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"*KUPIPAKVA RASAYANAS* (*RASASINDURA*, *MAKARADHWAJA*, *SVARNA VANGA* AND RELATED PREPARATIONS): A REVIEW OF PROCESS PARAMETERS AND CHARACTERISATION"

Dr. Abhay Gandhi[1]

AFFILIATIONS:
1. Director, IRA Consultancy and Research Organisation, Bhosari MIDC, Pune, Maharashtra, India

CORRESPONDENCE:
Dr. Abhay Gandhi
EMAILID:
director@icro.co.in

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ABSTRACT

Background: *Kupipakva rasayanas* are prepared by heating a *kajjali*-based charge in a clay-coated glass bottle (*kupi*) embedded in a sand bath (*valuka yantra*) or furnace, so that the product sublimes to the neck or collects at the base. They include some of the most important mercurial and stannic preparations of *Rasa Shastra*. **Objective:** To review the process parameters and analytical characterisation of *kupipakva rasayanas*, and to identify critical control points for standardisation. **Methods:** A critical narrative review of standard manufacturing procedure and pharmaceutico-analytical studies of *Rasasindura*, *Makaradhwaja*, *Svarna vanga*, *Rajata*, *Tamra* and *Malla sindura*, together with studies on their composition and safety. **Results:** Studies converge on a three-stage heating programme: mild (*mridu*, up to about 250 °C), moderate (*madhyama*, about 250–450 °C) and intense (*tivra*, about 450–650 °C or higher), lasting from about 10 to more than 36 hours, with corking of the bottle after sulphur fumes subside. Yields vary widely, from about 39% for *Tamra sindura* to 76–94% for *Makaradhwaja*, depending on the charge and the form of the added metal. *Rasasindura* is red trigonal mercuric sulphide (cinnabar) formed by sublimation of the black cubic sulphide in *kajjali*. In *Makaradhwaja*, gold content ranged from 19 to 268 ppm depending on whether gold foil, leaf or *bhasma* was used. Electric muffle furnaces have replaced sand baths in several studies. **Conclusion:** *Kupipakva* preparation is a reproducible sublimation process when temperature-time programmes are controlled. Defined heating profiles, phase identification and assay of mercury and added metals should form the basis of monographs.

KEYWORDS: *Kupipakva rasayana*; *Rasasindura*; *Makaradhwaja*; *Svarna vanga*; Sublimation; Mercuric sulphide; *Valuka yantra*

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INTRODUCTION

Kupipakva rasayanas are a distinctive group of *Rasa Shastra* preparations made by heating a charge, usually *kajjali* with or without metals, in a long-necked glass bottle coated with layers of clay-smeared cloth (*kupi*). The bottle is embedded in sand in an iron vessel (*valuka yantra*) and heated in stages over many hours. Depending on the preparation, the product either sublimes and collects at the neck (*kanthastha*), or remains at the bottom (*talastha*)[1,2]. The best-known *kanthastha* products are *Rasasindura* and *Makaradhwaja*; *Svarna vanga* is a well-known *talastha* product.

These preparations are potent, used in small doses, and highly regarded clinically. They also contain mercury, and their quality depends on a process that is difficult to observe directly. This review summarises what standard manufacturing procedure (SMP) studies have shown about the process, what analytical studies have shown about the products, and which parameters need to be controlled.

METHODS OF THE REVIEW

This is a critical narrative review. Studies were identified through PubMed, PubMed Central, DOAJ, Crossref-indexed records and journal archives using the terms *kupipakva*, *Rasasindura*, *Rasa sindura*, *Makaradhwaja*, *Svarna vanga*, *Rajata sindura*, *Tamra sindura*, *Malla sindura*, *valuka yantra*, standard manufacturing procedure and characterisation. Pharmaceutical and analytical studies reporting process parameters or product composition were included.

THE PROCESS

1. Preparation of the charge

The charge is usually *kajjali* prepared from purified mercury and sulphur, sometimes with gold, silver, copper, tin or arsenic compounds added. The mercury-to-sulphur ratio varies from equal parts (*samaguna*) to several times the weight of mercury (*dviguna*, *shadguna*), and additional processing such as *balijarana* (incorporation of sulphur into mercury) may precede bottling[3,4]. The amount of free sulphur in the charge affects the heating programme, because excess sulphur must burn off before the bottle can be corked[5].

2. The heating programme

Table 1. Process parameters reported in standard manufacturing procedure studies of *kupipakva rasayanas*

Preparation	Charge	Heating system and programme	Yield and observations
Makaradhwaja	Gold, mercury and sulphur 1:8:24; *kajjali* triturated 24 h; gold as foil, leaf or *bhasma*	Electric muffle furnace; graded heating to about 600 °C over about 12 h	Yield 94.2% (foil), 76.2% (leaf, affected by power interruption), 87.8% (*bhasma*); gold 131, 268 and 19 ppm respectively
Makshika bhasma (*kupipaka* stage)	*Kajjali* of mercury, sulphur and purified *Makshika* (100 g each)	Vertical electric muffle furnace: up to 250 °C (3 h), 250–450 °C (3 h), 450–650 °C (4 h), 650 °C for 30 min after corking	96.5 g partial *bhasma* at base and 112 g *Rasasindura* at neck
Tamra sindura	Copper, mercury and sulphur 1:2:2	Mild 0–8 h (about 100–250 °C), moderate 13 h (about 250–450 °C), intense 12.5 h (about 450–600 °C), then about 5.5 h after corking; maximum about 676 °C	78 g from 200 g *kajjali* (39%); vermilion colour
Samaguna balijarita Rasasindura	*Kajjali* after *balijarana*	Conventional vs modified method compared	Process parameters standardised
Samaguna, *dviguna* and *shadguna*	Different sulphur ratios	Pharmaceutico-analytical comparison	Effect of sulphur ratio on process and product

balijarita Rasasindura			
Rajata sindura	Silver with mercury and sulphur	Process standardised	Product characterised
Malla sindura	Arsenic trioxide with mercury and sulphur	Preparation standardised	Product characterised
Svarna vanga	Tin with mercury, sulphur and other ingredients	Pharmaceutical standardisation	*Talastha* product

Across studies, the heating programme follows a consistent three-stage pattern (Table 1). In the mild stage (*mridu agni*), up to about 250 °C, *kajjali* melts and moisture is driven off. In the moderate stage (*madhyama agni*), about 250–450 °C, sulphur boils and burns at the mouth of the bottle, producing dense fumes; the neck is cleared periodically with a heated iron rod (*shalaka*) to prevent blockage. In the intense stage (*tivra agni*), about 450–650 °C, mercuric sulphide sublimes and condenses in the cooler neck. When fumes cease and a cold rod or a copper coin shows no free mercury or sulphur, the bottle is corked and heated for a further period, then allowed to cool before it is broken to collect the product[7,8].

The total duration varies considerably: about 12 hours for *Makaradhwaja* in a furnace[6], about 10–11 hours for the *kupipaka* stage of *Makshika bhasma*[7], and about 36 hours for *Tamra sindura*[8]. These differences reflect the charge, the size of the bottle and the heating system, and they show why temperature-time profiles, rather than durations alone, need to be reported.

3. From *valuka yantra* to furnace

The classical sand bath is heated by wood or coal, and its temperature is controlled by adjusting the fire. Several SMP studies have replaced it with an electric muffle furnace, sometimes in a vertical configuration that accommodates the bottle[6,7]. Furnace heating allows programmed stages and continuous temperature logging, but it is vulnerable to interruptions in power supply, which affected one batch of *Makaradhwaja*[6]. The general advantages and limitations of furnaces are discussed in the review of *puta* in this series.

4. Critical control points

The SMP studies identify several points at which the process can fail:

- *Inadequate trituration of* kajjali*,* leaving free mercury that volatilises during heating.
- **Blockage of the neck** by condensed sulphur, which can cause pressure build-up and bottle breakage.
- **Premature corking,** which traps sulphur and leads to an impure product.
- **Overheating** in the intense stage, which can crack the bottle or drive off product.
- **Uneven heating,** which affects where the sublimate forms and how much is recovered.

CHARACTERISATION OF PRODUCTS

1. *Rasasindura*

Rasasindura is the red sublimate formed from *kajjali*. The black cubic mercuric sulphide (metacinnabar) in *kajjali* converts on heating to the red trigonal form (cinnabar, α-HgS), which sublimes and recrystallises in the neck[5,12]. Structural studies using X-ray absorption fine structure spectroscopy have been used to investigate the mercury environment in *Rasasindura* and to understand its putative low toxicity[13]. The effect of the sulphur ratio and of *balijarana* on yield and composition has been studied by comparing *samaguna*, *dviguna* and *shadguna* preparations[3,4].

2. *Makaradhwaja*

Makaradhwaja is *Rasasindura* prepared with gold. Its gold content is very low and depends on the form in which gold is added: 268 ppm with gold leaf, 131 ppm with foil and 19 ppm with *Swarna bhasma*, a difference the authors attributed to the finer division of gold leaf[6]. Gold content at the ppm level raises the question of how much of the therapeutic activity can be attributed to gold, and makes routine assay of gold essential for product claims.

3. Other *sinduras* and *Svarna vanga*

Rajata sindura (with silver), *Tamra sindura* (with copper) and *Malla sindura* (with arsenic trioxide) have each been prepared and characterised[8-10]. *Malla sindura* combines mercury and arsenic, two highly toxic elements, and therefore needs particularly close control of composition and dose. *Svarna vanga*, a

talastha preparation, is a tin sulphide-based product that collects at the base of the bottle; its pharmaceutical standardisation has been reported[11].

SAFETY ASPECTS

The mercury in well-made *kupipakva* products is in the form of mercuric sulphide, which is far less soluble and bioavailable than mercuric chloride or methylmercury[14,15]. Mercury bioaccessibility from selected Ayurvedic products has been measured in simulated gastrointestinal fluids[16]. Zebrafish and cell studies of *Rasasindura* have reported differences from other mercury compounds[17-19], but a scoping review identified only five peer-reviewed safety studies of *Rasasindura* and called for longer-term studies in higher mammals[20]. Occupational safety is also a concern: the heating stages release sulphur dioxide and may release mercury vapour if *kajjali* is incomplete, so fume extraction and monitoring are needed in manufacturing units.

PROPOSED SPECIFICATION FOR KUPIPAKVA RASAYANAS

Table 2. Proposed elements of a monograph for *kupipakva rasayanas*

Element	Specification
Charge	Ratio of mercury, sulphur and added metal; *kajjali* end-point including free mercury test
Heating	Programmed three-stage profile with temperature ranges and minimum durations; corking criteria; total heating time
Yield	Expected range for the *kanthastha* or *talastha* product
Identity	X-ray diffraction confirming the expected phase (for example α-HgS for *Rasasindura*)
Assay	Mercury and sulphur content; gold, silver, copper, tin or arsenic content for compound *sinduras*
Impurities	Free mercury; lead, cadmium and arsenic where not intended
Occupational safety	Fume extraction and mercury vapour monitoring during manufacture

RESEARCH GAPS

The main gaps are: temperature profiles measured inside the bottle; comparisons of sand bath and furnace products using instrumental methods; dissolution and bioaccessibility testing of *kupipakva* products; repeated-dose toxicity studies with tissue mercury measurement; and occupational exposure studies in pharmacies that manufacture these products.

CONCLUSION

Kupipakva rasayanas are made by a controlled sublimation process with a consistent three-stage heating pattern, and SMP studies show that the process can be standardised when temperature and corking criteria are defined. The products are mainly mercuric sulphide, with very small and variable amounts of added metals in preparations such as *Makaradhwaja*. Monographs should specify heating programmes, phase identity and assay of mercury and added metals, and safety research should move from short-term animal studies to longer-term and human data.

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