



Formulation, optimization and *In-vitro* evaluation of Hibiscus rosa-sinensis microparticle-loaded polyherbal cough syrup

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Account Information	ABSTRACT
<i>Original research article</i> Acceptance: Aug 2026 Published: September 2026 Volume 1 • Issue 1 • 2026 Keywords: Hibiscus rosa-sinensis; microparticles; ethyl cellulose; polyvinyl alcohol; polyherbal cough syrup; formulation optimization; particle size; PDI; zeta potential.	Herbal formulations continue to receive attention for the management of respiratory symptoms, and incorporation of herbal extracts into particulate delivery systems may improve formulation performance and reproducibility. The present study aimed to develop and optimize Hibiscus rosa-sinensis extract-loaded polymeric microparticles and incorporate the optimized system into a polyherbal cough syrup. Hibiscus extract was used for microparticle preparation with ethyl cellulose as the polymeric carrier and polyvinyl alcohol (PVA) as the stabilizing agent. Ethyl cellulose and PVA were selected as formulation variables, while particle size, polydispersity index (PDI), and zeta potential were used as optimization responses. Statistical optimization yielded an optimized formulation at an ethyl cellulose level of 424.108 and PVA level of 0.398213, with composite desirability of 0.539190. The predicted particle size, PDI and zeta potential were 25.3638 nm, 0.230231 and -18.5512 mV, respectively; experimentally observed values were 25.36 nm, 0.23 and -18.55 mV. The optimized microparticles were incorporated into polyherbal cough syrup formulations containing Tulsi, Ginger, Liquorice, Cardamom, Adulsa, honey and simple syrup. Four formulations (F1–F4) were evaluated for organoleptic properties, pH and viscosity. The formulations showed brownish colour, aromatic odour and sweet taste. pH ranged from 6.10 to 6.40 and viscosity from 0.67 to 0.84 N·s/m². Preliminary phytochemical screening indicated alkaloids, flavonoids, tannins and saponins. UV-visible analysis showed λ_{max} at 369 nm with reported absorbance of 0.49. FTIR analysis demonstrated characteristic hydroxyl, carbonyl, aromatic and ether/glycosidic functionalities. The study demonstrates the feasibility of incorporating optimized Hibiscus microparticles into a polyherbal cough syrup. Further quantitative studies on entrapment efficiency, marker loading, in-vitro release, stability and biological efficacy are required.

1. INTRODUCTION

Cough is a common respiratory symptom and represents a physiological mechanism that assists in clearing irritants and secretions from the respiratory tract. Persistent cough, however, may cause throat irritation, sleep disturbance and discomfort. Herbal preparations are widely used as supportive

formulations for respiratory complaints because medicinal plants contain diverse phytoconstituents with reported antioxidant, antimicrobial and anti-inflammatory properties. [1,2] *Hibiscus rosa-sinensis* Linn., belonging to the family Malvaceae, is commonly known as China rose or Gudhal. The plant is widely cultivated in tropical and subtropical regions, including India. Its flowers and leaves contain flavonoids, anthocyanins, polyphenols, tannins, saponins, terpenoids, alkaloids, glycosides, mucilage, vitamin C and organic acids. The reported biological activities of the plant include antioxidant, antimicrobial, anti-inflammatory and antitussive activities. [5,6]

Polyherbal formulations combine the traditional use of multiple medicinal plants in a single dosage form. In the present formulation, Tulsi, Ginger, Liquorice, Cardamom and Adulsa were used as supporting herbal components, while honey and simple syrup provided the syrup base and contributed to palatability. The Hibiscus component was separately processed into polymeric microparticles before incorporation into the final syrup. [7-10] Microparticle-based delivery may provide advantages over direct incorporation of an herbal extract by improving dispersion and allowing the active herbal material to be presented in a defined particulate system. Ethyl cellulose was selected as the polymeric carrier and PVA as the stabilizing/emulsifying agent. Statistical optimization was used to identify formulation conditions producing desirable particle size, size distribution and surface charge. [11]

The objective of the present investigation was therefore to develop *Hibiscus rosa-sinensis* extract-loaded polymeric microparticles, optimize the formulation using ethyl cellulose and PVA, characterize the optimized system, and incorporate it into a polyherbal cough syrup followed by preliminary physicochemical evaluation. [11]

2. MATERIALS AND METHODS

2.1 Materials

The herbal materials included *Hibiscus rosa-sinensis*, Tulsi, Ginger, Liquorice, Cardamom and Adulsa. Honey and simple syrup were used as formulation components. Ethyl cellulose was used as the polymeric carrier and PVA as the stabilizer. Other laboratory-grade materials were used as required.

2.2 Preparation of Hibiscus Extract

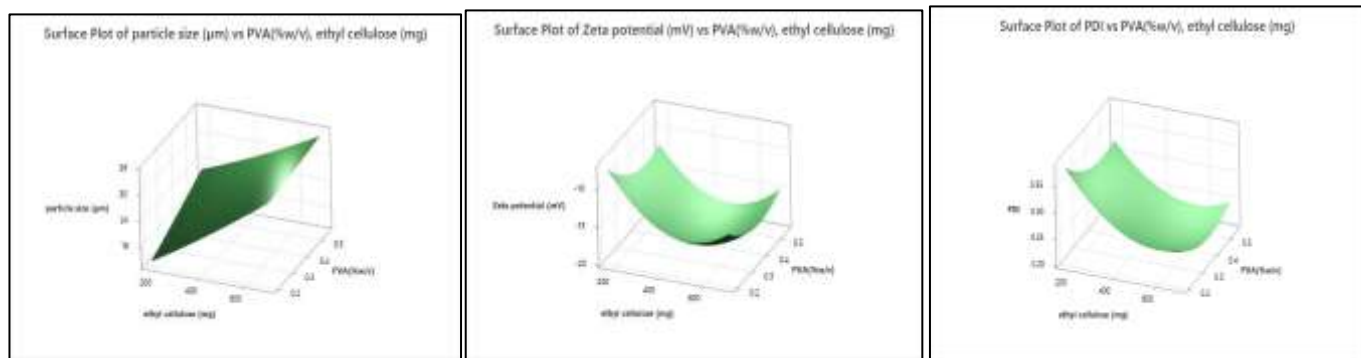
Selected Hibiscus material was cleaned and processed prior to extraction. The prepared material was subjected to the selected extraction procedure, and the resulting extract was filtered to remove undesirable particulate matter. The filtered extract was subsequently used for microparticle preparation.

2.3 Preparation of Hibiscus Microparticles

Microparticles were prepared using Hibiscus extract alone. Ethyl cellulose was selected as the polymer and PVA as the stabilizer. The required amount of ethyl cellulose was prepared in the selected phase, followed by incorporation of Hibiscus extract. A PVA solution was prepared separately. The polymer-extract phase was introduced into the PVA phase under continuous stirring, followed by homogenization/stirring to promote microparticle formation. The resulting suspension was processed and the microparticles were isolated for characterization. [11]

2.4 Statistical Optimization

Ethyl cellulose (X1) and PVA (X2) were selected as independent variables. Particle size (Y1), PDI (Y2) and zeta potential (Y3) were selected as dependent responses. Experimental observations were entered into statistical optimization software, response requirements were defined, and the optimized formulation was selected on the basis of composite desirability. [12]



2.5 Characterization

Particle size and PDI were determined using a particle-size analyzer. Zeta potential was measured using a suitable zeta-potential analyzer. UV-visible spectrophotometry was used for analytical characterization of the Hibiscus extract. FTIR spectroscopy was used to identify characteristic functional groups in the optimized microparticles. [11,13]

2.6 Preparation of Polyherbal Cough Syrup

The remaining herbal ingredients were processed independently. Simple syrup was prepared using sugar and purified water. The optimized Hibiscus microparticles were uniformly dispersed and incorporated into the syrup together with the processed Tulsi, Ginger, Liquorice, Cardamom and Adulsa components. Honey and simple syrup were added according to the formulation design with continuous mixing. Four formulations, F1–F4, were prepared and adjusted to a final volume of 50 mL.

Formulation	Extract (mL)	Honey (mL)	Simple syrup (mL)
F1	15	17.5	17.5
F2	15	20	15
F3	15	15	20
F4	15	10	25

2.7 Evaluation of Final Formulations

Organoleptic evaluation was performed for colour, odour and taste. pH was determined using a calibrated pH meter. Viscosity was measured using a suitable viscometer. Preliminary phytochemical screening was performed for alkaloids, flavonoids, tannins, saponins and steroids.

3. RESULTS AND DISCUSSION

3.1 Optimization of Hibiscus Microparticles

The formulation optimization study identified ethyl cellulose and PVA as important formulation variables for the particulate system. The optimized condition consisted of ethyl cellulose 424.108 and PVA 0.398213, with a composite desirability of 0.539190. The predicted responses were particle size 25.3638 nm, PDI 0.230231 and zeta potential –18.5512 mV.

Parameter	Optimized/Observed value
Ethyl cellulose	424.108
PVA	0.398213
Composite desirability	0.539190

Observed particle size	25.36 nm
Observed PDI	0.23
Observed zeta potential	−18.55 mV

The close agreement between predicted and experimentally observed particle-size, PDI and zeta-potential values supports the reproducibility of the selected optimized condition. The PDI of 0.23 indicates a relatively narrow particle-size distribution, while the negative zeta potential demonstrates measurable surface charge.

3.2 Organoleptic Evaluation

The final herbal cough syrup exhibited a brownish colour, aromatic odour and sweet taste. These characteristics were considered acceptable in the reported preliminary evaluation and are consistent with the presence of multiple herbal ingredients and the sweetening syrup components.

Parameter	Observation
Colour	Brownish
Odour	Aromatic
Taste	Sweet

3.3 pH Evaluation

The pH values of F1–F4 ranged from 6.10 to 6.40. F2 showed the lowest pH (6.10), whereas F4 showed the highest pH (6.40). The relatively narrow pH range indicates limited variation among the formulations despite changes in honey and simple-syrup proportions.

Formulation n	pH
F1	6.30
F2	6.10
F3	6.32
F4	6.40

3.4 Viscosity Evaluation

Viscosity ranged from 0.67 to 0.84 N·s/m². F3 exhibited the lowest viscosity, while F4 showed the highest value. The observed variation is associated with differences in the proportions of honey and simple syrup used in the four formulations and may influence handling and pourability of the final liquid dosage form.

Formulation n	Viscosity (N·s/m ²)
F1	0.72
F2	0.77
F3	0.67
F4	0.84

3.5 Preliminary Phytochemical Screening

Preliminary phytochemical screening showed positive reactions for alkaloids, flavonoids, tannins and saponins, whereas steroids were not detected. The presence of multiple phytochemical groups is

consistent with the complex phytochemical profile of the herbal ingredients. [14]

Phytochemical	Result
Alkaloids	+
Flavonoids	+
Tannins	+
Saponins	+
Steroids	—

3.6 UV-Visible Spectrophotometric Analysis

UV-visible analysis of the Hibiscus extract produced a maximum absorption wavelength of 369 nm, with a reported absorbance of 0.49. The identified wavelength provides an analytical reference for further characterization and standardization of the extract.

Parameter	Result
λ_{max}	369 nm
Absorbance	0.49

3.7 FTIR Characterization

FTIR analysis of the optimized microparticles showed characteristic bands associated with hydroxyl, aliphatic C–H, carbonyl, aromatic C=C, C–O and C–O–C functionalities. These bands are compatible with the functional groups expected from phenolic, alcoholic, aromatic and glycosidic constituents present in herbal materials. [11,15]

Peak (cm ⁻¹)	Functional group	Assignment
3487	O–H	Hydroxyl/phenolic compounds
2893	C–H	Aliphatic C–H stretching
1670	C=O	Carbonyl stretching
1560	C=C	Aromatic ring stretching
1360	C–H/O–H	Bending vibrations
1250	C–O	Phenolic/alcoholic C–O stretching
1095	C–O–C	Ether/glycosidic linkage
830	C–H	Aromatic C–H bending

3.8 Overall Discussion

The study followed a two-stage formulation strategy. In the first stage, Hibiscus rosa-sinensis extract-loaded polymeric microparticles were prepared and statistically optimized using ethyl cellulose and PVA. In the second stage, the optimized microparticles were incorporated into a polyherbal cough syrup along with Tulsi, Ginger, Liquorice, Cardamom and Adulsa, with honey and simple syrup as formulation components. The optimized microparticle system showed a particle size of 25.36 nm, PDI of 0.23 and zeta potential of –18.55 mV. These values indicate successful formation of a small particulate system

with relatively uniform size distribution and measurable surface charge. The agreement between predicted and observed responses supports the selection of the optimized formulation. The final formulations displayed consistent organoleptic characteristics. Their pH values showed only limited variation, while viscosity differed among formulations according to their syrup composition. Preliminary phytochemical screening demonstrated the presence of several phytochemical classes, and UV-visible and FTIR analyses provided additional analytical characterization of the Hibiscus-containing system.

Importantly, the available experimental record does not provide numerical results for entrapment efficiency, marker/drug loading, percentage yield, cumulative in-vitro release or comprehensive stability testing. These parameters should therefore not be inferred from the available data. Their determination would strengthen future evaluation of the formulation and is necessary for a more complete assessment of pharmaceutical performance.

4. CONCLUSION

The present study demonstrated the feasibility of developing Hibiscus rosa-sinensis extract-loaded polymeric microparticles using ethyl cellulose and PVA and incorporating the optimized system into a polyherbal cough syrup. Statistical optimization produced an optimized formulation with experimentally observed particle size of 25.36 nm, PDI of 0.23 and zeta potential of -18.55 mV. The resulting cough syrup formulations showed acceptable preliminary organoleptic and physicochemical characteristics, including brownish colour, aromatic odour, sweet taste, pH of 6.10–6.40 and viscosity of 0.67–0.84 N·s/m². Further studies should establish entrapment efficiency, marker loading, in-vitro release, release kinetics, stability, microbial quality, safety and pharmacological efficacy before further pharmaceutical development.

5. FUTURE SCOPE

Future investigations should include quantitative standardization using an appropriate marker such as determination of entrapment efficiency and loading capacity, in-vitro release and kinetic modelling, accelerated and long-term stability studies, microbial quality assessment, and suitable biological evaluation. These studies would provide a stronger scientific basis for assessing the reproducibility, quality and therapeutic potential of the developed polyherbal formulation.

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