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## Review Article

# Phytochemical Characterization of Udumbara Phala Churna (*Ficus racemosa*) and Krishnamrittika (Black Soil) Using FTIR and HR-LCMS: Implications in Heavy Menstrual Bleeding

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## ABSTRACT

Heavy menstrual bleeding (HMB), or Asrigdara in Ayurvedic terminology, is a prevalent gynecological disorder affecting women of reproductive age. Conventional therapies, including hormonal interventions and surgical procedures, often carry side effects and limitations, which encourages the exploration of safe, effective, and natural alternatives. Ayurveda, the traditional system of Indian medicine, describes Udumbara (*Ficus racemosa*) and Krishnamrittika (black soil) as agents with rakta-stambhana (hemostatic) and shothahara (anti-inflammatory) properties. The present study aimed to establish the phytochemical profile of these two formulations using Fourier Transform Infrared Spectroscopy (FTIR) and High-Resolution Liquid Chromatography-Mass Spectrometry (HR-LCMS). FTIR analysis of Udumbara phala churna revealed peaks corresponding to hydroxyl, alkane, carbonyl, carboxylate, ether, ester, aromatic, and halogen functional groups, while Krishnamrittika exhibited characteristic O-H, N-H, C=O, C=C, and C-O stretching vibrations. These findings indicate the presence of phenolics, flavonoids, alcohols, esters, amines, and aromatic compounds. HR-LCMS analysis further confirmed the presence of 5472 compounds across both formulations (Udumbara: 5237; Krishnamrittika: 235). Identified phytoconstituents included flavonoids, alkaloids, fatty acids, triterpenoids, carotenoids, and amino acids. Importantly, several of these compounds demonstrated pharmacological activities directly relevant to HMB, such as vasoconstriction (solenopsin, 8-iso Prostaglandin F1), anti-inflammatory effects (epilumafavanone B, neoenactin M2), antioxidant activity (decylubiquinone, homodimericin A), hormonal modulation (testosterone enanthate, 6 $\alpha$ -hydroxy-casterone), and hemostatic properties (pulcherriminic acid, 2-hydroxymethylserine). Collectively, these results

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provide a comprehensive chemical fingerprint supporting the traditional use of Udumbara and Krishnamrittika in Asrigdara. The polypharmacological properties of their bioactive compounds justify further in vitro, in vivo, and clinical validation to explore their potential as safe alternatives in menstrual health management.

## INTRODUCTION

Heavy menstrual bleeding (HMB) is defined clinically as menstrual blood loss exceeding 80 mL per cycle or bleeding that interferes with a woman's physical, emotional, and social quality of life. Globally, HMB is estimated to affect nearly 30% of women of reproductive age, making it one of the leading causes of gynecological consultations. Conventional therapies such as non-steroidal anti-inflammatory drugs (NSAIDs), hormonal contraceptives, antifibrinolytics, and surgical options (endometrial ablation, hysterectomy) may provide symptomatic relief but are often associated with side effects, contraindications, or limited accessibility. In Ayurveda, *Asrigdara* is described as an excessive flow of blood during menstruation, attributed to the aggravation of *Pitta dosha* and *Rakta dhatu*. Treatment approaches emphasize *stambhana* (arresting bleeding), *pachana* (metabolic correction), and *shothahara* (anti-inflammatory actions). Among the traditionally used formulations, Udumbara phala (*Ficus racemosa* Linn.) and Krishnamrittika (black soil) hold significant relevance.

- **Udumbara** fruits are noted for their *kashaya rasa* (astringent property), *stambhana karma* (hemostatic action), and *pitta-shamaka* (cooling effect). Modern studies have reported its antimicrobial, anti-inflammatory, antioxidant, and wound-healing properties.
- **Krishnamrittika**, a naturally occurring black soil, is used in folk and Ayurvedic practices for its cooling, detoxifying, and hemostatic

effects. Its mineral and organic components are believed to synergize in providing therapeutic efficacy.

Despite extensive traditional usage, modern analytical validation of these formulations remains limited. Advanced techniques such as FTIR and HR-LCMS allow precise characterization of chemical constituents and their potential bioactivities. This study aims to:

1. Identify functional groups and phytochemical classes present in Udumbara and Krishnamrittika using FTIR.
2. Characterize and catalog bioactive molecules through HR-LCMS.
3. Correlate the identified compounds with pharmacological activities relevant to HMB management.

## 2. MATERIALS AND METHODS

### 2.1 Sample Collection and Preparation

- **Udumbara phala (*Ficus racemosa*):** Fruits were collected, shade-dried, powdered, and sieved to prepare *churna*.
- **Krishnamrittika (black soil):** Collected from natural deposits, purified according to Ayurvedic guidelines to remove impurities, and dried for analysis.

### 2.2 FTIR Analysis

FTIR spectra were recorded in the range of **400–4000 cm<sup>-1</sup>** using a Fourier Transform Infrared Spectrophotometer. The peaks were interpreted based on functional group frequencies, allowing identification of chemical bonds and associated phytoconstituents.

### 2.3 HR-LCMS Analysis

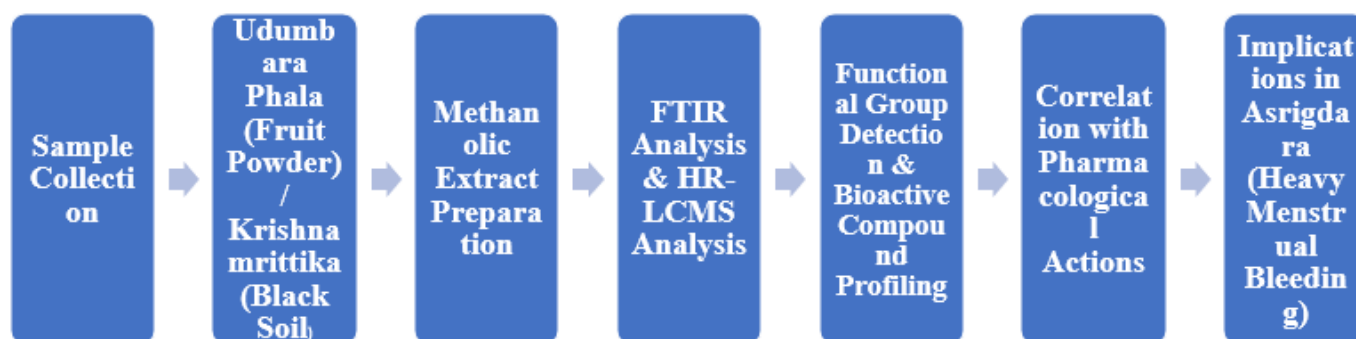


- **Instrument:** Orbitrap Eclipse Tribrid Mass Spectrometer (Thermo Fisher Scientific).
- **Chromatography:** UHPLC Dionex Ultimate 3000 RS with Zorbax Eclipse C18 column (2.1 × 150 mm, 5 µm).
- **Solvent System:** Gradient elution with water + 0.1% formic acid, acetonitrile + 0.1% formic acid, and methanol.
- **Flow Rate:** 0.2 mL/min.
- **Detection:** Positive and negative electrospray ionization (ESI), mass range 100–1200 m/z.
- **Extraction:** Methanolic extracts of both samples were prepared, filtered, and injected for analysis.

## 2.4 Data Interpretation

The FTIR spectra were matched with standard group frequencies. HR-LCMS peaks were identified through spectral libraries and databases, enabling structural elucidation and functional classification of compounds.

## Flowchart: Study Design



## 3. RESULTS

### 3.1 FTIR Analysis

#### Udumbara phala churna

- Broad O-H stretching (3436 cm<sup>-1</sup>) → hydroxyl groups (alcohols, phenols).
- Strong C-H stretching (2919 cm<sup>-1</sup>) → alkanes.
- C=C/C=O stretching (1627 cm<sup>-1</sup>) → alkenes, carbonyls (ketones, amides).
- COO<sup>-</sup> symmetric stretching (1432 cm<sup>-1</sup>) → carboxylates.
- Strong C-O stretching (1054–1243 cm<sup>-1</sup>) → alcohols, ethers, esters.

- Aromatic C-H bending (894–782 cm<sup>-1</sup>).
- Halogen stretching (622 cm<sup>-1</sup>, 531 cm<sup>-1</sup>) → chlorides and bromides.

#### Krishnamrittika

- Broad O-H stretching (3200–3600 cm<sup>-1</sup>) → alcohols, carboxylic acids.
- Sharp N-H stretching (3300–3500 cm<sup>-1</sup>) → amines, amides.
- Sharp/medium C-H stretching (2800–3000 cm<sup>-1</sup>) → alkanes, aromatics.
- Strong C=O stretching (1700–1750 cm<sup>-1</sup>) → aldehydes, ketones, esters.

- Medium C=C stretching ( $1600\text{--}1680\text{ cm}^{-1}$ ) → aromatic rings, alkenes.
  - Strong C-O stretching ( $1050\text{--}1300\text{ cm}^{-1}$ ) → alcohols, ethers, esters.
- Interpretation:** Both samples contained diverse functional groups indicative of phenolics, flavonoids, terpenoids, alkaloids, esters, and minerals, confirming complex bioactive composition.

**Table 1: FTIR Functional Groups of Udumbara and Krishnamrittika**

| Sample          | Peak ( $\text{cm}^{-1}$ ) | Functional Group | Phytoconstituent Class | Pharmacological Relevance |
|-----------------|---------------------------|------------------|------------------------|---------------------------|
| Udumbara        | 3436                      | O-H stretch      | Alcohols, Phenols      | Antioxidant, Hemostatic   |
| Udumbara        | 1627                      | C=O, C=C         | Ketones, Alkenes       | Anti-inflammatory         |
| Udumbara        | 1054–1243                 | C-O stretch      | Alcohols, Esters       | Wound healing             |
| Krishnamrittika | 1700–1750                 | C=O stretch      | Aldehydes, Esters      | Cooling, Stambhana        |
| Krishnamrittika | 3200–3600                 | O-H stretch      | Alcohols, Acids        | Detoxifying, Cooling      |

### 3.2 HR-LCMS Analysis

- **Total detected compounds:** 5472

- Udumbara phala churna: 5237
- Krishnamrittika: 235

#### Key Pharmacologically Relevant Compounds:

- **Vasoconstrictive:** Solenopsin, 8-iso Prostaglandin F1, 20-beta-Dihydrocortisol.
- **Anti-inflammatory:** Neoenactin M2, Epilumaflavanone B, Dictyoquinazol A.
- **Hormonal regulation:** Testosterone enanthate, 3-Dehydro-6-deoxoteasterone, 6 $\alpha$ -Hydroxy-castasterone.
- **Antioxidants:** Decylubiquinone, Homodimericin A, Octyl methoxycinnamate,  $\beta$ -Muricholic acid.
- **Hemostatic/Astringent:** Pulcherriminic acid, 2-Hydroxymethylserine, Jasmone, Lauric acid.

**Table 2: HR-LCMS – Pharmacologically Relevant Compounds**

| Activity            | Key Compounds Identified                         | Potential Role in HMB (Asrigdara) |
|---------------------|--------------------------------------------------|-----------------------------------|
| Vasoconstriction    | Solenopsin, 8-iso Prostaglandin F1               | Reduces uterine blood flow        |
| Anti-inflammatory   | Epilumaflavanone B, Lauric acid                  | Reduces endometrial inflammation  |
| Antioxidant         | Decylubiquinone, Homodimericin A                 | Protects endometrium from stress  |
| Hormonal Modulation | Testosterone enanthate, $\beta$ -Muricholic acid | Balances estrogen-progesterone    |
| Hemostatic          | Pulcherriminic acid, 2-Hydroxymethylserine       | Enhances clot stability           |



## 4. DISCUSSION

The FTIR analysis demonstrated the presence of hydroxyl, carbonyl, aromatic, and ether groups, which are commonly associated with antioxidant and anti-inflammatory bioactivities. The presence of halogenated groups in Udumbara may indicate natural defense compounds with antimicrobial properties.

The HR-LCMS profiling provided an extensive library of bioactives. Importantly, many of these compounds correspond to pharmacological pathways directly relevant to HMB:

- **Vasoconstrictive agents** (e.g., Solenopsin, 8-iso Prostaglandin F1) → reduce uterine blood flow and excessive bleeding.
- **Anti-inflammatory molecules** (Epilumaflavanone B, Lauric acid) → mitigate endometrial inflammation, a key contributor to abnormal bleeding.
- **Antioxidants** (Decylubiquinone, Homodimericin A) → reduce oxidative stress, protecting endometrial tissue from damage.
- **Hormonal regulators** (Testosterone enanthate,  $\beta$ -Muricholic acid) → stabilize estrogen-progesterone imbalance, which often underlies HMB.
- **Hemostatic and astringent compounds** (Pulcherriminic acid, 2-Hydroxymethylserine) → enhance platelet aggregation and clot stability.

Thus, both Udumbara and Krishnamrittika demonstrate multi-targeted actions, aligning with the Ayurvedic principle of *yoga* (synergistic polyherbal-mineral formulations).

## 5. CONCLUSION

This study provides the first comprehensive analytical validation of Udumbara phala churna and Krishnamrittika using FTIR and HR-LCMS. The findings highlight their phytochemical richness and reveal compounds with vasoconstrictive, hemostatic, anti-inflammatory, antioxidant, and hormonal regulatory effects that can rationalize their traditional use in *Asrigdara* (heavy menstrual bleeding). The results underscore their polypharmacological potential and pave the way for future pre-clinical and clinical studies to establish dosage, safety, and efficacy. Standardization of these formulations can facilitate their integration into evidence-based gynecological therapeutics.

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