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Original Research Article

Swarna Makshika Bhasma preparation using an alternative heating method to traditional Varaha Puta

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ABSTRACT

Background: Metals, minerals and gemstones are used to prepare drugs in combination with various herbal materials in ayurvedic treatments. During the process of preparation, metals, minerals or gemstones are converted into special form known as *bhasma* by series of pharmaceutical processes; *shodhana*, *bhavana* and *marana*. *Putra* is the amount of heat required to produce specific *bhasma* in a cycle of treatment in the process of *marana*. Traditionally, heat is produced by burning cow dung cakes and the amount of heat to be provided is described in terms of cow dung cakes (fuel) burnt.

Objectives: The present study was aimed to obtain the temperature profile of the traditional *Varaha Puta* and to establish a complementary temperature profile in a muffle furnace.

Materials and methods: The temperature profile of *Varaha putra* was determined using dried cow dung cakes (which were prepared using cow dung and paddy husk) with an average calorific value of 15.44 MJ/kg as the fuel. Then temperature profile of traditional *Varaha Puta* was mapped with an electric muffle furnace and *Swarna Makshika* (Chalcopryrite) *bhasma* was prepared using both traditional method and in electric muffle furnace.

Results: *Bhasma* prepared using both *Varaha Puta* and muffle furnace have shown similar properties according to classical tests of Ayurveda and laboratory techniques.

Conclusion: The results show the possibility of using a muffle furnace to prepare *Swarna Makshika bhasma* instead of using traditional *Varaha Puta*.

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1. Introduction

Bhasmas are very fine ayurvedic medicinal powders prepared from minerals, metals, poisonous materials and gems combining with various herbs in treatments. The conversion of metals and minerals into acceptable form for oral administration is done by a series of pharmaceutical processes; *shodhana*, *bhavana* and *marana* and preparation procedures of these medicines are time-consuming and complicated [1,2].

Shodhana is the process in which the external and internal impurities of metals and minerals are removed. It involves elimination of harmful matter from the drug, modification of undesirable physical properties of the drug, conversion of some of the characteristics of the drug to different stages and enhancement of the therapeutic action [3,4]. The second process, *bhavana* is the wet grinding process in which materials are ground with specific liquid media for a particular period and this process leads to unique and suitable physico-chemical changes and potentiate the efficacy of material. In the final process, *marana*, purified metals or minerals are made in to pellet form with required other ingredients and herbal extracts as prescribed in classical texts and then subjected to fire treatment in closed earthen crucibles in a pit by burning dried cow dung cakes to obtain *bhasmas* [5]. This process is repeated many times (number of heating cycles) as prescribed in classical

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texts for each preparation. The amount of heat required in a cycle of treatment in the preparation of specific *bhasma* is known as *Putra*. Amount of heat required for one *Putra* is described in terms of cow dung cakes. However, the temperature profiles or the amount of heat to be supplied are not defined for traditional *Putra*. According to the type of metal or mineral to be incinerated in *bhasma* preparation, dimensions of the pit, the number of cow dung cakes to be burnt and number of heating cycles to be employed are described in Ayurvedic texts.

This work was carried out with the objective of studying the temperature profile of the traditional *Varaha Putra* and to establish a complementary temperature profile in a muffle furnace. The established temperature and heating profile of the muffle furnace was compared with the properties of *Swarna Makshika Bhasma* produced using both *Varaha Putra* and the muffle furnace.

2. Materials & methods

2.1. Materials

Imported *Swarna Makshika* mineral, *Swarna Makshika Bhasma* and Copper Sulphide were purchased from a local supplier. Cow dung, paddy husk and saw dust were purchased from the local market.

2.2. Analysis of *Swarna Makshika*

Imported *Swarna Makshika* mineral samples purchased from three different suppliers and imported *Swarna Makshika Bhasma* available in the market were analyzed for its composition of Cu, Fe and Si using Atomic absorption Spectrophotometer (GBC933AA).

2.3. Cow dung cake preparation

Cow dung cakes were prepared using different compositions of cow dung, paddy husk and saw dust to identify suitable composition. The sample no. 1, 2 & 3 were prepared using cow dung and paddy husk and the compositions were 60:40, 82:18 and 76:24 respectively. The sample no. 4 was prepared using cow dung, paddy husk and saw dust and the composition was 63:20:17. Diameter and height of the mould used to prepare cow dung cakes were 6" and 1" [6] respectively. Calorific value of each sample was measured using a Bomb calorimeter (Parr 1341EE).

2.4. Establishment of temperature profile of *Varaha Putra*

In order to measure *Putra*, the pit for *Varaha Putra* was built using bricks and clay. According to Vagbhatacharya [13], *Varaha Putra* is defined as 1 *Aratne Pramana* and it is equal to 22 *Angulas* [7] (1 *Angula* = 0.75 inches and then 1 *Aratne* is approximately equal to 16.5 inches or 42 cm in SI units). Therefore, length, width and the depth of the pit are 16.5 inches each. The total number of cow dung cakes burnt to establish the temperature profile was 120 and the weight of the cow dung cakes was 12.7 kg.

Initially 80 cow dung cakes were filled to the *Varaha Putra* pit, sealed earthen crucible containing *Swarna Makshika* pellets was placed in it and then covered with the remaining 40 cow dung cakes. Thermocouple wire was inserted to the crucible containing *Swarna Makshika* pellets in order to record the temperature inside the crucibles using the Temperature Data Logger (Lutron TM-947SD) before placing the crucible in the pit. Partly filled *Varaha Putra* with cow dung cakes is shown in Fig. 1.

Then cow dung cakes were ignited from all four sides and in the middle of the pit. When burning was over, the contents in the crucible was allowed to self-cool completely.



Fig. 1. Partly filled *Varaha Putra* with cow dung cakes

2.5. Verification of temperature profile of *Varaha Putra* from muffle furnace

The temperature of the traditional *Varaha Putra* was mapped in the muffle furnace by following the temperature profile obtained for the *Varaha Putra*. Temperatures were set manually and the set temperatures with time are shown in Table 1.

2.6. *Swarna Makshika Bhasma* by traditional method and muffle furnace

Swarna Makshika Bhasma was prepared following the procedures given in the traditional method and using the muffle furnace for the verification of the temperature profile obtained from the traditional *Varaha Putra*.

Among the various methods described in different Ayurvedic classical texts, method described by Vagbhatacharya [13] was selected for the preparation of *Swarna Makshika Bhasma*.

i. Analysis of composition of initial mineral and imported *bhasma* samples

Three *Swarna Makshika* mineral samples those were purchased from different suppliers in local market and two imported *bhasma* samples were analyzed using Atomic Absorption Spectrophotometer (GBC933AA) to identify the composition of minerals and *bhasmas*. Since the samples did not contain the required Cu content of *Swarna Makshika* mineral, Cu was externally added in the form of Copper Sulphide. Therefore, 90 g of powdered *Swarna Makshika* mineral was mixed with 95 g of Copper Sulphide to adjust the Copper content and the sample was analyzed again to verify the composition.

Table 1

Temperatures with time duration for muffle furnace to prepare *Swarna Makshika bhasma*.

Time (min)	Temperature (°C)
0	25
20	60
30	120
40	275
50	500
60	650
70	800
80	850
95	off

Table 2Materials used for *marana* of *Swarna Makshika* pellets in *Varaha Puta* and in muffle furnace.

	Putra 1/Cycle 1	Putra 2/Cycle 2	Putra 3/Cycle 3	Putra 4/Cycle 4	Putra 5/Cycle 5
Wt of cow dung cakes used for (kg) <i>Varaha Puta</i>	12.5	12.9	12.4	12.6	12.4
No. of pellets used for <i>marana</i> in <i>Varaha Puta</i>	38	15	10	8	7
No. of pellets used for <i>marana</i> in muffle furnace	37	15	11	8	6
Wt of pellets before <i>marana</i> (g) in <i>Varaha Puta</i>	149.642	55.403	35.980	29.245	24.234
Wt of pellets before <i>marana</i> (g) in muffle furnace	148.214	54.45	35.065	28.825	23.578
wt loss (%) in traditional <i>Varaha Puta</i>	59.38	25.02	13.74	9.84	8.72
wt loss (%) in muffle furnace	60.44	26.20	13.20	9.52	8.34

ii. *Swarna Makshika Shodhana* process

Prepared *Swarna Makshika* mixture (180 g) was roasted in an open pan with 200 mL of lime juice for 48 min as proposed by Vagbhatacharya [13].

iii. Sulphur *Shodhana* process

Approximately 2 L volume clay pot was filled with 1 L of cow's milk and the mouth of the clay pot was tied with a piece of cloth. Cow's ghee was applied on the cloth and then 245 g of powdered Sulphur was placed on the cloth. Clay pot was covered with another similar size clay pot and sealed using clay-smeared cloth. Then the pot containing milk was buried and the upper clay pot was heated using 2.5 kg of cow dung cakes (approximately 20 cow dung cakes). Finally, Sulphur that was melted and dropped in to the milk was washed with warm water and the process was repeated three times using the resultant Sulphur.

iv. Preparation of pellets

Equal amounts of and *shoditha* Sulphur (200 g of each) were put into the mortar and lime juice was added until all the solids were covered. Then the mixture was ground until all the lime juice was evaporated, pellets were made (approximately 2 cm diameter and 3 mm thick) and sun dried.

v. *Marana* of *Swarna Makshika* pellets in *Varaha Puta*

38 numbers of sun-dried pellets (149.642 g) were placed in the earthen crucible and was sealed with another crucible using clay smeared cloth. Then it was incinerated in *Varaha Puta* (*Putra 1*) using 120 cow dung cakes and allowed to self-cool. The resultant *bhasma* from *Putra 1* was ground again with lime juice, pellets were prepared and incinerated in *Varaha Puta*. This process was repeated 5 times up to *Putra 5* and materials (no. of pellets & their weight) and weight of cow dung cakes used in each *Putra* is shown in Table 2.

vi. *Marana* of *Swarna Makshika* pellets in muffle furnace

37 number of sun dried pellets (148.214 g) were placed in the earthen crucible and sealed with another crucible using clay smeared cloth. Then it was incinerated in a muffle furnace in which the temperature was adjusted manually as described in 2.5.

The resultant *bhasma* from Cycle 1 was ground with lime juice; pellets were prepared and incinerated in the muffle furnace. This process was repeated 5 times and the number and the weight of *Swarna Makshika* pellets used in each cycle is shown in Table 2.

vii. Analysis of final *bhasma*

Final *bhasmas* prepared in both traditional *Varaha Puta* and in the muffle furnace were analyzed using traditional tests mentioned

in ayurvedic texts such as colour (*varna*), floatability (*varitara*), fineness (*Rekhapurnata*), *nirutta*. Further, loss on drying, total ash, acid insoluble ash, chemical composition and particle size distribution were done.

a) Floatability (*Varitara*)

Small amount of *bhasma* was taken and sprinkled slowly on to a stagnant water surface from a short distance [8].

b) Fineness (*Rekhapurnata*)

Small amount of *bhasma* was rubbed in between index finger and thumb to observe whether particle can fill furrows of finger tips [8].

c) *Nirutta*

In this test, *bhasma* was mixed with a fixed weight of silver leaf, kept in earthen pot and similar grade of heat was applied and after self-cooling, weight of the remaining silver leaf was measured [8,9].

d) Loss on drying

One gram of *bhasma* was taken in a crucible and dried in an oven at 105 °C for about 5 h. The sample was allowed to cool and the dry mass was determined [10].

$$\text{Loss on drying} = \left(\frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \right) \times 100$$

e) Total ash

Two grams of each ash samples were weighed accurately in silica crucibles. The samples were spread uniformly on the bottoms of the crucibles, incinerated, cooled and weighed. Difference between the weight of the crucible with incinerated *bhasma* and the empty crucible gives the total ash value [10].

Table 3Characterization of *Swarna Makshika* samples.

Constituent	Mineral samples			<i>Bhasma</i> samples	
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2
Fe (wt %)	37.3	44.10	40.11	60.44	69.83
Cu (wt %)	<0.01	<0.01	0.02	<0.01	<0.01
Si (wt %)	3.95	2.28	2.8	—	—

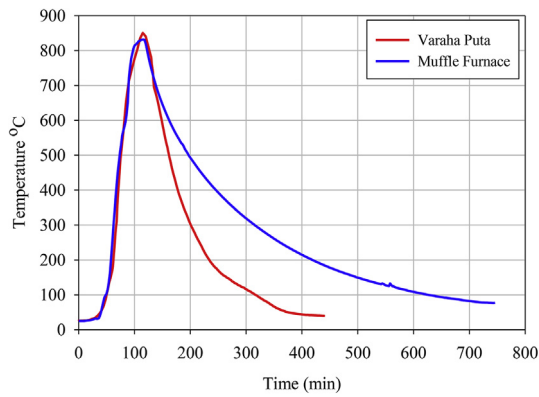


Fig. 2. Temperature profile of traditional Varaha Puta and Muffle Furnace.

f) Acid insoluble ash

The residues from total ash estimations were boiled with hydrochloric acid. The insoluble matter was washed with hot water, transferred to a crucible, dried and weighed. The weight difference between the crucible with incinerated *bhasma* and the empty crucible gives the acid insoluble ash value [10].

g) Chemical composition

The chemical composition of *bhasmas* were analysed using Atomic Absorption Spectrophotometer (GBC933AA).

h) Particle size distribution

Particle size distributions of *bhasmas* were analyzed using Laser Particle size analyzer (Chengdu Jingxin, JL-1177).

3. Results & discussion

3.1. Analysis of composition of Swarna Makshika

Cu is one of the major elements in *Swarna Makshika* (CuFeS_2) and it contains 34.5% Copper, 30.5% Iron and 35% Sulphur by weight [11]. *Swarna Makshika* is not available in Sri Lanka, and generally, it is imported from India for preparation of medicines. However, three *Swarna Makshika* mineral samples purchased from three different suppliers contained <0.02% Cu by weight. Further, two of the imported *Swarna Makshika bhasma* samples purchased from the local market also showed a considerable low amount of Cu. Fe, Cu and Si contents of initial mineral samples and imported *bhasma* samples are shown in Table 3. Since it was difficult to find good quality *Swarna Makshika* in Sri Lankan market, it was decided to use artificially prepared *Swarna Makshika* for *bhasma* preparation. Therefore, CuS was added externally to adjust the required Cu percentage in the initial mineral.

3.2. Analysis of cow dung cakes

According to the Nishteswar, K., & Vidyanath, R. (2010), bits and fragments of cow dung collected from a cow-pen is defined as *Gobara* and cow dung cakes are different from *Gobara*. Therefore, paddy husk and saw dust were mixed with cow dung to prepare cow dung cakes. The average calorific values of 4 cow dung cake samples prepared in this work were 15.18, 15.30, 15.44 and 14.65 MJ/kg respectively and the moisture contents (% dry basis) were 15.84, 14.97, 15.56 and 14.28 respectively.

Maximum Calorific Value, 15.44 MJ/kg was obtained from cow dung cakes prepared using 76% cow dung and 24% paddy husk mixture (dry basis) and it was the most stable mixture among the prepared samples. Therefore, all the cow dung cakes used as the

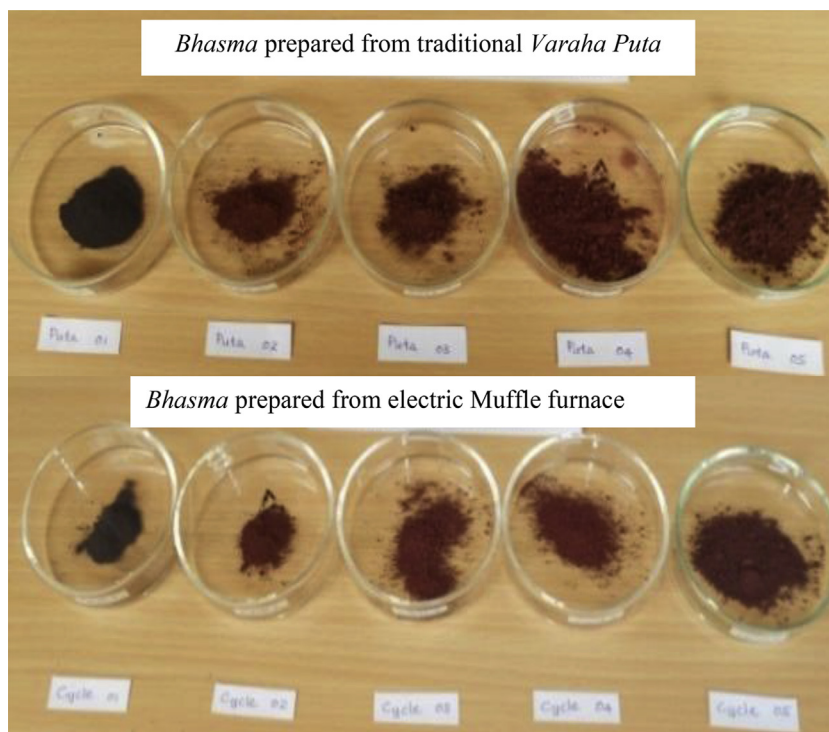
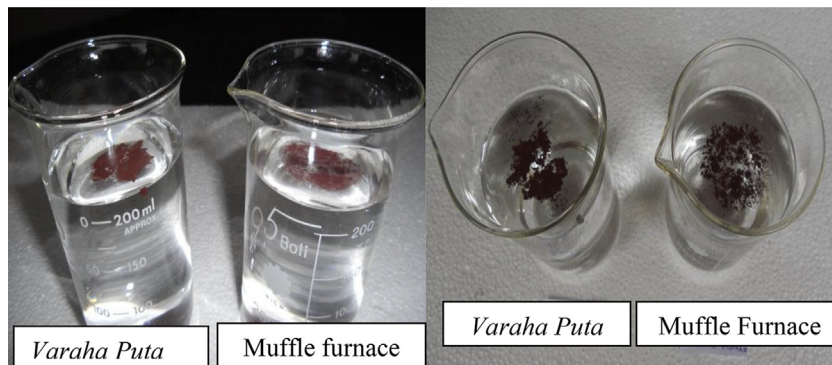


Fig. 3. Colour of resultant *Swarna Makshika bhasmas* after each puta and after each heating cycle in the muffle furnace.

Table 4Results for traditional tests and physico-chemical tests of final *bhasmas*.

Property	Traditional Varaha Puta	Muffle Furnace	Recommended values
Colour	Reddish Brown	Reddish Brown	Reddish Brown [12]
Rekapurnata	Fills the space between finger lines	Fills the space between finger lines	Fills the space between finger lines [12]
Varitara	Floats on surface of water	Floats on surface of water	Floats on surface of water [12]
Nirutta	Silver wt remain unchanged	Silver wt remain unchanged	Silver wt remain unchanged [12]
Loss on drying	0.16% (w/w)	0.25% (w/w)	Not more than 0.5% (w/w) [12]
Total ash	99.84% (w/w)	97.29% (w/w)	
Acid insoluble ash	19.39% (w/w)	16.95% (w/w)	Not more than 21% (w/w) [12]

**Fig. 4.** Floatability test for Swarna Makshika bhasma prepared from Varaha Puta and Muffle Furnace. Side view (left) and top view (right).

fuel for traditional *puta* furnace in this work were prepared by mixing 24% paddy husk and 76% cow dung.

3.3. Establishment of temperature profile of Varaha Puta

Temperature profiles of the traditional *Varaha Puta* and the muffle furnace are shown in Fig. 2.

As can be seen from Fig. 2, temperature of the *Varaha Puta* furnace started to increase 35 min after ignition and gradually reached the peak temperature 850 °C, 120 min after ignition. Temperatures above 750 °C and above 600 °C were maintained for 35 min and 70 ± 5 min respectively. It takes about 5 h to self-cool the *Varaha Puta* to 40 °C.

3.4. Verification of temperature profile of Varaha Puta from muffle furnace

As shown in Table 1, temperature of the muffle furnace was adjusted manually at specified times in order to establish a similar temperature profile as in the *Varaha Puta* and the temperature profile of the muffle furnace is also shown in Fig. 2. It clearly shows that the heating of the *puta* and the muffle furnace follows the same profile however, muffle furnace takes a longer time to cool compared to *Varaha putu*.

3.5. Swarna Makshika Bhasma by traditional method and muffle furnace

Moisture, volatile matter and Sulphur in the form of SO₂ can be escaped during heating in the *puta* as well as in the muffle furnace resulting in the reduction in the weight of pellets. Weight loss after incineration of pellets in the traditional *Varaha Puta* and in the muffle furnace is shown in Table 2.

The weight loss during each cycle in *Varaha Puta* and muffle furnace prepared *bhasmas* are approximate to each other. Therefore, this is an indication of the similarity of heat supplied in each cycle in both traditional *puta* method and electric muffle furnace.

Further, it can be seen that the amount of weight losses have been reduced with the increase of incineration stage. This is due to the amount of Sulphur remaining in the pellets has reduced with the *marana* process and therefore amount of SO₂ liberated during the *marana* is reduced with the *marana* stage.

There was a colour change in the ashes after each stage of heat treatment and the resulted ashes is shown in Fig. 3. It was observed that in both methods, colour has gradually changed from dark brown to reddish brown during 5 incineration stages. Therefore, colour of the final ashes (*bhasma*) obtained from both methods were reddish brown and it is similar to the colour of Chalcopyrite ash specified in Ayurvedic text [12]. This test further indicates the similarity of heat supplied and heat treatment.

Results obtained for traditional tests and physico-chemical tests are summarized in Table 4.

Both *bhasmas* filled the space between finger lines and floated on the surface of water (Fig. 4) confirming that they have achieved the required fineness required in the final *bhasma*.

In *nirutta* test, weight of silver leaf has not increased in both *bhasmas* and it indicates that there was no free metallic portion in the *bhasma* samples. If free metals were present in the *bhasma*, it formulates different compounds with silver and hence weight of silver in the *bhasmas* should be increased. Loss on drying of final *bhasmas* should not more than 0.5% w/w [12] and *bhasmas* prepared from both traditional *Putu* and from electric muffle furnace showed 0.16% and 0.25% of loss on drying respectively. Therefore,

Table 5Chemical Composition of raw mineral and resultant *bhasmas*.

Chemical constituent	Wt (%)			
	Raw mineral	Pellets	Final <i>bhasma</i>	
			<i>Putu</i>	Muffle
Fe ₂ O ₃	15	7.5	47	38
Cu	38	19.0	44	35
SiO ₂	1.8	0.9	2	traces

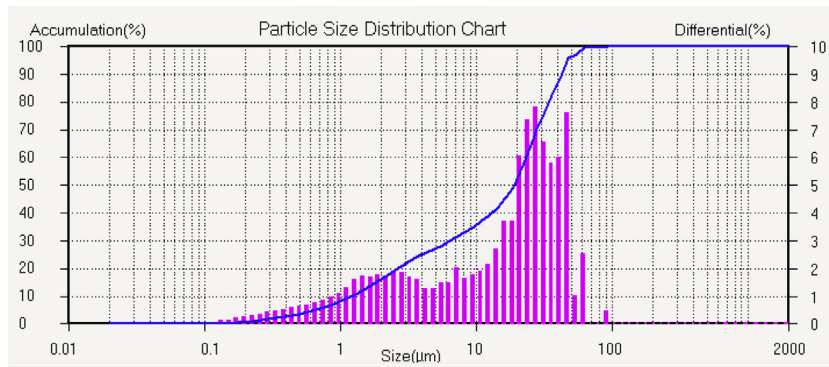


Fig. 5. Particle size distribution of Swarna Makshika bhasmas prepared in Varaha Puta.

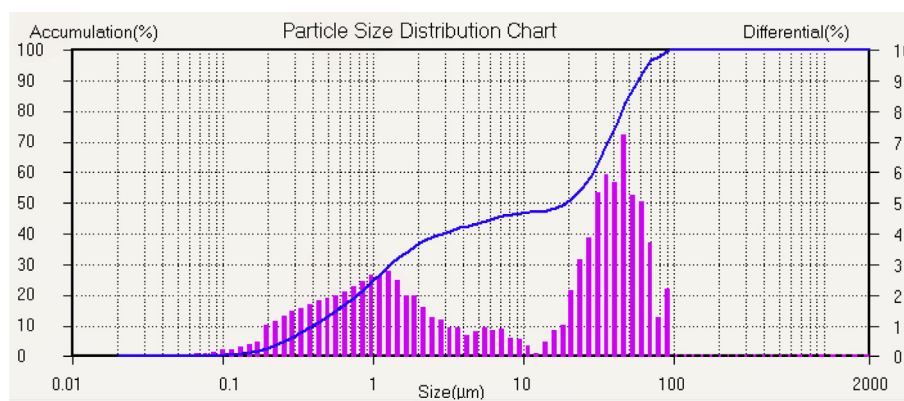


Fig. 6. Particle size distribution of Swarna Makshika bhasmas prepared in Muffle furnace.

results obtained were within the required level of loss on drying and these values of loss on drying are an indication of the absence of moisture in the final product. The total ash contents of Varaha Puta and muffle furnace prepared bhasmas were 99.84% and 97.29% respectively and it indicates the presence of very high inorganic content in both bhasmas. Acid insoluble ash indicates the presence of silica and oxalates in drugs and values obtained for Varaha Puta and muffle furnace prepared bhasmas were 19.39% (w/w) and 16.95% (w/w) respectively. Recommended acid insoluble ash content in Swarna Makshika bhasma should not be more than 21% (w/w) [12] and the results obtained from this study are within the recommended range.

Chemical composition of raw mineral and resultant bhasmas is shown in Table 5.

Initial compositions of formulated Swarna Makshika by externally adding CuS were 15% Fe₂O₃, 38% Cu and 1.8% SiO₂. In this preparation, more attention was paid to maintain correct Cu % in the initial sample as Cu is the main element in Swarna Makshika. The compositions of Fe, Cu, and SiO₂ in pellets become approximately half of the initial raw mineral composition since Swarna Makshika was mixed with equal amount of Sulphur in the preparation of pellets. After marana, Fe, Cu & SiO₂ contents in bhasmas prepared in Varaha Puta were 47%, 44% & 2% respectively while they were 38%, 35% & traces respectively in the bhasma prepared in the muffle furnace. The required copper content in final bhasma should be in the range of 15–18% [12]. Deviation in the results obtained could be due to formulation of Swarna Makshika mineral and therefore the chemical structure/bonding of artificially prepared mineral can be different from the original mineral.

It is well known that reduction of particle size increases the solubility and hence bioavailability of these bhasmas when used in therapeutics. The particle size distributions of bhasmas prepared in Varaha Puta & muffle furnace are shown in Figs. 5 and 6 respectively.

Swarna Makshika bhasmas prepared from both methods have particles in the range of 0.05–92.57 μm in diameter. 35.71% of total bhasma prepared using traditional Varaha Puta is below 10 μm in diameter while 47.03% of particles are below 10 μm in diameter in bhasma prepared in muffle furnace. Further it showed that 50% of particles of both bhasmas were below 20 μm. Previous study has shown that particle size of the Swarna Makshika bhasma is in the range of 3–100 μm in diameter. Therefore, particle size distribution of both bhasmas obtained in this study is comparable with previous studies.

4. Conclusion

Cow dung cakes prepared using 76% cow dung and 24% paddy husk mixture (dry basis) resulted the most stable mixture for cow dung cakes and gave a maximum calorific value of 15.44 MJ/kg.

Temperature profile of Varaha Puta was determined using dried cow dung cakes as the fuel and the same temperature profile can be established using a muffle furnace. Swarna Makshika bhasma prepared using both traditional method and the electric muffle furnace, showed comparable properties according to classical tests of Ayurveda and laboratory techniques, demonstrating heating employed in both methods are complementary. Therefore, muffle furnace can be used to prepare Swarna Makshika bhasma instead of

using traditional *Varaha Puta* and hence muffle furnace can be used to prepare *bhasmas* that are generally produced in *Varaha Puta*.

Conflicts of interest

The authors confirm that there are no conflicts of interest.

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