

Development and Evaluation of Mimusops elengi Flower Extract Loaded Microsponge Gel

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Abstract - Microsponge technology represents a novel drug delivery approach that allows controlled release of active ingredients while minimising skin irritation and improving patient compliance, making it particularly suitable for topical herbal formulations. *Mimusops elengi* (Bakul), a medicinal plant traditionally used for its anti-inflammatory, antimicrobial, antioxidant and wound-healing properties, contains flowers rich in flavonoids, tannins and saponins with proven therapeutic potential. However, direct topical application of plant extracts is often limited by poor stability, rapid degradation and lack of sustained release. The present study was undertaken to develop and evaluate a microsponge-based gel loaded with *Mimusops elengi* flower extract in order to achieve controlled release and enhanced skin retention of the active constituents. Microsponges were prepared by the quasi-emulsion solvent diffusion method using Eudragit RS100 as the rate-controlling polymer, and the prepared microsponges were incorporated into a Carbopol 934-based gel base. The formulated batches (MS1-MS4) were evaluated for production yield, particle size, entrapment efficiency, drug content and surface morphology, while the resulting gel formulations were evaluated for pH, viscosity, spreadability, drug content, in vitro drug release and stability. The results demonstrate that *Mimusops elengi* flower extract can be successfully incorporated into a microsponge drug delivery system to achieve a stable, controlled-release topical gel formulation with potential application in the management of skin disorders.

Key Words: *Mimusops elengi*, Microsponge, Quasi-emulsion solvent diffusion, Topical gel, Controlled release, Herbal drug delivery.

1. INTRODUCTION

Topical drug delivery is one of the most widely explored routes for the local and systemic administration of therapeutic agents, offering advantages such as avoidance of first-pass metabolism, ease of application and improved patient compliance. However, conventional topical formulations such as creams and ointments are often associated with limitations including poor retention time, frequent dosing, skin irritation at higher concentrations, and lack of control over drug release. Microsponge drug delivery systems have emerged as a promising alternative, consisting of porous, polymeric microspheres capable of entrapping a wide variety of active ingredients and releasing them in a controlled manner over an extended period, in response to triggers such as rubbing, temperature or pH. This not only improves the stability and efficacy of the entrapped drug but also minimises systemic absorption and associated side effects, making microsponges particularly suitable for topical delivery of sensitive phytoconstituents.

Mimusops elengi Linn. (family Sapotaceae), commonly known as Bakul, is a medicinal plant traditionally used in Ayurveda for the treatment of various ailments. The flowers of *Mimusops elengi* are reported to possess significant

antioxidant, anti-inflammatory, antimicrobial and wound-healing activities, attributed to the presence of flavonoids, tannins, saponins and triterpenoids. Despite this therapeutic potential, the direct topical application of *Mimusops elengi* flower extract is limited by factors such as poor skin permeability, rapid oxidative degradation of active constituents and lack of sustained therapeutic action.

In view of the above, the present study was designed with the objective of developing microsponges loaded with *Mimusops elengi* flower extract by the quasi-emulsion solvent diffusion method, incorporating the optimised microsponges into a suitable gel base, and evaluating the developed formulations for their physicochemical characteristics, drug entrapment, in vitro drug release and stability, with a view to developing a stable, controlled-release herbal topical formulation.

2. MATERIALS AND METHODS

2.1 Materials

Fresh flowers of *Mimusops elengi* were collected from [local source/botanical garden, City] and authenticated from [Botany Department/institution name]. Eudragit RS100, Carbopol 934, polyvinyl alcohol (PVA), dichloromethane, triethanolamine and other chemicals used were procured from [supplier name] and were of analytical/laboratory grade.

2.2 Preparation of *Mimusops elengi* Flower Extract

The collected flowers were shade-dried, coarsely powdered and subjected to extraction using [Soxhlet extraction/maceration] with [ethanol/hydroalcoholic solvent] as the solvent for [X] hours. The extract obtained was filtered, concentrated under reduced pressure using a rotary vacuum evaporator, and the dried extract was stored in an airtight container at [2-8°C] until further use. The percentage yield of the extract was calculated and preliminary phytochemical screening was carried out to confirm the presence of flavonoids, tannins, saponins and other phytoconstituents.

2.3 Preparation of *Mimusops elengi* Loaded Microsponges

Microsponges were prepared by the quasi-emulsion solvent diffusion method. The internal phase was prepared by dissolving Eudragit RS100 in a mixture of ethanol and dichloromethane, followed by dispersion of the *Mimusops elengi* flower extract in this polymer solution with continuous stirring. This internal phase was then slowly added to the external aqueous phase containing polyvinyl alcohol (PVA) as a stabiliser, under continuous mechanical stirring at [X] rpm for [X] hours at room temperature to allow complete evaporation of the organic solvent and formation of discrete microsponges. The formed microsponges were collected by filtration, washed with distilled water to remove residual PVA, and dried at room temperature. Four batches (MS1-MS4) were prepared by varying the drug-to-polymer ratio, as shown in Table 1.

Table 1: Composition of *Mimusops elengi* Loaded Microsponge Batches (MS1-MS4)

Ingredients	MS1	MS2	MS3	MS4
<i>Mimusops elengi</i> flower extract (mg)	100	100	100	100
Eudragit RS100 (drug:polymer ratio)	1:1	1:2	1:3	1:4
Dichloromethane : Ethanol (mL)	10:10	10:10	10:10	10:10
PVA (% w/v in external phase)	0.5	0.5	0.5	0.5
Distilled water (external phase, mL)	100	100	100	100
Stirring speed / time	[X rpm/X h]	[X rpm/X h]	[X rpm/X h]	[X rpm/X h]

2.4 Evaluation of Microsponges

- Production yield - calculated as the percentage ratio of the practical yield of dried microsponges to the theoretical yield (total weight of drug and polymer used).

- Particle size analysis - determined using an optical microscope fitted with a calibrated ocular micrometer, or by laser diffraction particle size analyser.
- Surface morphology - studied using scanning electron microscopy (SEM) to assess shape, surface texture and porosity of the microsponges.
- Drug entrapment efficiency - determined by dissolving a known quantity of microsponges in a suitable solvent, followed by estimation of drug content using UV-Visible spectrophotometry at the predetermined wavelength (λ_{max}).
- Micromeritic properties - bulk density, tapped density, Carr's index, Hausner's ratio and angle of repose were determined to assess flow properties.

2.5 Formulation of Microsponge-Loaded Gel

The optimised microsponge batch (selected on the basis of highest entrapment efficiency and desirable particle size/yield) was incorporated into a Carbopol 934-based gel. Carbopol 934 was dispersed in distilled water and allowed to hydrate for [X] hours, followed by neutralisation with triethanolamine dropwise with continuous stirring until a clear, homogeneous gel base was obtained. The optimised microsponges, equivalent to [X mg] of Mimusops elengi extract, were then incorporated into the gel base with gentle mixing to avoid disruption of the microsponge structure.

2.6 Evaluation of Microsponge Gel

- Physical appearance - colour, homogeneity and consistency were assessed visually.
- pH determination - measured using a calibrated digital pH meter for a 1% w/v aqueous dispersion of the gel.
- Viscosity - determined using a Brookfield viscometer at varying spindle speeds and room temperature.
- Spreadability - determined by measuring the diameter of gel spread between two glass slides under a fixed load within a specified time.
- Drug content - determined by dissolving a known quantity of gel in suitable solvent and estimating the drug content spectrophotometrically.
- In vitro drug release - studied using a Franz diffusion cell fitted with a suitable dialysis membrane, with samples withdrawn at predetermined time intervals and analysed spectrophotometrically; release kinetics were fitted to zero order, first order, Higuchi and Korsmeyer-Peppas models.
- Stability studies - the optimised gel formulation was stored at different temperature conditions (e.g., room temperature and $40^{\circ}\text{C} \pm 2^{\circ}\text{C}/75\% \text{ RH} \pm 5\% \text{ RH}$) for [X] weeks/months and evaluated periodically for changes in physical appearance, pH, viscosity and drug content.

3. RESULTS AND DISCUSSION

The results of the evaluation of the Mimusops elengi loaded microsponge batches (MS1-MS4) are summarised in Table 2, and the evaluation results of the optimised microsponge gel are summarised in Table 3.

Table 2: Evaluation of Microsponge Batches (MS1-MS4)

Parameter	MS1	MS2	MS3	MS4
Production yield (%)	[X.XX]	[X.XX]	[X.XX]	[X.XX]
Particle size (μm)	[X.XX]	[X.XX]	[X.XX]	[X.XX]
Entrapment efficiency (%)	[X.XX]	[X.XX]	[X.XX]	[X.XX]
Carr's index (%)	[X.XX]	[X.XX]	[X.XX]	[X.XX]
Angle of repose ($^{\circ}$)	[X.XX]	[X.XX]	[X.XX]	[X.XX]

Table 3: Evaluation of Optimised Microsponge Gel

Parameter	Result
Colour/Appearance	[Describe - e.g., light brown, homogeneous, smooth]
pH	[X.XX]
Viscosity (cps)	[X.XX]
Spreadability (g.cm/sec)	[X.XX]
Drug content (%)	[X.XX]
Cumulative drug release at [X] h (%)	[X.XX]
Best-fit release kinetic model	[e.g., Higuchi/Korsmeyer-Peppas]

SEM analysis of the optimised batch revealed [spherical/porous] microsponges with a [porous/smooth] surface, confirming successful formation of the microsponge structure. Among the four batches, entrapment efficiency was found to increase with increasing polymer concentration up to a certain ratio, beyond which a decline was observed, likely due to [drug leaching/polymer wall thickness effects]; batch [MSX] showed the highest entrapment efficiency and was therefore selected as the optimised batch for gel formulation. The pH of the developed gel was found to be within the range compatible with normal skin pH, indicating suitability for topical application without risk of irritation. The viscosity and spreadability values obtained indicate that the gel possesses satisfactory consistency for ease of application while remaining in place at the site of application. In vitro drug release studies demonstrated a [controlled/sustained] release pattern over the study period, with the release data best fitting the [Higuchi/Korsmeyer-Peppas] model, suggesting that drug release from the microsponge gel is governed predominantly by [diffusion/anomalous (non-Fickian) transport]. Stability studies indicated that the optimised gel formulation remained stable, with no significant change in physical appearance, pH, viscosity or drug content over the study period, supporting its suitability for further development.

4. CONCLUSION

In the present study, *Mimusops elengi* flower extract loaded microsponges were successfully developed by the quasi-emulsion solvent diffusion method and incorporated into a Carbopol 934-based gel to obtain a stable, controlled-release topical formulation. The formulated microsponge gel exhibited satisfactory physicochemical properties, acceptable drug entrapment and content, and a controlled in vitro drug release profile, indicating its potential as an effective and patient-compliant alternative to conventional topical herbal formulations. The study supports the application of microsponge technology for the delivery of phytoconstituents with otherwise limited topical bioavailability. Further studies involving ex vivo skin permeation, antimicrobial/anti-inflammatory activity evaluation and clinical/user acceptability studies are recommended to further establish the therapeutic potential of the developed formulation.

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