Research Article

# Effects of Shilajit Supplementation on Male Reproductive Parameters in Experimental Animal Models: A Systematic Review and Meta-Analysis

Srilakshmi Srinivasan[1], Sakthi Priyadarsini Sethuraman[1]*, Kamaraj R[1]

[1]Department of Pharmacognosy, SRM College of Pharmacy, Faculty of Medicine and Health Science, SRM Institute of Science and Technology, Kattankulathur, Chengalpattu District, Tamil Nadu, India – 603203

*Corresponding author: Sakthi Priyadarsini Sethuraman, Email: sakthips1@srmist.edu.in

**Abstract**

**Purpose**: To systematically review and meta-analyse preclinical animal studies evaluating the effects of Shilajit on male reproductive health, with particular emphasis on testosterone levels, sperm count, sperm motility, and the underlying reproductive mechanisms.

**Methods**: Eligible animal studies investigating the effects of Shilajit on male reproductive outcomes were systematically reviewed and quantitatively synthesised through meta-analysis. The primary outcomes were serum testosterone, sperm count, and sperm motility, while mechanistic findings were narratively synthesised. A random-effects model was used, and pooled effects were expressed as mean difference (MD) or standardized mean difference (SMD) with 95% confidence intervals (CIs).

**Results**: Four studies involving 35 animals per group were included in the meta-analysis of serum testosterone, while four studies involving 31 animals per group were included for both sperm count and sperm motility. Shilajit significantly increased serum testosterone levels (MD = 2.69, 95% CI: 1.85–3.53; $p < 0.00001$; $I^2 = 94\%$) and sperm count (SMD = 8.14, 95% CI: 2.92–13.37; $p = 0.002$; $I^2 = 91\%$). Sperm motility showed a positive but statistically non-significant effect (MD = 25.52, 95% CI: −2.96–53.99; $p = 0.08$; $I^2 = 99\%$). The included studies also demonstrated protection against chemically induced reproductive damage through improvements in spermatogenesis, steroidogenesis, and sperm quality. Mechanistic findings associated these effects with activation of antioxidant pathways, including Nrf2/Keap1 and Nrf2/HO-1, increased activities of steroidogenic enzymes such as StAR, 3β-HSD, and 17β-HSD, preservation of Sertoli cell function and blood–testis barrier integrity, improved mitochondrial function, and reduced oxidative stress and apoptosis. Additional narrative evidence supported the potential fertility-enhancing effects of Shilajit.

**Conclusions**: Preclinical evidence indicates that Shilajit has reproductive-protective effects, significantly improving serum testosterone and sperm count, while its effect on sperm motility remains statistically uncertain. The substantial heterogeneity observed across outcomes highlights the need for standardized experimental methodologies, consistent outcome assessment, dose-response studies, and well-designed clinical trials to establish its efficacy, optimal dosage, and safety in male reproductive disorders.

**Keywords:** Experimental animal models · Male infertility· · Shilajit · Spermatozoa · Spermatogenesis · Testosterone.

## Introduction

Male infertility is an important public health problem accounting for about one-half of all occurrences of infertility worldwide (1). Infertility affects approximately 15% of couples in their reproductive years with male factors alone accounting for approximately 20-30% of instances and contributing to an additional 20-30% when combined with female factors (2). Infertility is on the rise worldwide owing to changing lifestyles, environmental pollution, delayed parenting, obesity, metabolic diseases and exposure to reproductive toxicants (3) (4). In addition, the documented deterioration in semen quality over the past few decades has further brought to the forefront the increasing burden of male reproductive problems (5) (6). Oxidative stress is a major factor in the pathophysiology of male infertility (7). It disturbs the balance between reactive oxygen species and endogenous antioxidants (8). Excessive oxidative stress affects sperm membranes, DNA, proteins and mitochondria, which ultimately decrease spermatogenesis and sperm function (9) (10). Despite the availability of hormonal therapy, antioxidant supplementation, surgery and assisted reproductive technologies for the management of male infertility, their success is still uneven especially in idiopathic infertility (11). In addition, high treatment costs, side effects and poor long-term success have led to interest in alternate therapy options (12). Traditional medicinal systems have used natural materials with antioxidant, anti-inflammatory and adaptogenic characteristics for ages to control reproductive issues (13). The use of herbal medications as complementary therapies is attracting increasing attention since they often act on several biological pathways implicated in male fertility (14) (15). Experimental animal models play a crucial role in understanding the pathophysiology of male reproductive disorders and in evaluating the efficacy of potential therapeutic agents before clinical application (16) (17) (18). Various chemically induced, metabolically induced and environmentally induced models have been widely employed to mimic human male infertility by reproducing oxidative stress, hormonal imbalance, impaired

spermatogenesis and testicular damage (19) (20) (21). These preclinical models provide valuable insights into the mechanisms of reproductive dysfunction and facilitate the assessment of novel interventions targeting male fertility (22) (23). Furthermore, systematic synthesis of evidence from animal studies offers a comprehensive understanding of therapeutic efficacy, identifies knowledge gaps and supports the translation of promising preclinical findings into future clinical research (24) (25).

Natural products have gained considerable attention in recent years as potential therapeutic agents for male reproductive disorders because they possess multiple pharmacological properties that target the underlying mechanisms of infertility (26) (27). Numerous medicinal plants and herbo-mineral formulations have demonstrated the ability to improve reproductive function by reducing oxidative stress, suppressing inflammation, regulating endocrine function, protecting germ cells from apoptosis, and enhancing mitochondrial activity (28) (29) (30). Several phytochemicals, including polyphenols, flavonoids, terpenoids, alkaloids, and humic substances, have been reported to improve spermatogenesis, steroidogenesis, sperm maturation, and semen quality through modulation of multiple cellular signaling pathways (31) (32) (33). Unlike conventional therapies that often target a single mechanism, natural products exhibit pleiotropic actions, making them attractive candidates for the management of multifactorial disorders such as male infertility (34) (35) (36). Consequently, increasing scientific interest has focused on validating traditionally used medicinal substances through well-designed experimental studies to establish their pharmacological efficacy (37) (38). Further, to elucidate their mechanisms of action, and generate evidence for their potential clinical application in reproductive medicine (39) (40). Traditional medicines include Shilajit, an Ayurvedic herbo-mineral compound that has been traditionally utilized to improve vitality, longevity and reproductive health and is widely recognized as a Rasayana (41) (42) (43) (44). Its pharmacological potential has gained more and more scientific research in recent years (45) (46). Shilajit contains a number of biologically active molecules such as fulvic acid, humic substances, dibenzo-α-pyrones, amino acids and vital trace elements (47) (48). These compounds are thought to be responsible for its antioxidant, anti-inflammatory, immunomodulatory and energy boosting activities (49) (50).

Recent experimental research in many animal models of reproductive dysfunction have shown that Shilajit enhances testicular function, spermatogenesis, testosterone production, sperm quality and antioxidant defence (51) (52) (53). However, heterogeneity in findings have been seen due to variances in animal species, disease models, treatment regimens and outcome measures (54). Over the past two decades, research on the reproductive effects of Shilajit has been accumulating, but no previous comprehensive analysis has quantitatively integrated the relevant preclinical evidence (55). Hence, a thorough review is required to ascertain the overall effectiveness of Shilajit and to pinpoint areas for further research. Accordingly, the current systematic review and meta-analysis was conducted to evaluate the effects of Shilajit supplementation on male reproductive parameters in experimental animal models in a comprehensive manner, with quantitative synthesis of testosterone, sperm count and sperm motility outcomes and qualitative assessment of additional reproductive parameters.

## Materials & Methods

The protocol for this systematic review and meta-analysis was prospectively registered in the International Prospective Register of Systematic Reviews (PROSPERO) on Jul 03 2026 under registration number CRD420261440409 (56).

**Defining the Research Question**

The systematic review addressed the research question: "What are the effects of Shilajit supplementation on male reproductive parameters in experimental animal models?" The included studies were evaluated to determine the effects of Shilajit on reproductive outcomes, with quantitative meta-analyses performed for primary outcomes, including serum testosterone levels, sperm count, and sperm motility, where sufficient data were available. (57) (58).

**Eligibility criteria and Study Design**

The present systematic review and meta-analysis was designed and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines. Following systematic screening and eligibility assessment, six experimental animal studies investigating the effects of Shilajit supplementation on male reproductive parameters were included in the systematic review. Of these, five studies met the criteria for quantitative synthesis (meta-analysis), while one study conducted in healthy animals was included only in the qualitative synthesis. (Table 1) (59) (60).

**Search strategy and Study selection**

The search strategy for this systematic review was developed using the Population, Intervention, Comparison, and Outcomes (PICO) framework. The components of the PICO framework used in the present study are summarized in Table 2 (61) (62). A comprehensive literature search was conducted in Google scholar, PubMed, MEDLINE, Scopus, Web of Science, and Embase from database inception to 31 March 2026 (63) (64).

The search strategy was constructed using Medical Subject Headings (MeSH) terms and free-text keywords such as “Shilajit”, “Asphaltum”, “male fertility”, “male infertility”, “testosterone”, “sperm”, “sperm count”, “sperm motility”, “spermatogenesis”, “reproductive function”, “animal”, “rat”, “mouse”, and other related terms. The search phrases were combined suitably using Boolean operators (“AND” and “OR”) (65). The selected papers were checked for eligibility in a systematic way by examining the titles, abstracts and full texts according to the stated eligibility criteria. Furthermore, the reference lists of the included studies were manually searched for any relevant articles that were not identified by the electronic database search (66) (67) (68).

All entries identified by the electronic database search were retrieved and duplicate articles were eliminated. The remaining articles were evaluated by title and abstract to discover relevant investigations. The full texts of the included papers were obtained and reviewed for eligibility based on the pre-established inclusion and exclusion criteria (69). Studies that fulfilled eligibility criteria were included in the systematic review and meta-analysis. The entire research selection procedure was documented via PRISMA 2020 flow diagram (Figure 1) (70).

**Data extraction**

Data were extracted from all eligible studies using a standardized data extraction form to ensure systematic and consistent collection of study characteristics and outcome data. The extracted information included the first author and year of publication, animal species and strain, sample size, experimental or disease-inducing model, Shilajit formulation, dose, route of administration, treatment duration, comparator group, and reported reproductive outcomes. Quantitative data, including sample size, mean values, and standard deviations (SDs) for the relevant outcomes, were extracted wherever available for subsequent meta-analysis.

The included studies comprised different experimental animal models and reproductive injury conditions. The extracted intervention data included Shilajit doses ranging from 25–200 mg/kg, with treatment durations ranging from 2 to 8 weeks. The experimental models included cadmium-, cyclophosphamide-, diabetes-, monosodium glutamate (MSG)-induced reproductive toxicity models, as well as non-induced/healthy animal models. The principal reproductive outcomes extracted were serum testosterone, sperm count, and sperm motility, while luteinizing hormone (LH) and follicle-stimulating hormone (FSH) data were extracted when reported. Additional mechanistic findings related to spermatogenesis, steroidogenesis, oxidative stress, antioxidant activity, and reproductive tissue protection were also recorded for narrative synthesis.

Two of the authors (SS, SPS) independently performed the data extraction in order to reduce extraction errors. These data were systematically compiled and summarized in Table 3 (71) (72).

**Risk of bias assessment**

The methodological quality of the included studies was assessed using the Systematic Review Centre for Laboratory Animal Experimentation (SYRCLE) Risk of Bias tool. The assessment evaluated the risk of bias across the following domains: selection bias, performance bias, detection bias, attrition bias, reporting bias, and other sources of bias (73). Each domain was judged as having a low, high, or unclear risk of bias. The results of the risk of bias assessment are presented in Table 4 (74).

**Statistical analysis**

Statistical analysis was performed using RevMan 5.4 software. It was conducted for the primary outcomes, including testosterone, sperm count, and sperm motility. Mean Difference (MD) with 95% confidence intervals (95% CI) was used for testosterone and sperm motility, as these outcomes were measured using comparable units across the included studies. Standardized Mean Difference (SMD; Hedges' g) with 95% confidence intervals was used for sperm count due to differences in measurement scales among the included studies (75). A random-effects model was applied to account for between-study heterogeneity. Statistical heterogeneity was assessed using Cochran's Q test and the $I^2$ statistic, with $I^2$ values of 25%, 50%, and 75% indicating low, moderate, and high heterogeneity, respectively. Statistical significance was considered at a p-value $< 0.05$. Forest plots were generated to present the pooled effect estimates for each outcome (76).

## Results

**Eligibility criteria**

Application of the predefined inclusion and exclusion criteria resulted in the selection of 6 eligible studies for qualitative synthesis. Studies excluded during screening included review articles, human studies, conference abstracts, in vitro studies, duplicate publications, studies without a control group, and studies with insufficient quantitative data (Table 1).

**Table 1** Inclusion and exclusion criteria used for study selection in the systematic review and meta-analysis

| Inclusion Criteria | Exclusion Criteria |
|---|---|
| Original experimental animal studies | Human studies |
| Studies evaluating the effects of Shilajit on male reproductive parameters | Review articles, systematic reviews, meta-analyses |
| Presence of a control or comparison group | Conference abstracts, editorials, letters, book chapters |
| Quantitative data available or extractable (mean, SD/SE, and sample size) | In vitro or cell culture studies |
| Studies reporting at least one reproductive outcome (e.g., testosterone, sperm count, sperm motility, LH, FSH, testis weight, oxidative stress biomarkers, histopathology) | Studies without a control group |
| Articles published in English | Studies with insufficient or non-extractable quantitative data |
| Full-text articles available | Duplicate publications or repeated datasets |

**PICO Framework**

All included studies met the predefined PICO criteria. Serum testosterone level, sperm count, and sperm motility were analyzed quantitatively, while LH and FSH were summarized qualitatively (Table 2).

**Table 2** PICO framework describing the inclusion criteria for the systematic review and meta-analysis

| Component | Description |
|---|---|
| Population (P) | Male experimental animals evaluating male reproductive function or dysfunction |
| Intervention (I) | Shilajit administered at any dose, formulation, route, and duration |
| Comparison (C) | Placebo, vehicle-treated, untreated, or standard control groups |
| Outcomes (O) | Primary: Testosterone, sperm count, sperm motility. Secondary: LH, FSH, testis weight, epididymal weight, sperm morphology, oxidative stress biomarkers, and histopathological changes. |

**Study selection**

The literature screening process is summarized in the PRISMA flow diagram (Figure 1). After duplicate removal and screening of titles and abstracts, full-text articles were assessed for eligibility. 6 studies fulfilled all eligibility criteria and were included in the systematic review. Among these, 1 study involving healthy animals was excluded from the quantitative synthesis, resulting in 5 studies being included in the meta-analysis.

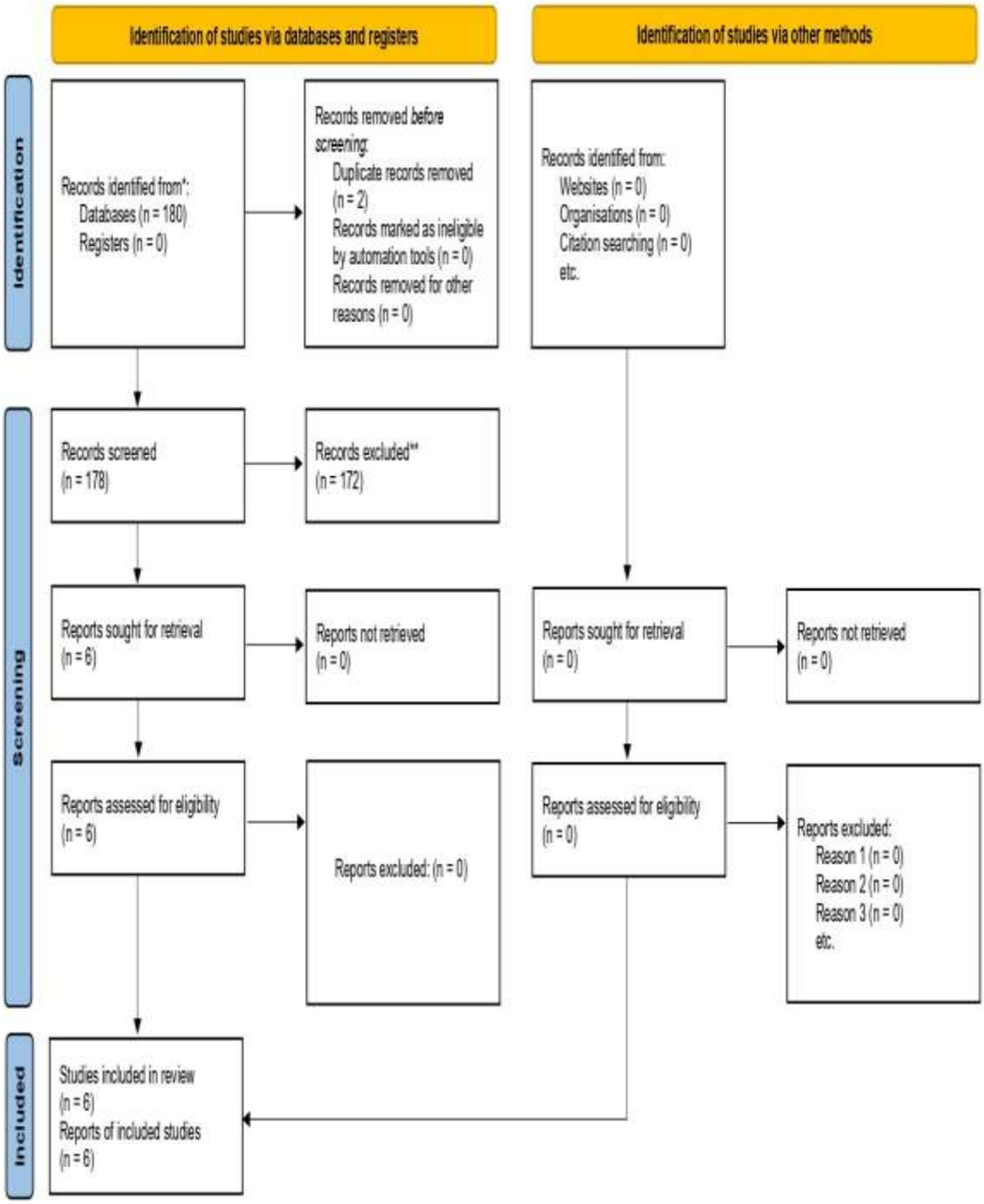



**Fig. 1** Preferred reporting items for systematic reviews and meta-analyses (PRISMA) flowchart

**Data extraction**

Relevant data were successfully extracted from all six included studies. The extracted information included publication year, animal model, Shilajit dose, duration of treatment, and reported reproductive outcomes. The studies were published between 2006 and 2025, used rats or mice as experimental animals, employed different disease models, administered Shilajit at doses ranging from 25–200 mg/kg, and reported treatment durations ranging from 2 weeks to 60 days. Testosterone, sperm count, and sperm motility were the most frequently evaluated outcomes. The detailed characteristics of the included studies are presented in Table 3.

**Table 3** Basic characteristics of the included studies

| Author, Year | Animal/Species | Inducing Model | Shilajit Dose | Duration | Outcome |
|---|---|---|---|---|---|
| Raghav Kumar Mishra et al., (2018) | Adult Swiss albino male mice (12–14 weeks) | Cadmium chloride (2 mg/kg/day orally for 35 days) | 50, 100, 200 mg/kg/day (oral) | 35 days (following cadmium exposure; one spermatogenic cycle) | • Restored spermatogenesis<br>• Increased daily sperm production<br>• Improved sperm count and motility<br>• Increased testosterone and steroidogenic enzyme activity<br>• Improved fertility and litter size |
| Jeong-Sook Park et al., (2006) | Sprague-Dawley male and female rats | Normal fertility model (no induction) | 25, 50, 100 mg/kg/day (oral) | 6 weeks (42 days) | • Increased sperm count in testes and epididymis<br>• Increased seminiferous tubule cell layers<br>• Enhanced ovulation in female rats<br>• No significant toxicity to major organs |
| Arti Rajpoot et al., (2024) | Adult Parkes male mice (14–15 weeks) | Cyclophosphamide (single IP injection 200 mg/kg) | 100, 200 mg/kg/day (oral) | 35 days (one spermatogenic cycle) | • Restored testicular histology<br>• Improved germ cell dynamics<br>• Improved sperm count, motility, and viability<br>• Enhanced testosterone production and Sertoli cell function<br>• Reduced oxidative stress and apoptosis |
| Arti Rajpoot et al., (2025) | Neonatal STZ-induced diabetic Parkes male mice | Streptozotocin (90 mg/kg IP at 2 days postpartum) | 100, 200 mg/kg/day (oral) | 35 days (one spermatogenic cycle; treatment started after diabetes confirmation) | • Improved glycemic control and insulin sensitivity<br>• Restored spermatogenesis<br>• Improved sperm count, motility, and |

| Author, Year | Animal/Species | Inducing Model | Shilajit Dose | Duration | Outcome |
|---|---|---|---|---|---|
| | | | | | viability<br>• Restored blood-testis barrier integrity<br>• Reduced oxidative stress and apoptosis |
| Hadeel Kamil Khaleel et al., (2025) | Adult male albino mice (18–22 g; 60–70 days old) | Monosodium glutamate (2 or 4 g/kg/day orally) | 100 mg/kg and 200 mg/kg/day (oral) | 2 weeks (14 days) | • Reduced monosodium glutamate-induced testicular damage<br>• Improved testicular histology<br>• Restored testosterone and progesterone levels<br>• Reduced inflammation<br>• Improved antioxidant status |
| Zahraa Kareem B. Almershdy et al., (2025) | Mature male Wistar rats (60 days old) | Cadmium chloride (5 mg/kg/day orally) | 100 mg/kg/day (oral) | 60 days | • Improved sperm count, motility, and viability<br>• Reduced sperm abnormalities<br>• Improved reproductive performance<br>• Reduced cadmium-induced toxicity<br>• Enhanced antioxidant protection |

**Risk of bias assessment**

The methodological quality of the included studies was evaluated using the SYRCLE Risk of Bias tool. Most studies demonstrated a low risk of bias, whereas several domains related to blinding and allocation concealment were rated as unclear. The detailed risk of bias assessment is presented in Figure 2 and Table 4.

**Table 4** Quality assessment of studies according to SYRCLE

| First author (Year) | Selection bias | | | Performance bias | | Detection bias | | Attrition bias | Reporting bias | Other bias |
|---|---|---|---|---|---|---|---|---|---|---|
| | Random sequence generation | Baseline characteristics | Allocation concealment | Random housing | Blinding of caregivers /investigators | Random outcome assessment | Blinding of outcome assessment | Incomplete outcome data | Selective outcome reporting | Other sources of bias |
| Arti et al. (2024) | Low | Low | Unclear | Unclear | Unclear | Unclear | Unclear | Low | Low | Low |
| Arti et al. (2025) | Low | Low | Unclear | Unclear | Unclear | Unclear | Unclear | Low | Low | Low |
| Mishra et al. (2018) | Low | Low | Unclear | Low | Unclear | Unclear | Unclear | Low | Low | Low |
| Khaleel et al. (2025) | Low | Low | Unclear | Low | Unclear | Unclear | Unclear | Low | Low | Low |
| Kareem et al. (2025) | Low | Low | Unclear | Low | Unclear | Unclear | Unclear | Low | Low | Low |
| Park et al. (2006) | Unclear | Low | Unclear | Unclear | Unclear | Unclear | Unclear | Low | Low | Low |

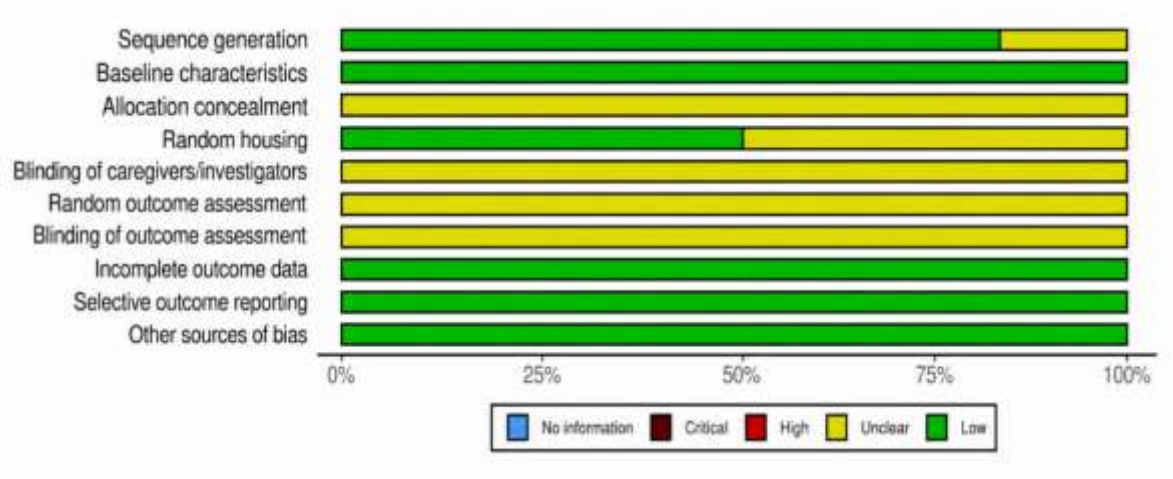



**Fig. 2** Article quality assessed with SYRCLE's ROB tool

**Statistical analysis**

Quantitative synthesis was performed for the primary outcomes of testosterone, sperm count, and sperm motility. Forest plots were generated for each outcome using a random-effects model. Mean Difference (MD) was used for testosterone and sperm motility, whereas Standardized Mean Difference (SMD) was used for sperm count. The pooled effect estimates, 95% confidence intervals, p-values, and heterogeneity ($I^2$) for each outcome are presented in Figures 3-5

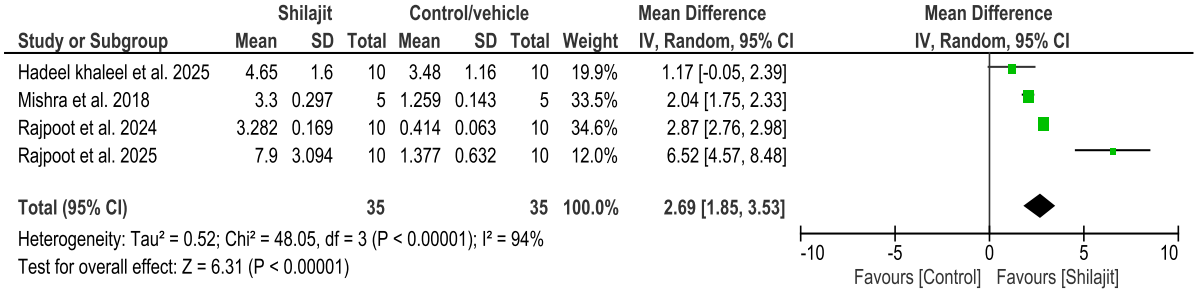



**Fig. 3** Results of the meta-analysis of studies evaluating the effect of Shilajit supplementation on serum testosterone levels in experimental animal models

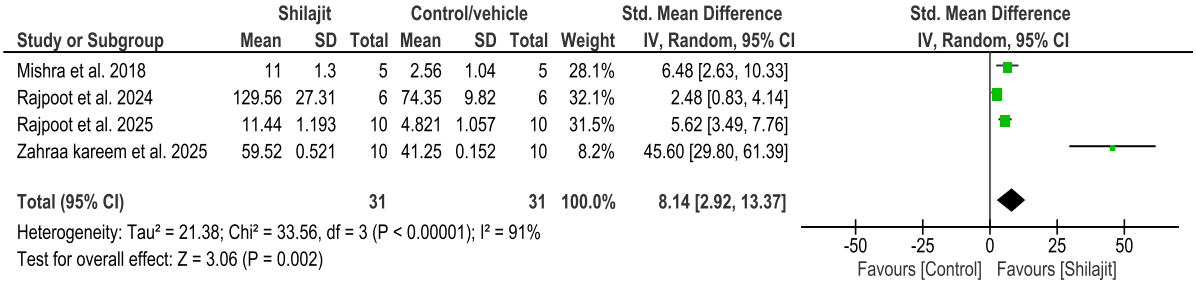



**Fig. 4** Results of the meta-analysis of studies evaluating the effect of Shilajit supplementation on sperm count in experimental animal models

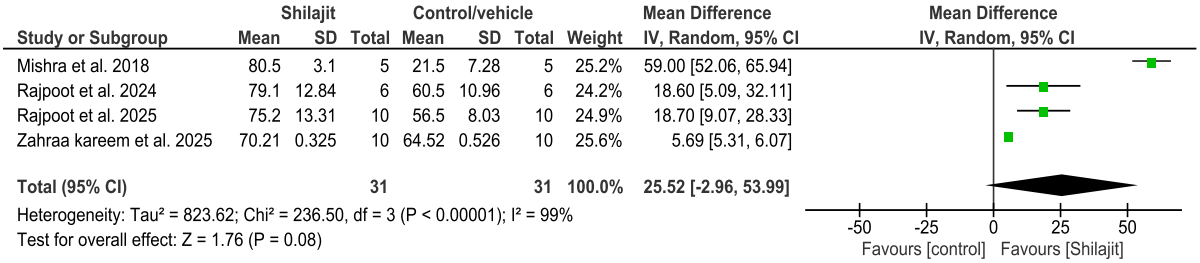



**Fig. 5** Results of the meta-analysis of studies evaluating the effect of Shilajit supplementation on sperm motility in experimental animal models

## Discussion

The reproductive advantages of Shilajit are likely mediated by one or more different but complimentary pathways (40). Shilajit has a variety of compounds including fulvic acid, humic substances, dibenzo-α-pyrones, amino acids and vital trace minerals which are all believed to contribute to its antioxidant and adaptogenic qualities (77) (78) (79). The studies included in the review consistently showed activation of endogenous antioxidant pathways such as Nrf-2/Keap-1 and Nrf-2/HO-1 signaling, which resulted in improved antioxidant enzyme activity, reduced lipid peroxidation and protection from oxidative stress-mediated germ cell death (80) (81). In addition, Shilajit promoted steroidogenesis by increasing the levels of StAR, 3β-HSD and 17β-HSD enzymes, maintained Sertoli cell function and blood–testis barrier integrity, improved mitochondrial energy metabolism and provided necessary minerals needed for proper spermatogenesis (82) (83) (84).

The present systematic review and meta-analysis demonstrated that Shilajit has a beneficial effect on male reproductive function in experimental animal models by significantly improving serum testosterone levels and sperm count, and also showing a positive but statistically non-significant trend in sperm motility. The

experimental studies included in this review consistently confirmed these results and indicated that Shilajit protected the testes from chemically induced reproductive harm by improving spermatogenesis, steroidogenesis, and sperm quality (85) (86). Rajpoot et al. reported the restoration of testicular germ cell dynamics and improvement of Sertoli cell function due to Shilajit administration in cyclophosphamide exposed mice. Shilajit also improved testosterone biosynthesis by activating the 3β-HSD and 17β-HSD enzymes, reduced oxidative stress by activating the Nrf-2/Keap-1 pathway and significantly improved the sperm quality (87) (88).
Similarly, Rajpoot et al. showed that Shilajit improved insulin sensitivity, steroidogenesis, blood–testis barrier integrity, oxidative stress, and apoptosis through the Nrf-2/HO-1 signaling pathway in streptozotocin-induced diabetic mice, and significantly improved sperm count, motility, viability, and testicular histology (89) (90). Mishra et al. also reported that Shilajit effectively reversed cadmium-induced infertility by increasing serum testosterone, stimulating testicular steroidogenic enzymes, restoring spermatogenesis, improving daily sperm production, sperm concentration and motility and enhancing fertility outcomes, thus supporting its potent androgenic and reproductive protective effects (91). Khaleel et al. also reported that Shilajit reduced monosodium glutamate-induced testicular injury by restoring the testosterone levels, decreasing the inflammatory alterations, improving the testicular histology and retaining the seminiferous tubule architecture, especially at the higher dose of 200 mg/kg (92) (93). In addition, Kareem et al. reported that Shilajit significantly improved sperm count, motility, viability, and reproductive function and decreased sperm abnormalities in cadmium-exposed rats, thus emphasizing its antioxidant and adaptogenic capabilities (94).
The results of the present evaluation are also confirmed by the narrative study of Park et al. one of the first studies to evaluate the reproductive effects of Shilajit. This study was not included in the quantitative meta-analysis, because it did not meet the predefined eligibility criteria for pooling. However, this study showed that six weeks of oral administration of Shilajit led to a significant increase in sperm counts in the testes and epididymides and increased the number of seminiferous epithelial cell layers without causing adverse changes in organ weights. The authors also noted that Shilajit improved ovulation in female rats, indicating that it has fertility-enhancing effects in both sexes (95) (96). These findings are congruent with the present results, particularly the considerable improvement in sperm count and provide additional biological justification for the traditional usage of Shilajit as a reproductive tonic (97) (98). Overall, these pathways may convince the observed improvements in production of serum testosterone levels and sperm count in the various experimental models (99) (100). Future research should use standardized formulations of Shilajit, comparable dose regimens, and identical ways of measuring outcomes to allow for better comparability among studies. Moreover, well-designed clinical trials are needed to validate the efficacy and safety of Shilajit in the management of male infertility.

## Conclusion

The current systematic review and meta-analysis shows that Shilajit improves male reproductive function in experimental animal models with significant increases in serum testosterone levels and sperm count and a positive but not significant effect on sperm motility. The substantially wider confidence interval observed for sperm motility (MD = 25.52; 95% CI: −2.96 to 53.99), compared with the narrower confidence intervals for serum testosterone (MD = 2.69; 95% CI: 1.85–3.53) and sperm count (SMD = 8.14; 95% CI: 2.92–13.37), indicates greater uncertainty and variability in the estimated effect of Shilajit on sperm motility. The reproductive effects of Shilajit are likely mediated through its antioxidant, endocrine-modulating and spermatogenesis-promoting characteristics. However, the substantial heterogeneity of the included studies underlines the necessity for standardized preclinical research and well-designed clinical trials to determine its efficacy and safety before widespread therapeutic usage in the management of male infertility.

## References


1. Patil DA, Deshpande DA. AYURVEDIC MANAGEMENT OF SERTOLI CELL-ONLY SYNDROME: INTERIM CASE STUDY HIGHLIGHTING IMPROVEMENTS IN OVERALL MALE REPRODUCTIVE HEALTH.
2. Agarwal S, Anwer K, Khanna R, Ali A, Sultana Y. Humic acid from Shilajit: A physico-chemical and spectroscopic characterization. J Serbian Chem Soc. 2010;75(3):413–22. doi:10.2298/JSC090316006A
3. Biswas TK, Pandit S. In Search of Spermatogenetic and Virility Potential Drugs of Ayurvedic Leads: A Review. Androl-Open Access. 2015;04(02). doi:10.4172/2167-0250.1000148
4. Yi YJ, Dissanayake WMN, Aganja RP, Lee SM. Shilajit improves sperm penetration on in vitro fertilization of pig oocytes. Korean J Agric Sci. 2023 Mar 1;50(1):131–9. doi:10.7744/kjoas.20230008
5. Biswas TK, Pandit S, Mondal S, Biswas SK, Jana U, Ghosh T, et al. Clinical evaluation of spermatogenic activity of processed Shilajit in oligospermia. Andrologia. 2010 Feb;42(1):48–56. doi:10.1111/j.1439-0272.2009.00956.x

6. Mosavi S, Tabarrai M, Tansaz M, Salehinia H, Grylka-Baeschlin S, Rahmani A, et al. Effects of oral Shilajit tablets on sexual function and sexual quality of life among reproductive-aged women: a triple-blind randomized clinical trial. Tradit Med Res. 2023;8(11):66. doi:10.53388/TMR20230305002
7. Rege A, Juvekar P, Juvekar A. IN VITRO ANTIOXIDANT AND ANTI-ARTHRITIC ACTIVITIES OF SHILAJIT. Vol. 4. 4(2).
8. Singh R, Kaushik S, Yadav P, Ruknuddin G, Prajapati PK, Department of Rasa Shastra and Bhaishajya Kalpana, All India Institute of Ayurveda, Gautampuri, Sarita Vihar, Mathura Road, New Delhi - 110 076, India. RESEARCH DEVELOPMENTS IN IMMUNOMODULATORY AND ANTIOXIDANT ACTIVITIES OF SHILAJATU. INDIAN DRUGS. 2021 Dec 4;58(09):7–20. doi:10.53879/id.58.09.11977
9. Kamgar E, Kaykhaii M, Zembrzuska J. SHILAJIT - KNOWN FOR AGES, BUT IS IT FULLY KNOWN? 2022.
10. Şengül Bağ F, Ovalı F, Vatansev H. Antioxidant Potential and Chemotherapy-Modulating Effects of Shilajit in A549 Lung Cancer Cells. Int J Tradit Complement Med Res. 2025 Aug 27;6(2):111–20. doi:10.53811/ijtcmr.1685664
11. Kiran R, Hussain S, Ahmad A, Javed M, Riaz M, Hanif MA, et al. REVIEW; CHEMICAL CHARACTERISTICS AND THERAPEUTIC POTENTIAL OF ASPHALTUM PUNJABIANUM (SHILAJIT).
12. Kishore K, K Thakur S, Singh Chaudhary V. A Literary Review on Shilajit. Int Res J Ayurveda Yoga. 2023;06(05):70–7. doi:10.47223/IRJAY.2023.6511
13. Singh R, Kaushik S, Yadav P, Prajapati PK. Antioxidant Profile of Shilajatu (Asphaltum punjabinum): Impact of Drava/Media and Bhumi/Geography. Free Radic Antioxid. 2021 Aug 2;11(1):19–23. doi:10.5530/fra.2021.1.4
14. Ojha DrR, Gupta DrAK, Pathak DrR, Pandey SK. Shilajit an elixir of Ayurveda: A literary review of traditional usage as well as modern findings. Int J Appl Res. 2021 Aug 1;7(8):323–32. doi:10.22271/allresearch.2021.v7.i8e.8883
15. Yadav D, Mishra S, Shah KM, Reddy ST, Gupta R, Pandey P. Safety and Efficacy of TruBlk™ Shilajit Resin Supplementation on Physical Performance and Blood Biomarkers in Healthy Adults: A 28-Day Open-Label Pilot Study. Cureus. 2026 Jan 27. doi:10.7759/cureus.102372
16. Bhardwaj P, Goel M, Rai DV. Effects of shilajit on the bone tissue of alcohol administered rats. Indian J Pharm Biol Res. 2016 Mar 31;4(01):74–80. doi:10.30750/ijpbr.4.1.9
17. Eltayef EM, Farhood ZH, Madlool ZS. The role of shilajit in reducing the toxicity of monosodium glutamate on liver enzyme and kidney functions in albino mice. KIDNEYS. 2025 Aug 1;14(3):199–206. doi:10.22141/2307-1257.14.3.2025.534
18. Carrasco-Gallardo C, Guzmán L, Maccioni RB. Shilajit : A Natural Phytocomplex with Potential Procognitive Activity. Int J Alzheimers Dis. 2012;2012:1–4. doi:10.1155/2012/674142
19. Reddy Ag, Anjaneyulu Y, Reddy Gd, Kumar Mr. Oxidative stress induced by lead and antioxidant potential of certain adaptogens in poultry. Toxicol Int. 2010;17(2):45. doi:10.4103/0971-6580.72668
20. Domiaty DMM. The Preventive and Restorative Potentials of Shilajit Extract in Rats Treated with Mercury Chloride. J Biochem Technol. 2022;13(3):56–62. doi:10.51847/vaqgEoLZjg
21. Dr. Aruna R. 1 DALT *2. SAMPRAPTI BASED APPLICATION OF USAKADI GANA IN POLYCYSTIC OVARIAN DISEASE [Internet]. 2026 Jan 1. doi:10.5281/ZENODO.18094659
22. Mirza MA, Alam MN, Faiyazuddin M, Mahmood D, Bairwa R, Mustafa G. Shilajit: An ancient panacea.
23. Gupta A, Kumar S, Singh P, Gupta P, Sastry J. Subacute Oral Toxicity Assessment of a Herbomineral Formulation with Shilajit, Swarna Bhasma and other Ingredients. J Drug Res Ayurvedic Sci. 2019;4(1):8–21. doi:10.5005/jdras-10059-0070
24. Das SS, Ramkumar M, Singh H, Sharma S. Evidence-Based Evaluation of Shilajit in Cancer: A Systematic Review. Cureus. 2026 Jan 17. doi:10.7759/cureus.101736
25. Iqubal A, Rehman SA, Ahmad F, Mahajan A, Bedi B, Singh T, et al. Shilajit For Female Health: An Evidence-Based Review. 2025.
26. Kangari P, Roshangar L, Iraji A, Talaei-Khozani T, Razmkhah M. Accelerating effect of Shilajit on osteogenic property of adipose-derived mesenchymal stem cells (ASCs). J Orthop Surg. 2022 Sep 24;17(1):424. doi:10.1186/s13018-022-03305-z
27. Janardhan Prasad Bhattarai, Dong-Hyu Cho, Seong-Kyu Han. Activation of Strychnine-Sensitive Glycine Receptors by Shilajit on Preoptic Hypothalamic Neurons of Juvenile Mice. Chin J Physiol. doi:10.4077/CJP.2016.BAE361
28. Jafari M, Forootanfar H, Ameri A, Foroutanfar A, Adeli M, Rahimi HR, et al. Antioxidant, cytotoxic and hyperalgesia-suppressing activity of a native Shilajit obtained from Bahr Aseman mountains. Pak J Pharm Sci. 2019.

29. Balkrishna A, Gohel V, Pathak N, Tomer M, Rawat M, Dev R, et al. Anti-hyperglycemic contours of Madhugrit are robustly translated in the Caenorhabditis elegans model of lipid accumulation by regulating oxidative stress and inflammatory response. Front Endocrinol. 2022 Dec 5;13:1064532. doi:10.3389/fendo.2022.1064532
30. Tripathi YB, Shukla S, Chaurasia S, Chaturvedi S. Antilipid Peroxidative Property of Shilajit. Phytother Res. 1996 May;10(3):269–70. doi:10.1002/(SICI)1099-1573(199605)10:3<269::AID-PTR817>3.0.CO;2-3
31. Vivek B, Wilson E, Devi SVN, Velmurugan C, Kannan M. Cardioprotective activity of shilajit in isoproterenol - induced myo- cardial infarction in rats: A biochemical and histopathological evaluation. 2011.
32. Schepetkin IA, Xie G, Jutila MA, Quinn MT. Complement-fixing activity of fulvic acid from Shilajit and other natural sources. Phytother Res. 2009 Mar;23(3):373–84. doi:10.1002/ptr.2635
33. Yaqoob Z, Batool SA, Khan A, Hussain R, Raza MA, Alqahtani MS, et al. Characterization and medicinal applications of Karakoram shilajit; angiogenesis activity, antibacterial properties and cytotoxicity. Mater Res Express. 2023 Oct 1;10(10):105403. doi:10.1088/2053-1591/ad04bd
34. Srivastava J, Chaturvedi S, Abraham A, Hanote V, Mohan R. Evaluation of organic and inorganic constituents of naturally occurring shilajit: augmentation of fulvic and humic acid and its fingerprinting. J Pharmacogn Phytochem. 2026 Jan 1;15(1):283–9. doi:10.22271/phyto.2026.v15.i1d.15735
35. Kordestani Z, Melki E, Vahidi R, Shideh R, Ghorbani N, Yazdi Rouholamini SE, et al. Modulation of IKK/NF-κB Signaling: A Therapeutic Mechanism of Shilajit in Breast Cancer Cells. J Kerman Univ Med Sci. 2024 Apr 29;31(2):66–71. doi:10.34172/jkmu.2024.12
36. Kaur S, Kumar P, Kumar D, Kharya MD, Singh N. Parasympathomimetic Effect of Shilajit Accounts for Relaxation of Rat Corpus Cavernosum. Am J Mens Health. 2013 Mar;7(2):119–27. doi:10.1177/1557988312462738
37. Cagno V, Donalisio M, Civra A, Cagliero C, Rubiolo P, Lembo D. In vitro evaluation of the antiviral properties of Shilajit and investigation of its mechanisms of action. J Ethnopharmacol. 2015 May;166:129–34. doi:10.1016/j.jep.2015.03.019
38. Kloskowski T, Szeliski K, Krzeszowiak K, Fekner Z, Kazimierski Ł, Jundziłł A, et al. Mumio (Shilajit) as a potential chemotherapeutic for the urinary bladder cancer treatment. Sci Rep. 2021 Nov 19;11(1):22614. doi:10.1038/s41598-021-01996-8
39. Bižanov G, Barinova N. Adjuvant effect of Shilajit and plant extracts on the immune responses to bovine serum albumin in hens. Cent Eur J Immunol.
40. Begum Z, Ismat MS, Lee J, Areej R, Ali M, Niaz A, et al. 3D-printed scaffolds reinforced with natural mineral (Asphaltum Punjabianum) for skin tissue engineering. Int J Adv Manuf Technol. 2026 Feb;142(9–10):4999–5014. doi:10.1007/s00170-025-17314-9
41. Qadir A, Rehman SA, Khan N, Bedi B, Ali A, Iqubal A. Beyond Fulvic Acid: A Mini-Review of the Diverse Chemical Constituents of Shilajit. 2025.
42. Yadav SC. Asphaltumpunjabinum (Shilajit): Antioxidant, Hepatoprotective Activity and Evaluation of Effects on Blood Factors against Alcohol Induced Liver Injury in Wistar Rats.
43. Ghosal S. Chemistry of shilajit, an immunomodulatory Ayurvedic rasayan. Pure Appl Chem. 1990 Jan 1;62(7):1285–8. doi:10.1351/pac199062071285
44. S L, Rc G, Jt G, Td C, Sr K. Anti-Inflammatory and Anti-Arthritic Efficacy and Safety of Purified Shilajit in Moderately Arthritic Dogs. J Vet Sci Anim Husb. 2013 Dec;1(3). doi:10.15744/2348-9790.1.302
45. Qadir A, Ali A, Singh T. Phyto-Therapeutic Potential and Pharmaceutical Impact of Shilajit (Asphaltum punjabianam): Current Research and Future Prospects [Internet]. 2024 [cited 2026 Jul 1]. Available from: https://www.qeios.com/read/RIXY86 doi:10.32388/RIXY86
46. Durg S, Veerapur V, Thippeswamy B, Ahamed S. Antiepileptic and antipsychotic activities of standardized Śilājatu (Shilajit) in experimental animals. Anc Sci Life. 2015;35(2):110. doi:10.4103/0257-7941.171675
47. Bhattacharyya S, Pal D, Banerjee D, Auddy B, Ganguly P, Majumder UK, et al. SHILAJIT DIBE ZO α PYRO ES: MITOCHO DRIA TARGETED A TIOXIDA TS. 2009.
48. Qadir A, Rehman SA, Khan N, Bedi B, Ali A, Iqubal A. Beyond Fulvic Acid: A Mini-Review of the Diverse Chemical Constituents of Shilajit. 2025.
49. Aminul I, Ghosh R, Banerjee D, Nath P, Mazumder UK, Ghosal S. Biotransformation of 3-hydroxydibenzo-a-pyrone into 3,8 dihydroxydibenzo-a-pyrone and aminoacyl conjugates by Aspergillus niger isolated from native shilajit. Electron J Biotechnol. 2008 Jul 15;11(3):0–0. doi:10.2225/vol11-issue3-fulltext-10
50. Singh R, Yadav P, Prajapati PK. Immunomodulatory Activity of Shilajatu (Asphaltum punjabinum) Processed in Different Media: An In Vivo Study. Vol. 8. 2023;8(4).
51. Biswas TK, Pandit S. In Search of Spermatogenetic and Virility Potential Drugs of Ayurvedic Leads: A Review. Androl-Open Access. 2015;04(02). doi:10.4172/2167-0250.1000148

52. Kumar A, Kumar S, Bisla A, Singh AK, Honparkhe M, Dhindsa SS. Fertility Improvement Following Herbal Treatment in Subfertile Buffalo Bulls. Indian J Anim Reprod. 2023;43(2):54–9. doi:10.48165/ijar.2022.43.2.12
53. Biswas TK, Pandit S, Mondal S, Biswas SK, Jana U, Ghosh T, et al. Clinical evaluation of spermatogenic activity of processed Shilajit in oligospermia. Andrologia. 2010 Feb;42(1):48–56. doi:10.1111/j.1439-0272.2009.00956.x
54. Stohs SJ. Safety and Efficacy of Shilajit (Mumie, Moomiyo). Phytother Res. 2014 Apr;28(4):475–9. doi:10.1002/ptr.5018
55. Zubair M. Effects of Asphaltum (Shilajit) on Male Reproductive System (Mini Review). Spatula DD - Peer Rev J Complement Med Drug Discov. 2016;6(3):1. doi:10.5455/spatula.20160413015359
56. SRILAKSHMI SRINIVASAN, SAKTHI PRIYADARSINI S, Harishkumar B. PROSPERO [Systematic review protocol registry] [Internet]. 2026 [cited 2026 Jul 3]. Effects of Shilajit Supplementation on Male Reproductive Parameters in Experimental Animal Models. Available from: https://www.crd.york.ac.uk/PROSPERO/view/CRD420261440409
57. Crocetti E. Systematic Reviews With Meta-Analysis: Why, When, and How? Emerg Adulthood. 2016 Feb;4(1):3–18. doi:10.1177/2167696815617076
58. Buchwald H, Avidor Y, Braunwald E, Jensen MD, Pories W, Fahrbach K, et al. Bariatric Surgery: A Systematic Review and Meta-analysis. JAMA. 2004 Oct 13;292(14):1724. doi:10.1001/jama.292.14.1724
59. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021 Mar 29;n71. doi:10.1136/bmj.n71
60. Rock PL, Roiser JP, Riedel WJ, Blackwell AD. Cognitive impairment in depression: a systematic review and meta-analysis. Psychol Med. 2014 Jul;44(10):2029–40. doi:10.1017/S0033291713002535
61. Beeldman E, Raaphorst J, Klein Twennaar M, De Visser M, Schmand BA, De Haan RJ. The cognitive profile of ALS: a systematic review and meta-analysis update. J Neurol Neurosurg Psychiatry. 2016 Jun;87(6):611–9. doi:10.1136/jnnp-2015-310734
62. Ahn E, Kang H. Introduction to systematic review and meta-analysis. Korean J Anesthesiol. 2018 Apr 2;71(2):103–12. doi:10.4097/kjae.2018.71.2.103
63. Ahn E, Kang H. Introduction to systematic review and meta-analysis. Korean J Anesthesiol. 2018 Apr 2;71(2):103–12. doi:10.4097/kjae.2018.71.2.103
64. McKenzie JE, Beller EM, Forbes AB. Introduction to systematic reviews and meta-analysis. Wolfe R, Abramson M, editors. Respirology. 2016 May;21(4):626–37. doi:10.1111/resp.12783
65. Modesti PA, Reboldi G, Cappuccio FP, Agyemang C, Remuzzi G, Rapi S, et al. Panethnic Differences in Blood Pressure in Europe: A Systematic Review and Meta-Analysis. Fuchs FD, editor. PLOS ONE. 2016 Jan 25;11(1):e0147601. doi:10.1371/journal.pone.0147601
66. Riley RD, Moons KGM, Snell KIE, Ensor J, Hooft L, Altman DG, et al. A guide to systematic review and meta-analysis of prognostic factor studies. BMJ. 2019 Jan 30;k4597. doi:10.1136/bmj.k4597
67. Garg AX, Hackam D, Tonelli M. Systematic Review and Meta-analysis: When One Study Is Just not Enough. Clin J Am Soc Nephrol. 2008 Jan;3(1):253–60. doi:10.2215/CJN.01430307
68. Westendorp WF, Nederkoorn PJ, Vermeij JD, Dijkgraaf MG, De Beek DV. Post-stroke infection: A systematic review and meta-analysis. BMC Neurol. 2011 Dec;11(1):110. doi:10.1186/1471-2377-11-110
69. Phan K, Tian DH, Cao C, Black D, Yan TD. Systematic review and meta-analysis: techniques and a guide for the academic surgeon. Ann Cardiothorac Surg. 2015;4(2).
70. Phyo AZZ, Freak-Poli R, Craig H, Gasevic D, Stocks NP, Gonzalez-Chica DA, et al. Quality of life and mortality in the general population: a systematic review and meta-analysis. BMC Public Health. 2020 Dec;20(1):1596. doi:10.1186/s12889-020-09639-9
71. Sethuraman SP, Velemurugan S, Raju K, Velayutham NK, Ahmed MS, Santhanabharathi B, et al. Physalis Genus, a Plant Source against Breast Cancer on MCF-7 Cell Line: A Systematic Review. Curr Pharmacol Rep. 2024 Sep 23;10(6):454–66. doi:10.1007/s40495-024-00375-x
72. Impellizzeri FM, Bizzini M. SYSTEMATIC REVIEW AND META□ANALYSIS: A PRIMER.
73. O'Connell MA, Leahy-Warren P, Khashan AS, Kenny LC, O'Neill SM. Worldwide prevalence of tocophobia in pregnant women: systematic review and meta-analysis. Acta Obstet Gynecol Scand. 2017 Aug;96(8):907–20. doi:10.1111/aogs.13138
74. Hooijmans CR, Rovers MM, De Vries RB, Leenaars M, Ritskes-Hoitinga M, Langendam MW. SYRCLE's risk of bias tool for animal studies. BMC Med Res Methodol. 2014 Dec;14(1):43. doi:10.1186/1471-2288-14-43
75. Russo MW. How to Review a Meta-analysis. N LY S.
76. Akobeng AK. Understanding systematic reviews and meta-analysis. Arch Dis Child. 2005 Aug 1;90(8):845–8. doi:10.1136/adc.2004.058230

77. Agarwal S, Anwer K, Khanna R, Ali A, Sultana Y. Humic acid from Shilajit: A physico-chemical and spectroscopic characterization. J Serbian Chem Soc. 2010;75(3):413–22. doi:10.2298/JSC090316006A
78. Stohs SJ. Safety and Efficacy of Shilajit (Mumie, Moomiyo). Phytother Res. 2014 Apr;28(4):475–9. doi:10.1002/ptr.5018
79. Kiran R, Hussain S, Ahmad A, Javed M, Riaz M, Hanif MA, et al. REVIEW; CHEMICAL CHARACTERISTICS AND THERAPEUTIC POTENTIAL OF ASPHALTUM PUNJABIANUM (SHILAJIT).
80. Andrade V, Wong-Guerra M, Cortés N, Pastor G, González A, Calfío C, et al. Scaling the Andean Shilajit: A Novel Neuroprotective Agent for Alzheimer's Disease. Pharmaceuticals. 2023 Jul 4;16(7):960. doi:10.3390/ph16070960
81. Basavaraja D, Katkar R, Dhaka P, Tomar S, Sircar D, Chikara G, et al. Chemical Analysis of Native Himalayan Shilajit: An Evaluation of an Ayurvedic Formulation. ACS Omega. 2025 Dec 2;10(47):57097–106. doi:10.1021/acsomega.5c05533
82. Biswas TK, Pandit S, Mondal S, Biswas SK, Jana U, Ghosh T, et al. Clinical evaluation of spermatogenic activity of processed Shilajit in oligospermia. Andrologia. 2010 Feb;42(1):48–56. doi:10.1111/j.1439-0272.2009.00956.x
83. NiZam MY, Çukur M, Parmaksız A, Kar İB. Effects of Shilajit on Post-Thaw Spermatological Quality of Bull Semen.
84. Özkök AO, Selcuk M. Effects of shilajit addition to honey bee diet on semen freezing. Int J Agric Environ Food Sci. 2024 Mar 25;8(1):235–41. doi:10.31015/jaefs.2024.1.23
85. Alipour S, Afshari A, Lavaee F, Sardoo MS. The Shilajit Mouthwash Effect Versus Conventional Treatment on Pain and Healing of Oral Lichen Planus: A Randomized Clinical Trial [Internet]. 2024 Nov 1. doi:10.21203/rs.3.rs-5031354/v1
86. Impact of Shilajit on Semen Quality and Reproductive Performance in Male Rats: A Protective Role Against Cadmium-Induced Toxicity. Al-Qadisiyah J Vet Med Sci. 2025 Mar 10. doi:10.29079/qjvms.2025.157187.1070
87. Rajpoot A, Yadav K, Yadav A, Mishra RK. Shilajit mitigates chemotherapeutic drug-induced testicular toxicity: Study on testicular germ cell dynamics, steroidogenesis modulation, and Nrf-2/Keap-1 signaling. J Ayurveda Integr Med. 2024 Jul;15(4):100930. doi:10.1016/j.jaim.2024.100930
88. Alshubaily FA, Jambi EJ. Correlation between Antioxidant and Anti-Osteoporotic Activities of Shilajit Loaded into Chitosan Nanoparticles and Their Effects on Osteoporosis in Rats. Polymers. 2022 Sep 23;14(19):3972. doi:10.3390/polym14193972
89. Rajpoot A, Pandey AK, Roy VK, Mishra RK. Shilajit Mitigates Diabetes-Induced Testicular Dysfunction in Mice: A Modulation in Insulin Sensitivity, Germ Cell-Junctional Dynamics, and Oxido-Apoptotic Status. Samir H, editor. Andrologia. 2025 Jan;2025(1):5517176. doi:10.1155/and/5517176
90. Ramya B, Kumar AA, Reddy GA, Lakshman M, Shivakumar P. Ameliorative effect of Withania somnifera and Shilajit on brain lesions and behaviour of hypothyroid rats. Indian J Vet Pathol. 2024;48(1):26–34. doi:10.5958/0973-970X.2024.00005.1
91. Mishra RK, Jain A, Singh SK. Profertility effects of Shilajit on cadmium-induced infertility in male mice. Andrologia. 2018 Oct;50(8):e13064. doi:10.1111/and.13064
92. Khaleel H, Thaker SM, Haneen Abdulsalam Ali. Improving Effects of Shilajit on Monosodium Glutamate Induced Testicular Changes in Male Mice. J Appl Sci Eng Technol Educ. 2025 Dec 31;7(3):581–93. doi:10.35877/454RI.asci4397
93. Maparu K, Singh S. Unlocking the potential of Shilajit in Vascular Dementia behind pathology and management - A concise review. Brain Disord. 2025 Sep;19:100244. doi:10.1016/j.dscb.2025.100244
94. Impact of Shilajit on Semen Quality and Reproductive Performance in Male Rats: A Protective Role Against Cadmium-Induced Toxicity. Al-Qadisiyah J Vet Med Sci. 2025 Mar 10. doi:10.29079/qjvms.2025.157187.1070
95. Park JS, Kim GY, Han K. The spermatogenic and ovogenic effects of chronically administered Shilajit to rats. J Ethnopharmacol. 2006 Oct;107(3):349–53. doi:10.1016/j.jep.2006.03.039
96. Idrees M, Ahmad M, Gul ST, Ahmad I, Sallam MA. Effects of Asphaltum (Shilajit) Combined with Vitamin E and Selenium on the Reproductive Parameters of Female Rabbits. Pak Vet J. 2016.
97. Quazi RS, Chougule V, Shinde MU, Quazi AI, Gunjegaokar SM, Joshi AA. A Powerful Molecule of Ayurveda Science. Pharmacogn Res. 2023 Jun 15;15(3):455–61. doi:10.5530/pres.15.3.046
98. A F, Rc G, Jt G, Ma L, Td C, Sr K. Anti-Arthritic Efficacy And Safety Of Crominex® 3+ (Trivalent Chromium, Phyllanthus emblica Extract, And Shilajit) In Moderately Arthritic Dogs. J Vet Sci Anim Husb. 2014 Feb;1(4). doi:10.15744/2348-9790.1.401

99. Pandit S, Biswas S, Jana U, De RK, Mukhopadhyay SC, Biswas TK. Clinical evaluation of purified Shilajit on testosterone levels in healthy volunteers. Andrologia. 2016 Jun;48(5):570–5. doi:10.1111/and.12482
100. Ding R, Zhao M, Fan J, Hu X, Wang M, Zhong S, et al. Mechanisms of generation and exudation of Tibetan medicine Shilajit (Zhaxun). Chin Med. 2020 Dec;15(1):65. doi:10.1186/s13020-020-00343-9

**Acknowledgements**
The authors sincerely thank the Department of Pharmacognosy, SRM College of Pharmacy, SRM Institute of Science and Technology, Kattankulathur, for providing the facilities and academic support to carry out this research. The authors also acknowledge the researchers whose published studies formed the basis of this systematic review and meta-analysis.
**Funding Statement**
The authors declare that no specific funding was received from any public, commercial, or not-for-profit funding agency for this study.
**Conflict of Interest**
The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this manuscript.
**Author Contributions**
SS: Conceptualization, literature search, study selection, data extraction, quality assessment, statistical analysis, interpretation of results, and manuscript drafting. SPS: Methodology, supervision, critical review, and manuscript editing. KR: Methodology, critical review, and manuscript editing.