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AYURVEDA AND THE GUT–LIVER–PANCREAS AXIS: INTEGRATING TRADITIONAL CONCEPTS WITH CONTEMPORARY INSIGHTS INTO THE MICROBIOME, METABOLISM AND INFLAMMATION

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ABSTRACT

The gut–liver–pancreas axis represents a complex bidirectional communication network connecting the gastrointestinal tract, liver and pancreas through microbial, metabolic, endocrine, neural and immune pathways. Increasing evidence indicates that alterations in gut microbiota, intestinal barrier integrity and microbial metabolites contribute to metabolic disorders including obesity, type 2 diabetes mellitus and metabolic dysfunction-associated steatotic liver disease (MASLD). Short-chain fatty acids, bile acids, microbial products and gut-derived hormones participate in the regulation of glucose and lipid metabolism, inflammation and pancreatic endocrine function. Ayurveda provides a traditional framework in which digestion and metabolism are central to health. Concepts including *Agni*, *Āma*, *Doṣa*, *Ahara*, *Jatharagni* and *Dhātu Agni* describe different aspects of digestion, transformation and systemic homeostasis. Although these concepts originate from a different theoretical framework than contemporary biomedical science, they may provide useful hypotheses for investigating the relationship between diet, gastrointestinal function, metabolism and systemic inflammation. This review explores the possible interface between Ayurvedic concepts and contemporary understanding of the gut–liver–pancreas axis, with

particular emphasis on gut microbiota, intestinal barrier function, microbial metabolites, bile-acid signalling, insulin resistance and inflammatory pathways. The potential relevance of Ayurvedic dietary and lifestyle principles in metabolic health is also discussed. Importantly, traditional concepts should not be regarded as direct equivalents of modern biological entities without appropriate experimental validation. Integrating Ayurvedic clinical phenotyping with microbiome science, metabolomics and conventional metabolic biomarkers may provide a promising framework for future research in personalized and integrative medicine.

KEYWORDS: Ayurveda, gut microbiome, gut–liver–pancreas axis, Agni, Āma, MASLD, insulin resistance, inflammation, metabolic syndrome, integrative medicine.

INTRODUCTION

The global burden of metabolic disorders has increased substantially during recent decades. Obesity, insulin resistance, type 2 diabetes mellitus and metabolic dysfunction-associated steatotic liver disease frequently occur together and share several biological mechanisms, including abnormal lipid metabolism, insulin resistance, chronic low-grade inflammation and altered gut microbial ecology.

The traditional view of metabolism as an interaction between multiple organs is increasingly supported by contemporary biomedical research. The gastrointestinal tract, liver and pancreas communicate continuously through endocrine, neural, immune and metabolic pathways. The gut microbiota adds another important dimension to this communication by producing metabolites capable of influencing distant organs.

This interconnected system is increasingly described as the **gut–liver–pancreas axis**. Microbiota-derived short-chain fatty acids, bile-acid metabolites and other microbial products can influence glucose and lipid metabolism, pancreatic hormone secretion and hepatic inflammatory pathways. Dysbiosis and impaired intestinal barrier function have been associated with metabolic disorders and MASLD.[1-4]

Ayurveda has traditionally considered digestion and metabolism fundamental determinants of health. The concepts of *Agni*, *Āma*, *Ahara*, *Doṣa* and tissue-level metabolism provide a holistic framework for understanding physiological balance and disease development.

The purpose of this review is to explore whether these traditional concepts can provide useful hypotheses within the contemporary framework of the gut–liver–pancreas axis, while

maintaining a clear distinction between traditional theory and experimentally established biomedical mechanisms.

THE GUT–LIVER–PANCREAS AXIS

The intestine, liver and pancreas are anatomically and functionally interconnected.

The gastrointestinal tract receives dietary nutrients and contains a highly complex microbial ecosystem. The liver receives a major proportion of its blood supply through the portal circulation and is therefore continuously exposed to substances absorbed from the intestine. The pancreas contributes digestive enzymes to the gastrointestinal tract and also regulates systemic metabolism through endocrine hormones including insulin and glucagon.

Communication among these organs occurs through several pathways:

- Gut microbial metabolites
- Bile acids and bile-acid receptors
- Gut-derived hormones
- Insulin and glucagon
- Neural signalling
- Immune mediators
- Intestinal barrier function
- Dietary metabolites

The gut microbiota is particularly important because microbial products can enter host metabolic pathways and influence the inflammatory and metabolic environment of the liver and pancreas.[1]

Recent reviews have emphasized that short-chain fatty acids, bile acids and gut-derived endocrine signals such as GLP-1 participate in the regulation of glucose and lipid homeostasis. Disturbances in these pathways have been linked with metabolic disease, including type 2 diabetes and MASLD.[1,2]

GUT MICROBIOME AND METABOLIC HOMEOSTASIS

The human gut contains a diverse microbial ecosystem comprising bacteria, viruses, fungi and other microorganisms. These organisms participate in digestion, nutrient transformation, immune regulation and production of bioactive metabolites.

Among the most extensively studied microbial metabolites are short-chain fatty acids (SCFAs), particularly acetate, propionate and butyrate. SCFAs can influence intestinal epithelial integrity, immune signalling and host metabolism.

Gut microbial composition and function are influenced by multiple factors, including:

- Dietary pattern
- Age
- Physical activity
- Medication exposure
- Host genetics
- Geography
- Metabolic status

Therefore, dysbiosis should not be interpreted simply as the presence or absence of a particular bacterial species. Functional alterations in microbial metabolism may be equally important.

In metabolic disease, alterations in microbial communities and microbial metabolites may influence intestinal permeability, inflammation, hepatic lipid metabolism and glucose homeostasis.[2-4]

INTESTINAL BARRIER AND SYSTEMIC INFLAMMATION

The intestinal epithelium forms a selective barrier between the intestinal lumen and systemic circulation. Tight junction proteins, mucus, immune components and the resident microbiota contribute to maintaining this barrier.

Disruption of intestinal barrier function may facilitate increased exposure of the host to microbial components. Lipopolysaccharide (LPS), derived mainly from Gram-negative bacteria, is one of the microbial products investigated in relation to metabolic inflammation.

Interaction between microbial products and pattern-recognition receptors such as Toll-like receptors can activate inflammatory pathways. These pathways may contribute to insulin resistance and hepatic inflammation.

However, the relationship between intestinal permeability, dysbiosis and metabolic disease is complex. Associations identified in observational or preclinical studies do not necessarily establish causality in humans.[3,4]

GUT–LIVER COMMUNICATION

The gut and liver are closely connected through the portal circulation and bile-acid circulation.

The liver receives microbial metabolites and dietary products absorbed from the intestine. In the opposite direction, bile acids secreted by the liver enter the intestine, where they are modified by gut microorganisms.

Bile acids are now recognized not only as digestive molecules but also as signalling molecules. Through receptors including FXR and TGR5, bile acids participate in the regulation of glucose metabolism, lipid metabolism, energy balance and inflammatory responses.

Alterations in gut microbial composition, intestinal permeability and bile-acid metabolism have been investigated extensively in MASLD.[2-5]

A 2024 systematic review and meta-analysis of randomized controlled trials reported that some microbiota-modulating interventions, particularly synbiotic interventions, showed improvements in selected MASLD-related outcomes, although evidence for individual interventions remains heterogeneous.[5]

GUT–PANCREAS COMMUNICATION

The gut–pancreas relationship extends beyond digestion.

Following nutrient ingestion, intestinal enteroendocrine cells release incretin hormones including glucagon-like peptide-1 (GLP-1) and glucose-dependent insulinotropic polypeptide (GIP). These hormones influence pancreatic insulin secretion and glucose homeostasis.

Gut microbial metabolites may influence enteroendocrine function and metabolic signalling. Changes in gut microbiota have therefore become an area of interest in diabetes research.

In type 2 diabetes mellitus, insulin resistance, β-cell dysfunction and altered glucose-regulatory signalling interact with dietary and environmental factors.

The gut–pancreas axis consequently provides a potential mechanistic framework for investigating interventions aimed at improving metabolic health.[1]

AYURVEDIC CONCEPT OF AGNI

Agni is one of the fundamental concepts in Ayurveda and is broadly associated with digestion, transformation and metabolism.

Ayurvedic literature describes different dimensions of metabolic activity, including *Jatharagni* and tissue-level metabolic processes described through *Dhātu Agni*.

From a modern biomedical perspective, digestion and metabolism involve gastric secretion, pancreatic enzymes, intestinal absorption, hepatic metabolism, endocrine regulation and microbial transformation.

Therefore, *Agni* should not be directly equated with any single modern biological entity. Nevertheless, *Agni* may be explored as a traditional systems-level concept representing aspects of digestive and metabolic homeostasis.

This raises a testable research question: whether clinically assessed variations traditionally interpreted as altered *Agni* are associated with measurable physiological variables such as gastrointestinal symptoms, insulin resistance, glycemic variability, body composition or microbiome-related metabolites.

ĀMA AND CONTEMPORARY METABOLIC CONCEPTS

Āma is traditionally described in association with impaired digestion and abnormal accumulation of incompletely processed material.

Contemporary medicine recognizes several processes that can contribute to metabolic dysfunction, including:

- Gut dysbiosis
- Intestinal barrier dysfunction
- Oxidative stress
- Low-grade systemic inflammation
- Altered microbial metabolites
- Metabolic endotoxemia

It would be scientifically inappropriate to state that *Āma* is identical to endotoxin, dysbiosis or inflammation.

Instead, *Āma* may be considered a **hypothesis-generating Ayurvedic construct** whose potential biological correlates can be investigated.

Future studies could evaluate whether individuals identified according to standardized Ayurvedic criteria for *Āma* demonstrate reproducible differences in inflammatory biomarkers, intestinal permeability markers, microbiome composition, oxidative-stress parameters or metabolic profiles.

AYURVEDIC DIETARY PRINCIPLES AND THE GUT MICROBIOME

Diet is one of the major determinants of gut microbial composition and function.

Ayurveda gives considerable importance to food quality, quantity, timing, preparation, compatibility and individual suitability. Contemporary nutrition science similarly recognizes that dietary patterns influence the microbiome, metabolic health and inflammatory status.

Dietary components such as dietary fibre and plant-derived polyphenols may influence microbial diversity and metabolite production.

This creates an important opportunity for integrative research. Rather than +evaluating isolated foods as universally beneficial or harmful, research should examine complete dietary patterns and their effects on

- Microbial diversity
- SCFA production
- Intestinal barrier function
- Glycemic regulation
- Lipid metabolism
- Inflammatory markers

Such research could help determine whether certain Ayurvedic dietary principles have measurable effects on the gut–liver–pancreas axis.

AYURVEDA AND MASLD

MASLD is closely associated with metabolic dysfunction, obesity, insulin resistance and abnormal lipid metabolism. Its progression can involve hepatic inflammation and fibrosis.

Current evidence indicates that gut microbiota and their metabolites may influence MASLD through intestinal barrier function, immune signalling, bile-acid metabolism and microbial metabolites.[2-4]

Ayurvedic management traditionally emphasizes dietary regulation, physical activity, appropriate daily routines and individualized therapeutic approaches.

These components may be investigated as adjuncts to standard medical management.
However, clinical research should use clearly defined interventions, appropriate controls and objective endpoints. Herbal medicines should additionally undergo appropriate quality control and safety assessment because natural origin does not guarantee absence of pharmacological interactions or adverse effects.

AYURVEDA AND TYPE 2 DIABETES MELLITUS

Type 2 diabetes mellitus is characterized by insulin resistance and progressive impairment of pancreatic β-cell function.

The gut–pancreas axis has gained importance because intestinal nutrient sensing, incretin secretion and microbial metabolites may influence glucose regulation.

Ayurvedic approaches emphasize dietary regulation, physical activity, individualized lifestyle measures and selected medicinal interventions.

Future clinical studies could evaluate Ayurvedic interventions using conventional metabolic endpoints such as

- HbA1c
- Fasting plasma glucose
- Postprandial glucose
- Insulin resistance
- Body mass index
- Waist circumference
- Lipid profile

Mechanistic studies may additionally evaluate GLP-1, inflammatory biomarkers and microbiome-derived metabolites.

CONCEPTUAL INTERFACE BETWEEN AYURVEDA AND THE GUT–LIVER–PANCREAS AXIS

A potential conceptual framework can be represented as:

Ahara and lifestyle → digestion → intestinal environment → microbiome and microbial metabolites → gut barrier and immune signalling → liver and pancreatic metabolism → systemic metabolic homeostasis

From the Ayurvedic perspective:

Ahara → Agni → transformation → Dhātu nourishment → physiological equilibrium

These two frameworks may provide a basis for translational investigation.

However, conceptual similarity should not be confused with biological equivalence. Scientific validation requires measurable definitions, reproducible assessment methods and appropriately designed clinical or experimental studies.

POTENTIAL ROLE OF AYURVEDIC INTERVENTIONS

Dietary intervention

Individualized dietary modification may influence energy balance, glucose regulation and microbial metabolism.

Lifestyle modification

Regular physical activity, adequate sleep and appropriate daily routines may support metabolic health and improve adherence to therapeutic interventions.

Herbal interventions

Several medicinal plants contain polyphenols and other bioactive compounds that may influence metabolic and inflammatory pathways. However, evidence varies considerably among individual herbs and formulations.

Yoga and mind–body interventions

Yoga and related practices may influence physical activity, stress, sleep and lifestyle behaviour. Their possible indirect effects on metabolic health warrant further investigation.

Future studies should distinguish between the effects of individual components and complete Ayurvedic treatment protocols.

RESEARCH GAPS AND FUTURE DIRECTIONS

Despite increasing interest in Ayurveda and microbiome science, substantial research gaps remain.

Many studies have small sample sizes, heterogeneous interventions and limited follow-up. Ayurvedic diagnostic constructs may also be assessed inconsistently between studies.

A more rigorous research framework could combine:

- Standardized Ayurvedic phenotyping.
- Clinical metabolic assessment.
- Gut microbiome analysis.
- Metabolomics.
- Inflammatory biomarkers.
- Assessment of liver steatosis and fibrosis.
- Insulin resistance measurements.
- Patient-reported outcomes.

Multi-omics approaches could be particularly valuable in exploring whether Ayurvedic phenotypes are associated with reproducible biological signatures.

An important future direction is **Prakriti-based metabolic research**. Studies could investigate whether Ayurvedic constitutional phenotypes are associated with differences in metabolic risk, microbial functional pathways, inflammatory markers or hepatic fat accumulation.

Such research should be hypothesis-driven rather than attempting to establish one-to-one equivalence between Ayurvedic terminology and biomedical molecules.

CLINICAL IMPLICATIONS

The gut–liver–pancreas axis offers a systems-based perspective that may be particularly relevant to patients with multiple metabolic disorders.

A patient with obesity, insulin resistance, type 2 diabetes and MASLD may have interconnected abnormalities rather than completely independent diseases.

Ayurveda's emphasis on individualized diet, lifestyle, digestive function and prevention may therefore provide useful complementary approaches.

Nevertheless, Ayurvedic interventions should be considered within an evidence-based framework and should not replace proven therapies for diabetes, hypertension, liver disease or other serious medical conditions.

CONCLUSION

The gut–liver–pancreas axis represents an important emerging framework linking intestinal microbiota, microbial metabolites, hepatic metabolism, pancreatic endocrine function and systemic inflammation.

Ayurveda provides a traditional systems-based framework centered on digestion, metabolism, dietary behaviour and individualized health. Concepts such as *Agni* and *Āma* may provide useful hypotheses for translational research, but they should not be presented as direct equivalents of modern biological entities such as the microbiome, endotoxin or inflammatory biomarkers without appropriate evidence.

The integration of Ayurvedic clinical phenotyping with microbiome analysis, metabolomics, metabolic biomarkers and rigorous clinical trial methodology may provide a promising pathway for developing evidence-based integrative medicine.

Future research should prioritize standardized interventions, reproducible Ayurvedic assessments, clinically meaningful endpoints and appropriate safety monitoring. Such an approach may help determine whether Ayurvedic principles can contribute to personalized strategies for prevention and management of metabolic disorders involving the gut–liver–pancreas axis.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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AUTHOR CONTRIBUTION

Dr. Arpita Jain contributed to literature review, conceptualization and preparation of the manuscript. Dr. Megha Dixit contributed to academic supervision, critical review and final revision of the manuscript.

REFERENCES

1. Marroncini G, Naldi L, Martinelli S, Amedei A. Gut-Liver-Pancreas Axis Crosstalk in Health and Disease: From the Role of Microbial Metabolites to Innovative Microbiota Manipulating Strategies. *Biomedicines*. 2024; 12(7): 1398.
2. Maher S, Rajapakse J, El-Omar E, Zekry A. Role of the Gut Microbiome in Metabolic Dysfunction-Associated Steatotic Liver Disease. *Semin Liver. Dis*., 2024; 44(4): 457-473.
3. Vallianou NG, Kounatidis D, Psallida S, et al. NAFLD/MASLD and the Gut-Liver Axis: From Pathogenesis to Treatment Options. *Metabolites*. 2024; 14(7): 366.
4. Gut-Liver Axis: The Role of Intestinal Microbiota and Their Metabolites in the Progression of Metabolic Dysfunction-Associated Steatotic Liver Disease. *[Journal article indexed in PubMed]*. 2025.
5. Wu J, Chen X, Qian J, Li G. Clinical improvement effect of regulating gut microbiota on metabolic dysfunction-associated steatotic liver disease: systematic review and meta-analysis of randomized controlled trials. *Clin Res Hepatol Gastroenterol*. 2024; 48(7): 102397.
6. Advances in the acting mechanism and treatment of gut microbiota in metabolic dysfunction-associated steatotic liver disease. *[Review article indexed in PubMed]*. 2025.
7. Metabolic dysfunction-associated steatotic liver disease and the gut microbiome: pathogenic insights and therapeutic innovations. *[Review article indexed in PubMed]*. 2025.
8. Breaking the barriers: the role of gut homeostasis in metabolic-associated steatotic liver disease. *[Review article indexed in PubMed]*. 2024.
9. Fermented Foods and the Gut-Liver Axis: Modulation of MASLD Through Gut Microbiota. *[Review article indexed in PubMed]*. 2026.sss

10. The Multifaceted Roles of Gut Microbiota and Their Metabolites in Metabolic Dysfunction-associated Steatotic Liver Disease: A Literature **Charaka Samhita – Sutra Sthana, Matrashiteeya Adhyaya:** *Ahara*, proper dietary quantity and eating practices.
11. **Charaka Samhita – Chikitsa Sthana, Grahani Chikitsa:** *Ama* and impaired digestion conceptual discussion.
12. **Charaka Samhita – Vimana Sthana:** *Agni*, *Ahara* and physiological assessment concepts.
13. **Sushruta Samhita – Sutra Sthana:** *Agni* and *Srotas* related concepts.
14. **Ashtanga Hridaya – Sutra Sthana, Dvividhopakrama/Dinacharya-related sections:** diet and lifestyle principles.
15. **Ashtanga Hridaya – Nidana/Sutra Sthana:** *Doṣa*, *Agni* and disease development for conceptual framework.