Egyptian Journal of Veterinary Sciences

https://ejvs.journals.ekb.eg/

A review on Selected Pharmacological and Phytochemical Activities of Ashwagandha (*Withania somnifera)*

Rasha A. Al-Eisa

Department of Biology, College of Sciences, Taif University, P.O. Box 11099, Taif 21944, Saudi Arabia; r.hasan@tu.edu.sa

Abstract

THE GENUS Withania belongs to the Solanaceae family and contains about twenty-six species that are found in Africa, the Himalayan areas, Australia, Canary Islands, Cape of Good Hope, Europe and the world at large. They are characterized by a wide range of phytochemical composition, with a special emphasis on steroidal lactones known as Withanolides. Ashwagandha is a potent adaptogen that strengthens the body's defenses against stress. Ashwagandha exerts its effects on several physiological systems. Firstly, it enhances the functioning of the nervous system, leading to improvements in brain function and memory, as well as a reduction in neurodegenerative processes. Secondly, it supports the maintenance of the reproductive system's optimal sexual and reproductive efficiency. Thirdly, it supports cell-mediated immunity, thereby enhancing the body's ability to resist diseases. Last but not least, it exhibits antimicrobial properties, anticancer, antidiabetic, hypolipidemic, anti-inflammatory anti-arthritic, liver tonic agent. Among others, *Withania somnifera (L)* Dunal has been extensively studied in the realms of pharmacology and agroindustry in humans and experimental animals. This review provides a comprehensive insight into, traditional applications in folk medicinal, botanical characteristics, phytometabolites, and pharmaceutical potential of *Withania somnifera* against neurodegenerative disorders, Anti-anxiety, Antistress, antioxidant, anti-inflammatory, antimicrobial, and Antiviral activity against COVID-19 are explored in humans and animals, as well as their safety and adverse effects.

Keywords: *Withania somnifera*, Botanical Features, Phytoconstituents, Biological activities.

Introduction

The genus *Withania* in Solanaceae comprises 26 species [1], mostly occurring in India, , Pakistan , Afghanistan , Iran the Middle East, and parts of Africa ,Canary Islands, Southern Europe [2, 3, 4]. Of the known species, there are five plant species, namely *Withania somnifera* (L.) Dunal, *Withania japonica* (Franch and Sav) Hunz, *Withania coagulans* (Stocks) Dunal, *Withania frutescens* (L.) Pauquy, and *Withania begonifolia* (Roxb.) Hunz that have been officially recognized and acknowledged as valid names according to The Plant List (2013). Among this variety of genus *Withania, Withania somnifera* (L.) Dunal and *Withania coagulans* (Stocks) Dunal are the most well-recognized species, which are mostly grown and sold in Iran, Afghanistan, Pakistan, and India due to their plethora of medicinal uses as well as their economic worth [2, 5, 6, 7]. Recently, a third species called *Withania ashwagandha* was identified in Indian germplasm [8].

Nowadays, Ayurvedic medicine recognises Ashwagandha (*W. somnifera*) as the most hallowed factory in Ayurvedic medicine for possessing several therapeutic properties, such as antipyretic, anticancer, anxiolytic, analgesic, anti-inflammatory, anti-arthritic, antioxidant, antidiabetic, hypolipidemic, adaptogen, memory enhancer, and possess an effect on neurodegenerative diseases. Furthermore, *W. somnifera* plant has been shown to exert antibacterial, aphrodisiac, and cardiovascular protective properties [9, 10].

From this perspective, this review provides a general overview of *W. somnifer's* botanical characteristics, traditional usage, phytochemical composition, biological activity, as s well as its safety and adverse effects

Botanical Features

*Corresponding author: Rasha A. Al-Eisa, r.hasan@tu.edu.sa, Tel.: 966560050047
(Received 21 August 2024, accepted 10 February 2025)
DOI: 10.21608/EJVS.2025.311925.2328

In terms of biological classification, Withania is categorized as belonging to the class Eudicots, division Angiospermae, the taxonomic classification of the mentioned plant species is as follows: it belongs to the order Solanales, family Solanaceae, sub-family Solanoideae, tribe Physaleae, genus Withania, and species somnifera (2n = 48). Additionally, there are three recognized species within the genus Withania, namely adpressa, coagulans, and frutescens [2, 11, 12]. The 84 genera that make up the Solanaceae family have about 3,000 species that are widely scattered worldwide [2, 13, 14]. Members of this family often exhibit characteristics of being annual shrubs. *Withania somnifera* (L.) Dunal, also known as *W. somnifera*, is a very effective and successful medicinal plant with extensive use in several regions especially in Africa, Asia, Australia, and Europe [15-17]. The genus Withania contains species that are woody herbs, shrubs, or sub-shrubs [18].

Ashwagandha (*Withania somnifera* (L.) Dunal), is often referred to as winter cherry, poison gooseberry or “Indian ginseng” due to its therapeutic characteristics [19, 20]. The perineal shrub *W. somnifera* is small and delicate, reaching heights of 180 to 200 cm and widths of about 1.0 m. It is woody, xerophytic, and evergreen, meaning it stays green all year round. The plant is nearly entirely covered with short, soft, branching, minute trichomes hairs that have a silver-gray color. Strong, tapered roots that are fleshy and have several secondary branches growing from the primary root have a strong odor. The brown, upright stalks occasionally have no leaves below. Its axilla is home to a cluster of cymbals, which are made up of four to twenty-five small, monochromatic, pale green flowers. The leaves on the vegetative stalks are big, alternating, and opposed, oriented somewhat laterally in pairs. The 1–7 hardly noticeable bisexual blooms sprout on 2–5 mm long stems at leaf nodes. The fruit's five-lobed calyx measures 5 mm in length; it is spherical or urn-shaped, membrane-covered, and has five to ten ribs. The corolla is 5-8 mm long, slightly campanulate, with hues ranging from pale yellow to yellow-green. It has five lobes. The five stamens are rather noticeable and have a yellow-orange color. The fruit has a long calyx and is a spherical, hairless berry with a diameter of 5-8 mm that turns scarlet to orange-red when ripe. The many kidney-shaped, compact, extremely pale brown seeds have a rough mesh surface and are 2.5 mm in diameter [21, 22, 23, 24].

Traditional Uses

Withania somnifera (L.) Dunal, commonly referred to as *W. somnifera*, is a valuable and well-known medicinal plant that has great value. It is extensively used in many regions such as Africa, the Himalayan mountains, Australia, Canary Islands, Cape of Good Hope and Europe [25, 26].

Its common name, ashwagandha, is a combination of two Sanskrit words, "asva_‘horse’, gandha_‘smell’) referring to" the root smells like horse" that is why it is called Ashwagandha (on consuming it gives the power of a horse) [27, 28, 29]. Because of its exceptional medicinal powers, this plant is often referred to as the "Queen of Ayurveda" or a Rasayana herb [30].

Withania somnifera among the Ayurveda, the traditional system of medicine practiced in India can be traced back to 3000 years [31]. It has been used as a Rasayana for most of these 3000 years [32].

It is also used as a bioremediation for phytoremed iation purposes [33, 34, 35]. *W. somnifera* extends over Africa's tropical regions and eventually reaches South Africa in the Mediterranean region [28]. *W. somnifera* is believed to be native to South Africa, where it is often used as a sedative hypnotic agent. Additionally, it is recognized for its efficacy in treating many diseases in the southern African region [33, 36]. Various components of the plant serve different functions.

The root, for example, has traditionally been used as an aphrodisiac, narcotic, tonic, diuretic, anthelmin tic, and stimulant.

It has also been used to treat snake venom, as an a stringent, for nutritional value, and as a popular suppl ement [37]. Additionally, the roots and leaves undergo a cooking process in clarified butter, known as ghee, together with Gurr, a kind of unrefined sugar. The resulting mixture is then used in the production of ethnoveterinary remedies. A decoction made from cooked roots and leaves has been shown to improve milk production in sheep, cows, and buffalo. This decoction has also been utilized for its antipyretic and sexual tonic qualities [38]. Moreover, extracts derived from the roots of *W. somnifera* are widely used as commercial commodities in the cosmetics and personal care sectors. These extracts are often included in various products, including skin conditioners, shampoos, and agents that combat the formation of wrinkles [39]. Also, in some African countries (Egypt, Djibouti, and Ethiopia) the plant has been widely used to treat Alzheimer’s disease, bronchitis, and malaria (in combination with other plants) (in combination with other decoction is also employed to treat hemorrhoids and rheumatism, Diabetes, Memory enhancer, obesity [40-42]. The leaf dthe Indiansalso employed to treat hemorrhoids and rheumatism, Diabetes, Memory enhancer, obesity [43-45]. Moreover, the Indians used the whole plant for treatment of fever , asthma, weakness, aphrodisiac ,Insomnia , constipation , eye diseases, painful , swellings and ulcers , anthelmintics , diabetes and as a memory enhancer. The various traditional medicinal uses of *W. somnifera* are presented in Table 1.

Phytoconstituents

Ashwagandha is characterized by rich phytochemical composition. More than 48 chemical compounds have been detected in *W. somnifera's* roots, 62 in the leaves, and 29 in both the roots and leaves, according to a chemical examination of the plant's various parts [46]. The steroidal lactones (witanolides A-Y, witanopherin A, witanone, witadomniferin A, and witasomnifer) are the most physiologically active chemical compounds of *W. somnifera* [30], Wothanolide glycosides, or glycowithanolides identified as withanosides [47, 48], the presence of an extra acyl group in saponins (specifically sitoindoside VII and VIII) and the attachment of glucose at carbon 27 in withanolides (specifically sitoindoside IX and X) may be seen [17]. Alkaloids such as somniferinin, pseudotropin, choline, pseudowitanin, kuskohigrin, isopeletierin, witanin, tropin, somniferin, somnin and anaferin are present in the substance under consideration [49], the flavonoids included in the sample consist of 3-O-rutinoside, 6,8-dihydroxycemferol, quercetin, and its glycosidic derivative. The compound referred to as 3-O-rutinoside-7-O-glucos [50]. Ashwagandha also contains tropine, choline, pseudotropine, coumarins (scopoletin , p-coumaric acid), sterols, phenols (gallic acid, chlorogenic acid), withasomnine, somniferine, hentriacontane, mesoanaferine, withanine,withananine, visamine, ashwagandhine, pseudowithanine, withaniol, reducing sugars, iron, and amino acids resins, lipids, Vanillic acid, syringic acid, benzoic acid, physagulin, and trigonelline and fatty acids [51, 52, 53, 54]**.** Among these pharmacologically active principles, Withanolides and alkaloids are the most physiologically active botanical constituents. Withanolides are considered the key player in displaying the pharmacological attributes of *W. somnifera*. Withanolides are a class of steroidal lactones, specifically generated on the ergostane-type skeleton, where the carbon atoms at positions 22 and 26 are oxidized to create a six-membered lactone ring [55-57]. The presence of β-sitosterol, stigmasterol, β-sitosterol glucoside, stigmasterol glucoside, and α + β glucose has been confirmed in the roots of *W. somnifera*. Furthermore, ongoing efforts include the isolation of Viscosa lactone B, stigmasterol, stigmasterol glucoside, and α + β glucose from the roots of *Withania somnifera*. [58]. The presence of nine withanolides has been confirmed in the water and methanol extract (1:1) of W. somnifera. The aforementioned compounds include a group of withanolides, namely 6α-chloro-5β-hydroxywithaferin A, (22R)-5β-formyl-6β,27-dihydroxy-1-oxo-4-norwith-24-enolide, 2,3-dihydrowithaferin A, withanone, withanoside IV, withaferin A, 2,3-didehydrosomnifericin, 3-methoxy-2,3-dihydrowithaferin A, and withanoside X. Furthermore, the presence of chlorinated withanolide and 6α-chloro-5β,17α-dihydroxywithaferin has been detected. Various compounds were identified, namely 24,25-Dihydrowithanolide VI, withanoside IV, withanoside V, withanoside VI, withanamide A, withanamide B, withanamide C, withanamide D, withanamide E, withanamide F, withanamide G, withanamide H, and withanamide I, within the extract obtained from the fruits of Withania somnifera [59]. The methanolic extract obtained from the fruits of the plant comprises withanamides A-I and 6,7α-epoxy-1α,3β,5α-trihydroxy-witha-24-enolide [45, 60]**.**

Approximately 140 specialised chemicals identified in *W. somnifera*. Among these are withanolides, a complicated category of steroidal lactones that also exist as glycosides (withanosides) [61]. More than 70 distinct withanolide derivatives have been characterized in *Withania somnifera* leaf and root [46, 62]**.** White Shilajit (*W.somnifera*) consists of four sitoindosides, namely sitoindosides IX and X, which are glycosylated derivatives of the withanolide withaferin A. Furthermore, *W.somnifera* contains sitoindosides VII and sitoindosides VIII, which are sitoindosides with long chain acyl groups [63]**.** Table 2 and Figure 2 illustrate some of the most important phytochemical compounds discovered in *Withania somnifera*, in terms of quantity, bioactive effects, and unique structures.

Biological activities

Ashwagandha is well recognized for its ability to augment the body's capacity to withstand stress, hence functioning as a potent adaptogen. Ashwagandha exerts its effects on various physiological systems, including the nervous system, reproductive system, immune system, and exhibits antimicrobial, anticancer, antidiabetic, anti-inflammatory, and anti-arthritic properties. Specifically, it enhances brain function and memory, preserves sexual and reproductive efficiency, supports cell-mediated immunity, improves the body's resistance to diseases, and acts as an antimicrobial, anticancer, antidiabetic, anti-inflammatory, and anti-arthritic agent. Initial research has shown that the components found in Ashwagandha have a variety of therapeutic actions, with little or negligible levels of related toxicity. Nowadays, Ashwagandha is one of the most essential herbs in Ayurveda and other traditional medicine systems. The Food and Drug Administration in the United States (US) has designated *W. somnifera* products as "botanical dietary supplements". The usage of *W. somnifera* is growing in popularity, and there are already more than 1,300 items on the US market that contain it, according to the National Institutes of Health Office of Dietary Supplements [64]. *W. somnifera* moved up from eighth place in 2016 [65] to sixth place in 2017 [66]**,** according to a list of the top-selling herbs in the US. With sales of more than $10 million through traditional channels (including supermarkets and drugstores) and more than $13 million through natural channels, *W. somnifera* was the fifth-most common dietary

supplement by 2019. Focusing the need for a better understanding of the biological characteristics and active phytochemicals of this plant in order to justify and optimize its use.

Neurodegenerative diseases

Neurodegenerative disorders are characterized by deposition of physiochemically changed protein variations in the brain and malfunction of the neuronal network and synapse of the central nervous system [67]. W. somnifera has garnered heightened interest in relation to its potential therapeutic use for neurodegenerative disorders, namely in the domain of memory impairment [68], manic depression [69], and disorders of the locomotor system [70]. Interestingly, the neuroprotective mechanisms most often documented in studies using extracts of Withania somnifera against various neurodegenerative diseases consist of the restoration of mitochondrial function, together with the concurrent decrease of oxidative stress, inflammation, and apoptosis [71- 73].

One of the most common neurodegenerative disorders, Alzheimer's disease (AD) is estimated to impact roughly 36 million individuals worldwide [74]**.** According to an intriguing study, if the current trend continues and there are no medical improvements, one in 85 people would get AD by the year 2050 [75].

The complicated pathophysiology of Alzheimer's disease is distinguished by linguistic impairment, a progressive loss of memory and the ability to recognize things or people, difficulty doing tasks, and psychological symptoms like depression, anxiety. It is the most common cause of dementia. The neuropathological changes symptoms largely arise because of the degradation of cholinergic neurons, dystrophic neuritis, gliosis, the presence of toxic beta-amyloid (Aβ) plaques, the formation of aberrant neurofibrillary tangles, and a deficiency in critical neurochemicals required for regular neuronal transmission [76].

Several publications established that Aβ cytotoxicity is the hallmark pathogenic feature of AD. Excessive ROS formation during the early stages of neuronal death has been shown to cause oxidative stress, which can signal the initiation of apoptosis [77]. Furthermore, H_2O_2, one of the traditional neuronal cell death triggers, has been shown to increase in response to Aβ poisoning [78, 79]. The in vitro function of an aqueous extract of the root of *W. somnifera* against H_2O_2 and Aβ -induced toxicity [80]. Isopelletierine and nicotine from W. somnifera were found to be able tsomnifera wereid precursor protein (APP), a key factor in AD, using molecular dynamics simulation (MDS) [81]. Neurite atrophy has been shown in the brains of individuals afflicted with many neurodegenerative conditions, including Parkinson's disease, Huntington's disease, and Creutzfeldt-Jakob disease. This phenomenon is considered a significant component of the pathophysiology of these illnesses. Multiple studies have shown that Ashwagandha has the capacity to decelerate, halt, reverse, or eradicate neurotic atrophy and synaptic loss. Consequently, Ashwagandha has potential therapeutic properties for the treatment of Alzheimer's and Parkinson's diseases [70, 82, 83], Huntington's [84], Furthermore, individuals with neurodegenerative illnesses, including but not limited to Alzheimer's disease, may benefit from interventions at any point in the disease progression, including the early stages characterized by moderate cognitive impairment, prior to formal diagnosis.

Anti-anxiety and Antistress effect

Sleep has a crucial role in preserving the overall physical and mental health of mammals. Sleep deprivation or disruption may give rise to a range of physiological, metabolic, and cognitive impairments, hence contributing to the development of stress, anxiety, obesity, and further neurocognitive dysfunctions. The sleep-dependent activity of the hippocampus and pyriform cortex, which are brain areas implicated in memory and perception, are diminished during complete sleep deprivation [85, 86]. Daily supplementation with 240 mg of *W. somnifera* extract can reduce Hamilton anxiety rating scale (HAM-A) and stress scale-21 (DASS-21). The anti-anxiety effect of *W. somnifera* root extract as capsules of commercially available preparations (KSM-66®, Sensoril®, Essentra®, or Shoden®) was studied in nine separate human trials involving participants aged 18-75 years. Participants in the study were classified as healthy [87], stressed [88, 89], diagnosed with general anxiety disorder or a similar disease [90, 91, 92, 93], sleeplessness [25, 94], or diagnosed with schizophrenia or schizoaffective disorder [95]. The sample sizes ranged from 39 to 130 [90, 91], with most of the studies having 60 to 80 participants [25, 87, 88, 89, 94, 95]. In most studies, anxiety improved after daily dosages of *W. somnifera* ranging from 125-1000 mg supplementation for 6-12weeks, as measured by improvements in anxiety levels. Considerable research has been dedicated to investigating the processes that underlie the anti-anxiety qualities of *W. somnifera*, with particular emphasis on the Gamma-Aminobutyric Acid (GABA) receptor system. GABA is well recognized as the predominant inhibitory neurotransmitter in the central nervous system, playing a crucial role in regulating neuronal activity. The modulation of GABAergic neurotransmission is believed to have significant implications for the therapy of anxiety-related conditions [96]. GABA type A (GABAA) receptors serve as the principal target for GABA agonist medicines, which enhance GABAergic activity and are often used in the treatment of anxiety disorders [97, 98]. It was shown that the methanolic

root extract of *W. somnifera* induced an elevation in chloride ion influx in human spinal cord neurons when GABA was absent, and it exhibited inhibitory effects on GABA binding comparable to those of GABAA receptor agonists [99]. Based on the findings of receptor-binding assays, it has been shown that the constituents present in methanolic root extracts of *W. somnifera* have a notable affinity towards GABAA receptors. However, their affinity towards GABAB, glutamatergic, and opioid receptors is comparatively lower [100-102]. Further investigation is required to ascertain the structure-activity connections pertaining to the interactions between withanolides and GABAA receptors. Additionally, it is necessary to identify the possible sites of interaction within the GABAA receptor complex and elucidate the underlying processes of these interactions [103]. It was discovered that *W. somnifera* was also a potent GABA1 receptor agonist, with these receptors being 27 times more responsive to *W. somnifera* than GABAA receptors [104].

W. somnifera's anti-stress impact has also been attributed to numerous pathways, including glucocorticoid decrease and immunological regulation [103]. W. somnifera has also been shown to have chronomodulatory effects on the brain [105]. Hydroalcoholic extract of *WS* leaves were reported to counteract age-related changes in the suprachiasmatic nucleus of middle-aged and elderly rats (including rBmall, rPer1, rCry1, and rPer2) [106]. One possible reason for the anti-stress effects of W somnifera is its serotonergic activity. Studies in animals have shown that WS has antidepressant properties, which may be due in part to its serotonergic activity. Among both wild-type and mutant Chaenorhabditis elegans strains, withanolide Serotonin receptor and transporter mRNA expression was upregulated [106]. Moreover, it was shown via molecular docking investigations that withanolide A exhibited a higher binding affinity to serotonin receptors and transporters in both human and C. elegans organisms compared to serotonin itself and the selective serotonin reuptake inhibitor fluoxetine [106]. Regrettably, limited number of human studies conducted so far has not explored the impact of WS administration on neurotransmitter levels as a potential mechanism. Consequently, more research is required to address this gap in knowledge.

Antioxidant activity

Oxidative stress is defined as an imbalance between the generation of reactive oxygen species (free radicals) and the protective mechanisms provided by antioxidants [107].

Polyphenols, sitoindosides VII-X, withaferin A, and glycowithanolides are among the antioxidant phytochemicals found in W. somnifera. [108, 109]. The extraction technique is critical in determining the biological effects of *W. somnifera* and other plants in the Withania genus, including antioxidant capacity and phytochemical composition [110].

Our brain utilizes around 20% of the total oxygen supply of the organism, and free radical injury to the nervous system causes considerable neuronal death [111].Previous studies examines the amounts of the key free-radical scavenging enzymes, namely superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPX), in the frontal cortex and striatum of the rat brain. The production of detrimental reactive free radicals and subsequent degeneration is attributed to the diminished activity of these enzymes. The antioxidant properties of the active components of *W. somnifera*, namely sitoindosides VII-X and withaferin A (glycowithanolides), were examined in the frontal cortex and striatum of rat brains [112]. The investigation focused on evaluating the effects of these components on the activity of key enzymes involved in free-radical scavenging, namely superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPX). Active *W. somnifera* glycowithanolides (10 or 20 mg/kg intraperitoneally) were administered once day for 21 days to groups of six rats. All enzymes increased in a dose-dependent manner, equivalent to those observed with deprenyl (a known antioxidant) therapy (2g/kg/day intraperitoneally). This implies that WS exists. There has been a documented rise in the levels of antioxidant enzymes, such as chloramphenicol acetyltransferase (CAT), superoxide dismutase, glutathione (GSH), and glutathione S-transferase (GST), in rats that have been subjected to lead nitrate exposure, subsequent to the administration of *W. somnifera* root extract [113]. The root extract of *W. somnifera* shows a significant capacity for preventing lipid peroxidation and rejuvenating neuronal cells. The capacity to restore extensively damaged neurons via the regeneration of neurites and the repair of synapses is evident [114]**.** *W. somnifera* has been shown to possess the capacity to reverse neuropathogenesis triggered by -amyloid. The potential of plant extracts containing withanosides and withanolides to mitigate the accumulation of β-amyloid peptides and oligomers in the brain, subsequently relocating them to the periphery, has been shown [115, 116].

Huntington's disease and other neurodegenerative illnesses are characterized by oxidative stress. It has been observed that neurotoxins like 3-NP increase lipid peroxidation and nitrite levels as well as decrease the activities of antioxidant enzymes like SOD and catalase. Sitoindosides VII–X and withaferin A (glycol–withanolides), which are found in WS, have been shown in numerous studies to exhibit free radical scavenging properties [111]. Extracts derived from the WS root had significant efficacy in reducing lipid peroxidation and nitrite

levels, while concurrently enhancing the activity of antioxidant enzymes. Additionally, the root extract has shown the ability to reinstate the proper functioning of mitochondrial enzyme complexes I, II, and III, along with other essential enzymes involved in the citric acid cycle**.** These enzymes include succinate dehydrogenase (SDH), isocitrate dehydrogenase, α-ketoglutarate dehydrogenase, and malate dehydrogenase, all of which were negatively affected by the administration of 3-NP [84]. In a similar vein, administering a 9-week therapy of a 100 mg/kg concentration of an ethanolic root extract from Withania somnifera resulted in neuroprotection of the nigrostriatal dopaminergic system against Parkinsonism caused by maneb and paraquat. This neuroprotective effect was achieved via the management of oxidative stress. Additionally, the subjects exhibited noteworthy enhancements in conventional indications of Parkinson's disease (PD), including a decrease in Bax protein levels and an increase in Bcl-2 protein expression. Moreover, there was a reduction in dopamine levels within the substantia nigra, a decrease in iNOS expression, and a decline in GFAP (a pro-inflammatory marker associated with astrocyte activation) [117].

The administration of *Withania somnifera* resulted in a decrease in blood glucose levels, tissue lipid peroxidation (LPO), and glutathione (GSH) levels, while concurrently increasing the activity of antioxidant enzymes such as glutathione peroxidase (GPx), glutathione reductase (GR), glutathione-S-transferase (GST), superoxide dismutase (SOD), and catalase (CAT). With its notable capacity to scavenge free radicals and enhance both nonenzymatic and enzymatic antioxidants, W. somnifera exhibits a substantial degree of free radical scavenging activity. The root extract of W. somnifera and its constituent withanolides [17]**.** Several studies have shown that *W. somnifera* and its bioactive constituents have hepatoprotective effects [118]**.** The hepatoprotective effects of *W. somnifera* were observed when an aqueous root extract was administered at a dosage of 500mg/kg, 60 minutes following acetaminophen (APAP) administration. This intervention resulted in a significant reduction in elevated biomarkers associated with hepatotoxicity, a decrease in lipid peroxidation, and an increase in the activity of key antioxidant enzymes such as glutathione, catalase, glutathione reductase, and glutathione peroxidase in mice treated with APAP [119]. The hepatoprotective effects of a methanolic extract derived from the roots of Withania somnifera in rats intoxicated with APAP was examined. The results demonstrated a notable hepatoprotective activity when the extract was administered two hours before APAP administration. This activity was attributed to the extract's ability to mitigate inflammation and oxidative stress, as well as its inhibitory effect on hepatic levels of proinflammatory cytokines, including tumor necrosis factor (TNF) and interleukin-1 [120]**.**

W. somnifera had a protective effect against hepatotoxicity in rats exposed to γ-radiation. This effect was seen by the considerable reduction of blood hepatic enzymes, hepatic nitrate/nitrite, and malondialdehyde levels [121]. Additionally, the antioxidant activity was enhanced, and there was a significant induction of heme oxygenase (HO^{-1}). Heme oxygenase-1 (HO^{-1}) enzymes serve a crucial function in safeguarding cells from oxidative and pathogenic stress, hence exerting a significant influence on cardiovascular protection [122].

Anti-inflammatory activity

Over the last thirty years, extensive research has substantiated these results and elucidated the molecular basis behind the bulk of chronic illnesses and their corresponding inflammatory processes. The Nuclear Factor-kappaB (NF-B), which serves as a transcription factor governing the expression of more than 500 distinct gene products, has been recognized as a prominent modulator of inflammatory processes. Therefore, pharmaceutical interventions that inhibit NF-B and mitigate persistent inflammation possess the capacity to proactively hinder or postpone the emergence of chronic ailments, and potentially serve as therapeutic measures for their treatment. Preclinical investigations have shown that the *Withania somnifera* plant has the ability to regulate mitochondrial activity and apoptosis, while also mitigating inflammation via the reduction of inflammatory markers including cytokines (namely IL-6 and TNF-a), nitric oxide, and reactive oxygen species [50]. The anti-inflammatory mechanism of the aqueous extract derived from the root of *W. somnifera* was examined, using the HaCaT human keratinocyte cell line. It was shown that the administration of Ashwagandha root extract resulted in the inhibition of the NF-B and MAPK pathways via the reduction of pro-inflammatory cytokine production, including interleukin (IL)-8, IL-6, tumor necrosis factor (TNF-), and IL [9]. The anti-inflammatory capabilities of Ashwagandha might potentially be used for the purpose of mitigating skin irritation. It was shown that *W. somnifera* had remarkable effectiveness in mitigating neurotoxicity generated by aluminum chloride ($AlCl_3$) in rats, despite its close association with antioxidant and anti-inflammatory properties. The exposure to aluminum resulted in an elevation in lipid peroxidation and nitric oxide levels, accompanied by a reduction in glutathione levels in the cortex, hippocampus, and striatum. Additionally, it inhibited the heightened enzymatic activity of acetylcholinesterase, Na^{+}, K^{+}, and ATPases created by $AlCl_3$ in the brain, hippocampus, and striatum. Furthermore, it effectively mitigated the significant elevation of

tumor necrosis factor caused by AlCl3 in the cortex and striatum. The results of this study suggest that the extract of *W. somnifera* has the potential to mitigate the neurotoxic effects of aluminum via its antioxidant and anti-inflammatory properties. Ensuring sufficient levels of acetylcholinesterase activity is also crucial in preventing reductions in cholinergic activity. This discovery might potentially provide evidence for the efficacy of *W. somnifera* as a cognitive enhancer [123]. The administration of *W. somnifera*, namely withaferin A, has been shown to induce the upregulation of type II collagen expression and enhance the production of reactive oxygen species [124].

In a mouse model of immunological inflammatio n, investigated the immunomodulatory effects of med icinal formulations WST and WS2, which are extract s of *Withania somnifera*. The administration of 1000 mg/kg WST and 300 mg/kg WS2 resulted in a significant rise in total white blood cell and platelet counts. WS2 therapy significantly reduced cyclophosphamide's immunosuppressive effects, as demonstrated by a large increase in the development of hemagglutinating and hemolytic antibodies targeting sheep red blood cells [125]. A study was conducted utilizing a randomized, double-blind, placebo-controlled design, with the inclusion of an open-label extension, to examine the impact of W. somnifera extract on the immune system of individuals who are in good health. The research investigation revealed that the administration of Ashwagandha extract resulted in a notable enhancement of natural killer cell activity and cytokine levels in comparison to a placebo [126].

Antimicrobial activity

The antibacterial activity of a methanolic extract obtained from *W. somnifera* and that that found it demonstrated microbial susceptibility and efficaciousness against all tested pathogenic bacteria including, *Pseudomonas aeruginosa, Citrobacter freundii, Salmonella typhi, Klebsiella pneumoniae* and *Escherichia coli*. Notably, the extract exhibited the largest inhibition zone against *Klebsiella pneumoniae, Citrobacter freundii, Salmonella typhi, Pseudomonas aeruginosa*, and *Escherichia coli* [11].

The organic extract of the aerial portions of *W. somnifera* exhibited significant antibacterial properties against *Staphylococcus aureus* and methicillin-resistant *Staphylococcus aureus* in a disc diffusion experiment [127]. The antimicrobial activity is contingent upon the extraction technique used, where water extract of *W. somnifera* had a more potent antibacterial effect against E. coli in compared to the alcoholic extract [128]. W. somnifera root extracts were also effective against multidrug-resistant *S. aureus* [129]. The methanol extract of *W. somnifera* has shown efficacy against Streptococcus mutans and Streptococcus sobrinus [130]. The antibacterial activity of *W. somnifera* against human pathogenic bacteria was studied and revealed that the pathogenic bacteria exhibited greater susceptibility to the extracts compared to the beneficial Bifidobacteria. Interestingly, [131]. **T**he supplementation of *W. somnifera* root powder has an immunotherapeutic effect against *Aeromonas hydrophila* in Nile tilapia [132]. The antimicrobial activity of various plant extracts of W. somnifera was assessed to determine their susceptibility to microbial agents. The results indicated that all tested extracts effectively inhibit all organisms. The methanolic extract demonstrated the highest inhibition zone against Streptococcus mutans, followed by Salmonella typhimurium. Conversely, the extracts displayed the least inhibition against Vibrio cholera among all the tested organisms [133].

W. somnifera extracts and purified components, showed different antibacterial activity against bacterial species including *Agerobacterium tumefaciens*, *Acinetobacter baylyi*, *Escherichia coli*, *Enterobacter aerogens, Enterococcus feacalis, Chlamydophila pneumonia, Citrobacter freundii, Corynebacterium diphtheriae, Bacillus cereus, Bacillus subtilis, Bacillus thuringiensis*, and *Klebsiella Methicillin* resistance *Neisseria gonorrhoeae, Staphylococcus aureus, Pseudomonas aeruginosa, Micrococcus luteus Mirabilis Proteus*, *Proteus vulgaris* and, *Proteus solanacearum* [134, 135]. *Serratia marcescens, Raoultella planticola, Pseudomonas fluorescens, Salmonella typhimurium, Salmonella typhi, Streptococcus aureus, Staphylococcus aureus* and *Staphylococcus epidermis* [136-138].

The literature research indicates that the disc diffusion method was most frequently used to assess the antibacterial efficacy of plant extracts from *W. somnifera* [139].

Somnifera aqueous fruit extract at 2% demonstrated possible antifungal activity against Fusarium oxysporum f. sp. radicis-lycopersici. The plant's extracts are thought to contain fixed oils, tannins, alkaloids, saponins, flavonoids, phenolic compounds glycosides, in addition to other components that have antifungal properties. Additionally, polar components such as withaferin A, ascorbic acid, and anthocyanin are also considered to contribute to this activity [140, 141]. Vanillic acid, salicylic acid, and o-coumaric acid were discovered to be the most effective phenolic compounds, whereas the flavonoid molecules detected in acetone extracts of W. somnifera fruits were rutin, myricetin, and kaempferol [142]. The black pointed disease produced by A. alternata in Triticum aestivum is considerably reduced when an aqueous extract of W. somnifera is supplied [143]. *W. somnifera* fruit and leaf methanol extract has been proven to diminish Ascochyta rabiei biomass, the cause of chickpea blight disease [144]. Furthermore, when W.

somnifera root methanolic extracts are administered, the biomass of Fusarium oxysporum f. sp. cepae is reduced by 93% [145]. *W. somnifera* antimicrobial activity Mechanisms of action can may be attributed to cytotoxicity, Gene silencing and immunopotentiation [146].

Antiviral activity against COVID-19

COVID-19, also known as coronavirus sickness 2019, is a severe acute respiratory syndrome coronavirus caused by the SARS-CoV-2 virus. This fast-spreading disease ranks among the world's leading causes of mortality [147, 148]. According to existing data, the majority of people are asymptomatic or have just minor symptoms**.** In the event of a severe development of the disease, patients develop pneumonia and acute respiratory distress syndrome (ARDS) and must be admitted to the hospital. The SARS-CoV-2 virus enters cells via the 2(ACE2) receptor and primes spike proteins via the transmembrane serine protease 2 (TMPRSS2) [149]. Once single-stranded RNA (ssRNA) entry into the host cell, it released. Subsequently, the ssRNA utilizes the ribosome machinery of the cell to facilitate the synthesis of structural proteins and enzymes required for the replication of the virus [150]. According to the findings, *W. somnifera* may play a function in regulating many metabolic processes in COVID-19 pathogenesis. Since nasal cells, the respiratory tract's mucosal surface, and the region around the ayes are the main sites where the viral entry site at the ACE2 receptor is located. *W. somnifera* and its formulation when administered intranasally may provide protection against human SARS-CoV-2 infections [151]. In the global cerebral ischemia model, an efficacious dose of Withanolide A was injected intramuscularly into the olfactory mucosa, producing a neuroprotective effect [152]. Nowadays, immunological processes linked to viral infections are understood in relation to COVID-19 treatment. It has been suggested that therapy efforts aimed at improving the immunological profile could improve clinical outcomes.

For example, it has been shown that combining the immunomodulator to cilizuma b with the antiviral remdesivir can increase pharmacological efficacy [153]. This is an excellent time to use *W. somnifera*, a powerful immunomodulator, because of its well-established safety and efficacy profile. The intriguing molecular and pharmacological characteristics of W. somnifera make it a promising therapeutic adjuvant for COVID-19 prevention and treatment. *W. somnifera* may therefore enhance the clinical outcomes of currently available COVID-19 pharmacotherapeutics. Using a molecular docking technique, investigations have shown that withanone interferes with host-virus interactions by causing ACE2 and the receptor-binding domain of the spike protein to become unstable. Withanone has been found to disrupt host-virus interactions by destabilizing the combination of ACE2 and the spike protein's receptor-binding domain. An in vitro investigation demonstrated that withanone downregulates the mRNA of TMPRSS2 in MCF7 cells [154]. Withacoagin and withanolide B were expected to have a high affinity for viral spike protein and RdRp enzyme [155].

Using molecular docking analysis, withaferin A was discovered to inhibit the host receptor glucose regulated protein 78 (GRP78), which has been reported to be elevated in COVID-19 patients [156, 157]. Moreover, several current virtual screening investigations have demonstrated that withanolides have a strong affinity for inhibiting SARS-CoV-2 proteins [158-161]. The pharmacophore of withanolides has been associated with both the suppression of HSP90 [162], and the stimulation of the cytoprotective heat shock response [163]. HSP90 serves as the host for SARS-CoV-2 [164, 165]. Thus, comprehensive pharmaco-mechanistic investigations could clarify the role that withanolides could play in suppressing the SARS-CoV-2 virus.

To better understand the real-world adjuvant potential, W. somnifera may be studied in healthcare staff getting COVID-19 vaccination for antibody titer regulation. Furthermore, W. somnifera may have a beneficial influence on various comorbidities on a variety of comorbidities associated with COVID-19 disease [166].

Safety

Several review articles extensively describe numerous human clinical trials, suggesting that when provided for a year, *W. somnifera* has no negative health impacts [109]. For example, a 300 mg capsule of *W. somnifera* root extract was given to 64 individuals aged 18 to 54 years. There were no statistically significant differences in adverse events between the placebo and *W. somnifera* groups [88]. Another study looked into the usage of W. somnifera in reproductive problems; for this, 41 males were given an oral dose of 4 tablets (500 mg each) three times per day containing *W. somnifera* root powder for 60 days [167]. There have been no known side effects from taking *W. somnifera* root powder. So far, research suggests that ingesting up to 100 mg per kg of body weight in a single dose, or around 21 g per day, is safe. Since a therapeutic dose is usually 10 g/day, taking the supplement in capsule form allows for more precise control over overall consumption. Oral dosages of 0, 500, 1000, and 2000 mg/kg body weight of *W. somnifera* extract were administered to an animal model for 28 days. The results show that the administration of *W. somnifera* extract up to 2000 mg/kg/day did not cause any advese effects [141]. Findings indicated that there were no significant adverse events seen, and the safety outcomes were within acceptable limits. There were no notable alterations in vital signs, as well as hematological

and biochemical indicators. [30]. To evaluate the safety of KSM-66® Ashwagandha root extract (Ixoreal Biomed, Inc.), a randomized, placebo-controlled experiment was conducted [93]. For eight weeks, a group of eighty healthy adults (18–45 years old) were randomized 1:1 to receive either 300 mg of KSM-66® or a matching placebo twice a day. Researchers examined vital signs, hematological and biochemical markers (platelet count, alkaline phosphatase, aspartate aminotransferase (AST), alanine aminotransferase (ALT), and thyroid hormone panel) and neutrophil percentage to determine safety. None of the safety metrics changed significantly from the placebo, and no adverse events were reported. Adults can safely take up to 1000 mg of W. somnifera per day for up to 12 weeks, but pregnant and breastfeeding women should avoid it [64].

National Institutes Animal toxicity tests have also found W. somnifera extracts to be safe. The acute and subacute toxicity of a *W. somnifera* hydroalcoholic root extract in female Wistar rats was investigated [75]. No major behavioral or illness issues have been seen as a consequence of acute dosages of up to 2000 mg/kg. Similarly, rats given daily doses of 500, 1000, or 2000 mg/kg of the extract for a duration of 28 days did not exhibit any indications of subacute toxicity. In a further investigation, a hydroalcoholic root extract of *W. somnifera* was administered to rats to examine its potential for inducing prenatal developmental toxicity. The extract was administered at dosages of 500, 1000, and 2000 mg/kg per day for a duration of 28 days [75]. There were no indications of toxicity, obvious pathological changes, or mortality in the pregnant rats or fetuses. Rats treated with W. somnifera root extract for long term period did not experience any analgesic effects from the extract, and rats treated acutely with the extract did not experience any morphine-induced analgesia. However, rats treated with morphine for ten days did not develop tolerance or morphine dependence. Nevertheless, the purpose of this study was not specifically to investigate side effects and safety [168].

Despite *W. somnifera* being generally considered safe and showing promise as an anti-anxiety, antidepressant, and sleep-promoting agent in a few modest animal and human trials, there has been a considerable increase in negative effects, variability in products, level of standardization, and specific dosages. Moreover, it's uncertain how herbal and prescription drugs might interact. Furthermore, most of the studies were short-term, so it's conceivable that they don't fully capture the long-term impacts of ingesting *W. somnifera* on human health. More investigation is required [50].

Conclusion

In conclusion, ashwagandha is a herb with signifi cant medicinal value that has been shown to impr ove human health. The extant scientific data substantiates the assertion that Ashwagandha is well recognized as a potent regeneration tonic (Rasayana of Ayurveda) owing to its multifarious pharmacological effects, including neuroprotective properties, anti-anxiety, antistress, anti-oxidants, anti-inflammatory, antimicrobial, Antiviral, sexual dysfunction diseases, autoimmune diseases, etc.. Despite the fact that a lot of research has been conducted to support ashwagandha's medicinal effects for many physiological systems. But it's crucial to keep in mind that ashwagandha research is still in its infancy. More research is required to ascertain the herb's possible medical applications as well as the ideal dosage and timing of administration. Furthermore, it's critical to assess ashwagandha's safety, particularly in combination with other prescription drugs or dietary supplements.

Acknowledgments

Not applicable.

Funding statement

This study didn't receive any funding support

Declaration of Conflict of Interest

The authors declare that there is no conflict of interest.

TABLE 1. Traditional uses of *Withania somnifera*

Regions	Plant parts	Medicinal usage	References
India		Diabetes neurodegenerative disorders, narcotics and sedative Constipation, Sleep disruption, diarrhoea, fever	[169, 170]
		Bleeding from the penis or Anal	[171]
		Various diseases	[172]
	Whole plant	Asthma, Rheumatic, Sleep disruption, Eye Anthelmintics, infection, fever, constipation swellings and ulcer	[173]
		Antimicrobial activity, asthma	[174]
		Fever, Rheumatism/ arthritis	[175, 176, 177]
		Anxiety, cancer, Asthma, Hepatitis, Female infertility, Arthritis	[178]
South Africa, India	Young shoots	Nutrition	[37, 179]
India, South Africa Tanzania Lesotho, Sudan, Egypt	Root	Anaemia, nervous tranquilizer, moderate diuretic, stimulant, alterative, aphrodisiac, rheumatic disease	[180, 181, 182, 183]
India		Anti-snake venom, Venomous snake bite	[184, 185]
India		Antipyretic, anticancer, anxiolytic, analgesic, cough, aging, Hair loss, memory enhancer, tonic	[186, 187, 188, 189, 190]
India		cardiovascular protective, Asthma, Paralysis	[191, 192, 193]
South Africa, Jordan		General weakness, A nocturnal emission, Rheumatism, painful swelling, arthritis	[167, 188, 194]
South Africa, India		Male sterility, leucorrhoea miscarriage, Aphrodisiac, impotency, increasing sperm count, Astringent.	[195, 196, 197]
South Africa, India		flu and cough, eye infection, moderate diuretic, epilepsy, insomnia, Gastroenteritis, leprosy, nervous disorders, tubercular	[198, 199]
South Africa, India		Antimicrobial activity, Anti-tumor	[198, 200]
South Africa, India		Wrinkles, Energy tonic	[68, 201, 202]
India	Leaves	Headache, erectile dysfunction and general weakness, rheumatic swellings, debility, aging, gonorrhoea, ringworm.	[203, 204]
India		Weight loss, obesity	[45, 205]
Egypt, Djibouti, Ethiopia, India,		Alzheimer's disease, Memory enhancer, obesity	[42, 45]
India, Pakistan, South Africa, Jordan		Aphrodisiac, ulcers, swellings, Haemorrhoids	[43, 206]
India, Pakistan,		Tuberculosis, Asthma and Malaria	[207, 208]
India, South Africa		Diabetes, Kidney problems, Fever, inflammation	[209, 210, 211]
India, South Africa		Body pain, inflammation, Backache, arthritis	[212, 213]
India		Intestinal worm infestation; rheumatic swellings, Stomach problems, Carminative	[212, 214]
India		Wound and burn, bed sores, haemorrhoids, abscesses and smallpox, Boils	[215, 216]
Morocco, South Africa, India	Leaf, root	Abortifacients	[190]
India	Stem	Menstrual disorder, Fever, cough asthma, migraine, Leucorrhea, Tumors , Piles , Nervous disorders , Rheumatism , Menstruation	[217, 218, 219, 220]
Lesotho, Pakistan, India	Seeds	Menstruation, Amukkuram,	[44, 221]
Tanzania, India	Flower and dried roots	Aphrodisiac	[209, 210]
India, Iran	fruit	Anxiety, hiccups, insomnia, cancer, fibromyalgia, asthma, tuberculosis, leukoderma, bronchitis, backache, liver disease, menstrual problems, Diuretic,	[222, 223, 224]

TABLE 2. List of the most phytochemical compounds isolated from different parts of *Withania somnifera* plant

Plant part	Phytochemicals	References
Roots	F, G, J, I, K, L, and M all belong to the class of compounds known as withanolides. Specifically, 5-epoxy-16-acetoxy-6-hydroxy-1-oxowitha-2, 20-dihydroxy-1-oxowitha-2, 24-dienolide, and 17-epoxy-24-trienolide.	[56, 215, 225, 226]
	Mesoanaferine, choline, withanine, visamine, withananine, Hentriacontane, isopelletierine, 3α-tigloyloxtropine tropine, dl-isopelletierine-3-tropyltigloate, cuscohygrine, anaferine, hygrine.	[227]
	Stigmasterol, stigmasterol glucoside, withaferin A and withanolide D, withanolideA, somniferinin, 4-α-hydroxywithanone, pseudowitanin, tropanol , choline, kuskohigrin, isopeletierin, and anaferin.	[30, 58]
	6α-chloro-5β-hydroxywithaferin A, (22R)-5β-formyl-6β,27-dihydroxy-1-oxo-4-norwith-24-enolide, 2,3-dihydrowithaferin A, withanone, withanoside IV, withaferin A, 2,3-didehydrosomnifericin, 3-methoxy-2,3-dihydrowithaferin A, and withanoside X.	[59]
Leaves	Glucosomniferanolide.	[56]
	Kaempferol, Quercetin.	[215]
	2-Cyclohexyl-4-hydroxymethyloctahydrobenzo[e][1,2]oxazine-3-carbonitrile.	[228, 229]
	Withanolide D, N, O, P.	[230]
	2,3-didehydrosomnifericin	[231]
	6achloro-5b-hydroxywithaferin A	[229]
	17α-hydroxy withaferin A	[232]
	2,3-dihydro-3β-hydroxy withanone-3β-O-sulfate	[233]
	4-O-caffeoylquinic aci	[234]
	Withanolide C, 4-deoxyphysalolactone	[235]
	(20R, 22R)-14α, 2OαF-dihydroxy-1-oxowitha-2, 5, 16, 24-tetraenolide	[236]
	Withaferin A	[237]
	withanolide F, hyperunolide A, A withanoside IV, withanoside X, withanoside VIII	[238, 239]
	27-deoxywithaferin A, 2,3-dihydro-3β-hydroxy withanone-3β-O-sulfate, 27-hydroxywithanolide B	[232, 233, 240]
	withanine; withananine, withasomnine ,3*α*-tigloyloxtropine, mesoanaferine, somniferine, choline, hentriacontane, pseudotropine, dl-isopelletierine, cuscohygrine, 3-tropyltigloate, visamine, anahygrine, hygrine, ashwagandhine, and pseudowithanine	[227]
Stem bark	Withasomnilide, somniferanolide, somniferawithanolide, withasomniferanolide, and somniwithanolide	[241]
Fruits	Linoleic acid, palmitic acid, tetracosanoic acid, elaidic acid, and oleic acid, Withanamides A-I	[60, 242]
	24,25-Dihydrowithanolide VI, 14α,17α-dihydroxywithanolide R withanoside IV, withanoside V, withanoside VI, withanamide A, B, C, D, E, F, G, H, I ,4-deocywithaperuvin.	[59, 243, 244]
Fruits and flowers	Amino acids, chamase,, condensed tannins, flavonoids, isopsoralen, peroxidases, proteolytic enzyme, Psoralen,	[24, 219]
	Withanone and tubacapsenolide F 54, withanone, withanoside IV, withanoside X 6α-chloro-5β,17α-dihydroxywithaferin Aα-chloro-5β hydroxywithaferin A, 3-methoxy-2,3-dihydrowithaferin A, n (22R)-5β-formyl-6β,27-dihydroxy-1-oxo-4-norwith-24-enolide, withaferin A, 2,3-dihydrowithaferin A, 2,3-didehydrosomnifericin,	[236, 245]

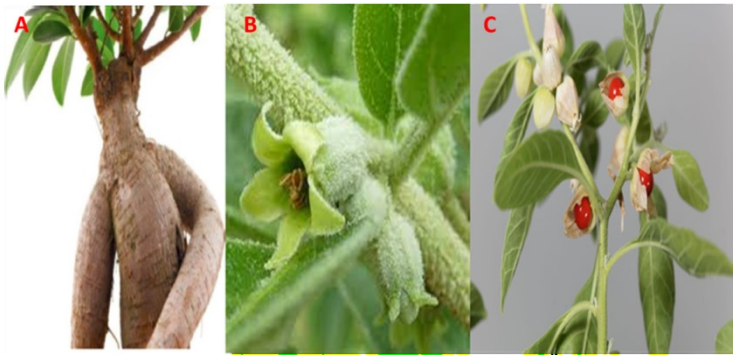

Fig. 1. *Withania somnifera* plant (A) roots; (B) flowers and (C) Leaves and Fruits.

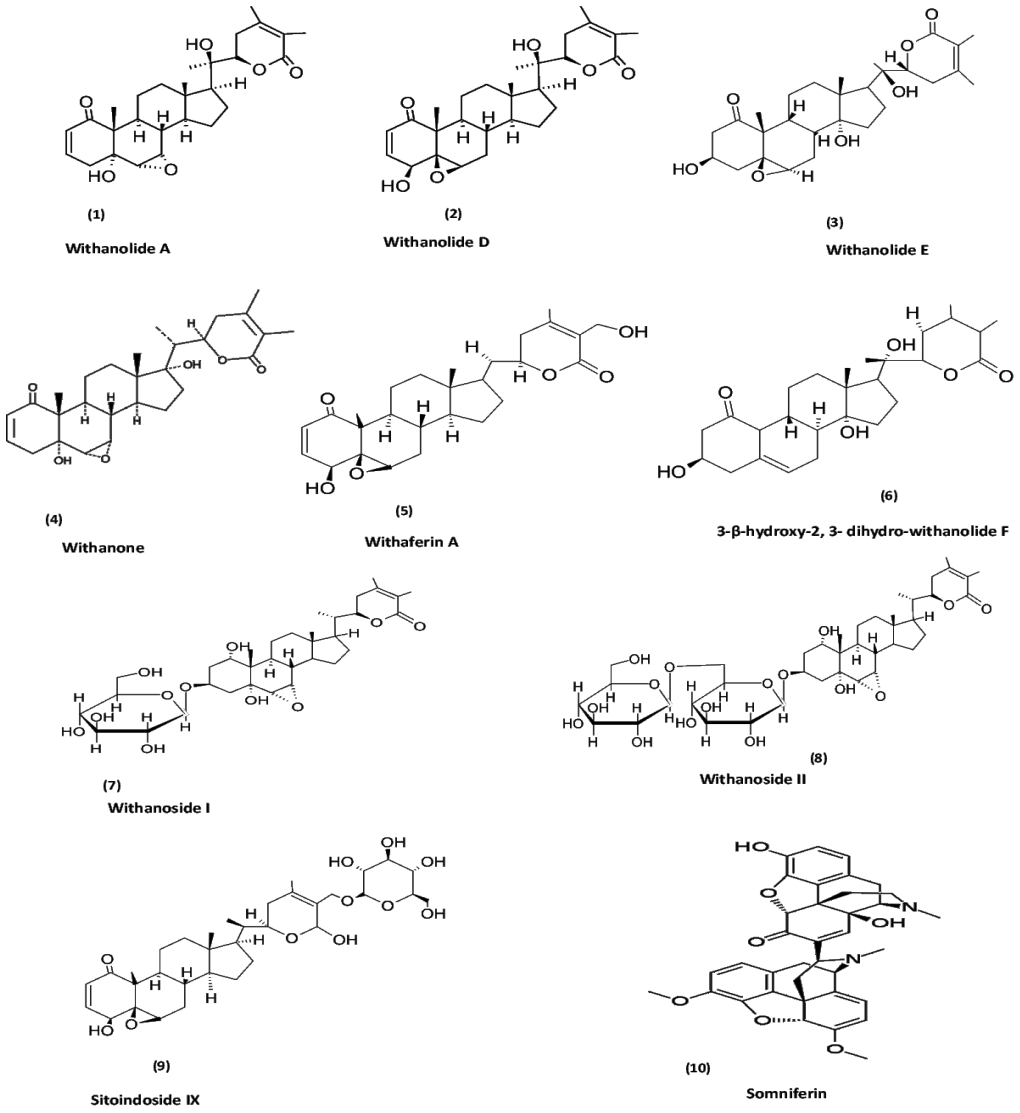

Fig. 2. ***Chemical structure of some major bioactive compounds in Withania somnifera plant extract: (1)Withanolide A ;(2) Withanolide D; (3) Withanolide E;(4)Withanone;(5) Withaferine ;(6) 3-β- hydroxy-2, 3- dihydro withanolide F; (7) Withanoside I; (8) Withanoside II;(9) Sitoindoside IX; (10) Somniferin.***

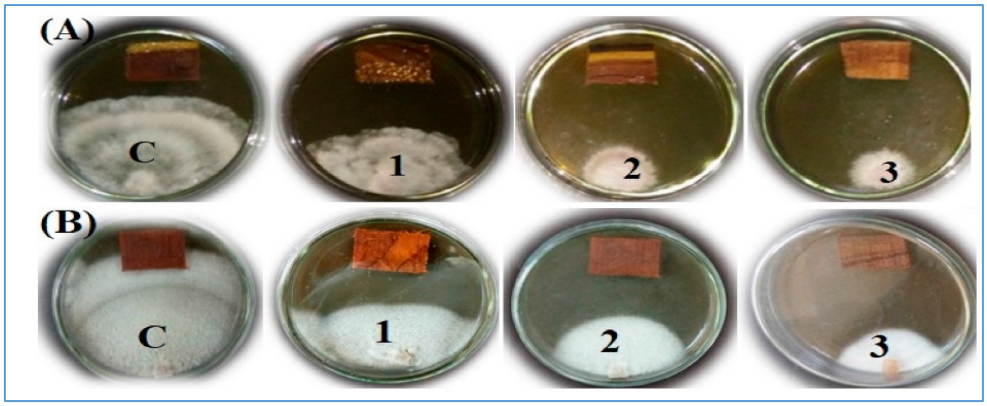

Fig. 3.

Antifungal activity of the treated wood with 100 µL of the concentrated extract Of *W. somnifer*. (A) *Fusarium culmorum*; (B) *Rhizoctonia solani* [142]

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دراسة مرجعية للأنشطة الدوائية والكيميائية النباتية المختارة لأشواغاندا (ويثانيا سومنيفيرا)

رشا عبد الرحمن العيسى
قسم الأحياء، كلية العلوم، جامعة الطائف، ص.ب. ص.ب 11099، الطائف 21944، المملكة العربية السعودية.

الملخص

ينتمي جنس ويثانيا إلى الفصيلة الباذنجانية ويحتوي على حوالي ستة وعشرين نوعاً تتواجد في أفريقيا ومناطق الهيمالايا وأستراليا وجزر الكناري ورأس الرجاء الصالح وأوروبا والعالم أجمع. وتتميز بمجموعة واسعة من التركيب الكيميائي النباتي، مع التركيز بشكل خاص على اللاكتونات الستيرويدية المعروفة باسم ويثانوليدات. اشواغاندا عبارة عن مادة تكيف قوية تعمل على تقوية دفاعات الجسم ضد الإجهاد. تمارس اشواغاندا آثارها على العديد من الأنظمة الفسيولوجية. أولاً، فهو يعزز عمل الجهاز العصبي، مما يؤدي إلى تحسين وظائف المخ والذاكرة، فضلاً عن تقليل عمليات التنكس العصبي. ثانياً، فهو يدعم الحفاظ على الكفاءة الجنسية والإنجابية المثلى للجهاز التناسلي. ثالثاً: يدعم المناعة الخلوية، وبالتالي يعزز قدرة الجسم على مقاومة الأمراض. أخيرًا وليس آخرًا، فهو يُظهر خصائص مضادة للميكروبات، ومضاد للسرطان، ومضاد لمرض السكر، وخافض شحميات الدم، ومضاد للالتهابات ومضاد لالتهاب المفاصل، ومنشط للكبد. من بين أمور أخرى، تمت دراسة ويثانيا سومنيفيرا (L.) دونال على نطاق واسع في مجالات علم الصيدلة والصناعة الزراعية لدى البشر وحيوانات التجارب. توفر هذه المراجعة نظرة شاملة حول التطبيقات التقليدية في الخصائص الطبية الشعبية والنباتية والمستقلبات النباتية والإمكانات الصيدلانية لـ Withania somnifera ضد الاضطرابات التنكسية العصبية، ومكافحة القلق، ومكافحة الإجهاد، ومضادات الأكسدة، ومضادات الالتهاب، ومضادات الميكروبات، والنشاط المضاد للفيروسات ضد كوفيد-19. يتم استكشافها في البشر والحيوانات، فضلا عن سلامتها وآثارها الضارة.

الكلمات الدالة: ويثانيا سومنيفيرا، السمات النباتية، المكونات النباتية، الأنشطة البيولوجية.