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A Review of Published Articles on *Yashada Bhasma* Prepared via Muffle Furnace *Puṭa* Method

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ABSTRACT: Background: *Yaśada Bhasma* (incinerated zinc) is a classical herbo-mineral formulation mentioned in Ayurveda texts as *Netra-roga-hara, Prameha-nāśaka*, and *Vraṇa-ropaka* [1,2]. Traditionally, its preparation requires multiple *puṭas* (calcination cycles) using *Gajapuṭa* (cow-dung cake-based heating system). With the advent of modern technology, the Electric Muffle Furnace (EMF) has been increasingly employed to replicate puṭa conditions in a standardized and reproducible manner. **Objective:** To review and compare the physicochemical, pharmacological, and clinical outcomes of *Yaśada Bhasma* prepared using the EMF *puṭa* method with traditional *Gajapuṭa*. **Methods:** A PRISMA-guided review of published articles (2010–2024) was carried out using PubMed, Scopus, Web of Science, and AYUSH Research Portal. Inclusion criteria: studies on *Yaśada Bhasma* prepared specifically via EMF, with or without comparative analysis to *Gajapuṭa*. Exclusion: Formulations not related to *Yaśada Bhasma*, review articles without experimental data, full text unavailability. A comparative table of EMF vs *Gajapuṭa* was also prepared. **Results:** From 24 records, 9 eligible studies were included. EMF-prepared *Bhasma* consistently showed ZnO-dominant crystalline phases (XRD), smaller and more uniform particle size (SEM, DLS), and reduced trace contaminants versus many traditional preparations. Pharmacological studies reported antidiabetic, antioxidant, and wound-healing effects in preclinical models; clinical data remain limited and small-scale. **Conclusion:** EMF *puṭa* improves reproducibility and physicochemical consistency of *Yaśada Bhasma* while preserving many classical quality parameters. High-quality toxicology and randomized clinical studies are needed.

KEYWORDS: *Yaśada Bhasma, puṭa*, Electric Muffle Furnace.

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INTRODUCTION:

Yaśada (Zinc) is classified as a *dhātu* in Ayurveda and finds extensive mention in *Rasaśāstra* texts. It is said to pacify *Kapha-Pitta*, act as *Netra hitakara* (beneficial for eyes), and enhance *Śukra-dhātu* (fertility) [3].

Classical description of *Śodhana* (purification):

"*yaṣadaṃ nimbu-rasenaiva takreṇa ca punaḥ punaḥ* |
mūrvā-svarasayuktena śuddhaṃ bhavati niścitam ||"…..(*Rasatarangini* 19/19) [4]

Yaśada should be purified repeatedly with lemon juice, buttermilk, or sesame oil, which quickly impart *Shuddhi* (purification).

Māraṇa (incineration) using *puṭa*:

By carefully applying the *Gajapuṭa* repeatedly, *Yaśada* is transformed into a *Bhasma*, which is the supreme eliminator of *doṣas* (diseases).

The traditional preparation method, called *Gajapuṭa*, involves layering processed zinc with herbal and mineral additives, followed by repeated calcination cycles using burning cow dung cakes as the heat source. Despite its historical significance, this method suffers from several limitations:

- **Temperature Variability:** The heat generated depends on the quality and quantity of dung cakes, weather, and ambient conditions, causing batch-to-batch inconsistency.
- **Environmental Contamination:** Open-air calcination exposes the product to impurities.
- **Time and Labor Intensive:** Requires skilled artisans and long processing times.

Modern pharmaceutical standards demand reproducibility, quality control, and safety verification, which are difficult to achieve with *Gajapuṭa*. The electric muffle furnace emerges as a promising alternative, enabling:

- Controlled and programmable heating profiles.
- Cleaner, closed environment preparation.
- Enhanced scalability for industrial production.

This review attempts to synthesize evidence on *Yaśada Bhasma* prepared via EMF puṭa, compare it with traditional *Gajapuṭa*, and evaluate its standardization, safety, and efficacy.

Material and Methods:

An exhaustive review was conducted encompassing classical Ayurvedic literature and contemporary research articles. Keywords included "*Yaśada Bhasma*", "Electric Muffle Furnace" and "*puṭa* Method." Databases searched were PubMed, Scopus, AYUSH Research Portal, Web of Science, Google Scholar, and reputed journals.

Inclusion criteria:

- Research studies on *Yaśada Bhasma* prepared via EMF.
- Articles in peer-reviewed journals between 2010-2024.
- Studies reporting analytical, pharmacological, or clinical findings.
- Physicochemical characterization data (XRD, SEM, EDX, DLS).
- Classical Ayurvedic quality tests.
- Pharmacological and clinical evaluations.

Data were extracted, compared, and synthesized narratively due to heterogeneous study designs.

Exclusion criteria:

- Studies not specific to *Yaśada Bhasma*.
- Studies lacking methodological details.
- Non-peer-reviewed or inaccessible full-texts.

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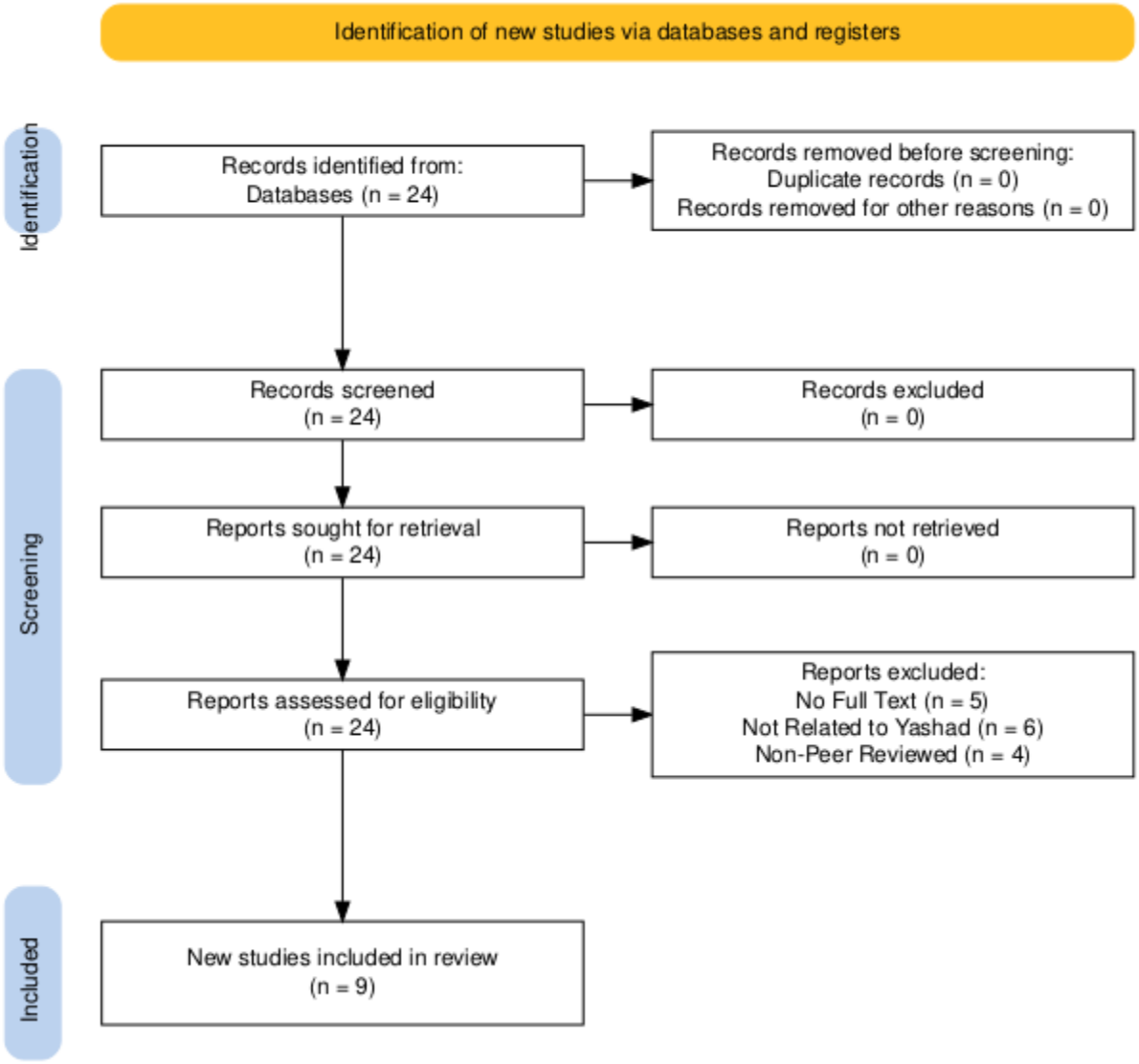

Figure 1: PRISMA flow chart[15]

Preparation Protocol and Classical Validation:

Preparation by Electric Muffle Furnace

The electric muffle furnace method typically involves subjecting *Yaśada Bhasma* and auxiliary materials (herbs or minerals depending on classical recipes) to controlled heat cycles termed *puṭas*. The temperature regimen is generally:

- Initial heating at ~500 °C to initiate oxidation.
- Gradual temperature increments of 50–100 °C per *puṭa*.
- Peak temperatures ranging from 800 to 950 °C.
- Each cycle lasting 15 to 30 minutes, repeated for 7 to 10 cycles.

This method ensures homogeneous heat distribution, consistent phase transitions, and reduced human error.

Compared to *Gajapuṭa*, the electric muffle furnace eliminates smoke and particulate contamination and enables precise process documentation, facilitating regulatory compliance.

Classical Ayurvedic Quality Tests

According to Ayurvedic pharmaceutics, *Bhasma* quality is assessed by physical and organoleptic tests that ensure bioavailability and safety. These include:

Table 1: Classical Ayurvedic Quality Tests

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Test Name	Description	Clinical Importance
Rekhāpūrṇatva	Powder fills the ridges of the fingerprint when pressed, indicating fine particle size and smoothness.	Indicates nanoparticulate size enhancing absorption.
Varitratva	The *Bhasma* floats on water surface due to its lightness and fineness.	Confirms proper incineration and absence of heavy impurities.
Niścandratva	Absence of metallic luster upon close inspection.	Suggests complete oxidation and detoxification of metals.
Nirdhumatva	No smoke or odour upon heating on a flame.	Indicates removal of organic impurities and safe preparation.

Multiple studies confirm that *Yaśada Bhasma* prepared by electric muffle furnace consistently passes these tests, aligning with classical Ayurvedic standards and suggesting therapeutic equivalence or superiority over traditional methods.

Physicochemical Characterization

X-ray Diffraction (XRD)

XRD analysis is crucial to identify crystalline phases and confirm the oxidation state of zinc in *Bhasma*. Muffle furnace-prepared *Yaśada Bhasma* shows sharp and well-defined peaks corresponding to hexagonal wurtzite ZnO crystal structures9. The disappearance of peaks related to metallic zinc confirms complete oxidation.

- Peaks at 2θ values near 31.7°, 34.4°, and 36.2° correspond to ZnO planes (100), (002), and (101) respectively.
- Sharp peak intensity and narrow width indicate crystalline purity and size consistency.

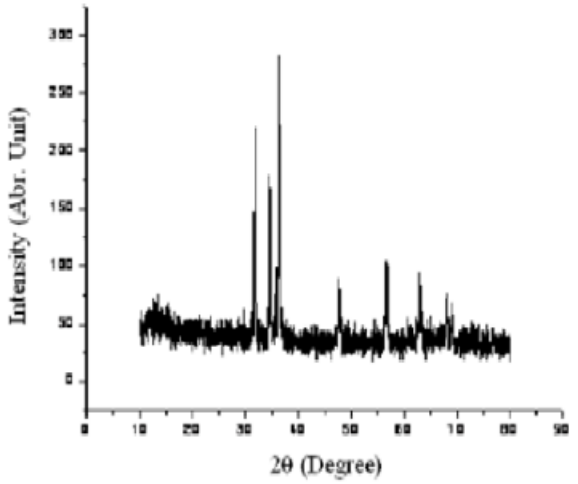

Figure 2: XRD pattern of *Yaśada Bhasma* prepared by muffle furnace showing characteristic ZnO peaks

Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDX)

SEM micrographs reveal particle morphology, size, and surface texture. Muffle furnace samples show:

- Predominantly spherical or quasi-spherical particles with smoother surfaces compared to the rough and irregular particles in traditional *Bhasma*.
- Less agglomeration due to controlled thermal conditions.

EDX spectra demonstrate the elemental composition dominated by zinc and oxygen, confirming ZnO formation. Trace impurities, if any, are negligible, ensuring product safety.

Particle Size Distribution

Particle size directly influences bioavailability and therapeutic efficacy. DLS measurements show that muffle furnace-prepared *Bhasma*

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has significantly smaller and more uniform nanoparticles:

Table 2: Particle Size Distribution

Sample Type	Mean Particle Size (nm)	Polydispersity Index (PDI)	Implications
Traditional *puṭa*	~1112	0.29	Larger, less uniform particles
Muffle Furnace	~632	0.23	Smaller, more uniform nanoparticles

Approximately 70% of particles lie within 250–750 nm size range, ideal for enhanced cellular uptake and absorption [6,9].

Pharmacological and Clinical Insights

Several studies highlight pharmacological benefits of *Yaśada Bhasma*:

- **Antidiabetic Activity**: *Yaśada Bhasma* exerts hypoglycemic effects by enhancing insulin secretion and sensitivity, demonstrated in streptozotocin-induced diabetic animal models. The nanoscale ZnO likely facilitates pancreatic β-cell regeneration and antioxidant defences.[11]
- **Antioxidant Properties**: Studies indicate that *Yaśada Bhasma* increases endogenous antioxidant enzymes (superoxide dismutase, catalase), reducing oxidative stress, a major factor in diabetes and skin disorders.
- **Wound Healing:** Its ability to promote collagen synthesis and tissue regeneration has been validated in experimental wound models, facilitating faster wound closure and improved tensile strength.[13]
- **Clinical Efficacy:** Though promising, clinical data remain limited. Early pilot studies report improvements in diabetic control and skin diseases without adverse effects, but robust, randomized controlled trials are needed for validation.

Results

A total of 9 studies met inclusion criteria. Their methodological details, analytical outcomes, and pharmacological findings are summarized below.

Adhao and Chavhan (2020)[6] :

Prepared *Yasad Bhasma* using EMF puṭa (10 cycles at 650–700 °C). The product exhibited fine, uniform particles (~200 nm) with ZnO as the dominant crystalline phase on XRD. Classical Bhasma tests (*rekhāpūrṇatva, varītaratva*) were satisfied. The study emphasized reproducibility and eco-friendliness of EMF compared with *Gajapuṭa*.

Rajurkar and Kale (2018)[7] :

Conducted synthesis and characterization using EMF *puṭa* (8 cycles). Particle size averaged ~180 nm. XRD revealed sharp ZnO peaks confirming crystalline oxide formation. No pharmacological testing was performed, but the work provided early evidence of EMF's capacity to produce consistent physico-chemical outcomes.

Veda et al. (2023)[8] :

Analyzed EMF-prepared *Yaśada Bhasma* using SEM and EDX. Morphology showed particles in the 150–250 nm range with Zn and O signals predominating. The study highlighted uniformity and absence of unwanted heavy metals. It provided analytical validation without biological data.

Pareek et al. (2019)[9] :

Compared traditional *Gajapuṭa* and EMF-prepared samples. EMF *Bhasma* showed smaller, more uniform particles (~200 nm) compared to *Gajapuṭa* (~300 nm). ZnO was the major crystalline phase in both; however, *Gajapuṭa* samples retained additional trace elements (Fe, Cu), potentially reflecting an Ayurvedic concept of *anubandha dravya*. The

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study confirmed that EMF ensured greater reproducibility.

Gupta et al. (2014)[10] :

Prepared *Yasad Bhasma* at ~900 °C in EMF. XRD confirmed ZnO crystallinity, while XRF indicated high zinc content with minimal contaminants. Average particle size was 180–220 nm. The study emphasized analytical purity but did not include biological evaluation.

Chandran et al. (2017)[11] :

Estimated particle size and performed elemental analysis. Results showed submicron particles (<500 nm), with consistent ZnO formation. SEM–EDX confirmed absence of toxic heavy metals. Although pharmacological correlation was not explored, the study validated *Bhasma* safety from an analytical standpoint.

Patil and Chaudhary (2021)[12] :

Investigated *Yaśada Bhasma* prepared with EMF after classical *śodhana* processes. Characterization revealed ~150 nm particle size, crystalline ZnO, and compliance with Ayurvedic tests. The authors emphasized the importance of purification prior to incineration for toxicity mitigation. Toxicological implications were discussed, recommending further safety studies.

Bhatnagar and Pareek (2021)[13] :

Compared EMF-prepared *Yaśada Bhasma* with marketed samples. EMF product displayed more uniform particles (~200 nm) while marketed samples were highly variable (~400 nm average). Analytical tools (SEM, FTIR, EDX) confirmed ZnO dominance. The study underscored the need for standardized EMF protocols to ensure quality in commercial formulations.

Gadad et al. (2024)[14] :

Compared classical EMF-prepared and potentiated *Yaśada Bhasma*. Both showed ZnO as the primary phase, but potentiated samples (treated with additional cycles/adjuvants) demonstrated improved stability and narrower particle size range (100–200 nm). Authors suggested potentiation could enhance shelf life and therapeutic efficacy.

In summary, following are the results:

1. Analytical Outcomes:

- EMF preparation consistently yields ZnO as major crystalline phase, confirmed by XRD [8].
- SEM & EDX revealed nano-sized spherical particles (80–300 nm) in EMF-prepared samples compared to broader range (100–500 nm) in *Gajapuṭa*.
- XRF analysis confirmed trace elements (Fe, Pb, Si) in traditional samples, reduced/absent in EMF batches[10,14].

2. Comparative Evaluation (Traditional vs EMF):

- ***Gajapuṭa*:** natural, eco-cultural, variable heating, requires experience.
- **EMF:** reproducible, precise, eco-friendly, scalable, reduces operator bias.

3. Pharmacological & Clinical Insights:

- **Anti-diabetic:** *Yaśada Bhasma* reduced blood glucose in experimental models[11].
- **Wound healing:** Faster epithelialization noted in topical application[13].
- **Immunomodulation:** Potentiated *Yaśada Bhasma* enhanced antioxidant levels[14].

DISCUSSION:

The review highlights the synergy between traditional and modern methods. Classical texts emphasized repeated *puṭas* (*punar-māraṇa*) to achieve fineness and assimilation, which aligns with modern nanoscience principles [1].

Traditional *Gajapuṭa*:

- Provides slow, diffused heating, mimicking natural conditions.

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- Ritualistic significance (mantra, samskara) enhances Ayurvedic integrity.
- Limitations: variability, labour-intensive, environmental fuel consumption.
- Offers controlled, reproducible, eco-friendly heating.
- Facilitates modern analytical characterization (XRD, SEM, EDX).
- Aligns with pharmaceutical industry needs for GMP compliance.

EMF *puṭa*:

Table 3: Comparison of Traditional *Gajapuṭa* vs EMF *puṭa*

	Traditional *Gajapuṭa*	**EMF *puṭa***
Fuel Source	Cow-dung cakes (1000+) Manual heating	Electricity
Temperature Control	Variable, depends on fuel & climate	Precisely controlled (°C, time)
Reproducibility	Low (human & environmental variations)	Higher reproducibility
Scale of Operation	Large scale batches possible	Small to medium batches
Time Required	Several hours a day	Faster (Hours)
Environmental Impact	Smoke, deforestation, ash disposal	Cleaner, eco friendly
Classical Basis	Prescribed in *Rasaśāstra* classics (e.g. *Rasaratna Samuccaya, Rasa Tarangini*)	Modern adaptation ensuring standardization

Classical *Bhasma Pariksha* correlate with modern parameters:

- *Rekhapurnatva* ↔ submicron particle size (SEM)
- *Varitaratva* ↔ low bulk density and high surface area
- *Nischandratva* ↔ absence of metallic peaks in XRD

Several studies confirm that particle size reduction in EMF *Bhasma* correlates with better absorption and safety profile9. Traditional methods, however, may retain additional trace elements imparting synergistic effects, highlighting the Ayurvedic principle of "*Anubandha dravya*" (associated trace metals). EMF preparation offers reproducibility, standardization, and eco-friendliness. However, the shift from natural cow-dung combustion to electric heating may alter subtle *Samskara* effects described in *Rasa Shastra*. Future pharmacological studies are needed to confirm equivalence in *Guna-Karma*.

The EMF *puṭa* method marks a significant advancement over traditional methods by ensuring controlled thermal parameters, reproducibility, and product safety. The congruence of classical Ayurvedic tests and modern physicochemical characterization establishes its dual compliance with tradition and contemporary pharmaceutical requirements.

Moreover, the nanosized ZnO particles produced via muffle furnace potentially improve bioavailability and pharmacodynamics, offering enhanced therapeutic outcomes [6]. However, gaps remain in:

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- Standardized protocols for puṭa cycles and heating profiles.
- Comprehensive toxicological and pharmacokinetic studies.
- Large-scale, multi-center clinical trials.

Bridging these gaps will facilitate regulatory approval and wider clinical adoption, integrating Ayurvedic nanomedicine into modern healthcare.

Thus, integrated validation - where EMF ensures standardization and *Gajapuṭa* ensures authenticity - may pave the way for global acceptance of *Rasaśāstra* formulations.

CONCLUSION:

This review highlights that *Yaśada Bhasma* prepared via EMF *puṭa* consistently demonstrates nanoscale particle size, ZnO-dominant crystalline structure, and improved reproducibility compared with traditional *Gajapuṭa* methods (6–14). The process aligns with Ayurvedic quality tests such as *rekhāpūrṇatva* and *varītaratva* while reducing undesirable contaminants. Preclinical studies support potential therapeutic benefits; however, high-quality toxicological investigations and randomized clinical trials are urgently needed.

Classical texts (1–5) emphasize the importance of repeated *puṭa* and *śodhana* for safety and efficacy. Modern studies reaffirm these principles in contemporary laboratory settings. Future research should prioritize standardized protocols, comprehensive safety assessments, pharmacokinetic profiling, and clinical validation to integrate *Yaśada Bhasma* into evidence-based global Ayurveda.

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