Published online in http://ijam.co.in ISSN No: 0976-5921

International Journal of Ayurvedic Medicine, Vol 15 (3), 2024; 781-789

Pharmaceutical and physicochemical analysis of *Mandura Bhasma*

Research Article

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Abstract

Introduction: *Mandura* (Slag of Iron) is a metallic oxide-cum-silicate of iron with the general formula Fe_2SiO_4 and is also known as Slag. In the classical text, different types of methods are explained in different classical books for the preparation of *Mandura bhasma* based on its utility. Objective: To prepare and analyse *Mandura bhasma* by employing various *Bhasma pariksha* mentioned in Ayurvedic science and Modern parameters along with analysis as per tools available today. Materials and methods: To standardise the standard operating procedure (SOP), *Mandura Bhasma* according to the method mentioned in classical Alchemy (*Rasatarangini* and *Rasamrita*). Mandura, detoxification process was followed by heating it in charcoal and dipping it in cow urine and the incineration process by levigating with juice of Aloe vera and heating system generated by cow dung cakes. Result: *Bhasma* became brownish, very fine, very soft and smooth and passed all classical characteristics of Ayurvedic parameters like *Rekhapurnatva, Varitaratva, Sukshmatva*, *Shlakshnatva* etc.,. All physic-chemical parameters are within the standard and presence of phytochemicals like steroids, alkaloids and tannin. X-ray diffraction analysis results revealed the crystalline size and FTIR revealed the presence of functional groups. Conclusion: The therapeutic efficacy of the *Bhasma* is believed to manifest only when it has successfully undergone the *Bhasma Pariksha*, a rigorous traditional assessment ensuring its quality and potency. This would undoubtedly aid in ensuring safety, efficacy, and batch-to-batch consistency.

Keywords: *Mandura, Bhasma,* Standard operating procedure, X-ray diffraction, Fourier Transform Infrared Spectroscopy.

Introduction

Ayurveda is an Indian traditional form of medicine that employs processed natural resources of herbal, metallic, mineral, and animal origin. Alchemy/ Iatrochemistry, a branch of Ayurveda, utilises processed metals and minerals in treatments. Herbomineral and metallic preparations eventually came to play an important role in the medicine of Ayurveda. (1) *Bhasma* is a product of the Herbo-metallic process, which includes both metallic and herbal chemicals, according to Ayurvedic metallurgy. They are calcined forms of metals/minerals that have been treated with herbs. Because their nano size particles are insoluble, they can absorb and enter the bloodstream and are more biocompatible than any chemically manufactured entity due to their size/volume ratio. In comparison to herbal drugs, it is more stable over time, requires a smaller dose, is easy to store, and has a longer shelf life. (2) Preparing *bhasma* is a laborious and time-consuming process.

Previously, it was created by Ayurvedic physicians based on their specific needs. They are now mass-produced on massive scales in pharmaceutical plants. This new technique has caused various complications because the use of new appliances has not been standardised in terms of the quality of these *Bhasma* preparations. Furthermore, different pharmaceutical processes utilised in the manufacture yield the same *Bhasma* with distinct characteristics. As a result, the metal level of the marketed samples containing *Bhasma* varies. In terms of standardisation, reproducibility is crucial. As a result, these *Bhasma* must be standardised based on their classical assessments utilising advanced analytical techniques. Setting up quality control parameters is required for this, which will offer the required standards, minimise variability, and check for adulteration. (3) *Bhasma* is a complex compound form of metals or minerals formed through repeated incineration with herbal extracts. These are delivered orally in tiny doses with acceptable carriers to make them biocompatible. A tiny amount of *Bhasma* can be employed in a variety of therapeutic applications. Various sorts of *Bhasma* and their indications are detailed in classical Alchemy books. *Bhasma* is claimed to be biologically formed nano-particles that are used in conjunction with other Ayurvedic medications. To be suitable for therapeutic use, *Mandura* must go through a series of traditional pharmaceutical processes such as detoxification and incineration.

Bhasma is Herbo-metallic ashes that are calcined with various herbal substances to create organometallic

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complexes. (4) Slag of iron, also known as Slag, is a metallic oxide-cum-silicate of iron with the general formula Fe_2SiO_4. *Mandura* is a by-product of the metallurgical process used to extract iron (Fe) and copper (Cu) from their respective ores. It occurs as lumps, boulders, or aggregates in regions where copper and irons are extracted through smelting. (5) Variations in the raw materials utilised, as well as the inability to follow standard operating procedures (SOP) for *Bhasma* preparation, cause changes in the completed product's qualities. Standardisation is a quality assurance measurement that is used to represent the measures done during the production process and quality control that contribute to reproducible quality. Failure to reproduce diminishes efficacy and raises safety issues. (6) *Mandura Bhasma* preparation was prepared by detoxification method of heating and dipping in Cow urine, incineration process by levigating with the juice of Aloe vera and Heating was given by Cow dung cakes. (7) *Mandura Bhasma* is used to treat oedema, jaundice, anaemia, worm manifestation, haemorrhoids, and liver disorders etc., (8)

Analytical technique development aids in understanding essential parameters and minimising their impact on accuracy and precision.. Ayurvedic literature has also placed a premium on product quality control. There are several tests described in Ayurvedic texts to check the quality of prepared *Bhasma*, such as *Rekhapurna* (small particle size), *Nischandra* (lack of metallic shine), and *Niruttha* (absence of alloy formation with silver), etc., but these tests do not provide any quantitative information about the standard composition and structure of the final drug. Before knowing the method of action of such drugs, standardisation of their contents as well as concentration of their elements is required. (9) To determine the material characterisation of burned ash, several current technologies are applied. XRD analysis is one of the main techniques for detecting material compounds and free metals, among others. As a result, in this scientific era, it is critical to determine material alterations through purification and incineration processes. This is the actual transformation of a substance into a compound or orally administrable form. The XRD method is likely the most well-known sensitive method as a phase characterization instrument. It can distinguish between distinct crystalline phases of different materials and can also be used to identify different crystal structures of the same chemical molecule. (10) FTIR (Fourier transform infrared spectroscopy) detects functional groups. Functional groups are structural units inside organic molecules that are defined by certain atom and bond combinations. (11) Classical testing, physicochemical criteria, and advanced analytical techniques were used to evaluate the final product.

Materials ans Methods

Raw materials

Mandura was obtained with precise features specified in traditional texts, such as being heavy and compact, black in colour, impermeable, and having a smooth texture. It was procured from the Ayurvedic Pharmacy and verified for authenticity by the pharmaceutical division of the Mahatma Gandhi Ayurved College, Hospital & Research Centre (MGACHRC). Fresh cow urine was collected from a nearby cowshed and Aloe Vera was freshly harvested from the Herbal Garden at MGACHRC, located in Salod (H), Wardha.

Methods

Pharmaceutical processing/Preparation of *Mandura Bhasma*

Shodhana (Detoxification/Purification)

Bhasma is made from incinerated ash, and the raw material goes through a vigorous cleansing process before entering the reaction phase, which includes the addition of various minerals and herbal extracts. (12) The detoxification process adheres to the principles outlined in the Alchemy classical text i.e., Rasatarangini, while the incineration process follows the guidelines described in Rasamrita.

The process began by igniting a fire while the charcoal remained inside the iron stove. *Mandura* was then extracted from the red-hot charcoal when it reached a temperature of 690-722°C and immersed in a vessel containing 200ml of cow urine. This heating and dipping process was repeated seven times, each time using fresh cow urine. Subsequently, it was washed with hot water. After these seven cycles, a purified *Mandura* was obtained. Due to its dryness and the fact that it was hot and brittle, it was ground into a fine powder and sieved through a 100-mesh sieve to achieve a purified *Mandura* in powdered form. (13)

Marana (incineration/calcinations)

This purified *Mandura* was then taken in a mortar and pestle, where it was mixed with Aloe vera juice until a homogeneous mixture was achieved, following the sign indicating the end of the process. After this, the mixture was formed into uniform-sized and thick pellets, which were left to dry in the sunlight. Once the pellets were thoroughly dried, they were weighed and placed in an earthen saucer. Another saucer was inverted over it, and the junction between the two saucers was sealed with seven layers of cotton cloth coated with Fuller's clay. This was then subjected to a heating process using cow dung cakes known as *Puta* (quantum/unit of heat). To heat 14000g cow dung cakes were taken. (14) The temperature was monitored, and after cooling, the saucers were opened. The pellets were collected, weighed, and further ground into a fine powder. The resulting *bhasma* was tested, and organoleptic qualities were observed. This entire process was repeated until *bhasma* of *Mandura* was obtained, which required a total of twelve cycles of heat given for the complete conversion of *Mandura* to *bhasma*.

After undergoing the 12th *Puta*, *Mandura Bhasma* displayed a brownish colour and successfully passed various *Bhasma* tests, affirming its quality and purity. To comprehensively assess the profile of *Mandura*

Bhasma, a combination of traditional Ayurvedic and modern analytical methods was employed. In Ayurveda, the assessment of *Bhasma* often relies on subjective parameters that cannot be precisely quantified for consistent results. Therefore, a systematic analytical study was conducted to establish fundamental standards for *Mandura Bhasma*. This study encompassed the examination of raw *Madura*, purified *Madura*, and the final *Mandura Bhasma* using physicochemical analyses.

Analysis

An analytical investigation was conducted to standardise and validate the preparation.

Bhasma Pariksha (classical methods for analysing *Bhasma*) indicate the sample's genuinity. These characteristics correspond to the sensory evaluation of Ayurveda. The sample's colour, odour, taste, and touch were evaluated here. Classical methods for analysing *Bhasma* are such as *Varitaratva* (floating test), *Rekhapurnatva* (finger thumb test), *Niswadu* (tasteless), *Uttama* (floating even with grains), *Dantagrekachabhava* (no grating sensation when chewed between teeth), *Slakshana* (smoothness), *Sukshmatva* (very fine particle), *Apunarbhavatva* (After strong heating with *Abrus precatorius* Linn, honey, ghee, *Commiphora mukul* Hook and Borax with *bhasma* should not regain its metallic nature), *Nirdhuma* (smokeless), *Nischandratva* (lack of metallic shine).

Table 1: Classical parameters interpretation (15)

Parameters	Interpretation
Varitara	Lightness and particle size
Rekhapurnatva	Fineness and particle size
Sukshmatva	Fineness
Niswadu	Free metal
Dantagrekachabhava	Hardness and particle size
Apurnabhava	Free metal particle
Slakshana	Particle size
Nischandratva	Free metal particle
Unnama	Hygroscopic natured
Nirdhuma	*Gandhaka* (Sulphur) and other vegetative drugs

Physicochemical analysis

Modern physicochemical parameters like determination of pH, loss on drying at 105^{0}C, ash value, acid insoluble ash, and water-soluble extractive, etc., were performed on three samples of Slag of Iron. The sample was analyzed by the Ayurvedic Pharmacopoeia of India (API) standards in the analytical laboratory of Mahatma Gandhi Ayurved College. Hospital, and Research Centre located in Salod (H) Wardha, Maharashtra.

Qualitative Phytochemical analysis

Various comparative qualitative chemical tests were conducted on multiple extracts with different polarities to assess the presence of various phytochemicals. Phytochemical screening confirmed the presence of phyto-constituents like alkaloids, flavanoids, glycosides, saponin, tannin, protein, carbohydrates and steroids in *Mandura bhasma.*

Sophisticated analysis

Advanced analytical techniques such as XRD (X-ray diffraction) and FTIR (Fourier Transform Infrared Spectroscopy). XRD and FTIR were accomplished at Jankidevi Bajaj College of Science, Wardha.

X-ray diffraction (XRD)

The technique of X-ray diffraction (XRD) is used to analyse the structure, composition, and physical properties of materials. X-ray powder diffractometry examines the atomic structure of a substance. The graph that represents XRD analysis is known as a diffractogram. A phase (compound) present in a specimen is represented by the peak. Each phase can be identified by comparing the experimentally obtained pattern to a standard database called a powder diffraction file. (16)

Fourier Transform Infrared Spectroscopy (FTIR)

The FTIR technique is used to obtain an infrared spectrum of a substance. It is caused by the superposition of absorption bands from various functional groups. Functional groupings represent a compound's structure. A functional group is an atom or group of atoms that contribute certain properties to an organic molecule. Functional groups are important in chemistry since they are the part of a molecule that can undergo certain reactions. As a result, they influence the properties and chemistry of many organic compounds. An organic compound is any compound that contains carbon and another element. (17)

Observations and Results

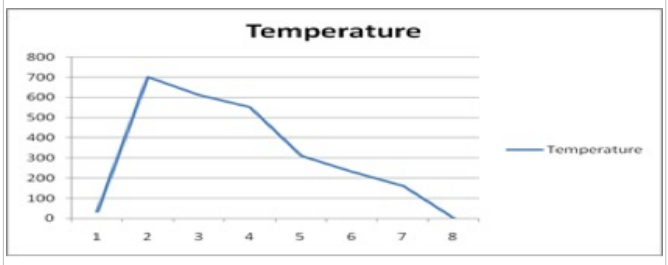
During the detoxification process, the quenching of *Mandura* into a specific medium produced a distinctive hissing sound and formed foam which disappeared after some time. This medium subsequently underwent a vigorous boiling process, leading to the generation of foam. After each immersion into the medium, it was observed that a residue, primarily in the form of powder, as well as the *Mandura* itself, fractured into smaller fragments. Upon the culmination of the thorough detoxification procedure, the *Mandura* underwent a significant transformation, presenting itself as a combination of coarsely textured black powder and fragments of the original *Mandura* material. Observation during detoxification weight changes was shown in Table 2.

Table 2: Detailed Overview of Weight Changes and Losses of *Mandura* during detoxification

Batch	Wt of Slag of iron		Loss of Weight after Detoxification	
	Before	After	(g)	%
A	200g	158g	42g	21%
B	200g	159g	41g	20.5%
C	200g	158 g	42g	21%
Average	**200g**	**158.3g**	**41.6g**	**20.8%**

During the First levigation process, there was a metallic sound at the beginning and took 4 hours to attain a homogeneous mixture. The average temperature of the *puta* is shown in Figure 1. Observation of weight before and after each *Puta* is shown in Table 3. Pellets were blackish for the first second *Puta* and later changes into brownish and reddish brown. The organoleptic properties of samples fulfilling *Bhasma Pariksha* (incinerated ash test) were evaluated and summarised in Table 4. After the 4th *Puta,* Pellets were found soft and brownish. *Bhasma* became brownish, very fine, very soft and smooth and classical characteristics of Ayurvedic parameters were observed like *Rekhapurnatva, varitaratva, Sukshmatva Shlakshnatva* etc. It required 12 *puta* for the sample to pass *Bhasma Pariksha*. Table 5 and 6 shows the lists of observations of the *Bhasma pariksha* made after each successive *puta.*

Figure 1: shows the Average Maximum Temperature during each *Puta* for all 3 batches in *Mandura*.



Organoleptic parameters

During the organoleptic evaluation, it was observed that *Mandura Bhasma* had a brownish colour, tasteless, soft to the touch, odourless and lustreless as shown in Table no. 3.

Table 3: Observation of weight of *Mandura Bhasma* during each *Puta*

Puta	Before *Puta* weight (g)	After *Puta* weight (g)	Loss (g)	Loss (%)
1st	A-159g B-160g C-159g	A-148g B-150g C-148g	9g 8g 9g	4% 5% 5.7%
2nd	A-149g B-151g C-149g	A-144g B-146g C-144g	3g 3g 3g	2% 2% 2%
3rd	A-145g B-147g C-145g	A-140g B-141g C-140g	3g 4g 3g	2% 2.7% 2%
4th	A-142g B-143g C-141g	A-137g B-138g C-137g	3g 2g 2g	2.1% 1.4% 1.4%
5th	A-138g B-139g C-138g	A-132g B-133g C-132g	4g 4g 4g	2.9% 2.9% 2.9%
6th	A-133g B-135g C-134g	A-126g B-128g C-126g	4g 4g 5g	3% 3% 3.8%
7th	A-127g B-129g C-128g	A-121g B-123g C-121g	4g 4g 4g	3.2% 3.2% 3.2%
8th	A-123g B-125g C-123g	A-118g B-120g C-118g	2g 2g 2g	1.6% 1.6% 1.6%
9th	A-120g B-121g C-120g	A-113g B-115g C-113g	4g 4g 4g	3.4% 3.4% 3.4%
10th	A-115g B-117g C-115g	A-109g B-110g C-109g	3g 4g 3g	2.6% 3.5% 2.6%
11th	A-110g B-112g C-110g	A-103g B-104g C-103g	5g 5g 5g	4.6% 4.6% 4.6%
12th	A-104g B-106g C-104g	A-98g B-99g C-98g	4g 4g 4g	3.9% 3.9% 3.9%
Average	**1567.3g**	**1489g**	**47g**	**36.5%**

Table 4: Classical Organoleptic character of *Mandura Bhasma* during and after processing

Number of Puta	Colour	Taste	Touch	Odor	Luster
1st	Blackish brown	Tasteless	Rough	Odorless	Lusterless
2nd - 4th	Blackish black	Tasteless	Soft	Odorless	Lusterless
5th- 10th	Reddish brown	Tasteless	Soft	Odorless	Lusterless
11th -12th	Brownish	Tasteless	Soft	Odorless	Lusterless

Table 5: *Bhasma Pariksha* of *Mandura bhasma* after each *Puta*.

No.of *Puta*	*Rekhapurnatva*	*Varitara*	*Nirswadu*	*Mrudutwa*	*Dantagrekachcha bhava*
1st	-	-	Tasteless	+	+++
2nd-3rd	+	-	Tasteless	+	++
4th-5th	+	+	Tasteless	+	++
6th-8th	++	+ +	Tasteless	+	+
9th	+++	++	Tasteless	+	+
10th-11th	+++	+++	Tasteless	+	+
12th	+++	+++	Tasteless	+	-

Note: Absent (-), Present (+), (pariksha achieved 10% indicate +, 40% indicate ++, 80% indicate ++)

Table 6: Test of *Mandura Bhasma*

Unnama	*Nirdhuma*	*Apurnabhava*
Mandura bhasma float even when rice grain kept over it.	Absent of smoke when *Mandura bhasma* was burnt.	After mixing with *mitrapanchaka* and *puta* given. *Mandura bhasma* did not return to its original form.

Physicochemical investigation

The physicochemical analysis of *Mandura* and *Bhasma* is given in table 7.

Table 7: Physicochemical parameters of *Mandura Bhasma*

Parameters	*Mandura Bhasma*
pH	7.88
Total Ash value	37.97%
Water soluble ash	0.96%
Acid insoluble ash	36.87%
Sulphated ash	0.1%
Moisture analysis	0%

Qualitative Phytochemical analysis

Alcohol and water extracts were subjected to phytochemical screening which identified the presence of steroids, alkaloids and tannin as shown in Table 8.

Table 8: Alcohol and Water extract Phytochemical constituents

Phyto-constituent	Water extract	Alcohol extract
Steroid	+	-
Glycosides	-	-
Alkaloids	+	+
Flavonoids	-	-
Tannins	+	+
Saponin	-	-
Carbohydrates	-	-
Proteins	-	-

X-rays Diffraction

XRD analysis showed sharp peaks indicating the crystalline nature of *Mandura bhasma.* In raw and purified Slag of Iron, the peaks are less and not sharp when compared to *Mandura bhasma*. Sharp peaks are assigned as Fe, Si and Oxygen. Many other peaks are unidentified. *Mandura* matches with a mixture of two minerals Fayalite and Ringwoodite. *Mandura Bhasma* is mostly iron oxide. *Mandura* is a form of iron silicate and has been reported in many studies. Fayalite and Ringwoodite are both iron silicate but structurally different. In raw and purified *Mandura* only Fayalite is detected but in *Mandura bhasma*, Iron Iron (III) Silicon Oxide and Fayalite are found. *Mandura Bhasma* shows crystallinity of $Fe_{2.719}O_4Si_{0.281}$ and $Fe_2O_4Si_1$ treated electrodes were examined by X-ray diffraction technique shown in figure 2 and table 9, 10, & 11. The crystal structure of $Fe_2O_4Si_1$ is orthorhombic with space group with lattice parameters a=10.4880Å, b=6.0760Å and c=4.8140 Å. The value matches precisely with the standard data (ICDD 98-001-0409). The crystal structure of $Fe_{2.719}O_4Si_{0.281}$ is cubic with space group F d-3m with lattice parameters a=b=c=8.2370 Å. The value matches precisely with the standard data (ICDD 98-015-8588). All XRD patterns reflect the existence of Fayalite, Ringwoodite, Fe_2O_3 and Haematite. The reference XRD pattern of $Fe_{2.719}O_4Si_{0.281}$, $Fe_2O_4Si_1$ and Fe_2O_3 is also shown for comparison with raw, purified and *Mandura bhasma* in Figure 3.

Figure 2: Showing XRD (A) Raw *Mandura* (AM-*Asuddha Mandura*) (B) Purified *Mandura* (SM-*Suddha Mandura)* (C) *Bhasma* of *Mandura* (MB-*Mandura Bhasma*)

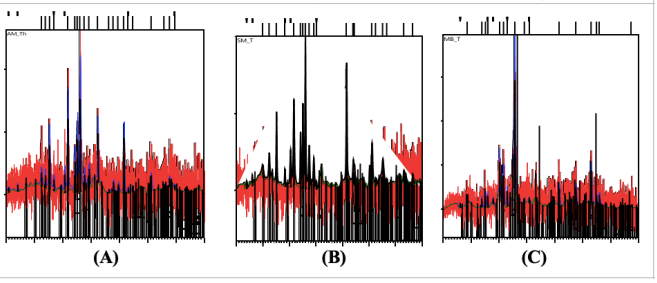


Table 9: Show XRD pattern list of raw *Mandura*

Visible	Ref. Code	Score	Compound Name	Displacement [°2Th.]	Scale Factor	Chemical Formula
*	98-001-0409	21	Fayalite	0.000	0.307	Fe_2 O_4 Si_1

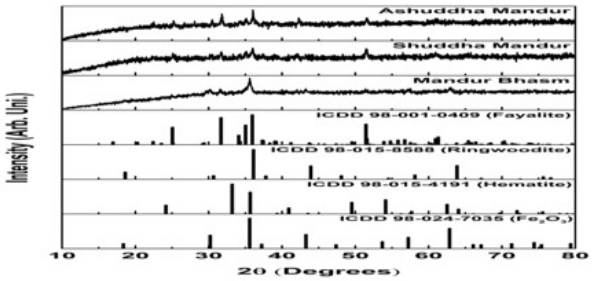
Table 10: Shows Pattern list of Purified *Mandura*

Visible	Ref. Code	Score	Compound Name	Displacement [°2Th.]	Scale Factor	Chemical Formula
*	98-001-0409	25	Fayalite	0.000	0.614	Fe_2 O_4 Si_1

Table 11: Show XRD Pattern List of *Mandura Bhasma*

Visible	Ref. Code	Score	Compound Name	Displacement [°2Th.]	Scale Factor	Chemical Formula
*	98-008-7459	20	Iron Iron(III) Silicon Oxide (1.28/1.44/0.28/4)	0.000	0.551	$Fe_{2.719}$ O_4 Si0.281
*	98-006-8762	8	Fayalite	0.000	0.186	Fe_2 O_4 Si_1

Figure 3: Showing XRD of comparison of *Mandura* with the reference



Fourier FTIR

Based on the peaks obtained from the FTIR reveals the presence of functional groups. In sample AM (*Asuddha Mandura*) sharp peaks indicate the presence of organic compounds such as alcohol, nitro compounds and alkenes (Figure 4 (A), table 12). In sample SM (*Suddha Mandura*) sharp peaks indicate the presence of organic compounds such as alcohol, carbon dioxide, conjugate acid halide, nitro compound and alkenes (Figure 4 (B), Table 13). In sample MB (*Mandura Bhasma*) sharp peaks indicate the presence of organic compounds such as alcohol, alkyne, carbon dioxide, acid halide, nitro compound, carboxylic acid and alkenes (Figure 4 (C), Table 14).

Figure 4: Showing FTIR (A) Raw *Mandura* (AM) (B) Purified *Mandura* (SM) (C) *Mandura Bhasma* (MB)

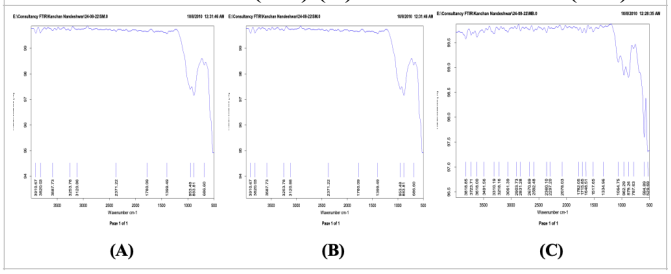


Table 12: Infrared absorption frequencies of Raw *Mandura*.

Frequency range	Absorption (cm^{-1})	Appearance	Group	Compound class
3748.38	3700-3584	Medium, sharp	O-H stretching	Alcohol
3645.27	3700-3584	Medium, sharp	O-H stretching	Alcohol
1542.75	1550-1500	Strong	N-O stretching	Nitro compound
878.58	895-885	Strong	C=C stretching	Alkenes

Table 13: Infrared absorption frequencies of Purified *Mandura*

Frequency range	Absorption (cm^{-1})	Appearance	Group	Compound class
3910.67	3700-3584	Medium, sharp	O-H stretching	Alcohol
3820.03	3700-3584	Medium, sharp	O-H stretching	Alcohol
3587.73	3700-3584	Medium, sharp	O-H stretching	Alcohol
3253.78	3550-3200	Strong, broad	O-H stretching	Alcohol
3120.88	3200-2700	Weak, broad	O-H stretching	Alcohol
2371.22	2349	Strong	O=C=O stretching	Carbon dioxide
1780.09	1800-1770	Strong	C=O stretching	Conjugated acid halide
1399.49	1550-1500	Strong	N-O stretching	Nitro compound
953.48	995-985	Strong	C=C stretching	Alkenes
883.81	895-885	Strong	C=C stretching	Alkenes
686.60	730-665	Strong	C=C stretching	Alkenes

Table 14: Infrared absorption frequencies of *Mandura bhasma*

Frequency range	Absorption (cm^{-1})	Appearance	Group	Compound class
3818.85	3700-3584	Medium, sharp	O-H stretching	Alcohol
3723.71	3700-3584	Medium, sharp	O-H stretching	Alcohol
3618.00	3700-3584	Medium, sharp	O-H stretching	Alcohol
3491.56	3550-3200	Strong, broad	O-H stretching	Alcohol
3310.19	3550-3200	Strong, broad	O-H stretching	Alcohol
3218.16	3550-3200	Strong, broad	O-H stretching	Alcohol
3061.39	3200-2700	weak, broad	O-H stretching	Alcohol
2903.73	3333-3267	Strong, sharp	C-H stretching	Alkynes
2831.28	3333-3267	Strong, sharp	C-H stretching	Alkynes
2670.89	3100-3000	Medium	C-H stretching	Alkenes
2592.48	3333-3267	Strong, sharp	C-H stretching	Alkynes
2360.10	2349	Strong	O=C=O stretching	Carbon dioxide
2297.20	2349	Strong	O=C=O stretching	Carbon dioxide
2078.03	2349	Strong	O=C=O stretching	Carbon dioxide
1782.05	1815-1785	Strong	C=O stretching	Acid halide
1715.85	1815-1785	Strong	C=O stretching	Acid halide

1648.51	1648-1638	Strong	N-O stretching	Nitro compound
1517.65	1550-1500	Strong	N-O stretching	Nitro compound
1334.96	440-1395	Medium	O-H stretching	Carboxylic acid
1064.75	440-1395	Medium	O-H stretching	Carboxylic acid
962.29	995-985	Strong	C=C stretching	Alkenes
879.24	895-885	Strong	C=C stretching	Alkenes
787.63	840-790	Medium	C=C stretching	Alkenes

Discussion

Pharmaceutical study

Mandura Detoxification was done by quenching in Cow urine as explained in Classical Alchemy text. The temperature to make *Mandura* red hot was 690-722^{0}C. Each quenching fresh Cow urine was taken. After the process, the average obtained purified *Mandura* was 158.3g and loss of 20.8% in all batches. The rationality of using Cow urine as media, aids in the breakdown of particles and the removal of unwanted substances from the material. Acidic contaminants in Slag of Iron, such as chlorides, sulphides, and nitrates, may be neutralised and washed away by the alkaline Cow urine. Because of the hardness of *Mandura*, repetitive heating and quenching in certain media destroys the compression tension equilibrium in the internal structure of the *Mandura*. The heating step in this quenching approach weakens electrostatic forces and the crystal lattice of *Mandura*. Because of the high temperature, there is a greater collision between the particles (Collision theory). Bonds weaken as a result of this, causing structural weakness that may grow into a crack (Griffith theory). After heating, immediate quenching in liquid media disrupts compression tension equilibrium. This causes the material to become more brittle and its hardness to decrease. As a result, of loss in weight purified Slag of Iron, some of the material is converted to coarse powder and some to fine powder. Powder was discovered in the media following each quenching. Ammoniated citric acid has been shown to dissolve Fe_2O_3 and create water-soluble Fe^{2+} and Fe^{3+} complexes. (18) *Mandura* is heated to red-hot temperatures before being dipped in a cool liquid medium, which aids in particle size reduction and the removal of exterior contaminants. Immediate quenching allows the liquid media to permeate inside the *Mandura* particles, disrupting ionic connections reducing hardness and increasing brittleness. Immediate quenching allows the liquid media to permeate inside the *Mandura* particles, disrupting ionic connections reducing hardness and increasing brittleness. Initially, it took 30 minutes for the entire *Mandura* to become red-hot, but this time was subsequently reduced due to the breakdown of the Slag of Iron's ionic bonds. (19)

Mandura Bhasma was prepared as per classical references. According to *Rasamrita,* the juice of Aloe vera was chosen as liquid media for the incineration process. The juice of Aloe vera functions as a catalyst, and trace elements will be added to *Mandura.* Juice of Aloe vera helps in particle size reduction, and uniform mixing of *Mandura* potentiating the product and bringing compactness. It may add some organic and inorganic trace elements into the final compound along with enhancement of therapeutic qualities of the compound**.** The homogeneous mixture was transformed into miniature pellets of regular size and shape. This aids in achieving a uniform heat pattern across the entire bulk due to the greater surface area. *Puta* was given by Cow dung cakes at a temperature of 670^{0}C as shown in figure 1. *Puta* was given with the help of an earthen saucer because of its inert nature, ease of availability, and even distribution of heat to the substance. For the first 4th *puta Mandura* was blackish brown, mild fine particles and tasteless was attained. From the 5th to the 10th *Puta Mandura* became reddish brown and the 12th *Puta Mandura* become brownish and passed all incineration tests. Classical texts have emphasized various *Bhasma pariksha* and suggested to use of *bhasma* only after fulfilling the *Bhasma pariksha* satisfactorily. *Bhasma pariksha* like *Mrudutva* and *Niswadu* was achieved right from the 1st *Puta*, and *Rekhapurnata* was gained towards the end of the 9th *Puta.* This signifies the fitness of *bhasma. Varitaratwa* and *Unnama* were positive after the 12th *Puta,* indicating the lightness and finess of *bhasma. Dantagrekachabhava*, *Shlakshanatva* and *Sukshmatva were* achieved after the 12th *Puta* also indicating the fineness of *bhasma* free from particles. *Nirdhuma* was performed which shows there were no smoke coming out while burning and in *Apunarbhava* there are no many changes seen. After incineration, the average obtained *Mandura Bhasma* was 295g and 36.5% loss in all batches (Table 3, 5 & 6). Thus the prepared *Mandura Bhasma* was satisfactorily fulfilled all above mentioned *Bhasma pariksha*.

Analytical study

Analytical studies can be used to predict the drug's pharmacokinetics and pharmacodynamics. Ayurveda has also stated several analytical methodologies for determining the quality of the chosen material and result. (20) However, Ayurvedic analytical tools are insufficient to solve modern science's questions. As a result, for improved Ayurvedic pharmaceutics utilisation, it is important to analyse the medicine using both classical and current qualitative and quantitative metrics. Analytical research was performed to determine the specific chemical composition of the final product. On organoleptic assessment, *bhasma* has a brownish colour, is smooth and has no distinct odour. Touch implies physical qualities of *bhasma* such as smoothness, softness, and fineness. Because each chemical compound has a unique colour, the specific colour of *bhasma* signals the creation of certain chemicals. All of the traditional analytical parameters have a definite meaning.

The results showed that *Mandura bhasma* has a pH of neutral, which allows for absorption in the small intestine. The loss on drying at 1050°C demonstrates the presence of moisture content. If the moisture content exceeds the allowable limit, the formulation is more prone to become infected with fungal growth. Furthermore, the presence of moisture can cause undesirable alterations. The moisture level of the manufactured batches is substantially lower, indicating that the formulation is more stable. All of the samples had a loss on drying value that was within the usual range, indicating that they were all genuine (Table 7).

Total ash value determination provides the foundation for judging the identification and cleanliness of any drug and provides information about its adulteration/contamination with inorganic materials; consequently, ash values are useful in determining the quality and purity of the drug. Acid insoluble ash refers to ash that is insoluble in dilute HCL. A higher limit of acid-insoluble ash is imposed especially in cases where silica may be present or when the *bhasma* is prepared from metals chance of the presence of an inorganic compound. As the *bhasma* was prepared at a temperature of 700^0C which is more of that ash temperature and *Mandura Bhasma* is in ash form sulphated ash was performed. Sulphated ash-dilute in sulphuric acid to measure the inorganic impurities in organic substance. Extractive value: water extract and alcohol are used as solvents to determine any adulterants or exhausted in the sample. Results shows are within the standard as shown in Table 8. *Mandura Bhasma* contains phytochemical constituents like steroids, alkaloids, tannin and saponin. This helps in understanding the pharmacological importance and health risks.

XRD (X-ray diffraction)

X-ray diffraction analysis results revealed the crystalline nature of *Mandura Bhasma* which is compared to raw and purified Slag of Iron. The common chemical compound present in all three samples is Fe_2O_3. This shows that the Ferric oxide phase is present in all three samples but the *Mandura* matches with a mixture of two minerals Fayalite and Ringwoodite. *Mandura Bhasma* is mostly iron oxide. *Mandura* is a form of iron silicate and has been reported in many studies. Fayalite and Ringwoodite are both iron silicate but structurally different. In raw and purified *Mandura* only Fayalite is detected but in *Mandura bhasma*, Iron Iron (III) Silicon Oxide and Fayalite are found. The difference in the molecular structure of Fe_2O_3 in three samples and clear free phase was not detected in AM and SM due to the pharmaceutical process such as *Bhavana* (levigation) and *puta* transforming the metal from its zerovalent state to a compound state, such as oxides in which it functions optimally. The treatment reduces the toxic character of the metal and changes in physical and chemical properties while increasing its medicinal potential. The structural information of these completed compounds is also required to deduce their mode of action. (21)

FTIR (Fourier Transform Infrared Spectroscopy)

The presence of functional groups was determined using FTIR; functional groups signify the structure of the compound as well as organic metallic ligands in the *Mandura* samples. (22) FTIR analysis can be used as a tool to differentiate the *bhasma* prepared by different techniques. FTIR results revealed that in AM are alcohol, nitro compounds and alkenes. In SM are alcohol, carbon dioxide, conjugate acid halide, nitro compound and alkenes. In MB are alcohol, alkynes, carbon dioxide, acid halide, nitro compounds, carboxylic acid and alkenes. Because these processes include the use of liquid media and the application of heat, several chemical reactions occur, resulting in the existence of organic molecules. As a result, it can enter the systemic circulation or cell structure and rapidly operate on the desired area by binding to an enzyme. It should also be mentioned that the presence of more functional groupings indicates that a single drug has a more complex activity. In general, a single drug is assigned to several actions just by modifying the adjuvants. Because of the parent element's large number of functional groups, which allows it to work differently in different illnesses, this dynamic activity may be possible. During levigation, a lot of changes happen all chemical constituents or organic compounds of drugs used for levigation are present in the *bhasma* and while giving heat their chemical reaction takes place the reason there are so many unidentified peaks in the XRD and FTIR.

Conclusion

Mandura bhasma was prepared by adopting a purification and incineration process by process with different herbal drugs. After the process, the average obtained purified *Mandura* was 158.3g and loss of 20.8% in all batches. *Mandura bhasma* satisfied all the Ayurvedic parameters as well as modern parameters within the standard. XRD analysis showed that *Mandura bhasma* is more crystalline and has formula $Fe_{2.719}O_4Si_{0.281}$, $Fe_2O_4Si_1$, cubic and orthorhombic crystal structure. FTIR analysis revealed the presence large number of functional groups. Analytical examination aided in determining the structural and chemical transformations of *Bhasma* caused by pharmaceutical manufacturing. *Bhasma Pariksha* is more qualitative in character, and contemporary analytical parameters help to fill in the gaps in such traditional procedures to some extent. The various processes utilised to prepare *Bhasma* resulted in compounds with varying chemical compositions and particle sizes. The therapeutic efficacy of the *bhasma* is believed to manifest only when it has successfully undergone the *Bhasma Pariksha,* a rigorous traditional assessment ensuring its quality and potency. This would undoubtedly aid in ensuring safety, efficacy, and batch-to-batch consistency. This approach combines both traditional Ayurvedic assessment methods and contemporary analytical techniques to ensure the quality and purity of *Mandura Bhasma*, exemplifying

how Ayurveda integrates time-honoured wisdom with modern quality standards.

Conflict of interest: There is no conflicts of interest.

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