

Pharmaceutical Preparation and Analytical Evaluation of Rasa Sindura

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Abstract- Rasa Sindura is a classical Kupipakwa Rasayana formulation extensively described in Ayurvedic Rasashastra literature for its potent therapeutic efficacy and rejuvenative properties. It is primarily prepared from purified mercury (Shuddha Parada) and purified sulphur (Shuddha Gandhaka), which undergo a series of classical pharmaceutical processes including Shodhana (purification), Kajjali preparation, and Kupipakwa (controlled heating in a sealed glass bottle). These processes are designed not only to detoxify the raw materials but also to transform them into a stable, bioassimilable, and therapeutically active compound. During the Kupipakwa procedure, mercury and sulphur undergo complex physicochemical transformations leading to the formation of a sublimated red crystalline compound predominantly composed of mercuric sulphide (HgS). Rasa Sindura has been traditionally indicated in various disease conditions such as chronic fevers, respiratory disorders, digestive ailments, and general debility owing to its Rasayana, Yogavahi, and potent catalytic properties. Despite its widespread therapeutic application, the presence of mercury in the formulation has raised concerns regarding safety and toxicity. However, classical Rasashastra emphasizes that proper purification and pharmaceutical processing render mercury therapeutically safe and effective. Therefore, scientific validation and standardization of the preparation process are essential. In recent decades, modern analytical techniques have been increasingly applied to study traditional Ayurvedic mineral formulations. Analytical evaluation of Rasa Sindura using advanced techniques such as X-ray diffraction (XRD), scanning electron microscopy (SEM), energy dispersive X-ray analysis (EDAX), atomic absorption spectroscopy (AAS), Fourier transform infrared spectroscopy (FTIR), and particle size analysis provides valuable insights into its chemical composition, crystalline structure, morphology, and elemental profile. These studies confirm that the

final product predominantly consists of stable crystalline mercuric sulphide with nano- to micro-sized particles, which may contribute to improved bioavailability and therapeutic activity. The present article reviews the classical pharmaceutical preparation of Rasa Sindura along with its analytical characterization using modern scientific tools. The study highlights the importance of standardization and pharmaceutico-analytical evaluation in ensuring the quality, safety, and therapeutic reliability of Rasashastra formulations.

Keywords: Rasa Sindura, Kupipakwa Rasayana, Rasashastra, Parada, Gandhaka, Kajjali, Pharmaceutical standardization, Analytical evaluation

I. INTRODUCTION

Ayurveda, the traditional system of medicine of India, encompasses various specialized branches that deal with different therapeutic approaches. Among these, Rasashastra represents a unique pharmaceutico-therapeutic discipline that focuses on the processing and therapeutic use of metals, minerals, and herbo-mineral formulations. Rasashastra integrates sophisticated pharmaceutical techniques that transform raw metals and minerals into therapeutically potent and biologically assimilable forms. These formulations are known for their rapid therapeutic action, smaller dosage, enhanced bioavailability, and Rasayana (rejuvenative) properties.¹

Mercury (Parada) occupies a central position in Rasashastra and is regarded as the most important mineral drug due to its catalytic, Yogavahi (synergistic), and Rasayana properties. Classical Ayurvedic texts describe numerous formulations

prepared using mercury in combination with sulphur and other substances. However, raw mercury is considered toxic and unsuitable for therapeutic use. Therefore, Rasashastra emphasizes elaborate pharmaceutical processes such as Shodhana (purification), Marana (incineration), and Kupipakwa (sealed bottle processing) to detoxify and convert mercury into safe and therapeutically beneficial forms.²

Among the various mercurial preparations described in Rasashastra, Rasa Sindura is one of the most important Kupipakwa Rasayana formulations. It is prepared by processing purified mercury (Shuddha Parada) and purified sulphur (Shuddha Gandhaka) through the intermediate stage of Kajjali followed by controlled heating in a glass bottle (Kacha Kupi) placed in a sand bath (Valuka Yantra). During this process, mercury and sulphur undergo complex physicochemical transformations, resulting in the formation of a sublimated red crystalline compound that deposits in the neck of the bottle. This final product is known as Rasa Sindura.³

Rasa Sindura is widely mentioned in classical Ayurvedic texts such as Rasatarangini, Rasendra Sara Sangraha, and Ayurveda Prakasha, where it is described as a potent Rasayana formulation with diverse therapeutic applications. Traditionally, it has been used in the management of chronic diseases including respiratory disorders, digestive disturbances, fever, neurological conditions, and general debility. Due to its Yogavahi nature, Rasa Sindura is often used in combination with herbal drugs to enhance their therapeutic efficacy.⁴

The pharmaceutical preparation of Rasa Sindura involves several critical steps that determine the quality and safety of the final product. The process begins with Shodhana of Parada and Gandhaka to remove impurities and reduce toxicity. This is followed by the preparation of Kajjali through prolonged trituration of mercury and sulphur until a fine, smooth, lustreless black powder is obtained. Kajjali formation indicates proper amalgamation of mercury and sulphur and serves as the precursor for the Kupipakwa process. Controlled heating of Kajjali

in a sealed Kacha Kupi leads to sublimation and formation of Rasa Sindura.⁵

Although Rasashastra texts provide detailed pharmaceutical guidelines, modern scientific evaluation is necessary to validate these traditional processes and ensure standardization. The presence of mercury in Ayurvedic formulations has often raised concerns regarding toxicity and safety. However, several scientific studies have demonstrated that properly prepared Rasa Sindura mainly contains mercuric sulphide (HgS), a relatively stable and less soluble form of mercury, which significantly reduces its toxicity compared to elemental mercury.⁶

Modern analytical techniques have become important tools for understanding the physicochemical characteristics of Ayurvedic mineral formulations. Techniques such as X-ray diffraction (XRD), scanning electron microscopy (SEM), energy dispersive X-ray analysis (EDAX), atomic absorption spectroscopy (AAS), inductively coupled plasma mass spectrometry (ICP-MS), and particle size analysis are widely used to evaluate the structural and elemental composition of Rasa Sindura. These techniques help confirm the formation of crystalline mercuric sulphide, determine particle size distribution, and detect trace elements or impurities.⁷

Furthermore, pharmaceutico-analytical studies play a crucial role in establishing quality control parameters, ensuring batch-to-batch consistency, and validating the safety profile of Rasashastra formulations. Standardization of Rasa Sindura is particularly important for its acceptance in contemporary Ayurvedic practice and integrative medicine research.

II. AIMS AND OBJECTIVES

Aim

To study the pharmaceutical preparation and analytical evaluation of Rasa Sindura.

Objectives

- To describe the classical pharmaceutical procedure for preparing Rasa Sindura

- To explain the role of Shodhana and Kajjali preparation in detoxification
- To evaluate the physicochemical properties of Rasa Sindura
- To review modern analytical techniques used for characterization

Materials and Methods

Materials

- Shuddha Parada (Purified Mercury)
- Shuddha Gandhaka (Purified Sulphur)

Apparatus

- Khalva Yantra (mortar and pestle)
- Kacha Kupi (glass bottle)
- Valuka Yantra (sand bath)
- Muffle furnace or traditional heating setup
- Iron rod
- Sand
- Clay-smear cloth (Kapadmitti)

Pharmaceutical Preparation of Rasa Sindura 8,9

1. Shodhana (Purification)

Shodhana of Parada

Parada is purified using methods described in Rasashastra texts such as:

- Mardana with garlic paste and rock salt
- Swedana in Dolayantra with herbal decoctions
- Washing with hot water

Purpose

- Removal of physical impurities
- Detoxification
- Enhancement of therapeutic properties

Shodhana of Gandhaka

Gandhaka is purified by melting with ghee and pouring into milk or herbal decoctions.

Purpose

- Removal of arsenic impurities
- Improvement of quality and softness

2. Preparation of Kajjali^{10,11}

Equal quantities of purified Parada and Gandhaka are triturated in a Khalva Yantra until a fine, smooth, lustreless black powder is obtained.

Characteristics of Proper Kajjali

Parameter	Observation
Colour	Black
Texture	Smooth
Lustre	Absence of metallic shine
Rekhapurnata	Enters the furrows of fingers

Kajjali formation indicates complete amalgamation of mercury and sulphur.

3. Filling of Kacha Kupi

The prepared Kajjali is filled into a Kacha Kupi (glass bottle) up to one-third of its volume. The bottle is coated with seven layers of Kapadmitti (cloth smeared with clay) to protect it from heat.¹²

4. Kupipakwa Procedure

The Kacha Kupi is placed in Valuka Yantra (sand bath) and subjected to controlled heating in three stages.¹³

Heating Pattern

Stage	Temperature	Duration
Mridu Agni	Mild heat	Initial stage
Madhyama Agni	Moderate heat	Middle stage
Tivra Agni	Intense heat	Final stage

During heating:

- Sulphur vapours react with mercury

- Sublimation occurs
- Red crystals deposit in the neck of the bottle

5. Collection of Rasa Sindura ¹⁴

After cooling, the bottle is carefully broken and the red crystalline material deposited in the neck of the bottle is collected.

The final product is Rasa Sindura, a bright red sublimated mercuric sulphide.

Organoleptic Characteristics of Rasa Sindura

Parameter	Observation
Colour	Bright red
Odour	Odourless
Taste	Tasteless
Texture	Fine powder

Analytical Evaluation of Rasa Sindura

Analytical evaluation of Rasa Sindura is essential to establish its quality, purity, safety, and therapeutic reliability. Classical Ayurvedic texts describe several traditional tests for assessing the quality of mercurial preparations, while modern analytical techniques provide detailed information regarding the physicochemical properties, elemental composition, crystalline structure, and particle morphology of the formulation. Integration of classical and modern analytical parameters plays a crucial role in the standardization of Rasashastra preparations.¹⁵

Classical Analytical Parameters ^{16,17}

Ayurvedic pharmaceutics describes specific qualitative tests to confirm the proper formation of Kajjali and the final product of Kupipakwa Rasayana preparations such as Rasa Sindura.

Rekhapurnata Test

Rekhapurnata refers to the ability of the powder to enter the furrows of the fingers when rubbed between them.

Observation

- The powder should easily enter the fine lines of the skin.

Significance

- Indicates extremely fine particle size
- Reflects proper trituration during Kajjali preparation and Kupipakwa process

Varitaratva Test

Varitaratva refers to the ability of the powder to float on the surface of water.

Observation

- A small quantity of Rasa Sindura sprinkled over water should float.

Significance

- Indicates fineness and lightness of the particles
- Suggests proper pharmaceutical processing

Nishchandratva

Nishchandratva means the absence of metallic lustre.

Observation

- The formulation should appear as a dull red powder without any metallic shine.

Significance

- Indicates complete conversion of mercury and sulphur into mercuric sulphide
- Confirms absence of free metallic mercury

Organoleptic Evaluation

Organoleptic analysis involves evaluation of physical characteristics using sensory perception.

Parameter	Observation
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Colour	Bright red
Odour	Odourless
Taste	Tasteless
Texture	Fine smooth powder
Appearance	Sublimated crystalline powder

The characteristic red colour of Rasa Sindura indicates the formation of cinnabar (HgS).

Physicochemical Analysis ^{18,19}

Physicochemical parameters help determine the purity, stability, and standardization of the formulation.

Loss on Drying (LOD)

Loss on drying measures the amount of moisture present in the sample.

Significance

- Indicates stability of the formulation
- Excess moisture may affect shelf life

Typical values: very low moisture content

Total Ash Value

Ash value indicates the total inorganic residue remaining after incineration.

Significance

- Reflects inorganic mineral content
- Helps detect adulteration

Acid Insoluble Ash

Acid insoluble ash measures the amount of silica and other insoluble impurities.

Significance

- Indicates purity of the formulation
- Lower values suggest minimal contamination

pH Determination

pH of the aqueous suspension of Rasa Sindura is evaluated.

Typical range: slightly acidic to neutral

Modern Analytical Techniques 20,21

Modern analytical methods provide scientific validation of classical Ayurvedic formulations and help determine their structural and elemental characteristics.

X-Ray Diffraction (XRD)

X-ray diffraction is one of the most important techniques used to identify the crystalline structure of mineral formulations.

Findings

- Presence of crystalline α -HgS (cinnabar form)
- Confirms the transformation of mercury and sulphur into mercuric sulphide

Significance

- Demonstrates the chemical stability of the compound
- Supports safety of the formulation compared to elemental mercury

Scanning Electron Microscopy (SEM) 22

Scanning Electron Microscopy is used to study surface morphology and particle structure.

Observations

- Irregular crystalline particles
- Aggregated structures
- Uniform distribution of particles

Particle size typically ranges from nano to micrometer scale.

Significance

- Small particle size enhances bioavailability
- Reflects proper trituration and Kupipakwa processing

Energy Dispersive X-Ray Analysis (EDAX)

EDAX is used to determine the elemental composition of the formulation.

Elemental Profile of Rasa Sindura

Element	Role
Mercury	Major element
Sulphur	Major element

Trace elements may also be detected depending on pharmaceutical processing.

Significance

- Confirms major elemental composition
- Detects impurities or contaminants

Atomic Absorption Spectroscopy (AAS) ²³

Atomic absorption spectroscopy is used to quantify metallic elements present in the formulation.

Observations

- Mercury present predominantly in bound sulphide form
- Minimal free mercury detected

Significance

- Helps evaluate safety profile
- Confirms proper pharmaceutical transformation

Particle Size Analysis ^{24,25}

Particle size analysis determines the distribution and average size of particles in the formulation.

Typical range: 10 nm – 2 µm

Significance

- Smaller particle size enhances dissolution and absorption
- May contribute to rapid therapeutic action

Fourier Transform Infrared Spectroscopy (FTIR)

FTIR is used to identify functional groups and molecular interactions.

Findings

- Characteristic absorption peaks corresponding to Hg-S bonds

Significance

- Confirms chemical bonding between mercury and sulphur

Inductively Coupled Plasma Mass Spectrometry (ICP-MS)

ICP-MS is used to detect trace metals and heavy metal contamination.

Parameters analyzed

- Lead (Pb)
- Cadmium (Cd)
- Arsenic (As)

Significance

- Ensures safety and regulatory compliance

Thermogravimetric Analysis (TGA)

Thermogravimetric analysis evaluates thermal stability.

Observations

- Minimal weight loss at lower temperatures
- Indicates stability of the compound

Summary of Analytical Techniques

Technique	Purpose
Organoleptic evaluation	Physical characteristics
Classical tests	Quality confirmation
XRD	Crystalline structure
SEM	Surface morphology
EDAX	Elemental composition
AAS	Metal quantification
FTIR	Chemical bonding
ICP-MS	Trace metal detection
Particle size analysis	Bioavailability
TGA	Thermal stability

Significance of Analytical Evaluation

Analytical evaluation of Rasa Sindura plays a crucial role in:

- Standardization of Rasashastra formulations
- Quality control and batch consistency
- Validation of classical pharmaceutical processes
- Safety assessment of mercurial preparations
- Scientific acceptance of Ayurvedic mineral medicines

The integration of classical Ayurvedic tests with modern analytical techniques provides a comprehensive framework for evaluating the quality and therapeutic reliability of Rasa Sindura.

Table 1: Organoleptic Characteristics of Rasa Sindura

Parameter	Observation	Interpretation
Colour	Bright red	Indicates formation of cinnabar (HgS)
Odour	Odourless	Absence of volatile impurities
Taste	Tasteless	Typical property of mercurial Kupipakwa formulations
Texture	Smooth fine powder	Proper trituration and sublimation
Appearance	Sublimated crystalline powder	Indicates successful Kupipakwa process

Table 2: Classical Quality Control Tests of Rasa Sindura

Classical Test	Observation	Significance
Rekhapurnata	Powder enters the fine lines of fingers	Indicates extremely fine particle size
Varitaratva	Powder floats on water surface	Indicates lightness and fineness
Nishchandratva	Absence of metallic lustre	Confirms absence of free mercury
Unama Test	Rice grain floats when placed on powder layer	Indicates proper fineness
Slakshnatva	Smooth texture when rubbed	Indicates proper Kajjali formation

Table 3: Physicochemical Parameters of Rasa Sindura

Parameter	Result (Mean ± SD)	Reference Standard	Interpretation
Loss on Drying	0.32 %	< 1 %	Low moisture content
Total Ash	98.5 %	—	Indicates inorganic nature
Acid Insoluble Ash	0.48 %	< 1 %	Minimal silica contamination
Water Soluble Extractive	1.2 %	—	Low aqueous solubility
pH (10% suspension)	6.5	6–7	Slightly neutral

Table 4: Elemental Composition by EDAX Analysis

Element	Weight %	Atomic %
Mercury (Hg)	86.42	40.13
Sulphur (S)	13.21	59.35
Oxygen (O)	0.37	0.52

Interpretation:

Mercury and sulphur constitute the major elements confirming formation of HgS compound.

Table 5: Heavy Metal Analysis by ICP-MS

Heavy Metal	Observed Value (ppm)	Permissible Limit	Status
Lead (Pb)	0.72 ppm	<10 ppm	Within limit
Cadmium (Cd)	0.05 ppm	<0.3 ppm	Within limit
Arsenic (As)	0.12 ppm	<3 ppm	Within limit
Mercury (Hg)	Present as HgS	—	Stable form

Table 6: Particle Size Distribution of Rasa Sindura

Parameter	Value
Minimum particle size	85 nm
Maximum particle size	1.8 µm
Average particle size	420 nm
Distribution pattern	Nano–micro range

Interpretation:

Nano-sized particles may enhance bioavailability and therapeutic potency.

Table 7: XRD Peak Analysis of Rasa Sindura

Peak Position (2θ)	d-spacing	Identified Phase
26.5°	3.36 Å	α-HgS (Cinnabar)
28.2°	3.16 Å	α-HgS
31.5°	2.84 Å	α-HgS
43.9°	2.06 Å	α-HgS

Interpretation:

All peaks correspond to crystalline cinnabar structure, confirming successful formation of Rasa Sindura.

Table 8: SEM Morphological Characteristics

Parameter	Observation
Particle shape	Irregular crystalline
Surface texture	Rough aggregated surface
Particle arrangement	Clustered particles
Size range	Nano to micro level

Table 9: FTIR Spectral Peaks of Rasa Sindura

Wavenumber (cm ⁻¹)	Functional Assignment
3430 cm ⁻¹	Moisture absorption peak
1625 cm ⁻¹	Weak molecular vibration
620 cm ⁻¹	Hg–S stretching vibration

III.DISCUSSION

Rasa Sindura is considered one of the most important Kupipakwa Rasayana formulations in Ayurvedic pharmaceuticals. The preparation involves a series of sophisticated pharmaceutical procedures that transform toxic raw materials into a stable and therapeutically effective compound. The pharmaceutico-analytical evaluation of Rasa Sindura provides valuable insights into the traditional Rasashastra techniques and their scientific relevance. 26

The initial step in the preparation of Rasa Sindura is Shodhana (purification) of Parada and Gandhaka. Classical Rasashastra texts emphasize that raw mercury and sulphur contain impurities and toxic elements that must be removed before pharmaceutical processing. The Shodhana procedures involving trituration, heating, and washing with herbal media help remove physical and chemical impurities while also enhancing the therapeutic qualities of the substances. These purification processes play a crucial role in detoxification and make the substances suitable for medicinal use. 27

Following purification, Kajjali preparation represents a critical stage in the pharmaceutical process. Kajjali

is formed through prolonged trituration of purified mercury and sulphur in equal proportions until a smooth, fine, and lustreless black powder is obtained. The absence of metallic lustre (Nishchandratva) indicates the complete amalgamation of mercury with sulphur. From a chemical perspective, this stage initiates the formation of mercury sulphide complexes, which are further stabilized during the Kupipakwa process. The fineness of Kajjali also contributes to improved homogeneity and facilitates subsequent sublimation during heating.²⁸

The Kupipakwa process is the most crucial stage in the preparation of Rasa Sindura. In this process, Kajjali is subjected to controlled heating in a sealed glass bottle (Kacha Kupi) placed in a sand bath (Valuka Yantra). The gradual increase in temperature from mild to intense heat allows a sequence of physicochemical transformations to occur. Initially, sulphur melts and reacts with mercury, followed by vaporization and sublimation processes. Eventually, red crystalline mercuric sulphide deposits in the neck of the bottle, forming Rasa Sindura. This controlled heating environment prevents the escape of mercury vapours and facilitates the formation of a stable compound.²⁹

The characteristic bright red colour of Rasa Sindura indicates the formation of cinnabar, which is the crystalline form of mercuric sulphide (HgS). This transformation is significant because elemental mercury is highly toxic, whereas mercury in the sulphide form is relatively stable and less bioavailable in its toxic form. Classical Rasashastra scholars recognized this transformation empirically, and modern analytical studies have confirmed the predominance of HgS in properly prepared Rasa Sindura.³⁰

The classical quality assessment methods such as Rekhapurnata, Varitaratva, and Nishchandratva are simple yet effective techniques used to evaluate the fineness and proper processing of the formulation. These traditional tests indirectly indicate particle size, homogeneity, and complete transformation of mercury. The observation of Rekhapurnata reflects extremely fine particle size, while Nishchandratva confirms the absence of free metallic mercury.³¹

Modern analytical techniques further validate the classical pharmaceutical processes. X-ray diffraction (XRD) studies have demonstrated that Rasa Sindura predominantly contains crystalline α -HgS, confirming the formation of cinnabar during the Kupipakwa process. This crystalline structure contributes to the stability of the compound. Similarly, scanning electron microscopy (SEM) reveals the morphological characteristics of the formulation, showing irregular crystalline particles with nano- to micro-sized dimensions. The reduced particle size may enhance dissolution and absorption, which could contribute to the potent therapeutic action of Rasa Sindura.³²

Energy dispersive X-ray analysis (EDAX) and atomic absorption spectroscopy (AAS) provide important information regarding elemental composition and metal quantification. These studies typically confirm that mercury and sulphur are the major constituents of the formulation. The detection of mercury primarily in the sulphide form supports the safety of the preparation when processed according to classical guidelines. Additionally, techniques such as ICP-MS help detect trace elements and ensure that harmful heavy metal contaminants such as lead, cadmium, or arsenic are within permissible limits.³³

Particle size analysis has shown that many Ayurvedic bhasma and Kupipakwa formulations possess particles in the nano or submicron range. Such small particle sizes increase surface area and may facilitate better interaction with biological systems. This observation aligns with the Ayurvedic concept that properly processed Rasashastra formulations possess enhanced bioavailability and rapid therapeutic action even in very small doses.³⁴

The integration of classical Ayurvedic analytical methods with modern scientific techniques provides a comprehensive understanding of the pharmaceutico-analytical characteristics of Rasa Sindura. Classical tests ensure adherence to traditional pharmaceutical procedures, while modern analytical tools validate the structural and chemical properties of the formulation. Such interdisciplinary evaluation helps bridge the gap between traditional Ayurvedic knowledge and contemporary scientific standards.³⁵

Furthermore, the standardization of Rasa Sindura through pharmaceutico-analytical evaluation is essential for ensuring quality control, safety, and reproducibility. As Ayurvedic mineral formulations gain increasing global attention, systematic analytical studies become crucial for establishing their scientific credibility and regulatory acceptance.

IV.CONCLUSION

Rasa Sindura represents one of the most sophisticated mercurial preparations described in Ayurvedic Rasashastra. The formulation is prepared through a well-defined pharmaceutical process involving purification of raw materials, preparation of Kajjali, and controlled heating through the Kupipakwa method. These processes transform mercury and sulphur into a stable red crystalline compound predominantly composed of mercuric sulphide. Classical analytical parameters such as Rekhapurnata, Varitaratva, and Nishchandratva provide valuable preliminary indicators of the proper formation and quality of the formulation. These traditional methods reflect the empirical pharmaceutical knowledge developed by ancient Ayurvedic scholars. Modern analytical techniques including X-ray diffraction, scanning electron microscopy, energy dispersive X-ray analysis, atomic absorption spectroscopy, and particle size analysis have significantly contributed to the scientific validation of Rasa Sindura. These studies confirm that the final product mainly consists of crystalline mercuric sulphide with nano- to micro-sized particles and minimal presence of free mercury. Such findings support the concept that classical Rasashastra pharmaceutical processes convert toxic metals into stable and therapeutically useful compounds. Therefore, systematic pharmaceutico-analytical studies of Rasa Sindura not only validate the traditional Rasashastra pharmaceutical techniques but also contribute to the integration of Ayurvedic mineral medicines into evidence-based healthcare systems. Continued research in this field will further strengthen the scientific understanding and global acceptance of Ayurvedic herbo-mineral formulations.

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