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Short Communication

Formulation and Pharmaceutical Evaluation of Polyherbal Granules Containing *Tinospora cordifolia*, *Leucas aspera*, and *Curcuma longa*

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ABSTRACT

Background: Impaired immune function increases susceptibility to infections and chronic diseases. Medicinal plants with immunomodulatory and antioxidant properties offer a natural approach to restoring immune balance, as emphasized in the Ayurvedic concept of Rasayana. *Tinospora cordifolia*, *Leucas aspera* and *Curcuma longa* are well known for their immune-supportive and antioxidant activities. The aim of this study is to formulate and evaluate the pharmaceutical properties of herbal granules containing *Tinospora cordifolia*, *Leucas aspera* and *Curcuma longa* as a convenient oral dosage form. **Methods:** Ethanolic extracts of the selected plants were used to prepare granules by the wet granulation technique using pharmaceutical excipients. The prepared granules were evaluated for organoleptic characteristics and pharmaceutical parameters. **Results:** The formulated granules exhibited a slight yellowish-green colour, characteristic odour, astringent-sweet taste, spherical shape and a particle size range of 355–710 μm . The angle of repose was $27.21^\circ \pm 0.02$, bulk density $0.60 \pm 0.01 \text{ g/cm}^3$, tapped density $0.66 \pm 0.01 \text{ g/cm}^3$, Carr's index $9.09 \pm 0.03 \%$ and Hausner's ratio 1.10, indicating excellent flow properties. Disintegration occurred within 15 ± 1 seconds. **Conclusion:** The developed herbal granules offer acceptable organoleptic and pharmaceutical characteristics suitable for oral administration. The formulation provides a stable and patient-friendly dosage form for delivering the selected herbal extracts. Further studies, including extract standardization, in vitro and in vivo immunomodulatory evaluation and stability testing, are required to establish biological efficacy and long-term quality.

1. INTRODUCTION

The concept of immunomodulatory medicinal plants represents a relatively recent yet rapidly evolving

area within pharmacognosy, bridging traditional knowledge with modern scientific validation (Swaroop et al., 2021). In various disease conditions, the immune

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response can become impaired due to infections, chronic illnesses, environmental pollution, unhealthy lifestyles and stress (Münzel et al., 2018). Modulating the immune system through stimulation or suppression offers a valuable therapeutic approach (Lee et al., 2018). Immunomodulators can serve as supportive therapy alongside conventional treatments, potentially enhancing the body's natural defenses while minimizing adverse effects (Pahade et al., 2023).

A key Ayurvedic concept is Rasayana, one of the eight clinical specialties, which focuses on rejuvenation. Rasayana therapies aim to delay ageing, preserve youth, improve mental health and combat diseases arising from infections or stress. These rejuvenating agents are thought to enhance tissue quality through enrichment of nutritional plasma (Poshaka rasa), improvement of digestive and metabolic processes (Agni), and enhancement of micro-circulatory channels (Srotasas) (Varsakiya et al., 2018). Many Rasayana plants exert immunostimulant effects attributed to polysaccharides, glycolipids, peptides and low-molecular-weight compounds such as alkaloids, sesquiterpenes and triterpenoids (Singh et al., 2021).

Extensively studied examples include *Tinospora cordifolia*, *Withania somnifera*, *Asparagus racemosus* and *Curcuma longa* (Chaudhry, 2021). Constituents of *Tinospora cordifolia* such as syringin and cordiol have been reported to increase IgG antibodies and support adjuvant therapy (Chaudhary et al., 2024; Sharma et al., 2012). The immunomodulatory effects of *Curcuma longa* are largely attributed to curcuminoids, particularly curcumin, which scavenges free radicals and enhances antioxidant enzyme activity (Jantan et al., 2021). *Leucas aspera*, a wild edible plant common in South India and Assam, exhibits strong antioxidant activity linked to flavonoids and phenolics that scavenge free radicals and inhibit lipid peroxidation (Kripa et al., 2011).

Although the individual plants have been studied extensively, their combined formulation into a convenient, patient-compliant oral dosage form such as granules remains limited. Granules offer advantages of uniform particle size, improved flowability, better chemical stability and ease of administration compared with raw powders. The present study therefore aimed to formulate herbal granules containing ethanolic extracts of *Tinospora cordifolia*, *Leucas aspera* and *Curcuma longa* by wet granulation and to evaluate their organoleptic and pharmaceutical (flow and disintegration) characteristics. The work focuses on establishing a pharmaceutically acceptable dosage form; biological (immunomodulatory) activity was not evaluated in the present investigation and is

recommended for future studies.

2. MATERIALS AND METHODS

2.1 Materials required

The active ingredients consist of plant extracts of *Tinospora cordifolia*, *Leucas aspera* and *Curcuma longa* (collected from three locations in Kerala, India: Kattakada, Kunnappuzha, and Neyyattinkara). Starch powder (bulking agent), stevia powder and liquorice (sweetening agent), cardamom (flavoring agent), dibasic calcium phosphate (bulking agent), citric acid (taste masker), magnesium stearate (lubricant) and methylparaben (preservative) have been purchased from commercial suppliers.

2.2 Preparation of extracts

Shade-dried powdered plant materials of *Tinospora cordifolia* (250 g), *Leucas aspera* (300 g) and *Curcuma longa* rhizome (250 g) were separately extracted with 90% ethanol (350 mL) in a Soxhlet extractor for 24–48 h (Figure 1). 90 % ethanol was selected because it efficiently extracts both polar and moderately non-polar phytoconstituents (including phenolics, flavonoids and curcuminoids) while limiting excessive extraction of highly polar impurities that may occur with absolute water or lower-alcohol concentrations. The extracts were concentrated under reduced pressure at 60–70 °C. The resulting extracts were dark-green gummy solids for *Tinospora cordifolia* and *Leucas aspera*, and a dark-brown gummy solid for *Curcuma longa*. (Note: extractive yields, marker-compound quantification and herbarium voucher numbers were not determined in the present study and constitute a limitation; future work should include these standardisation parameters).

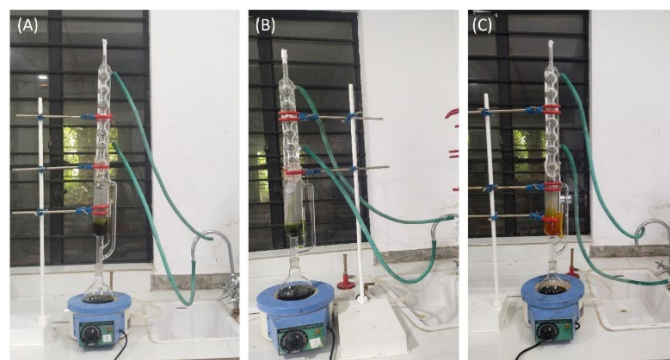


Figure 1: Soxhlet extraction of medicinal plants. (A) *Tinospora cordifolia* (B) *Leucas aspera* and (C) *Curcuma longa*.

2.3 Method of preparation of granules

A single-batch wet-granulation method was employed (Table 1). All ingredients except cardamom and magnesium stearate were accurately weighed and

mixed to form a homogeneous powder blend. Starch paste was added gradually with continuous mixing until a cohesive wet mass was obtained. The wet mass was passed through sieve no. 8 (2.36 mm / 2360 µm aperture) to form uniform wet granules. The granules were dried at 60 °C for 2 h in a hot-air oven. After drying, magnesium stearate and cardamom were added and the mixture was passed through sieve nos. 22 (710 µm) and 24 (600 µm) to obtain uniform-sized granules (Khandelwal & Shah, 2016; Patel et al., 2020; Zhang et al., 2019) (Figure 2). No multi-batch optimisation study was performed; the present work reports the characteristics of this single formulation.

Table 1: List of ingredients for the herbal granule formulation.

Sl no.	Ingredients	Quantity
1.	Plant extracts	
	<i>Tinospora cordifolia</i>	8.5g
	<i>Leucas aspera</i>	11g
	<i>Curcuma longa</i>	8.5g
2.	Starch powder	15g
3.	Starch paste	QS
4.	Stevia powder	6g
5.	Liquorice	5g
6.	Cardamom	QS
7.	Dibasic calcium phosphate	25g
8.	Citric acid	15g
9.	Magnesium stearate	2.5g
10.	Methyl paraben	1.5g



Figure 2: Granules prepared and dried.

2.4 Evaluation of granules

2.4.1 Organoleptic evaluation

The prepared granules were examined visually

and by sensory assessment for colour, odour, taste, shape, texture and approximate particle size. Observations were recorded by three independent observers under natural daylight.

2.4.2 Pharmaceutical evaluation

2.4.2.1 Angle of repose

Flow properties were assessed by the fixed-funnel method. A measured quantity of granules was allowed to flow freely through a funnel onto a horizontal surface to form a cone. The height (h) and radius (r) of the cone were measured and the angle of repose (θ) was calculated using the formula:

$$\theta = \tan^{-1} (h / r)$$

An angle of repose between 25° and 30° indicates excellent flow, 31–35° good flow, 36–40° fair flow and 41–45° passable flow (Khandelwal & Shah, 2016; Parajuli-Baral, 2023).

2.4.2.2 Bulk density

Approximately 15 g of granules (M) was gently introduced into a clean, dry 100 mL measuring cylinder without compaction. The unsettled apparent volume (V₀) was recorded. Bulk density (ρ_b) was calculated as:

$$\rho_b = M / V_0$$

2.4.2.3 Tapped density

The same cylinder was mechanically tapped (initially 500 taps, followed by additional sets of 750 taps) until the difference between consecutive volume readings was less than 2 %. The final tapped volume (V_f) was recorded and tapped density (ρ_t) calculated as:

$$\rho_t = M / V_f$$

2.4.2.4 Hausner's ratio

Hausner's ratio was calculated as the ratio of tapped density to bulk density:

$$\text{Hausner's ratio} = \rho_t / \rho_b$$

Values less than 1.25 indicate good flow, 1.25–1.5 indicate moderate flow, and values greater than 1.5 indicate poor flow (Khandelwal & Shah, 2016; Parajuli-Baral, 2023).

2.4.2.5 Carr's index

Carr's compressibility index was calculated as:

$$\text{Carr's index (\%)} = [(q_t - q_b) / q_t] \times 100$$

Values below 10 % indicate excellent flow, 11–15 % good flow, 16–20 % fair flow and 21–25 % passable flow.

2.4.2.6 Disintegration test

Disintegration behaviour was evaluated using a standard disintegration apparatus. Approximately 0.10 g of granules was placed in each of six tubes of the basket. Distilled water maintained at 37 ± 2 °C was used as the immersion medium because it represents a simple aqueous environment relevant to oral administration and is the default medium recommended in Pharmacopoeial guidelines for uncoated granules when no specific medium is prescribed. The apparatus was operated and the granules were observed after 30 min (or earlier if complete disintegration occurred). The test was considered satisfactory if no residue remained, or only a soft/muddy residue was present, in no more than one tube (Khandelwal & Shah, 2016).

3. STATISTICAL ANALYSIS

All pharmaceutical measurements were performed in triplicate ($n = 3$), and results are expressed as mean $\pm$ standard deviation. Formal inferential statistical analysis (e.g., ANOVA) was not applied because only a single formulation was prepared.

4. RESULTS AND DISCUSSION

4.1 Organoleptic evaluation

The prepared granules were slightly yellowish-green in colour, possessed a characteristic pleasant odour, had an astringent-sweet taste, were spherical with a brittle texture, and showed a particle-size range of 355–710 μm (Table 2). The yellowish-green colour is consistent with the combined presence of chlorophyll-derived pigments from *Tinospora* and *Leucas* extracts and curcuminoids from *Curcuma longa*. The odour was dominated by the cardamom flavouring agent, which successfully masked the inherent herbal notes. The astringent-sweet taste resulted from the balance between the natural astringency of the extracts and the natural sweeteners (stevia and liquorice), with citric acid providing mild sourness that improved overall palatability. The spherical shape and brittle texture indicate successful wet granulation with adequate binder concentration. The observed particle-size range falls within the typical pharmaceutical granule fraction and supports good flow and rapid dispersion.

4.2 Pharmaceutical evaluation

The pharmaceutical parameters of the granules are summarised in Table 3. The angle of repose was $27.21^\circ \pm 0.02$, which falls within the excellent-flow range (25–30°). Bulk density and tapped density were 0.60 ± 0.01 g/cm³ and 0.66 ± 0.01 g/cm³, respectively. Carr's index was 9.09 ± 0.03 % and Hausner's ratio was 1.10, both indicating excellent flowability and low inter-particulate friction. Disintegration occurred within 15 ± 1 s.

Table 2: Results obtained in organoleptic evaluation of formulated herbal granules

Parameters	Results
Colour	Slight yellowish green
Odour	Characteristic, pleasant
Taste	Astringent-sweet
Shape	Spherical
Particle size	355-710 μm
Texture	Brittle

Table 3: Results obtained in the pharmaceutical evaluation of herbal granules. The data were calculated as mean $\pm$ SD, $n=3$

Parameters	Results
Angle of repose	$27.21^\circ \pm 0.02$
Bulk density	0.60 ± 0.01 g/cm ³
Tapped density	0.66 ± 0.01 g/cm ³
Carr's index	9.09 ± 0.03 %
Hausner's ratio	1.1
Disintegration	Within 15 ± 1 sec

The excellent flow properties (angle of repose 27.21° , Carr's index < 10 %, Hausner's ratio 1.10) are comparable to those reported for other herbal granule formulations prepared by wet granulation. Khandelwal & Shah (2016) reported an angle of repose of approximately 28–32° and Carr's index values in the excellent-to-good range for oral herbal granules intended for asthma. Patel et al. (2020) obtained similar flow indices for polyherbal anti-obesity granules. The rapid disintegration observed in the present study is attributable to the combined effect of the hydrophilic starch binder and the presence of citric acid, which facilitates wetting and dispersion in aqueous media. These pharmaceutical attributes indicate that the granules are suitable for further processing (e.g., filling into sachets or compression into tablets) and for oral administration with the expectation of prompt release.

of phytoconstituents.

It must be emphasised that the present work evaluated only physical and pharmaceutical properties. No *in vitro* or *in vivo* immunomodulatory assays were performed; therefore, any claim of biological activity remains speculative and awaits experimental confirmation. Additional characterisation such as moisture content, loss on drying, detailed particle-size distribution analysis, extract standardisation (yield, marker quantification) and multi-batch optimisation would further strengthen the formulation data package.

5. CONCLUSION

Herbal granules containing ethanolic extracts of *Tinospora cordifolia*, *Leucas aspera* and *Curcuma longa* were successfully prepared by wet granulation. The granules exhibited acceptable organoleptic properties and excellent pharmaceutical characteristics (angle of repose $27.21^\circ \pm 0.02$, Carr's index 9.09 ± 0.03 %, Hausner's ratio 1.10, disintegration within 15 s), confirming their suitability as a stable and convenient oral dosage form. The formulation provides a practical vehicle for delivering the selected herbal extracts. However, because biological (immunomodulatory) activity was not evaluated in this study, claims of therapeutic efficacy cannot be made on the basis of the present data. Future investigations should include extract standardisation (yield, marker compounds, voucher specimens), moisture and stability studies, multi-batch optimisation, and rigorous *in vitro* and *in vivo* immunomodulatory assays to establish the biological potential of the formulation.

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Conflict of Interest

None declared.

Ethical Statement

There is no ethical approval is required.

Declaration of Generative AI

No artificial intelligence (AI) tools were used in the preparation of this manuscript.

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