



Physico-Chemical Characterization Of *Rajata Bhasma*

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Abstract

Rajata Bhasma is one of the herbo-metallic preparations used in *Ayurveda*, a traditional Indian system of medicine for treatment of various ailments. *Rajata* in itself is comparatively less explored and best advocated in classical texts. It needs to undergo various classical procedures like *Shodhana* and *Marana* to make it assimilable for the body. In present study *Rajata Bhasma* was prepared by classical method and physicochemical characterization through classical as well as modern analytical tools and techniques such as X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM) and Energy – Dispersive X-ray Spectroscopy Analysis (EDAX).

Key words: *Shodhana*, *Marana*, XRD, SEM, EDAX.

Introduction

Rasa Shastra, an integral part of *Ayurveda*, deals with the drugs of mineral origin, and details their varieties, characteristics, processing techniques, properties, therapeutic uses, possibilities of developing adverse effects and their management, etc. in a comprehensive way ⁽¹⁾. *Ayurvedic* medicines are mostly *Rasaushadhies* and they play an important role in *Ayurvedic* therapeutics because of their qualities such as *Alpamatropayogitvat* (low dose), *Arucher-aprasangata* (good palatability) and *Kshipramarogayadayitvat* (fast acting) ⁽²⁾. *Bhasma*, literally means ‘ash’ are inorganic preparations produced by alchemic process, which converts a metal or mineral into its compounds ⁽³⁾. These complexes should neither contain free metal nor contain free organic constituents, whose presence in *bhasma* indicates improper calcinations ⁽⁴⁾.

Rajata Bhasma is a very popular organo-metallic preparation indicated in *Sosha*, *Dhatukshaya*, *Prameha*, *Madatyaya*, *Visham Jwara*, *Pittaroga*, *Pleeharoga*, *Buddhimandya*, *Garbhashaya*, *Dosha* & *Apasmara* ⁽⁵⁾. Considering all these facts, to find out the analytical profile of *Ayurvedic* medicine is the need of hour to identify nature of final product. The present work was carried out to establish analytical profile of *Rajata Bhasma* by evaluating physicochemical characterization and using sophisticated modern tools and techniques.

Materials and Methods

Collection of raw materials

The best variety of *Rajata* was procured from the local jewelers market of Varanasi and *Parada*, *Gandhaka*, *Hingula*, *Tila taila* & *Kulattha* procured from local medicinal drug market, Gola Dinanath, Varanasi. *Nimbus* was collected from local vegetable shopkeeper and *Ghritakumari* collected from herbal garden of department of Dravya Guna, Faculty of Ayurveda, IMS, BHU, Varanasi. *Gomutra* was procured from Department of Animal Husbandry, Institute of Agriculture Sciences, BHU, Varanasi. All the samples were authenticated by the subject experts in the concerned department of the institute.

Preparation of *Rajata Bhasma*

Procedure

Samanya Shodhana of Rajata ⁽⁶⁾

The thin *patra* of *Rajata* were heated red hot and quenched subsequently into *Tila taila*, *Takra*, *Gomutra*, *Kanji* and *kulattha Kwatha* for seven times in each media. The details of *shodhana* media and references are mentioned in Table 1.

Table 1. *Shodhana* Media & Source

Media used for Shodhana	Source / Reference
<i>Tila (Sesamum indicum) Taila</i>	Local market
<i>Takra</i> ⁽⁷⁾	Prepared in the Dept. of Rasa Shastra & Bhaishajya Kalpana
<i>Gomutra</i>	Procured from Department of Animal Husbandry, IAS, BHU
<i>Kanji</i> ⁽⁸⁾	Prepared in the Dept. of Rasa Shastra & Bhaishajya Kalpana
<i>Kulattha (Dolichos biflorus) Kwatha</i> ⁽⁹⁾	Prepared in the Dept. of Rasa Shastra & Bhaishajya Kalpana
<i>Nimbu (Citrus medica)</i>	Local vegetable market
<i>Parada</i>	Local medicinal drug market
<i>Gandhaka</i>	Local medicinal drug market
<i>Hingula</i>	Local medicinal drug market
<i>Ghritakumari (Aloe vera) pulp</i>	Herbal garden of department of Dravya Guna

During every *nirvapa*, fresh and calculated amount of media was taken. The summary of *samanya shodhana* of *Rajata* mentioned Table 2.

Table 2. Summary of *Samanya Shodhana* of *Rajata*

Media	Quantity	Temp. / Duration for Red hot	Rajata		Observation
			Wt. before <i>Nirvapa</i> (g)	Wt. after <i>Nirvapa</i> (g)	
<i>Tila taila</i>	400ml/ each time	800°C / 15 min	100.00	100.267	Lusture of <i>Rajata patra</i> (RP) diminished and softness, brittleness increased. RP got adhered with carbonaceous particles & become grayish white.
<i>Takra</i>	400ml/ each time	800°C / 18 min	100.267	100.811	RP became reddish white, increase brittleness, luster decreased & turning into few small pieces.
<i>Gomutra</i>	400ml/ each time	800°C / 21 min	100.811	100.525	RP became golden reddish tinge in color, brittleness increased & turned into small pieces.
<i>Kanji</i>	400ml/ each time	800°C / 22 min	100.525	100.321	RP became dull white in color with slight yellowish tinge & turned into small size.
<i>Kulattha Kwatha</i>	400ml/ each time	800°C / 23 min	100.321	99.612	RP color became brighter as compared to <i>Gomutra</i> & <i>Kanji</i> , size reduced.

Vishesha Shodhana of Rajata ⁽¹⁰⁾

Samanya shodhita Rajata patra taken in an iron ladle and heating up to red hot and then dipped in a vessel containing *Agastya patra swarasa*⁽¹¹⁾. This process was repeated for two more times and every time taken fresh and calculated amount of media. The summary of *vishesha shodhana* of *Rajata* mentioned Table 3.

Table3. Summary of *Vishesha Shodhana* of *Rajata*

Media	Quantity	Temp. / Duration for Red hot	Rajata		Observation
			Wt. before Nirvapa (g)	Wt. after Nirvapa (g)	
<i>Agastya patra Swarasa</i>	400ml/ each time	800 ⁰ C / 18 min	99.612	99.812	RP became brittle, soft with greenish tinge & it converted into tiny pieces with few small particles.

Marana Process of Rajata⁽¹²⁾

The *marana* procedure of *Rajata* was followed the classical reference of *Rasa Tarangini* with a slight alteration in the method. The whole process was concluded into *Gandhaka Shodhana*⁽¹³⁾, *Parada Shodhana*⁽¹⁴⁾, preparation of *Kajjali* ⁽¹⁵⁾, Kupipakwa of *Kajjali* for *Bhasma* preparation was done and followed *puta* process of *Rajata Bhasma* by horizontal EMF.

The tiny pieces of *vishesha shodhita Rajata patra* cut into small pieces and shifted to the *khalva yantra* containing *shuddha Parada*, triturate and form amalgam. In this amalgamated product *shuddha Gandhaka* was added and triturated till a black colored, shining powder (*Kajjali*) obtained after that one *Bhavana* of *Gritakumari Swarasa* was given & triturated till shining black coloured powder of *Kajjali* obtained and dry in nature.

Now the *kajjali* was filled in *Kach-kupi* and transfer to vertical EMF for further processing of heating in controlled manner. *Kramagni* (gradual rise of temperature) was maintained in increasing order of *Mridu*, *Madhya* and *Teevragni*. Corking was done after complete cessation of flame and observing the *Siddhi Lakshanas*, like complete cessation of sulfur fumes, *Suryodaya Lakshana* (red appearance of the bottom) and positive copper coin test and finally *Kanch-Kupi* was left for self cooling. Next morning when the EMF cooled down, the bottle was carefully taken out form the furnace, removed heated *Kapada mitti* and a kerosene soaked cotton thread was wrapped below the neck of the bottle and burnt. After few moments, flame tumble and little amount of water sprinkled over the heating point of bottle and the bottle broken up. *Rajata Sindura* was collected from the neck of the *Kach-Kupi* and remains of partially prepared *Rajata Bhasma* procured from base of the *Kanch-Kupi*.

The partially prepared *Rajata Bhasma* triturated well with 1/10 part of *Hingula* and *Ghritakumari swarasa* till the paste became dough like in consistency. Then pellets were prepared and kept for drying under sunlight. After complete drying, these pellets were weighed and placed inside a *sharava* and covered with another *sharava*. The joint of two *sharava* were sealed with cotton cloth smeared with mud and again kept for drying. This *sharava samputa* was subjected for incineration in horizontal EMF at 350°C temperature and maintained for 20 minutes. The furnace was then switched off and allowed for self cooling. Next day morning, *sharava* was taken out and pellets were again triturated with *Hingula* and *Ghritakumari swarasa*. Like this total seven *putas* were given to obtain desired quality of dark black color of *Rajata Bhasma*. The summary of *marana* of *Rajata* has been depicted in Table 4.

Table 4. Summary of *Marana* of *Rajata*

<i>Putra</i>	Amount of Media	Triturating time	Set Temp. (ST)	Reaching duration on ST	Maintaining time on ST	Initial wt. of <i>Rajata</i> (gm)	Final wt. of <i>Rajata</i> (gm)
1 st	430ml	3 hour	350°C	78 min.	20 mins	76	78.5
2 nd	450 ml	3 hour	350°C	76 min	20 mins	78.5	80.2
3 rd	460 ml	3 hour	350°C	75 min	20 mins	80.2	84.4
4 th	470ml	3 hour	350°C	77 min	20 mins	84.4	86.8
5 th	480ml	3 hour	350°C	73 min	20 mins	86.8	89.1
6 th	490ml	3 hour	350°C	82 min	20 mins	89.1	92.2
7 th	500ml	3 hour	350°C	80 min	20 mins	92.2	95.6

Organoleptic Analysis

Organoleptic analysis of the prepared sample of *Rajata Bhasma* was carried out by classical parameters such as *Shabda* (sound), *Sparsha* (touch), *Roop* (color), *Rasa* (taste), *Gandha* (odor), *Apunarbhava* test, and *Niruttha* test ⁽¹⁶⁾. Physicochemical Analysis was also carried out by following the standard methods for estimation of loss on drying ⁽¹⁷⁾, ash value ⁽¹⁸⁾ and acid-insoluble ash ⁽¹⁹⁾. In addition to this, XRD, SEM and EDAX were also carried out.

Results

Finally prepared *Rajata Bhasma* is slightly brownish black in color and smooth in consistency with no specific taste and odor. It passed all the standard protocols for testing of *bhasma pariksha* (*varitara*, *nischandra*, *unnama*, *niruttha*, *apunarbhava*, *rekhapurnata* and *niswadutva*).

The Physicochemical analysis of *Rajata Bhasma* was carried out and detailed results are depicted in Table 5.

Table 5. Physicochemical analysis of *Rajata Bhasma*

S.No.	Parameters	Results
01.	Loss on Drying at 105 ⁰ C	0.412%
02.	Total Ash	74.10%
03.	Acid Insoluble Ash	68.67%

X-Ray Diffraction Analysis ^(20,21)

The X-ray diffraction pattern of raw *Rajata* shows sharp and well defined reflections of the face centered cubic structure of metallic silver. The well defined intense peaks in diffraction pattern confirm excellent crystallinity of silver particles. The XRD reports of intermediate product of *Rajata Bhasma* showing compound formation with orthorhombic crystal structure and the XRD report of final product of *Rajata Bhasma* shows Ag₂S acanthite form in major with traces of Fe sulphides (Figure 1,2,3).

Scanning electron microscope (SEM) and Energy-dispersive X-ray spectroscopy Analysis (EDAX) ⁽²²⁾

The SEM observation about raw *Rajata* particle size ranges from 100um-200um, *shodhita Rajata* in the size range of 135nm-638nm, *Kajjali* in the size range of 41.43nm-196.5nm, *Kupipakva Rajata Sindura* in the size range of 118.1nm-463nm, *Kupipakva Rajata Bhasma* in the size range of 117.2nm-197nm whereas *Rajata Bhasma* particle size ranges from 58.5 nm to 100.5nm. Almost all the particles were homogenous in composition and as per the EDAX analysis the percentages of Ag in RR, SR and RB were 96.19%, 73.28% and 35.39% respectively. The detailed results of EDAX analysis are depicted in Table 6.

Table 6. EDAX of Composition of Raw *Rajata*, *Shodhita Rajata* and *Rajata Bhasma* with elemental %

Elements	Raw <i>Rajata</i> (RR)		<i>Shodhita Rajata</i> (SR)		<i>Rajata Bhasma</i> (RB)	
	Weight %	Atomic %	Weight %	Atomic %	Weight %	Atomic %
C	3.81	26.22	2.68	9.86	0.00	0.00
Ag	96.19	73.78	73.28	29.98	35.39	10.30
O	0.00	0.00	19.90	54.89	35.81	70.26
Mg	0.00	0.00	0.77	1.39	0.00	0.00
P	0.00	0.00	0.51	0.73	0.00	0.00
Ca	0.00	0.00	2.86	3.15	0.00	0.00
S	0.00	0.00	0.00	0.00	7.80	7.64
Fe	0.00	0.00	0.00	0.00	20.99	11.80

Discussion

Rajata Bhasma is an Ayurvedic medicine with vast therapeutic utilities known since vedic period. Its internal application as a medicine has recognized from *Samhita* period. *Rasa Shastra* literature delineated various pharmaceutical processes of *Rajata Bhasma*, such as *shodhana*, *marana* etc, which are essential for converting the metals into *Bhasma*, the suitable form for internal use which makes it more absorbable and assimilable to the human body.

Rajata Bhasma has *Vata-Shamak*, *Madhura Vipaka*, *Kashaya-Amla Rasa*, *Sheetala*, *Snigdha* and also *Brimhana* so it play important role in nervous system. Therapeutic repertory of *Rajata Bhasma* ranging from *Madhumeha* (diabetes mellitus), *Jwara* (fever), *Pandu* (anaemia), *Yakrit vikara*(liver disorders) and *Manasa rogas* (Psychological disorders) etc. ⁽²³⁾

Rajata bhasma is an Ayurvedic medication prepared from *Rajata* that has been used in *Ayurveda* for the treatment of several conditions such as vertigo, polydipsia, and loss of memory ^(24, 25, 26). It has been shown to exhibit its therapeutic benefit when consumed in a dose of 30–125 mg/day ⁽²⁷⁾.

In *Rasa* literature *Bhasmikarana* is an important pharmaceutical procedure which converts the metals/minerals into desired compound form, suitable for internal use into a very fine absorbable state. *Shodhana* and *marana* are two main essential steps which converts metals/minerals into *Bhasma* form.

Shodhana (purification/detoxification) is the foremost step in the preparation of *Rajata Bhasma*. The process of *nirvapa* (heating & quenching) was adapted for *samanya* and *vishesha shodhana* of *Rajata*. The metal is heated up to red hot condition and immediately immersed in various plants and animal media (*Til taila*, *Takra*, *Gomutra*, *Kanji* & *Kulattha kwatha*) and kept for self cooling. It removes the inorganic impurities and incorporates beneficial organic moieties into the metal which render them suitable for further process of preparation of *Bhasma* (grinding with plant drug and repeated calcination). On repeated *nirvapa* (22 times in 6 different media), chemical reactions takes place, bonding between silver atoms becomes loose and some bonds are seen to break up, porosity develops in the *Rajata* foil, becomes brittle, soft with greenish tinge & it converted into tiny *pieces* with few small particles. The use of particular *shodhita* media and their particular sequence is notable. The probable concept behind using such variation may be removal of impurities from the drug in a particular acidic or alkaline media and also reduction in particle size of drug. After heating, immediate cooling in liquid media leads to decrease in tension and increase in compression force. Repetition in heating and cooling causes disruption in compression tension equilibrium and leads to increased brittleness, reduction in hardness, and finally reduction in particle size. In each steps of *samanya* and *vishesha shodhana*, progressive increase in surface area and reduction in particle size, probably due to micro cracks formed during heat treatment is observed.

In the *marana* procedure, *vishesha shodhita Rajata Patra* was amalgamated with mercury and triturated with *shuddha Gandhaka*, black coloured powder of *kajjali* obtained. *Acharya Rasa Vagbhatta* has acknowledged

that mercury is best for *marana* of metals ⁽²⁸⁾. Metals disintegrate when amalgamated with mercury and the surface area widely increased, which facilitates the rapid compounding reaction. Black colored *kajjali* was filled in *Kach-kupi* and transfer to vertical EMF for further processing. Finally *Rajata Sindura* was procured as by product from the neck of the *Kach-Kupi* and remains of partially prepared *Rajata Bhasma* procured at base of the *Kanch-Kupi*. This partially prepared *Rajata Bhasma* was subjected to bhawana and putapaka with Hingula and Ghritakumari swarasa till seven times and finally desired quality of *Rajata Bhasma* obtained.

Several physical and chemical parameters have been described for ascertaining the purity of *Rajata Bhasma*. Physical parameters include luster, color, fineness, floatability, etc. In this study, quality checks done by classical parameters. *Rajata Bhasma* was subjected to different physico-chemical characterization studies using modern analytical tools. Our results showed negligible moisture content (0.412% loss on drying), total ash value (74.10%) and acid insoluble ash (68.67%).

The results of XRD study revealed that face centered cubic structure of metallic silver in *Raw Rajata* whereas Ag_2S acanthite form of Silver in major with traces of Fe sulphides in *Rajata Bhasma*. The SEM of *Rajata Bhasma* showed irregular aggregates of various size and shapes with nanostructure of particle size ranges from 58.5 nm to 100.5nm. The EDAX analysis showed the percentages of Ag in RR, SR and RB were 96.19%, 73.28% and 35.39% respectively.

Conclusion

Rajata Bhasma preparation includes major steps such as *samanya shodhana*, *vishesha shodhana* and *marana*. It is essential to follow all the procedures as per our classical texts for getting good quality of *bhasma*. The partially prepared *Rajata Bhasma* collected from the base of the *Kach-kupi* and triturated with *Hingula* and *Gritakumari* by adapting conventional method of *puta* using horizontal EMF. This study exposed that a temperature of 350°C with a peak duration of 20 minutes in seven *puta* to obtained dark black coloured *Rajata Bhasma* which passed the classical *bhasma parikshas*.

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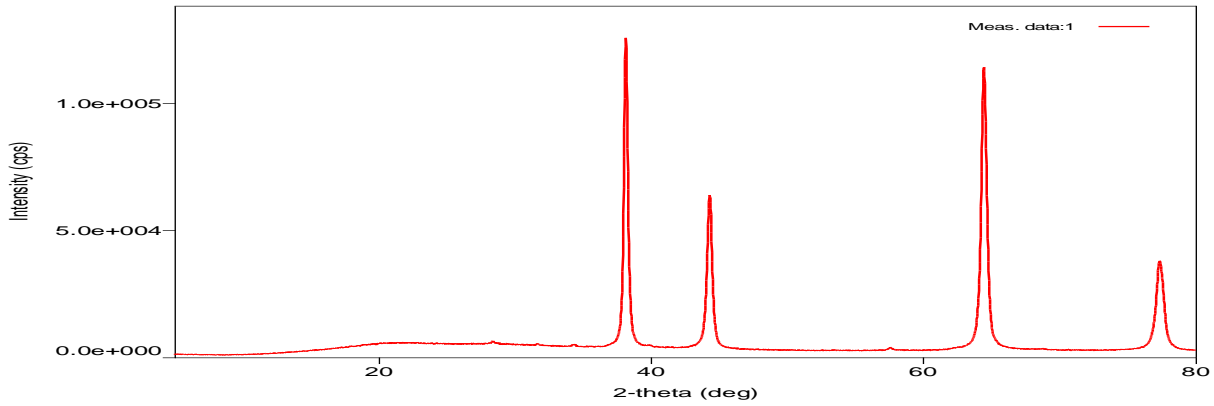


Figure 1. XRD graph of *Raw Rajata*

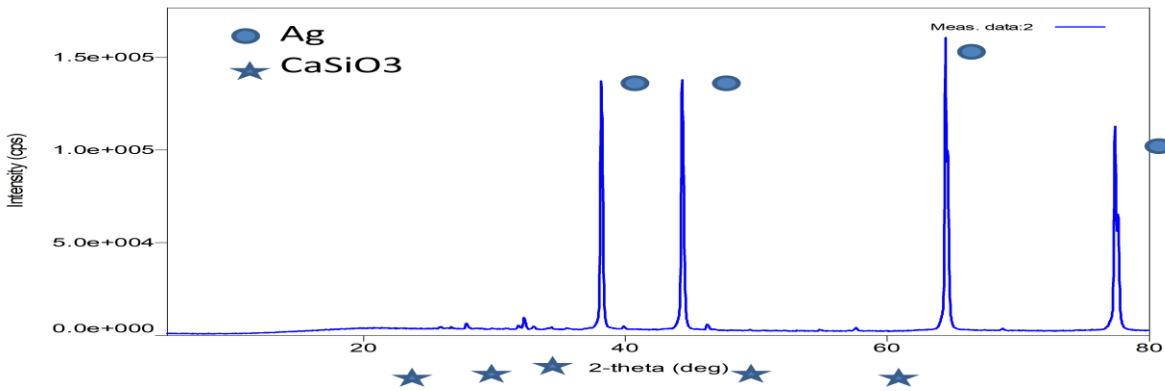


Figure 2. XRD graph of *Shodhita Rajata*

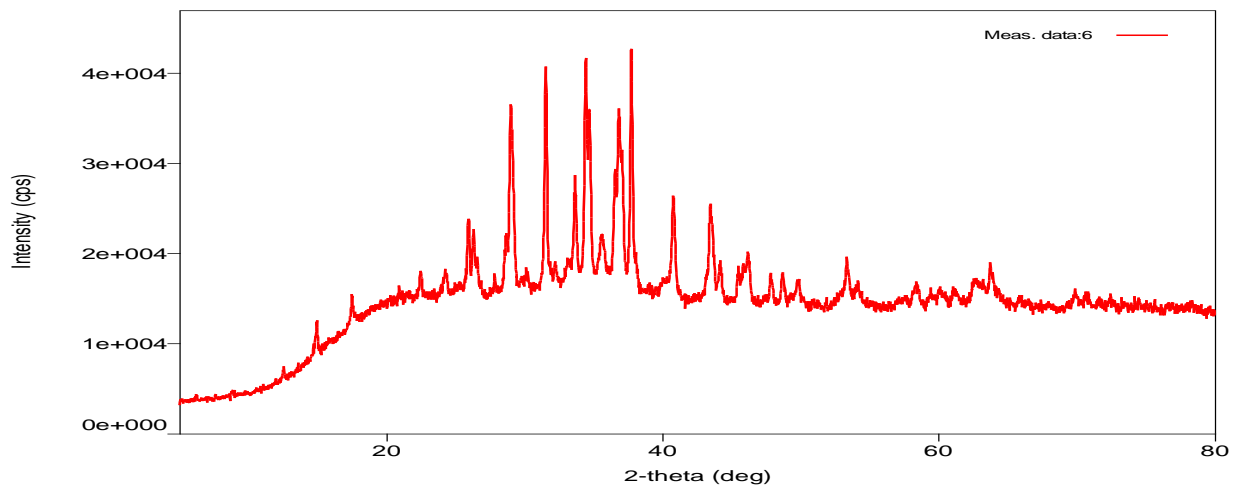


Figure 3. XRD graph of *Rajata Bhasma*