SJIF Impact Factor (2025): 8.688| ISI I.F. Value: 1.241| Journal DOI: 10.36713/epra2016 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Volume: 10 | Issue: 12 | December 2025 - Peer Reviewed Journal

METHODS OF EXTRACTION OF SHANKHPUSHPI (*Convolvulus pluricaulis / Clitoria ternatea*): A REVIEW

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Article DOI: https://doi.org/10.36713/epra25265
DOI No: 10.36713/epra25265

ABSTRACT

Shankhpushpi, a traditional Ayurvedic nootropic, usually refers to Convolvulus pluricaulis (sometimes called Convolvulus prostratus), though some traditions use Clitoria ternatea instead. Researchers have not done in on how extraction methods shape the bioactivity of Shankhpushpi getting the right technique means you actually preserve and concentrate compounds like scopoletin, flavonoids, alkaloids, coumarins, and anthocyanins. In this review, classic and newer extraction techniques for Shankhpushpi, weighing what each one does well and where it falls short. I've gathered details on which solvents researchers use and the conditions they rely on, then pointed out what still needs work and where future studies should head. The review draws from major studies both original research and reviews on both Convolvulus and Clitoria species.

KEY WORDS: *Shankhpushpi, Methods of Extraction, Convolvulus pluricaulis, Modern and green extraction techniques, Conventional extraction method.*

1.INTRODUCTION

1.1) Botanical identity and target phytochemicals

Shankhpushpi, they usually mean one of two plants: *Convolvulus pluricaulis* (CP) or *Clitoria ternatea* (CT). CP packs in coumarins like scopoletin, along with flavonoids, glycosides, and alkaloids. CT stands out for its anthocyanins think that deep butterfly pea blue plus flavonoids and its own unique set of polyphenols. Since their key compounds aren't the same, you need to adjust your extraction approach. If you're after scopoletin, you'll pick a different solvent and method than you'd use for anthocyanins[1].

1.2) Taxonomical Classification

Kingdom: Plantae, Subkingdom: Tracheobionta, Division: Magnoliophyte, Class: Magnoliopsida, order: Solanales, Family: Convolvulaceae, Genus: Convolvulus, Species: Pluricaulis. Reported by Neeraj K (2010) [2].

1.3) Comparative proximate analytical parameters

Determination	CP (*Convolvulus pluricaulis*)	CT (*Clitoria ternatea*)
Moisture content	7.38 ± 0.034	3.404 ± 0.089
Total ash	18.77 ± 0.26	8.732 ± 0.058
Acid insoluble ash	4.28 ± 0.089	3.842 ± 0.065
Sulfated ash	6.24 ± 0.071	4.83 ± 0.050
Water soluble ash	8.52 ± 0.05	3.493 ± 0.177
Water insoluble ash	11.40 ± 0.64	4.866 ± 0.039

Table 1: Comparative proximate analytical parameters[3].

1.4) Phytochemical constituents relevant to extraction

Clitoria ternatea flowers pack a punch when it comes to anthocyanins especially ternatins along with flavanol glycosides like kaempferol and quercetin derivatives, plus a mix of phenolic acids and other minor compounds. Interestingly, one review found

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that using ultrasound for extraction boosts the yield anywhere from 16% up to a whopping 247% compared to traditional maceration[4]. *Convolvulus pluricaulis* brings its own mix: alkaloids, coumarins such as scopoletin, various phenolics, and glycosides. To give a concrete example, researchers measured scopoletin at 0.1738% in a 50% ethanol extract[5].

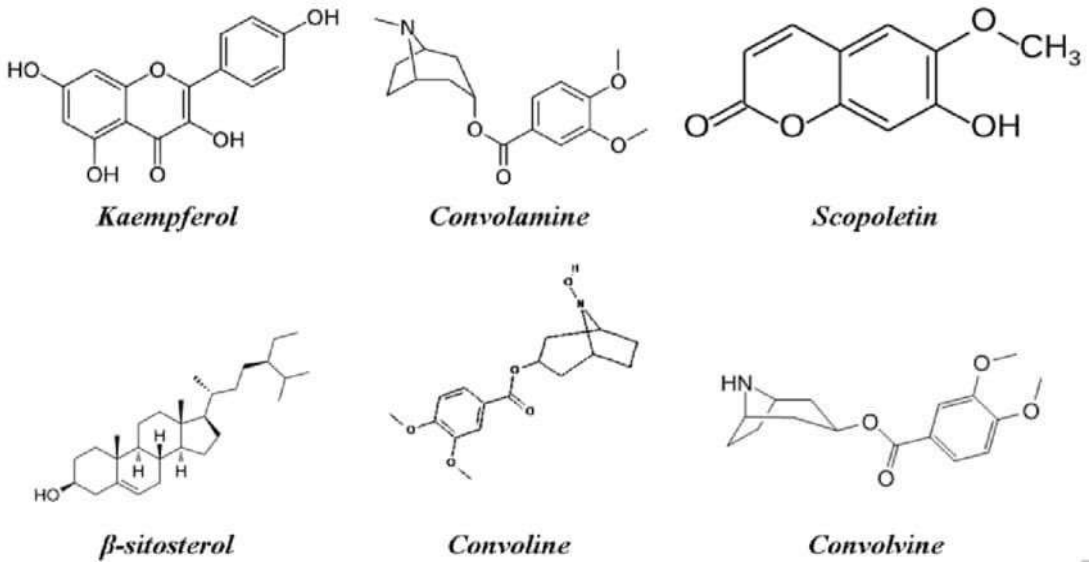

Figure 1: Chemical structures of constituents of Shankhpushpi[6].

Extraction methods are generally classified into two principal groups: conventional and modern techniques. Conventional extraction methods such as maceration, percolation, infusion, decoction, hot continuous extraction, and Soxhlet extraction have a longstanding history and have been widely used for decades, if not centuries. These approaches are valued for their simplicity and dependability and are often favored in settings where access to advanced technology is limited. However, they typically require prolonged extraction times and larger volumes of solvents to efficiently isolate the desired bioactive compounds from plant or other natural sources. Additionally, conventional methods may involve higher risks of thermal degradation of sensitive compounds due to extended exposure to heat[7].

In contrast, modern extraction methods have been developed to address the limitations associated with traditional techniques. Innovations such as ultrasound-assisted solvent extraction (USE),microwave-assisted solvent extraction (MAE), Accelerated Solvent Extraction (ASE), and Supercritical Fluid Extraction (SFE) utilize advanced technologies to enhance the efficiency and selectivity of the extraction process. These modern methods operate at faster rates and generally require less solvent, making them more environmentally friendly and cost-effective. For example, ultrasound waves can disrupt plant cell walls, allowing solvents to penetrate more effectively, while microwave energy rapidly heats the solvent and material, speeding up the release of target compounds. Supercritical fluid extraction, often using carbon dioxide, offers the benefit of extracting compounds at lower temperatures, thus preserving heat-sensitive constituents[7].

1.5) Plant Material

Researchers collected C. pluricaulis and C. ternatea from Vadodara, Gujarat, India, and confirmed their identity at the Department of Botany, M.S. University of Baroda. They deposited voucher specimens for all four plants (Pharmacy/EA/09-10/10/NS, Pharmacy/CP/09-10/11/NS, Pharmacy/CT/09-10/12/NS, and Pharmacy/CD/09-10/13/NS) in the Herbal Drug Technology Department at the same university[8].

2) CONVENTIONAL EXTRACTION METHODS

2.1) Maceration, percolation, and decoction:

All work by soaking powdered plant material in a solvent water, ethanol, or methanol for an extended period, sometimes at room temperature, sometimes with heat. These methods don't need fancy equipment, and they're pretty straightforward. But they take a long time, use a lot of solvent, and sometimes the extract isn't as strong as you'd hope. There's also the risk that some compounds break down during the process[7].

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2.2) Soxhlet extraction

For the Soxhlet extraction, I placed the measured amount of powdered drug and methanol into the flask as described earlier. I plugged the thimble with cotton to stop any sample particles from getting into the distillation flask. The extraction ran in cycles, over and over, until the drug was fully extracted basically, when the solvent leaving the extraction chamber turned completely colorless and left no residue. After that, I filtered the methanolic extract and concentrated it usinga rotary evaporator to get the final methanolic extract. Then I calculated the percentage yield of the extract[7].

3) MODERN AND GREEN EXTRACTION TECHNIQUES

3.1) Ultrasound-Assisted Extraction (UAE)

Principle: Ultrasonic waves disrupt plant cell walls, enhancing solvent penetration and release of intracellular compounds.
Advantages: Reduced extraction time, higher yield, and energy efficiency.

Parameters: Frequency (20–40 kHz), temperature (30–60°C), and solvent choice significantly affect yield.
Reported Use: UAE has been applied to extract phenolic and flavonoid constituents from
Clitoria ternatea flowers[9].

Ultrasound-assisted extraction (UAE) uses acoustic cavitation to break open cell walls and push solvents in faster. This cuts extraction time and often boosts both yield and phenolic content compared to older methods. Researchers have used UAE on all kinds of medicinal plants and flowers, including Clitoria. Head-to-head studies keep showing that UAE matches or even beats Soxhlet and maceration for yield, but with less solvent and shorter extraction times. For delicate compounds like anthocyanins and certain flavonoids, UAE's lower operating temperatures make a real difference, protecting these heat-sensitive constituents during extraction[10].

3.2) Microwave-assisted extraction (MAE)

Principle: Microwaves heat solvents and plant tissues internally, promoting rapid mass transfer. Advantages: Short extraction time, minimal solvent use, high extraction efficiency.
Applications: MAE of C. ternatea yielded enhanced concentrations of anthocyanins andflavonoids[11].

Microwave-assisted extraction (MAE) relies on microwave heating to quickly warm up polar solvents and plant material. This rapid heating bursts plant cells open and speed up mass transfer, so what once took hours now wraps up in minutes. Researchers have seen strong yields, especiallywhen extracting phenolics and alkaloids. Still, you need to fine-tune things like power, time, and solvent polarity too much heat or the wrong conditions can break down valuable compounds. MAE shows real promise for producing botanical extracts, and people are looking at scaling it up, though they urge a careful approach[12].

3.3) Pressurized liquid extraction / Accelerated solvent extraction (PLE / ASE): Principle: High pressure and temperature improve solvent efficiency and reduce time. Advantages: Automation possible; high reproducibility; minimal solvent usage. Applications: Effective for polyphenol-rich extracts from *Clitoria ternatea*[13].

Pressurized liquid extraction (PLE), also known as accelerated solvent extraction (ASE), uses high temperature and pressure to keep solvents in a liquid state, even when they're above their usual boiling point. This boosts both solubility and diffusion, so compounds get pulled out faster. PLE handles a wide range of polarities quickly, making it a solid choice when you need standardized, repeatable extraction of marker compounds. There isn't much published on PLE for CP specifically, but researchers often turn to it for phytochemical profiling[14].

3.4) Supercritical fluid extraction (SFE)

Principle: Utilizes supercritical CO_2 as solvent; sometimes modified with ethanol or methanol as co-solvent.
Advantages: Eco-friendly, solvent-free, high selectivity, suitable for heat-labile compounds.

Applications: Potential for isolating non-polar compounds like fatty acids and sterols from C. pluricaulis[15].
Supercritical fluid extraction, usually using CO_2, works especially well for non-polar and moderately polar compounds. Add a modifier like ethanol, and you can pull out even more polar substances. One big perk: the extracts come out solvent-free, so you don't have to worry about leftover chemicals. This method really shines when you need to extract lipophilic compounds without breaking them down with heat. While researchers haven't used SFE much alongside CP yet, it's catching attention as a promising area for future studies[14].

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3.5) Enzyme-assisted and hybrid methods

Enzyme-assisted extraction, which uses cell wall–degrading enzymes, and hybrid methods like combining UAE with MAE or using enzymes before UAE, show real promise. Studies in phytochemistry back this up they boost both yield and selectivity. For Shankhpushpi species, it makes sense to try these combinations next. Still, success depends on how well researchers optimize the process and document their methods so others can repeat them[16].

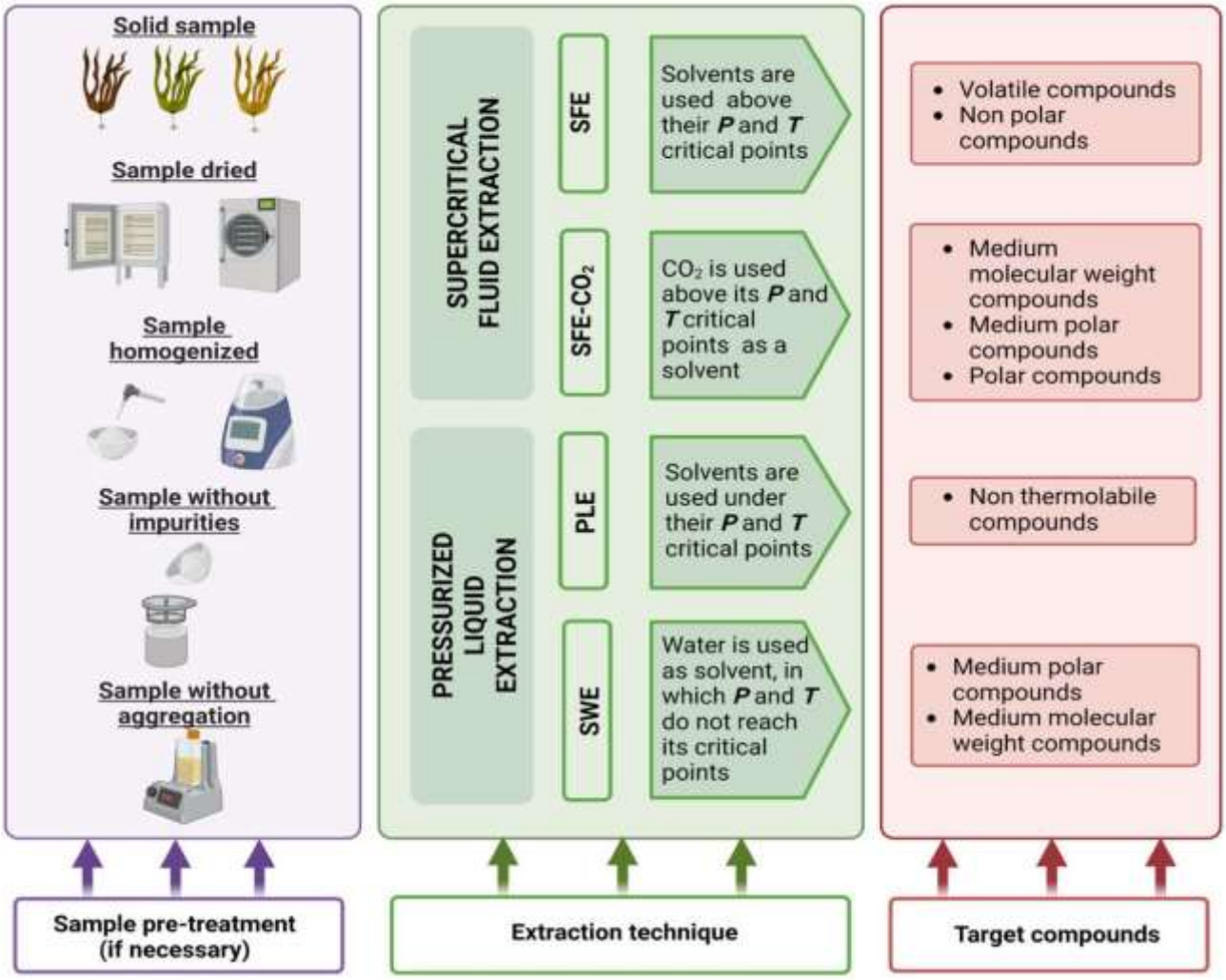

Figure 2: Extraction Techniques and Target Compounds[14].

4) SOLVENT SELECTION AND POLARITY CONSIDERATIONS

To extract polar compounds like scopoletin, flavonoid glycosides, and phenolics, researchers usually reach for aqueous ethanol anywhere from 30% to 80% methanol, or just water. Most studies on CP stick with ethanol or methanol as their go-to solvents. When it comes to anthocyanins in CT flowers, acidified aqueous ethanol or water works best. Keeping the pH in check and the temperature low helps protect both their color and stability. Non- thermal techniques like ultrasound-assisted or microwave-assisted extraction also cut down on degradation.

For nonpolar compounds think fatty acids and sterols hexane or supercritical CO_2 lead the pack. These solvents handle the job with efficiency and keep the extraction process clean.

Here's something to keep in mind: solvent-to-solid ratio, particle size, temperature, and time all work together they don't act alone. Studies show that using smaller particles, picking a solvent with the right polarity (especially for polar targets), and adjusting

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the solvent-to-solid ratio usually somewhere between 10:1 and 30:1 mL/g in lab settings can boost your yield. Still, you have to dial in the exact numbers for your own lab and your specific compound. There's no one-size-fits-all, but these guidelines give you a solid starting point[17].

5) COMPARATIVE PERFORMANCE

There aren't many direct, side-by-side studies on Convolvulus extraction, but when you look at broader research on similar medicinal plants, some trends stand out.

UAE and MAE slash extraction time compared to old-school methods like maceration or Soxhlet. They don't just save time they usually pull out more phenolics and flavonoids too[4].

Soxhlet's a classic for a reason: it gives consistent, high yields. But it's slow, uses more solvent, and the heat can break down sensitive compounds. That's a real drawback[16].

When you're after heat-sensitive anthocyanins, like those in CT, gentle methods work best. UAE at a controlled temperature or cold maceration with some acid in the solvent does a much better job at keeping both bioactivity and color intact, especially compared to a long Soxhlet run[18].

A lot of Convolvulus pharmacological research think neuropharmacology and antioxidant studies still depends on ethanolic extracts from maceration or Soxhlet. These extracts are definitely bioactive, but they can miss out on some of the more fragile, minor compounds[19].

6) ANALYTICAL CONSIDERATIONS AND STANDARDIZATION

Scopoletin serves as the main chemical marker for CP, while anthocyanins especially delphinidin derivatives mark CT. Labs usually rely on HPTLC, HPLC, or LC–MS/MS to measure these compounds and standardize extracts. Researchers often compare CP and CT using HPTLC or HPLC to highlight differences in their phytochemical profiles[20].

Quality control starts with confirming the plant's identity through morphology and microscopy. Labs also check moisture, ash content, and any residual solvents. After optimizing extraction, they use validated analytical methods to keep results consistent from one batch to the next.

7) QUALITY, STANDARDIZATION, AND ADULTERATION RISKS

This lack of taxonomic clarity can significantly impact both safety and pharmacological outcomes. It's best to choose products that provide clear botanical identification and, ideally, a voucher specimen for authentication[21].

As far as contaminants go, there's a real risk of heavy metals, pesticide residues, microbial contamination, or adulterants in products that aren't manufactured under GMP conditions. Brands that supply a certificate of analysis (COA) verifying identity, purity, and levels of heavy metals, aflatoxins, and microbes are much preferable[22].

Finally, regarding standardization: when available, select extracts that are standardized to scientifically relevant markers such as total flavonoids or specific alkaloids, with documentation ensuring consistency across batches. This level of quality control is essential for both safety and efficacy[20].

8) Pharmacological Actions of Scopoletin: A marker compound

scopoletin is a multifunctional phytochemical with diverse biological activities, including neuroprotective, antioxidant, anti-inflammatory, antimicrobial, and metabolic benefits. Its wide- ranging pharmacological actions justify its role as a key marker compound for standardization of Shankhpushpi (*Convolvulus pluricaulis*) extracts. Continued research is needed to further elucidate its mechanisms, optimize extraction methods for higher yields, and evaluate its therapeutic applications in clinical settings [21].

8.1) Nootropic and Neuroprotective Activity

Scopoletin plays a prominent role in the neuropharmacological profile of *Convolvulus pluricaulis*. Research indicates that extracts rich in scopoletin enhance learning behavior, reduce oxidative stress in neural tissues, and protect against chemically induced amnesia. These effects may be attributed to modulation of acetylcholine levels, antioxidant protection of neuronal cells, and suppression

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of neuroinflammation. Siddiqui et al. (2011) reported that *C. pluricaulis* extract containing scopoletin improved memory retention and produced anxiolytic effects in mice models [23].

8.2) Antioxidant Activity

One of the most significant pharmacological actions of scopoletin is its potent antioxidant activity. It scavenges reactive oxygen species (ROS), reduces lipid peroxidation, and enhances endogenous antioxidant enzymes such as SOD, CAT, and GPx. This antioxidant capacity supports its neuroprotective, hepatoprotective, and anti-inflammatory effects. Jeyaraj et al. (2021) highlighted that phenolic compounds, including coumarins like scopoletin, contribute strongly to antioxidant activity in medicinal plants [24].

8.3) Antidepressant Effects

Studies on *Convolvulus pluricaulis* indicate that scopoletin-rich extracts possess significant anxiolytic and antidepressant activity. These effects are linked to modulation of GABA and monoaminergic neurotransmission. Siddiqui et al. demonstrated that administration of *C. pluricaulis* extract led to reduced anxiety-like behavior in animal models. The neurochemical stabilization provided by scopoletin may contribute to enhanced mood and cognitive function [23].

9) FUTURE DIRECTIONS

9.1) Development of Hybrid Extraction Approaches

Combining techniques (e.g., enzyme pretreatment + UAE, UAE + MAE) could maximize release of bound phenolics and glycosides. Experimental validation is needed to confirm synergy.

9.2) Direct Comparative Studies of CP and CT

Most studies evaluate extraction of either *Convolvulus pluricaulis* or *Clitoria ternatea* independently. Future work should compare these species under identical extraction conditions using optimized parameters to identify which method offers maximum recovery for each plant type.

9.3) Optimization of Modern Green Extraction Techniques

Methods such as UAE, MAE, PLE/ASE, SFE, and SWE show significant promise but require:

- Optimization of temperature, time, solvent ratio, frequency/power
- Scaling-up feasibility studies
- Cost analysis for industrial production

9.4) Use of Computational Tools to Predict Optimal Extraction Techniques such as:

- Response Surface Methodology (RSM)
- Artificial Intelligence (AI)-assisted optimization
- Predictive modeling of solvent compound affinity can help design efficient extraction processes

10) CONCLUSION

Shankhpushpi, represented mainly by *Convolvulus pluricaulis* and *Clitoria ternatea*, contains various classes of bioactive phytochemicals, including scopoletin, flavonoids, phenolics, glycosides, and anthocyanins. The choice of extraction method is crucial for the quality, quantity, and stability of these compounds. Traditional methods such as maceration, percolation, decoction, and Soxhlet extraction are still popular due to their simplicity and reproducibility. However, these approaches have drawbacks, including long extraction times, high solvent usage, and the risk of heat damaging sensitive components.

Modern and environmentally friendly extraction techniques, such as ultrasound-assisted extraction (UAE), microwave-assisted extraction (MAE), pressurized liquid extraction (PLE/ASE), supercritical fluid extraction (SFE), and enzyme-assisted methods, provide improvements in extraction efficiency, selectivity, and environmental impact. These methods shorten processing times, safeguard delicate phytochemicals, and often yield higher amounts of important compounds.

Key factors influencing extraction effectiveness include solvent polarity, extraction temperature, particle size, and solvent-to-material ratio. Analytical tools like HPTLC, HPLC, and LC-MS/MS support standardization and quality control by allowing precise quantification of marker compounds like scopoletin and anthocyanins. Despite advancements, challenges persist, such as taxonomic confusion among plant sources, varying extraction protocols, risks of contamination, and insufficient industry-level standardization.

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This review underscores the need for improved, repeatable, and scalable extraction methods to ensure the therapeutic reliability of Shankhpushpi-based formulations. Merging modern extraction technologies with strong analytical validation and strict quality control will greatly improve the safety, effectiveness, and global acceptance of Shankhpushpi in both traditional and modern medicine.

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