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Withania somnifera : A Remarkable Herb to Improve Animal Fertility

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ABSTRACT

Since ancient times, herbal remedies have been utilized to treat male infertility, and in recent years, their usage has been gradually increasing. Research on the effectiveness of herbal remedies appears to be a resurgence of conventional medical methods. For more than three centuries, ashwagandha has been utilized in Ayurvedic and traditional medical systems. A rising number of human experiments are assessing ashwagandha efficacy under various situations, as a result of its growing popularity and interest in numerous Western countries. The majority of the results from these investigations suggested that consuming ashwagandha has benefits, despite large variations in treatment dosage, duration, and types of extract used. Overall, the reduction of stress and anxiety symptoms is the best proof of ashwagandha therapeutic effectiveness. The systematic review's findings indicate that ashwagandha may have a wide range of medicinal uses. Ashwagandha is a widespread herb in Ayurveda that is said to enhance youth, longevity, and general well-being. Additionally, it is a potent aphrodisiac herb that supports and enhances healthy sexual function. This review will address the function of herbal remedies in male infertility and offer a thorough analysis of the numerous *Withania somnifera* related human and animal research that have been conducted explaining a potential direct oxidative mechanism that would reduce oxidative stress and an indirect mechanism that would enhance male fertility by modifying hormone balance through the interaction of many endocrine glands through the gamma-aminobutyric acid-like mimic pathway.
Keywords: Ashwagandha, Aphrodisiac, Fertility, *Withania somnifera*, Sperm.

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INTRODUCTION

Withania somnifera, typically known as Ashwagandha in Sanskrit, Indian ginseng, or "Punir" or "Asgandh" in Hindi and "Asgand" in Urdu. *Withania somnifera* is a member of the Solanaceae family. For almost three millennia, Ayurvedic and traditional medicine have utilized *Withania somnifera* (L.) Dunal, better known by its popular name, ashwagandha, as a significant medicinal herb. Charaka Samhita, Susruta Samhita, and other ancient literature refer to ashwagandha by several names, including brusya (which improves sexual performance), vajikari

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(which is spermatogenic), kamarupini (which promotes sexual desire), and pustida (which nourishes). The term "Asvabati" refers to ashwagandha in the Rigveda and Atharvaveda. According to the Charaka Samhita, Susruta Samhita, and Astanga Hridaya of Ayurveda, ashwagandha is an essential plant. Due to its remarkable anti-stress properties, the species name "somnifera" has been assigned; "Ashwagandha" (from the words "ashwa" meaning horse and "gandha" meaning smell) has been given since the roots have a distinct "wet horse" smell.

The need for plants with medicinal properties has been growing daily due to its therapeutic significance for the treatment of numerous veterinary and medical challenges, and potential herbal sources are also exploited to create income globally (Munir *et al.,* 2022). This plant has more than 80 common phytochemicals, such as volatile oil, steroidal, alkaloids, saponins, and glycosides. Sitoindosides and withaferin A had the most significant role in the curative benefits of *W. somnifera* of these chemical components (Saleem *et al.,* 2020). The root of Ashwagandha contains properties of antioxidants which help in treating the immune system, treat fertility and also cardiovascular diseases. As (*Withania somnifera)* possesses anti-inflammatory properties, this improves the quality of human sperm and dried roots of this plant are used to treat sexual and nervous issues as well (Patil *et al.,* 2010). These substances, which are mostly found in the leaves and roots, have cholesterol-lowering, antibacterial, anti-inflammatory, anti-cytotoxic, and anti-tumor properties. The antioxidant and antibacterial qualities of the fruits, roots, and leaves of *W. Somnifera* were investigated (Alam *et al.,* 2012).

Plant extracts have recently emerged as a cheap and natural source of additives to preserve and enhance sperm function during semen storage. For both men and women, maintaining good sexual health is essential for overall personal wellness. According to the World Health Organization (WHO), sexual health is more than just the absence of illness, malfunction, or infirmity; it encompasses a condition of physical, emotional, mental, and social well-being about sexuality. Due to its many health advantages, ashwagandha is a significant medicinal herb that has long been utilized in Ayurvedic medicine. As a potent adaptogen, Ashwagandha boosts the body's ability to cope with stress, enhancing resilience. It enhances the body's immune response at the cellular level, bolstering defense against illnesses. Ashwagandha's noted antioxidant qualities safeguard against cellular harm induced by free radicals (Singh *et al.,* 2011). A versatile medicinal plant belonging to the Solanaceae family, *Withania somnifera* grows widely in subtropical climates around the globe. Several plant components, including those that may help with male infertility, OCD, anxiety, anti-inflammatory, hypolipidemic, and antidiabetic effects, have also been studied for their application in clinical studies.

GEOGRAPHICAL LOCATION, AVAILABILITY AND PRODUCTION OF *WITHANIA SOMNIFERA* IN INDIA

Withania somnifera is widely dispersed throughout the drier sections of tropical and subtropical climates, such as the Canary Islands, the Mediterranean region, Southwest Asia, and North Africa (Mirjalili *et al.,* 2009). It grows in dry arid regions of Pakistan, India, China and Bangladesh. It grows to a height of 1700 meters in the Himalayan area also (primarily Himachal Pradesh, Uttarakhand, and Jammu & Kashmir) (Aslam *et al.,* 2017). In India, it grows in Uttar Pradesh, Maharashtra, Madhya Pradesh, Haryana, Rajasthan and few regions of Himanchal Pradesh. India being the largest producer and consumer of ashwagandha, and it's deeply rooted in Ayurvedic fertility treatments for both men and women (Ambiye *et al.,* 2013). It grows and cultivates in a variety of vegetation types, from warm, dry regions to those that are typically very humid and have a lot of rainfall, such as coastal vegetation, savanna, grassland, scrubland, karoo, and woodland (Plotnik, 2022).

MEDICINAL POTENTIAL OF *WITHANIA SOMNIFERA*: PHYTOCHEMICALS AND THERAPEUTIC APPLICATIONS IN FERTILITY

Withania somnifera is a promising therapeutic agent that can be used to treat fertility, cancer, microbial infections, immunomodulation, and neurological diseases due to its extensive pharmacological characteristics. Withania somniferous biochemical components, such as withanolide A, D, and A, withaferin A, and withaniamides, are crucial to its pharmacological characteristics. When compared to allopathic medications, herbal medications have a relatively low rate of adverse effects. Favorable effects of some medicinal herbs on particular spermatozoa characteristics are caused by their strong antioxidant capability. Furthermore, the value of *W. somnifera* in treating infertility issues has been increased by the presence of phytochemical components and a sufficient number of antioxidant minerals. This natural herb might be helpful in storing/restoring

the sperm functions for intrauterine insemination and *in vitro* fertilization. It has been observed that *W. somnifera* is an intriguing option for retaining spermatozoa parameters by supplying different quantities of the extract (Mahdi *et al.,* 2011).

Phytochemicals like withanolides and flavonoids neutralize reactive oxygen species (ROS) in seminal plasma and reduces oxidative stress, which is a key contributor to sperm DNA damage, poor motility, and abnormal morphology (Mahdi *et al.,* 2011). Sitoindosides and withanolides regulate cortisol levels and reduce chronic stress. It reduces stress-induced suppression of testosterone and gonadotropins (LH, FSH), which are essential for spermatogenesis. (Mahdi *et al.,* 2011). Withanolides (primarily Withaferin A and Withanolide D) stimulate the hypothalamic–pituitary–gonadal (HPG) axis leading to increased secretion of Luteinizing Hormone (LH) and Follicle Stimulating Hormone (FSH) from the anterior pituitary. These hormones act on the testes to enhance Leydig cell activity and Sertoli cell function. It enhances sperm production (spermatogenesis) and improves sperm concentration and motility. (Ambiye *et al.,* 2013).

Supplements containing *W. somnifera* root are utilized in diets, and elderly and pregnant individuals benefit from its nutrient-rich root preparation. Combining a wide range of phytochemicals, such as flavonoids and phenolic compounds, its extract has a complicated combination. Withanolides, however, are thought to be responsible for the pharmacological action of *W. somnifera* roots (Udayakumar *et al.,* 2010). Numerous Ayurvedic medications are made from its root. Though phenolics and flavonoids have also been found in the root of this plant, withanolides and steroidal lactones are the active chemical markers found in the root (Saleem *et al.,* 2020). The infusion or decoction preparation method is used to extract water from most herbal remedies (Dhanani *et al.,* 2017). One significant source of bioactive compounds for therapeutic research is plants. Isolated bioactive molecules are used as a model to produce physiologically active chemicals and as building blocks for medication development in the laboratory.

Owing to the elevated antioxidant potential and several physiologically active components found in certain herbs, the impact of their hydroethanolic extracts on spermatozoa parameters was assessed *in vitro*. The strong antioxidant capacity of many medicinal plants may account for their advantageous effects on certain spermatozoa characteristics. Furthermore, the relevance of *W. somnifera* in treating infertility issues has been emphasized by the presence of phytochemical ingredients.

ROLE OF DIFFERENT PARTS OF *WITHANIA SOMNIFERA* IN SPERM QUALITY

Various plant components from the Solanaceae family, including *Withania somnifera* and Withania coagulants, were used in biochemical investigations. Plants in this family are frequently utilized as traditional herbal remedies and have a variety of secondary metabolites (Azhar *et al.,* 2020). *W. somnifera* roots, stem, and roots as shown in Fig. 1 are all significant from a therapeutic perspective. Ethanolic extracts of *W. somnifera* fruit and stem were shown to induce infertility in male rats by reducing sperm motility and count, as well as causing degeneration of the seminiferous tubules, although they did not affect sperm morphology (Mali *et al.,* 2008). In contrast, other studies demonstrated that extracts from *W. somnifera* roots, fruits, leaves, and stems, particularly the roots, improved sperm quality indicators such as motility and count in men. These studies utilized various parts of the plant: roots (29 studies), leaves (7 studies), fruits (2 studies), unknown extracts (2 studies), and stems (1 study). Different parts of the plant are known to treat impotence and enhance sexual appeal and fertility as shown in Table 1.

Table 1 : Effects by plant part on fertility parameters across studies

Plant Part	Species	Dosage	Duration	Effects Observed	References
Root	Animal (Wistar rats)	3000 mg/kg/day	7 days	Impaired libido and erectile function; effects partly reversible post-treatment; not related to testosterone levels or toxicity.	(Bhattarai *et al.,* 2010)
Root	Human (infertile men)	5 g/day	3 months	Increased sperm concentration, motility, and testosterone levels; improved fertility parameters.	(Ahmad *et al.,* 2010)
Root	Animal (Wister Rats)	1000 mg/kg	70 days	Semen characteristics and histopathological analysis showed no significant changes	(Prabu *et al.,* 2014)

Stem	Animal (Rats)	Ethanolic extract	30 days	Induced infertility by reducing sperm motility and count; seminiferous tubule degeneration observed.	(Mali *et al.*, 2008)

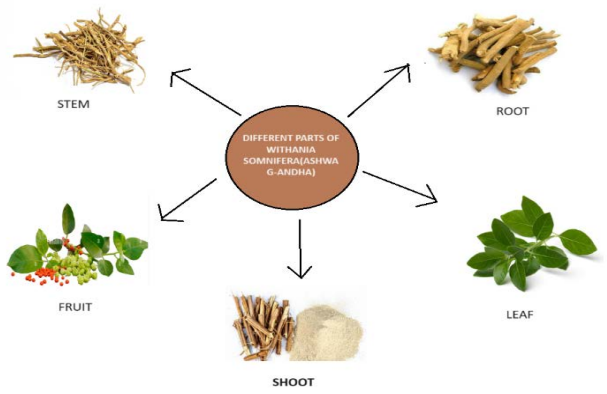
The colorimetric approach was utilized to determine the amount of flavonoids. The amount of flavonoids in the leaves, stem, and root were computed (43.51 mgRE/g in *W. somnifera* leaves). From leaves to roots, W. coagulans' flavonoid concentrations have been declining. Similarly, *W. somnifera* has lower flavonoid content in its roots and higher flavonoid content in its leaves. Secondary metabolites, including withanolides, from various plant parts and their molecular weights are listed in Table 2.

According to an overview of the literature, following different parts of the plant contain an array of chemical constituents which show its effect in sperm fertility.

Table 2: Secondary metabolites, including withanolides, from various plant parts with their molecular weights and techniques techniques

Class of metabolite	Part of plant	Technique	Molecular weight	Reference
27-Hydroxywithanolide A	Leaf	ESI-MS	488	(Trivedi *et al.*, 2017)
3β-(Adenin-9-yl)-2,3-dihydrowithaferin A	Leaf and twig	NMR	606.3	(Xu *et al.*, 2011)
Aswagandhanolide	Root	GC-MS	975.3	(Subbaraju *et al.*, 2006)
Cholesterol	Leaf	ESI-MS	386.7	(Takshak and Agrawal 2015)
Withaferin A	Root	ESI-MS	470.6	(Trivedi et *al.*, 2017)
Withanoside I	Fruit	HRMS	637.4	(Bolleddula *et al.*, 2012)
Withanoside II	Root	NMR	799	(Zhao *et al.*, 2002)
Catechin	Fruit and Root	HR-MS	290.3	(Zhao *et al.*, 2002)
Palmitic acid	Leaf and Root	GC-MS	256.4	(Takshak and Agrawal 2015)
β-Carotene	Leaf	GC-MS	536.9	(Takshak and Agrawal 2015)
Withanine	Root	NMR	486	(Kalra and Kaushik 2017)
Withasomnine	Root	NMR	184.2	(Rajalakshmy and Geetha 2016)

Fig. 1: Various parts of *Withania somnifera*



Root

The tuberous roots, sometimes referred to as "Asgand," are very beneficial for medical uses. Generally unbranched fleshy roots include fiber-like secondary growth (Mirjalili *et al.*, 2009), (Uddin *et al.* 2012). They have a pungent smell and a harsh flavor. There have been reports that in a 2013 study conducted in India, it was found that administering ashwagandha root extract at a dose of 675 mg three times a day for 11 days in infertile men with oligospermia led to a 53% increase in mean semen volume, a 167% rise in sperm count, and a 57% improvement in sperm motility (Ambiye *et al.*, 2013). Another study in India investigated the effects of consuming ashwagandha root in men, where a daily intake of 5 g of ashwagandha root powder for three months resulted in a 17% increase in sperm concentration and a 9% improvement in sperm motility in men with normal sperm under various environmental stresses. Furthermore, this plant was shown to enhance sperm concentration by 36% and sperm motility by 13% in infertile men without stress (Mahdi *et al.*, 2011).

Only roots have been shown to contain more than 35 chemical components (Singh *et al.*, 2010). Numerous bioactive substances, including glycoproteins, alkaloids, steroids, flavonoids, and phenolics, have been detected in it. Ashwagandhanolide is a novel dimeric thio withanolide (withanolide containing sulfur molecule) that was identified by Mirriljila (Mirjalili *et al.*, 2009) from the roots of

W. somnifera. Many alkaloids are thought to be responsible for the pharmacological action of roots (Jain *et al.,* 2012).

Fruit

In one of the studies, a 50% ethanolic extract of *Withania somnifera* fruit was prepared and administered orally to male albino rats at a dosage of 50 mg/kg body weight per day for 60 days. The treatment led to a significant decrease in sperm motility and density in both the testicular and cauda epididymal sperm. Additionally, a notable reduction was observed in the levels of ascorbic acid, sialic acid, cholesterol, protein, fructose, and acid phosphatase content in the treated rats (Mali *et al.,* 2008). Fruits of *Withania somnifera* are persistent calyx-encapsulated, globose berries and are 6 mm long and orange-red in color when fully grown. According to reports, W. somnifera›s main components—the roots, fruits, and leaves—all have a high polyphenol content and antioxidant properties that may be advantageous to human health (Alam *et al.,* 2011). In order to verify the ethno medical uses of this medicinal plant and to determine which plant part has the highest antioxidant activities, scientists reported the anthocyanin and ascorbic acid contents as well as the antioxidant and antimicrobial properties of W. somnifera in the roots, fruits, and leaves of the plant (Alam *et al.,* 2012).

Leaf

The leaves of this plant are said to have 12 withanolides, 5 unidentified alkaloids (yield, 0.09%), several free amino acids, glucose, glycosides, chlorogenic acid, condensed tannins, and flavonoids in its leaves (Khare, 2008). The most significant withanolide found in the extract of *Withania somnifera* ‘s dried roots and leaves is withaferin A, a steroidal lactone. It was found that feeding of ashwagandha leaf extracts showed the most consistent increases in testosterone levels in men (Smith *el al.,* 20

MECHANISM OF ACTION

The phytochemicals, or secondary metabolites, produced by the *Withania somnifera* plant regulate several physiological pathways as bioactive components to cure animals/primates body problems without causing any negative side effects. It is used to build Ayurveda and phytomedicines, which eventually become a worldwide health care system. The resurgence of Ayurveda and the most current research on effect of ashwagandha (Indian ginseng) on male infertility are the main topics of this review.

There are primarily two types of processes that *Withania somnifera* utilizes to impact fertility and the reproductive system: oxidative and non-oxidative mechanisms. The oxidative mechanism includes the control of antioxidant enzymes and the co-factors necessary for the appropriate activity of antioxidant enzymes, as well as the regulation of antioxidant activity. *Withania somnifera* ‘s effects on the hypothalamic-pituitary-gonadal (HPG) axis and its anti-stress effects via the hypothalamic-pituitary-adrenal (HPA) axis are the principal non-oxidative mechanisms. To increase male fertility, these biochemical components either directly affect testicular or other male reproductive cells or indirectly affect endocrine regulation. Moreover, *Withania somnifera* has other pharmacological properties. It has been demonstrated in several studies to have antioxidant action and to prevent lipid peroxidation in spermatozoa (Shukla *et al.,* 2011). Lipid peroxidation is thought to be a primary cause of idiopathic male infertility. Further confirming the adaptogenic properties of *Withania somnifera*, it has also been linked to the restoration of sex hormone levels in infertile male who are experiencing physiological, psychological, or both types of stress (Mahdi *et al.,* 2011). By tackling numerous concerns at once, *Withania somnifera* is able to overcome a variety of potential reasons of male factor infertility. The proposed mechanism of action of *Withania somnifera is* based on these observations.

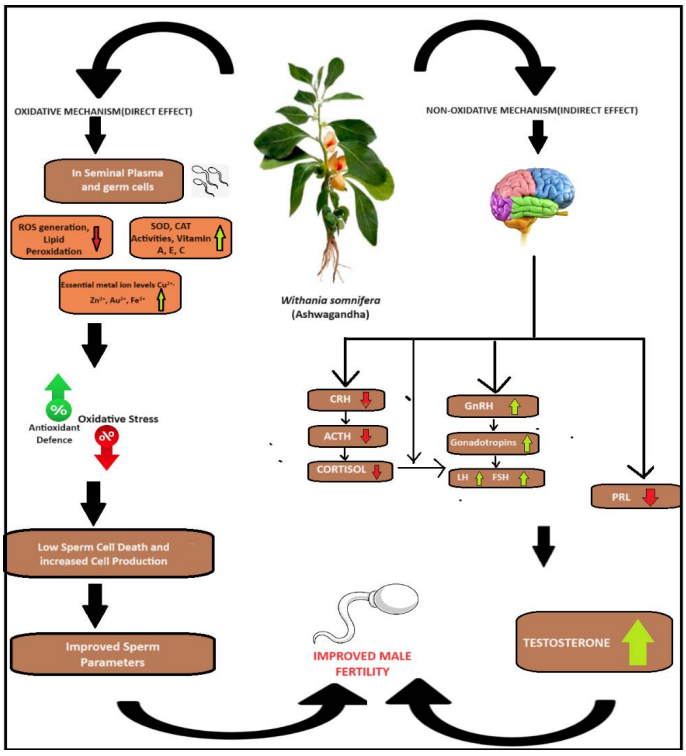


Fig. 2: Mechanism of action of *Withania somnifera on* sperm quality and the reproductive hormonal profile.

EFFECTS ON FERTILITY

In Animals

A short-term supplementation with *Withania somnifera* led to improved seminal volume and testicular function; additionally, increased odor intensity and appetitive or consummatory sexual behavior were correlated with improvements in certain hemogram response variables in Black Belly rams over time (Rodriguez-Sánchez et *al.,* 2024). Even in the wake of stress, *Withania somnifera* activates the HPG-axis, leading to a rise in endogenous estradiol, which in turn triggers the production of ERα in the testis; this boosts immunity and sperm count, ultimately enhancing reproductive function. Given that *Withania somnifera* reduces oxidative stress-mediated inflammatory response through enhanced testicular expression of ERα in quail, it may be the best treatment against reproductive damage caused by stress from caloric restriction (Baghel et *al.,* 2024). Sub fertile buffalo bulls administered with 400 mg/100 kg of body weight of *Withania somnifera* roots orally for 60 days increased the fertility and quality of their post-thaw semen (Kumar et *al.,* 2022).

Small animals:

Administration of a 50% ethanolic extract of Ashwagandha fruits (50 mg/kg/day for 60 days) resulted in decreased sperm motility, reduced density of testicular and cauda epididymal sperm, and decreased weight of testes and seminal vesicles. Additionally, levels of ascorbic acid, sialic acid, cholesterol, protein, fructose, and acid phosphatases were lowered, while degenerative changes in the seminiferous tubules and germinal epithelium were observed (Mali *et al.,* 2008). Treatment with a glycowithanolides extract of fresh leaves (20 mg/kg subcutaneously for 20 days) led to increased epididymal sperm count, enhanced weight of testes and epididymis, and improved histology of testes in protective and curative groups compared to the D-galactose treated group (Shaikh *et al.,* 2015*)*. An alcoholic root extract (50 mg/kg/day) was administered to female Swiss albino mice for eight weeks after they developed ovarian toxicity from chlorpyrifos. The treatment resulted in decreased estrogen and cholesterol levels, with recovery observed in germinal epithelium, Graafian follicles, and corpus luteum of the ovary (Kumar *et al.,* 2015).

Large animals:

The study investigated the potential of Ashwagandha extract, recognized for its antioxidant properties, to improve sperm quality in boar semen when stored at 17°C (Gamage *et al.,* 2024). Ashwagandha extract at concentrations ranging from 1 to 20 mg/mL in liquid boar semen preserved the quality of the semen throughout storage, leading to increased boar spermatozoa motility, viability, acrosome integrity, and chromatin stability compared to the control group that was not exposed to ashwagandha extract. Immature female Wistar rats were administered a lyophilized aqueous extract of Ashwagandha (47 mg/100 g body weight/day for 6 days). In 25-day-old rats, treatment led to increased FSH levels, ovarian weight, deep folliculogenesis, and proliferation of granulosa cells. However, in 17-day-old rats, no significant changes were observed in ovarian weight, folliculogenesis, or FSH and LH levels (Al-Qarawi *et al.*, 2000). Dose of 15mg/kg body weight of Ashwagandha root extract (KSM-66 Ashwagandha®) was linked to notable changes in the urinary cortisol-to-creatinine ratio (UCCr) in dogs exhibiting stress and anxiety, compared to a placebo (Kaur *et al.,* 2022). Additionally, Ashwagandha root extract led to significant improvements in various rating scales, including those related to fear, anxiety, aggression, and pain interference over time. One of the hypothesis suggests that supplementing with *Withania somnifera* enhances testicular size and function, sperm quality and quantity, odor intensity, as well as both appetitive and consummatory socio-sexual behaviors in Black Belly rams (Rodriguez-Sánchez *et al.,* 2024).

In Humans

Enzymatic antioxidant activity was measured through the evaluation of lipid peroxidation and protein carbonyl groups in seminal plasma in various studies examining the impact of *Withania somnifera* on semen quality in infertile males (Shukla *et al.,* 2011). This method indirectly illustrates the enzymatic activity of superoxide dismutase and catalase. A number of studies examined the concentration of metal ions, including arsenic (Kumar *et al.,* 2015), copper, zinc, iron, and gold in seminal plasma, and the way they were affected by *Withania somnifera* therapy, in addition to the decrease in lipid peroxidation observed in infertile males treated with the herb. superoxide dismutase requires zinc and copper as co-factors, while glutathione peroxidase and catalase require iron and selenium, respectively (Shukla *et al.,* 2011). According to reports, *Withania somnifera* raises the concentrations of vital metals (copper, zinc, iron, and gold), which may improve the process of testicular steroidogenesis and raise the amount of testosterone synthesized to promote the growth of testicular germ cells through spermatogenesis (Shukla *et al.,* 2011). Along with improving lactate, histidine,

citrate, alanine, and phenylalanine concentrations in seminal plasma, *Withania somnifera* may also have important effects on spermatogenesis and spermatozoa physiology. Withaferin A raises B-cell lymphoma 2 and inhibits Bcl-2 associated X-protein proapoptotic proteins, as well as TNF receptor superfamily member 6, Bim, caspase-3, and -9. It also showed significant hypolipidemic and anti-inflammatory properties against HCD-induced atherosclerosis in rats by regulating inflammatory mediators and apoptosis via the PI3K/AKT signaling pathway (Zhang *et al.,* 2022). Additionally, it raises sperm concentration, sperm motility, and semen volume. It combats stress and infertility overall. In addition to exhibiting the aphrodisiac properties being known as sukrala, it enhances semen quality.

ECONOMIC IMPORTANCES

The herbal, pharmaceutical, cosmeceutical, and nutraceutical sectors are witnessing a daily rise in demand for ashwagandha. Therefore, it is essential to produce high-quality raw materials by utilizing enhanced high-yielding cultivars and implementing enhanced agriculture and processing technologies. There is an approximate 7000 ton/tonne yearly demand for ashwagandha, but only 1500 ton/tonne is thought to be produced in India (Khan *et al.,* 2023). With a net return of Rs 75,000/ha, ashwagandha crops generate 8–10 q/ha of dried roots from 6–8-month-old plants on average (Kumar *et al.,* 2023). On the other hand, supply and demand determine the market rates. By choosing an enhanced variety with a higher yield based on the agro climatic parameters of a certain place, the net profit may be further boosted. According to Data Bridge Market Research, the worldwide ashwagandha market is predicted to develop at a compound annual growth rate (CAGR) of 11.4% between 2022 and 2029, with a projected value of USD 102.72 million by 2030 driven by rising cases of male infertility due to lifestyle and stress and increasing consumer preference for natural fertility products (Khabiya *et al.,* 2024). Using enhanced, high-yielding cultivars also increase the farmers' revenue. The new populations of ashwagandha do not contain the paralyzing tongue chemicals. As a result, they are chosen in formulations over the plant's natural population (Kaul 1957).

Ashwagandha has seen a significant surge in global demand, especially in the nutraceutical and fertility supplement market. Its proven benefits in male reproductive health such as improving sperm count, motility, and testosterone levels have made it a key botanical ingredient in male fertility supplements, testosterone boosters, stress-relief and libido enhancers and ayurvedic fertility tonics. Ashwagandha's clinically proven effects on male fertility have directly contributed to its economic importance, fueling a fast-growing market for herbal fertility supplements. As demand for natural fertility treatments rises, so does the commercial value of this ancient medicinal plant. Ashwagandha production and distribution in India involves a range of manufacturers and health product companies, including those specializing in standardized herbal extracts as well as large-scale consumer wellness and pharmaceutical firms.

Consequently, producers of ashwagandha want to enhance their output of ashwagandha powder. The combined market share of the powder and capsules/tablets was approximately 75.8%, with the former accounting for approximately 45.6% of the share. By 2031, it is projected that the combined share of powder and other sectors will have increased to 58.0% from 54.4% in 2021. *W. somnifera* and *W. coagulans* are the most studied and acknowledged out of the 23 species as being economically significant in a number of regions due to their medical use. CSIR-CIMAP, Lucknow releases high-yielding cultivars, including NMITLI-118, NMITLI-108, CIM-Pushti, CIMAP-Pratap, and Rakshita (Venugopal *et al.,* 2022; Lal *et al.,* 2014; Lal *et al.,* 2023). The domestic market has witnessed a rise in demand for *Withania somnifera* (L.) Dunal roots throughout the past ten years. The demand for *Withania somnifera* (L.) Dunal alkaloids has also recently increased in the US and international nutraceutical sectors (Ilayperuma *et al.,* 2002). The average cost of growing *Withania somnifera* (L.) Duna is Rs 28,747/ha. Harvesting fees were the largest variable cost (34.26%), followed by intercultural operations (21.19%), processing and packing (10.16%), land preparation (13.09%), and miscellaneous fees (21.03%) (Kumar *et al.,* 2023).

ADVANTAGES OF *WITHANIA SOMNIFERA* IN REPRODUCTION

a) This plant is recommended for usage as an adaptogen and energy booster because to its proven antioxidant and free radical scavenging properties (Singh *et al.,* 2011).

b) Besides its role as an aphrodisiac, the plant's root extract is reportedly used to treat erectile dysfunction, performance anxiety, and sexual weakness in males (Dongre *et al.,* 2015).

c) Ashwagandha has been proven to have aphrodisiac and testosterone-boosting effects in both human and animal studies (Khabiya *et al.,* 2024). Because of

some active chemicals in the plant extract, such as serotonin agonists and other neurotransmitters, the plant's anti-stress impact can be used to manage psychogenic erectile dysfunction (Mahdi *et al.,* 2011). Additionally, ashwagandha stimulates spermatogenesis and testicular growth, which is helpful in treating male infertility (Rahmati *et al.,* 2016).

d) The plant extract, particularly the root extract, increases the quantity and quality of sperm in males, reduces the negative effects of chemical toxins on the gonads of women and men, and balances the levels of LH, FSH, and testosterone (Rahmati *et al.,* 2016), (Saleem *et al.,* 2020).

LIMITATIONS OF *WITHANIA SOMNIFERA* IN REPRODUCTION

a) *W. somnifera* has been used to treat sexual incompetence, although a report has advised its negative effects due to sedative effects, hyperprolactinemic, GABAergic, or serotonergic activity. The results of this investigation showed that *W. somnifera* significantly reduced desire, sexual energy, penile erection, and sexual performance; these effects were only partially reversed upon treatment cessation (Ilayperuma *et al.,* 2002).

b) The extract's hyperprolactinemic, GABAergic, serotonergic, or sedative properties may be the cause of these anti masculine effects rather than variations in testosterone levels or toxicity (Ilayperuma *et al.,* 2002).

c) Typically, *W. somnifera* roots are processed for therapeutic effects. Because of component breakdown, the plant only regains its pharmacologic effectiveness for a short period of time i.e. less than two years. This disadvantage leads to the annual harvesting of fresh roots in January and March, which are then shade-dried for a higher yield and improved therapeutic results (Uddin *et al.,* 2012).

d) Though *Withania somnifera* is a versatile herb, it does have several drawbacks that can be resolved with more clinical research. Understanding the adverse effects and actions of biochemical molecules is essential for their therapeutic application.

e) Ashwagandha may interact with thyroid medications, sedatives or anti-anxiety drugs and hormonal therapies. These interactions could impact reproductive hormone levels or fertility treatments (Raut *et al.*, 2012).

CONCLUSION

The medicinal plant ashwagandha has been associated with human history for 6000 years. For millions of people, it has been demonstrated to be a safe alternative to traditional medical practices. Its commercial potential in the supplement, extract, capsule, and powder industries is enormous and has been expanding ever since. Nonetheless, the scientific community has to take a more proactive approach for creating research, conservation, and cultivation programs.

Natural herb may assist preserve or restore sperm functioning. There is currently insufficient information available on a number of elements of this plant, including its mechanisms of action, pharmacokinetics, possible interactions with standard-of-care drugs, side effects of the extracts, and active chemicals. Such discrepancies in knowledge necessitate further research. For in vitro fertilization and intrauterine insemination, this natural herb may assist preserve or restore sperm functioning. The study concludes that there is evidence to support the aphrodisiac effect of ashwagandha extract on male adult sexual well-being. It's possible that ashwagandha promotes better male sexual health by raising serum testosterone levels. Thus, it is possible to improve male sexual performance by using ashwagandha root extract.

CONFLICT OF INTEREST

Authors declare no conflict of interest.

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