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Original Article

Identification of *Gairika* (Red Ochre) by Classical and Contemporary Parameters and Structural Evaluation of *Gairika* Pre and Post Classical Purification Procedure

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ABSTRACT

Background: Given the growing adulteration and lack of genuine materials, it is imperative that *Rasadravya* (herbo-mineral substance) be identified and standardised in Ayurvedic pharmaceutics to assure therapeutic efficacy and safety. *Gairika* (Red Ochre), classified as *Uparasa*, is traditionally used in various treatments and is expected to contain at least 16% elemental iron or 21% Ferric Oxide (Fe_2O_3), as specified by the Ayurvedic Pharmacopoeia of India. **Aim and Objectives:** This study aimed to identify and authenticate *Gairika* samples collected from ten different regions using a multidisciplinary approach that included classical methods (*Grahya Lakshana*), geological analysis, and modern instrumental techniques. **Materials and Methods:** The initial phase involved screening based on classical characteristics, followed by a geological assessment and the quantification of iron content by titrimetric analysis. Three samples with iron content exceeding 20% were selected for further analysis using X-ray Fluorescence (XRF). Among these, the sample from Bagalakote was chosen for *shodhana* (purification) by the *Bharjana* method in Ghee. Post-purification, the sample underwent re-evaluation using XRF, XRD and SEM-EDX. **Results:** The results revealed slight alterations in its chemical composition compared to the pre- and post-purification processes. **Conclusion:** This integrated methodology underscores the importance of combining traditional and modern techniques for the accurate identification and safe therapeutic use of *Rasadravyas*, such as *Gairika*.

Keywords: Analytical Techniques, *Gairika*, Geological Identification, *Grahya Lakshaṇa, Shodhana*, XRF.

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INTRODUCTION

Identification of *Rasadravya* (herbo-mineral substances) is a crucial step in Ayurvedic pharmaceutics, especially due to the increasing unavailability and adulteration of genuine substances (Jagtap *et al*., 2024). In Classics, *Acharya* mentioned detailed methodologies for identifying *Rasadravya* based on *Grahya Lakshana* (the physical and chemical characteristics) (Kulkarni, 2010; Sharma, 2000a).

Gairika, one of the *Uparasa* (secondary minerals), has been traditionally used in the treatment of various diseases (Sharma, 2000b). *Acharya* mentioned *Shonita* (red colour), *Masruna* (soft and smooth), *Snigdha* (unctuous), and *Atikomala* (very soft) *Lakshana* for the identification of *Gairika* (Kulkarni, 2010; Sharma, 2000a). According to the Ayurvedic Pharmacopoeia of India (API), authentic *Gairika* (Red Ochre) must contain not less than 16% elemental Iron or 21% Ferric Oxide (Fe_2O_3) (Government of India, 2009). Therefore, proper identification and standardisation of *Gairika* is essential before it is incorporated into any medicinal preparation.

The identification of *Gairika* holds great significance, as its *Grahya Lakshana* and iron content may vary according to geographical origin. Hence, mere reliance on physical observation is inadequate; a multidisciplinary approach integrating classical parameters with modern analytical techniques becomes essential for its precise characterisation.

In the present study, multiple samples of *Gairika* were collected from different regions. Each sample was evaluated for its authenticity and quality using a combination of classical identification methods (*Grahya Lakshana*), geological identification techniques (Lumen Learning, 2025) and modern instrumental methods, such as X-ray fluorescence (Neikov & Yefimov, 2019).

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The study aims to identify a genuine sample of *Gairika* through classical and modern analytical methods, and to validate its purification process (*Shodhana*), thereby ensuring its safety and efficacy for therapeutic use by adopting the structural analysis by X-ray fluorescence, X-ray Diffraction and Scanning Electron Microscopy-Energy Dispersive X-ray Spectroscopy.

MATERIALS AND METHODS

A total of ten *Gairika* (Red Ochre) samples were collected from various pharmacies located in Mumbai, Delhi, Bangalore, Kadakola, Bagalakote, Kolhapur, Vashi, Belagavi (local), and two different sources within Belagavi. Initially, all samples were evaluated based on *Grahya Lakshana* as described in the classical *Ayurvedic* texts, *Rasaratna Samuccaya* and *Rasatarangini* (Kulkarni, 2010; Sharma, 2000a).

Subsequently, all ten samples were submitted to the Department of Geology, G.S.S. College, Belagavi, for geological identification. Based on the results obtained from the Department of Geology, including iron percentage determined by the titrimetric method (Research Gate, 2025) and geological identification, three samples were selected for further analysis using X-ray Fluorescence (XRF) at the Department of Chemistry, Rani Chennamma University, Belagavi, to estimate their iron content.

Based on the results of *Grahya Lakshana* and iron content analysis, the sample from Bagalakote was selected for the *Shodhana* (purification) procedure after assessing the microbial contamination. The *Shodhana* process was conducted using the *Bharjana* (roasting) method described in the *Ayurveda Prakasha* (Madhava, 2007).

For the *Shodhana* procedure, 750 g of *Gairika* was finely powdered and passed through a 120-mesh sieve. Out of this, 700 g were used for *Shodhana*. As per classical previous research, one-fourth of the quantity of *Ghrita* (clarified butter), i.e., 175 g, was used. (Charde *et al*., 2023; Ranade, 2022). An iron pan (*Loha Kadhai*) was heated on a low flame, and *Ghrita* was added until it melted. The powdered *Gairika* was then gradually added and roasted (*Bharjana*) until it became free-flowing and a distinct colour change was observed from dark red to brownish-red, accompanied by the characteristic aroma of Ghrita.

The duration of the process was 3 hr. After 3 hr, the purified *Gairika* was taken from the flame and allowed to cool. The purified *Gairika* was then filtered through a mesh and stored in an airtight container.

Then *Shodhita Gairika* was subjected to instrumental analysis, wherein XRF was selected to determine the percentage of elemental iron and iron oxide (Fe_2O_3), XRD and SEM-EDX for the structural characterisation.

Observations and Results

The samples collected from Mumbai, Bagalakote, Kolhapur, and Vasi passed all the *Grahya Lakshana*. The sample collected from Delhi was hard like stone; therefore, it did not pass the *Atikomal* parameter. The sample collected from Kadakola was hard and non-lustrous. Samples 1 and 3 from Belagavi did not pass these parameters. The second sample of Belagavi passed *Masruna* and *Atikomal* parameters. The results are presented in (Table 1, Figure 1).

The mineralogical identification of all ten *Gairika* samples was carried out in the Geology Department of G.S.S College, Belagavi. The different parameters were tested for identification. The results are presented in (Table 2 (a) and Table 2 (b), Figure 1).

The results obtained from the mineralogical identification showed that among 10 samples, 3 samples had an iron content above 20%. These three samples were further submitted for the XRF analysis. The results are presented in (Table 3).

Ghee was analysed as per the API for its quality. The results are presented in (Table 4).

Table 1: *Grahya Lakshana* of *Gairika* samples collected from different places.

Sample Collected from	*Shonita*	*Masruna*	*Snigdha*	*Atikomal*
Mumbai	+	+	+	+
Delhi	+	+	+	-
Bengauru	+	+	+	+
Kadakola	+	+	-	-
Bagalakote	+	+	+	+
Kolhapur	+	+	+	+
Vasi	+	+	+	+
Belagavi (1)	-	-	-	-
Belagavi (2)	-	+	-	+
Belagavi (3)	-	-	-	-

Note: + Passed, - Not passed.

Figure 1: Collection and Identification of *Grahya Gairika* Samples.

The *Gairika* Sample was evaluated for microbial contamination before the *Shodhana* procedure. The results are presented in (Table 5).

The *Gairika Shodhana* process details are presented in (Table 6).

The organoleptic evaluation of *Gairika* before and after *Shodhana* is presented in (Table 7 and Figure 2).

The *Gairika* was evaluated for its chemical composition before and after the *Shodhana* in *Go Ghrita* by XRF. The results are tabulated in (Table 8).

The structural characteristics of *Gairika* were evaluated before and after *Shodhana* in *Go Ghrita* using XRD and the findings are presented in (Table 9, Graphs 1a, 1b).

SEM-EDX

The structural characteristics of *Gairika* were evaluated before and after *Shodhana* in *Go Ghrita* using SEM-EDX and the findings are presented in (Graphs 2a, 2b, Figures 3a, 3b).

Table 2 (a): Mineralogical identification of *Gairika*.

Samples/ Parameters	*Gairika* Mumbai	*Gairika* Delhi	*Gairika* Bangaluru	*Gairika* Kadakola	*Gairika* Bagalakote
Colour	Brick red	Brownish red	Brick red	Light Brown	Deep Red
Hardness	Soft	Moderately hard	Soft	Soft to moderately hard	Soft to moderately hard
Lustre	Earthy	Earthy	Earthy	Earthy	Earthy
Streak	Red	Red	Red	Red	Cherry Red
Texture	Fine-grained and smooth to powdery	Fine-grained, slightly gritty	Fine-grained and smooth to powdery	Fine-grained and smooth to powdery	Fine-grained, slightly gritty
Opacity	Opaque	Opaque	Opaque	Opaque	Opaque
Composition	Hematite	Hematite	Hematite	Hematite	Hematite
Mineralogy	Clay mineral, quartz	Clay mineral, quartz	Clay mineral, quartz	Clay mineral, quartz	Clay mineral, quartz
Solubility	Insoluble in water	Insoluble in water	Insoluble in water	Insoluble in water	Insoluble in water
% of Iron content	15.9%	12.17%	14.9%	11.85%	24.68%

Table 2 (b): Mineralogical identification of *Gairika*.

Samples/ Parameters	*Gairika* Kolhapur	*Gairika* Vasi	*Gairika* Belagavi (1)	*Gairika* Belagavi (2)	*Gairika* Belagavi (3)
Colour	Deep Red	Deep Red	Light brown pink	Light Red	Light brown
Hardness	Soft	Soft	Hard	Moderately Hard	Moderately Hard
Lustre	Earthy	Dull	Dull	Dull	Dull
Streak	Cherry Red	Cherry Red	Brown	Light Red	Light Brown
Texture	Fine-grained, Smooth	Fine-grained, Smooth	Fine-grained, slightly gritty	Fine-grained, Smooth	Fine-grained, slightly gritty
Opacity	Opaque	Opaque	Opaque	Opaque	Opaque
Composition	Hematite	Hematite	Hematite	Hematite	Hematite
Mineralogy	Clay mineral, quartz	Clay mineral, quartz	Clay mineral, quartz	Clay mineral, quartz	Clay mineral, quartz
Solubility	Insoluble in water	Insoluble in water	Insoluble in water	Insoluble in water	Insoluble in water
% of Iron content	23.4%	20.4%	05.97%	07.48%	10.75%

DISCUSSION

The identification of *Rasadravya*, especially mineral substances like *Gairika* (Red Ochre), is crucial for ensuring the safety, efficacy, and authenticity of *Ayurvedic* formulations. Classical texts such as the *Rasaratna Samuccaya* and *Rasatarangini* describe the *Grahya lakshana* (a set of physical and chemical tests) precisely for recognising genuine *Rasadravyas* (Kulkarni, 2010; Sharma, 2000a). However, in modern science, with increasing adulteration and regional variations in mineral composition, traditional methods need to be complemented with contemporary scientific tools to verify the authenticity of *Rasadravya*.

In the present study, ten samples of *Gairika* were collected from various geographic regions across India and subjected to an analytical approach, including classical *Grahya lakshana* assessment, geological evaluation, and instrumental analysis using XRF. This approach emphasises the importance of integrating ancient wisdom with modern science for accurate identification and standardisation.

Out of ten collected samples, six met all four key *Grahya Lakshana* (*Shonita, Masruna, Snigdha, Atikomal*), indicating potential suitability for therapeutic use. Samples from Delhi, Kadakola, and two Belagavi sources failed to meet these criteria, suggesting impurity or a non-standard mineralogical composition. This underscores the importance of *Grahya Lakshana* as a first-level screening tool in Ayurvedic pharmaceutics.

Geological characterisation revealed hematite as the primary mineral constituent in all samples, accompanied by secondary minerals such as clay and quartz. Despite uniform mineralogy, iron content varied significantly among the samples. Only samples from Bagalakote, Kolhapur, and Vasi surpassed the API's minimum requirement of 16% of Iron content, underscoring that visual assessment alone is insufficient to confirm authenticity. A deep red colour correlated with higher iron content, aligning with the classical reference to *Shonita* (blood-like red colour) as a desirable trait. The samples had lower concentrations of iron oxides, which are often used in industrial settings rather than directly for medicinal purposes because of their low nutrient bioavailability.

XRF analysis further confirmed the high Fe_2O_3 content in the Bagalakote (73.2%), Kolhapur (75.3%), and Vasi (76.7%) samples. These values significantly exceed the API threshold, affirming their authenticity. Additionally, the presence of trace elements like Ti, K, and Si, along with oxides such as Al_2O_3 and SiO_2, reflects the natural heterogeneity of mineral samples. Importantly, toxic heavy metals such as Pb and Cr were found in negligible quantities, ensuring safety for pharmaceutical use.

Among the three quality passed samples, the Bagalakote sample was selected for *Shodhana* based on both classical parameters and iron content. The selected sample of the *Gairika* passed all microbial contamination tests. The *Bharjana* method using *Go Ghrita* (clarified butter) was chosen, as mentioned in *Ayurveda Prakash*. Post *Shodhana*, the *Gairika* showed notable changes in organoleptic properties, colour changed from deep red to reddish-brown, and the characteristic smell of *Ghrita* was imparted. These changes indicate a successful transformation, aligning with classical expectations of *Shodhana*.

XRF analysis after *Shodhana* revealed a decrease in elemental iron from 26.4% to 21.7% and a marginal reduction in Fe_2O_3

Figure 2: *Gairika Shodhana.*

Table 3: XRF report of *Gairika* samples collected from Bagalakote, Kolhapur & Vasi.

Sl. No.	Metals/ Minerals	% of the Composition			Oxides	% of the Composition		
		Sample 5	Sample 6	Sample 7		Sample 5	Sample 6	Sample 7
1.	Fe	22.85±0.11%	24.97±0.11%	21.54±0.09%	Fe_2O_3	73.2±0.6%	75.3±0.6%	76.7±0.6%
2.	K	0.59±0.25%	0.6±0.3%	0.4±0.3%	SiO_2	14.1±0.7%	12.1±0.6%	12.1±0.6%
3.	Ti	0.53±0.10%	0.46±0.10%	0.52±0.09%	Al_2O_3	10.5±1.3%	10.1±1.3%	8.7±1.3%
4.	Cr	0.03±0.03%	-	-	TiO_2	1.21±0.22%	1.07±0.22%	1.29±0.23%
5.	Ba	-	0.09±0.21%	-	P_2O_5	0.2±0.3%	0.2±0.3%	0.2±0.3%
6.	Sb	-	0.04±0.05%	-	CaO	0.2±0.3%	0.1±0.3%	-
7.	Sn	-	0.02±0.02%	-	PdO	0.10±0.04%	-	-
8.	Zr	-	0.02±0.00%	-	ZrO_2	0.10±0.01%	0.10±0.01%	0.13±0.01%
9.	V	-		0.03±0.04%	BaO	0.1±0.4%	0.1±0.4%	-
10.					Sb_2O_3	0.08±0.19%	-	-
11.					V_2O_5	0.06±0.12%	0.05±0.12%	0.07±0.12%
12.					Nb_2O_5	0.03±0.01%	0.03±0.01%	0.03±0.01%
13.					PbO	0.03±0.01%	0.03±0.01%	-
14.					SrO	0.02±0.01%	0.02±0.01%	0.02±0.01%
15.					NiO	-	0.02±0.04%	-
16.					K_2O	-	0.7±0.4%	0.7±0.4%
17.					SnO_2	-	-	0.10±0.11%
18.					Ta_2O_5	-	-	0.06±0.05%
19.					Rb_2O	-	-	0.02±0.01%

Table 4: Analytical report of *Ghrita* (Ghee).

Tests	Limits	Results
Organoleptic Characters		
Form	Semisolid with granular texture	Semisolid with granular texture
Colour	White to light yellow	White to light yellow
Odour	Rich and Characteristic	Rich and Characteristic
Taste	Pleasant	Pleasant
Physicochemical standards		
Moisture content	Not more than 0.5%	0.048%
Weight per ML	NA	1.012
Acid value	NA	3.899
Saponification value	Not more than 225	201.153
Iodine value	Not more than 35	32.474
Specific gravity	NA	0.956
Rancidity	NA	Negative

Table 5: Microbial evaluation of *Gairika*.

Test for specified Micro-Organisms (Qualitative)		
	Limits (As per IP)	Results
E. coli	Absent/100 mL	Absent
S. aureus	Absent/100 mL	Absent
P. aeruginosa	Absent/100 mL	Absent
S. Abony	Absent/100 mL	Absent
Microbial Limit Test (Quantitative)		
Total Bacterial Count	30 - 300 cfu/mL	No growth
Total Fungal Count	10 - 100 cfu/ml	No growth

from 73.8% to 73.1%. This minor reduction could be attributed to the thermal and oxidative interactions during *Bharjana*, possibly causing superficial loss or redistribution of iron compounds, phase transformation, and surface-level redistribution of iron species.

The XRD analysis of *Ashodhita Gairika* demonstrated sharp and intense peaks with high counts, confirming its higher degree of crystallinity and relatively larger crystallite size. In contrast, *Shodhita Gairika* exhibited peaks of reduced intensity and slight broadening, accompanied by marginal shifts in 2θ values. These changes indicate a reduction in crystallinity,

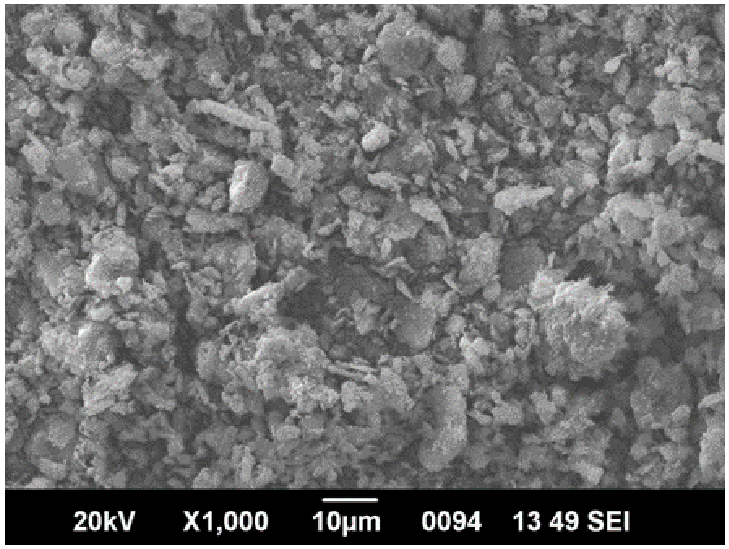


Figure 3a: SEM Ashodhita *Gairika*.

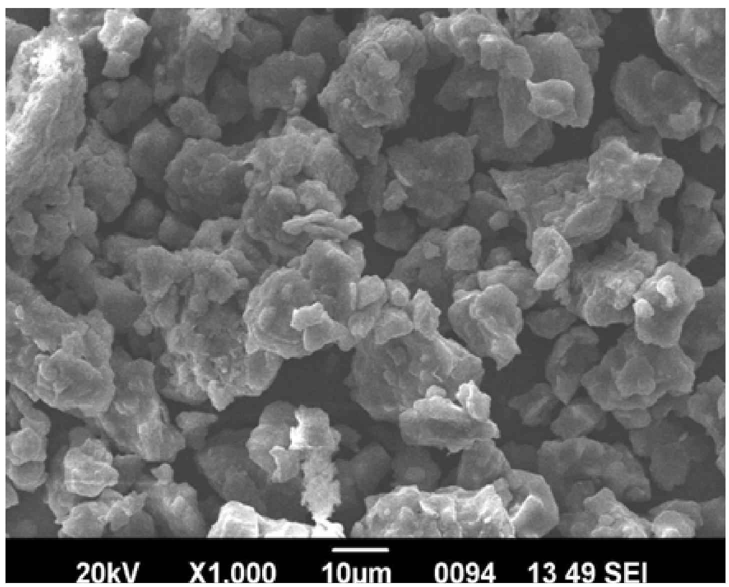
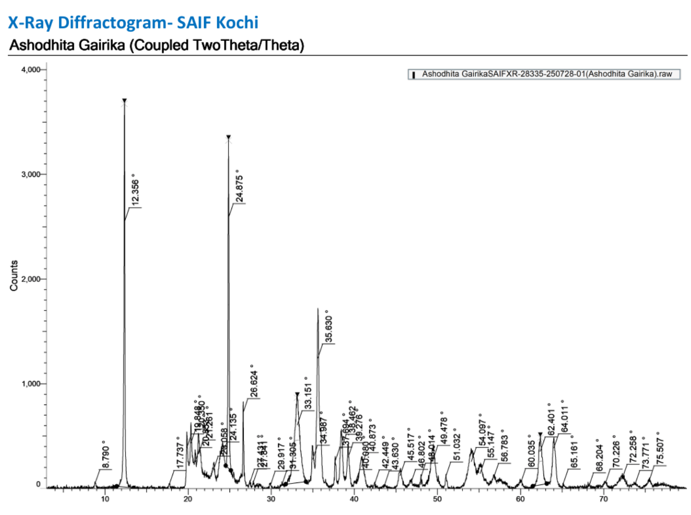
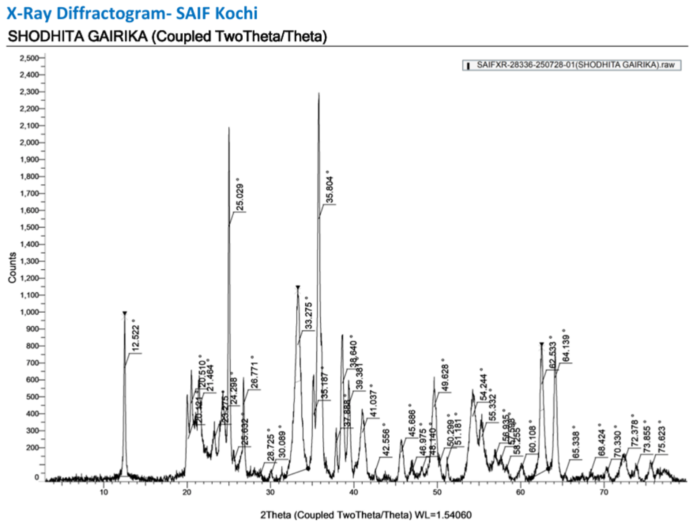


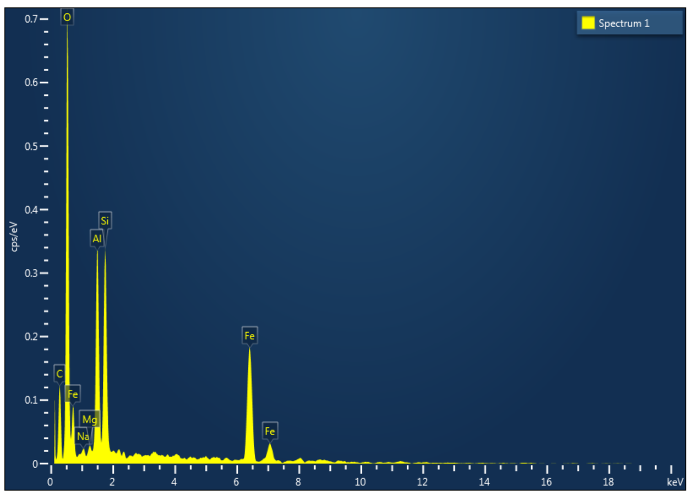
Figure 3b: SEM *Shodhita Gairika*.



Graph 1a: XRD Peaks of *Ashodhita Gairika*.



Graph 1b: XRD Peaks of *Shodhita Gairika*.



Graph 2a: SEM-EDAX Peaks of *Ashodhita Gairika*.

Table 6: Observations of *Gairika Shodhana*.

Gairika Shodhana	*Gairika*	*Go Ghrita*	Duration	Quantity obtained	Weight Gain
	700 g	175 g	3 hr	824.2 g	124.2 g

Table 7: Organoleptic evaluation of *Gairika* before and after *Shodhana*.

Organoleptic characters	Before *Shodhana*	After *Shodhana*
Colour	Deep red	Reddish brown
Touch	Soft	Soft
Odour	Muddy	*Ghrita gandha* (Ghee odour)
Taste	Kashaya	Kashaya Madhura

partial amorphisation, and lattice modifications induced by the *Shodhana* process.

A noteworthy observation was the decrease in crystallite size following *Shodhana*. The crystallite dimension, which was as high as 76.7 nm in *Ashodhita Gairika*, reduced to 41.1 nm in *Shodhita Gairika* at the corresponding peak (12.35° vs 12.52°). This refinement towards smaller particle sizes suggests that *Shodhana in Go Ghrita* facilitates particle disintegration and enhances surface area. Such a transformation is pharmaceutically significant, as finer and less crystalline particles are known to exhibit improved bioavailability and reactivity, thereby potentiating the therapeutic effects of mineral drugs.

SEM results of *Ashodhita Gairika* revealed an irregular, and heterogeneously aggregated structure. In contrast,Shodhita *Gairika* showed auniform, compact, and finely granulated microstructure**.**

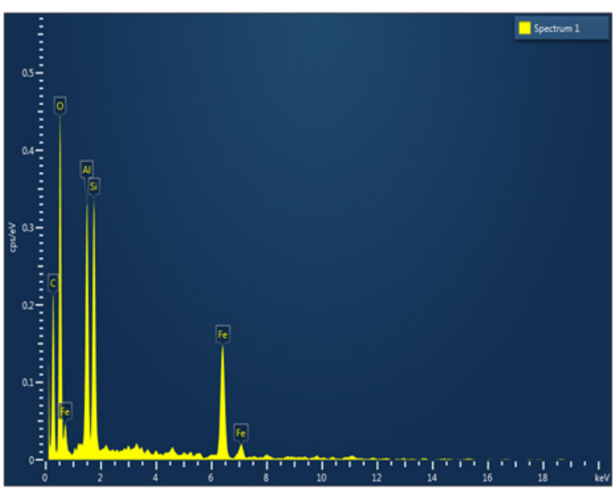
The EDAX spectrum of *Ashodhita Gairika* showed Fe and O as the dominant elements, confirming Iron Oxide (Fe_2O_3) as the principal component. Peaks corresponding to Si, Al, C and

Table 8: XRF results of *Gairika* before and after *Shodhana*.

Sl. No.	Metals/ Minerals	% of the Composition		Oxides	% of the Composition	
		Before *Shodhana*	After *Shodhana*		Before *Shodhana*	After *Shodhana*
1	Fe	26.4±0.05%	21.7±0.04%	Fe_2O_3	73.8±0.6%	73.1±0.6%
2	Ti	0.55±0. 05%	0.5±0. 04%	SiO_2	13.3±0.6%	14±0.6%
3	K	0.44±0.13%	0.33±0.12%	Al_2O_3	10.6±1.2%	10.8±1.3%
4	Ca	0.06±0.06%	0.07±0.05%	TiO_2	1.09±0.22%	1.13±0.22%
5	Cr	0.02±0.01%	0.01±0.01%	K_2O	0.5±0.4%	-
6	V	0.02±0.02%	0.02±0.01%	P_2O_5	0.2±0.3%	0.2±0.3%
7	Zr	0.02±0.00%	0.01±0.00%	CaO	0.1±0.3%	0.1±0.3%
8	Mn	0.02±0.00%	0.02±0.00%	ZrO_2	0.11±0.01%	0.11±0.01%
9	Pb	0.005±0.00%	0.00±0.00%	V_2O_5	0.05±0.11%	0.05±0.12%
10	Sr	0.004±0.00%	0.00±0.00%	Cr_2O_3	0.03±0.05%	0.04±0.05%
11	Rb	0.003±0.00%	0.00±0.00%	Nb_2O_5	0.03±0.01%	0.03±0.01%
12	Br	0.0005±0.00%	-	Rb_2O	0.02±0.01%	-
13	L.E	72.42±0.1%	-	SrO	0.02±0.01%	-
14	Sn	-	0.02±0.01%	Ga_2O_3	0.01±0.01%	-
15	Mo	-	0.00±0.00%	Co_3O_4	-	0.09±0.14%
16	Se	-	0.00±0.00%	BaO	-	0.1±0.4%
17				ThO_2	-	0.05±0.03%

Table 9: XRD peaks of *Gairika* before and after *Shodhana*.

Parameter	*Aśhodhita Gairika*	*Shodhita Gairika*
Major peak (2θ, d-spacing)	12.35° (7.15 Å), 24.87° (3.57 Å), 33.14° (2.70 Å), 62.38° (1.48 Å)	12.52° (7.06 Å), 33.27° (2.69 Å), 62.53° (1.48 Å)
Peak intensity (gross counts)	Strong peak at 12.35° (97.37 cps), 24.87° (88.34 cps)	Reduced peak intensity, 12.52° (18.86 cps)
Crystallite size	76.7 nm (12.35°), 65.9 nm (24.87°), 12.2 nm (33.14°), 19.0 nm (62.38°)	41.1 nm (12.52°), 11.6 nm (33.27°), 19.3 nm (62.53°)



Graph 2b: SEM-EDAX Peaks of *Shodhita Gairika*.

other trace elements were also noted, indicating the presence of siliceous and organic impurities naturally associated with mineral deposits. After purification, *Shodhita Gairika* exhibited a higher relative intensity peak of Fe, while peaks associated with Si, Al, and carbonaceous impurities showed significant reduction**.** This confirms that *Shodhana* effectively removed the impurities.

CONCLUSION

This study underscores the necessity of a comprehensive, multidisciplinary approach for identifying and standardising *Gairika*. While *Grahya Lakshana* remains foundational, geological and instrumental analyses such as titrimetric, XRF, XRD and SEM EDX assessments are indispensable for confirming elemental composition and ensuring compliance with pharmacopoeial standards. The selected sample from Bagalakote demonstrated both classical and modern acceptability, and its *Shodhana* process further enhanced its organoleptic and safety profile without compromising its mineral integrity.

The integration of traditional Ayurvedic wisdom with modern analytical techniques enhances confidence in the authenticity, safety, and therapeutic potential of *Rasadravyas* like *Gairika*. This approach may serve as a model for the standardisation of other herbo-mineral drugs in Ayurvedic pharmaceutics in future research.

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ABBREVIATIONS

API: Ayurvedic Pharmacopoeia of India; **XRF:** X-ray Fluorescence; **XRD:** X-ray Diffraction; **SEM:** Scanning Electron Microscopy; **EDX/EDAX:** Energy Dispersive X-ray Analysis; **TEM:** Transmission Electron Microscopy; **L.E:** Light Elements; **Fe_2O_3:** Ferric Oxide; **IP:** Indian Pharmacopoeia; **cfu/mL:** Colony Forming Units per milliliter.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

VBK: Conceptualisation, Methodology, Data collection, Writing; **PGJ:** Supervision, Review, and Editing.

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