



Shilajit: Nature's Elixir

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ABSTRACT:

Shilajit is a complex substance with a range of beneficial constituents that contribute to its pharmacological activities. Respected as a powerful rejuvenator and adaptogen, shilajit is well-known for its many therapeutic benefits, which are mostly ascribed to its abundant fulvic acid, humic, and vital mineral content. This paper explores the phytochemical profile of shilajit, its historical relevance, and its traditional uses in immune support, metabolic disease management, vitality promotion, and cognitive function enhancement. It also looks at recent research that supports its pharmacological potential, such as its neuroprotective, antidiabetic, anti-inflammatory, and antioxidant properties. In order to guarantee efficient and sustainable use, the assessment also discusses the difficulties associated with its toxicity due to presence of heavy metals and standardization, ensuring its safety. Thus, the aim of this paper is to summarize literary findings of different research works by the scholars around the world with modern techniques as well as emphasising the importance of Shilajit as described in classical texts.

1. Introduction:

Shilajit scientifically known as *Asphaltum punjabianum* and locally popular as salajit, shilajatu, mimie, or mummiyo is a complex, naturally occurring blackish-brown tar like substance which is the purest form found in the high mountain rocks especially in Himalayan mountains between India & Nepal [1]. The Sanskrit word "Shilajit" means "Winner of rock" and "Conqueror of mountains and destroyer of weakness." Shilajit is described as "Stones of metal like gold" in ancient Ayurvedic writings such as the Charaka Samhita and as "A gelatinous substance" in the Sushruta Samhita. It's a natural remedy that has been used for many years by people to improve their health and function in diabetes, as well as in the nervous, immune, digestive, heart, and urine systems, and to cure nearly any type of illness.

Shilajit is a fluid substance with a pale-brown to blackish-brown color that arises from the layers of rock across various mountain ranges around the world, notably the Himalayan peaks and the Indian subcontinent. Its complex blend of humic organic chemicals and plant and microbial metabolites found in the rhizospheres of rocks in its native habitat has been

identified as its composition. For thousands of years, shilajit has been used as an adaptogen and revitalizing plant in various traditional medical systems throughout various nations. Numerous medical benefits have been linked to it, many of which have been verified by recent scientific research. It is stated that Shilajit possesses numerous extraordinary abilities for healing.

2. Methodology:

We systematically reviewed scientific databases like PubMed, Web of Sciences, Google scholar, Scopus, Science direct and Cochrane library to obtain scientific data on Shilajit. This search approach involved retrieval and review of existing evidence on the therapeutic and health-promoting properties of Shilajit, particularly in the context of its role as an Ayurvedic remedy. The specific keywords used for the search included "Shilajit," "shilajatu," "mummiyo" [1] "Ayurveda," "Chemical composition," "Preclinical studies," "Clinical studies," and "Toxicological studies". All the articles were assessed and reviewed for relevance by examining both the titles and abstracts of the publications. Preference was given to the studies providing full texts or abstracts.



The information obtained was initially screened and the inclusion and exclusion criterias were applied. The inclusion criteria were defined as: a. chemical composition of shilajit, b.

Traditional uses of Shilajit, c. Toxicological studies of shilajit, d. Applications of shilajit, e. Preclinical and clinical studies of Shilajit. The exclusion criteria eliminated a. Studies demonstrating nutraceutical activity of shilajit with other rasayanas.

3. Origin of Shilajit:

Shilajit being procured from natural resources has been widely used in the traditional medicine for centuries being considered as a potent nutraceutical. Many experts assert that the shilajit that emerges from a mountainous layer of rocks is primarily vegetative in origin [2] [3] [4]. These topics are also covered in the Sushruta Samhita and rasarangini, two ancient scriptures. According to Sushruta Samhita, during May and June, the intense heat of the sun causes plant sap, or latex juice, to emerge as a gummy exudate from mountain rocks. Rasarangini and Dwarishtarang assert that shilajit is a plant exudate consisting of latex gum resin and other materials that emerge from mountain rocks under intensely hot conditions. However, precise scientific evidence about the genesis of shilajit is still lacking. Regarding the genesis of Shilajit, several theories exist. In particular, biological, geological, and bio-mineralogical. according to the biological theory of shilajit, it is the outcome of a biological conversion that occurs under particular physiochemical conditions and involves either animal feces, dead plant remains, or both. This is in opposition to the geological viewpoint, which sees shilajit as a consequence of geological processes. In conclusion, the idea that shilajit is a byproduct of the various migratory processes that produce the mineral constituents—such as mechanical contamination of a liquid shilajit precursor—is the foundation of the bio-mineralogical geological processes [5].

Furthermore, Shilajit originates from sea animals, specifically fossilised invertebrates such as ammonites and molluscs [6]. Nonetheless, Shilajit is derived from rocks as evidenced by its global distribution in sedimentary rocks, the remarkably similar nature of its principal active constituents, and its great abundance inside rocks at high altitudes and in places that are inaccessible to land animals [6]. Humus and other organic components are the primary components that

define soil and Shilajit. The most likely source of shilajit is latex-bearing plants, notably *Euphorbia royleana* and *Trifolium repens*, which are found close to the rocks that contain Shilajit [1] [7] [8] [9]. There have been claims made that the formation of shilajit is due to bryophytes, namely the mosses of species like *Barbula*, *Fissidenc*, *Minium*, *Thuidium*, and species of Liverworts like *Asterella*, *Dumortiera*, *Marchantia*, *Pellia*, *Plagiochasma*, and *Stephenrencellaa anthoceros*, which were found near rocks that exuded Shilajit [2] [10]. The minerals and metals found in the tissues of the bryophytes, such as copper, silver, zinc, iron, and lead ore, are comparable to those found in shilajit.

4. Shilajit in Indian Traditional Medicine:

In traditional books of Ayurveda Siddha and Unani medicine, Shilajit holds a special and significant position as it is useful in various physiological conditions. Shilajit is given to treat anaemia, chronic bronchitis, epilepsy, jaundice, gallstones, digestive disorders, enlarged spleen, and neurological disorders. There have also been claims that shilajit has strong aphrodisiac properties. Ayurveda states that shilajit prevents ageing and promotes regeneration, two crucial components of an Ayurvedic rasayana [11]. Kidney stones, oedema, piles, internal antiseptic, obesity, fat reduction, and anorexia can all be treated with shilajit. Guggul and shilajit are recommended together to cure fractures as it is thought to create a callus at the joints. Additionally, the same mixture is utilised to treat spondylitis and osteoarthritis. Shilajit is also utilised as yogavaha, an agent that improves the qualities of other medications. In order to boost their effectiveness, shilajit is soaked in the decoction of one or more of the following plants: *Sida cordifolia* (bala), *Catechu nigrum* (catechu), *Shoria robusta* (sala), *Bachanania lactifolia* (piala), *Acacia fernesiana* (acacia), *Terminalia tomentosa* (asana), and *Terminalia chebula* (myrobelan) [12] [13].

Shilajit is mentioned under rasayana category in Charaka Samhita, the oldest text of Ayurvedic system of medicine. Charaka has stated that shilajit can be used in several diseases by altering the anupana (vehicle) and adjuvant in combination with several drugs. Sushruta has described shilajit in madhumeha chikitsa (diabetes mellitus). In his text, purified shilajit is advocated in madhumeha along with the decoction of *Shorea robusta* group of plants [14].



Shilajit is an important drug of the ancient Hindu Materia Medica and was used extensively by the Hindu physicians for the treatment of a variety of diseases.

Several traditional and modern therapeutic uses of shilajit are given in the following Table no 1

Table 1. Traditional and Modern Therapeutic Uses of Shilajit [1].

Sr.no.	Indications	Reference
1	Panacea/rejuvenation	[15] [11] [16]
2	Longevity	[15] [17]
3	Skin disease (leprosy, parasitic and others)	[3] [15] [16] [18]
4	Digestive disorders (anorexia, abdomen enlargement, haemorrhoids/piles, rectal fistula, gastrointestinal worms, enlarged spleen, gallstone, ascites)	[3] [15] [19] [18] [16] [20] [21]
5	Cardiovascular/hematopoietic disorders (jaundice, oedema, elephantiasis, anaemia)	[15] [19] [18] [20] [16]
6	Neurological/psychiatry disorder (epilepsy, insanity, loss of consciousness, stress)	[3] [15] [19] [18] [16]
7	Respiratory disorders (cough, chronic bronchitis, dyspnoea, asthma)	[3] [20] [3] [18]
8	Urinary disorder (dysuria, kidney stones, chronic urinary tract disorders)	[16] [18] [22]
9	Diabetes mellitus (Madhumeha) (administered with milk)	[15] [11] [16]
10	Aphrodisiac	[11]
11	Obesity/adiposity	[16]
12	Musculoskeletal disorders (fractures, arthritis, osteoarthritis, spondylitis)	[3] [22] [19] [18] [21] [23] [24]
13	Yogavaha (agent that enhances the property of other drugs)	[25]
14	High altitude problems (hypoxia and weakness including muscular degradation, acute mountain sickness, pulmonary oedema and pain, cerebral oedema and dementia, GI disorders and dehydration)	[26]



15	Reproductive (including endocrine) disorders (sexual debility, infertility, menstrual disorders, postpartum disorders, thyroid dysfunction)	[22] [19] [18] [27] [28]
16	Cancer	[19]
17	Infectious diseases and immunology (weakness, debility, AIDS, fever/chronic fever, urinary tract infections)	[15] [22] [19] [18] [20] [16] [28]

Table 2. Phytoconstituents in Shilajit, their medicinal uses.

These compounds work synergistically to provide the wide range of health benefits associated with shilajit,

SrNo.	Composition	Pharmacological Activity	References
1	Fulvic acid	Antioxidant activity, Anti-inflammatory effects, Neuro-protective properties, Immunomodulatory effects	[29]
2	Humic acid	Antioxidant and free radical scavenging properties, Gastrointestinal protective effects, Anti-inflammatory and analgesic properties	[30]
3	Amino acid	Neurotransmission, Pain modulation, and Stress adaptation	[31]
4	Dibenzo-Alpha-Pyrones	Adaptogenic properties	[32]
5	Trace Elements (Minerals)	Selenium: Antioxidant & anti-inflammatory effect Iron: Hematopoietic and oxygen-carrying properties Manganese: Energy metabolism, Energy production Zinc: Immunomodulatory effects and wound healing Magnesium: Supports Bone formation Healthy Immune response	[33]

Table 3. Receptor binding mechanisms [2].

SrNo.	Pharmacological Activities	Mode of action
1	Adaptogenic properties	Helps regulate the production of stress hormones, supporting the body's ability to adapt to stress.
2	Antioxidant activity	Prevents oxidative damage to cells and tissues by acting as a scavenger of free radicals.
3	Anti-inflammatory activity	Decreases the production of prostaglandins, which are known to induce inflammation, and inhibits the expression of COX-2.



4	Anti-diabetic effects	Preserves pancreatic beta cells, increases insulin sensitivity, and modifies glucose metabolism.
5	Anti-aging	Shilajit increases the life of cells by boosting mitochondrial function, lowering oxidative stress, and activating genes linked to cellular repair and longevity

5. Physical properties:

Shilajit samples from various global regions exhibit consistent physical characteristics and similar chemical composition, but there are significant variations in the proportional ratio of their constituents. For example it is noticed that regional variations in fulvic acid content have been observed, with Kumaon (India) shilajit exhibiting a higher content of Fulvic acid ratio (21.4%) compared to shilajit sourced from Nepal (15.4%), Pakistan (15.5%), and Russia (19.0%).[12]

When Shilajit dissolved in water, approximately 30-50% of shilajit's weight dissolves into the liquid, while the remaining portion consists of mineral and plant residues, with quantities varying depending on the shilajit's purity. Shilajit is a viscous, resilient substance with a glossy surface, dissolving in water, alcohol, and acetone. The pH levels of 1% shilajit aqueous solutions fluctuate by different sources: India (Kumaon): 6.2 Nepal, (Dolpa): 7.5, Pakistan (Peshawar): 6.8, Russia (Tien-Shan): 8.2

The Thermal behaviour of shilajit sample varies by batch to batch as revealed by thermal analysis. In oxidizing conditions, shilajit exhibits exclusively exothermal processes, except during dehydration (up to 150°C), releasing approximately 7% water. Shilajit exists in two primary forms based on its physical properties viz Gomuthira Shilajit: A semi-hard, brownish-black to dark, greasy resin with a distinct coniferous smell and bitter taste and Karpura Shilajit: A white variety which is calcined oxide [5]

Gomuthira Shilajit is further classified into four subtypes based on the predominant metal ore found in the mountains from the place it is sourced.

1) Savrana Shilajit (Golden Shilajit): savarna is a word derived from Sanskrit which depicts gold hence it is called as golden shilajit which is present in red color, associated with gold.

2) Rajat Shilajit (Silver Shilajit): White in color, processed with silver elements.

3) Tamra Shilajit (Copper Shilajit): Blue in color, processed with copper.

4) Lauha Shilajit (Iron-containing Shilajit): Brownish-black in color, processed with iron.

The Tamra and Savrana varieties of Shilajit are rare whereas Lauha Shilajit is commonly found in the Himalayan Mountains. Shilajit consists of organic matter and total mass loss in air amount 67.6% and in an inert atmosphere a completely different behaviour is observed. The other physicochemical properties are: Loss on drying - 8.04%, Ash value - 18.76%, Acid insoluble ash - 10.57%, Water soluble ash - 84.66%.

6. Chemical composition:

Shilajit consists of three main components:

a. Bioactive compounds: Low to medium molecular weight non-humic substances, including free and conjugated fatty acids, amino acids, and lipids, as well as dibenzo- α -pyrones.

b. Chromoprotein complexes: Medium to high molecular weight compounds (DCPs) containing trace metals, carotenoids, indigoids, and other pigments.

c. Humic substances: Metallo-humates, comprising fulvic acids, fusins, and dibenzo- α -pyrones, forming the core nuclei. [6].

Shilajit's complex chemistry contributes to its potential therapeutic properties. The geo-environmental and climatic conditions significantly influence the chemical profile of shilajit such as Proximal flora, Geological substrate, Temperature regimes, Humidity levels altitudinal differences. Fulvic acid derived from organic matter biodegradation, boasts exceptional chelating properties and is standardised in premium supplements to comprise: At least 50% fulvic acids, polymers, and related compounds minimum 10% dibenzo-a-pyrones (DBPs) and DBP chromoproteins [34] [35]. Processed shilajit's mineral profile is predominantly potassium, calcium, and magnesium, accounting for over 90% of its



total mineral content, while sulphur and sodium are notable secondary constituents.

The composition of Shilajit are Humic acid in 80-85%, Non humic substances- 15-20%, Mineral- 18-20%, Protein- 13-17%, Lipids- 4-4.5%, Steroids- 3.3-6.5%, Nitrogen containing compounds- 18-20%, Carbohydrates- 1.5-2.0%, Alkaloids, amino acids- 0.5-0.8%, other compounds- 0.5% etc [36].

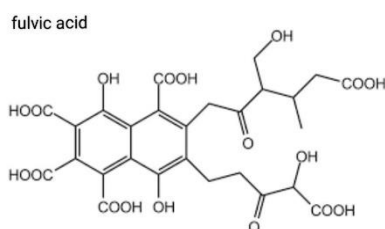


Figure 1. Structure of Fulvic acid.

7. Toxicity of Shilajit:

As an exudate of rocks, the composition of Shilajit exists as 60-80% organic matter, 20-40% mineral matter, and 5% trace elements, soil particles. Shilajit contains many impurities, including gravel, sand particles, plant debris, polymeric and toxic materials, etc.

Despite having abundant health benefits, it possesses some toxic effects if left unprocessed. The sources of toxicity in herbo-mineral preparation are improper identification of crude drugs, adulteration/substitution, manufacturing under unhygienic conditions, lack of technically qualified persons, improper quality control checks, and inadequacy of the present laws. Other than this, Shilajit is also highly susceptible to impurities, as it is contaminated with adulterants, mycotoxin, heavy metal ions such as lead, mercury, arsenic, polymeric quinones, reactive free radicals, and toxins. Therefore, it should be used after the purification process.

The elemental composition of Shilajit was determined with the help of leading-edge analytical methods such as LIBS, ICP, and EDX. The spectrochemical quantitative and qualitative analysis for nutrient and toxic heavy metals, it was found that Shilajit samples contain several elements like Ca, S, K, Mg, Al, Na, Sr, Fe, P, Si, Mn, Ba, Zn, Ni, B, Cr, Co, Pb, Cu, As, Hg, Se, and Ti by using Laser-Induced Breakdown Spectroscopy (LIBS) [37]. Shilajits from Pakistan and India contain not only the amounts of Al, Sr, Mn, Ba, Zn, Ni, B, Cr, Pb, As, and Hg toxins, but also useful nutrients like Ca, S, and K for the

human body, which are found in a greater concentration than the permissible limit.

Although the amounts of most elements such as Ca, Mg, K, Na, Fe, Cu, and Zn, were identical between both the Shilajits, overall the Indian Shilajit had higher concentrations of nutrients and toxins, except Hg and Ti. The reproducibility of element quantification was analyzed using self-developed calibration-free Laser-Induced Breakdown Spectroscopy (CF-LIBS) and the conventional ICP OES/MS method and validated by performing EDX spectroscopy.

The efficacy of ayurvedic products for addressing its therapeutic indications must be weighed against potential health risks, including lead poisoning, as evidenced by clinical findings [38].

The rhizosphere of Shilajit was found to be heavily infested, at the periphery with fungal organisms [12]. Some of these fungi produced lethal mycotoxins, e.g., 12,13-epoxy trichothecenes and naphtho-y-pyrones, in laboratory cultures.

Some toxicological studies to assess the potential dangers of the compound were examined:

a. In-vitro cytotoxicity study:

The in-vitro cytotoxicity assessment of Shilajit on L929 mouse fibroblast lines by MTT-based colorimetric assay using 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide was performed & it was found that as the dilution of the shilajit extracts increased, the amount of cell viability was also increased, thereby reporting that the diluted extract of the concentrated shilajit demonstrated to be less cytotoxic [39].

b. LD50:

The acute LD50 value of a purified shilajit was found to be 1,000mg/kg when administered intraperitoneally and more than 2,000mg/kg when given orally to rats [40].

The LD50 of Kumaon shilajit, when assessed in albino mice, was of a very low order; this suggests that there is a wide margin between the effective dose and the toxic dose [12]. This study also investigated the time and dose-dependent effects of shilajit solution on mouse peritoneal cells, revealing changes in cell morphology, enhanced phagocytic activity, and increased internalization.

c. Sub chronic toxicity study:

A 90-day sub chronic toxicity study found no adverse effects on major organs or systems in rats administered with shilajit at doses of 200-1,000 mg/kg [41].



Additionally, shilajit showed no embryotoxic or teratogenic effects in pregnant rats and mice.

d. Genotoxicity study:

10, 30, and 100mg/kg of processed shilajit did not produce any metaphase chromosomal aberrations in bone marrow [35].

e. Adverse effect:

A 45-day placebo-controlled study involving 20 healthy participants found no adverse effects on key vital signs (heart rate, blood pressure, body weight) and blood chemistry parameters (glucose, urea, creatinine) from daily 2000 mg Shilajit supplementation [42].

From the above studies involving animals and humans, it has been demonstrated that shilajit is remarkably safe. Despite the adverse effects of the heavy metal found in shilajit, vishadravya (poisonous substances) of plant and mineral origin (herbomineral) are used in Ayurveda owing to their efficacy in small doses as compared to nonpoisonous drugs. They can be utilized in therapeutics, individually or in formulations if they are subjected to some traditional processing techniques that render them safe for internal administration. Thus, marketed formulations of shilajit and shilajit-containing preparations that are unpurified or unprocessed and commercialized as proprietary 'health products' in India, Pakistan, and any seldom-used country will counter potential health risks.

8. Purification process:

There is a strong need to create a Shilajit formulation using its isolated active components. The concept of Rasa-shastra in Ayurvedic medicine describes that the shilajit in its natural state poses a synergistic mechanism producing enhancement in response if it is prepared, administered, and consumed properly. This not only enhances safety but also results in enhanced therapeutic efficacy.

The different methods for purification of Shilajit:

1) Traditional method:

The most traditional purification process named Shodhana is suggested by the Ayurvedic scholar, which works by imparting certain physical, chemical, and biological changes that influence phytochemicals, pharmacological, and toxicological profiles in the shilajit through the incorporation of medicinal properties into the drugs. This is done by preparing the decoction of Triphala, a blend of

three medicinal fruits (*Embelica terminalia*, *chebula*, and *Terminalia bellerica*).

Shodhana (purification) is the process that involves the conversion of any poisonous drug into beneficial, nonpoisonous/nontoxic ones. This comprises purification as well as a decrease in the levels of toxic constituents (active toxic principles), the removal of the Doshas apart from the incorporation of desired therapeutic activity.

Shodhana of Shilajit can be of 2 types:

Samanya Shodhana (applicable to a large number of metals or minerals) and Visesa Shodhana (applicable to certain drugs and in certain preparations such as bhasma, rasayana, kwatha). This transformed drug becomes fit for further processes like Marana, Amritikarana and Lohitikaraan.

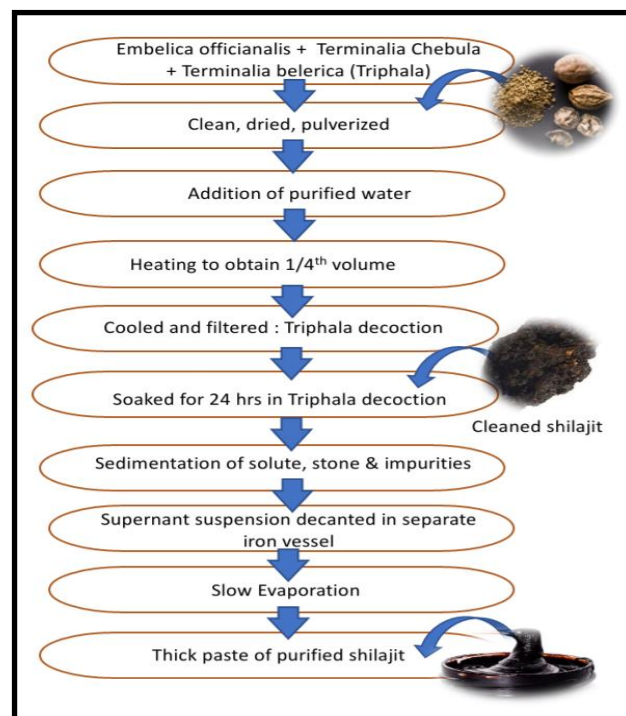


Figure 2. Shodhana process by Triphala decoction.

2) Modern Method:

The herbo-mineral drugs can be purified by following 2 steps: Heating & Quenching [43].

a. Heating: Simply the raw herbo-mineral is heated until red hot. This brings the reduction of rigidity and particle size of the drug structure, including redox reactions, dehydration, and thus structural distortion. The heating



temperature is estimated by determining the relationship between the structural stability of shilajit at an elevated temperature.

b. Quenching: Also meant as immediate cooling in liquid media after heating results in a decrease in tension and an increase in compression force. Thereby the liquid medium immediately penetrates inside the structure and soluble impurities get dissolved. Quenching brings ion exchange between the impurities and solvent, leaching out toxic elements and the incorporation of soluble ions. The major liquid medium could be cow urine, cow milk, vinegar, Triphala decoction, and gruel (a herbal mixture that is acidic like vinegar) used for quenching purposes. This heating and quenching or dipping is repeated a number of times depending on the rigidity of the mineral structure for complete purification.

3) Other Methods:

Vilayan and Prithakkaran:

Three principles of hammering, dissolution, filtration, and separation were adopted for the purification of crude Shilajit [44]. In this, a fractional or sequential treatment of different solvents on the exudated & powdered Shilajit is carried out. Includes successive extractions of raw Shilajit with hot organic solvents of increasing order of polarity (chloroform, ethyl acetate, and methanol) so as to obtain a broad spectrum of bioactive compounds [45]. The procured residue is dried by a hot air oven and approximately 37% yield can be obtained.

4) Modern technologies involving the influence of centrifugation, spray drying methods, an ultrasonic cavitation are also widely used for extraction and purification. The study aims to optimize Shilajit extraction and purification techniques by minimizing impurities. The key findings as per Bugaev et al. include: i. An optimal 1:2 ratio of raw Shilajit to extractant, without ultrasound, yields the lowest impurity levels. ii. Centrifugation significantly reduces aluminum and silicon contaminants during solution purification. iii. Incorporating spray drying in the production process further decreases impurities in the final Shilajit product. Further, the elemental analysis is done by using S8 tiger wave X-ray fluorescence spectrophotometer. The measurements were carried out in a vacuum using the software QUANT EXPRESS with the matrix CH2 result processing was obtained using Spectra Plus.

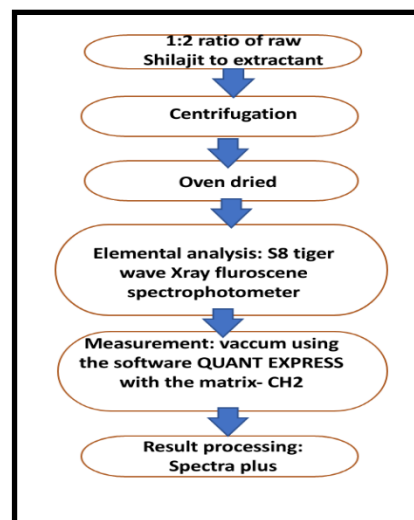


Figure 3. Modern technique of purification.

A purified Shilajit composition must contain at least 40% w/w Fulvic acid, and the active ingredient includes 0.5–40% weight of Fulvic acid. Appropriate Standardization techniques should be used to ensure consistency and quality of Shilajit [46]. Such techniques include U.V. spectral analysis, XRD (X-ray diffraction) analysis, SEM with EDAX analysis, FTIR (fourier transform infrared) analysis, TEM (transmission electron microscope) analysis, and MTT cell proliferation assays for drug cytotoxicity.

According to ancient literature, the Marana (incineration) process enhances the effectiveness of herbo-mineral drugs by producing nano-sized particles, increasing absorption. However, Shilajit's petroleum-based nature makes it unsuitable for direct heat, contradicting traditional purification methods. Specifically, the Kanta Lauha Bhasma and Vaikranta Bhasma processes, mentioned in RasRaj Sundar's Maharasa chapter, are inapplicable to Shilajit. Moreover, the Kushta method, involving contact heating and wet grinding with herbal extracts, boosts absorption by decreasing particle size of purified shilajit but is unsuitable for due to physical properties of Shilajit, this proves that the traditional Marana and kushta process for Shilajit is ineffective.

9. Preclinical Studies:

a. AntiInflammatory and antiulcerogenic activity:

An investigation was conducted on shilajit samples from various geographical locations to assess their potential



antiulcer and anti-inflammatory properties. Research revealed that shilajit supplementation enhanced the carbohydrate-to-protein ratio and reduced the gastric ulcer index, suggesting an augmented mucus barrier. It has been shown to effectively reduce inflammation in three models: acute, subacute, and chronic [40].

Shilajit (50 mg/kg, i.p.) was found to be effective in treating carrageenan-induced acute pedal oedema, comparable to phenylbutazone (0.25 mg/kg, i.p.) and betamethasone (i.p.).

The study found that shilajit is not only an anti-inflammatory but also a powerful anti-ulcer agent. This makes shilajit a promising candidate for clinical use as it is considered safe for mice at doses up to 3 grams per kilogram.

b. Antioxidant activity:

Studies conducted in adult male Wistar rats demonstrated that processed Shilajit offers full protection against hydroxyl radical-induced polymerization caused by methyl methacrylate. Administering 20-50mg/kg/day of shilajit for 21 days increased enzyme activities, specifically:

Superoxide dismutase (SOD), Catalase (CAT), Glutathione peroxidase (GPX). These results were comparable to the monoamine oxidase-B inhibitor, (-)-deprenyl [47].

c. Learning augmentation:

Shilajit's potential cognitive-enhancing and anti-anxiety effects was conducted on albino rats. The results showed that Shilajit significantly improved learning, memory, and reduced anxiety. Brain chemical analysis revealed that short-term use had minimal impact, but 5-day treatment

showed decreased serotonin (5-hydroxytryptamine) levels, Increased dopamine levels and related compounds and had no significant effect on norepinephrine levels. These changes suggest Shilajit's cognitive and anti-anxiety effects may be linked to reduced serotonin activity and increased dopamine function, supporting its potential as a natural nootropic and anxiolytic agent [48].

d. Osteoarthritis:

Osteoarthritis (OA) is a debilitating joint disease affecting millions worldwide, characterised by loss of motion and chronic pain. Conventional treatments often come with significant side effects, prompting the search for alternative therapies. Shilajit, a traditional folk medicine, has been used to treat arthritis and bone

fractures. A study investigated Shilajit's efficacy in alleviating OA symptoms using a rat model. Thirty-six adult male rats were divided into two groups: OA-induced and Shilajit-treated. OA was induced via monosodium iodoacetate injection, while Shilajit aqueous extract was administered daily for 21 days. Initial findings showed joint swelling and congestion in both groups. Histopathological examination revealed, surface irregularity and erosion, Cartilage fissures, Necrotic chondrocytes, Subchondral bone lysis. Synovial tissue analysis indicated synovial cell hyperplasia and inflammatory cell infiltration. After 7 and 14 days, both groups exhibited moderate to advanced OA without significant differences [49].

e. Antidiabetic:

Bhattacharaya (1995) demonstrated that oral administration of 50-100 mg/kg of standardised Shilajit extract significantly reduced streptozotocin-induced diabetes in rats. This beneficial effect was accompanied by increased superoxide dismutase (SOD) activity in pancreatic islets, leading to reduced free radical production and accumulation [50].

Shilajit (100 mg/kg) significantly lowered blood glucose levels and improved lipid profiles. Furthermore, combining Shilajit with either glibenclamide (5 mg/kg/day) or metformin (0.5 gm/kg/day) synergistically enhanced glucose reduction and lipid profile improvements, exceeding the efficacy of each drug administered alone [51].

Shilajit extracts (aqueous and ethanol) demonstrated potent inhibition of alpha-glucosidase and alpha-amylase enzymes, outperforming the standard diabetes medication acarbose. Additionally, Shilajit's antioxidant properties make it a promising therapeutic agent for diabetes management [52].

f. Cardiovascular System:

Shilajit exhibited significant cardioprotective effects by Reducing serum marker enzymes (SGOT, SGPT, LDH, CK), Decreasing lipid peroxidation, Increasing glutathione (GSH) levels

These benefits were attributed to Shilajit's ability to enhance endogenous antioxidant defenses & inhibit membrane lipid peroxidation. Shilajit demonstrated protective effects against isoproterenol-induced oxidative cardiac damage [53].

g. Reproductive System:



The administration of Shilajit to rats showed a remarkable increase in the number of sperm of the epididymides in male rats, and in the number of ovulation-induced rats in females. These spermatogenic and ovogenic effects of Shilajit may result from the combined effect of its many constituents, i.e. mineral, fulvic acid, etc. However, further research will be needed to identify the active components of Shilajit. A study on Wistar Albino rats investigated the effects of Shilajit at doses of 50 mg/kg/day and 100 mg/kg/day. The results showed a significant increase in Intromission Frequency (IF), indicating improved sexual function. Additionally, sperm count was significantly improved ($p < 0.01$) by day 43 of treatment. The study also found that Shilajit supplementation led to increased weight of the testes, seminal vesicle, and prostate glands, indicating enhanced reproductive health.

A study on rams investigated the effects of Shilajit administration at doses of 800 mg/kg/day and 1600 mg/kg/day for a period of 49 days. The results showed a significant increase in libido score, indicating enhanced sexual desire. Furthermore, the study found that Shilajit supplementation led to a notable elevation in serum testosterone levels, which is essential for reproductive health and overall well-being [54].

10. Clinical studies:

Despite the significance of Shilajit in traditional medicine, only a few well-designed clinical trials have been done or are now ongoing.

i. Spermatogenic activity:

Processed Shilajit (PS) was assessed for its safety and spermatogenic potential in oligospermic patients. Sixty male patients with sperm counts below 20 million/ml were given 100 mg of Shilajit twice daily for 90 days. The treatment significantly improved sperm health: sperm counts increased by 37.6%, total sperm count by 61.4%, sperm motility by 12.4% to 17.4%, and normal sperm count by 18.9%. Serum testosterone levels rose by 23.5%, and follicle-stimulating hormone (FSH) levels by 9.4% [55].

ii. Antioxidant activity:

A 2003 clinical study by investigated shilajit's antioxidant effects in diabetic patients. Sixty-one diabetic subjects (ages 31-70) received 1000mg of shilajit (2 x 500mg capsules, Dabur, India) twice daily for 30 days. Results displayed significant decrease in

malondialdehyde (MDA) levels, indicating reduced oxidative stress. Significant increase in catalase enzyme activity, enhancing antioxidant defences. This study demonstrates shilajit's potential to improve antioxidant status in diabetic individuals [56].

iii. Energy production and physical performance:

A pilot study conducted by found that daily supplementation with 200mg of processed shilajit for 15 days significantly enhanced energy production and physical performance in six healthy individuals, as evidenced by increased ATP, ATP/ADP ratio, CoQ10, and other biomarkers. However, the study's small sample size limits its conclusive validity [35].

iv. Androgenic effect:

According to a randomised, double-blind, placebo-controlled clinical study evaluated the effects of purified Shilajit, an Ayurvedic rasayana, on healthy individuals aged 45 to 55. Administering 250 mg twice daily over 90 days resulted in significant increases ($P < 0.05$) in total testosterone, free testosterone, and dehydroepiandrosterone (DHEAS) compared to the placebo. Levels of gonadotropic hormones (LH and FSH) were consistently maintained [57].

v. Antidiabetic:

Shilajatu and Asanadi Ghana Vati seem to be effective and completely safe for the management of *Madhumeha* (type-2 diabetes mellitus) [58].

32 type 2 diabetes patients received capsules with 250 mg of Shilajit extract and 250 mg of Ashwagandha twice daily, morning and evening, resulting in significant improvements in fasting blood sugar and lipid profiles. Additionally, 56% of the patients experienced an improvement in hyperglycemia symptoms [59]. Diabetic patients have lower levels of potassium, magnesium, and zinc in their skeletal muscles compared to healthy individuals. A clinical trial with 7542 adults found that higher potassium intake is linked to lower levels of abdominal obesity and fasting hyperglycemia [60].

vi. Anti-infective:

Shilajit containing humic acid can prevent cancers and cancer-causing viruses. Humic Acid (HA) has been shown to have antiviral properties, specifically against HIV, by reducing HIV infection and replication, inhibiting viral fusion with T-cells, Activating T-lymphocytes, Enhancing IL-2 production by TH1 cells in HIV patients Humi Acid (HA) exhibits antiviral and cytotoxic properties, demonst rating efficacy against



HSV-1 infection by blocking viral replication in infected cells [61].

Clinical studies involving HIV patients with a compound formulation containing processed shilajit revealed distinct improvement in the symptoms and augmentation of CD4 and CD8 cell counts [62]. Antimicrobial activity: Shilajit extracts showed significant antifungal activity against *Staphylococcus aureus* and *Candida albicans*. Cytotoxic activity: Shilajit extracts exhibited significant cytotoxic activity against Hep G2 cell lines, with an IC50 value of 19 $\mu\text{g mL}^{-1}$ [63].

vii. Adaptogen:

Shilajit helps the body deal with high-altitude stress and strengthens the immune system. Shilajit, with its blend of fulvic acid and essential minerals in ionic form, supports the transportation of these minerals into cells, which helps maintain and restore their electrical function, preventing decay and death. It aids in metabolism, boosting energy production and maintaining a balance between catabolism and anabolism. Shilajit enhances the body's capacity for nutrient absorption and detoxification, stimulates the immune system, and promotes blood formation. For maintaining optimal

health, a daily dose of 300-500 mg is recommended, typically taken with milk twice a day. It reaches peak levels in the bloodstream 12-14 hours after consumption [41].

viii. Muscle strengthening activity:

A recent study explored the effects of Shilajit supplementation on muscle strength and fatigue. Shilajit supplements, particularly at a dose of 500mg per day, can help to maintain muscle strength after intense exercise, decreased muscle fatigue, especially in stronger individuals. More studies are needed to confirm these findings. Shilajit's benefits were most noticeable in stronger individuals and those with higher initial muscle fatigue [64]. A study conducted by on the effects of shilajit supplementation on muscle adaptation in overweight/obese adults. Participants received 250mg of Shilajit twice daily for 8 weeks, followed by 4 weeks of supplementation with exercise. Shilajit supplementation promoted skeletal muscle adaptation. Genes involved in ECM production, such as collagen, elastin, and fibronectin, were upregulated [65].

11. Formulation of Shilajit [66]:

Table 4. Different Ayurvedic Formulations containing Shilajit as a part of the composition [67].

Sr.No.	Name of the Formulation	Dose/Vehicle	Quantity of shilajit	Therapeutic Indication
1	Satavari Guda	6g Milk	12g	Dysuria, bleeding disorder, chronic obstructive jaundice/chlorosis/advanced stage of jaundice, phthisis, burning sensation of feet, disorder of female genital tract, menorrhagia or metrorrhagia or both, urinary disorders, obstructed movement of vata dosha, jaundice, menstrual disorder, discharge from bones, disease due to vata dosha and pitta dosha, used as a rasayana (nutrient to body and mind with adapto-immuno-neuro-endocrine-modulator properties)



2	Siva Gutika	12g Milk, meat soup, juice of pomegranate seeds, grapes and suitable asavas and arishtas	768g	Disorder of liver and spleen, diseases of abdomen/enlargement of abdomen, hiccup, hernia, abdominal lump, chronic rhinitis/sinusitis, cough, anaemia, heart disease, vomiting, gout, stiffness in thigh muscles, epilepsy, mania/psychosis, diseases of skin
3	Traikantaka Ghruta	12 g Warm water, warm milk	9.140g	Dysuria, urinary disorders, urinary calculus, urinary disorders
4	Vastyamayantaka Ghruta	12 g Warm milk	128g	Dysuria, urinary calculus, urinary disorders, disorder of urinary tract and bladder due to vata pitta dosha
5	Kaccuradi Curna	Applied externally on the head, with breast milk, castor oil or butter	1 part	Hiccup, chronic rhinitis/sinusitis, fever, headache due to vata dosha, headache due to pitta dosha, dementia, eye disorder, disease of ear, disease due to kapha dosha
6	Candraprabha Vati	250–500mg Water, milk	96g	Constipation, distension of abdomen due to obstruction to passage of urine and stools, colicky pain, cyst, anaemia, jaundice, dysuria, urinary disorders, calculus, haemorrhoids, tumour, urinary obstruction, hernia, lower backache, diseases of skin, itching, disorder of spleen, ascites associated with splenomegaly, fistula-in-ano, dental disease, eye disorder, tastelessness, impaired digestive fire, gynaecological disorders, dysmenorrhoea, vitiation of semen, weakness
7	Prabhakara Vati	125–250mg Water, potion of Terminalia arjuna, milk	1 part	Heart disease
8	Manasamitra Vataka	1g Milk	1 part	Mental disorder, mania/psychosis, epilepsy, retarded intellect, disorder of speech, gastro-enteritis with piercing pain, intoxication, syncope, coma,



				psychological disorder, snake poison
9	Siva Gutika (Laghu)	6g	384g	Anaemia, diseases of skin, fever, bronchial asthma, haemorrhoids, fistula-in-ano, dysuria, tuberculosis, urinary disorders, splenic disease.
10	Kantavallabha Rasa	125mg Honey	6 parts	Impaired digestive fire, mal-absorption syndrome, abdominal lump, disorder of spleen, ascites associated with splenomegaly, anaemia, cough, dyspnoea/asthma, pthisis, haemorrhoids, fistula-in-ano, fever, tastelessness, emesis, diseases of skin, pain due to vata dosha, weakness, emaciation, oligospermia
11	Arogyavardhini Gutika	250–500mg Ginger juice, honey, juice of Azadirachta indica (neem), water, milk	3 parts	Chronic fever, disorder of adipose tissue, diseases of skin, disorder of liver
12	Vataraktantaka Rasa	500mg Leaf/flower/bark juice of neem	1 part	Gout, disease due to vata dosha
13	Varisoshana Rasa	62.5–125 mg Trikatu potion, Triphala potion, juice of Ficus hispida	5 parts	Malabsorption syndrome, anaemia, ascites, inflammation, pleural effusion/hydrothorax, diseases of skin, digestive impairment, splenic disease, gastric ulcer/duodenal ulcer/colic, diseases of abdomen/enlargement of abdomen, general weakness
14	Indu Vati	1 pill of 250mg size Dissolved in 12 g juice of Indian gooseberry consumed in the morning	25mg	Dissolved in 12 g juice of Indian gooseberry consumed in the morning Tinnitus and diseases related to the ears

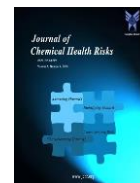


Table 5. Proprietary Drugs containing Shilajit [68].

Sr.No.	Drug	Indication	Quantity of Shilajit	Manufacturer
1	Tablet Abana (Heart Care)	Hypertension, hyperlipidemia and cardio-protection	20mg [69]	Himalaya Drug Company, Bangalore, India
2	Tablet Cystone (Uricare)	Urolithiasis, non specific urethritis including dysuria and chronic urinary tract infection	26mg [70]	Himalaya Drug Company, Bangalore, India
3	Tablet Diabecon (Glucocare)	Non-insulin dependant diabetes mellitus	60mg	Himalaya Drug Company, Bangalore, India
4	Syrup Evecare (Menstri care)	Dysmenorrhoea, menorrhagia and uterine tonic	5mg	Himalaya Drug Company, Bangalore, India
5	Syrup and Tablet Geriforte (Geri care)	Geriatric stress and general anxiety disorders	20mg	Himalaya Drug Company, Bangalore, India
6	Tablet Lukol	Non-specific leucorrhoea and pelvic inflammatory disease	18mg	Himalaya Drug Company, Bangalore, India
7	Tablets Nefrotec DS	Urolithiasis, diuretic and urinary antiseptic	25mg	Himalaya Drug Company, Bangalore, India
8	Tablet Pilex (Vein care)	Haemorrhoids and varicose veins	32mg	Himalaya Drug Company, Bangalore, India
9	Tablet Rumalaya (Joint care)	Arthralgia, osteoarthritis and cervical spondylosis	20mg	Himalaya Drug Company, Bangalore, India
10	Tablet Tentex forte (Vigour care for men)	Male sexual weakness	32mg	Himalaya Drug Company, Bangalore, India
11	Capsule Shilajit Gold	Gold Premature ejaculation, erectile dysfunction and increases the quality of the sperm	50mg	Dabur India, Ltd, New Delhi, India
12	Capsule Addyzoa	Oligospermia, asthenospermia, teratospermia and management of male functional infertility	30mg	Charak Pharma Pvt. Ltd. Mumbai, India



13	Tablets Femiforte and Femiplex	Excessive vaginal discharge due to fungal/bacterial/protozoal infection and recurrent vaginitis	20mg	Charak Pharma Pvt. Ltd. Mumbai, India
14	Tablet Hyponidd	Mild diabetes mellitus and polycystic ovarian syndrome	37.5mg	Charak Pharma Pvt. Ltd. Mumbai, India
15	Tablet Neo	Nocturnal semen emission and premature ejaculation	8mg	Charak Pharma Pvt. Ltd. Mumbai, India
16	Tablet Pallrywyn Forte	Premature senility or loss of libido in both sexes	20mg	Charak Pharma Pvt. Ltd. Mumbai, India
17	Tablet Pigmento	Vitiligo	0.9mg	Charak Pharma Pvt. Ltd. Mumbai, India
18	Tablet Prosteez	Benign prostatic hyperplasia	25mg	Charak Pharma Pvt. Ltd. Mumbai, India
19	Capsule Shilajit	Adaptogen	500mg	Charak Pharma Pvt. Ltd. Mumbai, India
22	Capsule Shilajit (3% fulvic acid)	Anti-stress, enhances memory and intellectual functions	400mg	Renaissance Herbs, California, USA and Dhanvantri Botanicals, Bangalore, India
23	Capsule Mumijo	Asthma, osteoporosis and diabetes	150mg	Apeiron Handels GmbH & Co. KG, Wallenhorst, Germany
24	Capsule Shilajit	Natural energy enhancer and aphrodisiac	500mg	Dabur International Limited, KBC Harrow Exchange, 2 Gayton Road, Harrow HA1 2XU, UK

12. Conclusion:

Shilajit is a naturally occurring safe, fulvic mineral complex exudate that is common to Indigenous system of medicine and is composed of fulvic acids, dibenzo- α -pyrones, proteins, and minerals. It also contains more than 84 minerals including copper, silver, zinc, iron, and

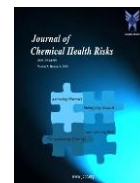
lead in their ionic forms. Shilajit purification is an important step to ensure its safety as without purification it may lead to risks of intoxication due to presence of mycotoxin, heavy metals, polymeric quinones etc. In this review attempts are made to highlight the purification methods both by utilising traditional as well as modern



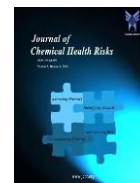
techniques. Many preclinical and clinical studies discussed emphasize its therapeutic activities. Apart from various claims regarding its therapeutic activity, it is need of the day that further research be undertaken based on modern scientific methods. Despite a number of claims about its therapeutic effectiveness, more research based on contemporary scientific methodologies is urgently needed. By investing in high-quality, evidence-based studies, we can ensure that we are not deprived of a potentially important natural substance with significant medicinal value. Thus the present review provides responsible exploration of Shilajit which could pave the way for new therapeutic applications in integrative and conventional medicine.

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