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CONCEPT OF BHASMA: FROM SHODHANA AND MARANA TO MODERN PHYSICOCHEMICAL CHARACTERIZATION

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ABSTRACT

Background: Bhasma represents a distinctive category of Ayurvedic medicinal preparations produced through a series of pharmaceutical procedures designed to transform metals and minerals into therapeutically suitable forms. The classical processes of Shodhana, Bhavana, Marana and subsequent processing are traditionally considered essential for reducing unwanted properties and achieving the desired therapeutic characteristics. With the advancement of analytical sciences, these preparations are increasingly being investigated using modern physicochemical techniques. **Objective:** To review the classical concept of Bhasma with particular emphasis on the pharmaceutical principles of Shodhana and Marana and to correlate these processes with modern physicochemical characterization. **Methods:** Classical Ayurvedic literature describing Bhasma preparation was reviewed along with contemporary scientific literature concerning physicochemical evaluation of Bhasma. The review considered changes produced during purification and incineration processes and examined their characterization through modern analytical techniques. **Results:** Shodhana involves systematic processing intended to modify the physical and chemical properties of the raw material and remove or reduce undesirable components. Subsequent Bhavana and Marana involve repeated trituration, levigation and controlled heating, resulting in substantial changes in particle size, morphology, crystallinity and chemical composition. Modern analytical techniques such as X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), energy-dispersive X-ray spectroscopy (EDX/EDS), Fourier-transform infrared spectroscopy (FTIR), inductively coupled plasma–mass spectrometry (ICP-MS), thermogravimetric analysis (TGA) and related methods can provide information regarding elemental composition, crystalline phases, morphology, particle characteristics and thermal behavior. Such characterization provides a scientific framework for understanding the transformations occurring during Bhasma preparation while complementing classical pharmaceutical concepts. **Conclusion:** Bhasma preparation represents a complex pharmaceutical transformation in which traditional procedures such as Shodhana and Marana may produce measurable changes in physicochemical characteristics. Integration of classical Ayurvedic principles with validated modern analytical techniques can enhance understanding, quality assessment, standardization and reproducibility of Bhasma preparations. However, physicochemical characterization should be interpreted alongside classical quality parameters and appropriate safety and pharmacological evaluation.

KEYWORDS: Bhasma; Shodhana; Marana; Bhavana; Rasashastra; Physicochemical Characterization; X-ray Diffraction; SEM; FTIR; Elemental Analysis; Standardization.

INTRODUCTION

Bhasma is one of the distinctive pharmaceutical preparations described in Rasashastra, in which metals, minerals and certain other substances are subjected to a sequence of specialized processing procedures to obtain a fine, therapeutically acceptable form. The transformation of the original material into Bhasma is not considered merely a process of physical pulverization; rather, it involves a series of pharmaceutical operations intended to modify the material and establish the desired characteristics of the finished product.[1]

The classical preparation of Bhasma generally involves procedures such as Shodhana, Bhavana, Marana and, where indicated, subsequent processes such as Amritikarana. The exact sequence varies according to the material and the classical method prescribed for its preparation. Shodhana is performed before further processing and may involve heating, quenching, trituration or treatment with specific liquid media. Marana involves repeated levigation and controlled heating, traditionally through the Puta system, resulting in progressive transformation of the starting material.[2]

Shodhana occupies an important position in Bhasma preparation. It is traditionally intended to eliminate or reduce undesirable characteristics of the raw material and make it suitable for subsequent pharmaceutical processing. The choice of Shodhana medium and method is material-specific, and repeated processing may produce changes in the physical and chemical characteristics of the starting substance. Modern investigations have demonstrated that processing can alter the composition and morphology of metallic and mineral materials.[3]

Following Shodhana, Bhavana and Marana contribute further transformation. During Bhavana, the processed material is repeatedly triturated with specified herbal juices, decoctions or other media. This facilitates intimate contact between the starting material and the processing substances. Subsequent controlled heating may promote oxidation, decomposition, phase transformation and reduction in particle dimensions. Experimental characterization of different Bhasmas has demonstrated that the final material can differ substantially from its raw precursor in crystalline phase, morphology and elemental or chemical characteristics.[4]

The traditional concept of properly prepared Bhasma is also associated with specific Bhasma Pariksha, including tests such as Varitaratva, Rekhapurnatva, Nishchandratva, Nirdhumatva, Niruttha and Apunarbhava, depending upon the preparation. These tests provide classical criteria for assessing completion and quality of the pharmaceutical process. Modern analytical approaches can complement these traditional examinations by providing measurable information about the physicochemical nature of the final product.[5]

The development of modern analytical science has provided new opportunities to investigate the transformations occurring during Bhasma preparation. X-ray diffraction (XRD) can identify crystalline phases and changes in crystallinity, whereas scanning electron microscopy (SEM) and transmission electron microscopy (TEM) can provide information regarding particle morphology and size. Energy-dispersive X-ray spectroscopy (EDS/EDX) can assist in elemental characterization, while Fourier-transform infrared spectroscopy (FTIR) can provide information regarding chemical bonds and functional groups.[6]

Other techniques, including dynamic light scattering, thermogravimetric analysis, differential thermal analysis, inductively coupled plasma-based elemental analysis and surface-area measurements, can further characterize particle-size distribution, thermal behavior, elemental composition and surface properties. Studies on different Bhasma preparations have demonstrated that the use of multiple analytical techniques can generate a physicochemical profile or fingerprint of the finished preparation.[7]

Importantly, physicochemical characterization has demonstrated that the transformation produced by traditional processing may involve more than simple size reduction. For example, studies of mineral and metallic Bhasmas have reported changes in crystalline phases and the formation of oxides or other chemical forms following repeated processing. Such findings provide a scientific basis for investigating how Shodhana, Bhavana and Marana influence the final material.[8]

Particle characteristics are another important area of investigation. Several studies have reported particles in the micro- and nanoscale range in particular Bhasma preparations. However, particle size should not be considered as the sole determinant of quality, because the biological and pharmaceutical characteristics of a Bhasma depend on multiple factors, including chemical composition, phase, morphology, surface characteristics and the manufacturing process.[9]

Standardization is particularly important because variations in raw-material quality, processing conditions, heating intensity, number of Puta cycles, Bhavana media and other pharmaceutical variables may influence the properties of the finished Bhasma. Therefore, reproducibility requires appropriate control of both classical pharmaceutical procedures and modern quality parameters.[10]

The integration of classical Rasashastra principles with modern physicochemical characterization can provide a broader understanding of Bhasma as a complex pharmaceutical material. Classical methods explain the sequential processing and quality assessment, whereas modern analytical techniques provide objective information regarding elemental composition, chemical phases, morphology, particle characteristics and thermal behavior. This complementary approach may strengthen quality control and facilitate reproducible preparation.[11]

Thus, the study of Bhasma should be approached as a multidisciplinary subject in which traditional pharmaceutical knowledge and contemporary analytical science are considered together. A systematic understanding of the transition from Shodhana and Marana to physicochemical characterization may contribute to improved standardization, quality assurance and scientific evaluation of Bhasma preparations.

AIM

To review the classical processes of Shodhana and Marana in Bhasma preparation and correlate them with modern physicochemical characterization techniques.

METHODOLOGY

A narrative review of classical Rasashastra literature and contemporary scientific studies on Bhasma preparation, characterization and standardization was undertaken.

2. Classical Concept of Bhasma

In Rasashastra, Bhasma is considered the final product obtained after appropriate processing of a specific metal, mineral or other substance. The desired preparation is expected to possess particular physical characteristics and should satisfy classical tests before therapeutic use.

The transformation from raw material to Bhasma involves multiple stages. Each stage has a specific pharmaceutical purpose, and the sequence may vary according to the substance being processed. Proper selection of raw material, appropriate Shodhana, suitable Bhavana media, controlled Marana and assessment of the final product are therefore essential components of Bhasma preparation.

3. Selection and Preliminary Processing of Raw Material

The quality of the final Bhasma begins with the selection of appropriate raw material. Traditional pharmaceutical texts emphasize the importance of identifying suitable varieties and avoiding materials with undesirable characteristics.

Raw materials may contain physical impurities, associated minerals or other substances that can influence the subsequent pharmaceutical process. Preliminary cleaning and preparation are therefore important before undertaking Shodhana.

Modern pharmaceutical interpretation also recognizes that variations in the starting material can influence the elemental composition, crystalline structure, particle characteristics and ultimately the properties of the finished preparation.

4. Shodhana

Shodhana is an important preliminary pharmaceutical procedure performed before Marana in many Bhasma preparations. The term is traditionally associated with purification or processing of the raw material.

The procedure may involve methods such as heating followed by quenching, trituration, immersion, washing or processing with specific herbal juices, decoctions, oils, sour liquids or other prescribed media. The exact method depends upon the substance being processed.

From a pharmaceutical perspective, Shodhana may produce several changes in the starting material. It can remove loosely associated impurities, modify surface characteristics, alter physical structure and facilitate subsequent processing. It may also introduce certain components from the processing medium into the material.

Therefore, Shodhana should be understood as a controlled transformation rather than merely a washing procedure.

5. Role of Bhavana

Bhavana involves repeated trituration or levigation of the processed material with a prescribed liquid medium. Herbal juices, decoctions and other substances may be selected according to the particular Bhasma.

Repeated wet trituration improves intimate contact between the solid material and the liquid medium. It can also facilitate reduction of particle size and improve uniformity of the material.

From a modern perspective, prolonged trituration may increase surface area and modify particle morphology. Components present in the Bhavana medium may also interact with the starting substance. Thus, Bhavana can influence the physical and chemical characteristics of the material before the heating stage.

6. Marana

Marana is the principal process through which the processed material is transformed into Bhasma. It generally involves repeated cycles of levigation, formation of pellets or similar units and controlled heating.

The heating process is traditionally performed using a specified Puta system. The intensity and duration of heating are important because different materials require different processing conditions.

During Marana, several physicochemical changes may occur. Depending on the substance and processing conditions, these may include oxidation, decomposition, phase transformation, reduction in particle size, alteration of surface characteristics and modification of crystalline structure.

Repeated cycles may progressively change the original material until the desired characteristics of Bhasma are achieved.

7. Importance of Controlled Heating

Heating is a critical variable in Bhasma preparation. The temperature achieved, duration of heating, heating environment and number of cycles can influence the final characteristics of the product.

Insufficient heating may result in incomplete transformation, whereas excessive or inappropriate heating may produce undesirable changes. Therefore, traditional descriptions of Puta can be viewed as pharmaceutical methods for providing controlled thermal exposure.

Modern temperature-controlled furnaces can provide greater reproducibility of heating conditions, although the traditional pharmaceutical principles remain important for understanding the intended processing sequence.

8. Transformation of Particle Characteristics

One of the important changes associated with repeated pharmaceutical processing is reduction in particle size. Repeated trituration and heating can progressively modify the physical dimensions of the particles.

Some investigated Bhasma preparations have demonstrated particles within the micro- and nanoscale range. However, particle size alone cannot be considered sufficient for establishing the quality of Bhasma.

Other properties, including chemical composition, crystalline phase, morphology, surface characteristics and degree of aggregation, must also be considered when evaluating the finished product.

9. Classical Bhasma Pariksha

Classical quality assessment of Bhasma is performed through various Bhasma Pariksha. These tests are intended to determine whether the preparation has undergone adequate transformation.

Important classical parameters include.

- **Rekhapurnatva** – the ability of the fine powder to enter the lines of the fingers.
- **Varitaratva** – the ability of the powder to float on water.
- **Nishchandratva** – absence of metallic or mineral luster.
- **Nirdhumatva** – absence of smoke during appropriate testing.
- **Niruttha** – resistance to restoration into the original metallic state.
- **Apunarbhava** – inability to regain the original form under specified conditions.

These tests represent practical traditional approaches for assessing fineness, transformation and completion of processing.

10. Modern Physicochemical Characterization

Modern analytical science provides objective methods for evaluating the characteristics of Bhasma. Physicochemical characterization can help identify changes produced during Shodhana, Bhavana and Marana.

A combination of analytical techniques is generally more informative than relying on a single method. Different techniques provide information about different properties of the preparation.

11. X-Ray Diffraction

X-ray diffraction is useful for determining the crystalline nature and phase composition of a material. It can help identify crystalline phases present in Bhasma and determine whether the phases differ from those present in the original raw material.

Changes in diffraction patterns following repeated processing can provide evidence of structural transformation during Marana.

12. Scanning Electron Microscopy

Scanning Electron Microscopy provides information about surface morphology and particle appearance. It can demonstrate differences in particle shape, aggregation and surface characteristics before and after pharmaceutical processing.

SEM images may therefore provide useful visual evidence of the physical transformation produced by repeated trituration and heating.

13. Transmission Electron Microscopy

Transmission Electron Microscopy can provide higher-resolution information regarding particle morphology and size. In selected Bhasma preparations, it has been used to investigate particles in the nanometer range.

However, the identification of nanoscale particles should be interpreted carefully because aggregation and sample preparation can influence apparent particle size.

14. Energy-Dispersive X-Ray Analysis

Energy-dispersive X-ray analysis is commonly combined with electron microscopy to determine the elemental composition of a sample.

It can help identify major and minor elements present in Bhasma and compare the elemental profile of the finished preparation with that of the starting material.

This is particularly relevant for preparations containing metals and minerals, where elemental composition is an important component of quality evaluation.

15. Fourier-Transform Infrared Spectroscopy

Fourier-transform infrared spectroscopy can provide information about chemical bonds and functional groups present in a sample.

Changes in infrared absorption patterns before and after processing may indicate alterations in chemical environment or interaction with substances used during Bhavana and other pharmaceutical procedures.

16. Elemental Analysis

Elemental analysis is particularly important for Bhasma containing metals or mineral substances. Techniques such as inductively coupled plasma-based methods can provide quantitative information about elemental concentrations.

Such analysis can assist in determining the consistency of different batches and may also contribute to safety assessment by identifying potentially undesirable elemental contaminants.

17. Thermal Analysis

Thermal analytical techniques can provide information regarding the behavior of Bhasma when exposed to increasing temperature.

Thermogravimetric analysis can demonstrate changes in mass associated with moisture loss, decomposition, oxidation or other thermal events. Differential thermal analysis can provide information about heat-related transitions.

These techniques may help understand the thermal stability and transformation behavior of the preparation.

18. Surface Area and Particle-Size Analysis

Particle-size distribution and specific surface area are additional physicochemical parameters that can influence the behavior of fine powders.

A reduction in particle size generally increases surface area, which may influence dissolution, interaction with biological fluids and other physicochemical characteristics. Nevertheless, these parameters should be evaluated along with chemical and structural properties rather than being considered independently.

19. Relationship Between Classical and Modern Evaluation

Classical Bhasma Pariksha and modern analytical characterization approach quality evaluation from different perspectives.

Classical tests provide practical indicators of completion, fineness and transformation, while modern techniques can provide quantitative information regarding elemental composition, particle morphology, crystal structure and chemical characteristics.

The two approaches can therefore be viewed as complementary rather than contradictory. Integrating both systems may provide a more comprehensive quality profile of Bhasma.

20. Standardization of Bhasma

Standardization is essential for ensuring reproducibility and quality. Variations in raw materials, Shodhana procedures, Bhavana media, number of processing cycles and heating conditions may influence the final product.

A standardized Bhasma should therefore be evaluated through a combination of:

- Raw-material authentication
- Standardized pharmaceutical procedures
- Classical Bhasma Pariksha

- Physicochemical characterization
- Elemental profiling
- Microbial and contaminant assessment
- Appropriate safety evaluation
- Batch-to-batch comparison

Such multidimensional evaluation can improve confidence in the quality and consistency of the preparation.

21. Safety Considerations

The presence of metals or minerals in Bhasma makes appropriate quality control particularly important. The safety of a preparation cannot be determined solely by its appearance, particle size or ability to pass classical tests.

Elemental composition, chemical form, potential contaminants, manufacturing conditions and dose must all be considered. Properly authenticated raw materials and controlled pharmaceutical processing are therefore essential.

Modern analytical methods can support safety evaluation by identifying elemental contaminants and determining the chemical and physical characteristics of the final product.

22. Pharmaceutical Significance of Shodhana and Marana

Shodhana and Marana can be regarded as sequential pharmaceutical processes with distinct but interconnected purposes. Shodhana prepares the starting material for further transformation, whereas Marana produces the final Bhasma through repeated mechanical and thermal processing.

The combination of these procedures may produce changes in particle size, morphology, chemical state and crystalline structure. Modern characterization provides an opportunity to investigate these changes systematically and establish relationships between processing conditions and final product characteristics.

23. Challenges in Modernization

Although modern analytical techniques provide valuable information, their interpretation should be integrated with the traditional pharmaceutical framework. A single analytical result cannot fully define the quality or therapeutic identity of a Bhasma.

Another challenge is the lack of universally accepted analytical specifications for every Bhasma preparation. Different formulations may require different quality parameters depending on their raw materials and pharmaceutical processes.

Development of standardized analytical protocols and reference profiles for individual Bhasmas is therefore an important area for future research.

24. Future Scope

Future studies should focus on correlating each pharmaceutical stage with measurable physicochemical changes. Systematic evaluation before Shodhana, after Shodhana, after Bhavana and after successive Marana cycles could help clarify the contribution of each process.

Advanced characterization may also assist in developing reproducible fingerprints for individual Bhasma preparations. Integration of pharmaceutical science, material science, analytical chemistry and Ayurvedic pharmaceutics may further strengthen scientific understanding of these preparations.

DISCUSSION

The concept of Bhasma represents a sophisticated pharmaceutical approach in Rasashastra in which raw metals and minerals are transformed through sequential processing into therapeutically intended preparations. The present review indicates that Bhasma preparation involves multiple interconnected stages, and the final characteristics are influenced by the quality of the raw material, Shodhana procedure, Bhavana media, number of Marana cycles and heating conditions.[12]

Shodhana is an important preliminary stage in the pharmaceutical processing of many Bhasma preparations. Traditionally, it is intended to remove undesirable characteristics and prepare the raw material for subsequent processing. From a modern pharmaceutical perspective, the repeated exposure of the material to different liquid media, heat and mechanical processing may modify its surface properties, chemical composition and physical structure. These changes can subsequently influence the efficiency of Marana.[13]

The role of Bhavana is also significant because repeated wet trituration creates intimate contact between the processed material and the selected liquid medium. Mechanical grinding may reduce particle size and increase surface area, while constituents of the Bhavana medium may interact with the material. Consequently, Bhavana should not be considered merely a grinding step; it may represent an important stage in the progressive transformation of the pharmaceutical material.[14]

Marana constitutes the major transformative stage of Bhasma preparation. Repeated trituration followed by controlled heating can result in substantial changes in morphology, particle size, chemical state and crystalline structure. Depending on the starting material and processing conditions, oxidation, decomposition or formation of new chemical phases may occur. Thus, the final Bhasma may possess physicochemical characteristics considerably different from those of the original material.[15]

The importance of controlled heating is particularly evident from modern characterization studies. Temperature, duration of heating and the number of heating cycles can influence the phase composition and physical characteristics of the final preparation. This supports the traditional emphasis on appropriate Puta and repeated processing rather than treating heating as an arbitrary incineration procedure.[16]

The classical Bhasma Pariksha provides another important dimension of quality assessment. Parameters such as Rekhapurnatva, Varitaratva and Nishchandratva are intended to assess properties including fineness, physical behavior and absence of metallic luster. These traditional tests provide practical evidence that the material has undergone the intended pharmaceutical transformation.[17]

Modern physicochemical techniques can complement these classical assessments. X-ray diffraction can identify crystalline phases, while scanning electron microscopy and transmission electron microscopy provide information regarding morphology and particle characteristics. Such techniques allow visualization and measurement of transformations that cannot be adequately assessed through conventional organoleptic examination alone.[18]

Elemental analysis is particularly important for herbo-mineral and metallic preparations. Techniques such as energy-dispersive X-ray analysis and inductively coupled plasma-based methods can identify and quantify elements present in a Bhasma. This information can help establish batch consistency and identify undesirable elemental contamination.[19]

Fourier-transform infrared spectroscopy and related spectroscopic techniques provide additional information regarding the chemical environment of the constituents. Changes in spectral patterns before and after processing may indicate alterations in chemical bonding or interactions with substances introduced during pharmaceutical processing. Therefore, spectroscopy can contribute to establishing a physicochemical fingerprint of a Bhasma.[20]

The observation of micro- and nanoscale particles in some Bhasma preparations has generated considerable scientific interest. Reduction in particle size may increase surface area and alter interactions with biological systems. However, particle size alone should not be regarded as evidence of superior quality or therapeutic activity. Particle morphology, chemical composition, crystalline phase, aggregation and surface properties must also be considered for meaningful interpretation.[21]

The standardization of Bhasma presents several challenges because the final product can be affected by differences in raw materials and pharmaceutical procedures. Variations in the number of Bhavana cycles, processing media, heating intensity, duration and number of Puta cycles may produce differences between batches. Consequently, reproducibility requires careful control and documentation of each pharmaceutical stage.[22]

Safety evaluation is another essential component of modern Bhasma research. The presence of metallic or mineral elements requires appropriate assessment of elemental composition and potential contaminants. A Bhasma should therefore not be evaluated only on the basis of classical appearance or particle fineness. Comprehensive quality assessment should incorporate authentication of raw materials, pharmaceutical standardization, physicochemical characterization and appropriate safety evaluation.[23]

The integration of traditional and modern approaches appears particularly valuable. Classical Rasashastra procedures provide the pharmaceutical framework and define the intended stages of transformation, whereas modern analytical methods provide objective measurements of the resulting material. Combining these approaches can improve understanding of how individual pharmaceutical procedures influence the final physicochemical profile of Bhasma.[24]

Overall, the discussion indicates that Shodhana and Marana should be considered controlled pharmaceutical transformation processes rather than simple purification and incineration procedures. Their effects may extend to particle size, morphology, chemical composition and crystalline structure. Modern physicochemical characterization provides an opportunity to scientifically document these changes and develop reproducible quality profiles for individual

Bhasma preparations. Further interdisciplinary research integrating Rasashastra, pharmaceutical sciences, material science and analytical chemistry is required to establish robust standards for their quality, consistency and safety.

CONCLUSION

Bhasma preparation represents a complex pharmaceutical transformation involving sequential procedures such as Shodhana, Bhavana and Marana. These processes may alter the physical, chemical and structural characteristics of metals and minerals, ultimately producing a fine and therapeutically intended preparation.

Classical Bhasma Pariksha provides traditional criteria for assessing the completion and quality of processing, while modern techniques such as XRD, SEM, TEM, EDX, FTIR, elemental analysis and thermal analysis provide detailed physicochemical information.

The integration of classical Rasashastra principles with modern physicochemical characterization can therefore provide a comprehensive approach to understanding, standardizing and evaluating Bhasma. Such integration may improve reproducibility, quality assurance and scientific interpretation while preserving the fundamental principles of traditional Ayurvedic pharmaceutical processing.

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