From Fermentation to Nano Medicine: Reviewing Ayurvedic Dosage Forms and Their Modern Relevance

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***Abstract*—Ayurveda, one of the world's oldest medical systems, encompasses a wide spectrum of dosage forms that reflect remarkable pharmaceutical ingenuity. Classical preparations such as *Asava* and *Arista* utilize fermentation to enhance solubility and stability, while solid forms like *Vati* and *Ghutika* provide standardized dosing. Powdered formulations (*Churna*) emphasize particle size reduction, and semi-solid preparations (*Leha/Avaleha*) ensure sustained delivery through sugar or jaggery bases. Most notably, mineral based *Bhasma* exemplifies Ayurveda's intuitive grasp of nanomedicine, as calcination produces ultra-fine particles with high bioavailability.**

This review highlights the scientific principles underlying these dosage forms and explores their modern relevance through nanotechnology and advanced drug delivery systems. Recent innovations, including curcumin nanoparticles, Ashwagandha nanoemulsions, Triphala nanocrystals, and Neem nano-formulations, demonstrate how traditional remedies can be transformed into validated nano-herbal medicines. Our work on curcumin microsponges for controlled release in psoriasis patients further illustrates the potential of integrating Ayurvedic wisdom with contemporary pharmaceutical engineering.

By examining both classical practices and emerging technologies such as phytosomes, liposomal carriers, hydrogel systems, and 3D printing of herbal formulations, this article underscores the vast scope for standardization, personalization, and global acceptance of Ayurvedic medicines. Bridging ancient knowledge with modern science, Ayurveda stands poised to contribute meaningfully to the future of evidence-based, innovative healthcare.

I. INTRODUCTION:

Ayurveda is recognized as one of the oldest medical systems originating in India, with a history spanning more than 5,000 years. It is also regarded as one of the most prominent traditional healthcare systems worldwide, with roots traced back to around 6000 BCE. The term *Ayurveda* is derived from Sanskrit, where "Ayur" signifies life and "Veda" refers to sacred knowledge or science. Hence, Ayurveda can be described as the "science of life." Considered an extension of the Atharvaveda, it encompasses knowledge of medicinal herbs, plants, human anatomy and physiology, as well as the fundamental principles of disease management and treatment. It continues to play a vital role in healthcare today. Rooted in the principles of balance between body, mind, and spirit, Ayurveda emphasizes individualized treatment through natural remedies, lifestyle modifications, and specialized formulations

Among its diverse therapeutic approaches, dosage forms such as Asava, Arista, Vati, Ghutika, Churna, Leha/Avaleha and Bhasma hold a central place in clinical practice.These formulations are not merely traditional preparations but represent sophisticated pharmaceutical techniques developed centuries ago. Asava and Arista are fermented liquid medicines known for their self-generated alcohol content, which enhances extraction and preservation of active compounds. Vati and Ghutika are solid dosage forms designed for convenience, controlled administration, and sustained therapeutic action. Bhasma, unique to Ayurveda, are calcinated mineral and metal preparations that embody the concept of nanomedicine, offering high bioavailability and potent therapeutic effects.

In recent decades, there has been growing global interest in Ayurvedic products due to their holistic approach, perceived safety, and potential role in managing chronic diseases. However, challenges such as standardization, quality control, and scientific

validation remain critical for their wider acceptance. This review aims to provide a comprehensive overview of these classical dosage forms, exploring their historical background, preparation methods, pharmacological basis, clinical relevance, and modern perspectives.

Apart from this several Ayurvedic formulations are prepared such as Lauha, Arka, Kvatha, Dravaka, Lavana Ksara, Guggulu, Rasa-Yoga, Pisti, Parpati Kalpas,Sattava , Kupipakva and Rasayana , Vartti-Netrabindu and Anjana , Mandura, Kalka, Ghana-saar, Swarasa, Siddhamilks, kajjali, Matras, Nassayas , Fant(fanta), Nikadha etc.

Ayurvedic formulations can be categorized into four types based on their physical nature of dosage forms.

1. Solid dosage forms- Eg: Vati & Ghutika.
2. Semi Solid dosage forms- Eg: Leha & Kalka
3. Liquid dosage forms- Eg: Aristas & Asavas
4. Powder dosage forms- Eg: Bhasmas & Churnas

II. ARISTAS AND ASAVAS (LIQUID PREPARATIONS):

These are important and unique liquid fermented medicinal preparations in Ayurveda, known for their efficacy, stability, and palatability. They are also known as preparations containing self-generated alcohol. They are prepared by adding powdered drug or its decoction into a solution of sugar or jiggery. It is then fermented for a specified time during which alcohol is generated which facilitates the maximum extraction of active principles present in the drugs. The self-generated alcohol also acts as a preservative. Both Aristas and Asavas are self-generating alcoholic preparations, but they differ in the methods of preparation. Aristas are prepared by extracting the powdered drug in the form of decoction and then added to the solution of sugar or jaggery. Asavas are prepared by directly adding the powdered drugs into the solution of sugar or jaggery, the remaining process of preparation remains the same.

III. METHOD OF PREPARATION OF ARISTA:

To prepare *Aristas*, the selected crude drugs are first coarsely powdered, and a decoction (*kashaya*) is made and carefully filtered. The filtrate is then combined with additional ingredients and mixed into a solution of sugar, jaggery, or honey. This mixture is boiled, allowed to cool, and subsequently transferred into wooden casks or earthen pots. The mouth of the vessel is sealed with an earthen lid, and the edges are secured using a cloth smeared with clay, traditionally wrapped in seven successive layers. The container is then placed either in an underground cellar or within a heap of paddy to maintain a stable temperature conducive to fermentation.

After the prescribed duration, the lid is removed and the preparation is examined to confirm completion of the fermentation process (*sandhana*). Once verified, the liquid is filtered and stored for therapeutic use.

Method of preparation of Asavas: The drug is finely powdered and mixed with other ingredients and these contents are added to a solution of sugar or jaggery or honey, mixed well. It is then boiled, cooled and transferred to wooden barrels or pots. The mouth of the container is covered with an earthen lid and the edges are sealed with clay smeared cloth which is wound in seven consecutive layers. The container is kept in an underground cellar or a heap of paddy in order to ensure a constant temperature is maintained during the process of fermentation. After the specified period, the lid is removed and the contents are examined to ensure that the process of fermentation (Sandhana) has been completed. The fluid is filtered and stored

IV. STANDARDIZATION PARAMETERS FOR ARISTAS AND ASAVAS:

- Aristas and Asavas should be clear without any froth or foam at the top.
- The preparations should not become sour upon standing.
- They should have a characteristic aromatic and alcoholic odour.
- There should be no effervescence produced.

Examples of Aristas: Ashokarista, Dasmularista & Ashwagandhaarista

Asavas: Arvindasava, Kumaryasava & Vasakasava.

V. VATI & GHUTIKA (SOLID PREPARATIONS):

These are Ayurvedic formulations presented in solid dosage forms, either as tablets (*vati*) or pills (*ghutika*). They may consist of single drugs or combinations derived from herbal, mineral, or animal sources.

VI. METHOD OF PREPARATION

The raw materials are first dried and finely powdered. Mineral substances are processed into calcinated forms (*bhasma*) or other specified preparations. According to the prescribed formula, the powdered drugs are blended with suitable liquids to form a soft paste. This paste is thoroughly ground and then shaped into tablets (*vati*) or pills (*ghutika*).

VII. STANDARDIZATION PARAMETERS

- Vati and Ghutika should retain stability for up to two years after preparation.
- Preparations containing only mineral ingredients may remain effective indefinitely.
- They must preserve their original color, odor, taste, and physical form during storage.
- Formulations containing sugar or salt should be safeguarded against moisture.

Examples

- Vati: Gandhaka Vati, Dugdha vati & Sankha Vati
- Ghutika*:* Pranda Ghutika , Lasunadi Ghutika & Eladi gutika etc.

VIII. CHURNA (POWDERED PREPARATIONS):

Churnas are formulations prepared in powdered form, containing either a single drug or a combination of multiple ingredients.

Method of Preparation The raw materials specified in the formula are individually dried, finely powdered, and sieved to obtain uniform particle size. These powders are then blended together to produce a homogeneous mixture.

Standardization Parameters

- Churnas should remain free-flowing and must not clump or absorb moisture.
- When stored properly, they retain efficacy for up to one year.
- Finer particle size enhances potency and therapeutic effectiveness.

Examples: *Triphala Churna, Drakshadi Churna & Sudarshan Churna*

IX. LEHA / AVALEHA (SEMI-SOLID PREPARATIONS):

Leha or Avaleha are semisolid formulations prepared by boiling powdered drugs or extracts with a sugar or jaggery solution.

Method of Preparation Sugar or jaggery is dissolved in a liquid, boiled, and filtered. The powdered drugs and other prescribed ingredients are added gradually with continuous stirring until a uniform semisolid mass is formed. If required, ghee or oil is incorporated while the mixture is still hot.

Standardization Parameters

- The preparation should maintain a stable semisolid consistency, neither hardening nor liquefying.
- It must remain free from fungal growth.
- No changes in color, odor, or taste should occur during storage.
- Shelf life is generally up to one year under proper storage conditions.

Examples: *Drakshavaleha, Vasavaleha, Bilvadileha*

X. BHASMA (CALCINATED MINERAL PREPARATIONS):

Bhasmas are fine powders obtained by calcination of metals, minerals, or animal products through specialized Ayurvedic procedures.

Method of Preparation Preparation involves two stages:

1. Śodhana (Purification): Metals and minerals are heated and quenched in specific liquids to eliminate impurities and reduce toxicity.
2. Mārana (Calcination): The purified substances are ground with herbal extracts as prescribed, shaped into small cakes, and dried in sunlight. These cakes are placed in earthen vessels, sealed with clay-smeared cloth, and buried in pits covered with cow dung. Controlled heating is applied until calcination is complete. The final product is collected, finely powdered, and stored.

Standardization Parameters

- Bhasmas typically appear as grey, whitish, yellowish, or black powders and should retain their color during storage.

- They are highly stable over long periods and maintain potency when properly prepared.

Examples: *Suvarna Bhasma, Shankha Bhasma &Taura Bhasma*

XI. AYURVEDA AND NANOTECHNOLOGY: BRIDGING ANCIENT WISDOM WITH MODERN SCIENCE

Ayurvedic dosage forms illustrate a continuum of pharmaceutical innovation, ranging from fermentation-based remedies such as *Asava* and *Arista* to mineral preparations like *Bhasma*, which inherently embody nanomedicine principles. Modern nanotechnology provides tools to refine these traditional concepts, ensuring improved safety, efficacy, and reproducibility. Herbal medicines, in particular, have been successfully reformulated into nano-delivery systems to overcome limitations of solubility, stability, and bioavailability.

Recent advances in nano-herbal medicine include the development of curcumin nanoparticles for enhanced anti-inflammatory and anticancer activity, Ashwagandha nanoemulsions for improved adaptogenic effects, and Triphala nanoparticles with superior antioxidant potential. In addition to these, our work on curcumin microsponges has demonstrated a novel approach for controlled and sustained drug delivery in psoriasis patients. By incorporating curcumin into porous microsponge carriers, the formulation allows gradual release of the active compound, thereby maintaining therapeutic levels over an extended period and reducing dosing frequency. This innovation highlights how Ayurvedic principles can be translated into modern nanotechnology platforms to address chronic conditions more effectively.

XII. PHYTOSOME TECHNOLOGY

Phytosomes are advanced delivery systems where herbal extracts are complexed with phospholipids to improve absorption and bioavailability. This approach has been particularly effective for compounds with poor solubility, such as flavonoids and polyphenols. For example, curcumin phytosomes have shown enhanced anti-inflammatory activity, while silymarin phytosomes are widely studied for liver protection. By integrating phytosome technology, Ayurvedic herbs can achieve greater therapeutic consistency and clinical relevance.

XIII. 3D PRINTING OF HERBAL FORMULATIONS

Three-dimensional (3D) printing offers a novel platform for personalized medicine by enabling precise control over dosage, shape, and release profiles of herbal formulations. Using biocompatible polymers, herbal actives can be printed into customized tablets or capsules tailored to individual patient needs. This technology allows for multi-drug combinations, controlled release profiles, and patient-specific dosing, making it highly relevant for chronic conditions where Ayurveda traditionally emphasizes individualized treatment.

Such examples underscore the relevance of Ayurveda in the era of nanomedicine, where traditional wisdom is not only validated but also expanded through advanced drug delivery systems.

XIV. CONCLUSION AND FUTURE SCOPE

Ayurvedic dosage forms illustrate a remarkable pharmaceutical continuum, and their relevance today lies in how they can be adapted through modern science. The next frontier is not only nanotechnology but also advanced delivery platforms that can transform herbal medicines into globally standardized therapeutics. Emerging approaches such as phytosomes for enhanced absorption, liposomal and niosomal carriers for targeted delivery, and hydrogel systems for sustained topical applications are already showing promise. Innovations like curcumin microsponges for controlled release in psoriasis exemplify how traditional remedies can be engineered into sophisticated formulations tailored for chronic conditions.

Looking ahead, technologies such as 3D printing of herbal formulations, biopolymer encapsulation, and smart packaging for stability monitoring could redefine how Ayurvedic medicines are produced and consumed. By integrating these advances, Ayurveda can evolve into a modern, evidence-based system of healthcare while retaining its holistic foundation. The scope is vast: from personalized herbal therapies to global acceptance as validated phytopharmaceuticals, Ayurveda stands poised to bridge ancient wisdom with cutting-edge biomedical innovation.

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