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Systematic Study of *Rajata* (Silver) *Bhasma* Prepared by Traditional Ayurvedic Method

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Abstract

According to Ayurveda, *Bhasma* means conversion of metal into such an irreversible form that one cannot derive the metal back from it again (*Apunarbhatva*). It should float on the water surface after sprinkling, called *Varitara*. Its particle should be so fine that it can enter into the furrows of fingers called *Rekhapurnatva*. The preparation of *Bhasma* is a complicated procedure. *Rasa* Scholars have developed number of methods for *Bhasma* preparation. But in *Rasa* texts, the method of *Bhasma* preparation of some metals and minerals are very brief. That's why there are many practical difficulties in the preparation of Bhasma. *Rajata Bhasma* is one of them. In the present research paper, the pharmaceutical and analytical study of *Rajata Bhasma* is presented which was conducted under the postgraduate research programme. *Rajata* was subjected to *Samanya Shodhana* and *Vishesha Shodhana* by *Agastyapatra Swarasa*. *Nimbu swarasa* was used as *Bhavanadravyas*. *Rasa Sindura*, *Shuddha Gandhaka*, *Shuddha Hartala* were used as *marana* medias and twenty *puta*s were required to get genuine *Rajata Bhasma*.

Keywords

Bhasma, Rajata Bhasma, Shodhana, Marana

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INTRODUCTION

Conversion of metals into *Bhasma* is a unique process mentioned under *Rasashastra*. *Bhasmas* are complex organometallic compounds of metals or minerals obtained by repeated incineration with different medias, which are well known for its quick effectiveness, smaller dose and long shelf life.

Rajata comes under the group of metals having high therapeutic value and it is one among the *Sara Lohas*. Analytical study is one of the imperative parts for drug standardization in *Ayurveda, Siddha, and Unani* (ASU) systems of medicine. Since from hundred of years the *Bhasmas* are in clinical practice but according to the need of hour we should scientifically validate the bhasmas using modern tools and techniques. Considering this, an effort has been made to analyze the raw material (*Raw Rajata*), and finished product (*Rajata Bhasma*) through XRD, IC-PAES and SEM-EDAX. Prior to subjecting the material to XRD, IC-PAES and SEM-EDAX, attempts were made to examine the *Bhasma* through classical parameters of analysis.

MATERIALS AND METHODS

Procurement of raw material

The *Grahyapatra Rajata Patras*[1] were collected from Bangara Jewellers, Udupi. Drugs required for the *Rajata Shodhana* and *Marana* was collected from SDM Ayurveda Pharmacy, Udupi. The preparation of *Rajata Bhasma* was carried out in *Rasashastra* and *Bhaishajya Kalpana* practical Laboratory, S.D.M. college of Ayurveda, Udupi.

Pharmaceutical processing

Samanyashodhana of *Rajata*[2]

a) Preparation of accessory drugs: *Takra, Aranala, Kulathakwatha* were prepared as per Ayurvedic classics.

b) *Shodhana* process:

Ingredients:

Main drug – *Rajata* 200gm

Accessory drugs - *Tilataila*- 7 Ltr; *Takra*- 7 Ltr; *Gomutra*- 7 Ltr; *Aranala*- 7 Ltr; *Kulatthakwatha*- 7 Ltr.

Procedure – The *Rajatapatras* were heated till they turned red hot and were dipped (seven times) in different media, i.e. *tilataila, takra, gomutra, Aranala and kulatthakwatha*, simultaneously. [Table.1 & 2]

Visheshashodhana of *Rajata*[3]

Ingredients – *Agastyapatra swarasa* 3.5 L.

Procedure – *Samanya Shodhita Rajata Patras* were heated to red hot and dipped in vessel containing *Agastya Patra Swarasa*. After *Rajatapatra* became cool it was taken

out and washed with warm water & *Rajatapatra* was again heated red hot and entire procedure was repeated for another two times. After each *Shodhana* procedure *Agastyapatra swarasa* was changed. [Table.1 & 2]

Table 1 Observations in *Rajata* during *Samanya* and *Vishesha Shodhana*

Media	Total Qty (In grams)		Loss/Gain		Colour Changes	
	Before Shodhana	After Shodhana	In grams	In %	Before Shodhana	After Shodhana
Tilataila	200	210	10 gm gain	5	Bright white	Blackish shade of burned oil
Takra	210	202	8 gm loss	3.80	Blackish shade of carbon dipposition	Bright White
Gomutra	202	200	2 gm loss	0.99	Bright whitish	Light coppery
Aranala	200	198	2 gm loss	1	Light coppery	Coppery white
KulatthaKwatha	198	196	2 gm loss	1.01	Light coppery tinge	More Brighter with little coppery tinge
Agastya Swarasa	191	190	1 gm loss	0.52	Silver with coppery tinge	Dull silver colour

Table 2 Observations in Medias during Samanya and Vishesha Shodhana

Media	Initial colour	Final colour	pH	
			Before shodhana	After Shodhana
Tilataila	Light yellowish brown	Slight Dark brown	6	6.5
Takra	Yellowish white	Dull White colourwith black carbon particles	4	4.5
Gomutra	Yellowish	Dark brown	9	8
Aranala	Milky white	Milky white with black tinge	3	4
KulatthaKwatha	Brown	Dark brown	6.5	6
AgastyaSwarasa	Dark green	Light green	6.5	5.5

***Marana* of *Rajata*[4]**

Marana of *Lauha* was performed according to the process described by *Rasaratna samuchchaya.*

1st puta

Materials- *Shodhita Rajata Patra*- 185gms, *Rasa Sindoora*- 185gms, *Shodhita Gandhaka* - 370gms, *Lakuchaphala Swarasa*- 400 ml

Procedure- *Rasa Sindoora* was taken in a clean *Khalvayantra* and fine paste of it was prepared with *Lakuchaphala Swarasa*. This fine paste was applied over *Rajata Patras* and dried in shade. After proper drying, *Rajata Patra* were placed in *musha* in a sandwich manner i.e. one layer of *Gandhaka* and then *Rajata Patra* and then *Gandhaka* and so on.1/3rd space was left in *Musha* and

strong sealing was done with the mixture of *Multanimitti, Guda* and *Chuna* (lime).After proper drying, *Musha* was placed in *Valukayantra* and *Teevragni* (550-765^{o}C) was given for 24 hrs. After cooling of *Valukayantra Musha* was taken out and opened. A black coloured bolus was removed from *Musha*.

The bolus was powdered and weighed. Weight of *Rajata Bhasma* after 1stputa was 360 gms.

2ndputa

Materials – *Rajata Bhasma* after 1stputa – 360 gms, *Shuddha Hartala* – 185 gms, *Nimbu Swarasa* – 400 ml, Cow dung cakes – 70 no (6.8 kgs).

Procedure- After 1stputa 185 gm of *Hartala* was added to *Rajata Bhasma* and *Nimbu Swarasa Bhavana* was given. After attaining appropriate consistency *chakrikas* were made and kept for drying in shade. After complete drying, the *chakrikas* were kept in earthen *sharava* uniformly. Another *sharava* was placed over it to make *samputa*.Gap between two *sharavas* was properly sealed with one layer of *Gopichandana* and then with seven layers of *Gopichandana lepita vastra* or cloth. This *Sharavasamputa* was subjected to *Laghuputa*. 2/3 rd part of the pit was filled with cow dungs and *Sharavasamputa* was placed over it. Pyrometer was placed vertically from the side of the pit at the junction of the upper 1/3rd of the cow dung cakes. Cow dung cakes were ignited. After *Swangasheeta Sharavasamputa* was taken out opened cautiously and *Rajata Bhasma* was collected and weighed. The same procedure was repeated till the proper *bhasmalakshanas* were appreciated.

Table 3 Organoleptic, Pharmaceutical and Chemical analysis of RajataBhasma 1st to 20thputa

Puta	Tests							
	Colour	**Taste**	**Appearance**	**Odour**	**Rekhapoornatwa**	**Varitaratwa**	**Apunarbhava**	**Nirutha**
1	Black Shiny	Metallic	Powder	Sulphur	-ve	-ve	-	-
2	Black Shiny	Metallic	Powder	Sulphur	-ve	-ve	-	-
3	Blackish Brown	Metallic	Powder	Sulphur	-ve	-ve	-	-
4	Blackish Brown	Metallic	Powder	Faint	-ve	-ve	-	-
5	Blackish Brown	Metallic	Powder	Faint	-ve	-ve	-	-
6	Blackish Brown	Metallic	Powder	Faint	-ve	-ve	-	-

7	Blackish Brown	Metallic	Powder	Faint	-ve	-ve	-	-
8	Blackish Brown	Metallic	Powder	Faint	-ve	-ve	-	-
9	Greyish	Metallic	Powder	Faint	-ve	-ve	-	-
10	Greyish	Tasteless	Powder	Faint	-ve	-ve	-	-
11	Dark Grey	Tasteless	Fine powder	Faint	+ve	-ve	-	-
12	Greyish black	Tasteless	Fine powder	Faint	+ve	+ve	-ve	-ve
13	Greyish black	Tasteless	Fine powder	Faint	+ve	+ve	-	-
14	Black	Tasteless	Fine powder	Faint	+ve	+ve	-	-
15	Black	Tasteless	Fine powder	Faint	+ve	+ve	-ve	-ve
16	Black	Tasteless	Fine powder	Faint	+ve	+ve	-	-
17	Black	Tasteless	Fine powder	Faint	+ve	+ve	-	-
18	Black	Tasteless	Fine powder	Faint	+ve	+ve	-	-
19	Black	Tasteless	Fine powder	Faint	+ve	+ve	-	-
20	Black	Tasteless	Fine powder	Faint	+ve	+ve	+ve	+ve

Table 4 Brief description regarding Upalas, Temperature and Marana media used for Rajata Bhasma during 2nd to 20thputa

Puta	**Upalas used**	**Max.Temp (°C)**	**Initial Weight(g)**	**Hartala added(g)**	**Total weight (g)**	**Weight After puta(g)**	**Loss (g)**	**Loss (%)**
2nd	70	675	360	185	545	350	195	35.77
3rd	30	525	350	185	535	450	85	15.9
4th	20	496	450	185	635	570	65	10.2
5th	20	480	570	185	755	700	55	7.2
6th	20	496	700	47	747	710	37	4.9
7th	20	510	710	47	757	717	40	5.5
8th	20	505	717	47	764	710	54	7.0
9th	20	498	710	47	757	707	50	6.6
10th	20	508	707	47	754	702	52	6.9
11th	20	480	702	--	702	692	10	1.42
12th	20	505	692	--	692	640	52	7.5
13th	20	492	640	--	640	580	60	9.3
14th	20	508	580	--	580	522	58	10
15th	20	512	522	--	522	446	76	14.5
16th	20	505	446	--	446	380	66	14.7
17th	20	507	380	--	380	316	64	16.8
18th	20	510	316	--	316	238	78	24.6
19th	25	515	238	--	238	195	43	18.0
20th	30	530	195	--	195	179	16	8.2

Ancient analytical methods

***Rekhapurnatvam*[5]:** A pinch of prepared *Rajata Bhasma* should be taken in between the thumb and index finger and rubbed. Properly prepared *Bhasma* should enter into the creases of the fingers. This test

confirmed the fineness of *Bhasma* [Table.5,Fig.1]

Nischandratwa[6]- Little quantity of RajataBhasma was rubbed between thumb and index finger and observed under sunlight, to check the shining particles, no any shining particles were found during the test. [Table.5]

Varitaratavam[7]: Small amount of the prepared *Bhasma* is to be sprinkled over the stagnant water in a beaker. An ideal *Bhasma* should float over the surface of the water and the Rajata Bhasma also proved the same [Table.5,Fig.2]

Unnama[8]**:** Little quantity of *Rajata Bhasma* was gently placed on the stagnant surface of water, in a glass container and a grain of rice was placed over the *Bhasma*. The rice particle was floating on the surface of water and did not sink at the bottom. [Table.5,Fig.3]

Apunarbhava Pariksha[9] *–Rajata Bhasma* (2gm) was mixed with *Mitrapanchaka* i.e., *Guda, Gunja, Ghrita, Madhu, Shuddha Tankana* each 2 gms and triturated well in a *khalvayantra* followed by preparation of pellets. These pellets were kept in Small *Musha* and placed in muffle furnance at 500^{o}C temperature for 5 minutes. After *Swangasheeta* pellets were collected and observed for any lustrous particles. [Table.5]

Niruttha Pariksha[10]*-Rajata Bhasma* (2 gms) was taken into a *Musha* and silver leaf (2 gms) was put along with Bhasma. Then it was sealed by *Kapadmitti* and subjected to 500^{o}C temperature for 15 minutes. After *Swangasheeta* the silver leaf was collected and weighed. There was no weight gain found in silver leaf. [Table.5]

Nirdhuma Pariksha[11]**-** A pinch of *Rajata Bhasma* was sprinkled over the burning coal and there was no smoke came out from the Bhasma. [Table.5]

OBSERVATIONS

Table 5 Classical parameters of Rajata Bhasma

Sl.No	Classical Parameters	Rajata Bhasma
1	Rekhapoorna	Positive
2	Nischandratva	Positive
3	Varitara	Positive
4	Unnama	Positive
5	Apunarbhava	Positive
6	Niruttha	Positive
7	Nirdhuma	Positive

DISCUSSION

Ancient pharmaceutical processes are known to convert metals and minerals into therapeutically potential drugs that are vogue since centuries. But need of the time is to explain the physico-chemical nature of raw material and the finished products as well.

Fig-1: Rekhapurna

Fig-2:Varitaratvam

Fig-3:Unnama

Table 6 Organoleptic characters of Rajata Bhasma[12]

Sl.No	Parameters	Result
1	Colour	Black
2	Odour	Odourless
3	Touch	Soft
4	Taste	Tasteless
5	Appearance	Fine Powder form.

For 1st puta the paste of *Rasa Sindoora* and *Lakuchaphal Swarasa* was prepared by trituration in *Khalwayantra* and then this paste was applied on *Rajata Patras*. In this *puta*, *Rasa* media was used along with *Mulika Dravya* which is said to prepare superior quality *Bhasma*. Here *Rajata Patras* were kept in *musha* with *Gandhaka* in a sandwich manner so that uniform contact with the drugs was achieved. The Musha was subjected to *Drudhagni* by using *Valukaputa.* Maximum temperature maintained was 765^{o}C for 24 hours. Here *Valukaputa* helps in maintaining the constant temperature throughout the procedure. The final product was in the black coloured bolous with shiny particles and which could be powdered very easily.

From 2nd puta onward Laghuputa were selected. From 2nd puta to 5th puta, *shuddha Hartala* was added in equal quantity to that of *Shodhita Rajata* taken. From 6th puta to 11th puta ¼ quantity of shuddhaHartala was added.So the criteria of adding *Shuddha Hartala* was according to reference of *Siddhiprada* commentary on *RasaratnaSamuchchya*[17].

According to the classical reference of *Kukkutaputa* for *Swarna, Rajatadi* dhatus available in *Rasaratnasamuchchya*, 70 number of upalas were decided to be used for 2nd puta . After 2nd puta, the *Chakrikas* were in irregular shape with shiny nature and bit hardness in *Chakrikas.* It might be because of high temperature generated by 70 *Upalas*. So by taking experts opinion and by reviewing previous research works it was decided to reduce the temperature by reducing number of Upalas from 70 to 30. Again in 3rd puta *Chakrikas* were hard losing their shape and developed shining so, the

number of *Upalas* further reduced upto 20 in 4th *puta*. The same numbers of *Upalas* were followed upto 18th *puta*. In 19th and 20th *puta* the numbers of *Upalas* were increased 25 and 30 *Upalas* respectively and *Chakrikas* were unaltered, so it suggests that the *Bhasma* became heat stable. [Table.3,4,5 & 6]

After 12thputa *Bhasma Pariksha* was performed, it passed the *Rekhapurna* and *Varitara* but it fails *Nirutha* and *Apunarbhave Pariksha*, it might be because of some metallic part remained in it. It was decided to continue more puta. Again after 15th puta *Nirutha* and *Apunarbhav Pariksha* was done, again it failed. After 20th puta the *Bhasma* passed all *Bhasma Lakshanas.* The *Bhasma* was black in colour devoid of shining particles and taste. It has passed all the *Bhasma Pariksha*. So, it confirms the completion of procedure. [Table.3,4,5 & 6]

Physical Parameters:

Loss on drying at 105^0C:

It informs about the stability and shelf life of the sample. When loss on drying at 105^0C is least, the better will be the drug. In the present study *Rajata Bhasma* possessed 0.3207% loss on drying at 105^0C. Hence *Rajata Bhasma* has least chances of deterioration. [Table no.7]

PH:

Table 7 Results of Physico-Chemical analysis of Rajata Bhasma[13]

Sl.No	Parameters	Result n=3 %w/w RajataBhasma
1	Loss on Drying at 105^oC	0.3207
2	Total Ash	100.00
3	Acid Insoluble Ash	87.599
4	Water Soluble Ash	47.756
5	Alcohol soluble extractive	4.281
6	Water soluble extractive	4.888
7	pH	4.81
8	Specific gravity	1.0224

Rajata Bhasma is having pH of 4.81. The value indicates the acidic nature of the drug which might be due to heat treatment as well as the *Swarasa* used for *Bhavana*. As a rule weakly acidic drugs are rapidly absorbed from the GI tract. [Table no.7]

Total Ash:

Total Ash value of *Rajata Bhasma* is 100.00%. It indicates absence of organic matter in bhasma and also it is as per the standards of *Bhasma* as mentioned in Ayurvedic pharmacopeia standards. [Table no.7]

Ash value:

The acid insoluble ash of *Rajata Bhasma* is 87.599%. The value is high as the silver might remain in the form of Silver Sulphide which is sparingly soluble in diluted HCl.

Water soluble ash is the difference in between total ash and residue after treatment of total ash with water. The water soluble

ash of *Rajata Bhasma* is 47.756%.[Table no.7]

Specific gravity:

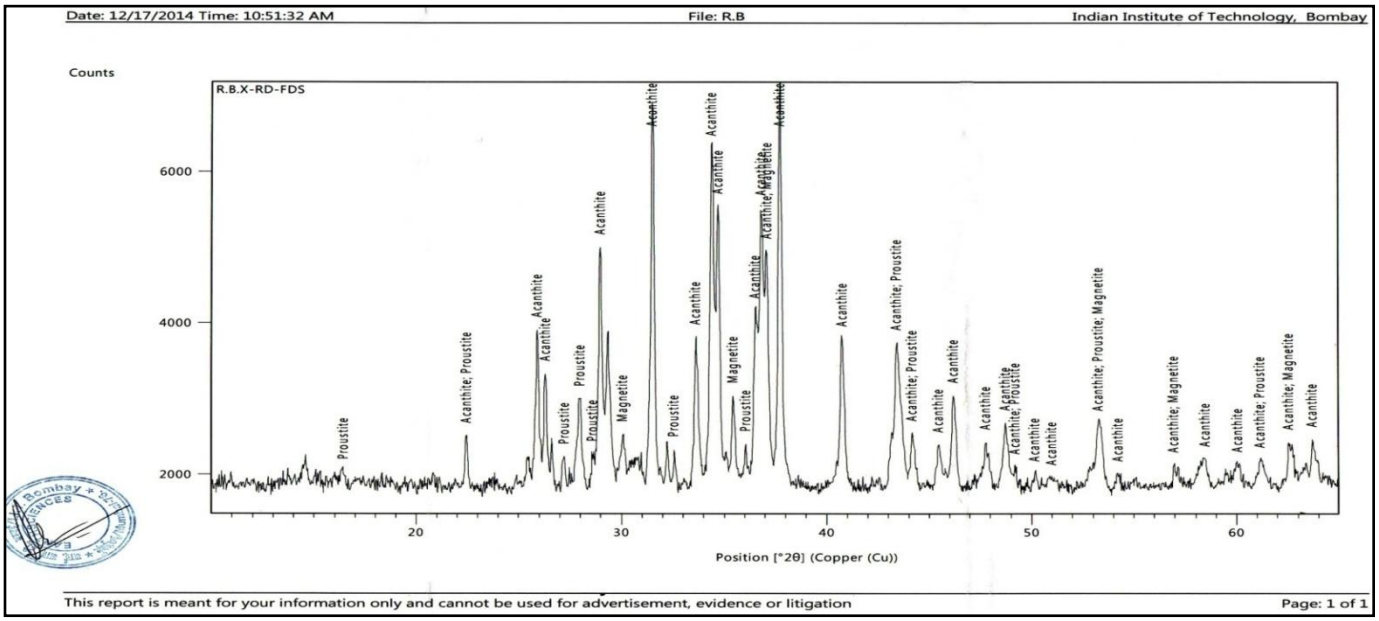
It is the ratio of the density of a substance to the density of water. The specific gravity of *Rajata Bhasma* 1.0224% which is as per Ayurvedic pharmacopeia standards. [Table no.7]

Elemental analysis:

Elemental analysis was done with the help of ICP-AES[14] which was done at IIT (SAIF), Powai, Mumbai.

Qualitative analysis: It showed presence of elements like Ag, Al, Ca, Cd, Cr, Cu, Fe, Hg, K, Mg, Na, P, Pb, Si, Sr and Zn in *Raw Rajata*. In *Samanya Shodhita Rajata* extra elements like As, Au, Ba, and Mn were observed as compared to Raw *Rajata* which may added due to medias used for the *Nirvapa*. In *Vishesha Shodhita Rajata* presence of B, P, Sb and Ti elements other than elements found in *Samanya Shodhita Rajata* could be because of media used for the *Nirvapa*. In *Rajata Bhasma* Co, Hg, Li, Ni, P, Sb, Sc, Ti, V, Y, Yb and Zr elements are extra other than elements observed in *Vishesha Shodhita Rajata*, it may be because of *Bhavana Dravya* used in each *puta* or contact with other medias used during *Marana* process.

Quantitative Analysis: Percentage of Silver present in *Raw Rajata* decreased from 99.47% to 82.12% in *Rajata Bhasma* as it was subjected to *Samanya Shodhana, Vishesha Shodhana* and *Marana.* This indicates conversion of Silver to compound form. Traces of Fe, Al & Cu were noted in all samples. It may be because of subjecting it to Shodhana and *Marana* procedure or may be because of variation in weight of total *Rajata.* Sulphur is 9.426% which is more in the final product as compared to other three samples, it is because of *Marana* procedure adopted and Sulphur found may be in Sulphide form. In final product heavy metals like Mercury, Arsenic, Lead and Cadmium were 0.000076%, 10.358%, 0.202% and 0.0016% respectively. Use of *Parada, Gandhaka* and *Hartala* as *Maraka Dravyas* were reason for the presence of these elements in final product but it was in permissible limits of heavy metals i.e. Lead 10 ppm, Mercury 01 ppm, Arsenic 03 ppm and Cadmium 0.3 ppm. Hence by concluding the elemental analysis, *Rajata Bhasma* is properly prepared and safe.



Graph-1 XRD Report of *Rajata Bhasma*

X-Ray Diffraction study[15]:

X- Ray diffraction study of *Rajata Bhasma* was done at IIT (SAIF), Powai, Mumbai. *Rajata Bhasma* is analysed for pure chemical or single element structure analysis and composition of the drug.

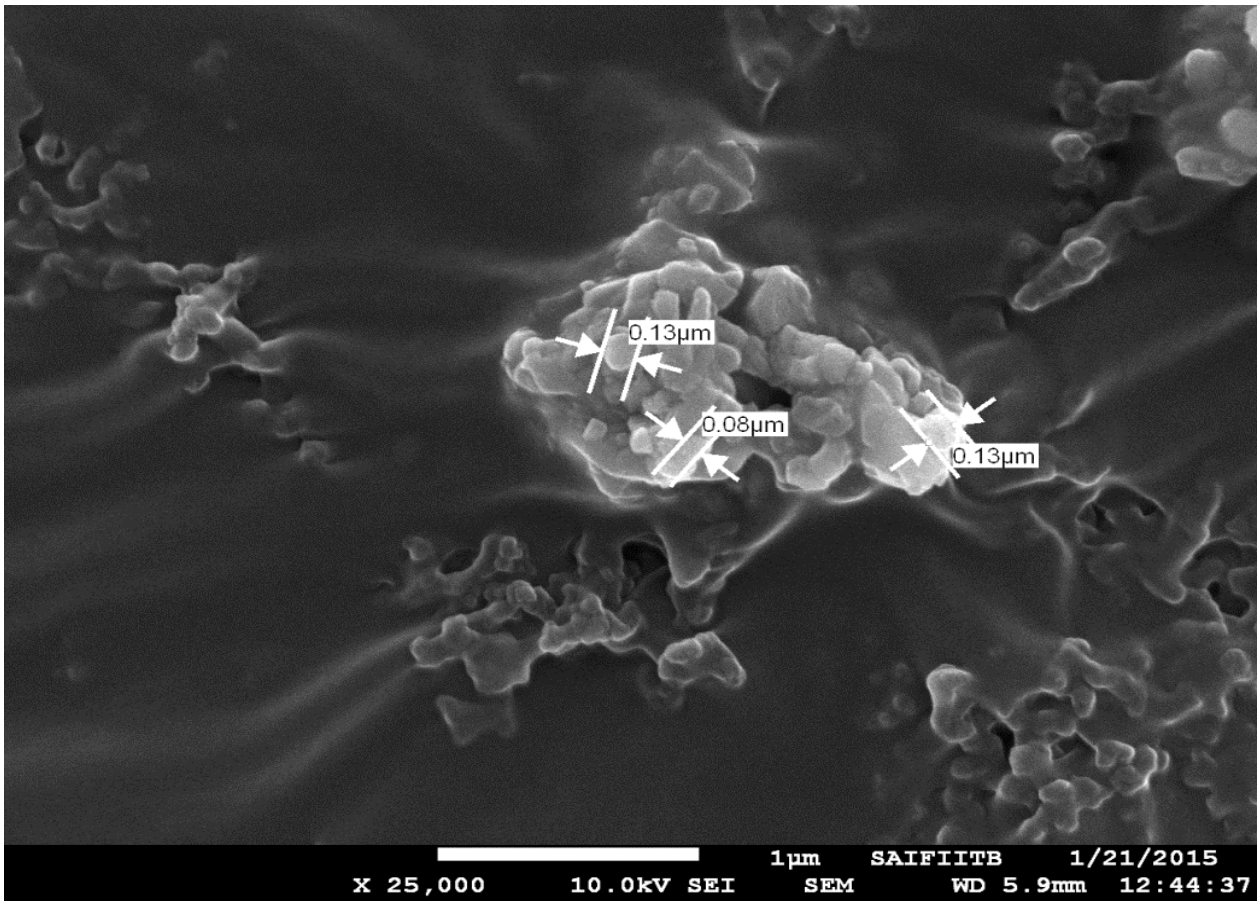
According to graph pattern of *Rajata Bhasma* showed crystalline structure [Gaph no-1]. According to identified peakes of sample Acanthite having chemical formula Ag_2S_1, Proustite having chemical formula $Ag_3\ As_1\ S_3$ and Magnetite having chemical formula $Fe_3\ O_4$ are identified. Silver found in the sample was in the form of Sulphide and Arsenic compound, it might be because of *Rajata* treated with *Shuddha Gandhaka* and *Shuddha Hartala* during *Marana* procedure.[Graph-1]

SEM-EDX study[16]:

SEM-EDX study of *Rajata Bhasma* was done at IIT (SAIF), Powai, Mumbai.

In sample of *Rajata Bhasma*, SEM analysis showed the presence of particle size ranges from 80 to 130 nm at 25,000X magnification. The average particle size is 105 nm [Fig.4]. Properly prepared *Bhasma* should have particle size in nanometer so, so that it can pass all the *Bhasma Pariksha* specially that is supported by *Rekhapurnata* and *VaritaraPariksha.*

Fig-4 SEM-EDX Report for particle size assessment



CONCLUSION

Preparation of *Rajata Bhasma* was first mentioned in the *Rasarnava* text for the purpose of *Dhatuvada* and *Dehavada.*

Rajata Bhasma prepared by using medias like *Rasa Bhasma (Rasa Sindura), Shuddha Gandhaka, Shuddha Haratala and Nimbuswarasa* was first mentioned in *Ananda Kanda* and the same methodology is also available in *Rasa Ratnasamuchchaya* , *Rasendra Chudamani* and *Rasajalanidhi*. Characteristic features of 99% pure *Rajata* are lustrous, bright white, smooth and soft to touch, without cracks, with white cut surface and heavy. These features are similar to *grahyalakshanas* of *Rajata* mentioned in classics.

Even though it is 99% pure, for the internal administration, it should be subjected to samanya and visheshashodhana to remove the harmful impurities.

In the presence of paste of *Rasa Sindura* with *Lakuchaphalaswarasa* and *Shuddha Gandhaka* as media and prolonged constant temperature helps in easy conversion of *Rajatapatra* into powder form. *Valukaputa*

is essential in providing constant temperature for prolonged time.

Further *Bhasmikarana* process requires addition of *Shuddha Haratala* in tapering manner up to 10^{th}puta and *puta* required is *Laghuputa* i.e., less than *Kukkutaputa* and more than *Kapotaputa*. After 10^{th}puta only *Mulikadravya* is sufficient for the preparation of *Rajata Bahsma*. Total 20 putas are required for *Rajata Bhasma* preparation. The features of *Rajata Bhasma* are viz., black in colour, *Nischandratva, Varitara, Rekhapurna, Apunarbhava, Nirutha* and *Nirdhuma.*

These features suggest the fineness, lightness, absence of metallic properties, which are essential features required to be present in the *Bhasma* for internal administration. Based on Quantitative analysis of *Rajata Bhasma* it contains Total. Ag- 80.12%, S- 9.426%,Al-0.363%,As-1.892%, Hg- 0.000076%, Cu- 0.866%, Fe-3.082%, Pb- 0.202% and Cd- 0.0016% . In *Rajata Bhasma* heavy metals like Lead, Mercury, Arsenic and Cadmium are in permissible limits. Hence *Bhasma* is safe for internal administration. As per XRD reports, *Rajata Bhasma* is in crystalline form with the chemical compounds Ag_2S_1, Ag_3 As_1 S_3 and Fe_3O_4.Based on SEM-EDX study, mean particle size of *Rajata Bhasma* is in nanometre range.

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