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Research Article

COMPREHENSIVE INSTRUMENTAL CHARACTERIZATION OF *GANDHAGA RASAYANAM* THROUGH SPECTROSCOPIC AND MICROSCOPIC TECHNIQUES

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ABSTRACT

Objective: The objective of this study is to establish the analytical profile of *Gandhaga Rasayanam*, a traditional *Siddha* poly herbo-mineral formulation mentioned in *Anuboga Vaidya Navaneetham part 6*, screening through Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Analysis (EDAX). **Methods:** FTIR analysis was used to identify the characteristic functional groups present in the formulation. Surface morphology and particle size distribution were assessed using SEM. Elemental composition was determined by EDAX. **Results:** FTIR spectra showed prominent absorption peaks corresponding to hydroxyl, aliphatic, carbonyl, and sulphur-associated functional groups, indicating the presence of organic moieties and mineral constituents. SEM micrographs revealed irregularly shaped, heterogeneous particles with sizes ranging from 1.265 to 4.297µm, suggesting effective particle size reduction during processing. EDAX analysis identified sulphur as the predominant elemental component (50.2 wt.%), followed by carbon (44.1 wt.%) and oxygen (5.7 wt.%), confirming the sulphur-rich nature of the formulation. **Conclusion:** The analytical findings establish characteristic physicochemical and elemental parameters for *Gandhaga Rasayanam*, thereby contributing to its scientific standardization. The integration of FTIR, SEM, EDAX provides reference data to support quality assessment of the drug but pharmacological evaluation is necessary to reveal the therapeutic efficacy of the drug.

INTRODUCTION

Traditional *Siddha* formulations have been widely employed for centuries in the treatment of chronic and systemic diseases by its natural therapeutic approach and unique therapeutic principles. [1] Among these various formulations, *Gandhaga Rasayanam* is a well-known herbo-mineral preparation indicated for conditions such as skin diseases, respiratory disorders, and chronic inflammatory ailments. [2] The therapeutic efficacy of this medicine is attributed to the synergistic activity of purified sulphur and associated herbal constituents prepared according to the classical *Siddha* text- *Anuboga Vaidya Navaneetham part 6*. [3,4]

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Even though these medicines are described in ancient siddha literatures the modern world accepts and validates these drugs when they are scientifically screened. Moreover, it is highly necessary for its quality and safety[5]. Variation in raw materials like subtypes, species variation, purification methods and preparation by unskilled persons will affect the quality and efficacy of siddha drugs. So, standardizing traditional medicines is crucial for setting quality standards and providing scientific proof for their use[6,7]. New analytical methods have made it easier to fully evaluate traditional herbo-mineral medicines. The tools like FTIR, SEM, and EDAX give important details about purity, elements, and structure[8,9]. In this context, the present study was undertaken to standardize *Gandhaga Rasayanam* through elemental, and instrumental analysis, thereby generating scientific evidence regarding its identity, safety, and quality. Such evidence-based validation is essential for strengthening the scientific credibility and global acceptance of Siddha herbo-mineral formulations. [10]

MATERIALS AND METHODS

Preparation of the drug *Gandhaga rasayanam* [3]

The raw materials were procured from an esteemed raw drug store, Chennai. The raw drugs were authenticated in the Post Graduate department of *Siddha* Pharmacology at Government Siddha Medical College, Chennai. Specimen samples of these ingredients were given numbers and stored in Pharmacology department for future reference.10 *Palam* (350 g) of *Nellikai gandhagam* was purified in the steam of milk, fermented rice water and pumpkin juice (*Benincasa hispida*) separately (*Aavi pudam/ Dhooma pudam*). All the other ingredients were taken in the weight of each ½ *Palam* (17.5 g) and purified as per *Sarakku suthi sei muraigal* [11]. All the purified ingredients were powdered into a *Chooranam*. It was then ground in a stone mortar- pestle for 2 *Saamam* (6 hours) with 100ml of cow's ghee till it attains the desired consistency. The prepared *Gandhaga rasayanam* was stored in an airtight container.

S.No	Drug	Latin name	Part used	Proportion
1	*Nellikai gandhagam*	*Sulphur*	Mineral	350 g
2	*Jadhikai*	*Myristica fragrans*	Dried seed	17.5 g
3	*Lavangam*	*Syzygium aromaticum*	Flower bud	17.5 g
4	*Elarisi*	*Eletteria cardomomum*	Dried fruit	17.5 g
5	*Vaaluzhuvai arisi*	*Celastrus paniculatus*	Dried Seed	17.5 g
6	*Chitrarathai*	*Alpinia officinarum*	Dried Root	17.5 g
7	*Vaividangam*	*Embelia ribes*	Dried Seed	17.5 g
8	*Kodiveli verpattai*	*Plumbago zeylanica*	Root bark	17.5 g
9	*Sukku*	*Zingiber officinale*	Dried rhizome	17.5 g
10	*Thippili*	*Piper longum*	Dried fruit	17.5 g
11	*Milagu*	*Piper nigrum*	Dried fruit	17.5 g
12	*Adhimadhuram*	*Glycyrrhiza glabra*	Dried root	17.5 g
13	*Nei*	Cow's ghee		100 ml

FTIR Analysis

Fourier Transform Infrared Spectroscopy (FTIR) was carried out to identify the characteristic functional groups present in GRM using Shimadzu IR Affinity-1 FTIR Spectrophotometer at Captain Srinivasa Murthy Central Council for Research in Ayurvedic Sciences, Chennai- 106. [14] The powdered sample was dried thoroughly and finely ground with spectroscopic grade potassium bromide (KBr) in the ratio of 1:100. The mixture was compressed into a translucent pellet using a hydraulic press. [15] The pellet was then subjected to FTIR analysis in the spectral range of 4000–400cm^{-1}. The absorption peaks obtained in the spectrum were recorded, and the corresponding functional groups were identified based on standard reference frequencies [16]. FTIR analysis was used to determine the presence of characteristic chemical bonds associated with the constituents of the formulation.

SEM Analysis

Scanning Electron Microscopy (SEM) was performed to study the surface morphology and particle characteristics of GRM using Zeiss Gemini SEM 300 at Sophisticated Analytical Instrument Facility, Indian Institute of Technology, Guindy, Chennai. [17] A small quantity of the powdered sample was mounted on an aluminium stub using double-sided adhesive carbon tape. The sample was then coated with a thin layer of gold under vacuum to improve electrical conductivity (sputter coating).[18] The prepared sample was examined under the scanning electron microscope at suitable accelerating voltage and magnification. Micrographs were obtained to observe the surface morphology, particle shape, and aggregation pattern of the formulation.

EDAX Analysis

Energy Dispersive X-ray Analysis (EDAX) was carried out in conjunction with SEM to determine the elemental composition of GRM at Sophisticated Analytical Instrument Facility, Indian Institute of Technology, Guindy, Chennai[19]. During SEM examination, the sample was subjected to an electron beam, causing the emission of characteristic X-rays from the constituent elements. These emitted X-rays were analyzed by the EDAX detector to identify the elements present in the sample. The elemental composition was expressed as weight percentage (wt%), and the presence of major and trace elements in the formulation was recorded. This analysis was used to confirm the mineral components and detect elemental and inorganic impurities if present in GRM.

RESULTS

FTIR Analysis

The FTIR spectrum of GRM revealed multiple characteristic absorption peaks as present in figure 01. The peaks indicate the presence of diverse functional groups as in Table 02.

Figure 01 FTIR Spectrum of GRM

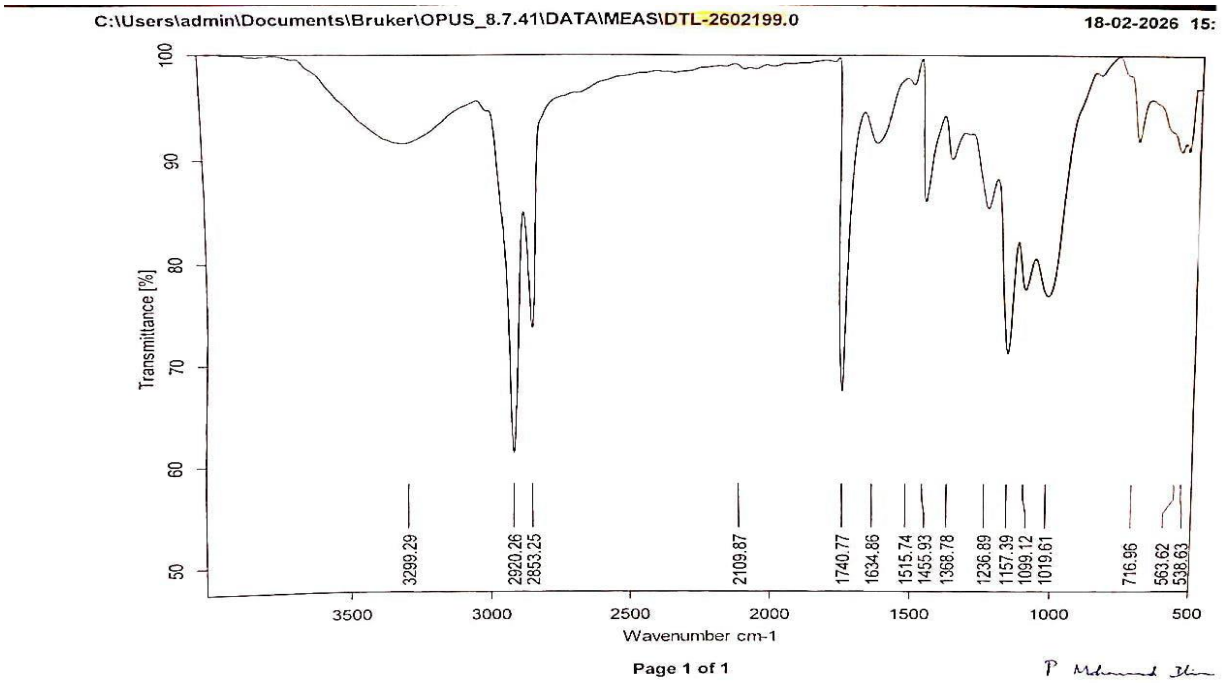


Table 2: FTIR Peaks of GRM

S.No	Wavenumber (CM^{-1})	Functional Group	Interpretation
1	3299.29	O-H stretching	Alcohols/phenolic compounds
2	2920.26	C-H stretching	Alkanes
3	2853.25	C-H stretching	Alkanes
4	2109.87	C≡C stretching	Alkynes
5	1740.77	C=O stretching	Esters/carbonyl compounds
6	1634.86	C=C stretching	Alkenes/ aromatic rings
7	1515.74	N-O/ aromatic C=C	Nitro/aromatic compounds
8	1455.93	C-H bending	Alkanes
9	1368.78	C-H bending	Methyl groups
10	1236.89	C-O stretching	Esters
11	1157.39	C-O stretching	Alcohols
12	1099.12	C-O stretching	Secondary alcohols
13	1019.61	C-O stretching	Primary alcohols
14	716.96	C-S stretching	Organosulphur compounds
15	563.62	S-S stretching	Disulphide bonds
16	538.63	S-S stretching	Disulphide bonds

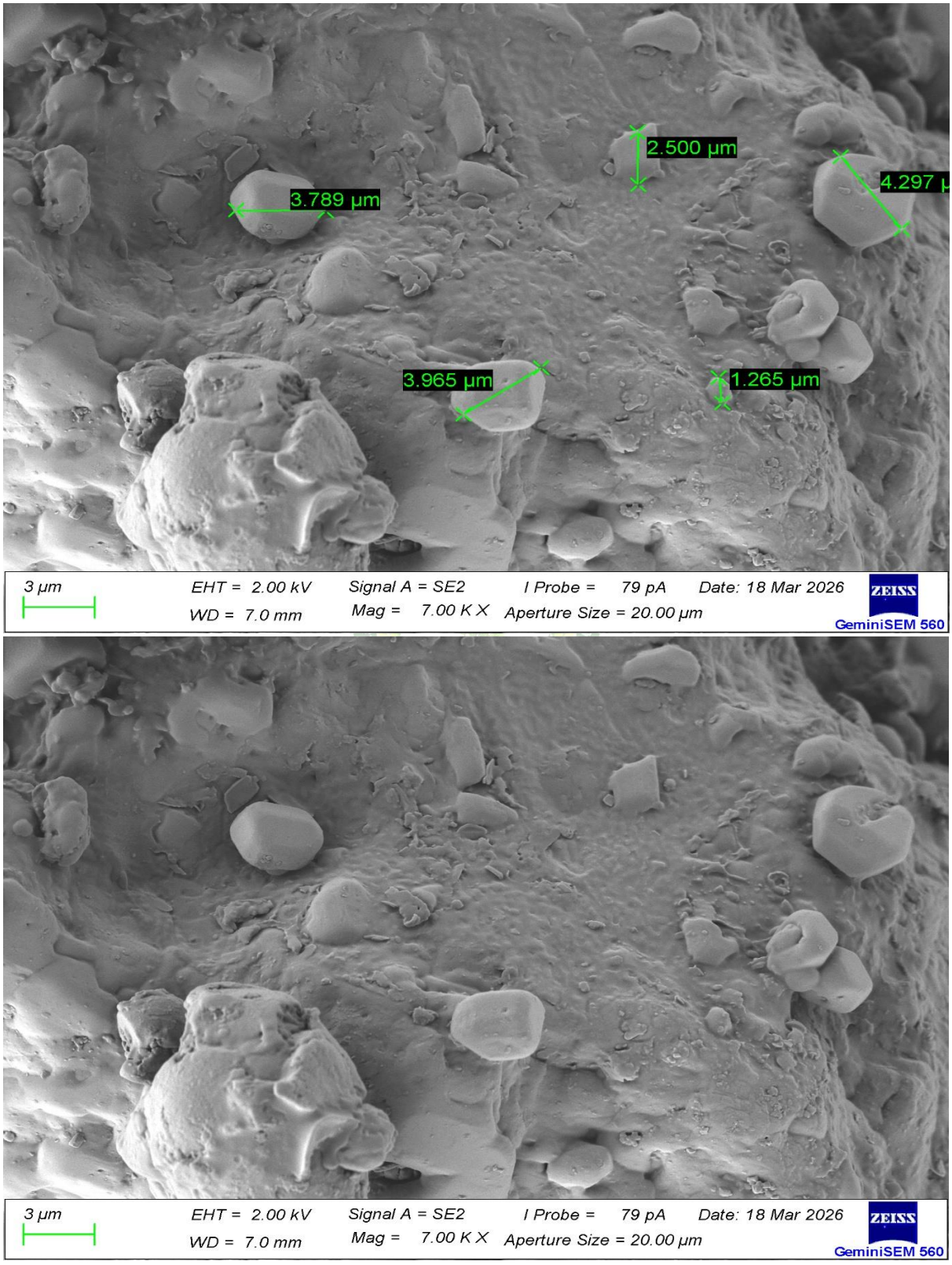
Interpretation

The FTIR spectrum indicates the presence of organic functional groups such as alcohols, esters, alkanes, and aromatic compounds suggesting complex phytochemical constituents along with processed sulphur.

Scanning Electron Microscope (SEM)

SEM analysis of GRM was done to know about the surface morphology as shown in figure 2, 3, 4, 5. GRM consisted of heterogenous particle distribution. Particles exhibited irregular and agglomerated morphology, sizes ranged approximately between 1.2µm to 4.3µm. The surface appeared rough and porous.

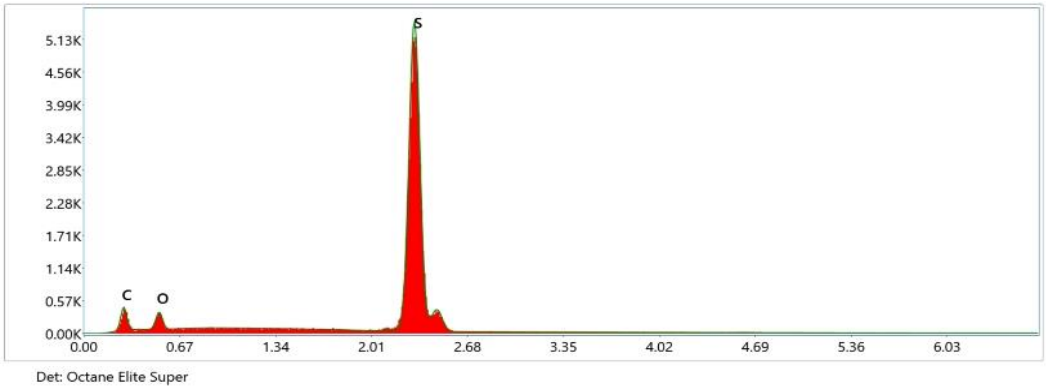
Figure 02,03: SEM images of GRM



Energy Dispersive Xray Analysis (EDAX)

The graph obtained in EDAX is shown in the figure 6 and elucidated in the table 04. High sulphur content confirms the presence of *Gandhagam* (Sulphur) as the major component. Carbon and oxygen indicate the organic matrix and phytoconstituents confirming the herbo- mineral nature of the drug.

Figure 04 EDAX graph of GRM



eZAF Quant Result - Analysis Uncertainty: 22.10%

Element	Weight%	MDL	Atomic%	Net Int.	Error%	R	A	F
CK	44.1	2.51	65.6	102.3	14.1	0.9079	0.0595	1.0000
OK	5.7	0.51	6.4	86.6	14.0	0.9203	0.1619	1.0000
SK	50.2	0.17	28.0	2485.8	3.2	0.9545	0.9496	1.0038

Table 04 Interpretation of EDAX of GRM

S No	Element	Weight %
1	Carbon (C)	44.7
2	Oxygen (O)	5.1
3	Sulphur (S)	50.2

DISCUSSION

The FTIR spectrum revealed a diverse array of functional groups, indicating the presence of both organic and inorganic constituents. FTIR study reveals that disulphide bonds in the wave number of 538 and 563 that indicate sulphur content. Moreover, the sulphur is converted to organosulphur by indication of carbon sulphur bonds at 716.96 wave peak. These findings suggest that the traditional processing of *Gandhaga Rasayanam* facilitates the transformation of elemental sulphur into stable, potentially bioavailable sulphur-containing compounds. Overall, the FTIR profile demonstrates that the formulation retains a complex phytochemical matrix, which may contribute to its therapeutic activity. Notably, no unusual or extraneous peaks indicative of synthetic contaminants were detected.

SEM revealed that GRM consists of irregular, non-uniform, and agglomerated particles with rough surface morphology. The particle size distribution ranged from approximately 1.2µm to 4.3µm, indicating a micro-scale particulate system.

The rough and porous surface architecture observed may enhance surface area, thereby potentially improving bioavailability of the drug. Such heterogeneous morphology is typical of herbo-mineral preparations and reflects the complex interplay between organic constituents and mineral components during formulation. The observed particle size range is favorable for gastrointestinal absorption, suggesting possible improved therapeutic efficacy.

EDAX analysis confirmed sulphur as the predominant element (50.2% by weight), validating the presence of *Gandhagam* (Sulphur) as the principal component of the formulation. The significant carbon content (44.1%) indicates the contribution of organic matter, likely derived from herbal ingredients used during processing. Oxygen (5.7%) further supports the presence of oxygenated functional groups identified in FTIR analysis. The coexistence of sulphur with carbon and oxygen suggests that sulphur may be present in a bound or modified form, possibly enhancing its stability and reducing toxicity.

CONCLUSION

The present study provides a comprehensive analytical characterization of *Gandhaga Rasayanam* using FTIR, SEM, EDAX techniques. The FTIR analysis confirmed the presence of diverse functional groups, indicating a complex phytochemical matrix derived from herbal constituents. SEM observations revealed irregular, agglomerated micro-sized particles with rough surface morphology, which may contribute to enhanced surface area and improved bioavailability. EDAX analysis demonstrated that sulphur is the predominant element, validating the herbo-mineral nature of the formulation, while the presence of carbon

and oxygen suggests the integration of organic components with mineral content.

In summary, GRM exhibits significant structural and compositional complexity. While the formulation shows promising physicochemical characteristics, ensuring compliance with safety standards is essential for its safe therapeutic application. Further studies focusing on toxicity evaluation, standardization, and pharmacological validation are recommended to support its clinical use.

Author Contribution

Pushpa P funded, collected, analyzed the data and prepared the manuscript. Shankar S supervised the project, interpreted the data and reviewed the final version.

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