

## Review Article



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## “AYURVEDIC ANTIOXIDANTS AND THEIR PHARMACOLOGICAL EVALUATION: AN INTEGRATIVE REVIEW”

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**ABSTRACT**

**Introduction:** Oxidative stress, caused by excess production of reactive oxygen species (ROS), plays a pivotal role in the pathogenesis of aging, metabolic syndrome, neurodegenerative disorders, cardiovascular disease, and cancer. Ayurveda, the traditional medical system of India, describes a wide range of herbs under *Rasayana* and *Varnya dravyas* that are rich in antioxidant phytoconstituents. These herbs, including *Emblica officinalis* (*Amalaki*), *Withania somnifera* (*Ashwagandha*), *Tinospora cordifolia* (*Guduchi*), *Glycyrrhiza glabra* (*Yashtimadhu*), and *Curcuma longa* (*Haridra*), are extensively used for health promotion and disease prevention.

**Methods:** A structured review was conducted by consulting classical Ayurvedic texts (*Charaka Samhita*, *Sushruta Samhita*, *Bhavaprakasha Nighantu*) and modern scientific databases (PubMed, Scopus, Web of Science, AYUSH Research Portal). Literature published from 1980–2025 was reviewed. Experimental studies, pharmacological assays, and clinical trials evaluating antioxidant potential of Ayurvedic herbs were included.

**Results:** Ayurvedic antioxidants act through multiple mechanisms including free radical scavenging, upregulation of endogenous antioxidant enzymes (SOD, catalase, glutathione peroxidase), mitochondrial protection, and modulation of redox-sensitive transcription factors such as Nrf2 and NF-κB. *Amalaki* exhibits strong vitamin C-linked antioxidant activity, *Guduchi* enhances glutathione metabolism, *Ashwagandha* reduces lipid peroxidation, and *Haridra* modulates inflammatory signaling. Clinical studies demonstrate benefits in metabolic syndrome, arthritis, neurocognitive decline, and cancer adjuvant therapy. However, limitations exist in terms of standardization, bioavailability, and long-term safety data. **Discussion:** Ayurveda’s holistic concept of *Rasayana* overlaps with modern antioxidant pharmacology. Emerging fields such as phytochemical standardization, nanotechnology, and integrative clinical trials provide promising directions for validation. **Conclusion:** Ayurvedic antioxidants offer a safe and multidimensional approach to combating oxidative stress. Integrating traditional wisdom with modern pharmacological evaluation can establish them as evidence-based interventions in oxidative stress-related disorders.

**KEYWORDS:** *Amalaki*, antioxidants, Ayurveda, oxidative stress, *Rasayana*



## INTRODUCTION

Oxidative stress arises from an imbalance between pro-oxidant and antioxidant mechanisms in the body.<sup>[1]</sup> Free radicals and reactive oxygen species (ROS) damage lipids, proteins, and DNA, contributing to aging and chronic diseases such as diabetes, atherosclerosis, neurodegeneration, and cancer.<sup>[2-3]</sup> Modern medicine recognizes antioxidants as therapeutic agents for preventing and managing oxidative stress-induced disorders.<sup>[4]</sup>

Ayurveda, a holistic healthcare system, describes several herbal formulations under *Rasayana Tantra*, aimed at rejuvenation, vitality, and immunity.<sup>[5]</sup> Many *Rasayana* herbs—*Amalaki*, *Guduchi*, *Haridra*, *Ashwagandha*, and *Yashtimadhu*—are now identified as potent antioxidants.<sup>[6-7]</sup> Ayurveda also emphasizes dietary antioxidants through fruits, vegetables, and spices, thus providing a preventive approach to health.<sup>[8]</sup>

The aim of this review is to provide an integrative analysis of Ayurvedic antioxidants and their modern pharmacological evaluation. The objectives are: (1) to document Ayurvedic herbs with antioxidant potential as described in classical texts; (2) to evaluate their pharmacological and clinical evidence in oxidative stress; and (3) to identify research gaps and future directions for integrating Ayurveda into evidence-based antioxidant therapeutics.<sup>[10]</sup>

## MATERIALS AND METHODS

A structured literature review was performed from March to August 2025.

**Sources:**<sup>[11]</sup>

- **Ayurvedic texts:** *Charaka Samhita*, *Sushruta Samhita*, *Ashtanga Hridaya*, *Bhavaprakasha Nighantu*, *Rasaratna Samuccaya*.
- **Databases:** PubMed, Scopus, Web of Science, AYUSH Research Portal, and Google Scholar.

**Search strategy:** Keywords used were: “Ayurveda AND antioxidants,” “*Rasayana* AND oxidative stress,” “Ayurvedic herbs free radical scavenging,” “*Amalaki* antioxidant,” “*Guduchi* oxidative stress,” and “clinical trials antioxidants Ayurveda.”<sup>[12]</sup>

**Inclusion criteria:**<sup>[13]</sup>

- Experimental studies evaluating antioxidant activity of Ayurvedic herbs.
- Pharmacological assays (*in vitro*, *in vivo*) of free radical scavenging.

- Clinical trials reporting oxidative stress biomarkers.
- Reviews/meta-analyses published between 1980–2025.

**Exclusion criteria:**<sup>[14]</sup>

- Non-Ayurvedic herbal antioxidants.
- Non-peer-reviewed reports.
- Studies lacking oxidative stress endpoints.

**Types of studies reviewed:** Pharmacognostic, pharmacological, biochemical, animal experiments, and clinical trials. Data were thematically classified into classical references, mechanisms, pharmacological assays, clinical applications, and limitations.<sup>[15]</sup>

## OBSERVATION AND RESULTS

### 1. Ayurvedic Concept of Antioxidants

- Ayurveda does not directly use the term “antioxidant” but describes *Rasayana* dravyas as substances that enhance vitality, delay aging, and protect against degenerative diseases.
- *Ojas* (vital essence) is considered the physiological correlate of immunity and resistance against oxidative damage.
- Herbs classified as *Vayasthapana Rasayana* (age-sustaining) and *Medhya Rasayana* (cognitive rejuvenators) demonstrate antioxidant actions in modern studies.

### 2. Major Ayurvedic Antioxidant Herbs

#### a) *Emblica officinalis* (*Amalaki*)

- Classical: Described as the best *Rasayana* in *Charaka Samhita*.
- Phytochemicals: Rich in vitamin C, tannins (emblicanin A & B), flavonoids.
- Mechanisms: Potent free radical scavenger, increases SOD, catalase, and glutathione.
- Studies: Animal models show protection against oxidative liver injury and neurotoxicity. Clinical trials report improved antioxidant status in diabetics and elderly subjects.

#### b) *Tinospora cordifolia* (*Guduchi*)

- Classical: Known as *Amrita*, “the immortal.”
- Phytochemicals: Tinosporaside, berberine, cordifolioside.
- Mechanisms: Enhances glutathione levels, reduces lipid peroxidation, modulates Nrf2 pathway.

- Studies: Experimental studies confirm hepatoprotective and nephroprotective antioxidant roles. Clinical use in metabolic disorders shows improved antioxidant markers.

**c) *Withania somnifera (Ashwagandha)***

- Classical: Described as *Balya* (strengthening) and *Rasayana*.
- Phytochemicals: Withanolides, sitoindosides.
- Mechanisms: Reduces cortisol-induced oxidative stress, protects mitochondria, enhances neuroprotection.
- Studies: RCTs show reduced oxidative stress markers in chronic stress and anxiety.

**d) *Curcuma longa (Haridra, Turmeric)***

- Classical: Classified as *Varnya* (skin-promoting) and *Rasayana*.
- Phytochemicals: Curcumin, demethoxycurcumin, bisdemethoxycurcumin.
- Mechanisms: Inhibits NF-κB, reduces ROS, modulates inflammatory cytokines.
- Studies: Demonstrated clinical benefits in arthritis, metabolic syndrome, and cancer adjunct therapy.

**e) *Glycyrrhiza glabra (Yashtimadhu)***

- Classical: Mentioned as *Vayasthapana Rasayana*.
- Phytochemicals: Glycyrrhizin, liquiritin, flavonoids.
- Mechanisms: Scavenges hydroxyl radicals, modulates HPA axis.
- Studies: Protective effects against gastric ulcers, stress-induced oxidative injury.

**f) *Centella asiatica (Mandukaparni)***

- Classical: Classified under *Medhya Rasayana*.
- Phytochemicals: Asiaticoside, madecassoside.
- Mechanisms: Enhances BDNF expression, reduces neuronal oxidative stress.
- Studies: Clinical evidence supports improved memory and antioxidant status in elderly.

**3. Mechanisms of Action of Ayurvedic Antioxidants**

- Direct free radical scavenging:** Neutralization of ROS, RNS, and hydroxyl radicals.
- Enzymatic upregulation:** Increased SOD, catalase, glutathione peroxidase.
- Mitochondrial protection:** Prevention of oxidative damage to mitochondrial DNA and proteins.
- Gene expression modulation:** Activation of Nrf2, downregulation of NF-κB.
- Anti-inflammatory synergy:** Reducing oxidative-inflammatory loop in chronic diseases.

**4. Clinical Evidence**

- Amalaki* improves antioxidant status and reduces markers of oxidative stress in type 2 diabetes.
- Ashwagandha* supplementation reduces lipid peroxidation in stress-related disorders.
- Turmeric (curcumin formulations) improves oxidative markers in arthritis and cancer patients.
- Guduchi* enhances antioxidant defense in patients with metabolic and hepatic disorders.
- Multi-herbal *Rasayana* formulations show synergistic antioxidant activity, though robust RCTs are limited.

**5. Limitations in Evidence**

- Variability in preparation methods (powder, extract, *bhasma*).
- Lack of standardized phytochemical quantification.
- Few large-scale, multicentric clinical trials.
- Limited data on long-term safety and bioavailability.

**DISCUSSION**

Ayurveda's *Rasayana Tantra* provides a holistic framework that aligns with modern antioxidant pharmacology. Herbs like *Amalaki*, *Ashwagandha*, *Guduchi*, and *Haridra* demonstrate strong experimental and clinical evidence for reducing oxidative stress. Their mechanisms extend beyond direct free radical scavenging to gene modulation, mitochondrial protection, and immune regulation, which parallels the modern systems biology approach to antioxidants.<sup>[16]</sup>

Unlike synthetic antioxidants, Ayurvedic herbs often act through multi-target pathways, offering superior adaptability. For example, curcumin modulates both



oxidative and inflammatory pathways, while *Ashwagandha* influences redox balance and stress hormones simultaneously. Such pleiotropy highlights the therapeutic advantage of Ayurvedic antioxidants.<sup>[17]</sup>

However, gaps remain. Standardization of herbal preparations is inconsistent, leading to variability in study outcomes. Bioavailability is another challenge; curcumin, despite strong efficacy in vitro, has poor systemic absorption. Recent innovations such as nanoparticle formulations, phytosome complexes, and synergistic herbal combinations offer promising solutions.<sup>[18]</sup>

Future research should focus on large-scale, randomized clinical trials with standardized preparations, integration of omics-based profiling, and validation of molecular mechanisms. Moreover, exploring Ayurvedic formulations (e.g., *Chyawanprash*) rather than isolated compounds may better reflect the holistic *Rasayana* approach.<sup>[19]</sup>

In summary, Ayurveda provides a rich pharmacopeia of antioxidants validated by modern science. Bridging traditional holistic models with contemporary pharmacological rigor could position Ayurvedic antioxidants as key interventions in oxidative stress-related diseases.<sup>[20]</sup>

## CONCLUSION

Ayurvedic antioxidants, described under *Rasayana Tantra*, represent a timeless approach to combating aging and oxidative stress. Modern pharmacological studies confirm their ability to neutralize free radicals, enhance endogenous antioxidant defenses, and protect mitochondria and genetic material from oxidative damage. Clinical studies demonstrate benefits in metabolic, neurodegenerative, inflammatory, and lifestyle-related disorders.

Among these, *Amalaki*, *Ashwagandha*, *Guduchi*, *Haridra*, and *Yashtimadhu* are particularly well-studied, with proven antioxidant and protective effects. The synergy of phytochemicals such as vitamin C, tannins, withanolides, curcuminoids, and flavonoids offers a broad-spectrum antioxidant response unmatched by single synthetic molecules. Despite encouraging evidence, standardization, bioavailability, and robust clinical validation remain major gaps. Integrative research employing systems biology, nanotechnology, and controlled clinical designs will help establish Ayurvedic antioxidants as evidence-based therapeutic agents.

In conclusion, Ayurvedic antioxidants provide a scientifically validated, safe, and holistic strategy to mitigate oxidative stress and its related diseases. Integrating traditional wisdom with modern research can pave the way for their global acceptance as nutraceuticals and pharmacological agents for health promotion and disease prevention.

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