Ayurveda and Modern Biomedical Science

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***Abstract*—Background: Ayurveda's classical framework, preserved in the Carakasaṃhitā, Suśrutasaṃhitā, and Aṣṭāṅgahṛdaya, organizes health around regulatory balance, constitutional individuality, digestive-metabolic transformation, bodily channels, rejuvenation, and disciplined daily living. Recent biomedical literature has increasingly examined whether these constructs can be translated into testable models relevant to systems biology, precision medicine, immunology, metabolism, microbiome science, and circadian health. [4]**

Objective: To critically evaluate how key Ayurvedic concepts—tridoṣa, prakṛti, agni, srotas, rasāyana, and dinacaryā—can be mapped to modern biomedical constructs without collapsing their original epistemic context, and to assess the strength, limits, and translational value of current evidence.

Methods: A structured integrative review was designed for manuscript development. Searches were conducted through May 31, 2026, using PubMed/MEDLINE and PubMed Central for peer-reviewed biomedical literature; WHO publications and WHO IRIS for policy and regulatory documents; and official digital repositories of classical Ayurveda texts for primary Sanskrit sources. The biomedical review focused on studies from 2000–2026, while classical sources were examined without date restriction. Eligible materials included primary studies, systematic reviews, narrative reviews with methodological value, mechanistic studies, and official regulatory documents.

Results: The review found the strongest contemporary bridges in prakṛti-omics research, including genomic and pharmacogenomic associations; in agni research linked to digestion, immunometabolism, and the gut microbiome; in rasāyana research linked to immunomodulation, telomerase activity, mitochondrial health, and aging biology; and in dinacaryā as a behavioral precursor of circadian medicine. Clinical evidence suggests benefit from Ayurvedic or Ayurveda-informed multimodal interventions in knee osteoarthritis, irritable bowel syndrome, and rheumatoid arthritis, but systematic reviews continue to note substantial heterogeneity, difficult blinding, modest sample sizes, and inconsistent standardization. [5]

Conclusion: Ayurveda can contribute a hypothesis-rich, person-centered, preventive, and systems-oriented vocabulary to biomedical inquiry, especially in chronic disease, healthy aging, rehabilitation, and lifestyle medicine. However, the most defensible path forward is not simplistic equivalence but methodologically rigorous translation supported by standardized phenotyping, omics integration, pragmatic whole-system trials, pharmacovigilance, and stronger regulatory oversight. [6]

***Index Terms*—Ayurveda, biomedical science, tridoṣa, prakṛti, agni, microbiome, rasāyana, circadian medicine**

I. Introduction

Ayurveda's authority in South Asian medicine rests above all on three classical textual pillars: the *Carakasaṃhitā*, the *Suśrutasaṃhitā*, and the *Aṣṭāṅgahṛdaya*. Official digital repositories maintained by the National Institute of Indian Medical Heritage and the Institute of Ayurveda and Integrative Medicine now make these Sanskrit sources searchable in ways that are especially useful for modern philology and concept-based research. At the same time, WHO has moved Ayurveda-related policy discussion from ad hoc recognition toward structured governance through its 2022 benchmarks for Ayurveda practice and training,

the launch of the WHO Global Traditional Medicine Centre in Jamnagar in 2022, and the adoption of the Global Traditional Medicine Strategy 2025–2034. Collectively, these developments create a stronger infrastructure for interdisciplinary evaluation than existed even a decade ago. [7]

Yet translation remains difficult. Biomedical categories typically seek specific mechanisms, tissues, pathways, and experimentally isolable variables. Ayurvedic categories are often functional, relational, multiscale, and normatively tied to lived balance, constitution, season, diet, and behavior. Several influential methodological papers therefore argue that Ayurveda should be engaged through bridge concepts, systems thinking, and whole-system research rather than by reducing every classical term to a single molecular analogue. That point is especially important for a publication-ready review: the manuscript will be stronger if it argues for *structured comparability* rather than identity. [8]

The guiding questions for the paper are therefore the following.

Research question	Corresponding objective
How can core Ayurvedic physiological concepts be translated into modern biomedical language without erasing their original logic?	Build a non-reductive conceptual mapping framework
Which Ayurvedic concepts already have meaningful empirical bridges to genomics, immunology, metabolism, microbiome science, and chronobiology?	Identify domains of strongest biomedical convergence
What is the current quality of clinical and mechanistic evidence for Ayurveda-informed interventions?	Distinguish promising evidence from overstated claims
Where do epistemological differences remain irreducible?	Clarify limits of translation and prevent category error
What research, regulatory, and policy priorities should come next?	Propose a future agenda for high-quality integrative scholarship

II. Methods

This paper is designed as a **critical integrative review** rather than a registered PRISMA systematic review. That format is better suited to a topic where classical textual interpretation, conceptual translation, mechanistic studies, and clinical outcomes all need to be synthesized within one argumentative frame. The search and selection strategy was nevertheless made transparent so the manuscript remains reproducible and journal-friendly.

Review component	Approach used in this draft
Review type	Critical integrative review with manuscript-ready IMRAD structure
Search window	Classical sources: no date restriction; biomedical and policy literature: 2000 to May 31, 2026
Primary sources	NIIMH *e-Samhita* for *Carakasaṃhitā* and *Suśrutasaṃhitā*; I-AIM *e-Vāgbhaṭa* for *Aṣṭāṅgahṛdaya*
Biomedical sources	PubMed/MEDLINE, PubMed Central, journal publisher pages, and citation chaining from key reviews

Review component	Approach used in this draft
Policy and safety sources	WHO publication pages, WHO IRIS, WHO GTMC pages, NCCIH
Core search strings	"Ayurveda AND prakriti AND genomics"; "Ayurveda AND microbiome"; "Ayurveda AND rasayana AND immunology"; "Ayurveda AND circadian"; "Ayurveda whole system trial"; "Ayurvedic osteoarthritis randomized trial"; "Ayurveda rheumatoid arthritis metabolomics"; "WHO Ayurveda benchmarks"
Inclusion criteria	Primary Sanskrit texts; peer-reviewed reviews; mechanistic studies; omics studies; randomized or controlled clinical studies; systematic reviews; official WHO and NIH/NCCIH documents
Exclusion criteria	Promotional webpages; unsourced opinion pieces; duplicate reports; papers with no clear methodological contribution to the topic; studies unrelated to concept mapping or integrative evidence
Analytic strategy	Conceptual mapping, evidence grading by design type, and critical discussion of translational validity

The search strategy emphasized six target domains in advance: *tridoṣa* and homeostatic regulation; *prakṛti* and precision medicine; *agni* and metabolism/microbiome; *srotas* and systems/network physiology; *rasāyana* and immunology/aging biology; and *dinacaryā* and circadian science. Clinical evidence was then used not to "validate Ayurveda as a whole," but to ask a narrower and more defensible question: whether Ayurvedic concepts have helped generate safe, useful, and empirically tractable interventions in selected biomedical contexts. Primary classical repositories and core policy documents used in this review are listed and cited here. [9]

III. Results, Discussion, and Future Agenda

The literature supports a clear overall conclusion: Ayurveda is most productively interpreted as a sophisticated **systems-oriented, person-centered, preventive medical framework** whose concepts can sometimes be translated into modern biomedical programs, but only partially and with methodological discipline. The best evidence supports *functional correspondence*, not ontological identity. [10]

Ayurvedic construct	Classical orientation	Best biomedical bridge	Brief analytical judgment
Tridoṣa	Dynamic principles of regulation and imbalance	Homeostasis, regulatory control, systems physiology, network physiology	Strong conceptual bridge; weak one-to-one mechanistic equivalence
Prakṛti	Constitution or baseline individuality	Phenotype stratification, precision medicine, genomics, metabolomics, microbiome profiling	Strongest translational bridge currently available
Agni	Digestion, transformation, metabolic intelligence	Metabolism, digestive efficiency, immunometabolism, host–microbiome interaction	Promising bridge, especially when defined beyond mere "digestion"

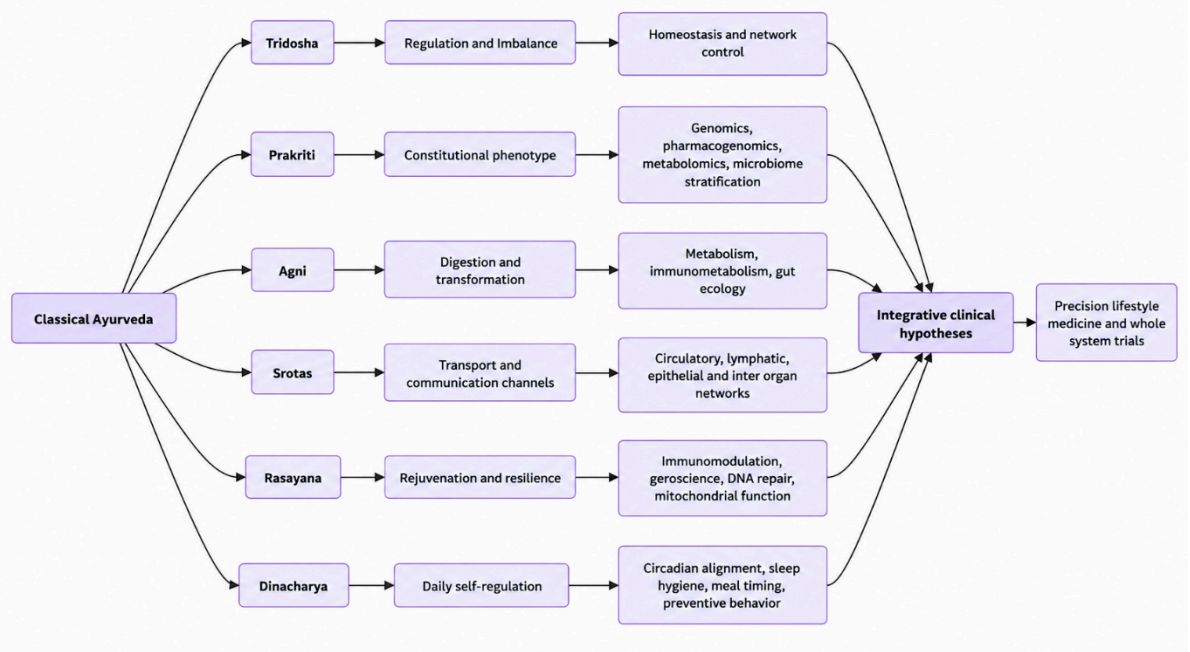
Ayurvedic construct	Classical orientation	Best biomedical bridge	Brief analytical judgment
Srotas	Channels of transport and transformation	Vascular, lymphatic, epithelial, neural, interstitial, and network communication systems	Best understood as a multiscale transport-communication model
Rasāyana	Rejuvenation, resilience, vitality, longevity	Immunomodulation, antioxidant defense, healthy aging, DNA repair, mitochondrial function	Strong mechanistic promise, but formulation-specific evidence varies
Dinacaryā	Daily regimen for preserving health	Circadian alignment, sleep hygiene, chrononutrition, behavioral preventive medicine	Conceptually robust; direct translational trials still sparse

Source note for the mapping table: The classical framing is anchored in searchable Sanskrit repositories and concept pages for *Carakasaṃhitā*, *Suśrutasaṃhitā*, and *Aṣṭāṅgahṛdaya*. The biomedical bridge work draws especially on reviews and primary studies in physiology, genomics, microbiome science, immunology, aging biology, and circadian medicine. [11]

Approximate period or year	Development	Why it matters
Late centuries BCE to early centuries CE	Redactional stabilization of the *Suśrutasaṃhitā* and *Carakasaṃhitā* in forms close to the surviving textual tradition	Establishes the classical physiological and clinical vocabulary later used for biomedical translation
Around the first millennium CE	*Aṣṭāṅgahṛdaya* synthesizes earlier Ayurvedic traditions into a compact and clinically influential compendium	Becomes a key source for *dinacaryā*, preventive lifestyle, and integrative clinical teaching
2008	Whole-genome expression study reports molecular correlates of extreme *prakṛti* phenotypes	Opens the ayurgenomics program
2010–2015	Conceptual bridge papers and genomic/*prakṛti* studies expand, including genome-wide SNP analysis and methodological reflections	Moves translation beyond metaphor toward testable stratification
2015	Systematic review and meta-analysis of Ayurvedic interventions for osteoarthritis published	Indicates promise, but also methodological weakness in the evidence base
2018	Randomized controlled trial reports superior symptom reduction for multimodal Ayurvedic treatment over conventional conservative care in knee osteoarthritis	One of the most cited whole-system efficacy signals
2022	WHO publishes Ayurveda training and practice benchmarks; randomized whole-system IBS trial published	Aligns regulation with evidence-building and supports clinically tractable whole-system research

Approximate period or year	Development	Why it matters
2023	WHO Traditional Medicine Global Summit held in Gujarat	Marks international policy consolidation around evidence-based integration
2024	Rheumatoid arthritis study reports clinical efficacy plus metabolomic normalization with Ayurvedic whole-system care	Links whole-system outcomes with contemporary biomarker science
2025	WHO adopts the Global Traditional Medicine Strategy 2025–2034	Establishes a global policy frame emphasizing evidence, safety, regulation, and health-system integration

Source note for the timeline: Ancient dates are approximate because textual redaction histories remain debated; modern entries are based on PubMed-indexed studies and official WHO documents. [12]



Interpretive note: The arrows above indicate *heuristic translation pathways*, not exact equivalence claims. [13]

Domain	Representative study or review	Design and scale	Main finding	Main limitation
Prakṛti and genomics	Govindaraj et al.	Genome-wide SNP analysis; 262 well-classified male participants after screening 3,416	Fifty-two SNPs differed significantly across *prakṛti* groups; PCA separated Vāta, Pitta, and Kapha clusters	Replication and broader demographic validation needed
Prakṛti and pharmacogenomics	CYP2C19 study	Healthy volunteer	Pitta showed predominance of extensive metabolizer genotypes; Kapha	Small study with phenotype-assessment variability

Domain	Representative study or review	Design and scale	Main finding	Main limitation
		genotyping study	showed more poor metabolizer genotypes	
Osteoarthritis	Chopra et al.	Randomized, double-blind, parallel-group equivalence trial; 440 participants	Ayurvedic formulations compared favorably with glucosamine sulfate and celecoxib in symptomatic knee OA	Formulation-focused rather than whole-system
Osteoarthritis	Kessler et al.	Multicenter randomized controlled pragmatic trial; 151 participants	WOMAC improvement at 12 weeks was greater in the Ayurveda group and effects were sustained at 6 and 12 months	Open-label multimodal design makes component attribution difficult
Osteoarthritis	Kessler et al.	Systematic review and meta-analysis	Signal of benefit, but evidence judged methodologically limited	Heterogeneity and variable study quality
Irritable bowel syndrome	Naik et al.	Randomized controlled whole-system trial	Significant improvement in IBS symptom scales and stool-pattern measures	Modest scale and limited biomarker differentiation
Rheumatoid arthritis	Krishna et al.	Longitudinal experiential profile over 7 years; 290 enrolled	Classical Ayurvedic management showed clinically relevant improvement trends	Unblinded and not methodologically equivalent to modern RCT standards
Rheumatoid arthritis	Rastogi et al.	Clinical metabolomics study	Reported clinical benefit and metabolic shift toward normalization with Ayurvedic whole-system intervention	Early-stage biomarker-linked evidence requiring independent replication
Rheumatoid arthritis	Park and Ernst	Systematic review	RCT evidence was insufficient for firm conclusions despite suggestive findings	Small number and quality of trials

Source note for the evidence table: [14]

Tridoṣa and homeostasis. The strongest contemporary reading of *tridoṣa* is as a high-order regulatory model rather than a primitive anatomy lesson. Rastogi argued that *tridoṣa* should be approached prospectively on its own terms rather than retrofitted after the fact into modern labels, while physiology

literature identifies homeostasis as a central organizing principle of life and network physiology literature emphasizes coordinated interactions across organ systems. The translational gain here is not that Vāta, Pitta, and Kapha "are" the nervous, endocrine, and immune systems, but that Ayurveda and systems physiology both seek lawful descriptions of dynamic balance, perturbation, compensation, and failure. [15]

Prakṛti and precision medicine. *Prakṛti* is the most empirically developed bridge concept. Reviews have linked *prakṛti* with metabolism, chronic disease patterns, and genotype; transcriptomic work has reported biochemical and gene-expression correlates for extreme constitutional types; SNP-based genome-wide work identified statistically differentiated variants across major *prakṛti* groups; and more recent ayurgenomics literature explicitly interprets *prakṛti* as a stratification framework for personalized care. Microbiome literature now adds an additional layer, proposing *prakṛti* phenotypes as a possible stratifier of gut microbial community structure. Even here, though, the correct conclusion is not that Ayurveda has already solved precision medicine, but that classical phenotyping may capture biologically meaningful variation that modern omics can investigate further. [16]

Agni, metabolism, and the microbiome. Classical Ayurveda treats *agni* as the principle of digestion and transformation, and the biomedical literature offers two particularly useful bridge zones. The first is metabolic function, where Ayurvedic authors have long interpreted *agni* as broader than gastric digestion alone. The second is host–microbiome ecology: modern reviews from an Ayurvedic perspective argue that diet, digestive quality, and microbial composition are tightly interwoven, while Ayurveda-based diet and lifestyle reviews in type 2 diabetes propose plausible microbiome-mediated mechanisms including enrichment of beneficial taxa and reduction of dysbiosis-linked bacterial patterns. The translational risk is reductionism: *agni* should not be collapsed into a single enzyme or stomach-acid concept, because the classical term also includes distributed transformation across bodily systems. [17]

Srotas and network physiology. *Srotas* are described classically as channels of transport and transformation. Modern discussions often compare them to ducts, vessels, and circulatory pathways, but that is only part of the picture. Reviews on *doshavaha srotas* and *mutravaha srotas* indicate that Ayurvedic physiology treats channel integrity as essential for the movement of nutrients, wastes, bodily factors, and pathology. That conceptual logic aligns more closely with modern network physiology and multiscale transport-communication thinking than with a single anatomical system. A careful paper should therefore present *srotas* as a plural, distributed systems concept spanning circulation, fluid regulation, barrier function, tissue exchange, and inter-organ communication. [18]

Rasāyana, immunology, and healthy aging. Classical sources place *rasāyana* at the center of rejuvenation and longevity discourse. Modern evidence gives this bridge unusual depth: experimental work on Āmalakī Rasāyana reported immunomodulatory activity; human blood mononuclear cell studies reported increased telomerase activity after Amalaki Rasayana administration; additional work linked Amalaki Rasayana to DNA-damage-related pathways, shifts in lipid and immune metabolites, and improved cardiac mitochondrial and contractile function in animal models; and broader reviews connect *rasāyana* with immunomodulation, antiviral potential, oxidative stress regulation, and geroscience. These signals are genuinely interesting, but they remain formulation-specific and do not justify treating all *rasāyana* therapies as proven anti-aging interventions. [19]

Dinacaryā and circadian medicine. *Dinacaryā* is among the cleanest conceptual bridges between Ayurveda and modern preventive biomedicine. Classical Ayurveda devotes explicit attention to daily routines of waking, hygiene, activity, and conduct, while modern circadian literature shows that sleep timing, light exposure, meal timing, and behavioral regularity influence metabolic, endocrine, and general health outcomes. In translational terms, *dinacaryā* can be framed as a classical program of behavioral entrainment. The evidence base is therefore conceptually strong even when direct Ayurvedic chronobiology trials remain limited. [20]

Clinical evidence and its real meaning. The clinical literature is promising but should be represented with restraint. The 2018 multicenter pragmatic knee osteoarthritis RCT is important because it demonstrated clinically meaningful symptom improvement with multimodal Ayurvedic care over conventional

conservative management in 151 participants, with sustained effects through follow-up. Earlier work in 440 patients found Ayurvedic formulations comparable with glucosamine sulfate and celecoxib for symptomatic knee OA. A randomized whole-system IBS study also reported superior improvement in key symptom endpoints. Rheumatoid arthritis data are more heterogeneous: a 290-patient longitudinal experiential profile suggested benefit, and a 2024 study added metabolomic evidence of a shift toward normalization, but systematic review evidence remains insufficient for firm disease-wide conclusions. The correct scholarly interpretation is therefore "active and promising but not yet definitive." [21]

Strengths of the Ayurvedic framework. Across the literature, Ayurveda's major strengths are consistency in constitution-based thinking, emphasis on prevention and self-regulation, the integration of diet-behavior-environment with treatment, and a whole-system orientation that resonates with current interest in systems medicine and precision health. These are not trivial assets in an era of multimorbidity, chronic inflammation, lifestyle-linked disease, and rising demand for low-cost, patient-engaged care. [22]

Limitations and epistemological differences. The central limitations are equally clear. Ayurvedic constructs are often defined at a level of abstraction not easily reducible to biomarkers; phenotype assessment tools remain variably standardized; reproducible intervention packages are difficult because Ayurveda is often personalized and multimodal; and many trials struggle with blinding, comparability, and quality control. Beyond methodology lies a deeper epistemological difference: Ayurveda's categories are frequently teleological, normative, and relational, whereas biomedical categories are usually material, localizable, and experimentally modular. A high-quality paper must state plainly that these are different knowledge architectures, and that translation is therefore partial by design. [23]

Ethical and regulatory issues. No publication-ready manuscript on Ayurveda and biomedicine should omit product safety and regulation. NCCIH warns that some Ayurvedic preparations may contain toxic levels of lead, mercury, or arsenic; WHO has long emphasized pharmacovigilance for herbal medicines; and WHO's 2022 Ayurveda benchmarks were explicitly framed around minimum standards for safety, quality, training, and practice. These issues are not peripheral—they determine whether integration is clinically defensible. Any modern translational program must therefore include authenticated raw materials, batch standardization, contaminant testing, herb–drug interaction monitoring, adverse-event reporting, and practitioner credentialing. [24]

Policy and clinical implications. A reasonable inference from the present evidence is that Ayurveda's strongest near-term role is as an **adjunctive and preventive system** in chronic disease management, rehabilitation, healthy aging, symptom reduction, and lifestyle restructuring rather than as a blanket replacement for acute biomedical care. WHO's new strategy, the GTMC, and the summit recommendations all favor evidence-based integration, not uncritical parallelism. In practical terms, that means Ayurveda-informed care pathways are most ready for development where they can improve self-management, symptom burden, long-term resilience, and culturally grounded health behavior, while remaining embedded in modern standards of diagnostics, safety, and referral. [25]

Future research agenda. The next generation of serious Ayurveda–biomedicine research should do five things at once. First, standardize *prakṛti*, *agni*, and related phenotyping with published reporting norms. Second, connect classical phenotyping to multi-omics, wearables, digital diet logs, and longitudinal clinical data rather than relying on cross-sectional association alone. Third, prioritize pragmatic and adaptive whole-system trials in chronic diseases where Ayurveda is already widely used. Fourth, build formulation transparency, contaminant testing, and pharmacovigilance into trial design from the beginning. Fifth, treat Sanskrit textual scholarship as part of the method, not mere background, so that modern research questions remain faithful to the conceptual range of the original terms. [26]

Conclusion. The most defensible publication claim is this: Ayurveda offers a rich conceptual grammar for person-centered and systems-oriented health research, and selected constructs—especially *prakṛti, agni, rasāyana,* and *dinacaryā*—now show meaningful points of contact with precision medicine, metabolism, microbiome science, immunology, aging biology, and circadian health. At the same time, neither the classical texts nor the modern evidence justify simplistic equivalence, triumphalist civilizational narratives,

or claims of total validation. What the field needs next is disciplined translation: philologically grounded, clinically responsible, biomarker-literate, and regulated. [27]

IV. Recommended Journals and Submission Strategy

For the manuscript in its current form, the strongest first-choice journal is **Journal of Ayurveda and Integrative Medicine** because its scope explicitly targets transdisciplinary work connecting Ayurveda, traditional medicine, and biomedicine. If you revise the paper toward phytochemistry, pharmacology, or formulation-level mechanism, **Journal of Ethnopharmacology** becomes more competitive. If you retain the present whole-system and methodological focus, **Integrative Medicine Research** and **BMC Complementary Medicine and Therapies** are strong alternatives. [28]

Journal	Why it fits this manuscript	What to emphasize in submission	Practical tip
Journal of Ayurveda and Integrative Medicine	Direct scope overlap with Ayurveda–biomedicine dialogue	Translational bridge framework, clinical evidence, WHO policy relevance	Use consistent Sanskrit transliteration and define each classical term at first use
Integrative Medicine Research	Welcomes holistic integrative health and convergence with biomedical sciences	Whole-system methodology, interdisciplinarity, clinical applicability	Frame the paper as an integrative research roadmap, not only a concept review
BMC Complementary Medicine and Therapies	Prefers evidence-based complementary interventions with biological mechanism	Methods transparency, safety, mechanism, and evidence quality	Sharpen inclusion/exclusion criteria and add a clearer limitations paragraph
Journal of Ethnopharmacology	Strong fit if the paper foregrounds formulations, natural products, and pharmacologic effects	Rasāyana, microbiome-active botanicals, formulation standardization	Add more pharmacognosy, bioactive, and formulation-quality detail before submitting
Frontiers in Pharmacology: Ethnopharmacology	Good if the article is repositioned toward mechanistic and omics-driven interpretation	Microbiome, immunology, pharmacology, translational mechanism	Increase figure count and emphasize experimentally testable pathways
Journal of Integrative Medicine	Broad East–West integrative scope, explicitly open to Ayurveda	Clinical and conceptual integration in a globally legible style	Keep language precise and avoid assuming Ayurvedic background knowledge in reviewers

Scope note: The fit judgments above are inferential and based on each journal's published aims and scope. [29]

A practical submission sequence for the current version would be: **Journal of Ayurveda and Integrative Medicine** first; **Integrative Medicine Research** second; **BMC Complementary Medicine and Therapies** third. If you add a stronger pharmacology section centered on botanicals, formulations, or bioactives, then **Journal of Ethnopharmacology** should move higher in your target list. Before submission, ensure the manuscript includes: a concise novelty statement; a transparent review methodology; a non-reductive

translation thesis; an explicit safety/regulatory subsection; a polished APA reference list; and language that is analytical rather than promotional.

V. APA Reference List

Primary Sanskrit and classical-source access

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