© June 2026 | IJIRT | Volume 13 Issue 1 | ISSN: 2349-6002

Integrative Pharmacology of Medicinal Plants: Understanding the Relationship Between Rasa Panchaka and Bioactive Phytoconstituents

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Abstract*—Medicinal plants have been utilized for centuries in Ayurveda based on their therapeutic properties, which are primarily interpreted through the framework of Rasa Panchaka. This classical pharmacodynamic model comprises Rasa, Guna, Virya, Vipaka, and Prabhava, and serves as the foundation for predicting the biological and therapeutic actions of medicinal substances. In contrast, modern pharmacology explains medicinal activity through the presence of bioactive phytoconstituents such as alkaloids, flavonoids, terpenoids, glycosides, tannins, and phenolic compounds. Recent advances in phytochemical and pharmacological research have revealed significant correlations between traditional Ayurvedic attributes and specific classes of phytoconstituents. The present review aims to explore the relationship between Rasa Panchaka and bioactive phytoconstituents from an integrative pharmacological perspective. Classical Ayurvedic literature and contemporary scientific evidence were critically examined to identify associations between sensory characteristics, physicochemical properties, and experimentally validated pharmacological activities. Evidence suggests that specific Rasas are frequently associated with distinct phytochemical groups and corresponding biological actions. Likewise, Guna, Virya, and Vipaka appear to reflect physicochemical behavior, pharmacodynamic responses, and metabolic outcomes of medicinal plants. Furthermore, the concept of Prabhava may provide insights into unique therapeutic effects arising from complex phytochemical interactions and synergistic mechanisms. Understanding these relationships can facilitate the scientific validation of Ayurvedic principles, strengthen evidence-based herbal medicine, and support future drug discovery efforts. The integration of Rasa Panchaka with modern phytochemistry offers a promising framework for advancing pharmacological research on medicinal plants.

Index Terms*—Rasa Panchaka; Dravyaguna; Phytoconstituents; Integrative Pharmacology; Medicinal Plants; Ayurvedic Pharmacology.

I. INTRODUCTION

Medicinal plants constitute the foundation of traditional healthcare systems and continue to serve as important sources of therapeutic agents worldwide. Ayurveda, the ancient Indian system of medicine, possesses a comprehensive framework for understanding the properties and actions of medicinal substances through the principles of Dravyaguna Vigyana. Among these principles, Rasa Panchaka occupies a central position and provides a systematic method for evaluating the pharmacodynamic behavior of medicinal plants. The framework comprises five key attributes Rasa, Guna, Virya, Vipaka, and Prabhava which collectively determine the therapeutic efficacy and biological effects of a drug. [1] Classical Ayurvedic scholars considered Rasa Panchaka as an essential tool for predicting drug action, selecting appropriate therapies, and understanding the interaction between medicinal substances and the human body. Through detailed assessment of these attributes, Ayurvedic physicians were able to anticipate the therapeutic outcomes of medicinal plants even in the absence of sophisticated analytical techniques. This holistic approach differs significantly from modern pharmacology, which primarily focuses on identifying active compounds and elucidating their molecular mechanisms of action. [2]

Modern pharmacological research has revealed that the therapeutic activities of medicinal plants are largely mediated by bioactive phytoconstituents such as alkaloids, flavonoids, terpenoids, glycosides, tannins, saponins, and phenolic compounds. These phytochemicals exhibit diverse biological activities including antioxidant, anti-inflammatory, antimicrobial, immunomodulatory, hepatoprotective, and anticancer effects. Advances in phytochemistry and analytical technologies have facilitated the identification and characterization of these compounds, thereby improving our understanding of plant-based therapeutics. [3]

Recent investigations have increasingly suggested that many traditional Ayurvedic descriptions of medicinal plants may have a scientific basis rooted in their phytochemical composition. For example, bitter-tasting medicinal plants often contain alkaloids, diterpenoids, and glycosides associated with anti-inflammatory and hepatoprotective activities, whereas astringent plants are frequently rich in tannins and polyphenols that contribute to antioxidant and wound-healing effects. Such observations indicate that classical Ayurvedic attributes may reflect underlying chemical and biological properties of medicinal substances. [4]

The growing interest in evidence-based Ayurveda and integrative medicine has encouraged researchers to explore possible correlations between Rasa Panchaka and bioactive phytoconstituents. Establishing such relationships may provide a scientific explanation for traditional therapeutic claims and facilitate the development of predictive models for drug discovery and pharmacological screening. Furthermore, integrating Ayurvedic pharmacodynamics with modern phytochemistry may contribute to a more comprehensive understanding of medicinal plant activity and support the validation of traditional knowledge systems. [5]

Therefore, the present review aims to examine the relationship between Rasa Panchaka and bioactive phytoconstituents from an integrative pharmacological perspective. By critically analyzing classical Ayurvedic concepts alongside contemporary phytochemical and pharmacological evidence, the review seeks to identify potential correlations that may strengthen the scientific foundation of Ayurvedic pharmacology and promote future interdisciplinary research in medicinal plant sciences. [6]

II. CONCEPTUAL BASIS OF RASA PANCHAKA

Rasa Panchaka represents the fundamental pharmacodynamic framework of Ayurveda for understanding the properties and therapeutic actions of medicinal substances. The concept encompasses five essential attributes Rasa (taste), Guna (qualities), Virya (potency), Vipaka (post-digestive effect), and Prabhava (specific action). These parameters collectively determine the pharmacological behavior, therapeutic efficacy, and clinical application of medicinal plants. According to Ayurvedic principles, a comprehensive understanding of Rasa Panchaka enables the prediction of biological responses and therapeutic outcomes following drug administration. [7]

Table 1. Components of Rasa Panchaka and Their Classical Significance

Component	Definition	Functional Significance
Rasa	Taste perceived by the tongue	Initial indicator of therapeutic action
Guna	Physical and functional qualities	Determines biological behavior
Virya	Potency or active energy	Governs immediate pharmacological effects
Vipaka	Post-digestive transformation	Influences long-term metabolic outcomes
Prabhava	Specific and unique action	Produces effects beyond other attributes

2.1 Rasa: Rasa is regarded as the primary determinant of drug action and is the first attribute perceived during administration. Ayurveda recognizes six Rasas Madhura, Amla, Lavana, Katu, Tikta, and Kashaya. Each Rasa possesses distinct physiological effects arising from its unique Panchamahabhuta composition. Classical Ayurvedic texts describe Rasa as an important predictor of therapeutic activity, disease indication, and interaction with bodily systems. Consequently, Rasa serves as the initial basis for evaluating medicinal substances. [8]

2.2 Guna: Guna refers to the inherent physical and functional qualities of medicinal substances. Twenty principals Gunas are described in Ayurveda and are arranged as ten opposite pairs. These qualities influence absorption, distribution, interaction with tissues, and overall therapeutic behavior. Characteristics such as Guru-Laghu, Snigdha-Ruksha, and Sheeta-Ushna contribute significantly to the pharmacological profile of medicinal plants and play an essential role in predicting therapeutic responses. [9]

2.3 Virya: Virya denotes the active potency responsible for the immediate therapeutic action of a drug. Although several classifications exist, Ushna Virya and Sheeta Virya are most commonly recognized in clinical practice. Virya exerts a dominant influence on physiological processes and frequently determines the direction and intensity of pharmacological responses. It is therefore considered one of the most important determinants of drug efficacy in Ayurvedic pharmacology. [10]

2.4 Vipaka: Vipaka refers to the final effect of a medicinal substance following digestion, absorption, and metabolism. Ayurveda classifies Vipaka into three categories: Madhura, Amla, and Katu. Unlike Rasa, which reflects immediate sensory perception, Vipaka represents the ultimate physiological consequences of a drug after biotransformation. This concept provides insights into the long-term effects of medicinal plants on metabolism, tissue nourishment, and homeostasis. [11]

2.5 Prabhava: Prabhava is defined as the unique and specific action of a medicinal substance that cannot be fully explained by Rasa, Guna, Virya, or Vipaka. Classical Ayurvedic scholars introduced this concept to account for exceptional therapeutic effects observed in certain drugs. From a contemporary perspective, Prabhava may reflect the influence of unique phytochemical constituents, synergistic interactions, or specific molecular mechanisms responsible for distinctive biological activities. [12] The collective assessment of Rasa, Guna, Virya, Vipaka, and Prabhava provides a multidimensional framework for evaluating medicinal substances. Unlike conventional pharmacology, which often focuses on individual active compounds, Rasa Panchaka considers the overall characteristics of a drug and its interaction with the living system. This holistic perspective forms the basis for exploring potential relationships between Ayurvedic pharmacodynamics and modern phytochemical science. [13]

III. BIOACTIVE PHYTOCONSTITUENTS OF MEDICINAL PLANTS

Medicinal plants synthesize a wide range of secondary metabolites that contribute significantly to their therapeutic properties. These bioactive phytoconstituents are responsible for various pharmacological activities and serve as the scientific basis for many traditional medicinal applications. Modern phytochemical investigations have identified numerous classes of compounds including alkaloids, flavonoids, terpenoids, glycosides, tannins, phenolics, and saponins. These constituents exhibit diverse biological effects and have attracted considerable interest in drug discovery and pharmacological research. [14]

Table 2. Major Classes of Bioactive Phytoconstituents and Their Pharmacological Activities

Phytoconstituent Class	Major Sources	Important Pharmacological Activities
Alkaloids	Guduchi, Nimba, Ashwagandha	Antimicrobial, analgesic, neuroprotective
Flavonoids	Amalaki, Yashtimadhu	Antioxidant, anti-inflammatory
Terpenoids	Haridra, Tulsi	Hepatoprotective, antimicrobial
Glycosides	Arjuna, Guduchi	Cardioprotective, immunomodulatory
Tannins	Lodhra, Arjuna	Astringent, wound-healing
Phenolic Compounds	Haridra, Amalaki	Antioxidant, anti-inflammatory

3.1 Alkaloids: Alkaloids are nitrogen-containing organic compounds widely distributed in medicinal plants. They are recognized for their potent physiological and pharmacological activities, including antimicrobial, analgesic, antimalarial, neuroprotective, and anti-inflammatory effects. Many clinically important drugs have originated from plant-derived alkaloids, highlighting their significance in modern therapeutics. The presence of alkaloids often contributes to the characteristic bitterness of medicinal plants and may influence their therapeutic profile. [15]

3.2 Flavonoids: Flavonoids constitute one of the largest groups of plant polyphenols and are known for their remarkable antioxidant properties. These compounds protect cells against oxidative stress by scavenging free radicals and modulating inflammatory pathways. In addition to antioxidant activity, flavonoids exhibit cardioprotective, hepatoprotective, anticancer, and immunomodulatory effects. Their widespread occurrence in medicinal plants has made them a major focus of pharmacological investigations. [16]

3.3 Terpenoids: Terpenoids represent a structurally diverse class of phytochemicals synthesized from isoprene units. They are responsible for many aromatic properties of medicinal plants and contribute significantly to their biological activities. Numerous terpenoids possess anti-inflammatory, antimicrobial, hepatoprotective, antidiabetic, and anticancer effects. Owing to their broad therapeutic potential, terpenoids are considered among the most valuable classes of natural products in medicinal research. [17]

3.4 Glycosides: Glycosides are compounds composed of a sugar moiety linked to a non-sugar component known as an aglycone. These substances exhibit a wide spectrum of biological activities depending on their chemical structure. Cardiac glycosides, saponin glycosides, and phenolic glycosides have demonstrated important pharmacological effects including cardioprotective, adaptogenic, anti-inflammatory, and immunomodulatory activities. Their therapeutic significance has been extensively documented in both traditional and modern medicine. [18]

3.5 Tannins and Phenolic Compounds

Tannins and phenolic compounds are widely distributed plant metabolites characterized by strong antioxidant activity. These compounds protect biological systems from oxidative damage and contribute to wound healing, antimicrobial activity, tissue protection, and anti-inflammatory effects. Medicinal plants rich in tannins frequently exhibit astringent properties, whereas phenolic compounds are often associated with broad-spectrum therapeutic activities. Their role in disease prevention and health promotion has been increasingly recognized in contemporary pharmacological research. [19] Collectively, bioactive phytoconstituents represent the chemical basis of medicinal plant activity and provide measurable parameters for scientific investigation. Understanding the nature and pharmacological functions of these compounds is essential for establishing correlations between traditional Ayurvedic concepts and modern phytochemical science. Such an approach may facilitate a deeper understanding of how classical descriptions of medicinal plants correspond to experimentally validated biological activities. [20]

IV. RELATIONSHIP BETWEEN RASA PANCHAKA AND BIOACTIVE PHYTOCONSTITUENTS

The growing convergence of Ayurvedic pharmacology and modern phytochemical research has provided new opportunities to understand the scientific basis of traditional medicinal knowledge. Although Rasa Panchaka and phytochemistry originate from distinct epistemological systems, both seek to explain the therapeutic actions of medicinal plants. Recent evidence suggests that specific Ayurvedic attributes may correspond with particular classes of phytoconstituents and their associated pharmacological activities. Such correlations offer a promising framework for integrative pharmacology and evidence-based interpretation of Ayurvedic principles. [21]

Table 3. Correlation Between Rasa, Phytoconstituent Classes, and Pharmacological Activities

Rasa	Common Phytoconstituents	Major Pharmacological Activities
Madhura	Polysaccharides, saponins, glycosides	Adaptogenic, immunomodulatory, rejuvenative
Amla	Organic acids, vitamin C, phenolics	Antioxidant, digestive stimulant
Lavana	Mineral salts and trace elements	Electrolyte balance, digestive action
Katu	Alkaloids, volatile oils, terpenoids	Antimicrobial, carminative, anti-obesity
Tikta	Alkaloids, diterpenes, glycosides	Anti-inflammatory, hepatoprotective
Kashaya	Tannins, flavonoids, polyphenols	Astringent, wound-healing, antioxidant

4.1 Correlation of Rasa with Phytochemical Classes

Among the components of Rasa Panchaka, Rasa demonstrates the most direct relationship with phytochemical composition. Taste perception arises from interactions between chemical constituents and sensory receptors, making it a practical indicator of underlying phytochemistry. Bitter (Tikta) medicinal plants frequently contain alkaloids, glycosides, and diterpenoids, which are associated with anti-inflammatory, antimicrobial, and hepatoprotective activities. Similarly, astringent (Kashaya) drugs are often rich in tannins and polyphenols that contribute to antioxidant and tissue-protective effects. These observations suggest that Rasa may serve as an indirect marker of bioactive phytoconstituents. [22]

4.2 Correlation of Guna with Physicochemical Characteristics

Guna describes the intrinsic physical and functional qualities of medicinal substances and may reflect physicochemical properties relevant to pharmacological behavior. For example, Snigdha Guna may correspond to lipid-soluble constituents such as terpenoids and fixed oils, while Ruksha Guna may be associated with tannin-rich substances possessing drying and adsorptive effects. Likewise, Guru Guna may indicate the presence of nutrient-rich macromolecules, whereas Laghu Guna may reflect compounds characterized by rapid absorption and metabolism. Such interpretations provide a bridge between traditional Ayurvedic descriptions and contemporary pharmaceutical science. [23]

Table 4. Possible Relationship Between Guna and Phytochemical Characteristics

Guna	Possible Phytochemical Association	Therapeutic Relevance
Guru	Nutrient-rich compounds, polysaccharides	Nourishing, anabolic
Laghu	Low molecular weight compounds	Easily digestible, metabolic enhancement
Snigdha	Lipids, essential oils, terpenoids	Lubricating, rejuvenative
Ruksha	Tannins, polyphenols	Drying, reducing
Sheeta	Cooling phytochemicals, flavonoids	Anti-inflammatory
Ushna	Volatile oils, pungent alkaloids	Stimulant, digestive

4.3 Correlation of Virya with Pharmacodynamic Effects

Virya represents the active potency responsible for the immediate physiological effects of medicinal substances. Modern pharmacological observations indicate that Ushna Virya drugs often contain pungent alkaloids, volatile oils, and terpenoids capable of stimulating metabolism, enhancing circulation, and exerting antimicrobial effects. Conversely, Sheeta Virya drugs are frequently rich in flavonoids, phenolics, and antioxidant compounds that produce cooling, anti-inflammatory, and tissue-protective actions. These correlations suggest that Virya may reflect the dominant pharmacodynamic influence of specific phytochemical groups. [24]

4.4 Correlation of Vipaka with Metabolic Outcomes

The Ayurvedic concept of Vipaka refers to the final physiological effect of a drug following digestion and metabolism. Contemporary pharmacology recognizes that metabolites generated during biotransformation often contribute significantly to therapeutic outcomes. In this context, Vipaka may be interpreted as a traditional representation of post-metabolic pharmacological effects. Understanding the relationship between phytochemical metabolism and Vipaka may provide valuable insights into the long-term actions of medicinal plants. [25]

4.5 Scientific Interpretation of Prabhava

Prabhava remains one of the most distinctive and scientifically intriguing concepts in Ayurvedic pharmacology. It describes unique therapeutic actions that cannot be adequately explained by other components of Rasa Panchaka. From a phytochemical perspective, Prabhava may result from specific bioactive molecules, synergistic interactions among multiple constituents, or novel molecular mechanisms not apparent through conventional classification systems. This concept highlights the complexity of herbal medicines and the importance of considering whole-plant interactions rather than isolated compounds alone. [26]

The available evidence indicates that meaningful relationships exist between Rasa Panchaka attributes and bioactive phytoconstituents. Although these correlations require further validation through systematic research, they provide a valuable framework for integrating Ayurvedic pharmacodynamics with modern phytochemistry. Such an integrative approach may enhance understanding of medicinal plant activity, facilitate evidence-based validation of traditional knowledge, and contribute to future pharmacological discoveries. [27]

V. EVIDENCE FROM SELECTED MEDICINAL PLANTS

The relationship between Rasa Panchaka and bioactive phytoconstituents can be better understood through the analysis of medicinal plants that have been extensively investigated in both Ayurvedic literature and modern pharmacological research. Several medicinal plants demonstrate remarkable concordance between their classical Ayurvedic attributes and experimentally validated phytochemical and pharmacological profiles. These examples provide practical evidence supporting the integrative pharmacological framework proposed in this review. [28]

Table 5. Correlation Between Rasa Panchaka, Phytoconstituents, and Pharmacological Activities of Selected Medicinal Plants

Medicinal Plant	Dominant Rasa Panchaka Attributes	Major Phytoconstituents	Validated Pharmacological Activities
Guduchi (Tinospora cordifolia)	Tikta Rasa, Ushna Virya	Alkaloids, diterpenoids, glycosides	Immunomodulatory, hepatoprotective, anti-inflammatory
Ashwagandha (Withania somnifera)	Tikta-Kashaya Rasa, Madhura Vipaka	Withanolides, alkaloids	Adaptogenic, antioxidant, neuroprotective
Haridra (Curcuma longa)	Tikta-Katu Rasa, Ushna Virya	Curcuminoids, terpenoids	Anti-inflammatory, antioxidant, antimicrobial
Yashtimadhu (Glycyrrhiza glabra)	Madhura Rasa, Sheeta Virya	Glycyrrhizin, flavonoids	Anti-ulcer, immunomodulatory, hepatoprotective
Nimba (Azadirachta indica)	Tikta-Kashaya Rasa	Limonoids, flavonoids, tannins	Antimicrobial, anti-inflammatory, antioxidant

5.1 Guduchi (Tinospora cordifolia)
Guduchi is one of the most extensively studied Ayurvedic medicinal plants and is traditionally described as possessing Tikta Rasa, Guru Guna, Ushna Virya, and Madhura Vipaka. Phytochemical investigations have identified alkaloids, diterpenoids, glycosides, and polysaccharides as major constituents. Modern pharmacological studies have demonstrated immunomodulatory, hepatoprotective, antioxidant, and anti-inflammatory activities that correspond closely with its Ayurvedic therapeutic indications. [29]

5.2 Ashwagandha (Withania somnifera)
Ashwagandha possesses Tikta-Kashaya Rasa, Guru-Snigdha Guna, Ushna Virya, and Madhura Vipaka. The plant contains withanolides, alkaloids, and steroidal lactones that contribute to its biological activity. Scientific investigations have validated its adaptogenic, neuroprotective, anti-stress, antioxidant, and immunomodulatory effects. These findings support the Ayurvedic description of Ashwagandha as a potent Rasayana drug. [30]

5.3 Haridra (Curcuma longa)
Haridra is characterized by Tikta-Katu Rasa, Laghu-Ruksha Guna, Ushna Virya, and Katu Vipaka. Curcuminoids and volatile oils constitute its principal phytochemical components. Numerous studies have confirmed its anti-inflammatory, antioxidant, antimicrobial, hepatoprotective, and antidiabetic properties. The observed pharmacological activities align closely with therapeutic actions predicted through its Rasa Panchaka profile. [31]

5.4 Yashtimadhu (Glycyrrhiza glabra)
Yashtimadhu possesses Madhura Rasa, Guru-Snigdha Guna, Sheeta Virya, and Madhura Vipaka. The plant is rich in glycyrrhizin, flavonoids, and triterpenoid saponins. Modern research has demonstrated anti-ulcer, anti-inflammatory, hepatoprotective, antioxidant, and immunomodulatory activities. The nourishing and tissue-protective effects described in Ayurveda correspond well with its phytochemical composition and pharmacological profile. [32]

5.5 Nimba (Azadirachta indica)

Nimba is predominantly characterized by Tikta-Kashaya Rasa, Laghu Guna, and Sheeta Virya. It contains limonoids, flavonoids, tannins, and various bitter principles responsible for its medicinal properties. Scientific studies have validated antimicrobial, antioxidant, anti-inflammatory, antidiabetic, and immunomodulatory activities. The strong correlation between its bitter taste, phytochemical composition, and therapeutic actions illustrates the predictive value of Ayurvedic drug characterization. [33] The examples discussed above demonstrate substantial agreement between traditional Ayurvedic descriptions and contemporary phytochemical evidence. The observed relationships suggest that Rasa Panchaka may reflect underlying phytochemical patterns that contribute to the biological activities of medicinal plants. Such findings support the integration of Ayurvedic pharmacodynamics with modern phytochemical science and provide a promising foundation for future evidence-based herbal research. [34]

VI. CONCLUSION

The integration of Ayurvedic pharmacology with contemporary phytochemical science offers a valuable approach for understanding the therapeutic potential of medicinal plants. The present review highlights that Rasa Panchaka, the classical pharmacodynamic framework of Ayurveda, provides more than a descriptive classification of medicinal substances; it represents a systematic method for predicting biological activity and therapeutic outcomes. The five components of Rasa Panchaka Rasa, Guna, Virya, Vipaka, and Prabhava collectively describe the multidimensional nature of medicinal plants and their interactions with the human body.

Analysis of available scientific evidence indicates meaningful associations between traditional Ayurvedic attributes and bioactive phytoconstituents. Specific Rasas appear to correlate with characteristic classes of phytochemicals, while Guna and Virya may reflect physicochemical properties and pharmacodynamic responses. Likewise, Vipaka can be interpreted in relation to metabolic transformations and long-term physiological effects, whereas Prabhava may represent unique pharmacological actions arising from complex phytochemical interactions. The examples of Guduchi, Ashwagandha, Haridra, Yashtimadhu, and Nimba demonstrate substantial agreement between Ayurvedic descriptions and experimentally validated pharmacological activities.

These observations suggest that Rasa Panchaka may serve as a traditional indicator of phytochemical composition and biological activity, thereby providing a bridge between classical Ayurvedic knowledge and modern pharmacological science. Although further interdisciplinary research is required to establish definitive mechanistic correlations, the available evidence supports the relevance of integrative pharmacology as a framework for exploring medicinal plants. Such an approach may strengthen evidence-based Ayurveda, facilitate rational herbal drug development, and contribute to future innovations in natural product research and healthcare.

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