RESEARCH PAPER

Computational Analysis of Traditional Ayurvedic Knowledge: A Study of Medicinal Plants from the Marathwada Region

Sana Shaikh[1], Lt. Dr. Vaishali A. Chavan[1], Dr. Siddiqui Bushra Zareen[2], Dr. Nazneen Akhter[3]
[1] Dr. G.Y. Pathrikar College of C.S. & I.T., MGM University, CPSN
[2] Dr. Rafiq Zakaria College for Women, BAM University, CPSN
[3] IRC Technical Institute, CPSN

shaikh.sana@outlook.com
vaishalichavan0605@gmail.com
siddiquibushra185@gmail.com
*getnazneen@gmail.com

Abstract: Medicinal plants are a part of traditional healthcare especially in areas where old knowledge about plants has been kept alive through Ayurvedic books and local customs. Much of this information is spread out across many books, government websites and traditional medical sources which makes it hard for computers to analyze.

The study expands a previously developed dataset from 21 to 100 medicinal plants associated with the Marathwada region of Maharashtra, India. Each plant entry was organized using 21 attributes to turn mixed up text information into a format that computers can understand.

Exploratory analysis was conducted to examine relationships among Ayurvedic properties including rasa, virya, and vipaka. Preliminary observations show that there are connections between taste categories and how plants affect the body. For instance, the analysis indicated that bitter taste frequently co-occurs with astringent attributes and that pungent post digestive effect is very common among the selected plants. The results provide an initial view of the relationships among Ayurvedic functional properties in the selected plants.

Although the dataset is limited in size, this study shows how organizing knowledge in a systematic way can make it possible for computers to analyze and can help lay the groundwork for future research on medicinal plants using AI. The study is focused on computational analysis of Ayurvedic functional properties and bridging the gap between scattered textual knowledge into AI driven healthcare research.

Keywords: Computational Analysis, Digital Healthcare, Knowledge Structuring, Medicinal Plants Marathwada, Ayurvedic Functional Property, Rasa-Virya-Vipaka, Co-occurrence Matrix.

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Introduction

Medicinal plants have been used in traditional healthcare systems. In Ayurveda, their therapeutic properties are described through concepts such as rasa (taste), guna (physical qualities), virya (potency), and vipaka (post-digestive effect). These attributes are considered important in determining the physiological action of medicinal substances [1,2].

Despite the availability of extensive knowledge regarding medicinal plants, much of the information remains scattered across classical texts, research publications, government databases, and digital repositories. The information is often presented in descriptive form, making systematic computational analysis difficult. As a result, the application of data-driven techniques to traditional medicinal knowledge remains limited. Converting dispersed information into structured and machine-readable formats is an important step toward allowing computational analysis of traditional medicinal knowledge. [3].

The Marathwada region of Maharashtra possesses considerable medicinal plant diversity distributed across forests, agricultural lands, and cultivated environments. Several ethnobotanical and floristic studies have documented medicinal plant species from the region [4]. However, structured datasets specifically designed for computational analysis of

Ayurvedic functional properties remain limited. This creates a gap between traditional knowledge resources and modern analytical approaches.

The present study develops a structured dataset containing 100 medicinal plants associated with the Marathwada region, with each plant represented through 21 descriptive attributes. The study addresses three questions: how dispersed medicinal plant information can be organized into a machine-readable dataset, what relationships exist among rasa, virya, and vipaka, and whether co-occurrence analysis can reveal useful patterns among these attributes. The main contributions are the development of the structured dataset and the exploratory computational analysis of Ayurvedic functional properties using co-occurrence matrices and heatmap visualizations.

1 Literature Review

The preservation and digitization of medicinal plant knowledge have received increasing attention in recent years. Several studies have documented medicinal plants and their traditional uses, while databases and reference resources have been developed to organize this information. Biradar [1] documented ethnomedicinal plant knowledge from parts of the Marathwada region, while Khare [13], the Database on Medicinal Plants Used in Ayurveda [15], and the Ayurvedic Pharmacopoeia of India [14] provide broader information on medicinal plants and their therapeutic applications. These resources are valuable for documentation and identification, but they do not directly provide a structured dataset for computational analysis of Ayurvedic functional properties.

Sharma and Meena [2] discussed Ayurvedic pharmacodynamic concepts including rasa, guna, virya, and vipaka in relation to therapeutic applications. Such work provides an important conceptual basis for understanding Ayurvedic functional properties, but the representation remains primarily descriptive rather than computational. A review of medicinal plant databases by Shaikh and Chavan [3] also highlighted the transition toward digital resources and identified gaps in machine-readable representations of traditional medicinal knowledge.

Existing studies therefore contribute either regional documentation, Ayurvedic conceptual understanding, or digital preservation of medicinal plant information. However, limited work combines these aspects into a structured, machine-readable dataset focused on Ayurvedic functional properties of medicinal plants from the Marathwada region. The present study addresses this gap through a structured dataset of 100 medicinal plants and exploratory analysis of relationships among rasa, virya, and vipaka.

2 Dataset

The dataset used in this study consists of 100 medicinal plants associated with the Marathwada region. Although the dataset contains a limited number of plants, each entry contains 21 key-value attributes, allowing a detailed representation of botanical and functional characteristics. This level of detail allows the dataset to support exploratory analysis of functional relationships among medicinal plants. The dataset was developed as an initial groundwork rather than an exhaustive catalog of the region's medicinal flora. The dataset was expanded from a previously developed collection of 21 medicinal plants to include 100 medicinal plants associated with the Marathwada region [5].

The dataset was designed as an initial representation of medicinal plant diversity in the Marathwada region rather than a comprehensive inventory. Additional medicinal plant species occur within the region; however, only selected species were included in the present study to ensure data quality and consistency during the structuring process. The selected plants represent diverse growth forms including trees, shrubs, herbs, and climbers, reflecting the ecological variability of medicinal flora in the region.

3 Methodology

3.1 Data Collection and Structuring

The information was gathered regarding medicinal plants of Marathwada region from multiple authoritative sources including classical Ayurvedic literature, government botanical databases, and medicinal plant reference texts [6-20]. These sources typically present plant descriptions in either narrative form or descriptive form, which makes systematic computational analysis difficult.

To address this limitation, the collected information was manually curated into semi-structured .txt files. Each plant file contained 21 key–value attributes, with botanical information, ecological characteristics, and Ayurvedic functional properties.

This process converts scattered textual knowledge into a machine-readable format suitable for computational analysis and exploratory data exploration [5].

3.2 Ayurvedic Functional Attributes

In Ayurveda medicinal plants have functional properties that describe their pharmacological behavior. Several Ayurvedic functional properties were included in the dataset, namely taste (rasa), physical qualities (guna), potency (virya), and post-digestive effect (vipaka). These attributes were selected to facilitate the analysis of relationships among key Ayurvedic concepts [2].

1. Taste (Rasa)

Rasa refers to the primary taste perceived when a substance is consumed. Ayurveda recognizes six primary rasas: sweet (madhura), sour (amla), salty (lavana), pungent (katu), bitter (tikta), and astringent (kashaya).

2. Physical Qualities (Guna)

Guna describes the inherent physical qualities of a substance. Classical Ayurvedic texts describe twenty gunas arranged in ten opposite pairs such as heavy–light, oily–dry, and hot–cold.

3. Potency (Virya)

Virya represents the energetic potency of a medicinal substance and is generally categorized as either heating (ushna) or cooling (shita).

4. Post-Digestive Effect (Vipaka)

Vipaka refers to the metabolic transformation of a substance after digestion. Ayurveda describes three types of vipaka: sweet, sour, and pungent [21].

3.3 Exploratory Analysis

Exploratory Data Analysis was conducted to examine relationships among the Ayurvedic functional attributes recorded in the dataset. To analyze relationships between taste categories, a rasa co-occurrence matrix was constructed. Each plant may possess multiple rasas; therefore, rasa attributes were encoded to allow pairwise frequency analysis of taste combinations across plants. The resulting matrix was visualized using a rasa co-occurrence heatmap, highlighting common taste combinations [22-24].

In addition, relationships between rasa and other Ayurvedic properties were examined using heatmap visualizations:

- **Rasa × Virya heatmap:** illustrating how taste attributes correspond to heating or cooling potency.
- **Rasa × Vipaka heatmap:** examining the relationship between primary taste and post-digestive metabolic effect.

These visualizations enable clearer interpretation of functional associations among Ayurvedic attributes within the dataset. As the present study is exploratory and does not involve a predictive classification model, model performance comparison was not undertaken; instead, relationships among the recorded attributes were examined through co-occurrence analysis and heatmap visualizations.

4 Results and Discussion

4.1 Dataset Composition

The curated dataset consists of 100 medicinal plants from the Marathwada region selected as an initial resource for the structured analysis of Ayurvedic plant properties. Although the plants are limited in number, but each entry contains 21 key–value attributes, allowing a detailed representation of botanical and functional characteristics.

The dataset includes plants belonging to different growth forms to maintain the ecological diversity. As shown in Fig. 1, trees constitute the largest group with 35 species, followed by shrubs (27) and herbs (26). Smaller groups include climbers (7), grasses (4), and a single succulent species. This distribution reflects the natural variation of medicinal flora found in the Marathwada region while avoiding excessive dominance of a single plant type.

Although the dataset does not yet capture the full botanical diversity of the Marathwada region, it only provides a sufficiently varied sample for demonstrating how Ayurvedic functional attributes can be organized and explored computationally.

4.2 Taste (Rasa) Complexity Analysis

The complexity of taste (rasa) attributes was examined by analyzing how many taste categories are associated with each plant. The Ayurveda recognizes six primary taste as sweet, sour, salty, pungent, bitter, and astringent. All the medicinal plants may possess one or multiple taste simultaneously.

The histogram of rasa complexity per plant Figure 2, shows that most plants exhibit two tastes, indicating that medicinal plants often combine multiple taste

attributes that collectively influence their pharmacological action. A smaller number, 28 plants possess only one taste, while 18 exhibit three taste.

Three plants currently have no documented rasa values because their Ayurvedic properties have not yet been reported in available sources.

Two plants in the dataset stand out due to their exceptionally diverse taste profiles. Gooseberry (*Emblica officinalis*) and Garlic (*Allium Sativum Linn*), both exhibit five rasa attributes, making them unique among the selected species and reflecting their complex pharmacological characteristics described in Ayurvedic texts.

4.3 Taste (Rasa) Co-occurrence Patterns

To understand how taste attributes appear together within medicinal plants, a rasa co-occurrence matrix was constructed and visualized using a heatmap, Figure 3. This analysis reveals the frequency with which different rasas are observed in combination.

The heatmap indicates that bitter rasa frequently co-occurs with pungent and astringent rasas. The heatmap indicates frequent co-occurrence of bitter rasa with pungent and astringent rasas. These combinations can be interpreted in the context of Ayurvedic descriptions of the functional properties of these tastes. However, the observed co-occurrence represents an association within the dataset and does not establish a causal explanation for the pattern.

The co-occurrence patterns observed in the dataset demonstrate how computational analysis can reveal relationships that correspond with classical Ayurvedic principles. Although the dataset size is limited, these patterns provide an initial glimpse into the functional associations between taste categories.

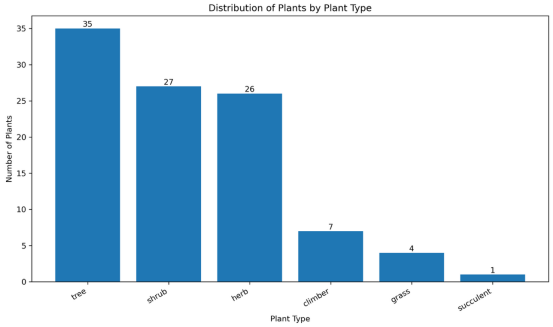


Fig. 1. Distribution of plants by plant type in the selected medicinal plant dataset from the Marathwada region.

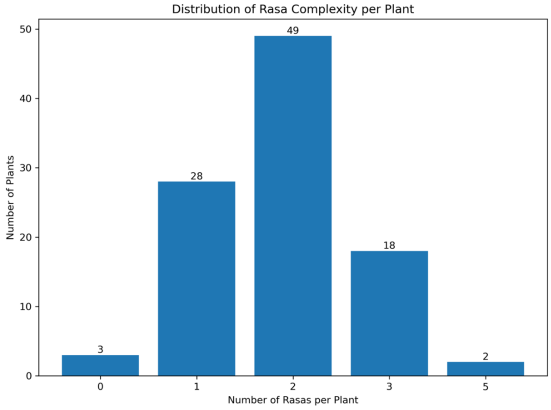


Fig. 2. Distribution of taste complexity per plant in the medicinal plant dataset.

4.4 Taste-Potency (Rasa–Virya) Relationship

The relationship between taste (rasa) and potency (virya) was explored using a heatmap that maps taste attributes against heating or cooling energetic effects, Figure 4. In Ayurveda, potency represents the immediate physiological impact of a substance on the body, typically categorized as heating (ushna) or cooling (shita).

The heatmap shows that taste categories tend to align with one of these energetic effects. Certain rasas appear more frequently in plants with heating potency, while others are more commonly associated with cooling potency. These observations align with Ayurvedic pharmacological theory, where taste is considered an indicator of the energetic behavior of a medicinal substance.

Although the present dataset does not attempt to quantify causal relationships, the visualization demonstrates that taste and potency are not independent attributes but rather part of an interconnected framework that influences the therapeutic action of medicinal plants.

4.5 Taste-Post Digestive Effect (Rasa–Vipaka) Relationship

The relationship between initial taste (rasa) and post-digestive effect (vipaka) was analyzed through a heatmap that compares these two attributes in Figure 5. In Ayurvedic pharmacology, post-digestive effect represents the metabolic transformation that occurs after digestion and may differ from the initial taste experienced during consumption.

The visualization reveals that plants with different initial tastes may ultimately produce a similar post-

digestive effect. For instance, a plant that tastes bitter at the time of consumption may exhibit pungent vipaka after digestion.

This relationship reflects a key Ayurvedic concept: the physiological impact of a substance cannot be understood solely from its immediate sensory characteristics. Instead, the metabolic transformation represented by post-digestive effect plays an important role in determining its therapeutic action.

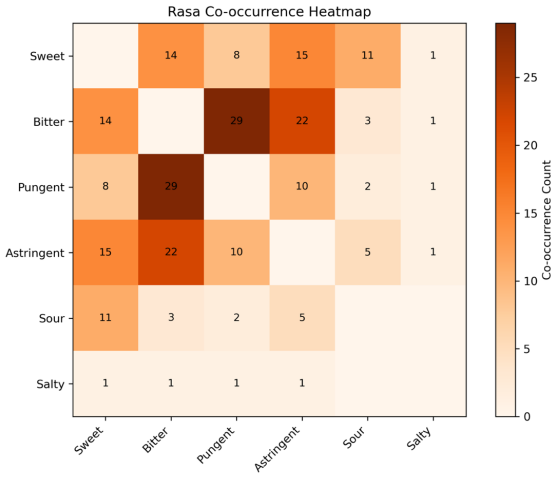


Fig. 3. Rasa co-occurrence heatmap for medicinal plants in the dataset.

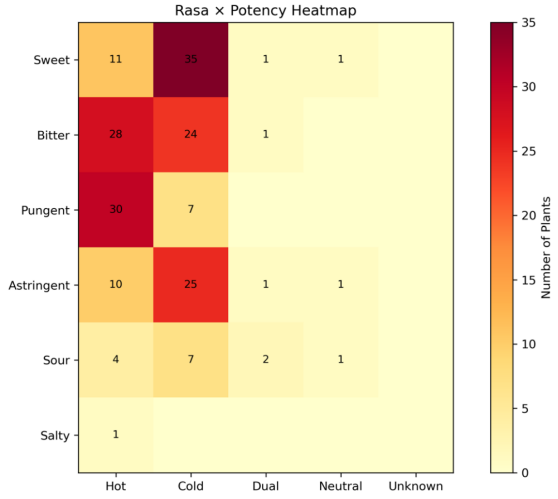


Fig. 4. Rasa-Virya heatmap showing relationships between taste and potency.

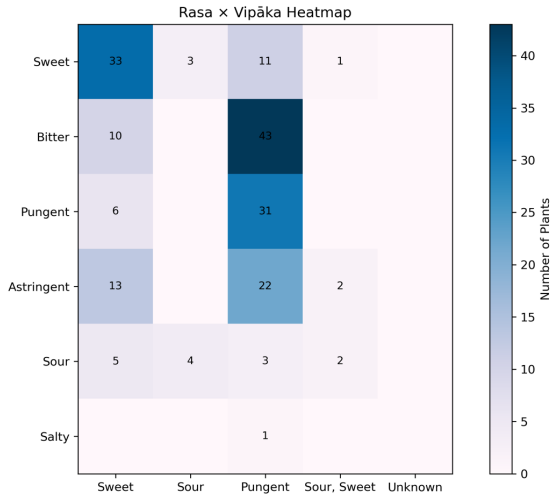


Fig. 5. Rasa-Vipaka heatmap showing relationships between taste and post-digestive effect.

5 Conclusion, Limitations and Future Work

This study presented a computational exploration of Ayurvedic functional properties using a structured dataset of 100 medicinal plants from the Marathwada region of Maharashtra. Information collected from classical Ayurvedic literature, medicinal plant references, and digital resources was organized into a machine-readable format containing 21 descriptive attributes for each plant. The dataset enabled exploratory analysis of key Ayurvedic properties including rasa, virya, and vipaka.

The analysis revealed several noteworthy patterns. Most plants exhibited two rasa attributes, while the co-occurrence analysis highlighted frequent associations between bitter, pungent, and astringent tastes. The heatmaps further demonstrated observable relationships between taste, potency, and post-digestive effect, reflecting the interconnected nature of Ayurvedic functional properties.

Practical Limitations: The dataset contains only 100 medicinal plants and does not represent the complete medicinal plant diversity of the Marathwada region. In addition, the dataset was created through manual curation, and some species lack complete Ayurvedic descriptions.

Theoretical Limitations: The study is exploratory in nature and identifies associations among Ayurvedic attributes rather than causal relationships. Variations across classical texts and regional

traditions may also influence the representation of certain plant properties.

Future Work: Future research will focus on expanding the dataset to include additional medicinal plant species and incorporating phytochemical and pharmacological information. Computational techniques such as clustering, classification, association rule mining, and knowledge graph construction may be applied to identify deeper relationships among medicinal plant properties and support the development of larger digital medicinal plant knowledge resources.

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