



**International Journal of Biology, Pharmacy
and Allied Sciences (IJBPAS)**

'A Bridge Between Laboratory and Reader'

www.ijbpas.com

**ASHWAGANDHA (*WITHANIA SOMNIFERA*): A COMPREHENSIVE
REVIEW OF ITS TAXONOMY, PHYTOCHEMISTRY, PHARMACOLOGY,
AND ETHNOPHARMACOLOGICAL SIGNIFICANCE**

MANDAL N AND VELMURUGAN V*

Department of Pharmaceutical Chemistry, SRM College of Pharmacy, SRMIST,
Kattankulathur, 603203

*Corresponding Author: Velmurugan V: E Mail: velmuruv@srmist.edu.in

Received 19th July 2024; Revised 25th Sept. 2024; Accepted 20th Nov. 2024; Available online 1st Dec. 2025

<https://doi.org/10.31032/IJBPAS/2025/14.12.9619>

ABSTRACT

Ashwagandha (*Withania somnifera*), is a venerable medicinal herb in the ancient system of medicine called Ayurveda, where it has achieved an illustrious 3 millennia-long history and recognition for being rejuvenative as well as adaptogenic. Regarding the taxonomy, phytochemistry and related pharmacology as well as ethnopharmacological importance Details: As a member of the *Solanaceaea* family it is unique due to its bell-shaped and greenish yellow flowers which are turned into bitter red berries. Several phytochemical studies have identified active compounds like alkaloids, steroidal saponins and withanolides responsible to its therapeutic potential Pharmacological studies reveal the wide biological activities of Ashwagandha including adaptogenic, anti-stress, neuroprotective, and much more related to antitumorigenic effects due to withanolides. Its traditional uses are well established and newer clinical studies have been added to its repertoire that validate the use for stress, anxiety, inflammation & cognitive decline thereby bridging knowledge of ancient past with modern medicine. In different traditional medicinal systems, Ashwagandha has a high standing ethnopharmacologically.

**Keywords: Ashwagandha, *Withania somnifera*, Anti-Stress, Neuroprotective,
Anticancer, Cardioprotective**

INTRODUCTION:

There is a vast diversity of medicinal plants in nature, like a treasure trove. Mankind has long searched the natural world for medicines, and as a result, several contemporary medical systems have developed [1]. According to the World Health Organization, traditional medicines are widely used in India. Approximately in developing countries 80% of people use traditional medicines for their most basic medical needs [2]. The World Health Organization (WHO) reports that about half of the world's population uses traditional plant-based medicines like Ayurveda, which is derived from plants, for medical conditions. Compounds derived from medicinal plants make up about 30% of all drugs. Around 7500 of the 15,000 plant species in India are known as having medicinal applications, corresponding to the Botanical Survey of India (BSI) [3]. All indigenous medical systems, including Siddha, Ayurveda, Unani, and Tibetan medicine, are based on the curative properties of medicinal plants [4]. One of the most significant sources of medications in the world is plants. Many of the medications used today, such as atropine (which is derived from *Atropa belladonna*), ephedrine (which is derived from *Ephedra vulgaris*), eugenol (which is derived from *Ocimum sanctum*), morphine (which is derived from *Papaver*), and reserpine (which is derived

from *Roulphia serpentina*). Secondary metabolites and essential oils with potential therapeutic applications are abundant in medicinal plants [5, 6]. In addition to being affordable, efficient, and readily available, medicinal plants are said to offer significant benefits for treating a variety of illnesses, including their safety [7].

Indian medicinal plants have been successfully used in traditional medical systems to treat a wide range of illnesses, including bronchial asthma, chronic fever, colds, coughs, malaria, dysentery, convulsions, diabetes, diarrhea, arthritis, emetic syndrome, skin conditions, insect bites, and disorders of the stomach, liver, heart, and immune system [8]. For the research of new drugs, plants are a valuable source of bioactive compounds. Isolated bioactive molecules are used as models for the synthesis of biologically active compounds and as building blocks for the synthesis of drugs in laboratories. In order to maximize the concentration of identified constituents and to sustain their activities, phytochemical processing of raw plant materials is fundamentally necessary [9]. Plants are used medicinally for a very long time. Writings from as far back as 4000 B.C. – 5000 B.C. suggest that plants have been used medicinally, and the Chinese were the first to use natural herbal preparations as remedies [1]. In India, however, the

Rigveda—said to have been composed between 3500 B.C. and 1600 B.C.—contains the first mentions of the use of plants as medicine. Later, the ancient doctors of Ayurveda, an indigenous medical system that forms the cornerstone of Indian ancient medical science, studied in-depth and documented empirically the properties and therapeutic applications of medicinal plants [10].

In traditional along with complementary medicine, the most widely used drug in the world is phytotherapy. About 60% of the global workforce works in it, and it plays a significant role in the public health systems of many nations. Many plants have been screened, which has resulted in the development of numerous drugs that are now commonly used in therapy [11, 12].

PLANT PROFILE:

Taxonomy:

- **Kingdom:** Plantae
- **Subkingdom:** Tracheobionta
- **Superdivision:** Spermatophyta
- **Division:** Magnoliophyta
- **Class:** Magnoliopsida
- **Subclass:** Asteridae
- **Order:** Solanales
- **Family:** Solanaceae
- **Genus:** *Withania*
- **Species:** *Withania somnifera*

❖ Vernacular name:

- ◆ Bengali: Ashvaganda, Asvagandha

- ◆ Hindi: Asgandh, Punir
- ◆ English: Winter Cherry
- ◆ Sanskrit: Ashvagandia, Aihvakandika, Gandhapatri, Palashaparmi
- ◆ Tamil: Amukkira. Asubam, Asuvagandi
- ◆ Telugu: Asvagandhi, Penneru, Pennerugadda, Dommadolu
- ◆ Odiya: Asugandha
- ◆ Marathi: Askandha, Kanchuki, Tilli
- ◆ Malayalam: Amukkiram, Pevetti
- ◆ Gujarati: Asan, Asana, Asoda, Asundha, Ghodaasoda

Morphology:

Withania somnifera is ashwagandha, also known as winter cherry and Indian ginseng. It is a very popular and well-known herb that has been used for centuries in Ayurvedic medicine to improve health and prolong life. It is also used as a tonic (rasayana), which strengthens the body's defences against illness [13]. *Withania somnifera* is a 30-150 cm-tall, tomentose, erect, evergreen shrub with branches. The leaves are simple, glossy, and smooth, with a length of 10 to 15 cm. Their petiolate, dull green elliptical shape is oblique and extipulate. They appear opposite on floral shoots, but they grow alternately on vegetative shoots. The tiny flowers are dull yellow or a delicate greenish-green, measuring 4-6 mm [14]. Clusters of five or fewer flowers typically occur in short axillary groups, umbellate

cymes, or axillary cymes. These supplementary inflorescences are bisexual, discrete, and supported by pedicellates. Five polyandrous stamens with ditheous anthers adorn the flowers, which have a gamosepalous calyx with valvate aestivation. The ovary has two chambers and is superior [15]. The fruits are membranous, inflated globose berries with a 6 mm diameter that turn orange-red when fully grown. The calyx is persistent and inflated. The seeds are light yellow, reniform, and have a diameter of 2.5 mm. They have a kidney- or lens-like shape, are smooth, and are small. The rounded branches have small trichomes covering them [16]. The plant's mature, dried roots display the following morphological traits. A solitary layer of epidermis envelops the young root, followed by a parenchymatous cortex consisting of four to five cell layers. The endodermis is clearly visible and is identified by prominent Casparian stripes. The outermost layer of the cortex gives rise to the cork cambium. It is remarkable that the endodermis endures after secondary growth has occurred [17]. The roots are cylindrical, straight, fleshy, and gradually taper to a length of 10–17.5 cm and a diameter of 6–12 mm when they are dried. From the main roots emerge secondary roots that resemble fibres. When it breaks, the outside is slightly brown, and the inside is cream coloured. That have a strong aroma,

an uneven, short fracture, and an unpleasant, mucilaginous, bitter taste [18].

Geographic Distributions:

This little, woody shrub is native to the Mediterranean region, Africa, India, and the United States. The 26 species that make up the genus *Withania* include ashwagandha, which is mostly grown in India for its therapeutic properties. There are just two species that are typically found in India: *Withania somnifera* and *Withania coagulans* Dunal. In the past, *Withania somnifera* ($2n = 48$) was thought to have a cytotype ($2n = 24$) with *Withania obtusifolia* (Tackh), a third species found in South India. Recent multidisciplinary research methods have led to the discovery of another species in the Indian germplasm, called *Withania ashwagandha* [2].

Phytochemistry:

The phytochemistry of *Withania species* has been entirely investigated, and different chemical components, including tannin, alkaloids, flavonoids, and steroidal lactones, have been found, extracted, and isolated. More than 35 chemical constituents have been identified by laboratory analyses in the roots of *W. somnifera*, and withanolides are thought to be responsible for the plant's special medicinal qualities [19].

1. Withanolides:

Withanolides are the most active constituent of ashwagandha, demonstrating pharmacological potentiation. The main

withanolides are Withaferin A, which has anti-inflammatory, anticancer, and immunomodulatory properties; Withanolide D, which has anti-inflammatory, antioxidant, and anticancer properties all in

one; Withanone, which is mostly being studied because it has antistress and anticancer properties; and Withanosides (IV) and (V), which have neuroprotective and antistress properties [20].

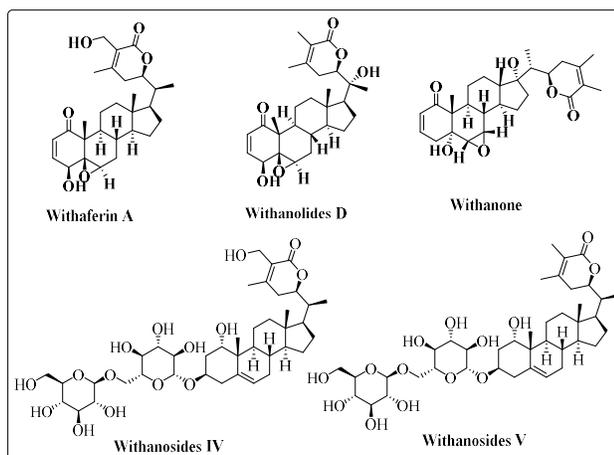


Fig 1 : Withanolides

2. Alkaloids:

The alkaloids found in ashwagandha contribute greatly to the effectiveness of this medicinal herb, especially as an effective sedative and anti-inflammatory. Some important alkaloids are: Anaferine has an

anti-inflammatory effect; Anahygrine has a relaxant activity; and Cuscohygrine shows effects on nervous system disorders. Tropine shows the effects on the central nervous system, and they increase the protency of the effect [9].

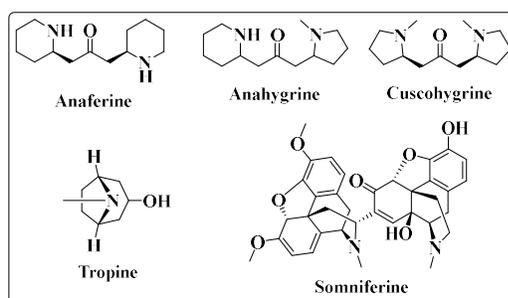


Fig2: Alkaloids

3. Sitoindosides:

Sitoindoside is one of the glycowithanolides found in ashwagandha and is well known for its stress-reducing effects (which can help with adaptogenesis). Specifically,

Sitoindosides VII and VIII are known to increase energy levels, improve performance, and augment resistance to stress [21].

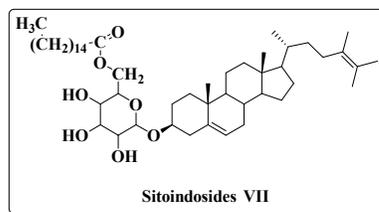


Fig3: Sitoindosides

4. Plant pigments:

High in flavonoids, colourful plant pigments have potent antioxidant effects. Indeed, these compounds are effective in clearing free radicals and reducing oxidative stress. Chief among them is Kaempferol, which is

famed for its ability to protect the heart, reduce inflammation, and fight against cancer, as well as Quercetin, known best of all for its fantastic anti-inflammatory and antioxidant benefits [20].

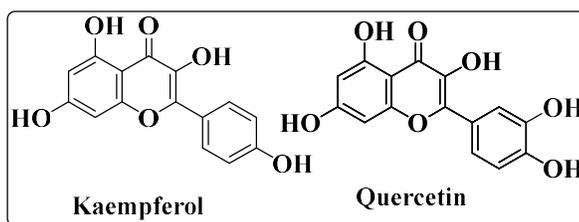


Fig4: Flavonoids

5. Inulins:

Ashwagandha's saponins, which also have anti-inflammatory and immune-boosting properties, are what cause that chancre. Of them, Withanoside IV has been identified as an immunomodulatory and anti-stress agent; the latter, Withanoside V, is known for its adaptogenic imprint. Ashwagandha's general efficacy is further enhanced by the activity of these immune-boosting and stress-relieving saponins [22].

6. Fatty Acids:

This works indirectly by enhancing the immune response and inhibiting inflammation as a result of the increased amounts of fatty acids in ashwagandha. Oleic Acid has anti-inflammatory activity, and Linoleic Acid shows anti-inflammatory activity. It also has an effect on skin and hair health and mostly enhances the therapeutic efficacy of herbal plants [2].

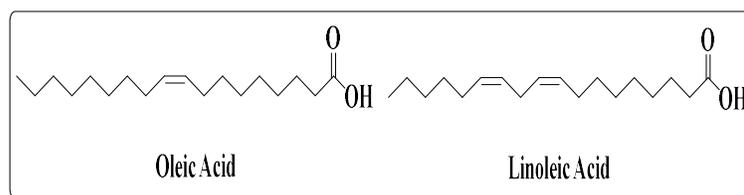


Fig5: Fatty Acids

7. Nutrients:

Its effectiveness at modulating our immune responses and reducing systemic inflammation is largely determined by its fatty acid content. Oleic acid is a pro-inflammatory fatty acid, whereas linoleic acids are anti-inflammatory and have positive effects on skin and hair health. Its effect on moderating the body's defence mechanisms was further increased when used alongside omega-3 and 6 essential fatty acids [23].

8. Glycosides:

The sterol presents in Ashwagandha ginsenoside, which is the active component of *Withania somnifera* root extract, has protected effects due to its anti-inflammatory activity and immunomodulating action. Glycosides found in β -sitosterol are key to the immunomodulatory and anti-inflammatory properties of the herb [24].

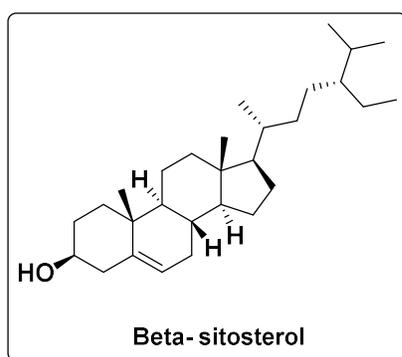


Fig6: Glycosides

Here's a detailed description of the phytoconstituents which are found in different parts of the ashwagandha plant:

Roots: Withanolides: withaferin A, withanolide D, and withanone withanolide A-Y, withanosides I-X, and withanone.

Alkaloids: anaferine, anahygrine, cuscolygrine, choline, somniferine, somnine, somniferinine, tropine, and withanine. Sitoindosides, and choline [25].

Leaves: Withanolides are high in Ashwagandha leaves, like Withaferin A.

Flavonoids—quercetin and kaempferol. The leaves are also astringent due to the tannins present in them [26].

Stem: There is a much lower amount of withanolides present in the stem of Ashwagandha than in the roots and leaves. And it also contains very low amounts of alkaloids and saponins [26].

Fruits: Lower levels of withanolides present, high amounts of antioxidant flavonoids present, and small amounts of alkaloids in the fruits of Ashwagandha [26].

Shoots: Ashwagandha shoots are valuable for their adaptogenic withanolides, antioxidant and anti-inflammatory flavonoids, and immune-boosting saponins [25].

Bark: High level of tannin content, also it contains withanolides, these are present in lower concentrations compared to the roots and leaves [25].

Flowers: There are very low levels of withanolides in the Ashwagandha flower. The flavonoid fraction responsibly for antioxidant activities. The tannins from the flowers are also astringent in nature [26].

Seeds: they contain small quantities of withanolides complemented by other alkaloids. They also contain linoleic acid, one of the essential fatty acids [26].

Pharmacological activity:

The study of the biochemical and physiological effects of a substance and its mechanisms of action. Ashwagandha exerts its effects through various mechanisms:

1. Anti-Stress and Adaptogenic Effects:

According to Ashok *et al.* (2015), Ashwagandha is very popular because it has anti-stress and adaptogenic effects, and it act through multiple mechanisms. It primarily modulates the hypothalamic-pituitary-adrenal (HPA) axis, crucial for stress response, by regulating cortisol levels and thereby reducing the physiological impact of stress. It influences neurotransmitter systems, e.g., serotonin and GABA and it

also promote the mood stability and relaxation. Its potent antioxidant properties help reduce oxidative stress and inflammation, common consequences of chronic stress, while its active compounds, withanolides, provide neuroprotection, bolstering cognitive function and resilience against stress-induced damage. Human clinical studies show that ashwagandha may be able to ease anxiety, improve sleep quality and increase overall well-being for daily use. Its adaptogenic properties of ashwagandha makes it the best natural remedy to deal with stress, improve mental clarity and support body adaptation against changing climatic conditions etc. By balancing key physiological systems, ashwagandha fosters resilience and helps maintain homeostasis amidst stress [27, 28].

2. Anti-Inflammatory and Immunomodulatory Effects:

According to Tamoli *et al.* (2022), Ashwagandha is known for its inflammatory and immunomodulatory properties which are the result of few complex mechanisms. One of the major mechanisms that is responsible for this effect must be through two very important pathways in inflammation, i.e. nuclear factor-kappa B (NF- κ B) pathway and the cyclooxygenase-2 pathway famously known as COX-2 based therapy. This naturally results in the downregulation of pro-inflammatory cytokine-producing pathways which fine-

tune inflammation by reducing total overall production. The group of active compounds responsible for this effect. Withanolides are believed to perform a very important role by suppressing the secretion of inflammatory signal molecules that support oxidative stress which is generally followed by inflammation. Ashwagandha helps to reduce the free radicals, which cause cells to damage and ultimately repair tissues. Moreover, ashwagandha has a role in regulating the immune system as it increases the activity of macrophages along with natural killer and lymphocyte cells. This balances the immune system and helps prevent over-activation of the immune system and imbalance in humanity (autoimmune) as well. Human research indicates ashwagandha can help improve markers of inflammation (C-reactive protein levels) and reduce symptoms in those with conditions like rheumatoid arthritis or asthma. With its potent anti-inflammatory and immunostimulatory properties, ashwagandha presents an all-in-one solution to correct inflammatory dysfunction as well as strengthen overall immunity [29, 30].

3. Antioxidant Activity:

According to Dhanani *et al.* (2017), Ashwagandha demonstrates significant antioxidant activity through multiple mechanisms, greatly enhancing its therapeutic benefits. Its primary action involves scavenging free radicals—unstable

molecules that contribute to oxidative stress and cellular damage. The herb's active compounds, especially withanolides, effectively neutralize these free radicals, thereby reducing oxidative stress. Ashwagandha also increases natural antioxidant defences by raising levels of the important antioxidants superoxide dismutase (SOD), catalase, and glutathione peroxidase that neutralize reactive oxygen species (ROS) molecules while repairing oxidative damage. It also regulates the expression of genes implicated in oxidative stress, inducing protective and inhibiting harmful effects and protecting cellular stability against it. The antioxidant effects of ashwagandha extend to various health aspects: it aids cardiovascular health by preventing lipid peroxidation and preserving endothelial function, and it supports brain health by reducing neuroinflammation and shielding neurons from oxidative damage associated with cognitive decline and neurodegenerative diseases. In conclusion, the antioxidant properties of ashwagandha make it an effective health-enhancing and disease-preventing herb [31, 32].

4. Neuroprotective Effects:

According to Bhatnagar *et al.* (2009), Ashwagandha has excellent neuroprotective effects (enhanced brain health and cognitive functions) through several pathways. The free-radical scavenging action of its active compounds, especially withanolides protect

neurons from damage and the powerful anti-inflammatory activity prevents neurodegeneration by protecting brain cells against oxidative stress. It is also beneficial for other neurotransmitter systems: boosting gamma-aminobutyric acid (GABA) and serotonin levels in the brain. This shows some effect like steady mood regulation, reduced anxiety, and improved mental health. Ashwagandha helps both lower neuroinflammation by inhibiting pro-inflammatory cytokines and promote the restorative processes of your brain to maintain overall well-being. It also promotes neurogenesis i.e., formation of new neurons and prevents the brain from being affected by a variety of neurodegenerative diseases. Research also suggests that ashwagandha may help to protect the brain and improve cognitive functions, relieve stress, anxiety, and their associated ailments like Alzheimer's disease (AD) and combat diseases like Parkinson's diseases (PD). In general, ashwagandha is an essential neuro-protector of the brain that helps improve cognitive function and clear mental status [33–35].

5. Anti-Cancer Properties:

According to Palliyaguru *et al.* (2016), Ashwagandha has prominent anti-cancer abilities. Its main mechanism is the induction of apoptosis, or programmed cell death (PCD), in cancer cells mainly by its bioactive compounds, namely withanolides,

that trigger intrinsic apoptotic pathways and inhibit anti-apoptotic proteins, leading to selective killing of various types of transformed malignant tumours. Furthermore, the inhibition of mitogen-activated protein kinases (MAPKs) activation and nuclear factor-kappa B (NF- κ B) was observed due to Ashwagandha treatment, which is essential for proliferation signalling. It can also boost the body's own cancer defence by raising immunity activity and improving immune cell production and effectiveness, such as macrophages. Natural killer cells that destroy cancers with minimal collateral tissue damage are increased when you take this hormone regularly, so their medicinal significance is greatly enhanced. One of the functions is an antioxidant activity that helps to reduce oxidative stress, a known promoter of cancer development. Numerous preclinical and clinical studies suggest that the anticancer potential of Ashwagandha includes breast cancer, lung cancer, and prostate cancer. In summary, ashwagandha exerts its antitumor activities by inducing apoptosis and autophagy pathways underpinning cell-specific cytotoxicity mechanisms in cancer cells [15, 36–39].

6. Cardioprotective Effects:

According to Jain *et al.* (2012), Ashwagandha is well-known for the great cardio protection it offers and achieved through multiple mechanisms that improve

heart health and reduce cardiovascular risks. These active compounds, mainly withanolides, are strong antioxidants that fight oxidative stress by annihilating free radicals, thereby protecting heart tissues and blood vessels from harm. ashwagandha ameliorates inflammation by blocking critical inflammatory pathways, including nuclear factor-kappa B (NF- κ B) and cyclooxygenase-2 (COX-2), safeguarding against endothelial dysfunction-related atherosclerosis. Additionally, it is good for cardiovascular health because it regulates blood pressure and improves the lipid profile. It is proven to reduce systolic and diastolic blood pressure, thus preventing hypertension-related complications. It has a beneficial effect on cholesterol levels by decreasing total and low-density lipoprotein (LDL) cholesterol, while raising high-density lipoprotein (HDL) cholesterol, or good units that reduce the risk of heart disease. Given these findings, ashwagandha has been described in clinical research as a potential cardioprotective natural agent due to its antioxidant, anti-inflammatory, and lipid-modulating actions, making it an ideal intervention for the prevention or control of cardiac conditions [20].

Ethnopharmacology:

Ashwagandha (*Withania somnifera*) ethnomedicine involves the traditional uses, bioactive compounds and probable health implications of this herb in relation to its

historical as well as cultural contexts. Here's a detailed overview:

Traditional uses:

1. Ayurvedic Medicine:

Called Indian ginseng, it is used as an important basic tonic in the thousands-year-old Ayurvedic system. According to the doctrine of Ayurveda, it is considered a rasayana, which translates into English as rejuvenatives, or those that increase longevity and vitality (Ayush-longevity + Aayu-vitality) and promote overall better health (parameter-boosting tests) [40].

2. Adaptogen:

The adaptogenic qualities of Ashwagandha have been celebrated as a means to help the body handle stress and adjust normal bodily mechanisms. Adaptogens are natural substances that work with a person's body and help them adapt, most notably to stress. Ashwagandha works by balancing cortisol, the stress hormone, which in turn alleviates stress and anxiety and increases resistance to issues relating to being too stressed [28].

3. Tonic:

As a general health tonic, Ashwagandha boosts energy, stamina, and endurance. It strengthens the body's systems, enhances physical strength, and supports overall vitality. It is particularly advantageous for individuals who are recuperating from illness and require an increase in vitality [41].

4. Aphrodisiac:

Ashwagandha has been traditionally employed as a substance that enhances sexual health and fertility. It is widely considered to enhance sexual desire, optimize sexual performance, and promote overall reproductive well-being. For males, it has the potential to enhance the quantity and movement of sperm, whilst for females, it can assist in regulating menstrual cycles and promoting reproductive health [42].

5. Anti-inflammatory and Analgesic:

Ashwagandha is utilized for its anti-inflammatory and analgesic attributes to alleviate inflammation and discomfort, specifically in illnesses such as arthritis. The active substances found in it, such as withanolides, have the ability to decrease inflammation in the body and alleviate pain [43].

6. Nervine:

Ashwagandha functions as a nervine, exerting a soothing influence on the nervous system. It is employed to alleviate nervousness and enhance mental acuity, memory, and cognitive performance [40].

7. Anti-Microbial Activity:

Ashwagandha has demonstrated its potential benefits in alleviating different types of infectious ailments and enhancing immunity via clinical and preclinical research, which presents it as an opportunity to serve the purpose for both preventions as well post-recovery management of infections [29, 30].

Ethnopharmacological Studies:

Cultural Context:

The review presents an analysis from ethnopharmacological perspective, depends on the traditional uses of Ashwagandha documented in Ayurveda — a foundational medicinal system of India. Such studies bring attention to the enduring historical and socio-cultural importance of Ashwagandha, along with knowledge systems that reveal its relevance in health promotion [14].

Clinical Trials:

To prove everything, a summary of numerous ongoing studies evaluating the safety and effectiveness of Ashwagandha is provided. These studies investigate what their claims are in the contemporary practice of acknowledged medicine and attest to it as a beneficial treatment for stress, anxiety, inflammatory responses, or dementia. These statistics help us uncover very effective methods by combining traditional knowledge with evidence-based modern methods [44].

Sustainable Use:

The ethnopharmacological research has shed light on the sustainable harvesting and cultivation needs of Ashwagandha. This data is essentially for the conservation part of this easily herb needed invaluable regarded medicinal plant species. The studies seek to strike a balance between the rapidly increasing domestic demand for Ashwagandha on one hand and its sustainability aspect (conservation of

natural habitats) through ecofriendly sustainable agriculture such methods [45].

CONCLUSION:

This comprehensive review underscores Ashwagandha's profound therapeutic potential, validated by both traditional use and modern pharmacological research. The fusion of ancient wisdom with contemporary clinical findings highlights Ashwagandha's efficacy in addressing stress, anxiety, inflammation, and cognitive decline. Emphasizing sustainable cultivation practices ensures the preservation of Ashwagandha for future generations, promoting its continued use and ecological conservation. The study reaffirms Ashwagandha's pivotal role in both historical and modern medicinal landscapes.

CONFLICT OF INTEREST:

Authors declare no conflict of interest.

REFERENCES:

- [1] Vyas VK, Bhandari P, Patidar R. "A comprehensive review on *Withania somnifera* dunal". Journal Of Natural Remedies. 2011 Jan 1;11(1):13.
- [2] Gaurav H, Yadav D, Maurya A, Yadav H, Yadav R, Shukla AC, Sharma M, Gupta VK, Palazon J. Biodiversity, biochemical profiling, and pharmaco-commercial applications of *Withania somnifera* : A review. Molecules. 2023 Jan 26;28(3):1208.
- [3] Alam N, Hossain M, Khalil MI, Moniruzzaman M, Sulaiman SA, Gan SH. Recent advances in elucidating the biological properties of *Withania somnifera* and its potential role in health benefits. Phytochemistry Reviews. 2012 Mar;11:97-112.
- [4] Singh G, Sharma PK, Dudhe R, Singh S. Biological activities of *Withania somnifera*. Annals Biological Research. 2010 Oct 13;1(3):56-63.
- [5] Owais M, Sharad KS, Shehbaz A, Saleemuddin M. Antibacterial efficacy of *Withania somnifera* (ashwagandha) an indigenous medicinal plant against experimental murine salmonellosis. Phytomedicine. 2005 Mar 22;12(3):229-235.
- [6] Abou-Douh AM. New withanolides and other constituents from the fruit of *Withania somnifera* . Archiv der Pharmazie: An International Journal Pharmaceutical and Medicinal Chemistry. 2002 Aug;335(6):267-276.
- [7] Mathur R, Gupta SK, Singh N, Mathur S, Kochupillai V, Velpandian T. Evaluation of the effect of *Withania somnifera* root extracts on cell cycle and angiogenesis. J Ethnopharmacol 2006;105:336-41.
- [8] Wankhede S, Langade D, Joshi K, Sinha SR, Bhattacharyya S.

- Examining the effect of *Withania somnifera* supplementation on muscle strength and recovery: a randomized controlled trial. *Journal of the International Society of Sports Nutrition*. 2015 Dec;12:1-1.
- [9] Kumar V, Dey A, Hadimani MB, Marcovic T, Emerald M. Chemistry and pharmacology of *Withania somnifera* : An update. *TANG [HUMANITAS MEDICINE]* 2015;5:1.1
- [10] John J. Therapeutic potential of *Withania somnifera* : A report on phyto-pharmacological properties. *International Journal of Pharmaceuttical Sciences and Research*. 2014 Jun 1;5(6):2131-48.
- [11] Glotter E, Kirson I, Abraham A, Lavie D. Constituents of *Withania somnifera* Dun—XIII: the withanolides of chemotype III. *Tetrahedron*. 1973 Jan 1;29(10):1353-64.
- [12] Khan R, Shahzad S, Choudhary MI, Khan SA, Ahmad A. Communities of endophytic fungi in medicinal plant *Withania somnifera* . *Pak. J. Bot.* 2010 Jan;42(2):1281-7.
- [13] Sharma V, Sharma S, Pracheta RP. *Withania somnifera* : a rejuvenating ayurvedic medicinal herb for the treatment. *International Journal of PharmTech Research*. 2011;3(1):187-92.
- [14] Alam MK, Hoq MO, Uddin MS. Therapeutic use of *Withania somnifera* . *Asian Journal of Medical and Biological Research*. 2016 Aug 9;2(2):148-55.
- [15] Gowtham HG, Murali M, Singh SB, Shivamallu C, Pradeep S, Shivakumar CS, Anandan S, Thampy A, Achar RR, Silina E, Stupin V. Phytoconstituents of *Withania somnifera* unveiled Ashwagandhanolide as a potential drug targeting breast cancer: Investigations through computational, molecular docking and conceptual DFT studies. *Plos one*. 2022 Oct 6;17(10):e0275432.
- [16] Sengupta P, Agarwal A, Pogrebetskaya M, Roychoudhury S, Durairajanayagam D, Henkel R. Role of *Withania somnifera* (Ashwagandha) in the management of male infertility. *Reproductive biomedicine online*. 2018 Mar 1;36(3):311-26.
- [17] Nasimi Doost Azgomi R, Zomorodi A, Nazemyieh H, Fazljou SM, Sadeghi Bazargani H, Nejatbakhsh F, Moini Jazani A, Ahmadi AsrBadr Y. Effects of *Withania somnifera* on reproductive system: a systematic review of the available evidence.

- BioMed Research International. 2018;2018(1):4076430.
- [18] Chatterjee S, Srivastava S, Khalid A, Singh N, Sangwan RS, Sidhu OP, Roy R, Khetrpal CL, Tuli R. Comprehensive metabolic fingerprinting of *Withania somnifera* leaf and root extracts. *Phytochemistry*. 2010 Jul 1;71(10):1085-94.
- [19] Uddin Q, Samiulla L, Singh VK, Jamil SS. Phytochemical and pharmacological profile of *Withania somnifera* Dunal: a review. *Journal of Applied Pharmaceutical Science*. 2012 Jan 30(Issue):170-5.
- [20] Jain R, Kachhwaha S, Kothari SL. Phytochemistry, pharmacology, and biotechnology of *Withania somnifera* and *Withania coagulans*: A review. *Journal of Medicinal Plants Research*. 2012 Oct 25;6(41):5388-99.
- [21] Vande V, Lame D. New Withanolides of Biogenetic Interest from *Withania somnifera*. *Phytochemistry*. 1981;20(6):1359-64.
- [22] Choudhary D, Bhattacharyya S, Bose S. Efficacy and safety of Ashwagandha (*Withania somnifera* (L.) Dunal) root extract in improving memory and cognitive functions. *Journal of dietary supplements*. 2017 Nov 2;14(6):599-612.
- [23] Saleem S, Muhammad G, Hussain MA, Altaf M, Bukhari SN. *Withania somnifera* L.: Insights into the phytochemical profile, therapeutic potential, clinical trials, and future prospective. *Iranian journal of basic medical sciences*. 2020 Dec;23(12):1501.
- [24] Mahdi AA, Shukla KK, Ahmad MK, Rajender S, Shankhwar SN, Singh V, Dalela D. *Withania somnifera* improves semen quality in stress-related male fertility. *Evidence-Based Complementary and Alternative Medicine*. 2011;2011(1):576962.
- [25] Subbaraju GV, Vanisree M, Rao CV, Sivaramakrishna C, Sridhar P, Jayaprakasam B, Nair MG. Ashwagandhanolide, a bioactive dimeric thiowithanolide isolated from the roots of *Withania somnifera*. *Journal of natural products*. 2006 Dec 27;69(12):1790-2.
- [26] Mishra LC, Singh BB, Dagenais S. Scientific basis for the therapeutic use of *Withania somnifera* (ashwagandha): a review. *Alternative medicine review*. 2000 Aug 1;5(4):334-46.
- [27] Ashok GA, Shende MB. A clinical evaluation of antistress activity of ashwagandha (*Withania somnifera* Dunal) on employees experiencing

- mental stress at work place. International Journal of Ayurveda and Pharma Research. 2015 Mar 4;3:37-45.
- [28] Salve J, Pate S, Debnath K, Langade D. Adaptogenic and Anxiolytic Effects of Ashwagandha Root Extract in Healthy Adults: A Double-blind, Randomized, Placebo-controlled Clinical Study. Cureus 2019 Dec;11(12).
- [29] Tamoli S, Gokarn V, Ibrahim M, Ahmad S. Comparative investigation of Ashwagandha FMB extract and standardized extract for their antioxidant, anti-inflammatory and immunomodulatory potential. Annals of Phytomedicine: An International Journal 2022;11 (1):405-12.
- [30] Rasool M, Varalakshmi P. Immunomodulatory role of *Withania somnifera* root powder on experimental induced inflammation: An in vivo and in vitro study. Vascular pharmacology. 2006 Jun 1;44(6):406-10.
- [31] Dhanani T, Shah S, Gajbhiye NA, Kumar S. Dhanani T, Shah S, Gajbhiye NA, Kumar S. Effect of extraction methods on yield, phytochemical constituents and antioxidant activity of *Withania somnifera*. Arabian journal of chemistry. 2017 Feb 1;10:S1193-9.
- [32] Visavadiya NP, Narasimhacharya AV. Hypocholesteremic and antioxidant effects of *Withania somnifera* (Dunal) in hypercholesteremic rats. Phytomedicine. 2007 Feb 19;14(2-3):136-42.
- [33] Bhatnagar M, Sharma D, Salvi M. Neuroprotective effects of *Withania somnifera* dunal.: A possible mechanism. Neurochemical research. 2009 Nov;34:1975-83.
- [34] Dar NJ, Ahmad M. Neurodegenerative diseases and *Withania somnifera* (L.): An update. Journal of ethnopharmacology. 2020 Jun 28;256:112769.
- [35] Kuboyama T, Tohda C, Komatsu K. Effects of Ashwagandha (roots of *Withania somnifera*) on neurodegenerative diseases. Biological and Pharmaceutical Bulletin. 2014 Jun 1;37(6):892-7.
- [36] Lavie D, Glotter E, Shvo Y. 1371. Constituents of *Withania somnifera* Dun. Part IV. The structure of withaferin A. Journal of the Chemical Society (Resumed). 1965:7517-31.
- [37] Rai M, Jogee PS, Agarkar G, Santos CA. Anticancer activities of *Withania somnifera* : Current research, formulations, and future perspectives. Pharmaceutical biology. 2016 Feb 1;54(2):189-97.

- [38] Singh N, Verma P, Pandey BR, Gilca M. Role of *Withania somnifera* in prevention and treatment of cancer: an overview. International Journal of Pharmaceutical Sciences and Drug Research. 2011;3(4):274-9.
- [39] Palliyaguru DL, Singh SV, Kensler TW. *Withania somnifera*: from prevention to treatment of cancer. Molecular nutrition & food research. 2016 Jun;60(6):1342-53.
- [40] Misra L, Mishra P, Pandey A, Sangwan RS, Sangwan NS, Tuli R. Withanolides from *Withania somnifera* roots. Phytochemistry. 2008 Feb 1;69(4):1000-4.
- [41] Bhattacharya SK, Bhattacharya A, Sairam K, Ghosal S. Anxiolytic-antidepressant activity of *Withania somnifera* glycowithanolides: an experimental study. Phytomedicine. 2000 Dec 1;7(6):463-9.
- [42] Jayaprakasam B, Zhang Y, Seeram NP, Nair MG. Growth inhibition of human tumor cell lines by withanolides from *Withania somnifera* leaves. Life sciences. 2003 Nov 21;74(1):125-32.
- [43] Chandran U, Patwardhan B. Network ethnopharmacological evaluation of the immunomodulatory activity of *Withania somnifera*. Journal of ethnopharmacology. 2017 Feb 2;197:250-6.
- [44] Tandon N, Yadav SS. Safety and clinical effectiveness of *Withania somnifera* (Linn.) Dunal root in human ailments. Journal of Ethnopharmacology. 2020 Jun 12;255:112768.
- [45] Verma SK, Kumar A. Therapeutic uses of *Withania somnifera* (Ashwagandha) with a note on withanolides and its pharmacological actions. Asian Journal of Pharmaceutical and Clinical Research. 2011 Jul 4;4(1):1-4.