I J C R M
International Journal of Contemporary Research In Multidisciplinary

Research Article

Pharmaceutical Analytical Study of Vanga Bhasma and Experimental Evaluation of its Nootropic Activity

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DOI: https://doi.org/10.5281/zenodo.20041366

Abstract

Vanga Bhasma, the incinerated preparation of tin (Vanga or Trapu) as described in classical Rasashastra texts, represents a quintessential herbo-metallic formulation in Ayurveda, transformed through rigorous pharmaceutical processes into a bioavailable, non-toxic nanoparticulate form. Ancient Ayurvedic granths such as *Rasaratna Samuccaya*, *Ayurveda Prakash*, *Rasatarangini*, and *Rasendra Chudamani* detail its preparation involving *Shodhana* (purification), *Jarana* (incineration with herbal aids), and *Marana* (repeated calcination with the *Puta* system). These processes convert the raw metal into tin oxides (primarily SnO_2, cassiterite form), rendering it suitable for therapeutic use while minimising toxicity.

Classically, Vanga Bhasma is praised for its *Sukrala*, *Vrushya*, *Medhya*, and *Rasayana* properties, influencing *Shukra Dhatu*, balancing *Kapha*, and supporting overall vitality, including aspects of intellect and cognitive function. Modern analytical techniques—XRD, SEM, EDX, XRF, and particle size analysis—confirm the conversion to nanoscale tin oxide particles (often 45–300 nm), with high oxygen content and crystalline structure that enhances absorption and safety.

While direct experimental evidence for the nootropic activity of Vanga Bhasma remains limited in contemporary literature, its traditional *Medhya* indications, combined with the known neuroprotective potential of Ayurvedic bhasmas and associated herbal processing media, warrant investigation. This review synthesises classical references from Upanishadic concepts of *Medha* and *Buddhi*, Rasashastra shlokas, and available pharmaceutico-analytical data. It proposes experimental models (e.g., scopolamine-induced amnesia in rodents using Morris's water maze or radial arm maze) to evaluate its effects on learning, memory consolidation, and antioxidant status in the brain. The paper underscores the need for integrated studies bridging ancient wisdom with rigorous pharmacology, highlighting Vanga Bhasma's potential as a safe, traditional nootropic agent in an era of cognitive demands.

Manuscript Information

- **ISSN No:** 2583-7397
- **Received:** 01-04-2026
- **Accepted:** 27-04-2026
- **Published:** 05-05-2026
- **IJCRM:**5(3); 2026: 49-53

- **Plagiarism Checked:** Yes
- **Peer Review Process:** Yes

How to Cite this Article

Sheikh H, Kinkar D, Urmalia N. Pharmaceutical Analytical Study of Vanga Bhasma and Experimental Evaluation of its Nootropic Activity. Int J Contemp Res Multidiscip. 2026;5(3): 49-53.

Access this Article Online

www.multiarticlesjournal.com

KEYWORDS: Vanga Bhasma, Rasashastra, Nootropic Activity, Ayurvedic Pharmaceutics, Nanoparticulate Medicine.

INTRODUCTION

Ayurveda, the ancient Indian science of life, integrates *Dravya* (substances), *Guna* (qualities), and *Karma* (actions) to restore equilibrium among *Doshas*, *Dhatus*, and *Malas*. Within *Rasashastra*—the branch dealing with alchemical and herbo-mineral preparations—*Bhasmas* occupy a premier position. These are incinerated metals or minerals processed to achieve *Nirutha* (non-reducibility), *Varitaratva* (floatability on water), *Rekhapurnatva* (fineness to enter skin furrows), and other classical parameters signifying biocompatibility and enhanced potency. Vanga Bhasma, derived from tin, exemplifies this tradition.

References to *Trapu* (tin, synonymous with Vanga) appear even in Vedic literature. The *Yajurveda* and *Atharvaveda* mention *Trapu* alongside *Suvarna*, *Rajat*, *Tamra*, *Loha*, and *Naga* as part of metallic resources. In *Caraka Samhita* (Chikitsasthana), *Trapu* is grouped under *Panchaloha* and indicated in conditions like *Mandalakushtha*. *Sushruta Samhita* includes it in *Trapvadi Gana*, attributing *Sheeta*, *Madhura*, and tissue-nourishing properties. Later Rasashastra texts elaborate extensively.

In *Rasaratna Samuccaya* and *Ayurveda Prakash*, Vanga is classified under *Puti Loha* (metals emitting odour on melting). Two varieties are described: *Khuraka Vanga* (preferred, white, soft, quick-melting, heavy, silent when struck, pure) and *Mishraka Vanga* (impure, mixed, harder). *Khuraka* is deemed *Grahya* (acceptable) for its *Dhavala* (white), *Mridu*, *Drutadrava*, *Guru*, *Nishabda*, *Nirmala*, *Laghu*, *Shweta*, *Snigdha*, and *Sheetala* qualities. Shlokas emphasise that improper processing leads to toxicity, while classical *Shodhana* and *Marana* yield a *Rasayana* par excellence.

The philosophical underpinnings draw from the *Upanishads*, where *Medha* (intellect), *Buddhi* (discriminative intelligence), *Dhi* (comprehension), and *Smriti* (memory) are vital for *Atma Jnana* (self-realisation). *Prashna Upanishad* and *Taittiriya Upanishad* discuss *Prana*, *Manas*, and higher cognitive faculties nourished by *Ojas* and *Tejas*. Vanga Bhasma, through its influence on *Shukra Dhatu* (which generates *Ojas*), is believed to indirectly support *Medhya* functions, aligning with *Medhya Rasayana* concepts in *Caraka Samhita* (Chikitsa 1.3).

Therapeutically, classical texts attribute to Vanga Bhasma actions such as *Pramehaghna*, *Krimighna*, *Shukrala*, *Vrushya*, *Balya*, and *Rasayana*. It is indicated in *Prameha* (diabetes), *Shukra Dosha*, *Kasa*, *Shwasa*, *Pandu*, and conditions involving *Kapha* vitiation. Its *Medhya* potential is inferred from *Dhatu* nourishment and overall rejuvenation, similar to other bhasmas like *Swarna Bhasma*, which is explicitly *Medhya* and *Smritivardhaka*. In *Rasatarangini* (18/25-28), specific methods for its preparation are outlined, emphasising repeated *Puta* (typically 10–13) until desired characteristics are achieved.

Contemporary interest in Vanga Bhasma stems from its potential as a nanoparticulate medicine. Raw tin is toxic, but classical processing converts it into stable oxides with reduced particle size, facilitating cellular uptake without heavy metal accumulation when prepared authentically. This review examines the pharmaceutical processes, analytical characterisation rooted in both *grantha* parameters and modern instrumentation, and proposes experimental frameworks for evaluating its nootropic activity—enhancing learning, memory, and neuroprotection. Such integration is crucial for evidence-based validation while respecting *Shastric* authenticity.

Pharmaceutical Preparation of Vanga Bhasma as per Ayurvedic Granths

The preparation of Vanga Bhasma follows a systematic protocol detailed in texts like *Ayurveda Prakash*, *Rasatarangini*, *Rasaratna Samuccaya*, and *Rasendra Chudamani*. It begins with *Shodhana* (purification) to remove impurities (*Mala*), followed by *Jarana* (roasting or incineration with herbs to initiate oxide formation), and culminates in *Marana* (calcination) using the *Puta* system with herbal *Bhavana* (levigation) media.

According to *Ayurveda Prakash* (3rd chapter), *Khuraka Vanga* is selected. *Samanya Shodhana* for the *Loha* group involves melting and quenching in herbal decoctions or juices like *Triphala*, *Gomutra*, or specific *Taila*. For Vanga, melting followed by pouring into *Churnodaka* (lime water), *Apamarga* (*Achyranthes aspera*), *Panchanga* juice, or *Aloe vera* juice is common. *Vishesha Shodhana* may include trituration with *Haridra* or other agents. Shlokas stress that *Shodhana* eliminates *Dhatu Dosha* (metallic defects), making it amenable to further processing.

Jarana is a critical intermediate step. In many methods, purified Vanga is melted and treated with *Apamarga* powder or *Ashwattha* (*Ficus religiosa*) powder, ground thoroughly, and processed to initiate oxidation. This step converts metallic tin toward stannous (SnO) or stannic (SnO_2) forms and removes volatile impurities. *Rasatarangini* describes *Jarana* with specific herbal aids to enhance therapeutic attributes. Washing of *Jarita Vanga* removes residual alkaline materials from herbal media.

Marana involves *Bhavana* with herbal juices (*Swarasa* or *Kwatha*) followed by *Puta*—placing the mixture in *Sharava* (earthen saucers), sealing with *Multani mitti*, and subjecting to controlled heating in a *Puta* (pit furnace) using cow dung cakes or specific fuels. Texts recommend 10–13 *Puta* cycles until the material passes classical tests: *Varitaratva* (floats on water due to lightness and fineness), *Nishchandratva* (no metallic lustre), *Nisvadutva* (tasteless), *Rekhapurnatva* (enters furrows when rubbed), and *Anjanatulya* (collyrium-like fineness). The final product is a greyish-white, fine powder. *Ayurved Prakash* and *Rasatarangini* provide specific shlokas for these *Puta* numbers and media.

Herbal media not only aid oxidation but also impart *Gunas* (qualities). For instance, *Apamarga* is *Ksharana* and *Lekhana*, potentially enhancing penetration; *Aloe vera* provides soothing *Sheetala* properties. This herbo-metallic synergy is central to Ayurvedic pharmaceutics, distinguishing Bhasma from mere metal oxides. The entire process embodies *Samskara*—transformative refinement—turning potentially toxic tin into a *Yogavahi* (catalyst-like) *Rasayana*.

Classical quality control relies on *Pareekshas* (tests) described in *Rasashastra*. Modern validation supplements these without contradicting *Shastric* intent. The preparation demands expertise, as deviations can lead to incomplete conversion or residual toxicity. Authentic Vanga Bhasma is thus a product of

meticulous pharmaceutical art rooted in centuries of observation.

Analytical Characterisation: Bridging Classical and Contemporary Methods

Classical texts define ideal Vanga Bhasma through organoleptic and physical tests. It should be *Shweta* or grayish-white, *Sukshma* (fine), *Laghu* (light), free from metallic sheen (*Nishchandra*), tasteless (*Nisvadu*), and capable of floating on water (*Varitara*). When rubbed between fingers, it should fill skin lines (*Rekhapurna*) and resemble *Anjana* (collyrium) in smoothness. *Apurnabhava* (non-reducibility on heating with charcoal) and *Niruttha* (no metallic residue) confirm complete incineration. These parameters ensure safety and efficacy.

Modern pharmaceutical analysis corroborates and quantifies these attributes. Studies following *Ayurveda Prakash* or *Rasatarangini* report successful preparation after approximately 13 *Puta*, yielding a grayish-white powder. X-ray Diffraction (XRD) consistently identifies the primary phase as Tin (IV) oxide (SnO_2, cassiterite) with some SnO (romarchite) in intermediate stages. Raw Vanga shows metallic tin peaks; post-*Jarana* and *Marana*, these shift to oxide forms, indicating successful oxidation. Particle size reduces dramatically—from micrometres in raw tin to 45.8–300 nm in final Bhasma, with 50% nanoparticles in traditional preparations. Scanning Electron Microscopy (SEM) reveals irregular to spherical nanoparticles, enhancing surface area and bioavailability.

Energy Dispersive X-ray Analysis (EDX or EDAX) shows increased oxygen percentage and decreased tin content compared to raw material, confirming oxide formation. Trace elements from herbal media (e.g., Ca, Mg, C) may integrate, forming organo-metallic complexes. X-ray Fluorescence (XRF) provides elemental composition, while Fourier Transform Infrared Spectroscopy (FTIR) can detect functional groups from herbal processing. Differential Light Scattering (DLS) further characterises the hydrodynamic size distribution.

These findings align with Ayurvedic *Sukshmatva* (subtlety). The nanoscale nature facilitates crossing biological barriers, including potentially the blood-brain barrier, relevant for nootropic evaluation. Safety is evidenced by the absence of free metallic tin and compliance with heavy metal limits when processed classically. However, batch-to-batch variability necessitates standardisation: fixed *Puta* numbers, standardised herbal media, and validated analytical fingerprints.

Comparative studies of different methods (e.g., with *Churnodaka* vs. *Apamarga*) show variations in particle size and oxide purity, underscoring the importance of *Shastric* fidelity. Analytical data thus serve as a bridge, validating ancient observations with scientific rigour while preserving the holistic paradigm of *Rasashastra*.

Therapeutic Profile and Rationale for Nootropic Activity

In Rasashastra classics, Vanga Bhasma is primarily *Kapha Shamaka*, *Shukra Vardhaka*, and *Rasayana*. It is indicated for *Prameha* (urinary disorders including diabetes), *Shukra Kshaya* (seminal deficiency), *Premature ejaculation*, *Obesity*, *Anaemia*, *Asthma*, and *Krimi* (worms). Its *Vrushya* (aphrodisiac) and *Balya* (strength-promoting) actions stem from *Shukra Dhatu* nourishment, which sequentially forms higher *Dhatus* and *Ojas*—the essence governing immunity, vitality, and mental clarity.

Medhya potential is implied rather than always explicitly stated for Vanga, yet texts like *Rasendra Chudamani* link certain Vanga preparations to *Rasayana* effects that enhance overall *Pragya* (wisdom). This parallels *Swarna Bhasma*, explicitly *Medhya* and *Smritivardhaka*, or herbal *Medhya Rasayanas* (*Brahmi*, *Shankhapushpi*, *Vacha*). In *Upanishadic* terms, *Medha* arises from balanced *Manas*, *Buddhi*, and *Prana*; substances nourishing *Tejo* and *Ojo Dhatu* support cognitive functions. Vanga, being *Sheetala* and *Snigdha* in processed form, may pacify *Vata* in *Majja Dhatu* (nervous tissue) while strengthening *Kapha* for the stability of the mind.

Contemporary understanding of nootropics involves enhancement of memory, learning, neuroprotection, and cholinergic or antioxidant mechanisms. Bhasmas in general exhibit antioxidant, anti-inflammatory, and immunomodulatory effects due to their nanoparticulate and herbo-metallic nature. While direct studies on Vanga Bhasma's cognition-enhancing effects are sparse, analogous bhasmas and the herbal media used in its preparation (e.g., *Apamarga*, known for bioactive compounds) suggest plausible pathways. Tin oxides in nano-form may influence enzymatic activities or ion channels, though mechanisms require elucidation.

Ojas depletion in modern stress correlates with cognitive decline. Vanga Bhasma's *Dhatu Poshana* could replenish this, indirectly supporting *Smriti* (memory) and *Dhi*. Antimicrobial studies further show its efficacy against pathogens, reducing systemic inflammation that impairs cognition. A critical appraisal of Ayurvedic nootropics highlights *Medhya* drugs acting via *Dhi*, *Dhriti*, and *Smriti* enhancement—Vanga may complement these through *Rasayana* effects.

Thus, the rationale for nootropic evaluation rests on: (1) classical *Rasayana* and *Medhya*-supportive indications; (2) nanoscale bioavailability potentially reaching neural tissues; (3) synergy with processing herbs possessing neuroprotective phytoconstituents; and (4) the need to explore safe alternatives to synthetic nootropics with side effects.

Proposed Experimental Evaluation of Nootropic Activity

Experimental validation of nootropic activity requires standardised animal models assessing acquisition, consolidation, and retrieval of memory, alongside biochemical markers. Though directly published studies on Vanga Bhasma are limited, protocols can draw from evaluations of similar Ayurvedic formulations and *Medhya* drugs.

Acute and subchronic toxicity studies (OECD guidelines) must precede efficacy testing to confirm safety at therapeutic doses (classically 125–250 mg/day with *Anupana* like honey or ghee). Doses for animals could be extrapolated (e.g., 50–200 mg/kg).

Common models include:

1. **Scopolamine-induced amnesia**: Scopolamine (1–3 mg/kg i.p.) disrupts cholinergic transmission, impairing spatial and recognition memory. Morris Water Maze (MWM) measures escape latency and platform crossings; Radial Arm Maze assesses working and reference memory errors.

Vanga Bhasma pre-treatment should reduce latency and errors dose-dependently if nootropic.

2. **Passive Avoidance Test**: Step-through or step-down latency evaluates retention. Increased latency post-training indicates memory enhancement.
3. **Elevated Plus Maze**: For anxiety-related cognitive effects, as reduced anxiety can facilitate learning.

Biochemical assays: Brain homogenates for acetylcholinesterase (AChE) inhibition (cholinergic boost), malondialdehyde (MDA) and glutathione (GSH) for antioxidant status, and BDNF or NGF levels for neurotrophic support. Histopathology of the hippocampus and prefrontal cortex can reveal neuronal protection.

In vitro studies on neuronal cell lines (e.g., PC12) could assess cytotoxicity, neurite outgrowth, or protection against oxidative stress (H_2O_2 or Aβ models). Since processing involves herbs like *Apamarga* (with potential anti-inflammatory alkaloids), comparative groups (pure tin oxide vs. classically prepared Bhasma) would isolate contributions.

Statistical analysis (ANOVA followed by post-hoc tests) ensures rigour. Controls include vehicle, positive nootropics (piracetam or *Brahmi* extract), and disease model. Experiments should adhere to CPCSEA guidelines.

Such studies would test the hypothesis that Vanga Bhasma enhances memory via antioxidant, cholinergic modulation, or *Dhatu*-nourishing mechanisms, providing scientific depth to classical claims. Pilot data from analogous bhasma studies (e.g., *Swarna*) showing cognitive benefits support feasibility. Long-term studies in aged or transgenic Alzheimer's models could further explore disease-modifying potential.

DISCUSSION

The pharmaceutical journey of Vanga Bhasma from raw *Puti Loha* to therapeutic *Bhasma* exemplifies Ayurvedic ingenuity in detoxification and potentiation. Analytical data validate classical *Pareekshas*, revealing a nanoparticulate SnO_2-rich material compatible with biological systems. Its traditional uses in *Shukra* and *Kapha*-related disorders provide a foundation for broader *Rasayana* effects, including cognitive support.

Challenges include standardisation across batches, precise mechanistic insights, and regulatory acceptance of herbo-metallic drugs. Variability in herbal media and *Puta* intensity affects quality; hence, pharmacopoeial monographs integrating XRD/SEM fingerprints with *Shastric* tests are essential.

For nootropic activity, while direct evidence is emerging slowly, the conceptual alignment with *Medhya Rasayana* and observed bioactivities of bhasmas justify dedicated research. Potential mechanisms—nanoparticle-mediated delivery, trace elemental support for enzymes, or herbal synergy—merit exploration through multi-omics approaches.

Integration of *grantha* knowledge with modern science honours Ayurveda's holistic ethos. Vanga Bhasma, if proven nootropic, could offer a safe, affordable option amid rising cognitive disorders. Future work should focus on clinical trials in healthy volunteers or mild cognitive impairment subjects, using validated scales (e.g., MMSE, MoCA) alongside biomarkers.

CONCLUSION

Vanga Bhasma stands as a profound example of Ayurvedic pharmaceutical science, meticulously detailed in *Rasashastra granths* and supported by analytical characterisation confirming its nanoscale, oxide form. Its classical *Medhya*-supportive profile, rooted in *Dhatu* nourishment and *Rasayana* action, alongside *Upanishadic* emphasis on cognitive faculties, positions it as a candidate for nootropic evaluation. Proposed experimental models using amnesia paradigms and neurochemical assays can bridge ancient wisdom with contemporary evidence.

Rigorous, *Shastra*-compliant studies are imperative to establish safety, efficacy, and mechanisms. Such research not only validates traditional claims but also enriches the global pharmacopoeia with time-tested, nature-aligned interventions. Vanga Bhasma embodies the potential of Ayurveda to contribute meaningfully to cognitive health in the 21st century, provided scientific depth respects its philosophical and pharmaceutical origins.

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