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INTEGRATIVE MECHANISMS OF AYURVEDIC ADAPTOGENS IN STRESS REGULATION AND COGNITIVE ENHANCEMENT: A REVIEW

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ABSTRACT

Dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis and high cortisol levels can cause diffuse inflammation, oxidative damage, and neurodegenerative mechanisms, making stress and cognitive impairment major problems in today's world. This review aims to look into the role of Ayurvedic adaptogens in stress reduction and cognitive improvement, with a focus on their pharmacological mechanism of action, therapeutic benefits, and consistency with current scientific knowledge. Information on adaptogens, their effect on HPA axis, cortisol management, neuroplasticity, and oxidative stress was gathered from clinical studies, traditional Ayurvedic literature, and contemporary scientific publications. Ayurvedic adaptogens have a significant effect in promoting Sattva guna (mental clarity), supporting Dhatus, and balancing Doshas. These herbs improve neuroplasticity, lower cortisol levels, control HPA axis and reduce inflammation and oxidative stress. Their ability to reduce anxiety, improve memory and concentration, and restore physiological and psychological balance is proven by clinical studies. Also, it presents a comprehensive knowledge of these medicines by merging modern scientific research with traditional Ayurvedic principles like Ojas and Medhya Rasayana. Ayurvedic adaptogens can be a holistic approach to stress management and cognitive impairment when used along with modern therapy. When used with other techniques like yoga and pranayama, these adaptogens can be a complete approach to mental clarity, resilience and overall well-being. To fully understand their role in integrative medicine, more research is needed on their safety profiles and mechanisms.

Keywords : Ayurveda, adaptogens, stress, mental health

INTRODUCTION

Stress is defined as a state of anxiety or mental tension caused by a stressful situation. Stress is a natural human response to obstacles and threats in our lives. [1] According to the World Health Report, 2001, mental health and stress-related disorders are major causes of death in Europe. The World Health Organization (WHO) says stress is a major contributor to the global burden of disease, linked to mental health disorders like anxiety and depression and physical illnesses like cardiovascular disease and diabetes. Chronic stress activates the hypothalamic-pituitary-adrenal (HPA) axis and increases cortisol production, leading to systemic inflammation, oxidative stress, and cognitive dysfunction.[2] This shows the need for effective ways to increase stress resilience and mental health.

Adaptogens are non-toxic plant-derived substances that enhance the body's "non-specific" resistance to a wide range of biological, chemical, and physical stressors. They are supposed to modulate physiological functions, restore homeostasis, and fortify systems compromised by chronic stress. Adaptogenic herbs are particularly known for their stress-relieving properties, which are mediated by their ability to lower cortisol levels by modulating glucocorticoid receptors.

In Ayurveda, adaptogens correspond to the concept of Rasayana, a branch of medicine dedicated to rejuvenation, enhancing vitality, and promoting longevity. Rooted in ancient texts like the Charaka Samhita and Sushruta Samhita, Rasayana therapies aim to strengthen the body, balance the mind, and increase resilience to stress. Among these, Medhya Rasayanas are specialized formulations that support mental clarity, memory, and emotional stability. Herbs like Ashwagandha (*Withania somnifera*), Brahmi (*Bacopa monnieri*), and Shankhpushpi (*Clitoria ternatea*) are prominent examples, known for their ability to reduce stress, enhance cognitive functions, and restore balance to the *Doshas.* [3] They work by increasing Ojas, which is the foundation of optimum immunity and the capacity for mental endurance.

In Ayurveda, stress and mental clarity are understood to be influenced by the dynamic interplay of the three Gunas- Sattva, Rajas, and Tamas and the balance of the three Doshas -Vata, Pitta, and Kapha. Sattva, associated with purity, fosters resilience and mental clarity, whereas Rajas, characterized by activity, can contribute to anxiety and agitation when excessive. Tamas, linked to inertia, manifests as lethargy and confusion. Stress is defined as the dominant role of Rajas and Tamas, or abnormalities in the Doshas.

An imbalance of Vata is linked to anxiety and restlessness, Pitta imbalance tends to manifest as anger and frustration, while a disturbance in Kapha often leads to stagnation and withdrawal. Ayurveda emphasizes cultivating Sattva through mindfulness practices, balanced daily routines, and the consumption of wholesome, nourishing foods as a foundational approach to managing stress and promoting mental clarity.

The scope of this review is to explore the role of Ayurvedic adaptogens in enhancing stress resilience and promoting mental clarity, emphasizing their relevance in modern healthcare. By

integrating traditional Ayurvedic principles, such as Rasayana therapy, Ojas enhancement, and Dosha balance, with contemporary scientific findings, this review aims to provide a holistic understanding of these adaptogens. It focuses on key herbs like Ashwagandha *(Withania somnifera)*, Brahmi *(Bacopa monnieri)*, shankhapushpi *(Clitoria ternatea*), Yashtimadhu (*Glycyrrhiza glabra*), etc, examining their pharmacological properties, mechanisms of action, and therapeutic benefits. Additionally, the review discusses their impact on the hypothalamic-pituitary-adrenal (HPA) axis, antioxidant activity, and neuroprotection. By summarizing clinical evidence and identifying research gaps, this review seeks to highlight the potential of Ayurvedic adaptogens as effective tools for managing stress and enhancing cognitive functions in integrative healthcare.

METHODOLOGY

This review was conducted through a comprehensive synthesis of information drawn from classical Ayurvedic texts, contemporary clinical studies, and modern scientific literature. Ayurvedic references were sourced primarily from foundational treatises such as the Charaka Samhita and Sushruta Samhita, as well as authoritative commentaries and modern compilations on Rasayana and Medhya Rasayana therapies. In parallel, an extensive literature search was performed using electronic databases, including PubMed, Scopus, Web of Science, and Google Scholar, focusing on clinical studies. Search terms included Ashwagandha and HPA axis, Brahmi and cognitive enhancement, Shankhapushpi and neuroprotection, adaptogens and cortisol regulation, and Ayurvedic herbs and oxidative stress. Discrepancies or gaps in the literature were critically analyzed to highlight areas requiring further investigation.

DISCUSSION

Ayurvedic Adaptogens

Adaptogens are a class of natural products that are well characterized by their ability to assist the body in responding to stress.[4] Three fundamental traits recognize adaptogens. Firstly, they boost the body's resilience against different stressors. Secondly, they aid the body and mind in returning to a state of balance. Thirdly, they are inherently non-toxic, posing no negative effects or harmful consequences when administered in normal doses. These compounds have been utilized for millennia in traditional medicine systems such as Ayurveda and Traditional Chinese Medicine.[5] Medicinal plants like Ashwagandha *(Withania somnifera*), Shankhapushpi *(Clitoria ternatea*), Yashtimadhu *(Glycyrrhiza glabra*), *Brahmi (Bacopa monnieri*), Guduchi *(Tinospora cordifolia*), Mandookaparni *(Centella asiatica*), Vacha *(Acorus calamus*), and Jatamamsi *(Valeriana jatamansi*) are commonly employed in the treatment of stress due to their anxiolytic properties.

Ashwagandha, through its prabhava (essential energy) and karma (therapeutic action), acts as a powerful rasayana (rejuvenator). It improves nutrition by directly enhancing the quality of rasa (nutritional fluid), strengthens Agni (digestive fire) to promote better digestion and metabolism, and supports the optimal operation of srotas (the body's microcirculatory channels), thus displaying strong adaptogenic attributes. It also has positive effects on oxidative stressors, enhancing physiological adaptation. In accordance with its properties (Guna and Karma), Ashwagandha supports overall body function due to its oleaginous nature (Snigdha Guna), ability to boost physical and mental strength (Balya), and revitalizing effects (Rasayana Karma). Its bitter flavor (Tikta Rasa) and light nature (Laghu Guna) enable it to navigate through subtle channels (Sookshma Srotas) to reach target tissues, thereby aiding cognitive functions (Medhya action).[6]

Shankhpushpi is considered a highly significant medicinal plant and one of the most effective nootropic agents. It is a rich source of carbohydrates, proteins, amino acids,, vitamins, and volatile oils, phytochemical categories that play a crucial role as key components in many formulations designed for various health issues. Shankhpushpi is well-known for its antioxidant, antidiabetic, anxiolytic, antidepressant, and cardiovascular properties, among others. Specifically, it is frequently utilized as a cognitive enhancer, particularly effective in alleviating stress, anxiety, and insomnia related to imbalances in Vata and Pitta Doshas. In addition, the herb is valued for its ability to improve memory, intellect, and concentration while relieving mental fatigue and restlessness.[7]

Yashtimadhu shows various pharmacological effects, including improving memory, antioxidant activity, anxiolytic effects, anabolic support, wound healing, and tissue rejuvenation, thus serving as an effective Rasayana. It is traditionally classified as Chakshushya (vision-enhancer), Balya (strengthening agent), Vranahara (wound healer), Shukrala (fertility booster), and Keshya (hair promoter). Yashtimadhu aids in strengthening the Indriyas (sensory organs) as well as the Manas (mind). Its predominant Madhura Rasa (sweet taste) is essential for the production of Ojas (vital essence), which nourishes the mental faculties and enhances cognitive and emotional functions. It also acts as an antioxidant and analgesic, improving mental function and promoting overall mental health.[8]

Brahmi *(Bacopa monnieri),* well-known in Ayurveda, demonstrates strong adaptogenic effects by enhancing the body's ability to cope with stress while improving cognitive capabilities and emotional resilience. It regulates the hypothalamic-pituitary-adrenal (HPA) axis, lowering cortisol levels and alleviating the adverse effects of stress. Rich in bacosides, Brahmi supports synaptic communication, protects neural tissues from oxidative stress, and improves memory, focus, and learning, even in challenging circumstances.[9] Its neuroprotective properties shield the brain from stress-related damage, while its calming effects soothe Vata and Pitta Doshas, reducing anxiety, restlessness, and emotional instability. Traditionally, it has been used to address cognitive decline related to stress, enhance concentration, and prevent neurodegenerative changes, embodying Ayurveda's holistic perspective on mental and emotional well-being.

Mechanism of Action

Modulation of the Hypothalamic-Pituitary-Adrenal (HPA) Axis: Adaptogens play a key role in modulating the body's response to various stressors by influencing the immune and stress response systems. They act on the central nervous system (CNS), including hypothalamic neurons that secrete corticotropin-releasing hormone (CRH) and arginine vasopressin (AVP), and on the peripheral nervous system. These systems work in coordination to manage external stress.

The interaction between corticotropin-releasing hormone (CRH) and catecholamine neurons establishes a functional and anatomical link between the sympathetic nervous system (SNS) and the hypothalamic-pituitary-adrenal (HPA) axis. During stress, catecholamines activate the HPA axis by promoting CRH release, while HPA hormones, in turn, modulate SNS activity. Stress triggers an increase in CRH and arginine vasopressin (AVP) secretion, which amplifies the production of cortisol and adrenocorticotropic hormone (ACTH). Furthermore, the stress response involves angiotensin, cytokines, and arachidonic acid

metabolites. The SNS supports rapid adaptation to stress through the release of catecholamines, neuropeptides, adenosine triphosphate (ATP), and nitric oxide (NO).[10] Adaptogens modulate these systems to regulate energy circulation, reduce stress perception, enhance resilience, improve mental focus, and promote deep sleep. By harmonizing these mechanisms, adaptogens help maintain balance and resilience during stress.

Antioxidant Activity: Adaptogens possess notable antioxidant properties, primarily due to their high polyphenol content, which serves as a powerful free radical scavenger and modulator of oxidative stress. Polyphenols, including flavonoids, phenolic acids, and tannins, play a critical role in neutralizing reactive oxygen species (ROS), enhancing the activity of endogenous antioxidant enzymes such as superoxide dismutase and glutathione peroxidase, and regulating stress-response pathways like the nuclear factor erythroid 2-related factor 2 (Nrf2), thereby strengthening cellular defense mechanisms. [11] These compounds also protect mitochondria from oxidative damage, which is essential for maintaining energy production and improving stress resilience. Additionally, adaptogens mitigate inflammation by inhibiting oxidative stress-induced pro-inflammatory pathways. Examples such as *Rhodiola rosea*, *Withania somnifera* (Ashwagandha), *Panax ginseng*, and *Ocimum sanctum* (Holy Basil) are rich in bioactive polyphenols and exemplify these effects, offering neuroprotective, anti-inflammatory, and anti-fatigue benefits.[10] These antioxidant properties are instrumental in reducing cellular damage, enhancing stress tolerance, and addressing chronic conditions linked to oxidative stress, such as cardiovascular and neurodegenerative disorders.

Anti-neuroinflammation: Ayurvedic adaptogens enhance neuroprotection and exhibit anti-inflammatory properties by employing diverse physiological mechanisms that harmonize neural and immune functions. They help regulate the hypothalamic-pituitary-adrenal (HPA) axis, thereby reducing the excessive and sustained release of stress hormones like cortisol, which can otherwise trigger neuroinflammation and lead to neuronal damage. Adaptogens such as *Withania somnifera* [6] and *Bacopa monnieri* enhance the activity of key antioxidant enzymes, including superoxide dismutase (SOD) and glutathione peroxidase, effectively reducing oxidative stress within neural tissues. Furthermore, it modulates inflammatory responses by suppressing the nuclear factor-kappa B (NF-κB) signalling pathway and decreasing the production of pro-inflammatory cytokines such as interleukin-6 (IL-6) and tumour necrosis factor-alpha (TNF-α). These combined actions contribute to its neuroprotective and anti-inflammatory benefits. [12] These actions protect neurons from oxidative damage and inflammation-induced apoptosis, while promoting neurogenesis and synaptic plasticity via brain-derived neurotrophic factor (BDNF) upregulation. Together, these mechanisms help maintain cognitive function, prevent neurodegenerative processes, and support overall brain health.

Stress resilience and Cognitive function: Adaptogens support cognitive function by modulating the hypothalamic-pituitary-adrenal (HPA) axis, reducing stress hormones, and mitigating stress-related cognitive decline. They also influence neuropeptides like Neuropeptide Y (NPY), enhancing stress resilience and sustaining cognitive performance under stress. [5] In Ayurveda, stress resilience and cognitive function are deeply connected to the balance of the three doshas—Vata, Pitta, and Kapha as well as the state of Ojas (vital essence) and Sattva (mental clarity). Stress, arises when there is an imbalance in the body's natural harmony, particularly when Vata becomes aggravated. This results in disturbances in the Manas (mind) and Indriyas (senses), leading to anxiety, fatigue, and cognitive impairments.

Stress Resilience is associated with the ability of the body and mind to maintain equilibrium despite external and internal challenges. When Ojas is strong, the body and mind have a higher capacity to endure stress and recover from it. Ojas is believed to be nourished by the proper digestion of food (strong Agni) and the balance of the doshas. The Sattvic state of mind, which is calm, balanced, and clear, is crucial for stress resilience, enabling an individual to react to external stressors with composure and wisdom.

Medha governs cognitive function in Ayurveda, the quality of intellect or mental clarity, which is closely related to the Rasa Dhatu (plasma tissue) and Sattva. When Sattva is balanced, the mind functions with sharpness, memory, concentration, and decision-making abilities. Brahmi (*Bacopa monnieri*), Ashwagandha (*Withania somnifera*), and Shankhapushpi (*Clitoria ternatea*) are traditionally used as Medhya Rasayanas, or rejuvenating herbs for the mind, which nourish Rasa Dhatu and support mental clarity, emotional stability, and memory. Furthermore, the HPA axis (which in Ayurveda corresponds to the balance of Manovaha Srotas and Vata Dosha) influences stress and cognitive performance. Adaptogens like Ashwagandha are thought to balance Vata and Pitta Doshas, calm the nervous system, and prevent excessive Vata from leading to mental unrest, fatigue, or memory problems.

By promoting the balance of Sattva and strengthening Ojas, Ayurveda encourages resilience to stress and optimal cognitive function, allowing individuals to maintain mental clarity, focus, and emotional well-being.

Therapeutic Benefits

Stress Resilience: Ayurvedic adaptogens help regulate the stress response and balance the doshas, particularly Vata and Pitta, by modulating the HPA axis and reducing cortisol levels.

Clinical studies have demonstrated that Ashwagandha (*Withania somnifera*) effectively lowers serum cortisol levels and enhances the body's resilience to stress. In comparison to the placebo group, individuals receiving Ashwagandha showed a significant reduction in cortisol concentrations ($P=0.0006$)[13]. Elevated cortisol corresponds to an imbalance in Prana Vata (mental functions) and Sadhaka Pitta (emotions and intellect), leading to disturbances in Manas (mind) and depletion of Ojas (vital essence), which is critical for resilience and mental stability. Brahmi (*Bacopa monnieri*): Brahmi reduces anxiety and improves stress response by calming Vata. A clinical study showed it helped reduce anxiety and improve cognitive function. [14] Tulsi (*Ocimum sanctum*): Studies indicate Tulsi reduces cortisol and modulates the stress response, promoting resilience. [15]

Cognitive Enhancement: Adaptogens support cognitive performance by providing neuroprotective effects and enhancing memory and concentration. Brahmi (*Bacopa monnieri*): Clinical trials show Brahmi improves memory and cognitive performance, especially in age-related decline. It enhances attention and memory retention. [9]

Shankhapushpi (*Clitoria ternatea*): Studies show Shankhapushpi improves cognitive performance by enhancing memory and focus.[16] Ashwagandha (Withania somnifera): Ashwagandha enhances cognitive function by reducing mental fatigue. Clinical research found it improved attention and memory. [17]

Ayurvedic adaptogens regulate mood by balancing *Sattva* and stabilizing emotional states, reducing anxiety and depression. Evidence from studies suggests that Jatamansi (*Nardostachys jatamansi*) effectively mitigates anxiety and fosters emotional stability.[18]

Gaps in Research and Future Exploration

Despite the growing evidence supporting the therapeutic potential of Ayurvedic adaptogens, significant research gaps remain that warrant further investigation. The standardization of herbal preparations is a critical issue, as variations in plant species, cultivation practices, and extraction methods contribute to inconsistencies in bioactive compound profiles. Mechanistic studies are needed to elucidate the precise molecular pathways through which these adaptogens exert their effects, particularly on the hypothalamic-pituitary-adrenal (HPA) axis, oxidative stress, and neuroinflammation. Additionally, dose-response relationships are poorly defined, necessitating studies to determine proper therapeutic dosages. While Ayurvedic formulations often involve synergistic herbal combinations, their combined effects have not been well validated.

Comparative studies examining Ayurvedic adaptogens alongside modern pharmacological agents or adaptogens from other traditions could provide valuable insights into their relative efficacy. Furthermore, large-scale randomized controlled trials (RCTs) involving diverse populations are essential to validate findings and generalize their applicability. Finally, systematic research on their integration with conventional treatments and their place in modern healthcare models is required to enhance their utility in evidence-based practice. Addressing these gaps will strengthen the scientific foundation of Ayurvedic adaptogens and support their broader adoption in integrative healthcare.

CONCLUSION

The present review highlights the significant potential of Ayurvedic adaptogens in enhancing stress resilience and promoting cognitive function through multifaceted mechanisms, including modulation of the hypothalamic-pituitary-adrenal (HPA) axis, antioxidant activity, and neuroprotection. Herbs such as *Withania somnifera*, *Bacopa monnieri*, and *Clitoria ternatea* demonstrate substantial pharmacological effects that align with both traditional Ayurvedic principles and contemporary biomedical understanding. While preliminary clinical evidence supports their efficacy, further well-designed, large-scale randomized controlled trials are essential to establish standardized therapeutic protocols, elucidate molecular mechanisms, and confirm long-term safety profiles. Integrating Ayurvedic adaptogens into modern healthcare systems offers a promising avenue for the development of comprehensive, evidence-based approaches to the management of stress and cognitive dysfunction. Continued interdisciplinary research will be critical to fully realize their potential in integrative medicine.

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