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Review on *Ghana* and extraction: Unveiling the pharmaceutical process in *Bhaishajya Kalpana*

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Abstract

In Ayurveda, *Bhaishajya* means "medicine". It refers to substances or preparations used for healing, treating diseases, and maintaining health. *Kalpana* means "preparation" or "formulation" refers to the method and process of creating medicinal formulations. This article aims to explore *Ghana Kalpana* and plant extraction processes. *Ghana Kalpana*, a derivative of *Kwath Kalpana*, involves extracting maximum water-soluble and some water-insoluble components via the *Kwatha* method, followed by reheating until solidified. Modern extraction techniques also bear similarities to *Ghana Kalpana*. This study aims to review all the literature available in classical text related to *Ghana* along with the various technologies of extraction.

Keywords: *Ghana*; Extraction; *Kwatha; Vati*

1. Introduction

Ayurvedic extraction techniques, meticulously documented by ancient Scholars like Acharya Charaka, emphasize the importance of preserving the holistic and synergistic properties of natural substances. These methods, known collectively as *Panchavidha Kashaya Kalpana*, include processes such as *Swarasa* (expressed juice), *Kalka* (paste), *Kwatha* (decoction), *Hima* (cold infusion), and *Phanta* (hot infusion).[1] Each technique is tailored to enhance the bioavailability and efficacy of the medicinal compounds, taking into account factors like the strength of the patient and the nature of the disease. While these five types of extractives form the cornerstone of Ayurvedic formulations, noted for their medicinal potency and ease of digestion in ascending order based on the severity of the condition (*Vyadhi*) and the patient's strength (*Atura*),[2] they also present certain challenges. These challenges include the inconsistent availability of raw materials, short shelf life, palatability issues, and dosage concerns. To overcome these limitations, secondary formulations such as *Ghana, Arka, Sneha Paniya, Pramathya, Laksharasa, Kshirapaka, Avaleha, Asava-Arishta Kalpana* have been developed using these basic preparations. The purpose of creating these secondary formulations is to maximize the extraction of active constituents, thereby enhancing their therapeutic efficacy.

Ghana is categorized under *Rasa Kriya*, and is also considered as *Phanita* & *Avleha* because of their method of preparation is same. *Ghana* is prepared by reducing the liquid portion of *Kwath, Swarasa* etc till it attains semisolid state. These preparations are usually used for internal administration. The history of preparation of *Ghana* is seen from Charaka Samhita, may be with single drug or multiple drugs. The main concept behind the *Ghana* preparation is re-boiling the prepared *Kwath*, *Swarasa* etc till its semisolid consistency. In some preparations *Praksepaka Dravyas* are added to this semisolid consistency before drying. Different varieties of *Ghana* are mentioned in various ayurvedic classics and they are one of the most accepted varieties of ayurvedic dosage forms due to its easy administration, palatability and long shelf life

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In contemporary pharmaceutics, extraction techniques span from basic traditional methods to sophisticated technologies like maceration, infusion, percolation, digestion, decoction, and Soxhlet extraction. Standardized extraction procedures for crude drugs, including medicinal plant parts, aim to extract therapeutic components while eliminating undesirable materials with selective solvents known as menstruums.[3] The consistent objective in pharmaceutical extraction is to isolate therapeutic portions and remove impurities. Due to commercialization, concentrated herbal forms have become popular, leading to the widespread acceptance of herbal extracts in the pharmaceutical industry.

2. Material and methods

The primary formulations are primarily made using water as a solvent, along with mild heat and either coarse powders or fine pastes. Secondary formulations, on the other hand, use different solvents such as milk, oil (*Taila*), or clarified butter (*Ghrita*), and require mild to moderate heat.

Table 1 Different extraction techniques described in Ayurvedic classics

S.No.	***Kalpana***	**Ingredients**	**Ratio**
1.	*Kwath*[4]	Coarse powder of raw drug: Water	1:16
2.	*Hima*[5]	Raw drug : Cold water	1:6
3.	*Phanta*[6]	Raw drug: Boiling water	1:4
4.	*Pramathaya*[7]	Fine paste of raw drug: Water	1:8
5.	*Kshirapaka*[8]	Raw drug: Milk: Water	1:8:32
6.	*Aushadhasiddha Paniya*[9]	Raw drug: Water	1:64
7.	*Laksharasa*[10]	Dried granules of *Laksha*: Water	1:8
8.	*Mantha*[11]	Raw drug: Water	1:4
9.	*Arka*[12]	Raw drug: Water	1:10
10.	*Rasakriya and Ghana*[13]	Coarse powder of raw drug: Water	1:16
11.	*Sneha*[14]	*Kalka: Sneha:* Water	1:4:16

3. Literature review of Ghana or Rasakriya

3.1.1. Charaka Samhita

Rasakriya is the solidified form of *Swarasa, Kwatha*, and so forth. Charaka mentions several *Rasakriya/Ghana* preparations, including *Darvyadi Rasakriya*[15]*, Khadiradi Vati*[15], *Pippalyadi Rasakriya*[16], *Krishnasarparasadi Rasakriya*[16], *Dhatryadi Rasakriya*[16], *and Kritavedhana Kalp*[17].

3.1.2. Sushruta Samhita

According to Acharya Sushruta, *Phanita* is made by reducing *Kwatha* to a semisolid state. *Kwatha* is made by adding 8 or 16 parts water, which is then reduced to 1/8th or 1/16th part to create *Phanita*[18]. A few *Phanita Kalpanas* listed in Sushruta Samhita are *Khadiradi Leha*[19], *Kashaya*[20], and *Salsaradivarga.*

3.1.3. Astanga Sangraha/ Hridaya

We discover the references to three sorts of *Rasakriya* in the context of *Anjana Kalpana*[21], which are *Pinda*, *Rasakriya*, and *Churna*.

Acharya Sharangdhara has mentioned *Rasakriya* and *Ghana* in *Madhyama Khanda's Avaleha Kalpanadhyaya* . It defines *Rasakriya* as the product obtained by repeatedly boiling the *Kwatha* till it reaches a semisolid consistency. A few of the preparations listed include *Darvyadi Rasakriya*[22] and *Babool Rasakriya*[23].

Acharya Bhavaprakash, Chakradatta, and Ayurveda Prakashakara defined *Ghana Kalpana* in terms of *Darvyadi Rasakriya* or *Rasanjana*. Acharya Yadavji Trikamji discussed *Ghanavatis* made from a single herb in his work Siddha Yoga Sangraha in the context of *Guduchi Ghana*[24].

3.2. Methods of preparation of *Ghana* includes

3.2.1. Procedure

- *Kwath Churna* (coarse powder) is made with a mortar and pestle.
- The drug was mixed with 16 parts water, heated, and reduced to 1/8th part.
- The water-to-drug ratio varies based on amount and quality.
- *Kwath* is filtered after it has undergone reduction
- After filtering, the *Kwatha* is reboiled till semisolid and then rolled into *Vati*.
- It is then kept in airtight glass jars.

3.2.2. General precautions

- Kashaya drugs should be coarsely ground and the water should be drinkable.
- Ensure reduced pharmaceutical substance is not burned off.
- Continuous stirring is essential at the end of the preparation procedure.
- To roll the pills, apply ghee to your fingertips as the finished product is sticky.

Dosage: The dose of *Ghana* is not indicated in our classics. In the context of *Samshamani Vati*, the dose is 250-500 mg (5 to 10 pills per day) .

Shelf life: One year.

In Pharmaceutical Science there is method for separating active plant material known as extraction.

Extraction: It is a process in which the animal or plant tissues are treated with specific solvents whereby the medicinally active constituents are dissolved out , cell tissues and most of inert components remain undissolved.[25]

The major processes in producing high-quality bioactive compounds include the selection of an appropriate solvent, extraction techniques, phytochemical screening procedures, fractionation methods, and identification techniques.

In general, extraction techniques include maceration, digestion, decoction, infusion, percolation, Soxhlet extraction, superficial extraction, ultrasound-assisted, and microwave-assisted extractions.

Maceration, infusion, percolation, digestion, decoction, hot continuous extraction (Soxhlet), aqueous-alcoholic extraction by fermentation, counter current extraction, microwave-assisted extraction, ultrasound extraction (sonication), supercritical fluid extraction, and distillation techniques. For aromatic plants, hydro water and steam distillation, hydrolytic maceration followed by distillation, expression, and effleurage (cold fat extraction) are possible. Some of the most recent extraction technologies for aromatic plants include headspace trapping, solid phase micro extraction, protoplast extraction, and micro distillation.

The basic parameters influencing the quality of an extract are:

3.2.3. Plant part used as starting material

- **Type of Plant Part:** Different parts of a plant (roots, leaves, stems, flowers, seeds, bark) contain different types and concentrations of bioactive compounds. This variation necessitates different extraction methods to optimize yield and purity.
- **Leaves and Flowers:** Typically contain volatile oils, flavonoids, and other phenolic compounds. Methods like steam distillation, solvent extraction, and Soxhlet extraction are commonly used.
- **Roots and Bark:** Often have higher concentrations of alkaloids, glycosides, and tannins. Techniques like maceration, percolation, and solvent extraction with strong solvents (like alcohol or acetone) are frequently employed.
- **Seeds and Fruits:** Rich in oils, fatty acids, and sometimes alkaloids. Cold pressing, solvent extraction, and supercritical fluid extraction are effective**.**

- **Water Content:** The moisture content in different plant parts can impact the choice of extraction method. Fresh plant material might need drying before certain types of extraction to avoid dilution of solvents and to facilitate better penetration**.** Dried plant materials might be more suitable for direct extraction with solvents as they are more concentrated and stable.
- **Specific Compound Stability:** Some bioactive compounds are sensitive to heat, light, or oxygen, which influences the extraction process. Heat-Sensitive Compounds require cold extraction methods like cold pressing or cold maceration to avoid degradation. Light-Sensitive Compounds need to be protected from light during the extraction process to prevent breakdown.
- **Presence of Interfering Substances:** Different plant parts may contain substances that can interfere with the extraction and subsequent analysis. Plants which contains lipids and waxes may require defatting steps using non-polar solvents before the main extraction process. Plants containing polysaccharides can complicate extraction and may necessitate additional steps for removal or degradation.

3.2.4. Solvent used for extraction

- **Solubility of Target Compounds**: The solvent chosen should ideally have high solubility for the target compounds to maximize extraction efficiency. For instance, polar solvents like water or ethanol are suitable for extracting polar compounds, while non-polar solvents like hexane are better for non-polar compounds.
- **Selectivity**: Solvents differ in their selectivity, meaning their ability to extract the target compounds while leaving unwanted substances behind. A selective solvent will result in a purer extract by minimizing the co-extraction of impurities.
- **Stability of Compounds**: Some solvents may cause degradation or transformation of the target compounds during extraction. For example, highly acidic or basic solvents can lead to hydrolysis or oxidation of sensitive compounds.
- **Toxicity and Safety**: The toxicity of the solvent is crucial, especially for extracts intended for food, pharmaceutical, or cosmetic applications. Solvents like methanol are effective but toxic, whereas ethanol is generally regarded as safe for food applications.
- **Solvent Residue**: Residual solvent in the final extract can affect its safety and quality. Regulations often limit the permissible levels of solvent residues in products, so a solvent that is easy to remove or has low toxicity is preferred.

3.2.5. Extraction procedure

Choice of Solvent

- Polarity: The solvent's polarity must match that of the desired compounds. Polar solvents (e.g., water, ethanol) extract polar compounds, while non-polar solvents (e.g., hexane) extract non-polar compounds.
- Solubility: The solubility of the target compounds in the solvent determines the efficiency of extraction. A poor choice can lead to low yield and incomplete extraction.
- Purity: Impurities in the solvent can contaminate the extract, reducing its quality**.**

Extraction Method

- Maceration: Simple but often less efficient. It can lead to degradation of heat-sensitive compounds if performed at room temperature for extended periods.
- Soxhlet Extraction: Continuous extraction process that can be more efficient but may degrade thermolabile compounds due to prolonged exposure to heat.
- Ultrasound-Assisted Extraction: Uses ultrasonic waves to enhance solvent penetration, often yielding higher quality extracts in shorter times.
- Supercritical Fluid Extraction: Uses supercritical CO_2, which can selectively extract compounds without leaving solvent residues, often resulting in high-purity extracts.

Temperature

High Temperature can increase the rate of extraction but may degrade sensitive compounds, leading to lower quality extracts while low temperature preserves thermolabile compounds but may require longer extraction times or more solvent.

Duration of Extraction

Long Duration can ensure complete extraction but risks degradation of compounds over time while short duration minimizes degradation but may result in incomplete extraction if not optimized.

Plant Material Preparation

Smaller particle size increase the surface area for extraction, improving efficiency and pre-treatment techniques like drying, grinding, and freezing can affect the yield and quality of the extract.

Post-Extraction Processing

It is of two types. First filtration which removes unwanted particulates but can also lead to the loss of small amounts of the target compound. Second is concentration techniques like evaporation can concentrate the extract but may also lead to the loss of volatile compounds.

Effect of extracted plant phytochemical depends on:

- **The nature of the plant material**: For example, roots might have higher concentrations of alkaloids, while leaves may be richer in flavonoids. Younger plants may have different phytochemical profiles compared to mature plants, affecting both the type and concentration of the extracted compounds.
- **Its Origin**: Plants grown in tropical climates may have different phytochemical profiles compared to those grown in temperate regions. Plants grown in nutrient-rich or specific soil types may produce higher levels of certain phytochemicals.
- **Degree of processing**: Excessive heat during drying can degrade heat-sensitive phytochemicals, while freeze-drying typically preserves a higher concentration of these compounds. Prolonged processing times can lead to the degradation of some phytochemicals or the extraction of unwanted compounds that may interfere with the desired phytochemicals.
- **Moisture content**: High moisture content can hinder the penetration of organic solvents into the plant matrix.
- **Particle size**: Smaller particle sizes increase the surface area available for solvent interaction. Greater surface area enhances the efficiency of solvent penetration and phytochemical extraction, potentially increasing the yield of desired compounds.

The variations in different extraction methods that will affect quantity and secondary metabolite composition of an extract depend upon:

- Type of extraction
- Time of extraction
- Temperature
- Nature of solvent
- Solvent concentration
- Polarity

Plant material Plant-based natural substances can be derived from any part of the plant, including bark, leaves, flowers, roots, fruits, and seeds, meaning that any part of the plant may have active components.

Polar solvents such as water, methanol, and ethanol are used to extract polar chemicals, while nonpolar solvents such as hexane and dichloromethane are used to extract nonpolar compounds.

The usual method for liquid-liquid extraction is to use two miscible solvents such as water-dichloromethane, water-ether, and water-hexane. Water is present in all combinations due to its high polarity and miscibility with the organic solvent. To facilitate separation, the substance to be extracted using liquid-liquid extraction must be soluble in an organic solvent but not in water.[26] Furthermore, solvents employed in extraction are classed according to their polarity, from n-hexane, the least polar, to water, the most polar. Solvents used for active component extraction are: Water, Ethanol, Methanol, Chloroform, Ether, and Acetone

Table 2 Solvents used for active component extraction

Water	Ethanol	Methanol	Chloroform	Ether	Acetone
Anthocyanins Starches Tannins Saponins Terpenoids Polypeptides Lectins	Tannins Polyphenols Polyacetylenes Flavonols Terpenoids Sterols Alkaloids	Anthocyanins Terpenoids Saponins Tannins Xanthoxyllines Totarol Quassinoids Lactones Flavones Phenones Polyphenols	Terpenoids Flavonoids	Alkaloids Terpenoids Coumarins Fatty acids	Phenol Flavonols

Table 3 Different extraction techniques described in text of Pharmaceutics

S.no.	Extraction Method	Description	Applications	Advantages	Disadvantages
1.	Maceration	Soaking plant material in a solvent at room temperature to extract active compounds.	Herbal medicine, plant extracts.	Simple and inexpensive; gentle on materials.	Time-consuming; solvent can degrade some compounds.
2.	Percolation	Involves passing a solvent through plant material to extract desired compounds.	Herbal extracts, pharmaceutical preparations.	Efficient for large-scale extractions.	Requires careful control of flow rates.
3.	Soxhlet Extraction	Uses continuous solvent extraction with a Soxhlet apparatus, where the solvent repeatedly cycles through the sample.	Extraction of fats, oils, and some active pharmaceutical ingredients.	Effective for exhaustive extraction.	Time-consuming; solvent recovery can be complex.
4.	Cold Press Extraction	Uses mechanical pressure to extract oils and juices without heat.	Essential oils, citrus oils.	Retains heat-sensitive compounds.	Limited to oily or juicy materials; lower extraction efficiency for some compounds.
5.	Steam Distillation	Uses steam to carry volatile compounds from plant material into a condenser where they are collected.	Essential oils, volatile compounds.	Effective for volatile compounds	Not suitable for non-volatile compounds; requires specialized equipment.
6.	Supercritical Fluid Extraction	Utilizes supercritical fluids (like CO_2) to extract compounds.	Extracting essential oils, pharmaceutical compounds	High efficiency and selectivity; minimal solvent use.	Expensive equipment; requires precise conditions.
7.	Ultrasonic Extraction	Uses ultrasonic waves to enhance solvent penetration and extraction efficiency.	Extraction of active compounds from plant material.	Faster extraction; efficient for complex matrices.	Equipment can be costly; potential degradation of heat-sensitive compounds.

8.	Microwave-Assisted Extraction	Uses microwave energy to heat the solvent and plant material, accelerating the extraction process.	Herbal medicine, active pharmaceutical ingredient	Rapid extraction; efficient energy use.	Requires specialized equipment; potential for uneven heating.
9.	Solid-Phase Extraction (SPE)	Utilizes a solid phase to separate and concentrate analytes from a liquid sample.	Purification and concentration of pharmaceutical compounds.	High efficiency; good for trace analysis.	Requires proper method development; can be costly.
10.	Liquid-Liquid Extraction	Separates compounds based on their solubility in two immiscible liquids.	Extraction of organic compounds, purification.	Effective for separating based on solubility.	Solvent recovery and disposal can be challenging.
11	Reflux Extraction	Involves boiling a solvent in a reflux apparatus to continuously extract compounds from the plant material.	Pharmaceutical extractions, herbal medicine.	Efficient extraction; avoids solvent loss.	Requires careful temperature control; can be time-consuming.

4. Discussion

Ghana of formulations does the justice to its name i.e., it is the concentration form of the plant drugs. Ghana is mentioned by Acharya Charak in the form of *Rasa Kriya*, *Phanita* by Acharya Sushruta. Sharangdhara has briefly explained the concept of *Ghana* & *Rasa Kriya* under the topic of *Avleha Kalpana*. In ayurveda, *Ghana Kalpana* has been used much as a therapeutic compare to modern science where method of extraction is used.

Extraction of medicinal plants is a process of separating active plant materials or secondary metabolites such as alkaloids, flavonoids, terpenes, saponins, steroids, and glycosides from inert or inactive material using an appropriate solvent and standard extraction procedure. And then other analysis are carried out in the plant extract for its phytochemical analysis.

So, it is pretty much clear that in Ayurveda *Ghana* is a therapeutic procedure are known for their high concentration of active compounds, making them suitable for chronic conditions requiring sustained treatment, are preferred for tablet and pill preparations, ensuring stable doses over time. *Ghana* have a longer shelf-life due to their solid form. The standardized process of *Ghana* ensures uniformity and consistency in the final product. But both are clearly the concentrated form. In modern there are multiple method of extractions such as maceration, digestion, decoction, infusion, percolation, Soxhlet extraction, superficial extraction, ultrasound-assisted, and microwave-assisted extractions, which also depends on a lot of factors. Liquid extracts are favored in tonics and topical applications due to their fast absorption , may require careful storage to maintain potency. Modern extraction techniques are used for liquid extracts to optimize bioavailability and ensure standardized potency and customizable dosing. Both procesess *Ghana* & extraction hold their own importance.

5. Conclusion

In conclusion, both Ayurvedic *Ghana* and extracts offer unique advantages depending on the therapeutic needs and formulation requirements. Their distinct characteristics make them valuable assets in Ayurvedic medicine, catering to both traditional practices and modern applications. Non standardized procedures of extraction may lead to the degradation of the phytochemical present in the plants and may lead to the variations thus leading to the lack of reproducibility. Thus we should use the both methods subjected to situations & according to availability and various other important factors. Further analytical studies can also be done to conduct a comparative data between *Ghana* & extract, and use it for better clinical studies.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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