant extracts were prepared and screened phytochemically. Five gels (F1-F5) were formulated using Carbopol 934 and HPMC as gelling agents at varying concentrations, with propylene glycol, parabens and triethanolamine. Gels were evaluated for pH, viscosity, spreadability, extrudability, homogeneity, drug content, in-vitro diffusion/release and accelerated stability. Results: Phytochemical screening confirmed flavonoids, tannins, phenolics, alkaloids and saponins. The gels had skin-compatible pH (5.6-6.7), viscosity 4200-6700 cP, spreadability 13.1-18.5 g.cm/s and drug content 96.2-99.2%. Drug release decreased as polymer concentration increased (95% to 75% at 8 h across F1-F5). F3 provided the best balance of viscosity, spreadability, controlled release and content uniformity, and remained physicochemically stable for three months. Conclusion: A stable, effective polyherbal anti-inflammatory gel was developed; F3 was the optimised formulation, supporting natural-polymer gels as a viable topical delivery platform.

INTRODUCTION

Inflammation is a protective physiological response, but when persistent it underlies pain, swelling and tissue damage in conditions such as arthritis, sprains and dermatological disorders. Conventional systemic non-steroidal anti-inflammatory drugs are effective but carry well-recognised gastrointestinal, renal and cardiovascular risks on prolonged use. Topical delivery localises drug action at the site of inflammation, minimises systemic exposure and improves patient acceptability, making it an attractive route for anti-inflammatory therapy.

Medicinal plants have long been used to relieve inflammation, and several common species possess scientifically supported activity. Aloe vera, turmeric (curcuminoids), neem, tulsi and hibiscus are each rich in flavonoids, tannins and phenolic compounds that exert anti-inflammatory and antioxidant effects through inhibition of inflammatory mediators and scavenging of reactive species. Combining such extracts in a single formulation can provide complementary, multi-target activity while retaining the favourable safety profile of botanical actives.

Gels are a preferred topical vehicle because of their high-water content, ease of application, non-greasy feel, good spreadability and cooling sensation, which together promote patient compliance. The performance of a gel - its consistency, spreadability and drug-release behaviour - is governed by the type and concentration of the gelling agent. Carbopol 934 forms clear, high-viscosity

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gels at low concentration, while HPMC provides film-forming and release-modulating properties; their combination allows the rheology and release rate to be tuned. The present study was therefore undertaken to formulate a polyherbal topical gel containing five anti-inflammatory extracts, to evaluate its physicochemical and release characteristics across a range of polymer concentrations, and to identify an optimised, stable formulation.

MATERIALS AND METHODS

Plant material and extraction

Authenticated Aloe vera, turmeric, neem, tulsi and hibiscus were collected, dried and powdered, and extracts were prepared by appropriate solvent extraction. Preliminary phytochemical screening was performed using standard qualitative tests to detect alkaloids, flavonoids, tannins, saponins and phenolics.

Formulation of herbal gels

Five gels (F1-F5) were prepared (Table 1). Carbopol 934 was dispersed in purified water and hydrated; HPMC was added; the herbal extracts, propylene glycol (humectant/penetration enhancer) and preservatives (methyl and propyl paraben) were incorporated; and the dispersion was neutralised with triethanolamine to form a smooth gel. The Carbopol and HPMC concentrations were varied to study their effect on gel properties.

Table 1: Composition of the herbal topical gel formulations.

Ingredient	F1	F2	F3	F4	F5
Aloe vera / Turmeric / Neem / Tulsi / Hibiscus (each, g)	1.0	1.0	1.0	1.0	1.0
Carbopol 934 (g)	0.5	1.0	1.5	1.0	1.5
HPMC (g)	0.5	0.5	0.5	1.0	1.0
Propylene glycol (g)	10	10	10	10	10
Methyl/propyl paraben (g)	0.2/0.02	0.2/0.02	0.2/0.02	0.2/0.02	0.2/0.02
Triethanolamine (g)	0.5	0.5	0.5	0.5	0.5
Purified water	q.s. 100 g	q.s. 100 g	q.s. 100 g	q.s. 100 g	q.s. 100 g

Evaluation

Gels were evaluated for appearance and homogeneity, pH (digital pH meter), viscosity (rotational viscometer), spreadability (parallel-plate method), extrudability (from a collapsible tube), and drug content. In-vitro drug release/diffusion was studied across a membrane over 8 h, and the optimised formulation underwent accelerated stability testing (pH, viscosity, drug content and appearance) over three months.

RESULTS

Phytochemical screening

Qualitative screening confirmed the presence of alkaloids, flavonoids, tannins and phenolics in all five extracts, with saponins present in all except turmeric (Table 2). Flavonoids, tannins and phenolics are the constituents most associated with anti-inflammatory and antioxidant activity, supporting the therapeutic rationale of the blend.

Table 2: Preliminary phytochemical screening of the plant extracts (+ present, - absent).

Phytoconstituent	Aloe vera	Turmeric	Neem	Tulsi	Hibiscus
Alkaloids	+	+	+	+	+
Flavonoids	+	+	+	+	+
Tannins	+	+	+	+	+
Saponins	+	-	+	+	+
Phenolics	+	+	+	+	+

Physicochemical evaluation

All gels were smooth, homogeneous and skin-compatible. pH ranged from 5.6 to 6.7, within the acceptable range for topical application and unlikely to cause irritation (Table 3). Viscosity increased with polymer concentration (4200-6700 cP), while spreadability showed the inverse trend (18.5 down to 13.1 g.cm/s), as expected for more viscous gels. Extrudability improved with polymer content, and drug content was high and uniform across all formulations (96.2-99.2%).

Table 3: Physicochemical properties of the herbal gels.

Formulation	pH	Viscosity (cP)	Spreadability (g.cm/s)	Extrudability (g)	Drug content (%)
F1	5.6	4200	18.5	480	96.2

F2	5.8	5100	16.2	520	97.5
F3	6.2	6200	14.0	580	98.8
F4	6.5	5800	15.2	550	98.1
F5	6.7	6700	13.1	600	99.2

In-vitro drug release and stability

Drug release over 8 h declined with increasing polymer concentration, from 95% (F1) to 75% (F5) (Table 4, Figure 1), confirming that the gelling agents act as matrix-forming, release-controlling components. F3 provided a desirable balance of moderate viscosity, good spreadability and controlled release. Accelerated stability testing of the optimised formulation (F3) showed negligible change in pH, viscosity and drug content and no change in appearance over three months (Table 5), indicating good physicochemical stability.

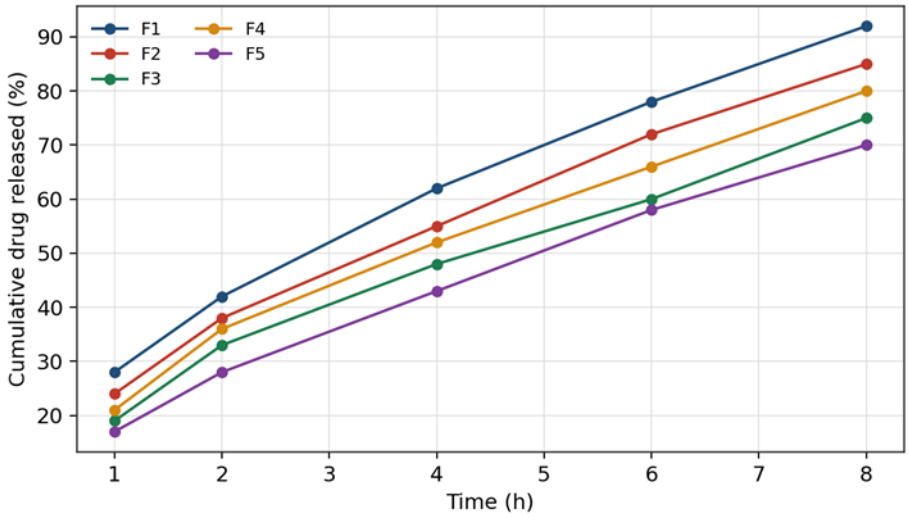

Figure 1: In-vitro cumulative drug release from herbal gel formulations F1-F5 over 8 h.

Table 4: In-vitro cumulative drug release (%) from the herbal gels.

Time (h)	F1	F2	F3	F4	F5
1	30	25	20	22	18
2	45	40	35	38	30
4	65	60	50	55	45
6	80	75	65	70	60
8	95	90	80	85	75

Table 5: Accelerated stability data for the optimised formulation (F3).

Parameter	Initial	1 month	3 months
pH	6.2	6.3	6.3
Viscosity (cP)	6200	6150	6100
Drug content (%)	98.8	98.5	98.2
Appearance	Smooth	No change	No change

DISCUSSION

The phytochemical profile of the extracts underpins the therapeutic rationale of the formulation. Flavonoids, tannins and phenolic compounds are well documented to suppress inflammatory mediators and to scavenge reactive oxygen species; their consistent presence across the five extracts supports a complementary, multi-constituent anti-inflammatory action that may be superior to any single botanical.

The physicochemical results demonstrate that the gels are suitable for cutaneous use. The slightly acidic to near-neutral pH matches that of healthy skin and minimises the risk of irritation, while the measured viscosity and spreadability indicate products that are firm enough to remain at the application site yet soft enough to spread

easily. The reciprocal relationship between viscosity and spreadability, and the parallel rise in extrudability with polymer content, are consistent with the known rheological behaviour of Carbopol-HPMC systems.

The drug-release data reveal that the gelling agents also govern release rate: higher polymer concentrations produced denser networks that retarded diffusion of the actives, reducing 8 h release. This allows the release profile to be engineered through polymer selection. Formulation F3, with intermediate polymer content, achieved the best compromise between adequate consistency, easy application, controlled release and high content uniformity, and was therefore selected as optimised. Its retention of pH, viscosity and drug content over three months confirms that the formulation is physicochemically stable under accelerated conditions, an essential requirement for shelf life.

The principal limitations are that anti-inflammatory efficacy was inferred from phytochemical composition and in-vitro release rather than demonstrated pharmacologically, and that skin-irritation and in-vivo efficacy studies were not performed. Future work should include quantification of marker constituents, in-vivo anti-inflammatory and dermal-safety evaluation, and longer-term real-time stability.

CONCLUSION

A stable polyherbal topical gel containing Aloe vera, turmeric, neem, tulsi and hibiscus extracts was successfully formulated and evaluated. Phytochemical screening confirmed anti-inflammatory constituents, and all formulations showed acceptable pH, homogeneity, viscosity, spreadability and drug content. Drug release was controlled by the gelling-agent concentration, and the intermediate-polymer formulation F3 provided the optimal balance of rheology, release and stability. Herbal gels prepared with natural and semi-synthetic polymers thus represent an effective, patient-friendly alternative for topical management of inflammation, meriting further in-vivo and safety evaluation.

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