

## Review Article



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**“ANALYTICAL EVALUATION OF MAKARADHWAJA: CORRELATING TRADITIONAL PARAMETERS WITH MODERN SCIENTIFIC APPROACHES”****Dr. Jalpa Gandhi<sup>1</sup>****AFFILIATIONS:**

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**ABSTRACT**

**Introduction:** *Makaradhwaja*, one of the most renowned *Rasaushadhi* formulations of Ayurveda, is prepared from mercury (*Parada*), gold (*Swarna*), and sulfur (*Gandhaka*). It is acclaimed for its rejuvenative, aphrodisiac, and immunomodulatory properties. Traditionally, its quality is assessed using organoleptic and classical tests, but modern analytical tools are increasingly applied to ensure safety, efficacy, and standardization.

**Methods:** A comprehensive review was conducted using Ayurvedic texts (*Rasaratna Samuccaya*, *Rasa Tarangini*, *Ayurveda Prakasha*) and scientific databases (PubMed, Scopus, AYUSH Research Portal, and Google Scholar). The search strategy included keywords “Makaradhwaja,” “analytical evaluation,” “Ayurvedic formulations,” “Bhasma standardization,” and “nanoparticles.” Studies published between 1990–2025 were included. Both classical quality assessment criteria and modern analytical validations were compared. **Results:** Traditional parameters for Makaradhwaja include *Varitaratva* (floatability), *Rekhapurnatva* (fineness), and *Nischandratva* (lustrelessness), along with organoleptic assessments such as taste, color, and odor. Modern analytical evaluations using X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), and inductively coupled plasma mass spectrometry (ICP-MS) have revealed nanoscale structures and the presence of elemental mercury, sulfur, and gold in stable sulfide forms. Toxicological studies suggest that properly prepared Makaradhwaja, when subjected to classical *Shodhana* and *Marana* procedures, is safe for therapeutic use. **Discussion:** A critical correlation between classical and modern parameters suggests that traditional tests emphasize physical characteristics indicative of particle fineness and assimilation, while modern tools confirm these through structural and elemental analysis. However, significant gaps exist in clinical validation, standardization of preparation protocols, and global regulatory acceptance.

**KEYWORDS:** Ayurveda, Gold preparation, Makaradhwaja, Nanomedicine, Rasaushadhi

## INTRODUCTION

Makaradhwaja occupies a central place in *Rasa Shastra*, the pharmaceutico-therapeutic branch of Ayurveda. Prepared by combining purified mercury (*Parada*), sulfur (*Gandhaka*), and gold (*Swarna*), this formulation is traditionally acclaimed for its *Rasayana* (rejuvenative) and *Vrishya* (aphrodisiac) actions<sup>[1]</sup>. Classical texts like *Rasa Tarangini* and *Ayurveda Prakasha* detail multiple methods of preparation such as *Kupipakwa*, *Khalviya*, and *Ananda Makaradhwaja*, each differing in heating techniques and physical characteristics of the final product<sup>[2-3]</sup>.

The assessment of Makaradhwaja in classical Ayurveda relies on specific *Bhasma Pariksha* (tests for incinerated products), which include both macroscopic and microscopic quality determinants<sup>[4-5]</sup>. These parameters ensured therapeutic safety and efficacy for centuries. However, with growing concerns over heavy metal toxicity and the need for global acceptance of Ayurvedic formulations, analytical validation using modern scientific tools has become essential<sup>[6-8]</sup>.

The aim of this review is to systematically analyze the traditional quality assessment criteria of Makaradhwaja and correlate them with modern analytical parameters. The objectives are (i) to document classical evaluation methods from Ayurvedic texts, (ii) to synthesize findings from modern pharmaceutical and analytical research, and (iii) to highlight gaps and propose future directions for standardization and safe global utilization<sup>[9-10]</sup>.

## MATERIALS AND METHODS

This review integrates data from both classical sources and modern scientific studies.

1. **Literature Search Strategy:** Classical Ayurvedic treatises including *Rasaratna Samuccaya*, *Rasa Tarangini*, *Ayurveda Prakasha*, and *Bhaishajya Ratnavali* were referred to. Modern research articles were identified through PubMed, Scopus, AYUSH Research Portal, and Google Scholar<sup>[11]</sup>.
2. **Search Terms:** Combinations of “Makaradhwaja,” “analytical evaluation,” “Ayurvedic formulations,” “Kupipakwa,” “nanoparticles in Ayurveda,” and “Bhasma standardization” were used<sup>[12]</sup>.
3. **Inclusion Criteria:** Peer-reviewed studies, theses, and dissertations published between 1990–2025, reporting analytical methods,

pharmacological assessments, or toxicological evaluations of Makaradhwaja, were included<sup>[13]</sup>.

4. **Exclusion Criteria:** Articles lacking methodological clarity, anecdotal reports, and non-authentic web sources were excluded<sup>[14]</sup>.
5. **Type of Studies Reviewed:**<sup>[15]</sup>
  - **Classical Sources:** Descriptions of preparation and evaluation.
  - **Pharmaceutical Studies:** Comparative evaluation of different types of Makaradhwaja.
  - **Analytical Studies:** SEM, TEM, XRD, ICP-MS, FTIR, and particle size distribution analyses.
  - **Pharmacological/Toxicological Studies:** In vivo and in vitro assessments of safety and efficacy.

## OBSERVATION AND RESULTS

### 1. Classical Descriptions of Makaradhwaja Preparation

Ayurvedic texts mention several varieties of Makaradhwaja: *Kupipakwa Makaradhwaja* (bottle-prepared), *Ananda Makaradhwaja*, and *Khalviya Makaradhwaja*. The *Kupipakwa* process involves heating mercury, gold, and sulfur sealed in a glass bottle under controlled heat. This process produces three types: *Rasendra Makaradhwaja* (red), *Swarna Makaradhwaja* (yellow), and *Ananda Makaradhwaja* (black). Each is prescribed for specific therapeutic indications.

Classical quality parameters (*Bhasma Pariksha*) include:

- **Varitaratva:** Ability to float on water, indicating lightness and fineness.
- **Rekhapurnatva:** Ability to enter fine lines of the skin, showing minute particle size.
- **Nischandratva:** Absence of metallic lustre, signifying complete transformation.
- **Apunarbhava:** Irreversibility of the form, ensuring stability.

These parameters were empirical yet effective in evaluating safety and efficacy.

### 2. Organoleptic and Traditional Tests

Traditional evaluation also includes examination of color, odor, taste, and therapeutic response in patients. The red variety is associated with *Vrishya* and *Rasayana* effects, while the yellow form is considered milder.

### 3. Modern Analytical Tools Applied to Makaradhwaja

Recent studies apply advanced tools to validate

traditional observations:

- **XRD (X-ray diffraction):** Confirms crystalline phases such as HgS (cinnabar/metacinnabar) and Au particles, indicating stable sulfide form.
- **SEM and TEM:** Show nanoparticle distribution, often ranging 50–150 nm.
- **ICP-MS/ICP-AES:** Determines elemental composition and confirms absence of free toxic mercury or gold beyond permissible limits.
- **FTIR and Raman Spectroscopy:** Detect chemical bonding and organic compounds incorporated during preparation.
- **Particle Size Analyzer (PSA):** Provides quantitative confirmation of fineness suggested by *Rekhapurnatva*.

#### 4. Correlation Between Traditional and Modern Parameters

- *Varitaratva* correlates with low density and fine particle distribution confirmed by SEM.
- *Rekhapurnatva* corresponds to nanoparticle penetration potential, validated by PSA and TEM.
- *Nischandratva* matches absence of metallic peaks in XRD analysis.
- *Apunarbhava* aligns with stable sulfide compounds identified by chemical analysis.

#### 5. Safety and Toxicology Studies

Toxicological studies reveal that raw mercury is highly toxic, but properly prepared Makaradhwaja shows negligible toxicity when administered at therapeutic doses. Animal studies show no significant alterations in liver or kidney function. Clinical trials highlight immunomodulatory and adaptogenic benefits.

#### 6. Pharmacological Insights

Pharmacological investigations suggest that Makaradhwaja:

- Enhances immune response by modulating cytokine activity.
- Acts as an aphrodisiac by improving testosterone levels in animal models.
- Exhibits antioxidant and adaptogenic properties.
- Provides anti-stress and rejuvenative effects consistent with *Rasayana* claims.

#### 7. Comparative Studies of Different Preparations

Studies comparing *Kupipakwa* and *Ananda Makaradhwaja* show variation in particle size, stability, and pharmacological activity, underlining the importance of method-specific evaluation.

#### 8. Standardization Challenges

Despite advancements, challenges include:

- Variability in preparation techniques across regions.
- Lack of uniform temperature control during classical heating.
- Limited clinical trials with standardized dosing.
- Skepticism in global markets due to mercury content.

#### DISCUSSION

The analytical evaluation of Makaradhwaja demonstrates Ayurveda's sophisticated empirical quality control measures. Classical tests like *Varitaratva* and *Rekhapurnatva* anticipated modern principles of particle size, density, and bioavailability. When compared, both systems reveal complementary insights: Ayurveda provided practical physical tests, while modern tools confirm them with quantitative precision<sup>[16-17]</sup>.

Modern analytical studies consistently report Makaradhwaja as a nanomedicine, with particle sizes in the nanoscale range. This property likely underpins its therapeutic efficacy, particularly in enhancing absorption and bioavailability. The stability of mercury in sulfide form (HgS) eliminates the toxicity associated with free mercury, validating classical detoxification (*Shodhana*) and calcination (*Marana*) processes<sup>[18]</sup>.

Nonetheless, gaps remain. First, variability in preparation techniques can alter the final product's chemical and therapeutic profile, emphasizing the need for Good Manufacturing Practices (GMP) tailored to Ayurvedic pharmaceuticals. Second, there is a paucity of clinical trials conducted with rigorous methodologies. While experimental and toxicological studies suggest safety, large-scale randomized controlled trials are essential to confirm clinical efficacy. Third, global regulatory concerns about mercury in medicine pose a significant barrier. To address this, further toxicokinetic studies are necessary, alongside transparent communication of preparation methods and safety data<sup>[19]</sup>.

The future of Makaradhwaja lies in integrative research that combines traditional Ayurvedic wisdom with modern scientific tools. Interdisciplinary studies involving Ayurveda, nanotechnology, pharmacology, and toxicology can provide a holistic understanding. Additionally, documenting therapeutic outcomes in real-world clinical practice will strengthen evidence-based acceptance<sup>[20]</sup>.

## CONCLUSION

Makaradhwaja is a classical Ayurvedic formulation that epitomizes the confluence of traditional wisdom and modern science. Its preparation and evaluation, rooted in *Rasa Shastra*, reflect an advanced understanding of detoxification, particle size reduction, and stability. Traditional parameters like *Varitaratva*, *Rekhapurnatva*, and *Nischandratva* remain relevant today, as their principles are validated through modern techniques such as SEM, TEM, XRD, and ICP-MS.

Scientific evidence indicates that properly prepared Makaradhwaja is safe, stable, and therapeutically potent, largely due to its nanoparticle nature and stable sulfide form of mercury. Pharmacological studies support its immunomodulatory, rejuvenative, and adaptogenic properties.

However, major challenges remain, including variability in traditional preparation methods, limited clinical trials, and international skepticism over mercury-based medicines. Future research should prioritize standardized protocols, rigorous safety evaluations, and translational clinical studies.

In summary, the analytical evaluation of Makaradhwaja underscores Ayurveda's scientific foundation while highlighting the need for modernization and standardization. By bridging classical parameters with modern analytical validation, Makaradhwaja has the potential to be recognized globally as a safe and effective nanomedicine.

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