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AUTHENTICATION OF *MANDOORA* COLLECTED FROM DIFFERENT GEOGRAPHICAL ZONES IN INDIA

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ABSTRACT

Mandoora is a commonly used mineral raw drug in the field of ayurveda. As per the Ayurveda Pharmacopoeia of India (API), *mandoora* is an iron-cum-silicate compound having the composition of fayalite. According to the classics, *mandoora* is quite difficult to obtain because most authors recommend that 100-year-old *mandoora* should be utilised in pharmaceutical processes. Nowadays most of the pharmacies are using old rust, wrought iron, ferric oxides etc in the place of *mandoora*. Hence the study was conducted to find out the authenticity of *mandoora* available in the Indian market. For this study twelve samples of *mandoora* were collected from different geographical zones in India, like north, east, west, and south. The classical and mineralogical characters of Mandoora mentioned in API were analysed using sophisticated instruments like XRD and EDXRF. In the XRD study most of the samples detected a higher concentration of anorthite and wustite than the required fayalite. The fayalite quantity in some samples was found to be lower than the reference range as mentioned in the API. None of the samples were detected with the required quantity of silica in the ED-XRF analysis except the sample from Trivandrum. The Pune sample was found to be authentic due to its fayalite content(>80%) in the XRD and its Fe content(>30%) in the geochemical analysis (ED-XRF).

Keywords- Authentic *mandoora*, Iron-cum-silicate, fayalite, XRD, ED-XRF

INTRODUCTION

Mandoora is a popular iron-containing mineral in Ayurveda. *Mandoora* and its formulations are widely employed in the treatment of Haematological system diseases. *Mandoora* is nothing but the waste of iron that is generated during the forging of iron. During this process, the iron flakes that are abandoned to the soil become solidified and combine with soil over time to form *mandoora*[1]. Formation of *mandoora* is a very lengthy process, *acharya* stated that 100-year-old *mandoora* is preferable and should be used for medicinal preparation. *mandoora* under the age of 60 is regarded as substandard[2]. According to API, *mandoora* is a metallic oxide cum silicate of iron with a fayalite composition that is frequently referred to as slag[3]. It is difficult to obtain the quality *mandoora* as per classics. So currently pharmaceutical industries are using rusted wrought iron, ferric oxides, old, rusted slag and rust itself for *mandoora bhasma* preparation[4]. Since ayurvedic drug manufacturing industries are preparing *mandoora* containing formulations on a large scale its authenticity is still ambiguous. This implies a detailed study needs to be conducted to find out the authenticity of *mandoora*. The present study aims to analyse the classical and mineralogical characters of *mandoora* samples collected from different geographical zones of India.

AIM AND OBJECTIVES

AIM

Authentication of *mandoora* from samples collected from different geographical zones in India.

OBJECTIVES

- To collect the *mandoora* samples from different geographical zones in India.
- To analyse the classical characters and mineralogical characters of collected samples of *mandoora*.

MATERIALS AND METHODS

Collection of *mandoora*

For procuring *mandoora* many ayurvedic raw material shops, ayurvedic pharmacies were contacted all over India and got 12 samples of *mandoora* from different zones in

India. Most of the samples were collected from the south zone and the identity of the samples were confirmed with the help of a Geologist.

Table No 1: Details of procured place and locations of *mandoora* from different Geological zones in India.

Zone	Place	Location
South	Trivandrum	Drug merchant, Puli mood
	Thrissur 1	Drug merchant, Jaihindh market.
	Thrissur 2	Drug merchant, Jaihindh market.
	Thrissur 3	Drug merchant, Jaihindh market.
	Ernakulam	Ayurvedic RM shop, Puthiyakavu.
	Palakkad	Ayurvedic Drug Manufacturing unit, Cheruplassery.
	Bellary	Ayurveda Pharmacy
	Hyderabad	Unani & Ayurveda RM dealers, Begum bazar.
North	Amritsar	Drug merchant, Majitha mandi.
	Hathras (UP)	Ayurvedic Drug Manufacturer, Lahra Road.
East	Kolkata	Santragachi market.
West	Pune	Drug merchant, Ravi war peth.

Image of Collected samples of *mandoora.*

Figure 1: *mandoora* from Trivandrum

Figure 2: *mandoora* from Ernakulam

Figure 3: *mandoora* from Thrissur 1

Figure 4: *mandoora* from Thrissur 2

Figure 5: *mandoora* from Thrissur 3

Figure 6: *mandoora* from Palakkad

Figure 7: *mandoora* from Bellary

Figure 7: *mandoora* from Hyderabad

Figure 8: *mandoora* from Punjab

Figure 9: *mandoora* from Uttar Pradesh

Figure 11: *mandoora* from West Bengal

Figure 12: *mandoora* from Pune

Method of analysis

For authenticating *mandoora,* the classical characters mentioned in the relevant texts such as *Guru, Snigdham*, *Dridam, Akotaram and Krishnam* were assessed. and the mineralogical characters were analysed by assessing the physical and chemical properties of the collected samples of mandoora.

Method of assessing the physical properties

The following properties were assessed for each collected sample of *mandoora*[6].

- **Color** The sample was scratched to see the fresh surface and to observe a color.

- **Streak** -The sample was rubbed on unglazed porcelain and the color of the powder was observed.
- **Luster**- The surface of the sample was observed under ordinary light.
- **Diaphaneity**-Thin slices of sample were observed to find out whether light is passing through it.
- **Cleavage** - The sample was broken, and it was observed to find out whether it breaks along any plane or is parallel to any crystal face.
- **Fracture** - The broken surface of sample was observed.
- **Elasticity** - The sample was hammered by a small hammer, and it was observed.
- **Hardness** - Here relative hardness test was done.
- **Magnetism**-magnetism can be strong, weak, or nonexistent in minerals. It is tested with a magnet. The specimen is nonmagnetic if it is not at all attracted to a magnet. Weakly magnetic if it has a slight attraction to a magnet. Strongly magnetic if it has a strong attraction to a magnet.
- **Specific gravity**-determined by water displacement method.

Method of assessing the Chemical properties

The chemical analysis of *mandoora* was done as per the tests specified in API[7].

- *mandoora* should contain not less than 80% fayalite when analyzed by XRD method.
- *mandoora* should contain not less than 30% iron (Fe) when analyzed by gravimetric method.
- *mandoora* should contain not less than 30% silica when analyzed by gravimetric method.
- Heavy metals and arsenic: *mandoora* should not contain more than the state limits for the following.
- Arsenic-6ppm, Cadmium-8ppm, other elements ±20% of state limits i.e. Cu-0.45%, Zn-50ppm, Ag=7ppm.

Powder X-Ray Diffraction (PXRD)technique was used to determine the quantity of fayalite in the collected sample and Energy Dispersing X-Ray Fluorescence (ED-XRF) was used for elemental analysis (Fe% & SiO_2%) including Heavy metals.

Sample preparation for analysis (PXRD, EDXRF)

Samples of *mandoora* collected were cleaned properly in water and dried well in sunlight. The pieces were crushed into uniform size with the help of iron pestle and mixed well. From that 100gm *mandoora* were crushed to the cores powder form,10gm of cores

powder was further ground to fine powder form with the help of mortar and pestle. It was then sieved through double layered cloth and took 1gm of the sample for analysis.

RESULT

The classical characters were assessed as per the features mentioned in the texts. Each *mandoora* was observed keenly for any voids present in it, the texture of surface (smooth or rough), color of the surface, heaviness by assessing the weight of pieces and hardness by hammering the piece of *mandoora*. The assessment score of each sample is tabulated in table no 2 below.

Table No 2: Classical characters of *mandoora* samples collected from different Geographical zones of India.

Samples	*Guru*	*Snigdham*	*Dhridam*	*Akotaram*	*Krishnam*
Trivandrum	-	-	-	-	+
Ernakulam	+	-	+	+	-
Thrissur 1	++	+	++	++	+
Thrissur 2	++	+	++	+	++
Thrissur 3	+	+	+	+	+
Palakkad	+	+	+	+	++
Bellary	++	-	++	+	+
Hyderabad	-	-	+	-	+
Uttar Pradesh	+	+	+	+	+
Punjab	+	+	+	+	++
West Bengal	+	+	+	+	+
Pune	++	+	++	+	+

- Less present, + present, ++ more present

Physical properties of the collected *mandoora* samples were assessed and the details of the result were tabulated in table no 3 and 4 below.

Table No 3: Physical properties of the *mandoora* samples from different Geographical Zones in India

South Zone						
	Trivandrum	**Ernakulam**	**Trissur 1**	**Trissur 2**	**Trissur 3**	**Palakkad**
Nature	Rough mass with numerous voids	Rough stony mass with voids	Rough stony mass with voids	Rough stony mass with a few voids	Rough stony mass with voids	Rough but somewhat smooth stony mass with voids
Color	Greyish black	Black	Black	Black	Brownish black	Black
Streak	Black	Black	Black	Black	Black	Black
Cleavage	None	None	None	None	None	None
Fracture	Un even	Un even	Un even	Un even	Un even	Un even
Luster	Dull	Dull	Dull	Dull	Dull	Submetallic
Tenacity	Brittle but moderately hard	Brittle but hard	Brittle but hard	Brittle but very hard	Brittle but hard	Brittle but hard
Transparency	Opaque	Opaque	Opaque	Opaque	Opaque	Opaque
Magnetism	Weak	Moderate	Moderate	Moderate	Weak	Weak
Hardness	6-6.5	6-6.5	6-6.5	6.5-7	6-6.5	6-6.5
Specific gravity	1.359	3.328	3.0316	2.858	3.2658	3.3072

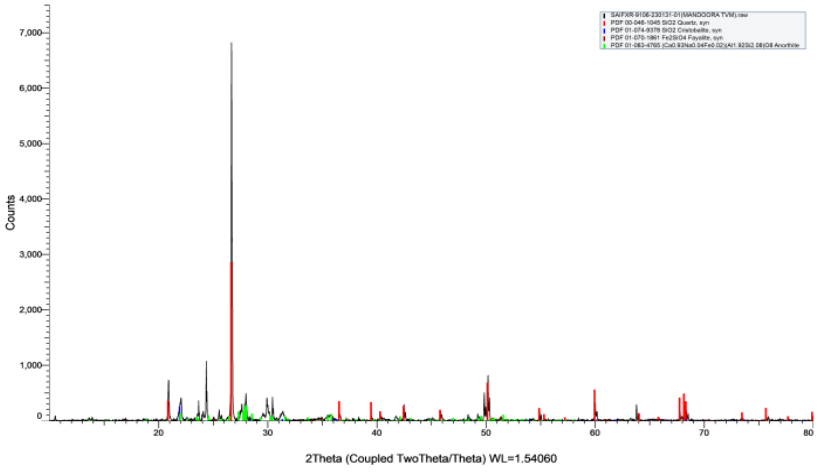
Table No 4: Physical properties of the *mandoora* samples from different Geographical Zones in India

	South zone		North zone		West zone	East zone
	Bellary	**Hyderabad**	**Punjab**	**Uttar Pradesh**	**Pune**	**West Bengal**
Nature	Rough stony mass with numerous voids	Rough mass with numerous voids	Rough somewhat smooth with voids	Rough stony mass with numerous voids	Rough stony mass with voids	Rough stony mass with voids
Color	Black	black	Black	Brownish black	black	black
Streak	Black	Black	Black	Black	Black	Black
Cleavage	None	None	None	None	None	None
Fracture	Un even	Un even	Uneven	Un even	Un even	Un even
Luster	Dull	Dull	Dull	Dull	Dull	Dull
Tenacity	Brittle but hard	Brittle but moderately hard	Brittle but hard	Brittle but hard	Brittle but hard	Brittle but hard
Transparency	Opaque	Opaque	Opaque	Opaque	Opaque	Opaque
Magnetism	Moderate	Weak	Weak	Weak	Weak	Moderate
Hardness	6-6.5	6-6.5	6-6.5	6-6.5	6-6.5	6-6.5
Specific gravity	4.218	1.235	2.060	3.3528	4.408	3.235

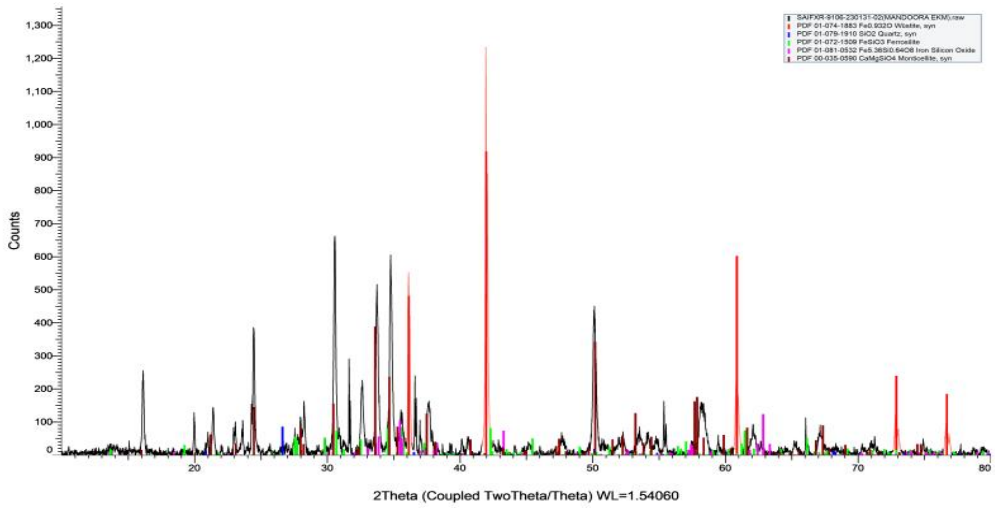
Table No 5: Determination of Fayalite compound in *mandoora* samples from PXRD -PDF data

Samples of *mandoora*	**Compounds detected in %**			
Trivandrum	Quartz (57.6)	Anorthite (35)	**Fayalite (3.7)**	
Ernakulam	Monticellite (48.5)	Wustite (24)	Ferrosilite (14)	
Trissur 1	**Fayalite (53.3)**	Anorthite (35.5)	Magnetite (5.8)	Quartz (5.4)
Trissur 2	Anorthite (49.7)	**Fayalite (41.1)**	Magnetite (4.7)	Quartz (4.5)
Trissur 3	**Fayalite (69.9)**	Anorthite (21.5)	Magnetite (8.5)	
Palakkad	**Fayalite (66.2)**	Ferrosilite (14.1)	Quartz (11)	Wustite (8.6)
Bellary	Anorthite (52.5)	**Fayalite (20.1)**	Wustite (17.2)	Magnetite (5.6)
Hyderabad	**Fayalite (43.1)**	Albite (30.9)	Quartz (18.2)	Magnetite (5.8)
Punjab	Magnetite (61.1)	Maghemite (20)	**Fayalite (13.1)**	Quartz (4.7)
Uttar Pradesh	Anorthite (41.5)	**Fayalite (35.1)**	Quartz (15.3)	Wustite (8.1)
West Bengal	Wustite (50.4)	Quartz (26.5)	**Fayalite (16)**	
Pune	**Fayalite (93.4)**	Quartz (6.6)		

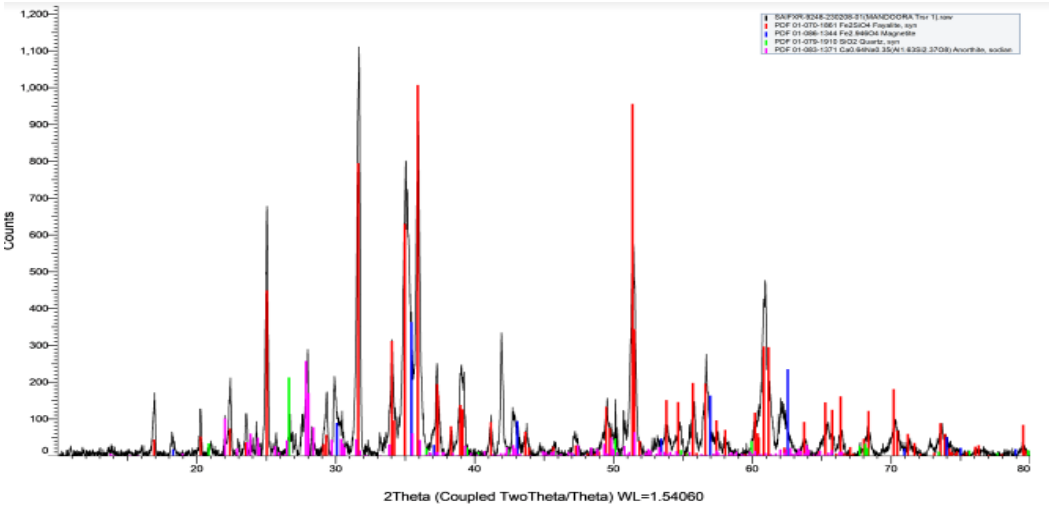
Graphical XRD data of collected samples of *mandoora*.



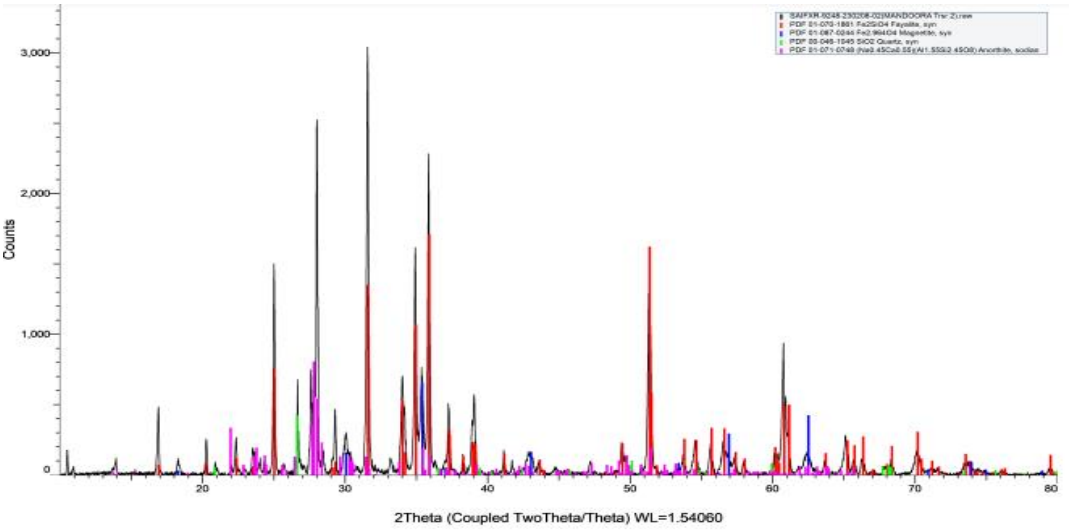
Graph 1: - XRD of mandoora sample from Trivandrum



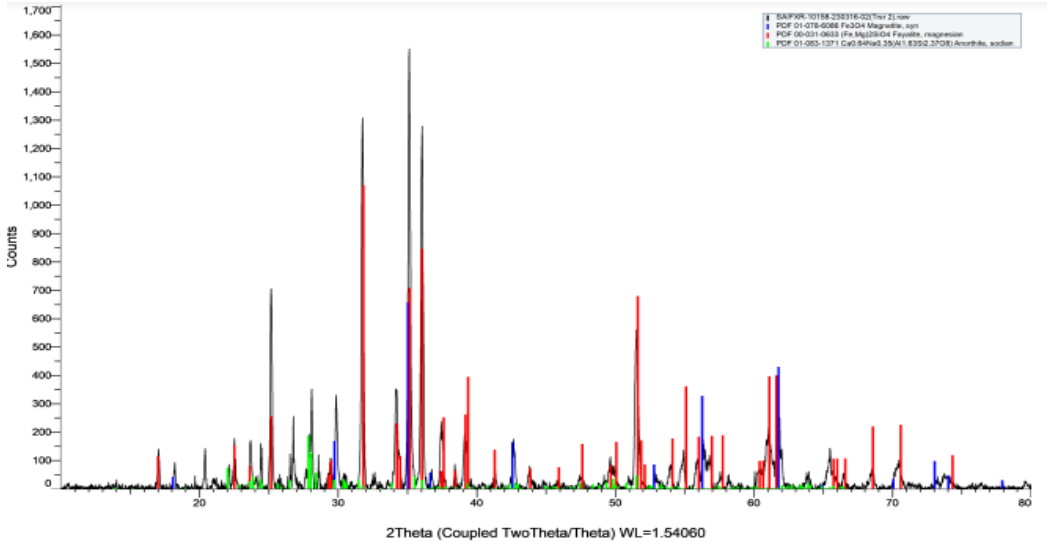
Graph 2: - XRD of mandoora sample from Ernakulam



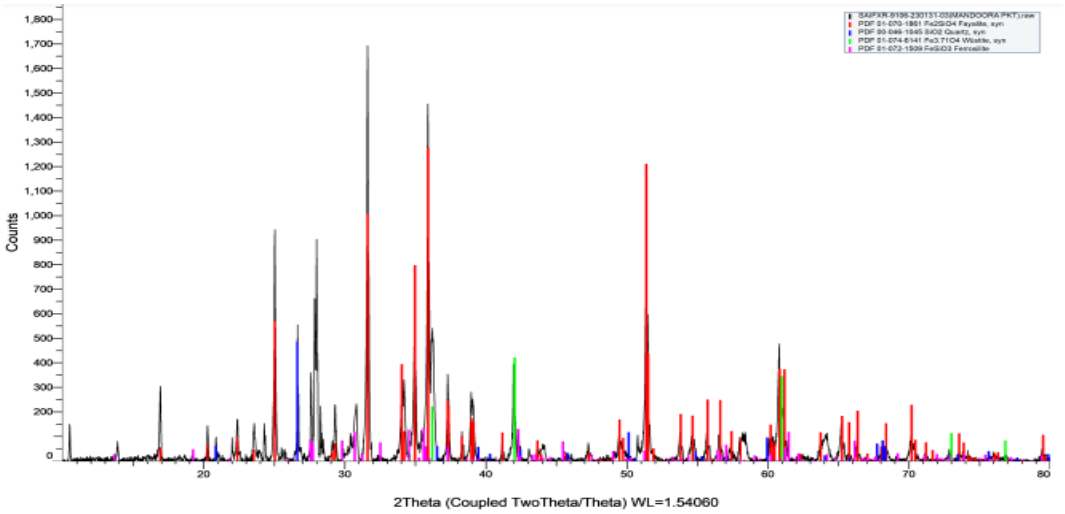
Graph 3: - XRD of *mandoora* sample from Thrissur 1



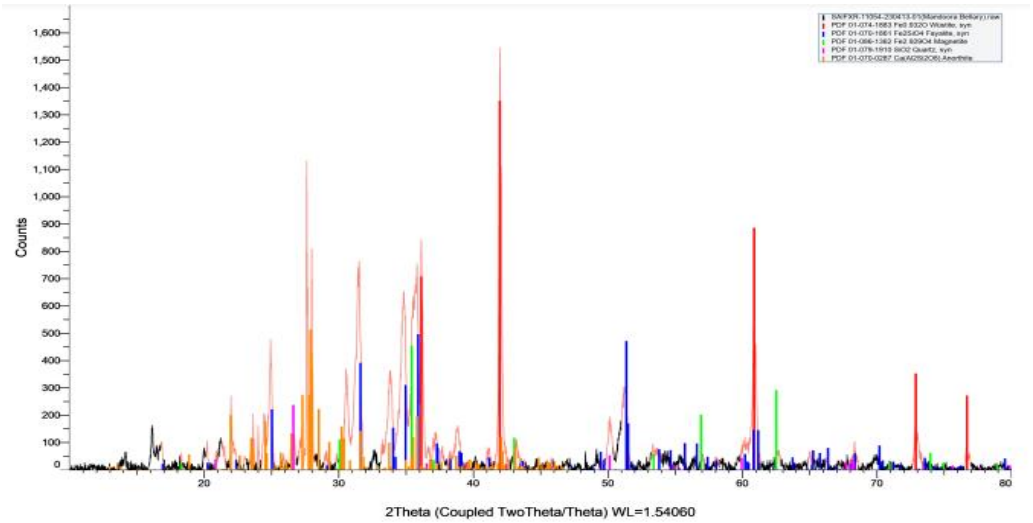
Graph 4: - XRD of mandoora sample from Thrissur 2



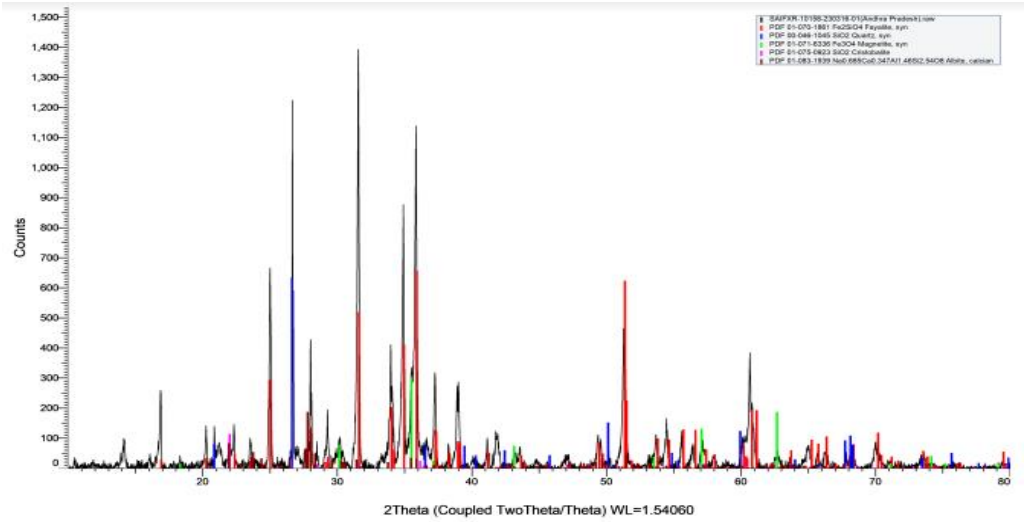
Graph 5: - XRD of *mandoora* sample from Thrissur 3



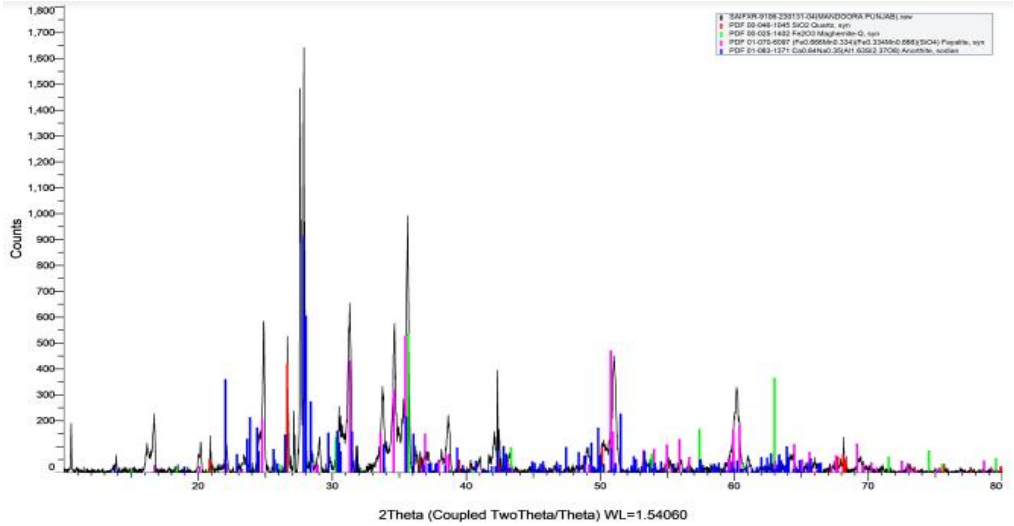
Graph 6: - XRD of *mandoora* sample from Palakkad



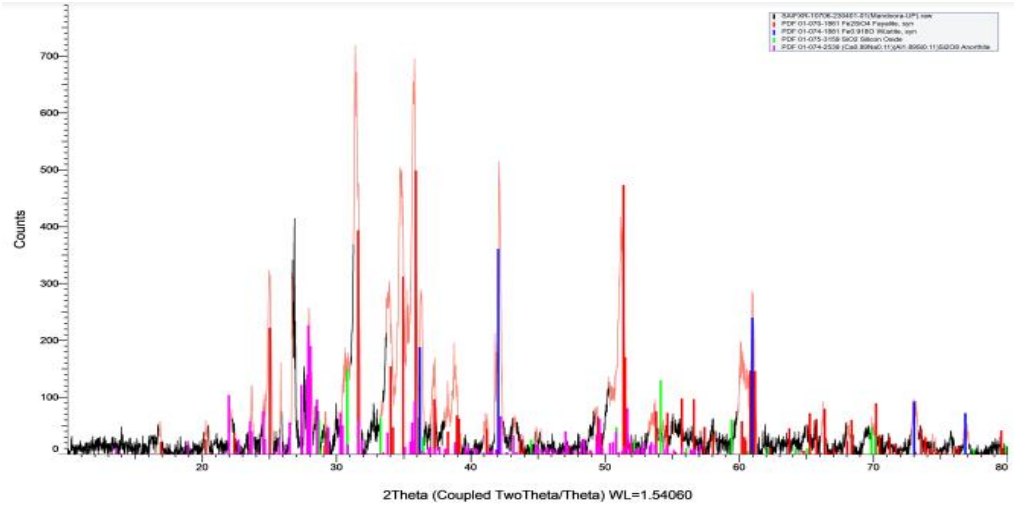
Graph 7: - XRD of *mandoora* sample from Bellary



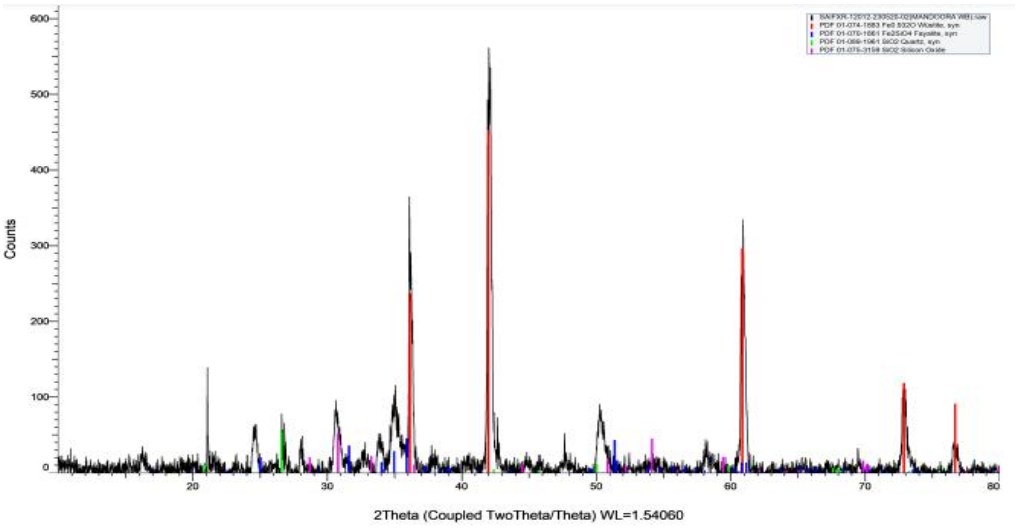
Graph 8: - XRD of *mandoora* sample from Andra Pradesh



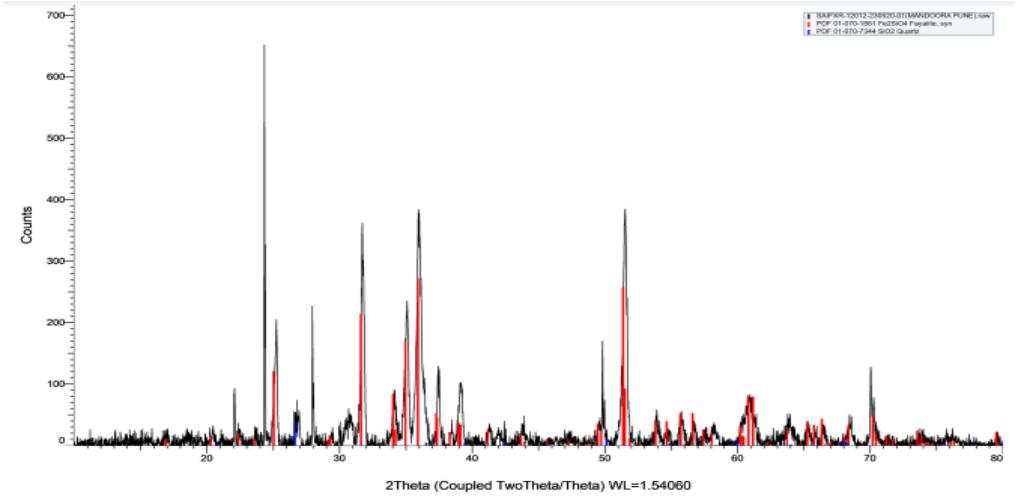
Graph 9: - XRD of *mandoora* sample from Punjab



Graph 10: - XRD of *mandoora* sample from Uttar Pradesh



Graph 11: - XRD of *mandoora* sample from West Bengal



Graph 12: - XRD of *mandoora* sample from Pune

Elemental analysis of procured *mandoora* samples done by ED XRF method.

Table No 6: ED-XRF analysis report of *mandoora* samples from different Geographical Zones in India

SN	South Zone						
	Elements	**Trivandrum**	**Ernakulam**	**Trissur 1**	**Trissur 2**	**Trissur 3**	**Palakkad**
1	MgO	0.317%	ND	ND	0.371%	0.106%	ND
2	Al_2O_3	2.47%	1.333%	1.416%	3.119%	1.657%	1.438%
3	SiO_2	40.662%	8.348%	7.941%	17.852 %	10.803 %	8.629%

4	P_2O_5	0.789%	0.31%	0.347%	0.56%	0.376%	0.322%
5	Cl	454.5 ppm	259.6 ppm	ND	ND	762.8 ppm	ND
6	K_2O	5.304%	0.985%	0.61%	1.493%	1.17%	0.949%
7	CaO	11.596%	3.472%	2.696%	3.26%	7.299%	3.199%
8	TiO_2	0.917%	1.93%	2.806%	4.364%	0.555%	1.739%
9	V_2O_5	175.1%	470.8 ppm	691.4 ppm	791.2 ppm	141.1 ppm	383 ppm
10	MnO	0.215%	0.228%	0.248%	0.168%	809.4 ppm	0.216%
11	Fe_2O_3	36.986%	82.697%	83.289 %	68.116 %	77.46%	82.921%
12	CuO	227 ppm	74.1 ppm	ND	0 ppm	136 ppm	146.7 ppm
13	ZnO	141.5 ppm	0 ppm	ND	69.8 ppm	ND	0 ppm
14	HgO	41.3ppm	0 ppm	19.4 ppm	7.3 ppm	27.6 ppm	0 ppm
15	PbO	81.6 ppm	ND	ND	ND	ND	0 ppm
16	Cr_2O_3	ND	597.6 ppm	ND	ND	352.4 ppm	554.1 ppm
17	NiO	ND	ND	ND	110.1 ppm	ND	

Table No 7: ED XRF analysis report of *mandoora* samples from different Geographical Zones in India

SN	**Elements**	**South zone**		**North zone**		**East zone**	**West zone**
		Bellary	**Hyderabad**	**Uttar Pradesh**	**Punjab**	**West Bengal**	**Pune**
1	MgO	ND	ND	ND	0.219%	ND	ND
2	Al_2O_3	0.758%	0.559%	1.378%	2.616%	1.389%	1.927%
3	SiO_2	5.939%	9.655%	7.829%	15.064%	8.625%	8.619%
4	P_2O_5	0.288%	0.361%	0.508%	0.523%	0.323%	0.269%
5	Cl	0.292%	0.117%	492.6 ppm	382.3 ppm	0.112%	709 ppm
6	K_2O	1.21%	1.451%	1.297%	1.217%	2.078%	1.375%
7	CaO	5.671	3.13%	8.489%	9.53%	10.141%	4.905%
8	TiO_2	0.385%	0.21%	0.254%	0.267%	0.374%	0.161%
9	V_2O_5	124 ppm	17.9 ppm	791 ppm	168.7 ppm	215 ppm	152.1 ppm
10	MnO	848.1 ppm	0.565%	2.051%	1.82%	0.121%	0.199%

11	Fe_2O_3	85.079%	83.42%	77.799%	68.363%	76.081%	82.13%
12	CuO	141.1 ppm	ND	125.1 ppm	126.7 ppm	ND	ND
13	ZnO	14.8 ppm	ND	ND	ND	ND	ND
14	HgO	16.9 ppm	ND	ND	ND	ND	ND
15	PbO	ND	ND	ND	ND	ND	ND
16	Cr_2O_3	ND	597.4 ppm	ND	ND	ND	ND
17	NiO	ND	ND	243.1 ppm	ND	ND	ND
18	Eu_2O_3	ND	0.264%	ND	ND	ND	ND

ND-Not Detected

Table No 8: Comparison of the chemical properties of procured *mandoora* samples.

SN	Samples from	Fayalite % PXRD	SiO2 % ED-XRF	Fe % ED-XRF
1	Trivandrum	3.7	**40.662**	25.84
2	Thrissur 1	53.3	8.348	54.13
3	Thrissur 2	49.7	7.941	57.79
4	Thrissur 3	69.9	17.852	58.20
5	Ernakulam	Nill	10.803	47.60
6	Palakkad	66.2	8.629	57.94
7	Bellary	20.1	5.939	59.46
8	Hyderabad	43.1	9.655	58.29
9	Uttar Pradesh	35.1	7.829	54.36
10	Punjab	13.1	15.064	47.76
11	West Bengal	16	8.625	53.17
12	**Pune**	**93.4**	8.619	**57.39**

DISCUSSION

Numerous minerals share the same color, luster, shape, size, and texture. For a *Rasasastra* practitioner, it will be challenging to distinguish between two identical minerals. Although several characteristics that aid in identification are stated in *Rasa* textbooks, these are insufficient for effectively distinguishing one mineral from another. The correct identification of raw mineral using contemporary mineralogical techniques can aid in quality assurance and standardization.

Here in the collected samples of *mandoora*, except the samples from Trivandrum and Hyderabad all other samples met the classical characters of *mandoora* to an extent. Sample from Trivandrum was not heavy as compared to other samples which contain numerous voids and was brittle than the others. Similar observation was seen in the Hyderabad sample also.

The physical properties of the samples received were almost identical in nature. Sample from Trivandrum and Hyderabad were similar in texture both were light in nature compared to the other samples. The sample from Trivandrum was greyish black in color with many voids. The specific gravity was found to be low in samples from Trivandrum (1.359) and sample from Hyderabad (1.235). Sample from Trissur 1 and 2 were heavy with a few numbers of voids. The luster of sample from Palakkad was submetallic while the other samples were dull in nature. Sample from Punjab had a peculiar smell because of the mud present in it. Sample from Uttar Pradesh and Trissur 3 were identical, having pale brown outer color. The rest of the samples were black after clearing the mud. All the samples had black streaks without cleavage. The samples from West Bengal, Bellary, Ernakulam, and Trissur possessed moderate magnetic property. While other samples showed weak magnetic property. The physical properties of all *mandoora* samples were matched with the physical properties mentioned for *mandoora* in API.

In the XRD analysis of the collected samples, fayalite was not detected in the sample from Ernakulam. The least quantity of fayalite was found in Trivandrum sample (3.7%). The fayalite was found in the samples from Bellary, West Bengal, and Punjab in the range 10-20%. Fayalite was detected between 30-50% range in the samples from Hyderabad and Uttar Pradesh. Samples from Trissur 1, Trissur 2, Trissur 3, and Palakkad had 50 - 70% fayalite. While the sample from Pune contained 93.4% fayalite. Instead of fayalite, anorthite was detected as major concentration in samples from Bellary, Uttar Pradesh, and Punjab. Some samples contained compounds such as wustite, monticellite, magnetite & quartz as major phase.

In ED-XRF analysis almost all samples had a percentage of iron above 50%. Only the sample from Trivandrum showed less iron percentage (25%). The majority of samples had 5-10% silica, sample from Trivandrum had high silica% (40%). Copper (Cu) was not detected in sample from Trissur 2, Hyderabad, west Bengal, and Pune. The highest amount of Cu was detected in the sample from Trivandrum (227ppm). Zinc (Zn) was detected in the sample from Trivandrum(141.5ppm), Trissur 3(69.8ppm) and Bellary (14.8ppm). Among the heavy metals, Mercury (Hg) was detected in the samples from Trivandrum, Trissur 2, Trissur 3, Ernakulam, and Bellary (7-27ppm). Higher concentration of Hg was seen in the sample from Ernakulam. Lead (Pb) was detected only

in the sample from Trivandrum (81.6 ppm). Heavy metals like Arsenic (As)and Cadmium (Cd) were not detected in the ED-XRF analysis.

CONCLUSION

Even though the physical properties of *mandoora* samples were identical, the chemical composition was found to vary from sample to sample. From the twelve collected samples of *mandoora*, the sample from Pune was more authentic as it possessed the required quantity of Fayalite (93.4%) and Fe% (57.3%). Other *mandoora* samples did not meet the required quantity of fayalite even though they possessed a good Fe%. Compounds like Anorthite, Wustite, Monticellite, etc. were detected as major compounds in some samples. This implies the need for quality assurance of *mandoora* to ensure its proper identity, quality, and purity.

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