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Review Article

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"CALCIUM-BASED *BHASMAS* (*SHANKHA*, *SHUKTI*, *PRAVALA*, *MUKTA* AND *KUKKUTANDA TWAK*) AS CALCIUM SOURCES: A CRITICAL REVIEW OF COMPOSITION, BIOAVAILABILITY AND CLINICAL USE"

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ABSTRACT

Background: Calcium-rich animal and mineral materials, grouped in *Rasa Shastra* as *Sudha varga*, are incinerated to prepare *bhasmas* such as *Shankha* (conch), *Shukti* (oyster or pearl oyster shell), *Pravala* (coral), *Mukta* (pearl), *Varatika* (cowry) and *Kukkutanda twak* (eggshell). These are increasingly marketed as natural calcium supplements. **Objective:** To review the chemical composition of calcium-based *bhasmas*, the factors that govern their calcium bioavailability, and the evidence for their clinical use, and to compare them with conventional calcium supplements. **Methods:** A critical narrative review of physicochemical characterisation studies, together with established literature on calcium absorption, requirements and supplement safety. **Results:** Calcination converts biogenic aragonite to calcite and removes the organic matrix; with stronger or repeated heating, part of the carbonate is converted to calcium oxide and then calcium hydroxide (portlandite). In *Mukta bhasma*, calcium content rose from 34.1% in raw pearl to 46.3%, above the 40% expected for pure calcium carbonate, consistent with partial decarbonation. Eggshell *bhasma* has been reported as mainly calcium hydroxide. At classical doses of a few hundred milligrams per day, these *bhasmas* supply only a small fraction of the adult calcium requirement. Their absorption is expected to follow that of the corresponding calcium salt, and no comparative human absorption study was identified. **Conclusion:** Calcium *bhasmas* are best understood as calcium carbonate, oxide or hydroxide of biogenic origin. Claims of superior bioavailability are unproven, and their phase composition, calcium content and heavy metal levels should be stated on labels.

KEYWORDS: *Sudha varga*; *Shankha bhasma*; *Mukta bhasma*; *Kukkutanda twak bhasma*; Calcium carbonate; Calcium hydroxide; Calcium supplementation

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INTRODUCTION

Calcium deficiency and osteoporosis are major public health concerns, particularly in post-menopausal women and older adults, and calcium supplements are among the most widely used products in the world. Recommended intakes for adults are about 1000–1200 mg of calcium per day, mostly from diet[1]. In India, Ayurvedic calcium products based on marine and other biogenic materials are widely sold, often with claims of natural origin and superior absorption.

Rasa Shastra groups calcium-rich materials as *Sudha varga*[2] and prescribes them for conditions such as hyperacidity (*amlapitta*), indigestion, cough, bone weakness and bleeding disorders[3]. The materials are purified (*shodhana*), often by boiling in acidic media such as lemon juice or *kanji*, and then incinerated (*marana*) through one or more *puta* cycles, sometimes after trituration with herbal juices such as aloe[4]. Some, such as *Pravala* and *Mukta*, are also prepared as *pishti* by prolonged trituration with rose water without heating.

This review examines what these preparations are chemically, how their calcium is likely to be absorbed, and what evidence supports their use, particularly as calcium supplements.

METHODS OF THE REVIEW

This is a critical narrative review. Characterisation studies of calcium-based *bhasmas* were identified through PubMed, PubMed Central, DOAJ, Crossref-indexed records and journal archives, using the terms *Shankha bhasma*, *Shukti bhasma*, *Mukta bhasma*, *Muktashukti*, *Pravala*, *Kukkutanda twak*, eggshell *bhasma*, *Sudha varga*, calcium and characterisation. Established literature on calcium absorption, requirements and supplement safety was used to interpret the findings.

CHEMISTRY OF CALCIUM BHASMA FORMATION

1. Starting materials

The raw materials of *Sudha varga* are biogenic calcium carbonate. Pearl, mother-of-pearl and many mollusc shells consist largely of aragonite bound in an organic protein–polysaccharide matrix (nacre), whereas eggshell is mainly calcite with an organic membrane. Coral consists of calcium carbonate with small amounts of magnesium and other elements.

2. Changes during calcination

Heating produces three main changes, in sequence:

- **Loss of the organic matrix.** Organic material burns off at a few hundred degrees, which is why the product becomes white and brittle. In *Shankha bhasma*, the nacre matrix was absent from the finished product[4].
- **Aragonite to calcite.** Aragonite converts to the more stable calcite at about 400–500 °C. This conversion was shown by X-ray diffraction in both *Mukta bhasma* and *Shankha bhasma*[4,5].
- **Decarbonation.** At higher temperatures, from about 600–800 °C upwards, calcium carbonate loses carbon dioxide to form calcium oxide (quicklime). On cooling and exposure to air or moisture, calcium oxide takes up water to form calcium hydroxide (portlandite) and slowly recarbonates.

The extent of decarbonation depends on the temperature, duration and number of *puta* cycles, and it largely determines the chemical identity of the final product.

3. Evidence from characterisation studies

Table 1. Composition of calcium-based *bhasmas* reported in characterisation studies

Bhasma	**Main phases**	**Calcium content and other findings**
Mukta (pearl), three batches	Calcite with minor portlandite (raw pearl: aragonite)	Calcium 34.11% in raw pearl and 46.32% (mean) in *bhasma*; mean weight loss 47.04% on calcination; SEM particle size 79.9–279.2 nm
Shankha (conch)	Calcite (raw conch: aragonite)	Nacre organic matrix absent; heavy metals measured by ICP-OES
Kukkutanda twak (eggshell)	Calcium hydroxide (portlandite) reported in *bhasma*; raw shell calcite	Crystallite size about 13 nm in *bhasma* versus 24 nm in powder; organic bands lost on FTIR
Kukkutanda twak, two methods	Analytical profile compared between two methods of preparation	Composition depends on method

Eggshell powder vs eggshell *bhasma*	Comparative study of micro-fined powder and the Ayurvedic formulation	Calcium-based composition compared
Muktashukti (pearl oyster shell)	Characterisation of an indigenous traditional medicine	–
Several *Sudha varga* compounds	Calcium ion content compared	Calcium ion content differed between compounds

The calcium content of *Mukta bhasma* is particularly revealing. Pure calcium carbonate contains 40.0% calcium by weight, calcium hydroxide 54.1% and calcium oxide 71.5%. A mean calcium content of 46.3% in *Mukta bhasma*[5] is therefore higher than calcium carbonate could provide, and is consistent with partial conversion to calcium oxide or hydroxide, in agreement with the portlandite detected by XRD. In eggshell *bhasma* prepared by five muffle-furnace *puta*, calcium hydroxide was reported as the main phase[6]. Different calcium *bhasmas*, and even different batches of the same *bhasma*, can therefore range from almost pure calcite to largely calcium hydroxide.

This distinction matters clinically. Calcium carbonate is a mild antacid that needs gastric acid to dissolve. Calcium oxide and hydroxide are strong bases that dissolve more readily and neutralise more acid, but in concentrated form they are caustic. The classical tests applied to these *bhasmas*, such as absence of irritation on the tongue, may in part be tests for incomplete conversion to quicklime.

BIOAVAILABILITY OF CALCIUM FROM BHASMAS

1. What determines calcium absorption

Calcium is absorbed in the small intestine by an active, vitamin D-dependent transcellular route and a passive paracellular route. Fractional absorption is typically around 25–35% of the dose and falls as the dose increases. Calcium carbonate needs gastric acid to dissolve; its absorption is impaired in achlorhydria when taken fasting, but is adequate when taken with food[11]. Under controlled conditions, absorption from calcium carbonate and calcium citrate is broadly comparable[12]. These principles apply equally to calcium of biogenic origin: once dissolved, calcium ions are absorbed in the same way whatever their source.

2. Claims of superior bioavailability

Calcium *bhasmas* are often promoted as more bioavailable than conventional supplements because of their fine particle size or natural origin. Crystallite and SEM particle sizes in the nanometre range have been reported[5,6], and the general claims for *bhasmas* as nanomedicines are discussed elsewhere in this series[13]. For calcium salts, however, particle size has little influence once the material is dissolved in gastric acid, and a calcium hydroxide-rich *bhasma* is expected to dissolve readily in any case. No study was identified that compared calcium absorption from a *bhasma* with calcium carbonate or citrate in humans using accepted methods, such as isotopic tracers or serial serum and urinary calcium measurements. The claim of superior bioavailability is therefore unproven.

3. How much calcium does a *bhasma* supply?

Classical doses of *Shankha*, *Shukti*, *Mukta* or *Pravala bhasma* are typically in the range of 125–500 mg per day. Even at the upper end, and assuming a calcium content of 40–50%, a daily dose provides about 50–250 mg of elemental calcium. This is a modest fraction of the adult requirement of about 1000–1200 mg per day[1]. Calcium *bhasmas* at classical doses are therefore better understood as small calcium supplements or as antacids than as replacements for standard calcium supplementation in osteoporosis. Products that claim to meet calcium requirements need to state the elemental calcium per dose.

CLINICAL USE AND EVIDENCE

1. Classical indications

The main classical indications for *Shankha* and *Shukti bhasma* are disorders of acid and digestion, consistent with their antacid chemistry, while *Mukta* and *Pravala* are used for heat-related (*pitta*) conditions, bleeding, palpitations and as *rasayana*. *Kukkutanda twak bhasma* is used for leucorrhoea, bleeding and as a calcium source[3].

2. Clinical evidence

Controlled clinical evidence for calcium *bhasmas* is scarce. Studies on hyperacidity and bone health are mostly small and uncontrolled, and none identified in this review measured bone mineral density, fracture risk or calcium balance against a standard calcium supplement. Preclinical studies of antacid and anti-

ulcer activity are consistent with the chemistry of calcium carbonate and hydroxide but do not show an advantage over conventional antacids.

SAFETY CONSIDERATIONS

1. Heavy metals and contaminants

Marine and other biogenic calcium sources can concentrate lead and other metals from the environment. Lead has been measured in commercial calcium supplements of natural origin[14], and Ayurvedic products sold online have been found to contain lead, mercury or arsenic[15]. Heavy metal testing of the raw materials and the finished *bhasma* is therefore essential, and was included in some characterisation studies[4].

2. Calcium load

At classical doses, calcium *bhasmas* add little to total calcium intake. When used as high-dose supplements, however, the same considerations apply as for any calcium supplement, including the debated association between calcium supplements and cardiovascular events[16], the risk of kidney stones and the milk-alkali syndrome with very high intakes of calcium together with absorbable alkali. Calcium hydroxide-rich products are more alkaline than calcium carbonate and could contribute to this risk at high doses.

3. Mucosal irritation

Because calcium oxide is caustic, incompletely hydrated or poorly processed *bhasmas* could irritate the oral and gastric mucosa. Quality standards should therefore set limits for free calcium oxide.

PROPOSED QUALITY SPECIFICATION

Table 2. Proposed quality specification for calcium-based *bhasmas*

Parameter	Method	Purpose
Phase composition	X-ray diffraction with quantitative phase analysis	Distinguish calcite, aragonite, calcium oxide and calcium hydroxide
Calcium content	Titrimetry or ICP-OES	State elemental calcium per dose
Loss on ignition	Thermogravimetric analysis	Estimate residual carbonate and degree of decarbonation
Free calcium oxide and pH of suspension	Standard chemical tests	Control causticity
Heavy metals	ICP-MS or AAS for Pb, Cd, As, Hg	Safety of biogenic raw materials
Particle size	Laser diffraction or image analysis	Consistency between batches

RESEARCH GAPS

The main gaps are: human calcium absorption studies comparing calcium *bhasmas* with calcium carbonate and citrate at equal elemental doses; clinical trials with bone and gastrointestinal end-points; systematic surveys of heavy metal content in marketed calcium *bhasmas*; and studies of how preparation methods and number of *puta* determine phase composition, so that classical end-points can be linked to measurable chemical specifications.

CONCLUSION

Calcium-based *bhasmas* are biogenic calcium carbonate that, depending on how strongly they are heated, contains variable amounts of calcium oxide and hydroxide. Their calcium content, alkalinity and likely behaviour in the gut follow from this composition. At classical doses they supply only a small part of the daily calcium requirement, and there is no human evidence that their calcium is better absorbed than that of conventional salts. They may have a place as antacids and as components of classical formulations, but claims of superior calcium bioavailability should not be made until comparative human studies are available. Labels should state phase composition, elemental calcium per dose and heavy metal results.

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