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Review Article

GUT HEALTH IN AYURVEDA: THERAPEUTIC MECHANISMS AND MICROBIOME INTERACTIONS

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ABSTRACT

The gut microbiota is a dynamic microbial ecosystem essential for digestion, metabolism, immune regulation, and overall health. Disruption of this ecosystem, known as dysbiosis, is associated with metabolic, inflammatory, and chronic diseases. Ayurveda explains gastrointestinal health through the interconnected concepts of *Agni*, *Ama*, and *Grahani* (the organ responsible for digestion and absorption). These concepts show important similarities to modern understandings of gut microbiome function and intestinal physiology. This narrative review examines the relationship between Ayurvedic principles and contemporary microbiome science. Balanced *Agni* corresponds to efficient digestion, microbial homeostasis, adequate short-chain fatty acid production, and maintenance of intestinal barrier integrity. In contrast, impaired *Agni* and *Ama* accumulation resemble dysbiosis, endotoxemia, oxidative stress, and increased intestinal permeability. *Grahani* dysfunction parallels conditions such as functional gastrointestinal disorders, malabsorption, and microbial imbalance. The review also highlights the microbiome-modulating potential of Ayurvedic interventions, including herbal formulations such as *Triphala, Guduchi*, *Haridra, Ashwagandha*, and *Kutaja,* along with *Ritucharya*, *Panchakarma*, and *Rasayana*. Emerging evidence suggests that these interventions may influence microbial composition, immune function, intestinal barrier health, and gut–organ axis communication. Integrating Ayurvedic concepts with microbiome research may provide a valuable framework for personalised gut health management and future therapeutic development.

INTRODUCTION

The human gut microbiota comprises approximately 38 trillion microorganisms that play vital roles in digestion, metabolism, immune regulation, and overall health.[1] Dysbiosis, or disruption of microbial balance, has been linked to several chronic disorders, including inflammatory bowel disease, obesity, type 2 diabetes, non-alcoholic fatty liver disease, and autoimmune diseases.[2] Ayurveda explains gastrointestinal health through the concepts of *Agni* (digestive fire), *Ama* (products of impaired digestion), and *Grahani* (the organ of digestion and absorption), which closely parallel modern concepts of gut microbiome function and intestinal physiology.[3]

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This review explores these conceptual relationships, summarizes evidence on Ayurvedic microbiome-modulating interventions, and examines their role in regulating gut–organ axis interactions and promoting health. Relevant literature was identified through PubMed, Google Scholar, Scopus, and ScienceDirect using keywords related to the gut microbiome, Ayurveda, gut dysbiosis, and associated therapeutic interventions. The objective of this review is to explore the relationship between Ayurveda and the gut microbiome, highlighting the role of Ayurvedic interventions in modulating gut microbiota and regulating gut–organ axis interactions to promote gastrointestinal and systemic health.

MATERIALS AND METHODS

This narrative review integrated classical Ayurvedic textual analysis with contemporary scientific evidence to explore the relationship between Ayurvedic concepts of gut health and modern microbiome science.

Classical Ayurvedic Sources

Primary sources included the *Charaka Samhita*, *Sushruta Samhita*, and *Ashtanga Hridaya.* Additional insights into *Grahani* physiology were obtained from the Kalaanveshan compendium. Sanskrit terminology was retained with English explanations to preserve conceptual accuracy.

Inclusion and Exclusion Criteria

Priority was given to randomised controlled trials, prospective clinical studies, systematic reviews, meta-analyses, and mechanistic investigations examining Ayurvedic interventions and gut microbiome modulation. Well-designed preclinical studies were included where clinical evidence was limited. Editorials, opinion articles, conference abstracts, and studies with significant methodological limitations were excluded.

RESULTS AND DISCUSSION

Ayurvedic Conceptual Framework of Gut Health

Agni: The Central Metabolic Regulator

Agni is the central metabolic force in Ayurveda, responsible for digestion, metabolism, immunity, and overall health. *Jatharagni*, the primary digestive fire, governs all other forms of *Agni*.[4] Its four states- *Sama, Manda, Tikshna*, and *Vishama*-correspond to healthy digestion, dysbiosis, inflammatory gut conditions, and functional gastrointestinal disorders, respectively.[5] The *Agni*–gut microbiome axis determines host physiology through two divergent pathways, as given in Flowchart 1. Thus, *Agni* serves as a useful conceptual framework linking digestion, metabolism, and microbial homeostasis.

Diet and Lifestyle	
↓	
Balanced *Agni (Sama Agni)*	Impaired Agni (*Manda / Vishama*)
↓	↓
Proper digestion & assimilation	Incomplete digestion
↓	↓
Healthy diverse microbiome	*Ama* formation
↓	↓
SCFA production (Butyrate, Propionate)	Dysbiosis & endotoxaemia (LPS ↑)
↓	↓
Intestinal barrier integrity (ZO-1, Occludin)	Increased gut permeability
↓	↓
Immune homeostasis (Treg, IgA ↑) (TNF-α, IL-6 ↑)	Systemic inflammation
↓	↓
Health	**Disease**

Flowchart 1: Agni–Gut Microbiome Axis- Divergent Physiological Pathways

Ama: Metabolic Toxin and Pathological Mediator

Ama is the toxic by-product of impaired digestion caused by *Agni* dysfunction.[6] It obstructs bodily channels, disturbs *Dosha* balance, and promotes disease. Conceptually, *Ama* parallels endotoxaemia, toxic microbial metabolites, oxidative stress, and intestinal barrier dysfunction associated with dysbiosis.[7] Ayurvedic management includes *Ama-pachana* (digestive correction using *Deepana-Pachana* herbs) and *Ama-shodhana* (elimination through *Panchakarma*), aiming to restore digestive and metabolic balance.[8]

Grahani: The Integrative Organ of Digestion and Absorption

Grahani, the principal seat of *Agni*, is responsible for digestion, absorption, retention, and discrimination of nutrients from waste.[9] Functionally, it corresponds to the small intestine and performs *Grahana, Dharana, Pachana, Shoshana, Munchana*, and *Vivechana*.[10] Impaired *Agni* leads to *Grahani* dysfunction, resulting in *Ama* formation, malabsorption, and altered bowel habits. These features closely resemble IBS, SIBO, and other chronic gastrointestinal disorders, linking Ayurvedic concepts

with modern understandings of dysbiosis and intestinal inflammation.[11]

The Gut Microbiome in Health and Disease

Composition and Metabolic Functions

The healthy gut microbiome is dominated by *Firmicutes* and *Bacteroidetes*, with contributions from Actinobacteria, Proteobacteria, and Verrucomicrobia.[2] It supports digestion, metabolism, immunity, and overall health by producing short-chain fatty acids (SCFAs), synthesising vitamins, regulating bile acid metabolism, and preventing pathogen colonisation. Additionally, the microbiota promotes mucosal immune responses and produces neuroactive compounds such as serotonin and GABA, contributing to gut–brain communication.[12]

Dysbiosis and Disease

Dysbiosis is an imbalance in gut microbiota characterised by reduced microbial diversity, altered bacterial composition, decreased SCFA production, and increased harmful metabolites such as LPS and uremic toxins.[13] It is associated with IBD, obesity, T2DM, NAFLD, autoimmune disorders, and neuropsychiatric diseases. Major mechanisms include increased intestinal permeability, chronic inflammation, immune dysregulation, and disturbed gut–organ communication.[14] These changes closely parallel the Ayurvedic concepts of impaired *Agni* and *Ama* accumulation, highlighting the central role of gut health in maintaining systemic homeostasis.

Gut Microbiome-Modulating Actions of Ayurvedic Herbs

Ayurvedic herbs support gut health through prebiotic, antimicrobial, immunomodulatory, and anti-inflammatory actions. They promote beneficial microbes, suppress pathogens, strengthen intestinal barrier function, and regulate inflammatory pathways.[11] Microbiota-mediated conversion of herbal compounds into bioactive metabolites further enhances their therapeutic effects, contributing to microbial balance and overall health. The evidence on the gut microbiome-modulating effects of Ayurvedic herbs is summarised in the table 1.

Table 1: Mechanisms of Gut Microbiome Modulation by Ayurvedic Herbs

Herbs (Botanical Name)	Mechanism of Gut Microbiome Modulation
Triphala (Amalaki – Emblica officinalis Gaertn*; Bibhitaki – Terminalia bellirica* Roxb*; Haritaki– Terminalia chebula* Retz)	*Triphala* exerts prebiotic effects by promoting beneficial bacteria such as *Bifidobacterium* and *Lactobacillus* while suppressing pathogenic microbes. It enhances SCFA production, strengthens intestinal barrier integrity, and reduces NF-κB-mediated inflammation. Microbial biotransformation of its polyphenols produces urolithins with potent antioxidant and anti-inflammatory properties.[15,16]
Haridra (*Curcuma longa* Linn)	Curcumin selectively modulates microbiome composition — increasing *Lactobacillaceae* and *Bifidobacteriaceae*, reducing Enterobacteriaceae; reduces LPS-induced mucosal inflammation via NF-κB and NLRP3 inflammasome suppression; upregulates ZO-1, occludin, and claudin-1, restoring barrier integrity; anti-dysbiotic effects demonstrated in experimental colitis models.[17,18]
Guduchi (*Tinospora* cordifolia Hook.f and Thoms*)*	Prebiotic arabinogalactans stimulate *Bifidobacterium* and *Lactobacillus* growth; immunomodulatory alkaloids (berberine, tinosporin, palmatine) enhance mucosal IgA, Th1/Th17 balance, and NK cell activity; anti-inflammatory effects reduce intestinal macrophage overactivation and TLR-4 signalling; supports hepatic phase II detoxification downstream of gut–liver axis.[16]
Ashwagandha (*Withania somnifera* Linn.Dunal*)*	Withanolides and withanosides attenuate corticotropin-releasing factor (CRF)-driven gut dysbiosis by modulating the HPA axis; reduce stress-induced intestinal permeability and mast cell degranulation; improve microbiome alpha-diversity; are associated with cognitive improvement in RCTs, possibly mediated through gut–brain microbiome pathways.[19]
Kutaja (*Holarrhena antidysenterica* Roth)	*Kutaja* contains steroidal alkaloids such as conessine and kurchicine that selectively inhibit enteric pathogens, including *Entamoeba histolytica*, Shigella, and Salmonella. It improves intestinal barrier function and is clinically effective in diarrhoeal and dysenteric disorders.[15]
Shunti (*Zingiber officinale* Roscoe)	6-Gingerol and 6-shogaol modulate gut microbial diversity; support *Lactobacillus* and *Bifidobacterium* proliferation; inhibit *Helicobacter pylori*; reduce gut pro-inflammatory cytokines (TNF-α, IL-6); enhance gastric motility and digestive enzyme secretion (*Agni Deepana*).[15]

Brahmi (*Bacopa monnieri* L.Wettst)	Bacosides I and II reduce stress-induced intestinal permeability; attenuate neuroinflammation secondary to gut-derived LPS via NF-κB suppression in microglial cells; modulate ENS-mediated serotonin synthesis; and are relevant to IBS-associated anxiety and cognitive symptoms via the gut–brain microbiome axis.[19]

Ritucharya: Seasonal Dietary Synchrony and Microbial Ecology

Ritucharya, the Ayurvedic practice of adapting diet and lifestyle to seasonal changes, helps maintain *Agni*, *Dosha* balance, and overall health.[20] Recent studies suggest that seasonal dietary patterns influence gut microbial diversity and composition. Evidence suggests that *Ritucharya*- aligned practices may promote beneficial changes in the microbiome and improve metabolic and inflammatory health, supporting Ayurveda's preventive approach to maintaining gut homeostasis.[21] The classical seasonal dietary regimens *(Ritucharya*) and their potential impact on the gut microbiome are summarised in table 2.

Table 2: *Ritucharya* and Gut Microbiome Modulation

***Ritu* (Season)**	**Classical Dietary Regimen and Gut Microbiome Impact**
Hemanta (Early Winter, Nov–Jan)	*Snigdha, Guru* (unctuous, heavy) foods: whole grains, ghee (*Ghrita*), milk, legumes, and fermented preparations (*Takra*, *Sura*). High-fibre intake stimulates *Bifidobacterium* and *Roseburia* (SCFA producers); fermented foods introduce *Lactobacillus* and butyrate-precursor substrates; ghee's short-chain fatty acids nourish colonocytes and support *Grahani* integrity.
Shishira (Late Winter, Jan–Mar)	Warm, unctuous diet with pungent (*Katu*) digestive spices: *Shunti* (ginger), *Maricha* (black pepper), *Jeeraka* (cumin), *Ajwain*. Spice-derived phenolics (gingerols, piperine, thymol) maintain gut metabolic activity during cold-induced *Manda Agni*; inhibit mucosal pathogens; volatile oils modulate mucus composition.
Vasanta (Spring, Mar–May)	*Laghu, Ruksha* (light, dry) foods: barley (*Yava*), honey (*Madhu*), millet, bitter vegetables (*Tikta Rasa*), *Takra* (buttermilk). Season of *Kapha* aggravation and heightened dysbiosis risk; bitter compounds reduce mucus overproduction and inhibit pathogenic overgrowth; honey's oligosaccharides exert prebiotic effects on *Bifidobacterium*.[22,23]
Grishma (Summer, May–Jul)	Hydrating, cooling (*Sheeta Virya*) foods: coconut water, rice gruel (*Manda*), seasonal fruits, cooling herbal drinks. Dehydration is the primary driver of summer gut dysbiosis; adequate fluid intake preserves mucosal hydration and colonic SCFA-producing microbial activity.
Varsha (Monsoon, Jul–Sep)	Warm, freshly cooked foods; *Takra*, *Pippali* (long pepper), *Shunti* (ginger), *Saindhava Lavana* (rock salt), sour fermented preparations. Season of *Vishama Agni* and highest water-borne pathogen burden; pungent and sour *Rasas* restore *Agni*; *Takra* probiotic fermentation provides *Lactobacillus* colonisation resistance.
Sharad (Autumn, Sep–Nov)	Cooling, bitter (*Tikta*), astringent (*Kashaya*) foods: *Amalaki*, *Patola* (*Trichosanthes dioica*), ghee processed with bitter herbs (*Tikta Ghrita*). Season of *Pitta* aggravation and gut inflammation; bitter compounds modulate Bacteroides-mediated secondary bile acid metabolism; *Amalaki*'s polyphenols reduce intestinal oxidative stress and support *Akkermansia muciniphila*.[24]

Panchakarma on Gut Health and Gut Microbiome Modulation

Panchakarma, comprising *Vamana, Virechana, Basti, Nasya*, and *Raktamokshana*, aims to eliminate *Ama*, balance *Doshas*, and restore *Agni*.[25] Emerging evidence suggests that these therapies may improve gut microbial balance and metabolic health. *Virechana* and *Vamana* have shown benefits on microbial, digestive, and metabolic parameters, while *Basti* appears particularly promising for modulating the colonic microbiome.[26,27] Effects of *Panchakarma* therapies on gut health and gut microbiome modulation are given in table 3.

Table 3: Gut Microbiome-Modulating Effects of *Panchakarma* Therapies

***Panchakarma* Therapy**	**Mechanism and Evidence for Gut Health and Microbiome Modulation**
Snehana (internal oleation) *Snehapana* with medicated ghee	Internal *Snehapana* provides exogenous butyrate and medium-chain fatty acid substrates, reducing bacterial adhesion to the epithelium; it promotes M2 anti-inflammatory macrophage polarisation in the lamina propria.
Vamana (therapeutic emesis)	Targeted elimination of upper GI *Ama* and *Kapha*-type microbial burden from the gastric and proximal duodenal environment indirectly restores *Jatharagni* by evacuating stasis-associated microbial overgrowth; post-emetic improvement in

	digestive enzyme profiles and metabolic markers indicates modulation of the hepato-enteric circulation.[27]
Virechana (Therapeutic Purgation)	Targeted cleansing of the small intestinal and colonic *Ama*; documented reduction of pathogenic *E. coli* and Staphylococcal burden; improves insulin sensitivity, lipid metabolism, and hepatic function markers consistent with microbiome-mediated metabolic reset.[26]
Basti (medicated enema) *Anuvasana* (oil) + *Niruha* (decoction)	*Anuvasana Basti* introduces medicated sesame oil directly into the colon: reduces *Firmicutes*:*Bacteroidetes* ratio, Proteobacteria abundance, attenuates mucosal inflammation, and modulates gut–brain and gut–immune axes. *Niruha Basti* introduces prebiotic polysaccharides and antimicrobial phenolics directly to the colonic microenvironment.[25]
Nasya (nasal insufflation)	Modulates the nasal–nasopharyngeal microbiome; olfactory and trigeminal nerve pathways may allow top-down modulation of gut ENS function via the hypothalamic–gut axis.
Samsarjana Krama (post-procedural dietary rehabilitation)	Graded reintroduction - *Peya* (thin gruel) → *Vilepi* (thick gruel) → *Akrita Yusha* (light soup) → *Krita Yusha* → *Akrita Mamsa Rasa* → *Krita Mamsa Rasa* → normal diet (3–7 days). Mirrors evidence-based post-antibiotic microbiome recovery protocols; sequentially nourishes SCFA-producing bacteria, restores mucus layer integrity, and consolidates microbial diversity.

Ayurvedic Therapeutics and Gut–Organ Axis

Ayurveda and modern medicine both recognize the gut as a central regulator of systemic health. Concepts such as *Srotas* and *Prana–Vyana–Apana Vata* parallel the modern gut–brain, gut–liver, gut–immune, gut–lung, and gut–metabolic axis. Disturbances in *Agni* and gut function can affect distant organs through microbial, immune, and neuroendocrine pathways. Ayurvedic therapies that restore *Agni* and reduce *Ama* may help modulate these gut–organ interactions and support overall health. The mechanisms by which selected Ayurvedic drugs influence gut–organ communication and contribute to systemic health are given in table 4.

Table 4: Gut–Organ Axis Modulation by Ayurvedic Drugs

Drug / Formulation	**Gut–Organ Axis**	**Mechanism and Systemic Impact**
Triphala	Gut–Brain; Gut–Liver	Polyphenol-derived urolithins and gallic acid promote *Bifidobacterium*, reduce gut-derived LPS, attenuate neuroinflammation (NF-κB suppression in microglia); hepatoprotective via modulation of secondary bile acid production and attenuation of LPS-induced Kupffer cell activation.[16,28]
Guduchi (*Tinospora cordifolia Hook.f and Thoms)*	Gut–Immune; Gut–Liver	Arabinogalactans and tinosporin augment mucosal IgA, NK cell activity, and dendritic cell maturation; reduce LPS-induced hepatic NF-κB activation; and modulate Treg/Th17 balance.[16]
Amalaki (Emblica officinalis Gaertn)	Gut–Liver	Vitamin C, tannins, and gallic acid provide antioxidant mucosal and hepatic protection; support *Akkermansia muciniphila* (mucin layer integrity, inversely correlated with obesity and T2DM); enhance hepatic phase II detoxification enzymes.[24]
Haritaki (Terminalia chebula Retz)	Gut–Liver; Gut–Brain	Chebulic acid and chebulanin promote microbial diversity and SCFA production; reduce gut-derived LPS translocation and hepatic oxidative stress; may support BDNF production via microbiota–enteric serotonin pathways.[16]
Ashwagandha (*Withania somnifera Linn.Dunal)*	Gut–Brain; Gut–Immune	Withanolides modulate the HPA axis, reducing stress-induced intestinal permeability and inflammation. They may improve gut microbiome diversity and have shown benefits in

Drug / Formulation	Gut–Organ Axis	Mechanism and Systemic Impact
		cognition and anxiety reduction, possibly through microbiota-mediated serotonin and dopamine pathways.[19]
Brahmi (*Bacopa monnieri* L.Wettst)	Gut–Brain	Bacosides enhance BDNF expression and neurogenesis; reduce neuroinflammation secondary to gut-derived LPS via microglial NF-κB suppression; modulate ENS–CNS interface through cholinergic and GABAergic mechanisms.[29]
Shankhapushpi (Convolvulus pluricaulis Choisy*)*	Gut–Brain	Flavonoids (baicalein, scutellarein) support GABAergic neurotransmission; modulate microbiota-mediated tryptophan-to-serotonin conversion; may attenuate anxiety-related gut dysbiosis through HPA-axis normalisation.[30]
Pippali (Piper longum L*)*	Gut–Lung; Gut–Liver	Piperine enhances the bioavailability of co-administered phytochemicals, modulates the gut–lung axis through immune regulation, and may reduce hepatic steatosis by influencing bile acid metabolism and FXR signalling.[31]
Haridra (*Curcuma longa* Linnaeus*)*	Gut–Liver; Gut–Immune	Curcumin upregulates tight junction proteins (occludin, claudin-1, ZO-1); suppresses NLRP3 inflammasome; modulates microbiota-mediated secondary bile acid production; reduces hepatic NF-κB activation in NAFLD models.[31,32]
Yashtimadhu (*Glycyrrhiza glabra* Linnaeus)	Gut–Lung; Gut–Immune	Glycyrrhizin and glabridin promote mucosal IgA production; reduce LPS-induced TLR-4 signalling; protect airway mucosa via gut–lung axis IgA recirculation (BALT activation); attenuate microbiome-mediated allergic sensitisation.[31]

Rasayana Therapy and the Gut Microbiome

Rasayana promotes longevity, immunity, cognition, and healthy ageing.[9] Its effects appear partly microbiome-dependent, as gut microbes convert herbal phytochemicals into bioactive compounds such as urolithins with antioxidant and anti-inflammatory properties. This supports the Ayurvedic practice of administering *Rasayana* after Panchakarma to optimise gut health and therapeutic response. Evidence from *Amalaki Rasayana* suggests potential benefits in healthy ageing and immune regulation through antioxidant and microbiome-mediated mechanisms.[24]

CONCLUSION

Ayurveda and modern microbiome science both emphasise the central role of gut health in maintaining systemic well-being. The concepts of *Agni, Ama*, and *Grahani* parallel contemporary understanding of digestion, microbial balance, and gut–organ communication. Ayurvedic interventions and *Prakriti*-based personalisation show potential for microbiome modulation, though further high-quality clinical and translational research is needed to validate and integrate these approaches into modern healthcare.

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