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ORA- Analytical Study

Synthesis and Characterization of *Vanga Bhasma* (VB)

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ABSTRACT:

Background: Various raw materials (mercury, sulphur, and herbal compounds) and methods were recommended by ancient scholars to prepare *Vanga Bhasma* (VB). Variation in raw materials and methods can leads to the variation in the physicochemical parameters of VB. **Aim:** To analyze the VB prepared through the *Shodhana* (mandatory preliminary process), *Jarana* (poling) and *Marana* (Calcination process of making *Bhasma*). **Material and methods:** VB was prepared following *Shodhana*, *Jarana*, washing of *Jarita Vanga*, and *Marana* steps as per the classics. Sophisticated Instruments (XRF, XRD, and SEM) were used to analyze VB to explore elemental composition, compounds and its crystals, and topographical changes at different steps. **Results:** Tin crystals are converted into stannous oxide (Rhomarchite-SnO) and stannic oxide (Cassiterite –SnO2) during the *Shodhana*, and *Jarana* process as per XRD reports. XRD shows presence of stannic oxide in the VB. After every step of VB, there was increase in the oxygen percentage with decrease in the tin percentage. The crystal particle size was decreased from raw *Vanga* (239 nm) to VB (45.8 nm). **Conclusion:** *Jarana* and washing of *Jarita Vanga* is a step necessary in between *Shodhana* and *Marana* of *Vanga* when mercurial compounds are not used. The *Jarana* process may helpful to initiate the conversion of Sn to SnO_2 and to enhance the tin tolerance to withstand the *Puta* heat. The introduction of washing of *Jarita Vanga* process is helpful in removing the alkaline material introduced from herbal media used during *Vanga Jarana*. *Marana* of *Jarita Vanga* is essential to complete the conversion of tin to stannic oxide and particle size reduction to the nanoscale.

KEYWORDS: *Bhasmikarana*; Cassiterite; *Jarana*, Tin oxide, *Vanga Bhasma*

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1. INTRODUCTION

As per ancient classics, every substance on the earth can be a potential medicine. [1] Large particle size, non-bioassimable form, non-ionized elemental form, and harmfulness due to impurities hinder the use of these substances in its natural form. *Shodhana* (mandatory preliminary process), *Marana*(Calcination process of making *Bhasma*), *Kupipakva Rasayana* (a specific formulation prepared in a specially designed glass bottle), and *Pottali* (a formulation manufactured using *Pottali* of the medicines) formulations are the various processes recommended to overcome above problems. [2] Metal *Shodhana* was carried out after quenching the red-hot or molten metal in herbal media. [3] The pellets were formed when *Shodhita* metal was levigated with herbal liquids until doughy mass was formed. These pellets were kept in earthen saucers, and it is subjected to a specific quantum of heat (*Puta*) to convert the metal into the *Bhasma*. [4]

Vanga Bhasma (VB) is useful to treat various disorders, including obesity, diabetes mellitus, worm infestation and genitourinary tract diseases. [5] Contemplation of Rasa literature point out that the *Shodhana*, *Jarana* and *Marana* of *Vanga* (tin) can be carried out using the various herbal and mineral substances. [6] VB prepared from mercury, sulphur and various raw materials was analyzed in few research works. [7-10] It becomes necessary to evaluate the effect of variation in raw material and methods of VB on the physicochemical parameters and compounds present in the VB.

Aims and Objectives:

1. To prepare VB using different raw materials (non-mercurial substances) and methods (*Prakshalana* –washing of *Jarita Vanga*) than the previous research works.
2. To evaluate VB quality using ancient parameters and sophisticated advanced instruments like XRF, XRD and SEM.
3. To compare physicochemical parameters of VB with VB of previous research works to evaluate the effect of variation in raw materials and addition of *Jarita Vanga* washing process.

2. MATERIAL AND METHODS

Raw *Vanga* (Tin), *Churna* (lime), *Appamarga Panchanga Churna* (powder of root, stem, leaves, flower and fruits of Achyranthus aspera pennel), and *Kumari* (Aloe barbadensis Miller) are required to prepare the VB. They were purchased from local vendors. The *Dravyaguna* department of our college authenticated *Appamarga* and *Kumari* plants. Purity of raw tin was authenticated through XRF. Raw tin is in pure form as it contains 99.97 % of Sn with 0.03 % of cooper as impurity. The limewater (*Churnodaka*) [11], juice of Aloe barbadensis Miller leaves (*Kumari Swarasa*) [12] were manufactured in the department as per the classics.

Vanga Shodhana [13]

Limewater was kept in "*Pithara Yantra*", a specially designed instrument having a vessel covered with a lid having an aperture. Melted raw tin was poured through an aperture of *Pithara Yantra* (Specification: Depth of the lid: 4 cm, Middle hole: 2 cm, Circumference: 52.5 cm, Height: 30 cm and Capacity: 6 liter) into the limewater. The quenching of molten tin into limewater was repeated for seven times. The limewater was changed every time.

***Shuddha Vanga Jarana* (Poling)** [14]

Rasa Tarangini introduced *Jarana* process after the *Vanga Shodhana*. The *Shuddha Vanga* was kept in an open iron pan (Specification: Diameter: 57.5 cm, Depth: 23.5 cm, Circumference: 183.5 cm) and heat was applied until its melting. The powder of *achyranthus aspera* was added to an open pan in small quantities. This powder is rubbed with melted *Vanga* using an iron ladle (Specification: Length: 100 cm, diameter of the cup: 15 cm Depth: 6 cm). This rubbing process was continued until melted *Vanga* and *Appamarga* powder converts into greyish white ash. Total three hours

required for this conversion. Greyish white ash was covered with an earthen saucer after collecting at the iron pan center. The strong heat (up to 625^{O}C) was applied to the pan so that bottom of an iron pan became red hot. The ash was collected once the temperature of an iron pan reaches to room temperature.

***Jarita Vanga Prakshalana* (washing)** [15]

Jarita Vanga (195 g) was kept in S S vessel. The distilled water (1600ml) was added to the SS vessel. The *Jarita Vanga* and distilled water rubbed with hand for proper mixing. Then it was allowed to settle for three hours. After settling of *Jarita Vanga*, the supernatant fluid was carefully drained. The pH of this fluid was checked. The above procedure was repeated until no change was observed in the pH of distilled water. The sediment powder was collected. It was kept in the sunlight for drying.

Marana* of *Jarita Vanga [16]

The washed *Jarita Vanga* powder was levigated with aloe vera juice to form a uniform doughy mass. The pellets (*Chakrika* - Diameter -2 to 3 cm, thickness- 0.5 to 0.8 cm) were prepared from this doughy mass and kept for shade drying. The dried pellets were kept in the earthen saucer and it is covered with another earthen saucer. The joint of these earthen saucers was closed with mud-smeared cloth (*Sharava Samput*) and it is kept for drying. The *Ardha-Gaja Puta* was applied to the *Sharava Samputa* in the electric muffle furnace (EMF: specification: Horizontal with 1100^{0}C capacity, 4.5 kw, digital temperature controller system, working size 9x9x18"). The temperature of EMF was increased up to 550^{O}C within one hour. 550^{O}C temperature was maintained for 30 minutes. After that, EMF was switched and it is allowed to reach room temperature after self-cooling. Pellets containing earthen saucers were removed after self-cooling. Pellets were converted into powder. The above procedure was repeated until VB passes all ancient parameters. (Figure 1 and 2]

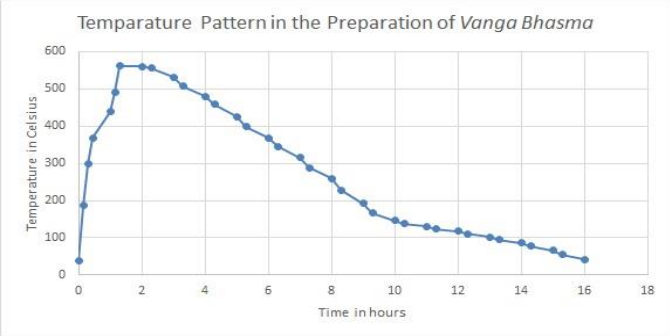

Figure 1: Temperature pattern required in the preparation of *Vanga Bhasma*(VB)

Characterization of *Vanga Bhasma* (VB)

Both ancient and contemporary analytical parameters were used to characterize the VB.

Traditional Parameters of *Bhasma*

VB was analysed for physical parameters using *Nischandratvam* (lusterless), *Rekhapurnatvam* (particle size entering the furrows of finger), and *Varitaratva* (floating of the *Bhasma* on the surface of water).

Figure 2: *Vanga Bhasma* Images (a) Raw Tin (b) After *Shodhana* Process (c) After *Jarana* process (d) After pelletisation (*Chakrika Nirmana*) (e) Drying of pellets (f) Pellets after 7th cycle of calcination

Physicochemical Parameters of VB

Physico-chemical parameters (loss on drying [17], ash value [18], and acid insoluble ash [18]) of VB were analyzed as per API guidelines.

Identification of the Compounds and its crystallinity

The crystallinity of the samples taken after each step was analysed using an X-ray diffractometer (XRD). XRD patterns were recorded on a Bruker D8 Discover X-ray diffractometer, CuKα (λ = 1.54056 A), scan range (2θ – 5.0 – 120.00), scan speed 30/min. XRD facility was availed from the Earth Science department of IIT, Mumbai.

Elemental Composition and surface topography using a Field Emission Gun Scanning Electron Microscopy (FEM-EDAX)

FEG-SEM was done to know the surface topography and elemental composition by using JSM-7600 with SEI resolution 1.0 nm at 15 kv, 1.5 nm at 1 kv in GB mode, low magnification at 25X to 10000X,high magnification at 100x to 1000000x at 4X5 photo size by using accelerated voltage 0.1 to30 kv with probe 1pA to >200nA. Energy Dispersive X-Ray Analysis (EDAX) was carried out to know detailed quantitative and qualitative elemental analysis in the characterization of materials with magnification of 10x to 400000x.

Particle Size

Particle size was calculated using Scherer's equation. SEM was used to measure the particle size.

3. OBSERVATIONS AND RESULTS

The observations of *Vanga Shodhana* are stated in Table 1.

Table 1: Mean Observations and Results of *Vanga Shodhana* for all batches

Mean Values	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5	Batch 6
Weight after *Vanga*	191 gm	195 gm	197 gm	197 gm	199 gm	199 gm
Time taken for melting	3.5 Min	3.6 Min	4.8 Min	4.4 Min	6 Min	6 Min
Temperature of melted *Vanga* (^{0}C)	216	220	216	210	192	198
Temperature of *Churnoduka* before quenching (^{0}C)	33	34	33	32.28	32	34.57
Temperature of *Churnoduka* after quenching (^{0}C)	43	44	43	44.28	48	49.42
Volume of *Churnoduka* after quenching	567 ml	560 ml	567 ml	574 ml	570 ml	571.42 ml

Traditional Parameters

VB is having white color without any taste (*Niswadu*) and odor. These organoleptic findings are in accordance with ancient classics. VB after 7th *Puta* passes ancient tests such as *Nishchandratva*, *Rekhapurnatva*, and *Varitaratva*. (Table 2).

Physicochemical Parameters

VB showed 100% of a total ash and an acid insoluble ash with absence of moisture in loss on drying test.

Table 2: Classical analytical tests of different Samples Obtained at Different Stages of *Vanga Bhasma* Preparation

Stages of *Vanga Bhasma* Preparation	***Jarana***	**VB after 1st *Puta***	**VB after 3rd *Puta***	**VB after 7th *Puta***
Touch (*Sparsh*)	Soft powder	Pellets are Hard	Pellets are Hard	Pellets are Soft, Broken on touch
Rekhapurnatva	+	+	+ +	+ ++
Varitaratva	Partially present	Partially present	Partially Present	Present
Color	Blackish white	Blackish white	Whitish Gray	White

XRD

The crystallinity of VB was checked using XRD technique. XRD peaks of samples taken during different steps of VB preparation are given in figures 3-8 and Table 3. Raw tin (starting raw material) has distinguishing peaks of tin (Sn) at 2θ values of 32.00, 32.09, 44.84, and 44.90 in XRD (Figure 3). These peaks were not observed in the VB. The XRD peaks of *Shuddha Vanga* has peaks of tin and stannous oxide (rhomarchite-SnO) (Figure 4). *Jarita Vanga* after washing contains peaks that matches with peaks of standard tin metal and standard cassiterite (Stannic oxide-SnO_2) (Figure 5). Raw *Vanga* (tin), *Jarita Vanga* after washing, VB after 3rd *Puta* and VB after 7th *Puta* doesn't contains peaks that matches with reference of rhomarchite. The samples of VB at different stages of calcination cycles has peaks at 2θ values of 26.56, 26.64, 33.85, and 33.95. These peaks matches with reference of cassiterite- stannic oxide of tetragonal-rutile phase (Figure 6-7). This observation is consistent with the observations of previously reported studies. [7-10]

Table 3: XRD Analysis with compound and its structure

Sr. No.	**XRD Sample**	**Compound Formed**	**Peak Score**	**Chemical formula**
1	V(Raw *Vanga*)	Tin	90	Sn1
2	VP (Purified *Vanga*)	Tin, Romarchite	81,30	Sn1,SnO
3	VJ (*Jarit Vanga*)	Tin, Cassiterite	78,90	Sn1, SnO2
4	VB3(*Vanga Bhasma* after 3rd *Puta*)	Cassiterite	90	SnO2
5	VB7(*Vanga Bhasma* after 7th *Puta*)	Cassiterite	93	SnO2

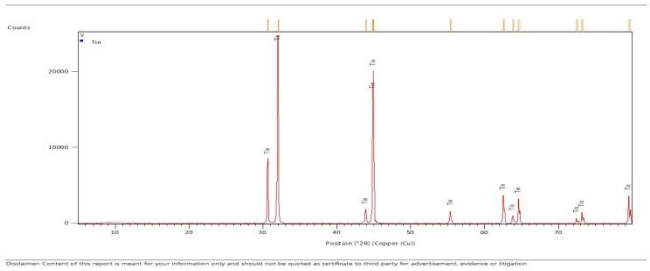

Figure 3: X-ray diffraction pattern of Raw *Vanga* (V)

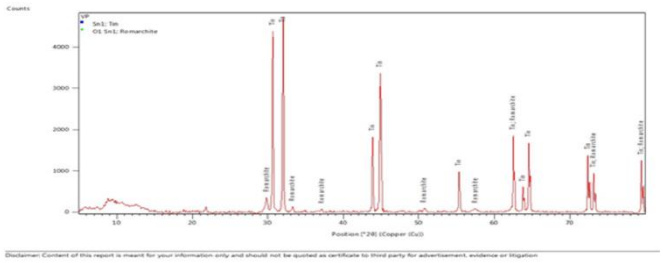

Figure 4: X-ray diffraction pattern of *Shodhita Vanga*

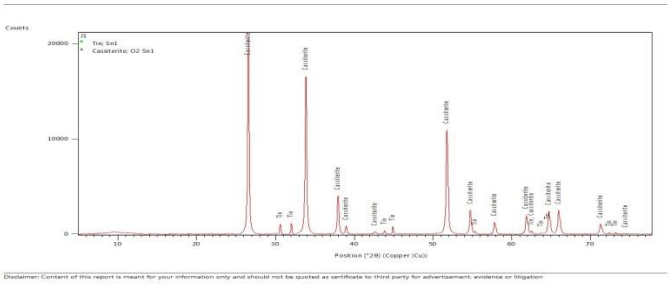

Figure 5: X-ray diffraction pattern of *Jarita Vanga*

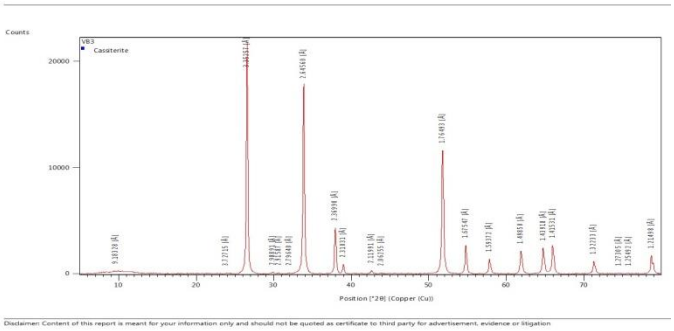

Figure 6: X-ray diffraction pattern of *Vanga Bhasma* after 3rd *Puta*

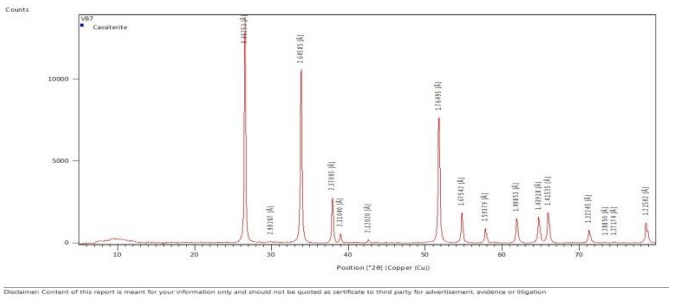

Figure 7: X-ray diffraction pattern of *Vanga Bhasma* after 7th *Puta*

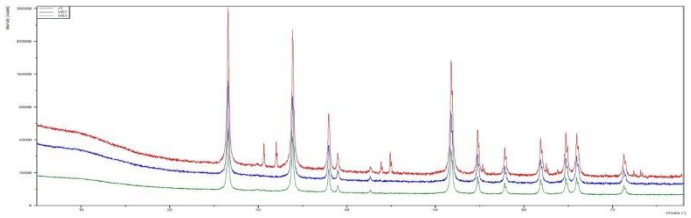

Figure 8: XRD spectra for *Vanga Bhasma* (a) after *Jarana*, (b) after 3rd cycle of calcination, (c) after 7th cycle of Calcination

SEM images for the raw material (tin), in process material (*Shodhita Vanga*, *Jarita Vanga*, VB after 3rd *Puta*) and finished product (VB after 7th *Puta*) are depicted in Figure 9. The surface topography of raw tin is hard with non-definite borders (Figure 9a). *Shodhita* and *Jarita Vanga* contain small particles with granular morphology, smooth spongy surface and well-defined borders (figure 9d, e).

Crystalline size was calculated from Scherer's equation using 2θ values of sharp, tall peaks with 100% intensity observed in XRD. The crystalline size of tin was reduced from 176 to 134 nm during the *Shodhana*. *Jarita Vanga* contains crystals having particle size in between 74.8 nm to 177.5 nm. VB has crystals with particle size of 87.2 nm. There is reduction in the particle size from raw material (tin) to finished product (VB). The maximum reduction in the particle size was observed after *Jarana* and *Marana* process. (Table 4, 5)

Energy Dispersive X-ray Analysis (EDAX)

The elemental composition of samples of various steps of *Vanga Bhasma* preparation are given in Table 6.

Table 4: XRD Crystalline Sizes of Different Samples Obtained At Different Stages of *Vanga Bhasma* Preparation

Sample Name	Element Name	Pos. [°2θ]	FWHM in rad	Kλ	Crystallite size	Score
Raw *Vanga* (V)	Tin	32.0031	0.0468	1.386	176.6 nm	79 %
Shodhita Vanga (VP)	Tin	30.7101	0.0468	1.386	176.0 nm	81 %
	Tin	32.0093	0.0624	1.386	132.5 nm	30 %
Jarita Vanga (VJ)	Cassiterite	33.9477	0.0468	1.386	177.5 nm	78 %
	Cassiterite	26.5643	0.1092	1.386	74.8 nm	90 %
Vanga Bhasma - after 3rd cycle of calcination (VB3)	Cassiterite	33.9473	0.0468	1.386	177.5nm	59 %
	Cassiterite	26.5638	0.0895	1.386	91.2 nm	77 %
Vanga Bhasma - after 7th cycle of calcination (VB7)	Cassiterite	26.5666	0.0936	1.386	87.2 nm	93 %

Note: FWHM: Full-width at half Maximum

Table 5: Topography Pattern of Different Samples Obtained At Different Stages of *Vanga Bhasma* preparation

Sample	Particle size	Surface	Border
V(Raw *Vanga*)	239 nm	Hard	Not defined
VP (Purified *Vanga*)	800 nm	Moderate hard	partially defined
VJ (*Jarit Vanga*)	34.8nm	Spongy	Well defined
VB3(*Vanga Bhasma* after 3rd *Puta*)	32.1nm	Spongy	Well defined
VB7(*Vanga Bhasma* after 7th *Puta*)	27.4nm	Spongy	Well defined

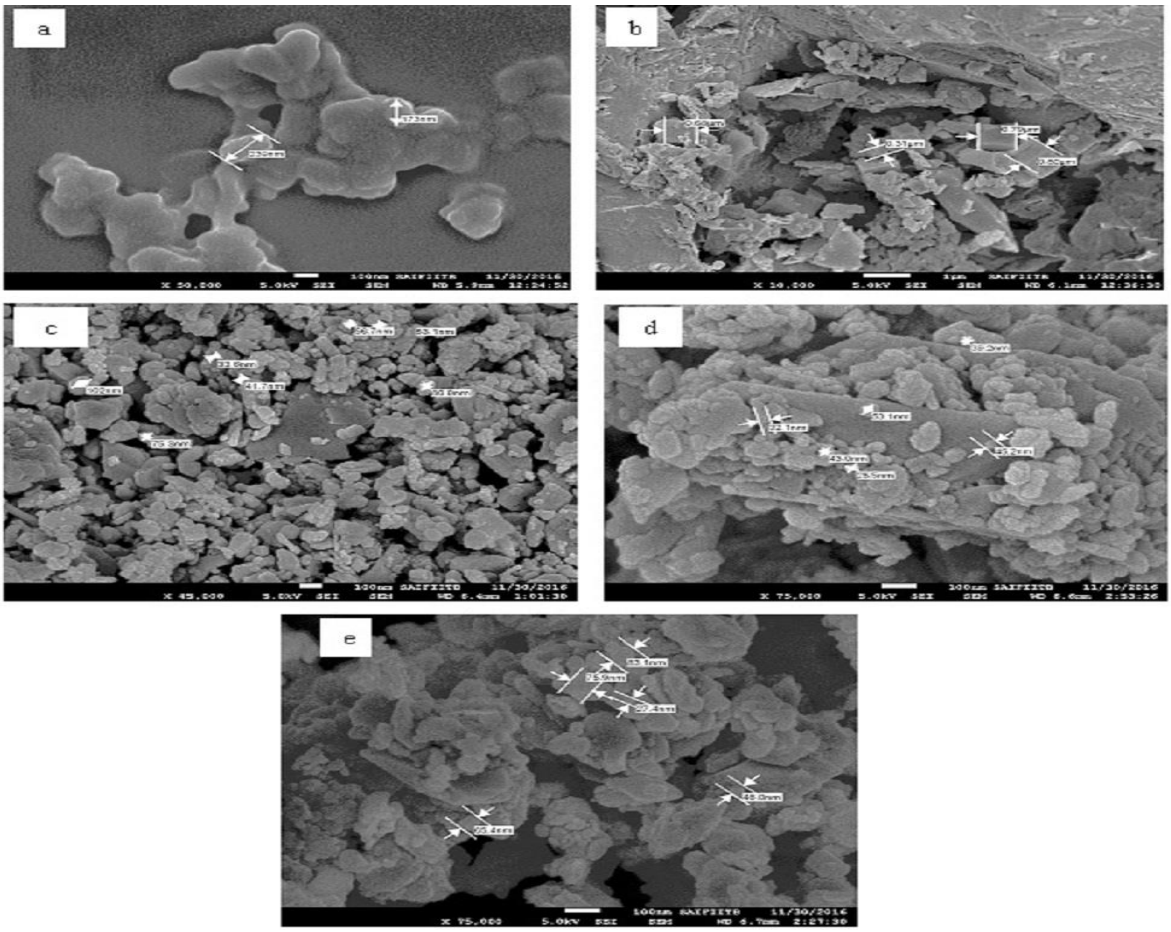

Figure 9: SEM images (a) Raw Tin, (b) After *Shodhana*, (c) after *Jarana*, (d) VB after 3rd Calcination Cycle, (e) *Vanga Bhasma* after 7th calcination cycles.

Table 6: Energy Dispersive X-ray Analysis (EDAX) of Different Samples Obtained at Different Stages of *Vanga Bhasma* Preparation

Sr. No.	EDS	O	Fe	Cu	Zn	Sn	As	Cd	Hg	Zr	Total
1	V(Raw *Vanga*)	7.1	0.0	0.0	0.0	92.99	0.0	0.0	0.0	0.0	100
2	VP (Purified *Vanga*)	30.57	0.0	0.0	0.0	69.43	0.0	0.0	0.0	0.0	100
3	VJ (*Jarit Vanga*)	36.94	0.0	0.0	0.0	63.06	0.0	0.0	0.0	0.0	100
4	VB3(*Vanga Bhasma* after 3rd *Puta*)	36.78	0.0	0.0	0.06	63.22	0.0	0.0	0.0	0.0	100
5	VB7(*Vanga Bhasma* after 7th *Puta*)	37.24	0.0	0.0	0.0	62.76	0.0	0.0	0.0	0.0	100

Energy Dispersive X-ray Analysis (EDAX)

Raw tin contains the maximum percentage of tin. It reconfirm the purity of raw tin procured from market in the present study. VB contains maximum percentage of Sn and trace of oxygen. The relative Sn percentage decreased from raw tin to Vanga. The oxygen percentage has started increasing from *Shodhana* to *Marana* of *Vanga*. The heat applied during the steps of *Vanga Marana* (*Shodhana*, *Jarana* and *Marana*) may convert Sn to SnO_2.

4. DISCUSSION

Vanga Bhasma (VB) can be prepared using four (1. Mercury compounds, 2. Sulphur compounds, 3. Herbal, and 4. Other metals) different media. VB is prepared following *Shodhana* and *Marana* steps when mercury or its compounds are utilized. However, *Jarana* method was introduced in between *Shodhana* and *Marana* step of VB whenever non-mercury compounds are used as raw material. [14]

The pouring of melted *Vanga* into limewater creates a loud, blasting sound with increase in the temperature of limewater. It is indicative of exothermic reaction. It also justifies the use of specially designed instrument,"*Pithara Yantra*" during *Vanga Shodhana*. After *Vanga Shodhana*, raw tin was converted into silvery metallic pieces, which are covered with inseparable blackish material. Rhomarchite (stannous oxide – SnO) is blackish in color which is formed due to heating of tin in an open pan. An increased oxygen percentage in the *Shodhita Vanga* is indicative of the tin oxide compounds formation. The presence of stannous oxide as blackish particle was confirmed with presence of stannous oxide peaks in the XRD spectrum of *Shodhita Vanga*. Hiremath et al. proposed possible changes during *Vanga Shodhana*. Free Sn radicals energized during melting. The Sn-Sn bond breaks into smaller fragment upon reacting with water in the presence of lime. Further, these free radicals react with water to produce SnOH (tin hydroxide). [8]

During repeated heating, this SnOH may transforms into blue-black tin oxide (stannous oxide), which is more stable form. This stannous oxide form is water insoluble. [19] In short, stannous oxide formation takes place through tin hydroxide during *Shodhana*. The quenching of melted *Vanga* into the limewater also reduces the particle size slightly.

Jarana process leads to an increase in the weight of *Shodhita Vanga* by an average of 10 %. This increase is due to the addition of ash from plant material (*Appamarga*) used during the *Jarana*. Hydrocarbon gases were released due to wood ignition during the *Jarana* process. These gases may reduce the metal oxides formed during the *Shodhana* process. These reduced metal oxides are converted into finely powdered metallic form. A substantial quantity of air gets absorbed throughout the rubbing and stirring. This air leads to oxidation of easily oxidisable substances. This oxidized material either may evaporate or is condensed into "Scum", which accumulates on the melted metal. The continuation of rubbing leads to conversion of all materials into oxide form that is obtained as powder. The generated powder is collected at the center of an iron pan. It is covered with an earthen saucer. It may create an air-free surrounding. Then strong heat is applied to the centrally collected powder until bottom of an iron pan became red-hot. This step may enhance the melting point of *Vanga* after the *Jarana* process. This may useful during calcination process by preventing the melting of *Vanga*. [20]

The pH of distilled water increases to 10.5 from 6.6 after washing of *Jarita Vanga* with distilled water. Three cycles of washing are necessary until pH of distilled water will not alter. The pH rise after washing of *Jarita Vanga* with distilled water was due to dissolution of alkaline substances from the *Appamarga* plant used during *Jarana*. Hence, washing of *Jarita Vanga* is necessary to remove *Kshara* (alkaline substances) to preserve *Shukral* (spermatogenesis) action of *Vanga Bhasma*. [15] The presence of stannic oxide

(Cassiterite) peaks and absence of stannous oxide (Rhomarchite) peaks in XRD spectrum of *Jarita Vanga* indicate the transformation of stannous oxide into stannic oxide during *Jarana* process. This observation is supported with an increase in oxygen percentage in *Jarita Vanga*. Hiremath et al. quoted the presence of strong peak for tin oxide, several weak peaks of unreduced metallic tin and a low intensity peak of potassium tin oxide in the *Jarita Vanga*. The presence of potassium tin oxide is due to addition of potassium from the *Appamarga* plant used during *Vanga Jarana*. [6] However, in the present study, *Jarita Vanga* has no peaks that matches with potassium tin oxide. The addition of *Jarita Vanga* washing process in the present work removes the alkaline substances added from the *Appamarga* plant. *Vanga Jarana* step is useful for further reducing particle size.

A zero loss on drying is revealing moisture freeness of VB. The total ash value assures the absence of free organic content. [21] 100 % w/w ash value is indicative of the exclusive presence of inorganic matter. These findings are consistent with previously reported studies. [8-9] Acid-insoluble ash is indicative of acid non-digestible material. Therefore, lower acid insoluble ash specifies higher bioavailability of the drug. [22] An acid insoluble ash of 100 %w/w may indicate that VB is composed of some tin compounds, which are insoluble in dilute hydrochloric acid (HCL). Stannic oxide is soluble in concentered HCL.

Rekhapurnatva indicate that tin is reduced up to such particle size that can enter the furrows of the finger. *Varitartva* is indicative of the lightness of the particles, which can float on the surface of the water. Traditional parameters (*Rekhapurnatva*, *Varitaratva*, and *Nishchandratva*) were not observed in VB before 7th *Puta*. So desired particle size and lightness as per ancient parameters were not achieved before 7th *Puta.* Stannic oxide is a compound found in the VB as per XRD reports. The standard stannic oxide has maximum of 78.76% tin. VB sample contains 62.76% of tin, which corresponds with 79.68% of SnO_2, as per stiochiometry. Crystals of tin was not observed in VB as per XRD spectrum. This indicates the complete conversion of tin into stannic oxide after *Marana* process. An oxygen percentage increase during the steps of *Marana* may indicate that cycling of calcination process is required for complete conversion of free, ionic tin metal into stannic oxide. Previous studies reported the presence of other elements in small quantity. These other elements may came from the herbal media used during *Jarana*. In the present study, washing of *Jarita Vanga* was done that may remove the other elements, which are detected in the previous studies.

VB contains spongy granules with well-defined borders in the nano size as per SEM reports. The bioavailability of particles increases with reduction in size. Therefore, reduction in the particle size during the *Marana* process may increase the bioavailability. However, calculation of particle size from XRD peaks, SEM microscope has limitation, as it indicate the particle size of particular crystal or particle under microscope. It doesn't indicate the range of particle size and count of particles with specific size. VB prepared using EMF has particles in the nano-range (50-100nm) with uniform particle size distribution as per Kale et al. Wadekar et al. projected a stepwise oxidation of the tin, which is mediated through its hydroxide formation. [10] However, stannic oxide formation in the present study has occurred through stannous oxide. It may be due to change in the raw material and inclusion of washing of *Jarita Vanga* process. The washing of *Jarita Vanga* process may responsible for the absence of potassium tin oxide peaks in VB. The final product VB contains stannic oxide even though there is change in raw material and method used in the VB preparation.

5. CONCLUSION

Jarana is the process included in the *Vanga Bhasma* preparation when non-mercurial compounds are used as media in the *Marana*. The various steps of *Vanga Bhasma*

preparation (*Shodhana*, *Jarana*, and *Marana*) are helpful to reduce the particle size up to nano level. The introduction of *Jarita Vanga* washing removes the alkaline material, which is added from herbal media used in the *Jarana* process. *Vanga Bhasma* contains cassiterite (stannic oxide) in tetragonal form. The stannous oxide formed during *Vanga Shodhana* converts into stannic oxide during *Marana*. Cycling of calcination for seven times is essential for complete conversion of free metallic tin into stannic oxide. The major compound (stannous oxide) present in *Vanga Bhasma* remains same even though various raw materials and methods are used in VB preparation.

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