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REVIEW ARTICLE

Yashada Pushpa: Bridging classical rasashastra and modern science - A review of its textual evolution, pharmaceutical perspectives, therapeutic potential, and safety

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Abstract

Introduction: *Yashada Pushpa* is a specialized herbo-mineral formulation of *Pushpa Kalpana* in classical Rasashastra. Although traditionally used in topical, ocular, and mucosal disorders, its classification, pharmaceutical preparation, and distinction from *Yashada Bhasma* remain insufficiently clarified. This review evaluates its historical evolution, pharmaceutical processes, physicochemical mechanisms, therapeutic applications, and contemporary relevance. **Materials and Methods:** Classical Ayurvedic texts, including Samhita, Nighantu, and Rasagranths, were critically reviewed alongside modern literature from PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar. Historical, archaeometallurgical, pharmaceutical, physicochemical, clinical, and toxicological evidence was comparatively analyzed. **Results:** The review identified five principal pharmaceutical approaches for *Yashada Pushpa*, predominantly involving high-temperature open-pan processing and aerial oxidation of zinc, producing a characteristic white, low-density sublimate. Its formation through vapor-phase oxidation and condensation differs fundamentally from the repeated *Putapaka* incineration employed for *Yashada Bhasma.* Classical applications include topical, ocular, and mucosal therapies, with formulations, such as *Yashadamruta Malahara, Shweta Netranjana*, and *Netra Rakshaka Bindu*. The analytical findings established that *Yashada Pushpa* predominantly consists of zinc oxide (ZnO). Contemporary evidence supports the biocompatibility and therapeutic potential of ZnO in wound healing, eczema, burns, and ocular disorders, while highlighting the importance of controlled processing and quality assessment. **Conclusion:** *Yashada Pushpa,* as a distinct pharmaceutical preparation of *Pushpa Kalpana*, has classical nomenclature, pharmaceutical procedures, therapeutic applications, and analytical characteristics that demonstrate continuity between traditional Rasashastra concepts and the physicochemical identity of ZnO.

Key words: *Pushpa Kalpana, Pushpanjana*, rasashastra, *Yashada Pushpa*, zinc oxide

INTRODUCTION

Ayurveda, the traditional Indian system of medicine, encompasses an extensive pharmacopeia derived from botanical, zoological, mineral, and metallic matrices. Within this discipline, Rasashastra (Ayurvedic alchemy and iatrochemistry) represents a specialized pharmaceutical branch dedicated to the processing of metals, minerals, and metalloids for therapeutic applications.[1] The foundational philosophy of Rasashastra posits that toxic or non-absorbable inorganic raw materials can be transformed into therapeutically suitable formulations through intricate, step-wise pharmaceutical operations. These processes include *Shodhana* (purification), *Dhalana* (melting and quenching), *Nirvapa* (heating and quenching), *Jarana* (roasting), *Marana* (incineration), and *Bhavana* (levigation). Such processing can produce substantial physicochemical, crystalline, particle-size, and morphological changes in the starting materials.[1]

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Yashada Pushpa represents a specialized yet comparatively underexplored pharmaceutical form of *Yashada* (metallic zinc), an element holding considerable therapeutic importance in later Ayurvedic and Rasashastra literature. Historical evidence indicates the early development of zinc metallurgy in India, with medieval texts, such as the Dhanvantari Nighantu (14th century) providing explicit documentation of *Yashada*/*Jasada*.[2] While *Yashada Bhasma* (zinc calx) has been extensively investigated regarding its preparation, material properties, and clinical efficacy, *Yashada Pushpa* retains a distinct identity in classical sources. The term *Pushpa*, literally meaning "flower," denotes a delicate, light, or flower-like morphology,[3] indicating that *Yashada Pushpa* is a distinct transformation of zinc rather than a mere synonym for *Yashada Bhasma*.

Emerging analytical studies indicate that although both *Yashada Pushpa* and *Yashada Bhasma* are primarily composed of zinc oxide (ZnO),[4] they differ markedly in particle morphology and crystalline characteristics: Scanning electron microscopy (SEM) reveals that *Yashada Pushpa* exhibits crystalline, polyhedral particles, whereas *Yashada Bhasma* displays a comparatively amorphous structure with smaller particle size.[4] These findings substantiate the classical Ayurvedic principle that variations in pharmaceutical processing can yield distinct physicochemical and therapeutic profiles from the same raw material. Nevertheless, the classical identity and pharmaceutical development of *Yashada Pushpa* remain inadequately consolidated, with relevant information scattered across diverse texts and historical periods under various nomenclatures, such as *Pushpanjana*, *Jasada ka Phula*, *Yashada Bhasma*, and *Yashada Pushpa*. This fragmentation underscores the need for a dedicated and systematic review to synthesize classical references, reconstruct the textual identity of *Yashada Pushpa*, and critically evaluate its pharmaceutical procedures, characteristics, therapeutic applications, and relationship with other *Yashada*-derived preparations.

Accordingly, the present review aims to critically examine the classical literature pertaining to *Yashada Pushpa* and to reconstruct its textual and pharmaceutical identity through a comprehensive assessment of nomenclature, historical evolution, pharmaceutical processing, physicochemical characteristics, therapeutic indications, and its differentiation from related *Yashada* formulations. By integrating classical textual evidence with contemporary analytical insights, this review seeks to provide a consolidated reference for scholars, researchers, and practitioners engaged in Rasashastra and Ayurvedic pharmaceutics.

MATERIALS AND METHODS

The present review was conducted through a systematic analysis of classical Ayurvedic literature and contemporary peer-reviewed research publications pertaining to *Yashada Pushpa*. Primary qualitative data were sourced from foundational and medieval Rasashastra treatises, including Rasendra Mangala, Rasopanishada, Rasahridaya Tantra, Rasendra Chudamani, Rasendra Chintamani, Rasamanjari, Rasadarpana, Rasamitra, Rasa Ratnakara, Rasa Chandanshu, Rasarnava, Anandakanda, Rasendra Sara Samgraha, Rasapaddhati, Rasendra Sambhava, Bhaishajya Ratnavali, Bruhad Rasaraj Sundar, Rasakamadhenu, Ayurveda Prakasha, and Rasaratna Samucchaya, alongside modern authoritative compendia, such as Rasatarangini, Rasamruta, Rasajalanidhi, and Ras Tantra Saara evum Siddha Prayoga Sangraha. Lexicographical works, particularly the Amarakosha and classical Nighantus, were consulted to establish the etymological derivation and contextual semantics of the term *Pushpa*. To complement classical textual mining, relevant modern scientific literature was retrieved from electronic databases – including PubMed, Scopus, ScienceDirect, and Google Scholar – using targeted keywords and Boolean combinations, such as *Yashada Pushpa*, *Pushpanjana*, *Jasada ka Phula*, Zinc calx, and Physicochemical characterization. Data extraction and qualitative synthesis were systematically categorized according to historical chronology, nomenclature, pharmaceutical processing methods, organoleptic and physicochemical characteristics, therapeutic indications, and formulation profiles to establish a comprehensive critical assessment.

OBSERVATIONS AND RESULTS

Textual analysis reveals that *Yashada Pushpa* was not classified as an independent pharmaceutical entity during the Vedic, Samhita, medieval (*Madhyama Kala*), or early contemporary (*Adhunika Kala*) periods of Ayurveda. Instead, its evolution occurred alongside the broader emergence of *Pushpa* derivatives in later Rasashastra compendia, which were characterized by specialized sublimation dynamics and distinct therapeutic profiles. Across the surveyed classical corpus, four authoritative texts explicitly establish the pharmaceutical and clinical identity of *Yashada Pushpa*. Rasatarangini provides its earliest dedicated pharmaceutical methodology and sublimation protocol, which was subsequently corroborated and expanded by Aryabhishakaand Rasamrutaregarding standardized unit operations, compound formulations, adjuvant selection (*Anupana*), and multi-systemic therapeutics. Subsequently, the taxonomic positioning of *Yashada Pushpa* (oxidized zinc sublimate) was formalized by Harishankara Sharma in Ayurvediya Rasashastra, wherein it was classified as one of the three principal formulations comprising *Pushpa Kalpana*, alongside *Rasa Pushpa* (mercurous chloride sublimate) and *Navasadara Pushpa* (sublimated ammonium chloride).

Synonyms

Synonyms of *Yashada Pushpa* mentioned in Table1.

CLASSICAL AND CONTEMPORARY PHARMACEUTICAL METHODOLOGIES FOR THE SYNTHESIS OF *YASHADA PUSHPA*

Method 1 (Open-Pan Aerial Oxidation)

Shuddha Yashada (purified metallic zinc) is placed in an iron pan (*Loha Kadahi*) over a fireplace (*Chulha*) and heated under intense fire (*Teevra Agni*) until completely liquefied. Once molten, the metal is subjected to continuous, vigorous stirring using only an iron ladle (*Loha Darvi*) while sustaining high heat. Upon complete oxidation and powdering of the metallic zinc, the vessel is removed from the heating source, allowed to cool to ambient room temperature (*Swangasheeta*), and subsequently passed through a clean cloth sieve (*Vastragalita*). Any coarse or unoxidized residual particles retained on the cloth are reintroduced into the iron vessel, resubjected to strong calcination under intense heat, cooled, and refiltered. Across this specialized process, a superior-grade, luminous white calx of zinc resembling a delicate flower or the serene whiteness of moonlight (*Kundendu Dhavala*) is obtained. The product prepared through this specific pharmaceutical modality is classically recommended for external therapies, specifically as collyrium (*Anjana*) and Intranasal administration (*Nasya*).[9]

Method 2 (Brass Thermal Oxidation and Commentary)

When *Pittala* (brass; copper -zinc alloy, Cu - Zn) is melted, the zinc content within the alloy melts, vaporizes, and reacts with atmospheric oxygen to form a fine white powder, traditionally designated as *Pushpanjana* (or *Yashada Pushpa*). Alternatively, it is synthesized directly by heating pure metallic zinc alone in an iron or earthen container over intense heat. In his commentary, Pandit Kashinath Shastri notes that this preparation is specifically termed *Pushpanjana* due to its primary utilization as a collyrium. Shastri explicitly correlates this substance with modern ZnO and emphasizes its broad therapeutic efficacy across ophthalmic, topical, and other external formulations.[10]

Method 3 (Mechanical Trituration Under Heat)

Metallic zinc is placed in a pan (*Loha Kadai*) and continuously stirred/triturated with an iron ladle (*Loha Darvi*) under heat until it transforms completely into a calx (*Bhasma*). This preparation is designated as *Jasta na Phool* (or *Yashada Pushpa*).[7]

Method 4 (Regional Pyrometallurgical Synthesis)

When metallic zinc is placed in an iron vessel and subjected to intense heat from below, the molten metal continuously oxidizes to yield light, puffed flocculent flakes resembling popped grain (*Kheela*/*Lava*), traditionally termed *Jaste ke Phoola*. This substance is identical to classical *Pushpanjana*, which is commercially correlated with modern ZnO in contemporary pharmaceutical practice; although rarely obtained in its native mineral form, it is conventionally synthesized through such artificial pyrometallurgical methods in places, such as Jaipur (Rajasthan).[5]

Method 5 (Botanico-Pyrometallurgical Phyto-Oxidation)

Metallic zinc is melted in an iron pan and heated up to 800°C. Upon adding neem (*Nimba*) leaves over the molten surface and stirring with a Wooden twig (*Seenk*), the zinc begins to convert into flowers (*Phool*) while emitting a characteristic brilliant white flame. The oxidized flower-like flakes are progressively harvested as they form, while neem leaves are added to the remaining molten portion with continuous stirring. Through this repeated unit operation, the entire mass of zinc transforms into light, white flocculent flakes. This calx is subsequently triturated into a fine powder and applied as an ocular collyrium.[11]

Method 6 (Meenakshi *et al.* 2018)

The same principle as described in Rasatarangini (Method 1) was followed; however, instead of the classical method of heating in an iron vessel over a high flame, a silica crucible and a horizontal electric muffle furnace were used.[12]

INDICATIONS

Indications of Yashada Pushpa mentioned in Table 2.

Amayika Prayoga[7]

Amayika Prayoga of *Yashada Pushpa* mentioned in Table 3.

Formulations (*Yoga*)

Total 5 formulations mentioned in Classics which is mentioned in Table 4.

DISCUSSION

Historical Evolution and Textual Trajectory of *Yashada Pushpa*

The pharmaceutical evolution of *Yashada Pushpa* represents a trajectory from mineral by-products and metallurgical condensates to a standardized, pharmacopeial therapeutic entity. Textual and lexicographical analyses reveal

historical synonymity among *Pushpanjana*, *Yashada Pushpa*, *Shwetanjana*, *Jasada-ka-phula*, and occasionally *Yashada Bhasma* (as cited in regional compendia, such as Aryabhishaka). In early traditions where metallic zinc was not readily isolated in its elemental form, *Pushpanjana* was obtained either from zinciferous ores, such as *Kharpara* (*Khapariya*) or through the pyrometallurgical thermal oxidation of *Pittala* (brass; copper-zinc alloy, Cu-Zn). During the high-temperature processing of *Pittala*, the volatile zinc fraction selectively vaporized and underwent spontaneous aerial oxidation to form a fine, white, low-density condensate. Commentaries across authoritative treatises – including Rasadarpana,[17] Bhasma Vijnaniya,[18] and critical translations of Rasendra Chudamani[19] explain that this open oxidation produces a delicate, flocculent mass resembling floral petals or parched puffed grains (*Lava/Kheela*), justifying the classical designation *Pushpa* (flowers of zinc).

This specialized pharmaceutical preparation is directly tied to the chronological transition of its base metal, *Yashada* (elemental zinc), from an unisolated alloying constituent to an independent therapeutic element. During the Vedic and classical Samhita periods, zinc was not cataloged as an independent metallic element; rather, its therapeutic utility was documented indirectly through *Pittala* (brass), featured in formulations, such as ocular collyrium (*Anjana Prayoga*) in the Charaka Samhita.[20] Archaeometallurgical evidence from the Zawar mining complex in Rajasthan corroborates this indigenous technological proficiency, confirming that downward distillation pyrometallurgy for zinc extraction operated as early as the 6th century BCE and reached industrial-scale production by the 12th century CE.[21] Consequently, ancient Indian metallurgists isolated elemental zinc centuries before comparable industrial developments in Europe.[21] The formal categorization of zinc as an independent metal (*Yashada* or *Jasada*) in Ayurvedic compendia was consolidated by the 14th century, most notably within the Dhanvantari Nighantu.[2] The taxonomic positioning of sublimate-derived pharmaceuticals was subsequently formalized within specialized classification schemes. Notably, Harishankara Sharma, in Ayurvediya Rasashastra, established *Pushpa Kalpana* (flocculent/sublimated dosage forms) as an independent pharmaceutical class comprising three primary formulations: *Rasa Pushpa* (calomel/mercurous chloride sublimate), *Navasadara Pushpa* (sublimated ammonium chloride), and *Yashada Pushpa* (oxidized zinc sublimate), defined by vertical sublimation and condensation in specialized apparatuses, such as the *Damaru Yantra*.[22]

From a materials science perspective, contemporary scholarly commentaries correlate this classical preparation directly with pharmaceutical-grade ZnO. While foundational Samhitas, including the Charaka Samhita,[20] cited *Pushpanjana* primarily as a topical collyrium without detailing explicit manufacturing protocols, later medieval and contemporary Rasashastra treatises codified its synthesis. The standard method involving the direct open-pan ignition and aerial oxidation of elemental *Yashada* was formally instituted in Rasatarangini, and subsequently adapted by Aryabhishaka and Rasamrita. The therapeutic relevance of this zinc sublimate persists in regional ethnomedicine; in Punjab, for instance, it is traditionally known as *Mali* and widely employed as a domestic remedy for inflammatory and infectious ocular disorders.[18] Synthesizing the literary, archaeometallurgical, and pharmacological data demonstrates that while the conceptual origin of *Yashada Pushpa* traces back to the Samhita era as *Pushpanjana*, its definitive isolation, specialized taxonomy under *Pushpa Kalpana*, and standardized open-pan manufacturing protocols were established through the evolution of classical Rasashastra literature.

Nomenclature, Synonyms, and Ethnomedicinal Lexicography of *Yashada Pushpa*

The diverse nomenclature associated with *Yashada Pushpa* across classical Sanskrit compendia, vernacular dialects, Unani-Tibb literature,[23] and Western alchemy provides vital insights into its raw material precursors, pyrometallurgical origins, physical morphology, and specialized routes of therapeutic administration. The classical designation *Pushpanjana* directly highlights its primary historical formulation as an ophthalmic collyrium (*Netra Anjana*), encapsulating both its physical delicacy (*Pushpavata*) and its specific clinical role in soothing ocular inflammation and treating chronic conjunctival disorders. Furthermore, classical designations, such as *Reetija* and *Reetipushpa* (flowers of brass), explicitly denote its genealogical and metallurgical connection to *Reeti*, confirming that early practitioners retrieved this medicinal compound as an oxidized sublimate during the open calcination of brass alloys before the widespread pyrometallurgical isolation of pure elemental zinc. The consistent appearance of the morpheme *Pushpa* (flower) across Sanskrit and vernacular terminologies, including *Yashada Pushpa*, *Pushpanjana, Jasada ka Phula* in Hindi, and Jasta na Phool in Gujaratiderives directly from the unique macro- and micromorphology of the product, which condenses into a light, flocculent, snow-white mass resembling delicate floral petals or parched puffed grains (*Lava/Kheela*) during open-air oxidation. Corroborating this taxonomic placement, Harishankara Sharma explains that its light, delicate texture and snow-white, flower-like morphology justify both the nomenclature *Yashada Pushpa* and its formal classification under *Pushpa Kalpana*, noting that Rasatarangini designates this exact formulation under the authoritative synonym *Yashadamruta*.[22] In traditional regional trade and Unani lexicons, monikers, such as *Safeda Kashghari* point to historical Central Asian mineral trade routes while highlighting its pure white pigment (Safed), whereas the Northern Indian and Punjabi ethnomedicinal descriptor *Jashada Mali* reflects its entrenched household

application as a traditional domestic remedy (*Mali*) for ocular ailments.[18] Although certain texts, such as Aryabhishaka, describe this preparation broadly as *Yashada Bhasma* because it involves a specialized form of thermal destruction (*Marana*), it is fundamentally distinct from standard incinerated zinc. Standard *Yashada Bhasma* requires repeated, multi-cycle closed-crucible incineration (*Putapaka*) with herbal matrices to generate an ultra-fine, systemically bioavailable calx intended for internal metabolic disorders, such as *Prameha*, whereas the open-pan aerial oxidation protocol of *Yashada Pushpa* is engineered specifically to yield a crystalline, non-irritant sublimate for topical, ocular, and nasal applications, warranting its distinct pharmaceutical taxonomy. Historically, open-air sublimated ZnO was similarly designated in Western alchemy as Philosopher's Wool (Lana Philosophica), White Snow (Nix Alba), and Flowers of Zinc (Flores Zinci).[8] This cross-cultural convergence is scientifically justified by the pyrometallurgical phenomenon wherein zinc heated in ambient air spontaneously oxidizes and vaporizes, generating dense white oxide fumes that condense into light, wool-like, non-compacted flocculent filaments, thereby prompting both Indian Rasashastra scholars and Western alchemists to independently adopt identical floral and wool-like morphological descriptors.

Critical Pharmaceutical and Pyrometallurgical Evaluation of *Yashada Pushpa* Synthesis

A systematic evaluation of the five classical and contemporary preparation methodologies reveals the underlying thermodynamic, pyrometallurgical, and chemical mechanisms governing the formation of *Yashada Pushpa*. Historically and procedurally, these synthetic pathways are broadly categorized into two fundamental paradigms: Indirect extraction through the pyrometallurgical oxidation of volatile zinc vapor from intermetallic copper–zinc alloys (*Pittala*),[10] and direct high-temperature open-air thermal oxidation of elemental metallic zinc (*Shuddha Yashada*), conducted either with or without organo-botanical adjuvants.[9] In the alloy-based method documented in Rasatarangini (Method 2), differential vaporization drives the synthesis. Because metallic zinc possesses a relatively low boiling point (~907°C) compared to copper (~2562°C), intense thermal processing of molten brass (*Pittala*, Cu-Zn) induces selective volatilization of zinc. As the liberated zinc vapor rises and interfaces with ambient atmospheric oxygen near the molten pool surface, it undergoes spontaneous aerial oxidation ($2Zn + O2 \rightarrow 2ZnO$). This rapid vapor-phase reaction generates an ultra-fine, low-density white condensate traditionally designated as *Pushpanjana*, optimized for non-invasive external therapeutics. Crucially, this gas-phase oxidation and condensation proceed spontaneously above the melt surface without necessitating mechanical agitation or manual trituration. However, sustained prolonged heating of the alloy substrate often results in progressive darkening of the resultant powder, a chromatic alteration attributed to secondary lattice defects, structural phase alterations, over-oxidation of trace metals, or the thermal entrapment of volatilized copper oxide impurities, which prompted subsequent Rasashastra treatises to progressively shift toward the pyrometallurgical processing of pure elemental zinc to ensure chemical homogeneity.

The direct open-pan oxidation of purified elemental *Yashada* represents a technologically advanced, standardized synthesis route, though comparative textual analysis reveals procedural variations among authoritative authors. In Rasatarangini,[9] elemental zinc is heated above its melting point (419.5°C) in an open iron vessel and subjected to continuous manual shear/trituration with an iron ladle until complete oxidation into a fine powder occurs, followed by an intermediate cooling step and fine cloth filtration (*Vastragalita*) where unoxidized coarse residues are returned to the vessel for secondary calcination to ensure uniform particle size distribution and stoichiometric conversion to ZnO. Previous research studies have predominantly followed the direct open-pan method described in Rasatarangini.[4,12,24] Aryabhishaka[11] outlines a parallel protocol involving thermal processing coupled with continuous manual levigation using an iron ladle but omits the formal intermediate sieving and fractional re-calcination step. Rasamritam[5] describes an unagitated open-air thermal oxidation model, where zinc is heated under intense bottom-firing until it spontaneously oxidizes into puffed, flocculent flakes resembling parched grain, without requiring continuous manual mechanical rubbing or subsequent cloth filtration. Conversely, specialized compendia, such as Rasa Tantra Saara evum Siddha Prayoga Sangraha (RTSSPS) do not document dedicated primary synthesis procedures for *Yashada Pushpa*, instead citing it directly as a finished active pharmaceutical ingredient in compound therapeutic formulations, demonstrating its established status as an independent pharmaceutical commodity.

The botanico-pyrometallurgical method described in Bhasmavijnana[11] involves open-pan calcination of zinc at approximately 800°C, with the sequential addition of dried *Nimba* (*Azadirachta indica* A. Juss.) leaves. Thermal decomposition of the leaves promotes localized combustion and enhances zinc oxidation, producing the characteristic brilliant white flame and fine, flocculent ZnO flowers. Sequential leaf addition and continuous collection of the surface product help minimize slag formation, thereby facilitating the formation of a light, finely divided *Yashada Pushpa.*

Across all classical and contemporary texts, the core thermodynamic driver is consistently defined as *Tivragni* (intense heating), which is essential to overcome the high activation energy of zinc vaporization and maintain sustained exothermic oxidation kinetics. Although classical texts quantified heat through empirical firewood metrics rather than standardized pyrometric units, the endpoint was objectively determined through macroscopic transformation into an ultra-fine, non-metallic calx. Organoleptic assessment

served as the definitive benchmark for chemical purity: Rasatarangini specifies the endpoint as *Kundendu Dhavala* (a lustrous, moonlight/jasmine whiteness), corroborated by Rasamrutam as a pure white hue devoid of metallic luster. This persistent emphasis across core treatises confirms the synthesis of high-purity, stoichiometric ZnO free from unoxidized metallic residues (ZnO), thereby ensuring optimal particle softness, fineness, and therapeutic safety for delicate ocular (*Netra Anjana*) and mucosal (*Nasya*) surfaces.

Recent pharmaceutical and analytical investigations by Chauhan *et al*.[25] have provided important empirical support for the interpretation of classical pharmaceutical processes. Their findings indicate that *Tivragni* may be operationally correlated with a controlled furnace temperature range of approximately 900–950°C. This observation is further supported by another independent research study, which reported *Tivragni* at approximately 900°C,[12] which lies immediately below and around the boiling point of zinc (~907°C) to maximize vapor-phase sublimation.[12] Furthermore, Chauhan *et al*.[25] demonstrated that continuous manual rubbing or mechanical agitation of the molten zinc pool as advocated in Method 1 and Method 4is not indispensable for the synthesis of *Yashada Pushpa* and may in fact be counterproductive, as intensive mechanical scraping disrupts the static interfacial boundary layer, impedes the upward escape of free zinc vapors, and promotes localized solid-state roasting (*Yashada Jarana*) rather than true gas-phase sublimation into *Pushpa*. In addition, repeated contact with a cold iron spatula induces localized thermal quenching, destabilizing the uniform surface temperature required for continuous, efficient sublimation, indicating that the optimal formation of true, flower-like, flocculent *Yashada Pushpa* relies primarily on precise thermodynamic control (900–1000°C) and undisturbed aerial vapor-phase oxidation rather than excessive physical trituration.

Modern analytical characterization across published research articles definitively corroborates this pyrometallurgical transformation, confirming that *Yashada Pushpa* is predominantly composed of high-purity, stoichiometric ZnO. Quantitative X-ray fluorescence spectrometry validates near-theoretical elemental stoichiometry, demonstrating 80.33% elemental zinc (Zn) and 19.66% elemental oxygen (O),[12] confirming the near-total absence of unreacted precursor contaminants. X-ray diffraction profiling reveals sharp, well-defined diffraction peaks corresponding strictly to the crystalline hexagonal wurtzite lattice of ZnO,[25] verifying complete phase purity and high crystallinity without amorphous background noise. Surface morphological analysis using SEM reveals well-crystallized, distinct polyhedral and prismatic micro-architectures characteristic of vapor-condensed particulates,[4] while SEM energy-dispersive X-ray spectroscopy provides complementary semi-quantitative elemental confirmation with values of 66.98% Zn and 20.58% O.[25] Particle size analysis demonstrates the micro- to sub-micron dispersion of the product: Depending on specific pyrometallurgical cooling rates and harvesting protocols, particle size distributions range from 1.73 to 11.6 μm[4] in open-pan syntheses down to 0.15–0.91 μm[25] in rapid-quench Condensation regimes. This narrow, sub-micron to low-micron dimensional profile accounts for the soft, non-gritty, non-irritating texture of *Yashada Pushpa*, validating its classical selection for delicate ocular collyrium (*Netra Anjana*) and mucosal barrier repair.

Industrial Translation, Large-Scale Continuous Pyrometallurgical Manufacturing, and Commercial Ecosystem

The scale-up of *Yashada Pushpa* (ZnO) from classical batch-style crucibles to commercial-scale manufacturing operates on continuous pyrometallurgical principles analogous to the indirect French (vapor-phase) process. India possesses a robust industrial ZnO manufacturing base with key producers, including J.G. Chemicals Ltd.,[26] Rubamin Pvt. Ltd.,[27] Silox India Pvt. Ltd.,[28] Upper India Inorganic Industries Ltd., and MLA Group of Industries, which supply high-purity rubber (White Seal), ceramic, cosmetic, and pharmacopeial grades of ZnO. Translating these industrial capabilities to Ayurvedic good manufacturing practice standards requires an automated, continuous closed-loop pyrometallurgical assembly comprising four core stages: Melting and vaporization, controlled combustion, rapid pneumatic quenching, and fractional collection.

In an industrial setup, purified metallic zinc ingots (minimum 99.9% purity) are continuously fed into a refractory-lined, electrical induction or resistance furnace maintained between 920°C and 1000°C. Because this exceeds the atmospheric boiling point of zinc (~907°C), the molten pool continuously produces dense, high-pressure zinc vapor (Zn(g)). The generated zinc vapor is drawn into an adjacent oxidation combustion chamber, where preheated, filtered air or oxygen is continuously introduced. Upon contact, the zinc vapor undergoes spontaneous, highly exothermic combustion ($2Zn(g) + O2(g) \rightarrow 2ZnO$), producing a persistent white flame and rapidly nucleating fine, microcrystalline ZnO. The entrained aerosol of oxidized ZnO "flowers" is drawn through stainless steel (SS 316L) ducts under induced draft suction, undergoing rapid thermal quenching to prevent particle coalescence and sintering, thereby preserving the low-density, flocculent (*Pushpavat*) morphology. The aerosol passes into a multi-stage cyclone separator that isolates and returns coarse unoxidized particles to the furnace, while the fine, ultra-light ZnO calx fraction is continuously captured in high-efficiency reverse-pulse-jet polytetrafluoroethylene bag house collectors. The harvested ZnO (*Yashada Pushpa*) is discharged through rotary airlocks into automated vibratory sieves (300–400 mesh, fulfilling the classical *Vastragalita* standard), micronized through air-jet milling to ensure non-gritty texture, and packaged under ISO Class 7 cleanroom conditions to ensure stoichiometric ZnO purity, batch

uniformity, and regulatory compliance for ophthalmic and topical formulations.

Therapeutic Utility, Pharmacodynamics, and Synergistic Poly-Mineral Formulations of *Yashada Pushpa*

The clinical versatility of *Yashada Pushpa* is fundamentally governed by its specialized topical, mucosal, and ocular routes of administration, reflecting its targeted local bioavailability, biocompatibility, and non-irritant pharmacodynamic profile. As codified in the Rasatarangini,[9] its primary delivery modalities include *Anjana* (ophthalmic collyrium), *Nasya* (intranasal errhine/insufflation), and *Bahya Prayoga* (external dermatological and mucosal therapeutics). The explicit classical preference for topical and transmucosal delivery over systemic ingestion highlights its functional attributes as an ultra-fine, microcrystalline astringent (*Kashaya*), cooling (*Sheeta*), and wound-healing (*Vranaropana*) agent. By bypassing first-pass hepatic metabolism and systemic circulatory exposure, localized delivery mitigates potential systemic heavy-metal accumulation while optimizing active tissue saturation at vulnerable ocular and epidermal barrier sites.

The compounding strategies (*Amayika Prayoga*) documented in regional compendia, such as *Aryabhishaka*[7] demonstrate an advanced polypharmaceutical rationale engineered to balance astringency, antimicrobial activity, and mucosal cytoprotection across diverse ocular pathologies (*Netra Roga*). When co-triturated with *Sharkara* (sucrose/sugar), *Yashada Pushpa* serves as a soothing, demulcent preparation that alleviates conjunctival hyperemia, photophobia, and localized burning sensation. Formulations incorporating *Yashada Pushpa* with *Sphatika* (potassium alum, $KAl(SO_4)_2.12H_2O$) in a calibrated 1:4 ratio demonstrate enhanced styptic, protein-precipitating, and anti-exudative efficacy, wherein the inert, biocompatible ZnO lattice effectively attenuates the corrosive mucosal irritation typically induced by hypertonic alum. Furthermore, the quaternary multi-mineral collyrium combines equal proportions of *Yashada Pushpa*, *Sharkara*, and *Sphatika* with one-eighth part *Tuttha* (copper sulfate, $CuSo_4.5H_2O$). The combination may provide complementary pharmacological effects, with copper contributing antimicrobial activity and ZnO contributing antimicrobial, anti-inflammatory, and tissue-repair effects.[29] Consequently, these classical poly-mineral formulations establish the dual therapeutic utility of *Yashada Pushpa,* functioning both as a primary, non-cytotoxic wound-healing entity and as an essential biocompatible modulator that tempers the mucosal toxicity of potent inorganic mineral therapeutics.

Multi-Ingredient Formulations, Modern Pharmacological Correlations, and Safety Considerations of *Yashada Pushpa*

The integration of *Yashada Pushpa* across diverse classical and contemporary multi-ingredient formulations (*Yoga*) highlights its therapeutic utility as both a primary active base and a cytoprotective mineral carrier, with concentration gradients ranging from 0.48% to 98%. In dermatological therapeutics, preparations, such as *Yashadamruta Malahara*[13] (25% w/w in a *Siktha Taila*/beeswax–oil matrix) harness the astringent, antimicrobial, and re-epithelializing actions of ZnO in an occlusive, lipophilic base to manage *Agnidagdha Vrana*,

Table 1: Synonyms of *Yashada Pushpa* according to different texts

S. No.	Synonyms	Texts
1	*Jasde ka Phula*	Rasamruta,[5] Rastantra Saara evum Siddha Prayoga Sangraha[6]
2	*Jashada Pushpa*	Rasamruta[5]
3	*Pushpanjana*	
4	*Reetija*	
5	*Reetipushpa*	
6	*Jashada Mali*	
7	*Safeda Kashghari (Safaida)*	
8	Oxide of zinc	
9	*Jashada na Phula*	Aryabhishaka[7]
10	*Yashada Bhasma*	
11	Philosopher's wool	Modern literature[8]
12	White snow	

Table 2: Indications of *Yashada Pushpa* according to different texts

S. No.	Indications	Texts
1	*Nasya* (Intranasal administration)	Rasatarangini[9]
2	*Anjana* (collyrium)	Rasatarangini[9] Rasamruta[5] Bhasma Vigyan[11]
3	Bahya Prayoga (External application/use)	Rasatarangini[9]
4	*Netra Roga* (Eye disorders)	Aryabhishaka[7]

Table 3: *Amayika Prayoga* of *Yashada Pushpa* according to indications

S. No.	Indications	***Amayika Prayoga***
1	*Netraroga* (External use)	*Yashada Pushpa* is indicated in combination with *Sharkara.* *Yashada Pushpa* is indicated in ¼ part with 1 part of *Sphatika*. *Yashada Pushpa, Sharkara*, and *Sphatika* are indicated in equal proportions, along with ⅛ part of *Tuttha*.

Table 4: Details of *Yashada Pushpa* used in the different formulations

S. No.	Formulations	Proportion of *Yashada Pushpa* (%)	Proportion of other ingredients (%)	Indications
1.	*Yashadamruta Malahara*[13]	25	*Siktha Taila* (75)	*Vrana Ropana* (Wound healing), *Vicharchika* (Eczema), *Agnidagdha Vrana* (Burns)
2.	*Tuttha Kharpara Bhasma*[6]	98 (*Yashada Pushpa/Bhasma*)	*Nilathotha (Shuddha Tuttha*) (2)	*Jirna Jwara* (Fever), *Jirna Atisara* (Diarrhea), *Sangrahani* (Chronic diarrhea with malabsorption of nutrients)
3.	*Shweta Netranjana*[14]	27.27	*Sharkara* (13.8) Boric acid (55.5) *Karpura* (2.7)	*Abhishyanda* (Conjunctivitis), *Netra Raga* (Redness of eyes), *Ashrustrava* (Lacrimation)
4.	*Navagraha Rasa*[15]	11.11 (*Yashada Pushpa/ Kharpara*)	*Somala* (11.11) *Shuddha Parada* (11.11) *Shuddha Gandhaka* (11.11) *Tuttha* (11.11) *Godanti* (11.11) *Hartala* (11.11) *Manahshila* (11.11) *Hingula* (11.11)	*Vataroga* (disease caused by vitiation of *vata* in the body), *Arsha* (Hemorrhoids), *Granthi* (Nodular swelling/cyst), *Gulma* (Lumps or growths, stable or transitory) in (abdomen), *Shoola* (Pain), *Raktavikara* (Disorders related to blood), *Vidradhi* (Abscess), *Shwasa* (Dyspnea), *Vata- Kaphaja Jwara* (Fever due to vitiation of *Vata* and *Kapha*)
5.	*Netra Rakshaka Bindu*[16]	0.47	*Mahendra Jala* (98.26) *Sphatika* (0.47) Boric acid (0.47) *Selkhadi* (0.32)	All types of *Netra Roga* (Eye disorders), *Netra Kandu* (Itching of eyes), *Netra Daha* (Burning of eyes), *Abhishyanda* (Conjunctivitis), *Ashru Strava* (Lacrimation), *Kukunaka* (Ophthalmia Neonatorum)

Vrana Ropana, and *Vicharchika*. Translating these classical principles into contemporary clinical evidence, recent case reports and clinical trials have documented the marked efficacy of *Yashada Pushpa* when compounded into standard topical formulations, such as *Yashadamrita Malahara*.[13] In clinical settings, *Yashadamrita Malahara* has demonstrated robust therapeutic utility across chronic, recalcitrant dermatological and anorectal conditions, including *Vicharchika*[30] (atopic and contact eczema), *Dushta Vrana* (non-healing chronic wounds, including diabetic foot ulcers),[31] and *Parikartika* (fissure-in-ano presenting with severe cutting anal pain).[32] In these settings, ZnO may promote re-epithelialization, support zinc-dependent matrix metalloproteinase activity involved in tissue remodeling, reduce inflammation and bacterial burden, and provide a protective antimicrobial environment at compromised tissue interfaces.[33]

In ophthalmic delivery, such as *Shweta Netranjana*[14] (27.27%) and *Netra Rakshaka Bindu*[16] (0.48% in *Mahendra Jala*/distilled aqueous medium), *Yashada Pushpa* is described in ocular applications alongside agents, such as *Sharkara, Karpura*, and *Sphatika*. Classical sources associate *Pushpanjana* with *Netrabhishyanda* and describe cooling and soothing attributes, while modern evidence supports the antimicrobial and tissue-repair potential of ZnO.[34]

When evaluated through the lens of modern translational pharmacology, these traditional indications directly align with the established biomedical mechanisms of pharmaceutical-grade ZnO. In contemporary dermatology, topical ZnO is standardly utilized at 10–40% concentrations as an occlusive epidermal barrier protectant, a broad-spectrum physical ultraviolet reflector, and an enzymatic promoter of matrix metalloproteinase-mediated re-epithelialization across cutaneous ulcers and thermal burns,[35,36] closely mirroring the classical clinical indications of *Yashadamruta Malahara*. Similarly, the application of microcrystalline ZnO as a soothing, anti-exudative ocular astringent in modern ophthalmic solutions validates the classical rationale underlying *Pushpanjana* and *Netra Rakshaka Bindu* in the management of ocular surface inflammation.

However, a critical distinction must be made regarding compound formulations documented for systemic ingestion. In compendia, such as RTSSPS, preparations, such as *Tuttha Kharpara Bhasma*[6] (containing 98% *Jasada ka Phula*/*Bhasma* alongside 2% *Shuddha Tuttha*), are prescribed for chronic fevers (*Jirna Jwara*) and refractory gastrointestinal conditions (*Jirna Atisara*, *Sangrahani*), while complex herbo-mineral formulations, such as *Navagraha Rasa*[15] (11.11% *Kharpara*/*Jasada ka Phula*) incorporate the mineral alongside mercurial, sulfur, and arsenical compounds for severe neuromuscular disorders (*Vataroga*) and chronic respiratory conditions (*Shwasa*). While contemporary medicine utilizes systemic zinc ions as essential catalytic cofactors for metallothionein induction, immune modulation,

and intestinal enterocyte membrane stabilization, classical Rasashastra taxonomy mandates that open-air sublimated *Yashada Pushpa* is predominantly intended for external (*Bahya*) and topical mucosal administration.

Where internal administration is documented under ambiguous nomenclature (*Jasada ka Phula*/*Bhasma*), the textual reference is best interpreted as fully incinerated *Yashada Bhasma* or *Kharpara Bhasma* processed through repeated, closed-crucible *Jarana* and *Marana* cycles with botanical matrices rather than raw, sublimated *Yashada Pushpa*. This pharmacological distinction is substantiated by contemporary non-clinical toxicological studies demonstrating that high-dose internal ingestion of open-pan synthesized *Yashada Pushpa* can induce dose-dependent systemic toxicity, manifested by significant reductions in body weight, alterations in hematological parameters, biochemical markers of hepatic and renal stress, and histopathological evidence of parenchymal organ damage. Consequently, while *Yashada Pushpa* remains an exceptional, biocompatible agent for topical, ocular, and dermatological therapeutics, its internal administration must be approached with caution, reaffirming that systemic metallic therapy should strictly adhere to validated, multi-cycle *Bhasma* protocols.

CONCLUSION

This comprehensive review systematically delineates the historical, pharmaceutical, and clinical trajectory of *Yashada Pushpa* (ZnO), establishing its identity as a specialized sublimate-derived dosage form (*Pushpa Kalpana*) distinct from multi-cycle incinerated *Yashada Bhasma*. Textual and metallurgical analyses demonstrate that *Yashada Pushpa* evolved from early alloy-derived condensates (*Pushpanjana* from *Pittala*) into a standardized open-pan, high-temperature vapor-phase aerial oxidation process (900–1000°C), a mechanism strongly corroborated by cross-cultural alchemical records (Philosopher's Wool) and contemporary industrial pyrometallurgy (French process). Therapeutically, its low-density, flocculent microcrystalline structure provides non-irritant, cytoprotective, astringent, and re-epithelializing properties tailored predominantly for ocular (*Anjana*), nasal (*Nasya*), and topical dermatological (*Bahya Prayoga*) applications, demonstrating direct translational equivalence to modern pharmaceutical-grade ZnO in formulations, such as *Yashadamruta Malahara*. Furthermore, toxicological and pharmacological distinctions emphasize that while raw sublimates are optimized for topical barrier repair, systemic indications require fully calcined *Bhasma* matrices. By synthesizing classical Rasashastra literature with modern physicochemical, toxicological, and industrial paradigms, this review establishes a standardized, evidence-based foundation to support the integration of *Yashada Pushpa* into contemporary topical and ophthalmic drug delivery systems.

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