



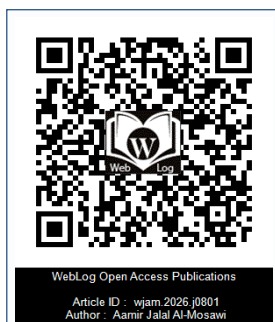
Shilajit in Andrology: Experimental Evidence, Clinical Studies, and Therapeutic Potential for Male Reproductive Health

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Abstract

Background: Shilajit is a naturally occurring, mineral-rich organic exudate. Increasing scientific interest has focused on its potential role in male reproductive health, testosterone regulation, and fertility. A recent 2024 systematic review of 52 human studies evaluating 27 testosterone-boosting supplements identified Shilajit as one of the few supplements with possible efficacy in aging-related late-onset hypogonadism.

Objective: To summarize the experimental and clinical evidence regarding the pharmacological properties and andrological applications of Shilajit.

Methods: A review of published experimental and clinical studies from 1965 to 2024 was performed. Evidence included animal experiments, mechanistic studies, toxicology investigations, and human clinical trials evaluating the effects of Shilajit on reproductive function, endocrine parameters, oxidative stress, and related biological mechanisms.

Results: Early investigations established the scientific basis for Shilajit research. Gupta et al., (1965) first suggested anabolic activity through improved growth and food utilization in rats. Ghosal et al., (1976) demonstrated that Shilajit is a chemically complex natural substance containing numerous bioactive organic constituents. Experimental studies subsequently documented adaptogenic, anti-inflammatory, anti-ulcer, antioxidant, neuropharmacological, and mitochondrial protective properties.

Reproductive studies consistently demonstrated beneficial effects on male fertility. In experimental animals, Shilajit increased spermatogenesis, sperm production, seminiferous tubular development, steroidogenic enzyme activity, testosterone synthesis, and fertility while protecting against toxin-induced reproductive damage through antioxidant, anti-apoptotic, and Nrf2-mediated mechanisms.

Human studies reported significant improvements in oligospermic men after three months of supplementation, including increases in sperm concentration (+61.4%), sperm count, motility, serum testosterone (+23.5%), and follicle-stimulating hormone, together with reduced seminal oxidative stress. A randomized placebo-controlled study in healthy men aged 45-55 years demonstrated significant increases in total testosterone, free testosterone, and dehydroepiandrosterone following three months of supplementation. Long-term animal toxicology studies demonstrated a favorable safety profile at doses up to 2,500 mg/kg/day.

Conclusions: Current evidence suggests that Shilajit possesses multiple pharmacological properties relevant to andrology, including androgenic, spermatogenic, antioxidant, adaptogenic, and mitochondrial protective effects. Clinical studies indicate potential benefits in improving testosterone concentrations and semen quality, particularly in men with oligospermia and age-related testosterone decline.

Keywords: Shilajit; Andrology; Testosterone; Male Infertility; Oligospermia; Spermatogenesis; Hypogonadism; Antioxidants; Male Reproductive Health

In 2024, Afonso Morgado from Portugal, Georgios Tsampoukas from the United Kingdom, Ioannis Sokolakis from Greece, Nadja Schoentgen from France, Ahmet Urkmez from the United

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Received Date: 07 Sep 2026

Accepted Date: 06 Oct 2026

Published Date: 08 Oct 2026

Citation:

Aamir Jalal Al-Mosawi. Shilajit in Andrology: Experimental Evidence, Clinical Studies, and Therapeutic Potential for Male Reproductive Health. WebLog J Ayurvedic Med. wjam.2026.j0801. <https://doi.org/10.5281/zenodo.23307961>

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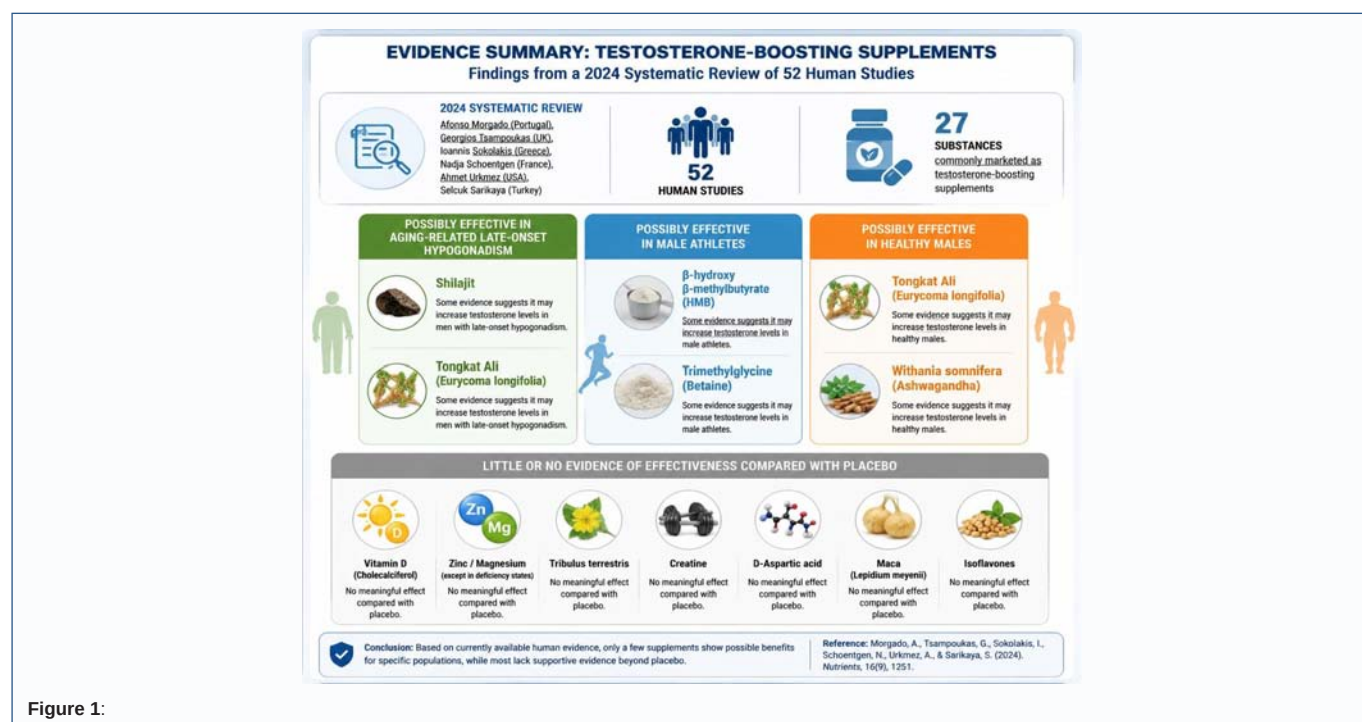


Figure 1:

States, and Selcuk Sarikaya from Turkey conducted a systematic review involving 52 human studies evaluating 27 substances commonly marketed as testosterone-boosting supplements (Figure 1).

The study found that testosterone-boosting supplements that are possibly effective in aging-related late-onset hypogonadism include Shilajit and Tongkat Ali (*Eurycoma longifolia*).

Testosterone-boosting supplements that are possibly effective in male athletes include β-Hydroxy β-Methylbutyrate (HMB) and trimethylglycine (Betaine).

Testosterone-boosting supplements that are possibly effective in healthy males are Tongkat Ali and *Withania somnifera* (Ashwagandha).

Testosterone-boosting supplements with little or no evidence of effectiveness when compared with placebo, include vitamin D (cholecalciferol), Zinc / magnesium (except in deficiency states), *Tribulus terrestris*, creatine, D-aspartic acid, Maca (*Lepidium meyenii*), and isoflavones [1].

Shilajit is a brownish, mineral-rich organic exudate that seeps from rock layers in mountainous regions, particularly the Himalayas.

Gupta *et al.*, (1965) reported one of the earliest experimental studies of shilajit. Over approximately one month, shilajit-treated young rats gained more body weight than controls despite consuming less food relative to body weight, suggesting improved food utilization. Because the increased weight gain was not caused by fluid retention, the authors proposed that shilajit might have an anabolic effect. However, the biological mechanism was unknown [2].

The landmark 1976 study by Ghosal and colleagues established that shilajit is a chemically complex natural substance containing multiple organic compounds rather than simply a mineral exudate. It provided an early chemical foundation for later research into shilajit's composition [3].

Acharya *et al.*, (1988) demonstrated that Shilajit exhibits multiple pharmacological activities in experimental models, including adaptogenic, anti-inflammatory, anti-ulcer, and other biological effects [4].

In 1990, Goel and colleagues from India reported a study which shilajit can increase the carbohydrate/protein ratio and decrease gastric ulcer index, suggesting an increased mucus barrier. Shilajit also had marked antiinflammatory effect in carrageenan-induced acute pedal edema, granuloma pouch and adjuvant-induced arthritis in rats [5].

In 1997, Reinhard Schliebs from Germany and his research team reported an experimental study in adult male Wistar rats which showed that intra-peritoneally injection of shilajit (40 mg/kg of body weight) for one week exhibited cholinergic neuro-pharmacological activity by reducing acetylcholinesterase activity in basal forebrain regions associated with learning and memory. Unlike broader neurotransmitter modulators, Shilajit did not significantly affect GABAergic or glutamatergic receptor systems, suggesting a selective mechanism of action. Its pharmacological effects appear to enhance cortical and basal forebrain cholinergic signaling, which is important for cognitive function [6].

The early scientific investigation of shilajit from 1965 to 1997 (Figure 2) progressively transformed it from a traditional natural remedy into a subject of modern biomedical research.

Gupta and colleagues (1965) provided the first experimental evidence suggesting that shilajit may enhance growth and improve food utilization in young rats, raising the possibility of anabolic activity.

The landmark chemical studies of Ghosal and coworkers (1976) demonstrated that shilajit is a chemically complex natural substance containing numerous organic constituents, thereby establishing a scientific basis for subsequent pharmacological investigations.

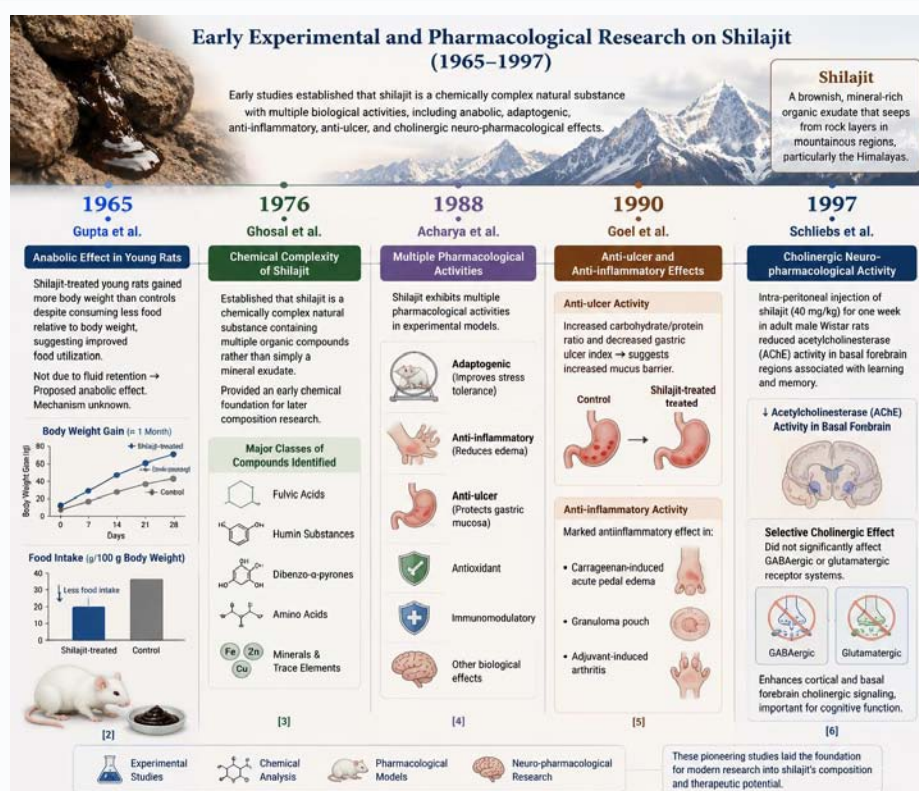


Figure 2: The early scientific investigation of shilajit from 1965 to 1997.

During the 1980s and early 1990s, studies by Acharya *et al.*, (1988) and Goel *et al.*, (1990) documented a broad spectrum of biological activities, including adaptogenic, anti-inflammatory, and anti-ulcer effects, supporting the traditional medicinal use of shilajit.

Subsequently, Schliebs and colleagues (1997) expanded the scope of shilajit research by demonstrating selective cholinergic neuropharmacological activity, suggesting potential cognitive and neuroprotective benefits.

Collectively, these pioneering studies established the fundamental chemical, pharmacological, and neurobiological foundations of shilajit research. They provided the scientific framework for contemporary investigations into its bioactive constituents, mechanisms of action, and potential therapeutic applications in metabolic, inflammatory, gastrointestinal, and neurological disorders.

In 2003, Praveen Sharma from India and his research team reported a study in healthy volunteers which showed that supplementation with Shilajit 2 grams daily for 45 days was associated with a marked decrease in serum triglycerides, serum cholesterol with improvement in HDL cholesterol. In addition, the use of shilajit was associated with improvement in the antioxidant status of volunteers. The use of shilajit was not associated with important changes in pulse rate, blood pressure, body, and hematological parameters.

The authors concluded that shilajit has a significant hypolipidemic and strong antioxidant effects [7].

In 2006, Jeong-Sook Park from South Korea and her research team reported an experimental study on rats which showed that the use of oral shilajit in 7-week-old male rats for six weeks markedly increased the number of sperms in the testes and epididymides.

Shilajit also increased the number of seminiferous tubular cell layers in the testes. Shilajit did not cause important change in weights of heart, spleen, liver, kidney, brain, testes and epididymides. In female rats, shilajit induced ovulation over five days in 7 out of 9 female rats. Ovulation was observed in only 3 out of the control nine rats. The authors concluded that shilajit has both a spermiogenic and ovogenic effect in mature rats [8].

In 2010, Biswas *et al.*, from India reported a study which included 28 oligospermic male patients who had total sperm counts less 20 million/ml. The patients were treated with Shilajit 100 mg capsule twice a day (After meals) for 3 months. Treatment was associated with marked improvement in spermia (+37.6%), total sperm count (+61.4%), and motility (12.4-17.4%). Treatment was also associated with reduced pus and epithelial cell count when compared with baseline value. Marked reduction of semen Malondialdehyde content (-18.7%) was also noted [9].

In addition, treatment was associated with marked increase in serum testosterone (+23.5%; $P < 0.001$) and follicle-stimulating hormone (+9.4%; $P < 0.05$) levels. Hepatic and renal function tests were not changes. Therefore, the authors considered Shilajit to be safe at the used dose.

During the same year, Kumar *et al.* reported a study evaluated the antioxidant effects of shilajit in broiler chickens exposed to lead-induced oxidative stress. Lead exposure significantly disrupted antioxidant defense enzymes and increased oxidative damage, indicating substantial oxidative stress. Shilajit administration, both during and after lead exposure, restored antioxidant enzyme activity and improved liver antioxidant status. Its protective effects were comparable to other antioxidant interventions, including a

polyherbal formulation, amla, and vitamin E plus selenium. These findings suggest that shilajit has antioxidant and cytoprotective pharmacological properties, with potential clinical relevance as an adjunct for managing conditions associated with oxidative stress, although confirmation in human studies is needed [10].

In 2012, Velmurugan *et al.*, reported an experimental study in albino rats evaluated the safety of shilajit. Rats received placebo or 500, 2500 and 5000 mg/kg of shilajit for 91 days. The study showed that shilajit up 2500 mg/kg was not associated toxic effects. The concluded that shilajit is safe for long term use as a dietary supplement [11].

During the same year, Dinesh Kumar Surapaneni from India and his research team reported an experimental study in rats demonstrated that shilajit has significant anti-fatigue activity, reducing immobility, improving climbing behavior, and alleviating anxiety-like symptoms.

The pharmacological effects were associated with modulation of the Hypothalamic-Pituitary-Adrenal (HPA) axis, as evidenced by restoration of plasma corticosterone levels and adrenal gland weight.

Shilajit preserved mitochondrial bioenergetics by maintaining the activities of mitochondrial respiratory chain complexes and stabilizing mitochondrial membrane potential.

It also exhibited potent antioxidant effects by reducing oxidative stress markers and restoring endogenous antioxidant enzyme activities.

These findings suggest that shilajit's therapeutic actions involve both mitochondrial protection and regulation of the physiological stress response.

The study identified mitochondrial function as a key pharmacological target underlying shilajit's adaptogenic and anti-fatigue properties [12].

In 2016, Pandit *et al.*, from India reported a placebo-controlled study which included healthy male volunteers aged between 45 to 55 years who received Shilajit (250 mg) twice a daily for three months. Treatment with marked increase in total testosterone, free testosterone and dehydroepiandrosterone. Gonadotropic hormones (LH and FSH) levels were well maintained [13].

In 2018, Raghav Kumar Mishra from India and his colleagues evaluated the effects of Shilajit on cadmium-induced male infertility in adult Swiss male mice over one complete spermatogenic cycle (35 days). Oral Shilajit administration (50, 100, and 200 mg/kg/day) significantly improved the weights of male reproductive organs. Treatment enhanced daily sperm production, sperm concentration, and sperm motility compared with cadmium-treated controls. Shilajit increased testicular steroidogenic enzyme activities ($\Delta 5$ 3β -HSD and 17β -HSD) and elevated serum testosterone levels.

Histopathological findings demonstrated restoration of spermatogenesis, with dose-dependent recovery of germ cell layers in the testes. Secretory functions of the epididymis and seminal vesicles were also improved following Shilajit treatment.

Functional reproductive outcomes, including libido, fertility, and litter size, showed marked improvement despite cadmium exposure.

These findings suggest that Shilajit has androgenic and fertility-enhancing potential in a toxin-induced infertility model [14].

In 2024, Arti Rajpoot from India and her research team evaluated

the protective effects of Shilajit against cyclophosphamide-induced testicular toxicity in male mice.

Cyclophosphamide impaired spermatogenesis, disrupted testicular architecture, and reduced Sertoli cell function and steroidogenesis.

Shilajit supplementation restored normal germ cell development by promoting the differentiation of spermatogonia into spermatids.

It enhanced sperm production and quality while increasing germ cell proliferation and supporting Sertoli cell integrity.

Shilajit also improved testosterone biosynthesis by increasing the activity of key steroidogenic enzymes (3β -HSD and 17β -HSD).

Its antioxidant effects included increased SOD activity, reduced lipid peroxidation, and activation of the Nrf2/Keap1 pathway.

The treatment also reduced apoptosis by maintaining a favorable Bax/Bcl-2 balance, contributing to improved testicular function.

These findings suggest that Shilajit may have therapeutic potential in andrology for protecting male fertility during chemotherapy [15].

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