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Review Article

PRECISION NUTRITION FOR GUT HEALTH: BRIDGING GUT MICROBIOME SCIENCE AND AYURVEDIC *AHARA* PRINCIPLES

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ABSTRACT

The gut microbiome is increasingly recognised as a key determinant of digestive, metabolic and immune health. Ayurveda has traditionally advocated individualised dietary planning through concepts including *Prakriti* (constitutional phenotype), *Agni* (digestive and metabolic capacity), *Dosha* status, *Ahara* (diet), and *Pathya* (wholesome dietary practices) emphasising that dietary recommendations should be tailored according to individual characteristics. This review explores the relationship between gut microbiome science and precision nutrition and examines their conceptual convergence with Ayurvedic dietary principles. Current evidence indicates that the gut microbiome significantly influences nutrient metabolism, dietary responses, and disease susceptibility, supporting personalised nutritional strategies. Studies investigating associations between constitutional phenotypes and gut microbial profiles have provided insights into integrating Ayurvedic concepts with contemporary microbiome science. Furthermore, technological advances including next-generation sequencing, metabolomics, artificial intelligence, and digital health platforms further facilitate individualised dietary interventions. Although direct equivalence between Ayurvedic concepts and modern biomedical constructs cannot be established, meaningful conceptual parallels exist. While precision nutrition relies on microbiome science, multi-omics technologies, and artificial intelligence, Ayurveda employs constitution-based assessment and digestive capacity to guide dietary planning. Integrating these complementary approaches may support personalised gut health management, sustainable dietary interventions, preventive healthcare strategies, and improved dietary counselling. Further interdisciplinary research and well-designed clinical studies are required to validate these approaches and facilitate their application in evidence-informed healthcare.

INTRODUCTION

The gut microbiome plays a critical role in digestion, metabolism, immune regulation and maintenance of overall health.[1,2] Increasing recognition of inter-individual variability in dietary responses has led to the emergence of precision nutrition, which aims to develop personalised dietary recommendations based on biological characteristics including gut microbial composition.[3,4] Ayurveda has long advocated an individualised approach to diet through concepts such as *Ahara* (diet), *Prakriti* (constitutional phenotype) and *Agni* (digestive and metabolic capacity). This review explores the convergence of contemporary precision nutrition and Ayurvedic dietary principles and discusses the potential role of technological innovations in promoting personalised gut health.

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METHODS

A structured narrative review was undertaken to explore the emerging relationship between precision nutrition, gut microbiome science, and Ayurvedic dietary principles. Relevant literature published in English was retrieved from PubMed, Scopus, Google Scholar, and Web of Science databases.

Additional relevant publications were identified through manual screening of reference lists. Classical Ayurvedic concepts related to diet, digestion, and individual constitution were reviewed from

authoritative texts including *Charaka Samhita*, *Sushruta Samhita*, *Ashtanga Hridaya*, and *Kashyapa Samhita.*

Priority was given to studies addressing diet–microbiome interactions, personalised nutrition approaches, microbiome-based technologies, and Ayurvedic concepts of individualised dietary planning. The retrieved literature was critically examined and narratively synthesised to identify conceptual parallels, emerging evidence, and opportunities for integrating contemporary precision nutrition strategies with Ayurvedic dietary principles for the promotion of gut health.

Gut Microbiome and Precision Nutrition

The human gastrointestinal tract harbours a complex and dynamic community of microorganisms collectively known as the gut microbiome. This microbial ecosystem consists predominantly of bacteria, along with viruses, fungi and archaea, which collectively influence digestion, metabolism, immune regulation and maintenance of intestinal homeostasis.[1,2] The gut microbiome has increasingly been recognised as a key determinant of health, with disturbances in microbial composition and function, termed dysbiosis, being associated with obesity, metabolic syndrome, inflammatory bowel disease, type 2 diabetes mellitus and several neuropsychiatric disorders.[5,6]

Diet is one of the most influential factors shaping the composition and metabolic activity of the gut microbiota. Dietary patterns rich in microbiota-accessible carbohydrates, dietary fibre and fermented foods promote microbial diversity and enhance the production of beneficial microbial metabolites, including short-chain fatty acids (SCFAs) such as acetate, propionate and butyrate.[7,8] These metabolites contribute to maintenance of intestinal barrier integrity, modulation of immune responses and regulation of host metabolism. Conversely, diets rich in refined carbohydrates, saturated fats and ultra-processed foods may reduce microbial diversity and promote dysbiosis, thereby increasing susceptibility to chronic diseases.[7,8] Conventional nutritional recommendations are generally designed for populations and often fail to account for individual biological variability. However, growing evidence indicates that individuals exhibit markedly different physiological responses to identical foods. Variations in genetics, lifestyle, environmental exposures and gut microbial composition contribute significantly to these differences.[9] In a landmark study, Zeevi and colleagues demonstrated considerable inter-individual variability in postprandial glycaemic responses to similar meals and showed that these responses could be predicted using clinical and microbiome-related parameters.[3]

These findings have led to the emergence of precision nutrition, an approach that seeks to provide personalised dietary recommendations based on individual characteristics, including genomic, metabolomic and microbiomic profiles.[4] Unlike conventional dietary guidelines, precision nutrition acknowledges that dietary interventions should be tailored to the unique biological makeup of each individual to achieve optimal health outcomes.[4,10] Recent advances in microbiome research have substantially strengthened the scientific foundation of precision nutrition. High-throughput technologies such as 16S ribosomal RNA sequencing, shotgun metagenomics, meta transcriptomics and metabolomics allow comprehensive assessment of microbial composition and function.[11] These technologies facilitate identification of microbial biomarkers associated with dietary responses, disease susceptibility and therapeutic outcomes. Consequently, microbiome-guided dietary interventions are increasingly being explored as tools for disease prevention and personalised healthcare.[11,12]

The relationship between diet and the gut microbiome is bidirectional. While dietary components shape microbial communities, microbial metabolism influences nutrient bioavailability, energy extraction and production of bioactive compounds that affect host physiology.[13] Therefore, individuals consuming similar diets may experience different health outcomes depending on their microbial composition and metabolic potential. This concept forms the cornerstone of microbiome-based precision nutrition.[13,14]

Advances in artificial intelligence, machine learning, digital dietary monitoring and multi-omics integration have further expanded the scope of precision nutrition.[15] These technological innovations enable prediction of individual dietary responses and development of customised nutritional strategies. As a result, precision nutrition represents a transformative paradigm that shifts nutritional science from a population-based approach towards truly personalised healthcare.[16]

Ayurvedic Concepts Relevant to Personalised Nutrition

Long before the emergence of modern personalised nutrition, Ayurveda recognised the importance of individual variability in dietary planning. Rather than advocating a universal dietary regimen, Ayurvedic dietary recommendations are tailored according to factors such as *Prakriti*, *Agni*, *Bala*, *Desha*, *Kaala*, *Satva*, *Satmya*, age (*Vaya*), disease status, and an individual's digestive (*Jarana Shakti*) and food intake (*Abhyavaharana Shakti*) capacities.[17] This individual-centred approach forms the foundation

of Ayurvedic nutrition and closely resembles the contemporary concept of precision nutrition.

Ahara (Diet)

Ayurveda regards *Ahara* as one of the three fundamental pillars of life and considers proper diet essential for growth, health maintenance, and disease prevention. Classical texts describe food not only as a source of nourishment but also as a determinant of strength, vitality, complexion, and longevity.[18] Acharya Kashyapa further emphasised its importance by describing *Ahara* as *Mahabhaishajya* (the supreme medicine), highlighting its role in health preservation and disease prevention.[19]

Ayurvedic dietary recommendations extend beyond nutritional composition and incorporate factors influencing individual dietary responses. The concept of *Ashta Ahara Vidhi Vishesha Ayatana* describes eight determinants of dietary effectiveness: *Prakriti* (constitution), *Karana* (processing), *Samyoga* (combination), *Rashi* (quantity), *Desha* (habitat), *Kala* (time), *Upayoga Samstha* (rules of intake), and *Upayokta* (consumer characteristics).[20] In addition, *Ahara Vidhi Vidhana* provides guidance regarding the manner of eating, attention during meals, pace of consumption, and consideration of hunger and digestive capacity.[20] These principles emphasize that the effects of food depend not only on what is consumed but also on how, when, and by whom it is consumed.

Several foods described in *Annasvarupa Vijnaniya Adhyaya* exhibit functional similarities to modern prebiotic and probiotic interventions. Fibre-rich grains, legumes, and fruits may support microbial fermentation and short-chain fatty acid production, whereas fermented foods such as curd and buttermilk may promote beneficial microbial populations.[11,16,21] When selected according to *Prakriti* and *Agni*, such dietary practices may influence gut microbial composition and function. Ayurveda also recommends dietary modifications during different stages of disease progression. During the *Sanchaya* stage of *Kriyakala*, foods and lifestyle measures possessing qualities opposite to the accumulating *Dosha* are advised to prevent disease progression.[17] Collectively, these principles highlight Ayurveda's longstanding emphasis on personalised dietary planning.

Agni (Digestive and Metabolic Capacity)

Among the determinants of health, *Agni* occupies a central position in Ayurveda. Proper functioning of *Agni* is considered essential for digestion, absorption, assimilation, and metabolism, whereas impaired *Agni* is regarded as a major contributor to disease development.[22] Digestive and metabolic status may be assessed through *Jarana Shakti*, which reflects an individual's capacity to digest and utilise food effectively.

Ayurveda describes different functional states of *Agni*, including balanced, diminished, irregular, and excessive digestive capacity.[23,24,25] Individuals with different states of *Agni* may respond differently to the same food, resulting in variations in digestion and metabolism. This concept parallels contemporary observations of inter-individual variability in metabolic responses to dietary interventions.

Ayurveda also recognises *Koshta* (gastrointestinal functional constitution) as an important determinant of dietary suitability. Depending on *Dosha* predominance, individuals may exhibit *Krura Koshta*, *Mridu Koshta*, or *Madhyama Koshta*, influencing bowel habits, digestion, food tolerance, and response to dietary interventions.[23] Assessment of *Koshta* therefore contributes to dietary individualisation.

The concept of *Ama* is closely linked to impaired digestive function and is described as a harmful product resulting from incomplete digestion and metabolism.[26] Although *Ama* cannot be directly equated with any single biomedical entity, it has been proposed to share conceptual similarities with metabolic dysfunction, inflammatory processes, and disturbances in gut microbial ecology.[27,28] Together, these concepts emphasise Ayurveda's recognition of digestive individuality and the need for tailored dietary recommendations.

Prakriti (Constitutional Phenotype)

Prakriti refers to the inherent psycho-physiological constitution of an individual determined by varying predominance of *Vata*, *Pitta*, and *Kapha*. It influences physical characteristics, physiological functions, disease susceptibility, and dietary preferences.[29,30] The concept of *Prakriti* represents one of the earliest documented models of biological individuality and forms the basis of constitution-specific dietary recommendations.

Ayurveda recognises that foods beneficial for one individual may not be suitable for another. Dietary advice is therefore tailored according to constitutional characteristics. Individuals with predominant *Vata*, *Pitta*, or *Kapha* constitutions are advised to consume foods that help maintain physiological balance. *Vata* individuals commonly exhibit *Vishamagni* and are advised to consume light, nourishing foods; *Pitta* individuals with *Tikshnagni* are generally suited to moderate quantities of cooling foods; whereas *Kapha* individuals with *Mandagni* benefit from light and easily digestible diets.

Table 1: *Prakriti*-Based Dietary Characteristics and Food Preferences

Prakriti Type	**Astangahrdaya**	**Charaka**	**Susruta**
Vata	*Bahubhuja* (eats lot of food) *Madhura-amla-padu- ushana satmyakamsha* (desire for food that are sweet, sour, salty, and hot)	Due to *Laghu guna* of *Vata*, consumes *Laghu ahara*	*Dandakhadi*
Pitta	*Teekshna trishna- bubhuksha* (increased thirst and voracious appetite) *Bhukte annam Madhura-kashaya-tikta-seetam* (consumes food of sweet, astringent and bitter taste which is cool) *Bhuri paana-asana* (increased thirst and hunger)	Due to *Usna guna – Kshut-pipasavanta* Due to *Tikshna guna – Teekshna agnayah*, *prabhuta asana-paana* (increased consumption of food and drinks) *Dandasooka*	*Bahubhuk* (eats lot of food)
Kapha	*Kshut-thrit apapta* (unaffected by hunger and thirst) *Tiktam-kashaym- kadu-ushnam-rooksham-alpam sa bhunkte* (consumes food of bitter, astringent, spicy tastes, hot, dry and in less quantity) *Alpa pana-asana* (consumption of food and drinks will be less)	Due to *Manda guna* – consumes *Manda ahara* Due to *Seeta guna – Alpa Kshut-trishna* (reduced hunger and thirst)	*Madhura Priya* (desire for sweet taste)

Emerging microbiome studies have reported constitution-associated differences in gut microbial composition among individuals belonging to different *Prakriti* groups.[31,32] Distinct microbial signatures and variations in bacterial abundance have been observed among *Vata*-, *Pitta*-, and *Kapha*-dominant individuals, suggesting that constitutional assessment may capture biologically relevant variability within the gut ecosystem. For example, *Vata*-dominant individuals have been associated with enrichment of certain fibre-degrading and metabolically diverse taxa, whereas *Pitta* and *Kapha* constitutions have shown distinct microbial communities related to metabolic and energy-harvesting functions.[31] Although these findings remain preliminary and population-specific, they provide support for potential biological correlates of *Prakriti* and warrant further investigation in personalised nutrition and gut health research.

Pathya and *Apathya*

Ayurveda places considerable emphasis on *Pathya* (wholesome diet and lifestyle) and *Apathya* (unwholesome diet and lifestyle). The suitability of food depends not only on its intrinsic properties but also on an individual's constitution, digestive capacity, disease condition, and environmental context.[33] Consequently, a dietary item considered beneficial for one individual may be unsuitable for another. This principle is elaborated in the *Hitahitiya Adhyaya* of *Sushruta Samhita*, where substances are classified as universally beneficial (*Ekanta Hita*), universally harmful (*Ekanta Ahita*), or conditionally beneficial and harmful depending on context (*Hitaahita*).[33] Thus, the concepts of *Pathya* and *Apathya* reinforce the Ayurvedic view that dietary recommendations should be individualised rather than universally prescribed. This principle closely aligns with the central philosophy of modern precision nutrition.

Convergence of Precision Nutrition and Ayurvedic Principles

Precision nutrition and Ayurveda, although developed in different scientific and historical contexts, share the fundamental principle that dietary recommendations should be individualised rather than universally prescribed. Both recognise that biological variability influences dietary responses and that nutritional interventions should be tailored to individual characteristics.

A central concept of precision nutrition is biological individuality, whereby genetic, metabolic, lifestyle and gut microbiome differences influence responses to food.[4,10] Similarly, Ayurveda recognises inter-individual variability through the concept of *Prakriti* (constitutional phenotype), which forms the basis for personalised dietary and lifestyle

recommendations. Individuals with different constitutions are advised to follow dietary practices that help maintain physiological balance and reduce disease susceptibility.[33]

Another important area of convergence relates to digestive and metabolic function. Contemporary nutritional science acknowledges that nutrient absorption, metabolism and physiological responses vary among individuals due to host and microbial factors.[14] Ayurveda attributes such variability primarily to differences in *Agni* (digestive and metabolic capacity). Balanced *Agni* is considered essential for optimal nourishment, whereas impaired *Agni* may contribute to disease development.[22]

The gut microbiome has emerged as a major determinant of individual dietary responses, influencing nutrient metabolism, production of microbial metabolites and overall health outcomes.[13] Several studies have demonstrated that microbial signatures can predict responses to dietary interventions, highlighting the importance of microbiome-based personalisation.[3] Although Ayurveda does not explicitly describe microorganisms in the modern sense, its emphasis on digestive function, dietary suitability and physiological balance provides a broader conceptual framework for understanding gut health. These similarities should be viewed as complementary perspectives rather than direct equivalences.

The concept of *Ama* has attracted interest in integrative research. Classical Ayurvedic texts describe *Ama* as a pathological product of impaired digestion and metabolism. Contemporary authors have proposed possible associations with metabolic dysfunction, chronic inflammation and disturbances in gut microbial homeostasis.[27] However, these interpretations remain theoretical and require further scientific validation.

Diet–microbiome interactions also exhibit similarities to Ayurvedic dietary principles. Precision nutrition recognises that foods exert variable physiological effects depending on individual biological characteristics.[12] Ayurveda similarly emphasises that dietary suitability depends on factors such as constitution, digestive capacity, season, habitat and disease condition. This principle is reflected in the concepts of *Pathya* and *Apathya*, which advocate context-specific dietary recommendations.[33]

Emerging studies reporting associations between *Prakriti* classifications and distinct gut microbial profiles have further strengthened interest in this field.[31,32] Although current evidence is preliminary, it suggests that traditional constitutional assessment may capture biologically relevant variability within the gut ecosystem.

Integration of precision nutrition and Ayurvedic principles may provide a comprehensive framework for personalised gut health management. Modern technologies offer objective insights into microbial composition and metabolic responses, whereas Ayurveda contributes a holistic perspective encompassing constitution, digestion, lifestyle and environmental influences. However, robust clinical evidence remains limited. Standardisation of Ayurvedic assessment methods, validation of constitutional classifications and large-scale interdisciplinary studies are required before such integrative models can be routinely applied in clinical practice.

Technological Innovations Enabling Integration of Precision Nutrition and Ayurvedic Dietary Principles

Advances in biotechnology, computational sciences and digital health have transformed the understanding of diet–microbiome interactions and accelerated the development of precision nutrition. These innovations facilitate characterisation of individual biological variability and support the design of personalised dietary interventions aimed at improving gut health.[16]

Microbiome Sequencing and Multi-Omics Technologies

Next-generation sequencing technologies, including 16S ribosomal RNA gene sequencing and shotgun metagenomics, have revolutionised gut microbiome research by enabling detailed analysis of microbial diversity, composition and functional potential.[11] These approaches facilitate identification of microbial signatures associated with dietary patterns, metabolic disorders and gastrointestinal diseases, thereby supporting microbiome-guided dietary recommendations.[12] Metagenomic analyses also provide insights into microbial genes involved in nutrient metabolism and bioactive compound production, improving understanding of individual dietary responses.[13]

Precision nutrition increasingly integrates genomics, metabolomics, proteomics and microbiomics through multi-omics approaches.[10] Among these, metabolomics is particularly valuable because it identifies metabolites generated through interactions between diet, host metabolism and gut microorganisms. Such biomarkers may improve prediction of dietary responses and disease risk, thereby enhancing the precision of personalised nutritional interventions.[34]

Artificial Intelligence and Digital Health

Artificial intelligence (AI) and machine learning enable analysis of complex datasets comprising dietary records, microbiome profiles, clinical parameters and lifestyle information to predict individual responses to

foods.[15] Predictive models have demonstrated the ability to estimate postprandial glycaemic responses and generate personalised dietary recommendations based on microbiome-derived information.[3] Mobile health applications, wearable devices and digital dietary assessment platforms further support continuous monitoring of dietary intake and physiological parameters, enabling real-time personalised feedback.[35]

Relevance to Ayurveda

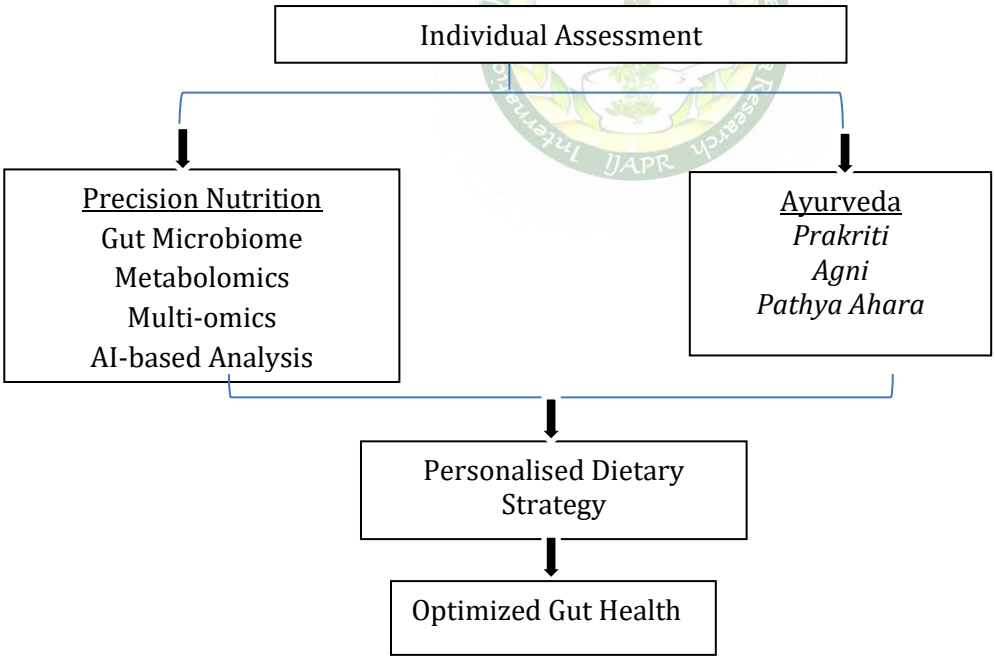
Although Ayurveda evolved before the advent of modern technologies, these innovations provide opportunities to objectively investigate traditional concepts related to *Prakriti*, *Agni* and dietary suitability. Emerging studies linking *Prakriti* classifications with gut microbial profiles illustrate the potential for interdisciplinary research integrating traditional Ayurvedic knowledge with contemporary scientific methodologies.[31,32]

Technological tools should be viewed as complementary rather than alternative approaches to Ayurvedic clinical assessment. Integration of microbiome science, multi-omics technologies, AI and traditional dietary principles may facilitate the development of evidence-informed personalised nutrition strategies for gut health.

Table 2: Emerging Technologies in Precision Nutrition and Their Potential Relevance to Ayurveda-Based Personalized Nutrition

Technology	Application in Precision Nutrition	Potential Relevance to Ayurveda
16S rRNA sequencing	Microbial profiling	Study of constitution-microbiome associations
Metagenomics	Functional microbial analysis	Understanding dietary responses
Metabolomics	Biomarker identification	Exploring metabolic correlates of digestive function
Artificial intelligence	Prediction of dietary responses	Personalised dietary recommendation systems
Mobile health applications	Dietary monitoring	Recording constitution-based dietary practices

Integrative Framework for Personalised Gut Health



Challenges and Future Directions

Despite growing interest in integrating precision nutrition with Ayurvedic dietary principles, several scientific and methodological challenges remain. Evidence supporting microbiome-based personalised nutrition is still evolving, and many reported associations between dietary patterns, microbial composition and health outcomes have not yet translated into universally accepted clinical recommendations.[36] Furthermore, inter-individual variability, population heterogeneity, differences in study design and lack of standardised methodologies continue to limit the reproducibility and generalisability of findings.[12]

From an Ayurvedic perspective, standardisation of traditional assessment methods remains a major challenge. Although concepts such as

Prakriti (constitutional phenotype), *Agni* (digestive and metabolic capacity) and *Pathya* (wholesome dietary practices) underpin personalised dietary recommendations, variations in assessment tools and practitioner interpretation may affect consistency across studies.[37] Development of validated and reproducible assessment methods is therefore essential.

Another important limitation involves interpretation of traditional Ayurvedic concepts within modern biomedical frameworks. While similarities have been proposed between *Agni*, *Ama* and gut microbial function, these relationships remain largely hypothetical and should not be regarded as direct equivalences without adequate scientific validation.[27] Future investigations should adopt rigorous interdisciplinary approaches that respect the theoretical foundations of both Ayurveda and contemporary biomedical science.

Advances in microbiome sequencing, metabolomics, artificial intelligence and digital health technologies offer promising opportunities for future research.[15] Longitudinal studies exploring relationships among dietary practices, *Prakriti*, gut microbiota and clinical outcomes may clarify the relevance of Ayurvedic principles in personalised nutrition. If constitution-associated microbial patterns are consistently validated, *Prakriti* assessment may provide a cost-effective and culturally acceptable framework for preliminary dietary individualisation. However, such applications require robust scientific validation.

Future research should prioritise large-scale clinical studies, standardised methodologies and interdisciplinary collaboration to develop evidence-informed models of personalised nutrition that integrate traditional Ayurvedic knowledge with emerging technological innovations.

CONCLUSION

The growing understanding of gut microbiome –diet interactions has strengthened the scientific basis of precision nutrition and highlighted the importance of individual variability in dietary responses. Although developed within different epistemological frameworks, precision nutrition and Ayurveda share the common principle that dietary recommendations should be tailored to individual characteristics. Ayurvedic concepts such as *Prakriti*, *Agni* and *Pathya* offer a holistic framework for personalised dietary planning, while contemporary technologies including microbiome profiling, multi-omics approaches and artificial intelligence provide objective tools for characterising biological variability.

Emerging evidence suggesting associations between constitutional phenotypes and gut microbial profiles provides a promising foundation for interdisciplinary research at the interface of Ayurveda and microbiome science. However, current evidence remains preliminary, and direct equivalence between traditional Ayurvedic concepts and modern biomedical constructs cannot be assumed. Further well-designed clinical studies, standardised assessment methods and rigorous interdisciplinary research are required to validate these relationships.

Integration of Ayurvedic dietary wisdom with advances in precision nutrition may contribute to the development of evidence-informed, culturally relevant and patient-centred approaches to personalised gut health management, disease prevention and nutritional counselling.

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