

Original Research Article

CAN RASAYANA PROMOTE HEALTHY AGEING? A QUESTION-ORIENTED NARRATIVE REVIEW OF BIOLOGICAL EVIDENCE, CLINICAL EVIDENCE, AND FUTURE RESEARCH

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ABSTRACT

Background: Healthy ageing is a global public health priority as populations age and chronic disease burden increases. Rasayana, a principal branch of Ayurveda, is traditionally described as a comprehensive rejuvenative approach involving herbal interventions, diet, lifestyle, and behavioural practices to preserve vitality, resilience, and longevity. The objective is to critically evaluate the potential role of Rasayana in promoting healthy ageing by integrating classical Ayurvedic concepts with contemporary evidence from geroscience.

Materials and Methods: A narrative review was conducted using literature identified through PubMed, Scopus, Web of Science, and Google Scholar for studies published up to June 2026, together with relevant classical Ayurvedic texts. The review addressed four questions concerning the potential contribution of Rasayana to healthy ageing, available biological and clinical evidence, current uncertainties, and priorities for future research.

Results: Available evidence indicates that Rasayana has biological plausibility through antioxidant, anti-inflammatory, immunomodulatory, mitochondrial-protective, and neuroprotective effects targeting multiple ageing-related pathways. However, clinical evidence remains limited by methodological weaknesses, small and heterogeneous studies, variability in formulations, inadequate standardization, short follow-up periods, limited safety reporting, and inconsistent assessment of clinically meaningful healthy-ageing outcomes. Evidence in healthy older adults remains particularly limited.

Conclusion: Current evidence supports the mechanistic rationale for Rasayana as a potential healthy-ageing intervention but is insufficient to establish its clinical effectiveness in promoting healthspan. Future research should prioritize standardized Rasayana interventions, adequately powered randomized controlled trials, validated multidimensional healthy-ageing outcomes, comprehensive safety assessment, and interdisciplinary collaboration to establish its role within evidence-based integrative healthcare.

Keywords: Rasayana, Ayurveda, Healthy ageing, Geroscience, Healthspan.

INTRODUCTION

Population ageing is one of the defining demographic transitions of the twenty-first century. According to the World Health Organization (WHO), the number of people aged 60 years and above is projected to exceed 2.1 billion by 2050, highlighting the urgent

need for strategies that promote not only longevity but also the maintenance of functional ability, independence, and quality of life throughout the lifespan. Consequently, the focus of healthcare has shifted from increasing lifespan alone to extending healthspan, the period of life spent in good health and free from significant disability. Healthy ageing is

therefore recognized as a multidimensional process involving the preservation of intrinsic capacity, physiological resilience, cognitive function, and social participation rather than merely the absence of disease.^[1] Advances in geroscience have demonstrated that ageing is driven by interconnected biological processes, including oxidative stress, chronic low-grade inflammation (inflammaging), mitochondrial dysfunction, impaired proteostasis, cellular senescence, genomic instability, and immunosenescence. These mechanisms contribute to frailty and increase susceptibility to cardiovascular disease, neurodegenerative disorders, metabolic diseases, cancer, and other age-related conditions.^[2,3] Accordingly, interventions capable of targeting multiple ageing-related pathways simultaneously are increasingly being explored as potential strategies for promoting healthy ageing. Ayurveda has long recognized ageing (Jara) as a natural yet modifiable process. Among its preventive and promotive health approaches, Rasayana Tantra occupies a central position. Classical Ayurvedic texts describe Rasayana not merely as rejuvenative formulations but as a comprehensive strategy encompassing appropriate nutrition, lifestyle regulation, behavioural conduct (Achara Rasayana), and selected herbal and herbo-mineral interventions aimed at maintaining tissue integrity, enhancing vitality (Ojas), improving cognitive function, strengthening disease resistance (Vyadhikshamatva), and delaying functional decline.^[4-6] Unlike disease-specific therapeutic approaches, Rasayana emphasizes the preservation of health through optimization of physiological functions across multiple body systems. Growing scientific interest in traditional medical systems has led to increasing investigation of Rasayana botanicals such as *Withania somnifera* (Ashwagandha), *Phyllanthus emblica* (Amalaki), *Tinospora cordifolia* (Guduchi), and *Centella asiatica* (Mandukaparni). Experimental and clinical studies have reported antioxidant, anti-inflammatory, immunomodulatory, neuroprotective, and metabolic effects that may be relevant to mechanisms implicated in biological ageing. However, the available evidence is heterogeneous with respect to study design, intervention standardization, outcome measures, and methodological quality, limiting definitive conclusions regarding their role in healthy ageing.^[7-10] Several reviews have summarized the pharmacological properties of Rasayana drugs or discussed their traditional applications in geriatric care. However, relatively few have critically examined whether the current body of evidence supports Rasayana as a scientifically plausible strategy for healthy ageing by integrating classical Ayurvedic concepts with contemporary geroscience while explicitly evaluating the strengths, limitations, and translational implications of the available evidence. Accordingly, this narrative review critically synthesizes the classical foundations of Rasayana with current evidence from healthy-ageing research. Rather than providing a descriptive

catalogue of Rasayana formulations, this review addresses four key questions: (i) Can Rasayana contribute to healthy ageing? (ii) What is the current biological and clinical evidence? (iii) What remains uncertain? and (iv) What research priorities should guide future translational and clinical investigations? By addressing these questions, the review aims to provide a balanced evidence-based perspective that may inform future research and integrative approaches to healthy ageing.

MATERIAL AND METHODS

This narrative review critically examines the potential role of Rasayana in promoting healthy ageing by integrating classical Ayurvedic literature with contemporary biomedical evidence. The review was guided by four predefined questions: (i) Can Rasayana be interpreted within the contemporary framework of healthy ageing? (ii) What biological and clinical evidence supports its role? (iii) What are the major limitations of the current evidence? and (iv) What research priorities are needed to advance the field? A comprehensive literature search was conducted in PubMed, Scopus, Web of Science, and Google Scholar for studies published up to June 2026 using combinations of the keywords "Rasayana," "Ayurveda," "healthy ageing," "healthspan," "geroscience," "oxidative stress," "inflammaging," "immunosenescence," "mitochondrial dysfunction," "cognitive ageing," and major Rasayana botanicals. Peer-reviewed systematic reviews, meta-analyses, randomized controlled trials, observational studies, experimental studies, and landmark publications in geroscience and healthy-ageing research were preferentially included. Classical Ayurvedic concepts were interpreted using standard published editions of the Charaka Samhita, Sushruta Samhita, and Ashtanga Hridaya, while reports from the World Health Organization were consulted to contextualize healthy ageing within current public health frameworks. Studies were selected based on their relevance to the objectives of the review, with emphasis on biological mechanisms, clinical outcomes, and translational relevance of Rasayana in healthy ageing. Conference abstracts, duplicate publications, and studies lacking sufficient methodological detail or relevance were excluded. Owing to the heterogeneity of study designs, interventions, and outcome measures, a quantitative synthesis was not appropriate. Therefore, the retrieved literature was critically synthesized narratively, with emphasis on the strength and consistency of evidence, biological plausibility, methodological quality, clinical relevance, and remaining research gaps.

Can Rasayana contribute to healthy ageing?

Healthy ageing is increasingly viewed as the preservation of functional ability and physiological resilience rather than simply the prevention of disease. Contemporary geroscience recognize ageing

as a multifactorial process driven by interconnected mechanisms such as oxidative stress, chronic low-grade inflammation, mitochondrial dysfunction, impaired immune function, and cellular senescence. Consequently, interventions capable of influencing multiple biological pathways simultaneously are considered promising strategies for extending healthspan.^[1–3] Within this context, the Ayurvedic concept of Rasayana offers a distinctive perspective. Classical texts describe Rasayana as a comprehensive approach aimed at promoting longevity, maintaining tissue integrity, enhancing vitality (Ojas), strengthening disease resistance (Vyadhi-kshamatva), improving cognitive function, and delaying age-related functional decline.^[4–6] Although these concepts originate from a different medical paradigm, their overall objectives show notable convergence with the modern concept of healthy ageing, which emphasizes preserving intrinsic capacity, resilience, and quality of life throughout the life course. Rather than equating traditional Ayurvedic concepts with specific molecular mechanisms, this convergence provides a rationale for exploring Rasayana using contemporary scientific methods. Importantly, Rasayana should not be viewed solely as a collection of herbal medicines. Classical Ayurveda describes it as a holistic intervention that integrates rejuvenative formulations with appropriate nutrition, lifestyle modification, behavioural practices (Achara Rasayana), and individualized care. This systems-oriented approach aligns with the growing recognition that effective healthy-ageing interventions may need to address multiple interacting determinants of ageing rather than isolated biological targets. Emerging experimental research has further strengthened the biological plausibility of Rasayana by demonstrating antioxidant, anti-inflammatory, immunomodulatory, neuroprotective, and mitochondrial-protective effects of several classical Rasayana botanicals. However, biological plausibility alone does not establish clinical effectiveness, and the extent to which these findings translate into meaningful healthy-ageing outcomes in humans remains uncertain. Therefore, the relevance of Rasayana to healthy ageing lies not only in its traditional rejuvenative philosophy but also in its potential to complement contemporary geroscience through a multi-target approach to preserving physiological function. The following section critically examines the current biological and clinical evidence supporting this proposition.

What is the current biological and clinical evidence?

Healthy ageing is increasingly recognized as a consequence of preserving physiological resilience by simultaneously targeting multiple biological processes that drive ageing. Unlike conventional therapeutic approaches directed at a single disease, Rasayana interventions are traditionally intended to maintain systemic homeostasis, improve adaptive capacity, and delay functional decline. Contemporary research has therefore focused on evaluating whether

Rasayana botanicals and related interventions influence key biological mechanisms implicated in ageing. Although the available evidence is heterogeneous and predominantly preclinical, several mechanistic domains have consistently emerged.

Oxidative stress and redox homeostasis:

Oxidative stress is widely recognized as one of the fundamental mechanisms underlying biological ageing. Excessive production of reactive oxygen species (ROS) results in cumulative oxidative damage to DNA, proteins, and lipids, thereby impairing cellular homeostasis and accelerating tissue dysfunction. Persistent oxidative stress also contributes to mitochondrial dysfunction, cellular senescence, and chronic low-grade inflammation, creating a self-perpetuating cycle that promotes age-related functional decline and increases susceptibility to multiple age-related disorders.^[2,3] Experimental evidence consistently demonstrates that several classical Rasayana botanicals possess antioxidant properties through diverse yet convergent mechanisms. *Phyllanthus emblica* (Amalaki), rich in polyphenols, tannins, vitamin C, and other bioactive phytochemicals, has consistently demonstrated potent antioxidant and anti-ageing effects by enhancing endogenous antioxidant enzymes, scavenging reactive oxygen species, reducing lipid peroxidation, and protecting mitochondrial function.^[8–11] *Withania somnifera* (Ashwagandha) has similarly been shown to attenuate oxidative stress, preserve mitochondrial integrity, modulate redox-sensitive signalling pathways, and improve cellular resilience through the actions of bioactive withanolides.^[12] *Tinospora cordifolia* (Guduchi) exhibits antioxidant, cytoprotective, and immunomodulatory activities through suppression of oxidative stress and enhancement of endogenous defence mechanisms, whereas *Centella asiatica* (Mandukaparni) demonstrates antioxidant and neuroprotective effects that may contribute to preservation of cognitive function during ageing.^[13,14] Collectively, these findings indicate that maintenance of redox homeostasis is one of the most consistently supported biological mechanisms underlying the rejuvenative effects attributed to Rasayana therapy. Despite encouraging experimental findings, translation into clinical practice remains limited. Human studies evaluating Rasayana interventions have reported favourable changes in oxidative stress biomarkers; however, most clinical trials have been characterized by relatively small sample sizes, heterogeneous study populations, short intervention durations, and variability in formulations, limiting comparison across studies. Furthermore, existing studies have primarily assessed biochemical surrogate markers rather than clinically meaningful healthy-ageing outcomes such as physical function, intrinsic capacity, frailty, or quality of life, making it difficult to determine whether the observed biological effects translate into improvements in health span. Overall, experimental evidence provides moderate support for the antioxidant mechanisms of Rasayana,

whereas the certainty of clinical evidence remains low to moderate because of methodological limitations, heterogeneity of interventions, and inconsistent outcome assessment. Future adequately powered randomized controlled trials employing standardized Rasayana formulations together with validated biomarkers and clinically relevant healthy-ageing outcome measures are required to determine whether antioxidant effects translate into meaningful improvements in healthspan.^[15]

Chronic low-grade inflammation (inflammaging):

Ageing is characterized by persistent sterile, low-grade systemic inflammation, commonly referred to as inflammaging, which is increasingly recognized as a central mechanism linking biological ageing with frailty, sarcopenia, cardiovascular disease, neurodegeneration, metabolic dysfunction, and immune decline. Sustained activation of inflammatory signalling pathways, particularly nuclear factor-kappa B (NF- κ B), together with elevated circulating concentrations of pro-inflammatory mediators such as interleukin-6 (IL-6), tumour necrosis factor- α (TNF- α), and C-reactive protein (CRP), contributes to progressive tissue dysfunction and loss of physiological resilience.^[16] Experimental evidence indicates that several classical Rasayana botanicals exert anti-inflammatory effects through complementary molecular mechanisms. *Withania somnifera* (Ashwagandha) suppresses NF- κ B activation, reduces pro-inflammatory cytokine production, and attenuates oxidative stress, thereby targeting two closely interconnected hallmarks of ageing.^[12] *Tinospora cordifolia* (Guduchi) exhibits immunomodulatory and anti-inflammatory properties by regulating inflammatory mediators and innate immune responses, whereas *Phyllanthus emblica* (Amalaki) reduces oxidative stress-induced inflammation through its polyphenol-rich phytochemical profile.^[11,13] Collectively, these findings support the biological plausibility that modulation of chronic low-grade inflammation is an important mechanism through which Rasayana may promote healthy ageing. However, translation into clinical practice remains limited. Few adequately powered randomized controlled trials have evaluated inflammatory biomarkers as predefined primary outcomes in older adults, and available studies are constrained by heterogeneity in Rasayana formulations, dosage, treatment duration, participant characteristics, and outcome measures. Furthermore, improvements in inflammatory biomarkers have not been consistently associated with clinically meaningful healthy-ageing outcomes, including physical function, frailty, intrinsic capacity, or quality of life. Consequently, although mechanistic evidence supports the anti-inflammatory potential of Rasayana, its effectiveness in modifying inflammaging and improving healthspan in humans remains uncertain. Overall, preclinical evidence provides moderate support for the anti-inflammatory actions of Rasayana, whereas the certainty of clinical evidence remains low to moderate because of

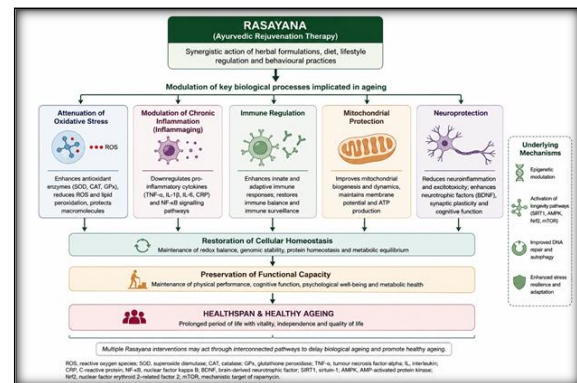
methodological limitations and the scarcity of high-quality human trials. Future studies should employ standardized Rasayana formulations together with validated inflammatory biomarkers and clinically relevant healthspan outcomes to determine whether modulation of inflammaging translates into sustained improvements in healthy ageing.^[15]

Immunosenescence and physiological resilience:

Immunosenescence is characterized by progressive remodelling of innate and adaptive immune function, resulting in increased susceptibility to infections, reduced vaccine responsiveness, impaired tissue repair, diminished immune surveillance, and persistent low-grade inflammation. These age-related immune alterations contribute to frailty, multimorbidity, and reduced physiological resilience. Consequently, contemporary healthy-ageing research emphasizes interventions that preserve immune homeostasis rather than simply enhancing immune activation.^[17,18] The Ayurvedic concept of *Vyadhikshamatva*, describing the body's capacity to resist disease and maintain physiological resilience, provides a relevant framework for investigating the immunomodulatory actions of Rasayana. Experimental studies indicate that *Tinospora cordifolia* (Guduchi), *Withania somnifera* (Ashwagandha), and *Phyllanthus emblica* (Amalaki) regulate macrophage and natural killer cell function, cytokine production, and adaptive immune responses, suggesting broad immunomodulatory rather than merely immunostimulatory effects.^[11–13,17] Collectively, these findings support the biological plausibility that Rasayana may enhance immune resilience by maintaining immune homeostasis during ageing. However, clinical evidence remains limited. Although some studies have reported improvements in selected immune parameters and reductions in recurrent infections, most have been constrained by small sample sizes, heterogeneous study populations, inconsistent immunological endpoints, and short follow-up periods. Moreover, convincing evidence that Rasayana delays or reverses immunosenescence in humans is currently lacking. Overall, preclinical evidence provides moderate support for the immunomodulatory actions of Rasayana, whereas the certainty of clinical evidence remains low because of methodological limitations and the scarcity of robust human studies. Future randomized controlled trials should incorporate standardized immune biomarkers together with clinically relevant outcomes, including vaccine responsiveness, infection burden, frailty, and functional status, to determine whether Rasayana can meaningfully improve immune resilience during healthy ageing.^[15,19] Rasayana may support healthy ageing through mitochondrial protection and neuroprotection. Preclinical studies suggest that botanicals such as *Withania somnifera*, *Phyllanthus emblica*, and *Tinospora cordifolia* improve mitochondrial function, ATP production, antioxidant defence, and reduce oxidative stress.^[20–21] Similarly, *Withania somnifera* and *Centella asiatica*

demonstrate neuroprotective, anti-inflammatory, antioxidant, and neurotrophic effects that may support memory and cognitive function. However, clinical evidence remains limited, with few rigorous studies involving healthy older adults. Overall, preclinical evidence is moderate, while clinical certainty is low to moderate. Well-designed randomized trials using validated mitochondrial, cognitive, neuroimaging, and functional ageing outcomes are needed (figure 1). Rasayana therapy has considerable biological potential for promoting healthy ageing through antioxidant, anti-inflammatory, immunomodulatory, mitochondrial, and neuroprotective mechanisms. However, current evidence remains insufficient to establish definitive clinical effectiveness.^[22-24] A major limitation is the predominance of in vitro and animal studies, whose findings cannot be directly extrapolated to healthy older adults. Clinical evidence is further weakened by small sample sizes, short follow-up periods, methodological limitations, heterogeneous outcome measures, and inadequate reporting of adverse events. Substantial variability exists among Rasayana interventions regarding botanical species, plant parts, extraction methods, dosage, formulation, phytochemical composition, and manufacturing processes. Lack of authentication, standardization, and quality-control procedures limits reproducibility and comparison across studies.^[25-28] Furthermore, most clinical trials focus on disease-specific populations or biochemical outcomes rather than meaningful indicators of healthy ageing, such as intrinsic capacity, frailty, physical performance, cognition, functional independence, and quality of life. Long-term safety, herb–drug interactions, contamination, adulteration, and pharmacovigilance also require greater attention.^[29-31] Future research should prioritize adequately powered, prospectively registered randomized controlled trials with standardized Rasayana formulations, appropriate comparators, rigorous randomization, blinded outcome assessment, predefined statistical plans, and sufficiently long follow-up.^[32] Studies should include community-dwelling older adults and individuals with pre-frailty or early functional decline. Multidimensional healthy-ageing outcomes should be complemented by validated biomarkers, including inflammatory markers, mitochondrial measures, epigenetic ageing clocks, metabolomic, and proteomic signatures. Systems biology, multi-omics, network pharmacology, artificial intelligence, and computational modelling may help elucidate the complex mechanisms underlying Rasayana effects. Adoption of GACP, GMP, phytochemical fingerprinting, and internationally accepted quality standards is essential. Interdisciplinary collaboration among Ayurvedic practitioners, geriatricians, pharmacologists, epidemiologists, biostatisticians, and molecular scientists will strengthen research quality. Ultimately, Rasayana should be investigated not merely as herbal therapy but as a comprehensive, personalized healthy-ageing strategy integrating

nutrition, lifestyle, preventive care, and therapeutic interventions.



CONCLUSION

Rasayana is an Ayurvedic approach traditionally associated with vitality, resilience, functional capacity, and longevity. Emerging evidence suggests benefits through antioxidant, anti-inflammatory, immunomodulatory, mitochondrial, and neuroprotective mechanisms. However, clinical evidence remains limited by methodological weaknesses and inconsistent standardization. Rigorous randomized trials, validated ageing outcomes, safety assessment, and interdisciplinary research are needed to establish its role in promoting healthy ageing.

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