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REVIEW ARTICLE

Shilajeet: Classical *Ayurveda* Texts to Current Research - A Review

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Abstract

Shilajeet is popular worldwide for its medicinal, anti-aging, aphrodisiac, and many other properties. However, it has a wide and long history of use, and its availability, identification, and characterization are some of the most difficult conundrums, even for the related traditional medicine experts on scientific parameters. Information about it is scattered in various classical texts and research publications. This review gives a detailed description from various sources about the natural origin of *Shilajeet, its* availability, collection, classification, identification, purity, and analysis criteria, classical organoleptic characteristics and classical qualitative tests, physicochemical characteristics, organic composition, and elemental composition. Further, the properties of *Shilajeet*, research scopes, and the need and purpose of working on this drug from Indian medicine have been discussed.

Keywords: *Shilajeet, Shilajatu, Shilajit, Ras Shastra, Rasayan, Ayurveda*

1. Introduction

The *Ayurveda* system of medicine has its origin in *Vedas* onwards, later texts like *Charak Samhita, Sushruta Samhita*, etc., classical *Ayurveda* texts became the backbone of knowledge of *Ayurveda*. Further, with continuous research and experiences, some new branches evolved and became a very important part of *Ayurveda*. One such specialty of *Ayurveda* is *Ras Shastra and Bhaishajya Kalpana*. The development of *Ras Shastra* led to the trend of many new methods of formulation and use of many new substances of mineral, animal, and plant origin; e.g., Mercury, Mica, Tourmaline, Diamond, Coral, Gold, Silver, and many poisonous herbs. Many among them were already in use before the development of *Ras Shastra*'s specialty and *Shilajeet* is one among them.

It is popular worldwide for its medicinal, antiaging aphrodisiac and many other properties and is commonly known as *Shilajeet* in India in the *Hindi* language, originally known with *Shilajatu, Shiladhatu, Adrija*, etc. many names in *Sanskrit*[1] and *Hindi*[1] texts, *Shilaju* in Nepal, *Zhaxun*[2] in Tibetian and Chinese[2] or *Mumiyo*[3] in Russian, *Moumia* in Greek, *Mumie* in German, *Myemu, Moomiaii* or *Mumnaei* in Persian, *Brag-shun* or *Barakhshin* in South Siberian (Sayano-Altai Mountains), *Khakassia, Buryatia* in Mongolia, in Arabian region it is called *Araq-al-jibal* or

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Hajarul-Musa and it has also been claimed to be found in Peru and named as *Andean Shilajit*[3].

Even if it has a wide and long history of use; availability, identification, and characterization of *Shilajeet* is one of the difficult conundrums even for the experts. Even *Ayurveda Pharmacopoeia* of India does not have any details about the Identification and standardization of *Shilajeet.*

Raw *Shilajeet* is brittle stony[3] to crumbly material[4], without any specific shape, or porosity and it may have a significant quantity (by weight), of stony, sandy, and earthy impurities. As its nature of origin is not understood clearly, it has not been categorized absolutely as mineral, plant, or animal origin.

The composition of *Shilajeet* shows variations from source to source and study to study[5]. Broadly the composition of *Shilajeet* has been reported to have inorganic to organic materials like more than 85 minerals, Ca, Fe, Mg, Al, Na, K, P, S, Li, C, Mn, Ni, Si, etc. elements and compounds- eighteen free amino acids, m–hydroxybenzoic acid, sterols, tri-terpenes, ellagic acid, three bencoumarins[6] also Fulvic acid and Humic acid[7], benzoic acid[8].

As we see its description in classical texts and some recent work, *Shilajeet* is one of the most used and important drugs in *Ayurveda* and *Ras Shastra*. However, a large percentage of *Shilajeet* samples available in the market are not genuine. The analytical standards of *Shilajeet* are still not in Ayurvedic Pharmacopeia of India (API) or any authoritative publication.

2. Origin of *Shilajeet*

Following, the hypothesis about the origin of *Shilajeet* has been given by various researchers;

a. The *Shilajeet* organic matter in the rock formation is postulated to have evolved from the remains of paleontology[2]. This looks to be the best theory about the formation of *Shilajeet*. Indian researcher Ghosal S[9] suggested that *Shilajeet* originated from marine invertebrates and also a Russian[10] scholar suggested that it was derived from the fossils of higher plants[2,10].
b. Vegetation fossils[11] origin: The mode of origin of vegetation fossils[11] is similar to paleontological origin. This theory supports the availability of *Shilajeet* at sites other than the Himalayas.
c. Soil material origin is also possible. It may be thermally evolved from organic-rich mudstone and muddy sandstones adjacent to the mother rock[2].
d. It may also be derived from granitic magmatic differentiation. The magmatic activity was closely related to hydrocarbon accumulation and mineralization[2].
e. Vegetative origin[11]: A group of researchers consider *Shilajeet* to be of vegetative origin. As *Shilajeet* analysis shows it is mainly composed of humus and some other organic constituents.
f. Bryophytes[11] origin: Some species of mosses and liverworts of division Bryophyta have been observed around *Shilajeet*-exuding rocks and so these bryophytes may be responsible for the formation of *Shilajeet*.
g. Animal origin: The hypothesis of biological source believed that *Shilajeet* is a dry fecal coagulum of *Trogoupterus xanthotis, Ochotana erythrotis* i.e., fecal and urine conjugate of a species of squirrel[2,12]. Some researchers support this theory on account of the presence of albuminoids and hippuric acid[6].

Although *Shilajeet* is a natural product found in high hilly rocks its source is still unknown. Many hypotheses are there about its origin but its categorization like mineral, animal, or plant origin material, has not been done. By composition, *Shilajeet* is primarily organic and also contains mineral and trace elements. Raw *Shilajeet* that is found in rocks is somewhat brittle stony to crumbly material, without any specific shape and porosity, and commonly has a lot of stony, sandy, and earthy impurities. Its taste varies from sample to sample from Bitter, acrid, and pungent to salty and the odour is typically pungent like cow's urine.

3. Availability, Collection, and Procurement

Shilajeet is found in some rocky hills, mostly Himalayas from 1000 to 5000 meters. *Shilajeet* is generally collected by laymen and laborers and not by any scientific person or agency and used in various traditional medicines on experience-based identification methods. Although it is commonly available in the market with a lot of reported adulterations and substitutes also. The areas of availability are;

As per classical *Ayurveda* texts, Himalayan hills are the source[1,4] of *Shilajeet* though some recent

publications[4,5] claim the presence of *Shilajeet* in other parts of India[5,13,14] and also some other countries[2,3,14-16]. It is found in India; in the *Himalayan* region from Jammu and Kashmir- union territory, Himachal Pradesh[4], Uttarakhand[4] to Arunachal Pradesh[5] in India and also in Tibbat[2], China[2], Nepal[3], Bhutan, Russia, Central Asia, Iran, Mongolia and in the south of Peru[3]. It is also reported to be found in Badakhshan-Afghanistan[3,14,16], Muzaffarabad, Skardu, Chilas, Gilgit and Chitral[16] of Pakistan[14,16].

4. *In Situ* Collection Studies

Two in situ studies on *Shilajatu*, discussing *Shilajatu* analysis and availability have been published, one has been done in the North-East state of Arunachal Pradesh in Bomdila and Zero region[5].

Another work has been done in the Cuddapah district of Andhra Pradesh-south of the *Vindhayas*[13], published as "discovery of *gomutra Shilajatu* from South India[13]".

A protocol paper has been published claiming the availability[4,17] referring to a pilot study for the collection of *Shilajeet* from various sites of the Rampur region of Himachal Pradesh, India[4] (Figure 1).

A study on Quantitative Analysis for elemental composition published using Laser-Induced Breakdown Spectroscopy (LIBS) and Inductively Coupled Plasma/ Optical Emission Spectroscopy (ICP/OES) from Pakistan, reports the collection of samples from the northern Himalayan mountainous range at locations in Pakistan namely Muzaffarabad, Skardu, Chilas, Gilgit and Chitral[16].

One study published[14] on the inorganic analysis of *Shilajatu* samples from Afghanistan and Pakistan, however, the details of the source of the sample have not been described. An extensive in situ study has been done by a team of Chinese scientists[2] on *Shilajatu*, however, it was focused only on surveys to determine the origin of *Shilajatu* and mechanisms of generation and exudation.

5. Classification of *Shilajeet*

As per classical texts, *Shilajeet* has various types; six types[18,19]/four types[20-22]/two types[23] and have various colours[20] (Table 1). A colour similar to Guggul[19] i.e., blackish brown is considered the best[19].

Figure 1. Collection of *Shilajeet* from natural source; geological positions and samples[4,18].

Table 1. Types of *Shilajatu*

Sr. No.	No. of Types	Name of types	References
1	6	*Swarna, Rajat, Tamra, Lauh, Naag, Vang*	19
2	4	*Swarna, Rajat, Tamra, Lauh,*	20,21,22
3	2	*Gomutragandhi, Karpoorgandhi/ Suryatapi, Agnitapi/Sasatva, Nishatva*	23

6. Identification, Composition, Purity, and Analysis Criteria of *Shilajeet* (Figure 2)

6.1 Analysis Employed in Various Research (Table 2)

6.1.1 Elemental Analysis[14]

Following Methods has been used in various studies:

- Energy dispersive X-ray fluorescence (ED-XRF)[14]
- Inductively coupled plasma-optical emission spectrometry (ICPS-OES)[14]
- Laser-induced Breakdown Spectroscopy (LIBS)[16]
- Spectroscopy (ICP/OES)[16]
- Scanning electron microscopy[28]

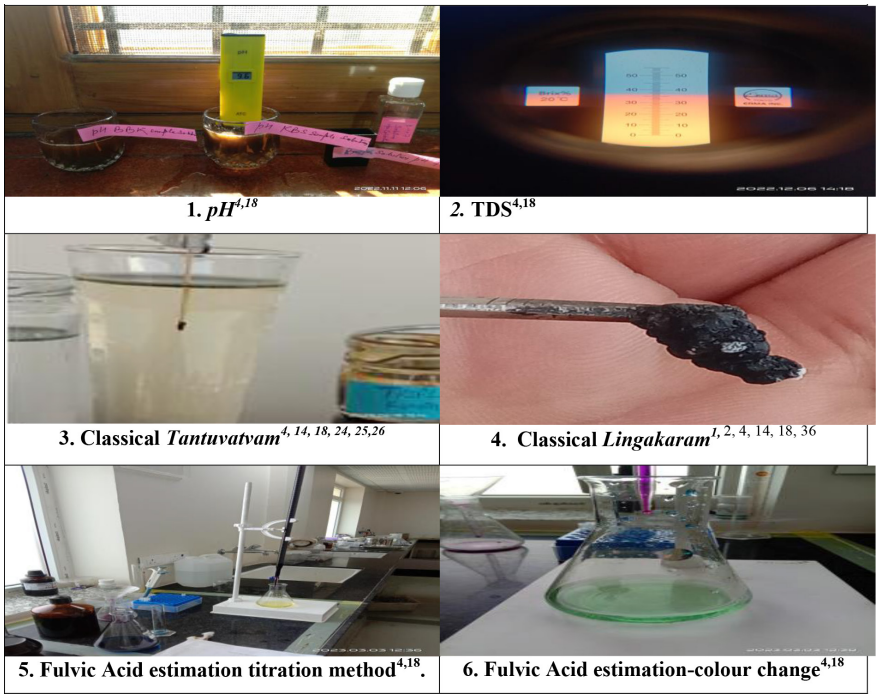

Figure 2.: Analysis of Shilajeet[4,18].

Table 2. Analysis employed in various research on *Shilajeet*[5,14,16,27]

Sr. No.	Qualitative Analysis as per *Ayurveda* (Classical Tests)
1	Organoleptic Analysis (including classical tests)
2	*pH*
3	Loss on Drying
4	Ash Value
5	Water Soluble Ash
6	Acid Insoluble Ash
7	Water Soluble Extractive
8	Alcohol Soluble Extractive

Table 2. Continued...

9	Assay for Elements; ICP-OES, LIBS-Spectroscopy, SEM-EDX, ED-XRF etc.
10	TLC (Various Methods) Manual, HPLC
11	Functional group study (FTIR)
12	Specific Spectroscopic methods/Analysis; *E4/E6* ratio
13	Fulvic Acid estimation
14	Humic Acid estimation
15	HPLC (methanolic extract[7])
16	Qualitative assays for constituents
17	Other Spectral analysis[28] - UV/Vis, FTIR, DSC and X-ray diffraction

6.1.2 Other Spectral Analysis[28]

Such as UV/Vis, FTIR, DSC, and X-ray diffraction, were performed. The *E4*/*E6* ratio was also determined. The spectral properties were compared with a humic acid standard from Sigma Aldrich[28].

6.1.3 Functional Group Identification

Different functional groups were identified using Fourier Transform Infrared (FTIR)-Spectroscopy[16,28].

6.2 Findings of Identification, Composition, Purity Criteria and Analysis of *Shilajeet* in Various Studies (Tables 3-6)

Here raw samples or processes are discussed; process is as per reference or as per details in publication, or unidentified process

- Organoleptic Findings Regarding Identification (Tables 3).
- Classical Qualitative Analysis/Tests (Tables 4).

Table 3. Classical organoleptic characteristics/other organoleptic analysis/characteristics

Sr. No.	Criteria	Value of *Raw *Shilajeet*	Value of *Processed/*Shudha/Bhawita Shilajeet*
1	Appearance/ Consistency	Somewhat brittle-stony to crumbly material, without any specific shape and porosity. Commonly have a good percentage of stony, sandy and earthy impurities[4]. Stony[24], *Maleenam*[25] *(Turbid, having impurities).*	The processed *Shilajeet* is most commonly found as Brownish-Black/Brown/Greyish-Brown, stick[29] and tenacious[29], paste (may be blended with some powder to convert in to powder form to be filled in the capsule or compressed in to tablets and occasionally dissolved in to some solvent (may be water) to make in to easily dispensable suspension form. Semi-solid[24], *Mridu*[27] (Soft), *Guggulabh*[30] (Like Indian myrrh), *Jatvabh*[30].
2	Colour	Brownish[24], *Maleena*[25]. Guggulabh[6,30] (Like Indian myrrh), *Jatvabh*[30].	Brownish-Black[20] *Krishna*[31] (Black), *Guggulabh*[27] (Like Indian myrrh), *Jatvabh*[30].
3	Odour	Gomutragandhi[1,24,32] (Like Cow urine)	Gomutragandhi[1,30,32] (Like Cow urine), Typical[24]
4	Touch	Hard[24]	Soft[24], Mridu[27] (Soft)
5	Taste	A combination of Salty, Bitter, Astringent, Pungent.	A combination of Salty, Bitter, Astringent, Pungent. (*Lavan, Tikta, Kashaya*[30]) (*Tikta, Katu, Kashaya*[32])

Table 4. Classical qualitative analysis/tests

Sr. No.	Criteria	Characteristic of *Raw *Shilajeet*	Characteristic of *Processed/ *Shudha/ Bhawita Shilajeet*
1	Test with Fire (*Vahano kshipatam*[1,24,26])	*Bhaved Lingakaram*[1,24,27], Bloats in fire.	*Bhaved Lingakaram*[1,24,26] Bloats in fire.
2	Test with Fire (*Vahano kshipatam*[1,24,26])	*Adhoomakam*[1,24,26]. Burns without smoke.	*Adhoomakam*[1,24,26] Burns without smoke.
3	Test with Water (*Ambhasi-Kshipatam*[24,25,26])	*addho-tantuvat*[24,25,26] descends in water in thready appearance.	*addho-tantuvat*[24,25,26] descends in water in thready appearance.

Table 5. Physicochemical characteristics

Sr. No.	Criteria	Value of *Raw *Shilajeet*	Value of *Processed/ *Shudha/Bhawita Shilajeet*
1	pH (1% aq. Solution[14]);	(6.8 and 6.2)[5] (6.2, 7.5, 6.8, 8.2)[29]	5.13[14], 4.74[14], 7.46[8], 6.5[24], 5.10[27], 5.26[27],
2	Loss on Drying	--	22.54[8], 12.0[24], 8.04%[27], 9.03%[27]
3	Ash Value	--	29.49[8], 6.0[24], 18.76%[27], 19.19%[27]
4	Water Soluble Ash	--	84.66%[27], 95.57%[27]
5	Acid Insoluble Ash	--	3.15[8], Traces[24], 10.57%[27], 11.70%[27]
6	Water Soluble Extractive (Solubility)	(30–50%)[29]	76.60[8], 94.8[24] (60%)[29]
7	Alcohol Soluble Extractive	--	19.12[8]
8	Benzoic Acid (Qualitative)	--	positive[8]
9	TLC (Manual Method)	--	R_f Value: - (0.25, 0.45, 0.62, 0.81; Solvent-$CHCl_3$: MeOH Iodine)[8]

- Physicochemical Characteristics (Tables 5).
- Quantitative Analysis (Tables 6).

Broadly these 36 criteria have been studied in various studies, though all studies were specific for one two, or some of these criteria, moreover, sample types also vary a lot.

- Organic Composition of Shilajeet: Shilajeet samples of different regions vary in organic composition[5,6,14], although they have in common (Table 7)
- Elemental Composition of Shilajeet (Tables 8.1 and 8.2)

Table 6. Quantitative analysis

Sr. No.	Criteria	Value of *Raw *Shilajeet*	Value of *Processed/ *Shudha/Bhawita Shilajeet*
1	HPLC methanolic extract[7])	--	Shilajeet showed maximum amount of tannic acid (319.33 µg/g) followed by gallic acid (20.76 µg/g) and ferulic acid (37.55 µg/g)[7]. (Possibly this is a *shudha Shilajeet* sample).
2	Palaeohumus	(around 80–85 %)[28], 67.6%[29]	--
3	(Non-Humic) Organic	15-20% of Organic[28]	--
4	Humic (Organic)/ Humus %age[28]	60-80% of Organic[28,33]	--
5	Humic Acid% age	(2.5 ± 0.3, 9.2 ± 0.3, 8.7 ± 0.5, 8.9 ± 0.4)[28]	(18.5% and 20.3%)[5]
6	Fulvic Acid %age	(22.6, 17.48, 12.23)[34]	and 22.6)[5], 33.20[34]
7	Anti-oxidant Activity: - ORAC index Andean *Shilajeet* in Chile[33]	--	50 - 500 Trolox units/g[33]; (higher than Noni and blueberries)
8	Anti-oxidant Activity: - DPPH radical scavenging activity	(96.797 ± 0.561% and 95.297 ± 2.884%)[14] (Strong), With IC50 value of 11.9µg/ml[35] (Significant)	--
9	Humidity/ (Can be loss on drying)	--	14-20 %[14]
10	Minerals	--	18-20 %[14]
11	Proteins (with a wide range of amino acids)	--	13-17 %[14]
12	nitrogen-free compounds	--	18-20 %[14]
13	Lipids	--	4-4.5 %[14]
14	Steroids	--	3.3-6.5 %[14]
15	carbohydrates	--	1.5-2 %[14]
16	alkaloids	--	0.05-0.08 %[14]
17	Trace elements (approximately)	--	5%[14]
18	Organic Composition	Detailed in Table No.- 7 Organic Composition of *Shilajeet*	
19	Elemental Assay (Elemental Composition)	Detailed in Table No: - 8.1. Elemental Composition of Raw Shilajeet	Detailed in Table No.: - 8.2; Elemental Composition of Processed Shilajeet

Table 7. Organic composition of *Shilajeet*

Sr. No.	Various studies and reviews about Shilajeet document the composition
1	*Shilajeet* was reported to contain a large number (65)[29] of organic compounds and at least 85 minerals form as well as Humic acid and Fulvic acid[7].
2	Active constituent of *shilajit* consists of dibenzo-α-pyrones and related metabolites, tirucallane triterpenes, small peptides consisting of non-protein amino acids, some phenolic lipids, small tannoids and fulvic acid[29]. (metallo-humates like fulvic acids and fusims with dibenzo-α-pyrones in their core nuclei)[29].
3	Organic compounds like sterols, tri-terpenes, ellagic acid, benzoic acid, m–hydroxybenzoic acid, three bencoumarins and as many as eighteen free amino acids[6].
4	*Shilajeet* contains albuminoids, gums, resins, benzoic acid, fatty acids and hippuric acid etc.[6]. organic matter, humic acid, fulvic acid, volatile and fat-soluble components such as taxol, verbenol, á-pinene, cypress Brain[4].

Table 7. Continued...

5	Major organic mass of *Shilajeet* was comprised of humus (60–80%) along with other components, such as benzoic acid, hippuric acid, fatty acids, ichthyol, ellagic acid, resin, triterpenes, sterol, aromatic carboxylic acid, 3,4-benzocoumarins, amino acids and phenolic lipids[28].
6	Other molecules present in *shilajeet* preparations are eldagic acid, some fatty acids, resins, latex, gums, albumins, triterpenes, sterols, aromatic carboxylic acids, 3,4-benzocoumarins, amino acids, polyphenols, and phenolic lipids[33]
7	Vitamins like B1, B12, vitamin D3[29], DCPs (dibenzo-α-pyrones-chromoproteins), containing trace metal ions and colouring matter such as carotenoids and indigoids[29].
8	Organic acids including adipic, succinic, citric, oxalic and tartaric, waxes, resins, polyphenols, essential oils[29]
9	2-Chloro-10-(3-Dimethylaminopropyl)-Phenothiazine, Several phenylpropanoid-acetate-derived aucuparins, oxygenated biphenylcarboxylates, isolated and characterized as their permethylated derivatives, and oxygenated dibenzo-α-pyrones, fattyacyl, aminoacyl, lipoidal), dibenzo-α-pyrones[29].
10	Shilajityl acetate, shilajitol, shilacatechol, shilaxanthone, shilanthranil and naphsilajitone along with pyrocatechol and their stereostructures[29].

Table 8.1. Elemental composition of *Shilajeet* (raw *Shilajeet*)

Raw Shilajeet; - Elemental Composition (%age) by LIBS[16]/ICP-OES[16] methods; (LIBS[16] Laser-Induced Breakdown Spectroscopy and ICP-OES[16] - Inductively Coupled Plasma/Optical Emission Spectroscopy)

Sr. No.	Ele-ment[16]	Sample 1[16]	Sample-2[16]	Sample-3[16]	Sample-4[16]	Sample-5[16]	Range (%age)
1	Ca	19/18	18/16.3	16.8/15	15/14	13.78/13	13-19
2	P	3/2	10/11	14/13.8	15/14.1	15.7/15	2-15.7
3	K	13/11.5	12/11	10.3/9	9/8	8.42/7.7	7.7-13
4	C	10/ANP*	9/ ANP*	7/ ANP*	6.6/ANP*	5/ ANP*	5-10
5	Fe	8.04/6.2	7/5.6	5/4	3.5/2.6	2.53/1.7	1.7-8.04
6	Li	8/6.7	ND/ND**	ND/ND	ND/ND	ND/ND	0***-8
7	S	5/4	4/8.7	5.0/4.3	6/5	6.7/6	4-6.7
8	Mg	6/5.04	5/3.4	4/3	3.5/2.7	2.5/1.59	1.59-6
9	Na	2/1.5	3/2	4/2.7	4.7/4.5	5/4	1.5-5
10	Si	1.8/1.4	5/3	5/3	4.5/3.7	5/4.2	1.4-5
11	Al	5/4	3/2	2.5/1.7	2/1	1.57/0.57	0.57-5
12	Mn	3/2	ND/ND	ND/ND	ND/ND	ND/ND	0-3
13	Ni	ND/ND	ND/ND	ND/ND	ND/ND	1.66/1	0-1.66

ANP = Analysis Not Performed; Instrument mode limitation for Carbon,*

*ND** = Not Detected.*

*0*** - Value = 0 means not detected even in ICP-OES (Sensitive Method).*

Table 8.2. Processed# *Shilajeet* - elemental analysis by ICP-OES and ED-XRF methods[14]

Sr. No.	Ele-ment	Sample-1[14] ICP-OES (ppm)	Sample-2[14] ICP-OES (ppm)	ED-XRF sample 1[14] (%age)	ED-XRF Sample2[14] (%age)	Range (%age ****)
1	Ca	30292 ± 21	877.09 ± 0.63	50.289 ± 0.021	20.933 ± 0.010	0.877-50.289
2	K	21587 ± 13	1433.8 ± 9.2	17.194 ± 0.002	24.309 ± 0.013	0.1434-24.309
3	S	ANP*	ANP*	21.299 ± 0.010	9.120 ± 0.010	9.120-21.299
4	Cl	ANP*	ANP*	8.405 ± 0.008	18.614 ± 0.017	8.405-18.614
5	Si	ANP*	ANP*	0.781 ± 0.004	15.197 ± 0.011	0.781-15.197
6	Fe	145.52 ± 0.010	15.028 ± 0.029	0.574 ± 0.002	7.100 ± 0.006	0.0015-7.100

Table 8.2. Continued...

7	Al	1.848 ± 0.002	5.854±0.025	4.727 ± 0.004	ND**	0.00019-4.727
8	Sr	ANP*	ANP*	1.433 ± 0.006	ND**	Up to 1.433 *****
9	Mg	2079.8 ± 8.4	147.96 ± 0.51	ND**	ND**	0.0148- 0.208
10	P	204.27 ± 0.47	0.000 ± 0.000	ND**	ND**	0.000-0.204***
11	Na	1580.3 ± 7.7	513.08 ± 7.8	ND**	ND**	0.0513-0.1580
12	Rb	ANP*	ANP*	0.015 ± 0.001	ND**	Up to 0.015
13	B	114.19 ± 0.042	66.491 ± 0.032	ND**	ND**	0.0067-0.0114
14	Se	0.000 ± 0.000	93.595 ± 0.050	ND**	ND**	0.000-0.0094***
15	Zr	ANP*	ANP*	0.008 ± 0.000	ND**	Up to 0.008
16	As	68.078 ± 0.024	73.654 ± 0.053	ND**	ND**	0.0068-0.0074
17	Pb	66.509 ± 0.063	60.292 ± 0.046	ND**	ND**	0.0060-0.0067
18	Ba	4.566 ± 0.022	35.802 ± 0.044	ND**	ND**	0.00046-0.0036
19	Zn	31.481 ± 0.022	18.324 ± 0.020	ND**	ND**	0.0018-0.0032
20	Mn	16.343 ± 0.058	1.617 ± 0.016	ND**	ND**	0.00016-0.0016
21	Cu	9.098 ± 0.030	13.476 ± 0.018	ND**	ND**	0.0009-0.0014
22	Ni	0.000 ± 0.000	12.068 ± 0.021	ND**	ND**	0.000-0.0012***
23	Ag	2.864 ± 0.012	0.000 ± 0.000	ND**	ND**	0.000-0.00029***
24	Cd	0.000 ± 0.000	0.000 ± 0.000	ND**	ND**	0.000 (ND)***
25	Sb	0.000 ± 0.000	0.000 ± 0.000	ND**	ND**	0.000 (ND)***
26	Cr	0.000 ± 0.000	0.000 ± 0.000	ND**	ND**	0.000 (ND)***

ANP = Analysis Not Performed; Instrument mode limitation for Carbon,*

*ND** = Not Detected.*

*0*** - Value = 0 means, not detected even in ICP-OES (Sensitive Method); Moreover, not detected (ND) in ED-XRF ≠ not present.*

*%age**** - Calculated as per conversion 1ppm = 0.0001%.*

*****Up to – as Analysis Not Performed by ICP-OES (Sensitive Method).*

Processed# - As seen in the image in the publication, though described as crude; possibly sample processed in water for extraction and the processed sample is procured from some vender, not collected in situ from natural sources; high constituent element values (Ca, K etc. indicates processing, may be simply in water).

- Physicochemical Characteristics (Tables 5).
- Quantitative Analysis (Tables 6).

Broadly these 36 criteria have been studied in various studies, though all studies were specific for one two, or some of these criteria, moreover, sample types also vary a lot.

- Organic Composition of Shilajeet: Shilajeet samples of different regions vary in organic composition[5,6,14], although they have in common (Table 7)
- Elemental Composition of Shilajeet (Tables 8.1 and 8.2)

6.2.1 *Observations in Various Studies;* Changes expected due to atmospheric and soil properties[16] (Table 9)

Table 9. Observations in various studies regarding chemical composition; changes expected due to atmospheric and soil properties·

Sr. No.	Criteria	Observations
1	Grossly Elements reported	(C, Li) [16] (Al, Ca, Fe, K, Mg, Mn, Na, Ni, P, S, Si)[14,16] (B, Be, Ag, Se, Cl, Rb, Sr, Zn, Cu, As, Pb)[14]
2	Elements increases with altitude	(Al, C, Ca, Mg, Mn, Fe)[16]
3	Elements decreases with altitude	(Na, Ni, P, S)[16]
4	Very low concentrations	(Li, Mn, Ni)[16]

Table 9. Continued...

5	Studied but not reported	(Cd, Cr, Sb)[16]
6	Inorganic Compound	Calcium Banzoate[36]
7	Colour Variations	Fresh exudation is golden yellow which turns to coppery brown and finally blackish brown[6]
8	Molecular weight of Humic Acid	5–10 kDa[33]
9	Molecular weight of Fulvic Acid	Around 2 kDa[33]
10	Solubility	Humins are not soluble in water under any *pH* condition[33].
11		Humic acid is soluble in water under alkaline conditions and has a molecular weight of 5–10 kDa[33].
12		Fulvic acid is soluble in water under different pH conditions, and because of its low molecular weight (around 2 kDa), it is well absorbed in the intestinal tract and eliminated within hours from the body[33]
13	Classification issue	Not in any; Mineral, Animal or Plant origin drug. As origin is unknown and composition is rich in organic as well as inorganic constituents.
14	Critical Quality Control Criteria	*(pH*, Solubility, Thermal analysis)[29] (Classical tests also stress on - *Ambhasi-Kshipatam*[24,25,26] *and Vahano-kshipatam*[1,24,26]

7. Details of *Shilajeet* in Classical *Ayurveda* Texts (Table 10)

8. Pharmaceutical processing of *Shilajatu* (Table 11)

As per classical texts of *Ayurveda*, its processing involves three primary steps.

- *Extraction/Shodhan*[1,30].
- *Bhawana*[30] with suitable material to fortify *Shilajeet* as a drug or *Rasayan.*
- *Shilajeet Bhasma* Preparation[1]. Details has been given in Table 11.

The process of *Bhasma* preparation has also been described in the classical text *Ras Rattan Sammucchaya*, with the use of *Manshila, Gandhak* and *Hartal,* but this process is not in much use nowadays as *Shilajeet* is primarily used after *Shodhan* and *Bhawana* process.

So, after these processing, the *Shilajeet* becomes consumable, with a vast range of therapeutic and *Rasayan* properties.

9. Properties of *Shilajeet*

9.1 Properties of Shilajeet in Various Texts (Table 10)

Charaka Samhita[44] discusses *Shilajeet* in a chapter on *Rasayana*[30] i.e., rejuvenation or adaptogenic substance. If administered as per specific protocol and regimen they gradually tend to improve overall physical and mental strength and thereby confer long healthy life and so retard aging[30].

As per *Ras Rattan Sammuchaya*[45] a classical text of *Ras Shastra*, *Shilajeet* possesses all the properties and actions of *Maharasa, Uparasa, Suta, Ratna, and Lauha*[45]. *Shilajeet* has been used since long as a *Rasayana*[30] (rejuvenator and anti-aging) and for treating diseases[46]. *Shilajeet* possesses anti-inflammatory[11], anti-oxidant[11,47], and anti-mutagenic properties[48], effective in dyslipidaemia[47], diabetes mellitus[49], bone healing[50] and testosterone level[51], even observed to stimulate and tone up the body as *Shilajeet* in combination with some herbs increases the performance in athletes as local application (balsam[52]). One interesting observation in a study shows its effect as a plant growth stimulant[53].

9.2 Research Work: Experimental Studies In *Vivo*/*In Vitro*, Clinical Studies and Uses (Table 12)

It has been stated in a review that, the primary physiological action of *Shilajeet* is because of bioactive dibenzo-á-pyrones, humic and fulvic acids, which act as carrier molecules for active substances[28] (Table 12). However, the presence of a lot of minerals in it is worth considering.

Table 10. Details of Shilajeet in Classical Ayurveda texts

Sr. No.	Classical Text			General Description of *Shreshtha (lauh type)*						
		Types	Colour	*Odour*	*Ras*	*Vipak*	*Virya*	*Guna*	Processing indicated	Use; - Dose-Duration-*Anupana*
1	*Charak Samhita*[30]	*4**	*Gugulabh, Jatvab*h	*Gomutra gandhi*	*Lavan,Tikta, Kashaya*	*Katu*	*Sheet, Natyushana-sheet*	*Rasayan, Vrishya, Sarva-sadhay rog, Sarvakarmasu yogika.*	*Shodhan and Bhawana*	*1 pala/1/2 pala/1 karsh- 7/3/1 Week. With Lauh and Payas.*
2	*Sushruta Samhita*[32]	*6***	*Jatuparbh*	*Gomutra gandhi*	*Tikta,Katu, Kashaya*	*Katu*	*Ushan*	*Madumeh, Prameh, Kushth, Unmad Apasmar, Vish, Shoth, Shosh, Arsh, Gulm, Pandu, Sar, Shoshan, Chhedan,*	*Shodhan and Bhawana*	*With Shalsaradi gan and Jangal Mansarasa*
3	*Ras Rattan Sammuchay*[1]	*2****	--	*Gomutra gandhi and Karpoor gandhi*	--	--	--	*Jwar, Pandu, Shosh, Prameh, meda, Rajyakshama, Shool, Gulma, Pliha,*	*Shodhan and Bhawana and also Maran*	*Duration Up to 6 months; With Lauh, Vaikrant, Triphala,Trikatu*
4	*Rasendra Sar Sangrah*[21]		--	--	*Tikta, Katu,*	--	--	*Rasayana, Kshay, Shoth, Udar, Arsh, Basti-ruja*	--	--
5	*Bhav Prakash Nighantu*[22]	*4*	*Jatayu-pakshabh*	--	*Katu, Tikta*	*Katu*	*Sheet*	*Madumeh, Prameh, Kushth, Unmad Apasmar, Vish, Shosh, Arsh, Gulm, Pandu, Sar, Shoshan, Chhedan,*	--	--
6	*Ras Tarangini*[31]	*4**	*Krishan*	--	*Tikta, Lavan, Kashaya*	*Katu*	*Sheet*	*Guru, Snigda. Sar, Shoshan, Chhedan, and Madumeh, Prameh, Kushth, Unmad Apasmar, Vish, Shoth, Shosh, Arsh, Gulm, Panduhar.*	--	*2-8 ratti.*
7	*Yogratnakar*[25]	-	*Maleenam*	*Gomutra gandhi*	*Katu, Tikta*		*Ushan*	*Rasaayan, vali Palita, Kas, Pandu, Kshay, Shoth, Udar, Arsh, Ashamari, Manas Rog.*	--	--

,, *** [(Swarna, Rajat, Tamra, Lauh,)*[30] *Trapu, Naga]*[32] */Surya tapi, Agani Tapi/ Gomutragandhi and Karpoorgandhi*[1]****. ***Sasatva and Nisatav.*

Shilajeet Priksha: - Following characteristics have been describes as the tests of Shilajeet in classical texts; - Vahano kshipatam – Bhaved Lingakaram[1]*, Adhoomakam*[1,26]*. Ambhasi-Kshipatam addho-tantuvat*[25,26]*. Gomutra Gandhi*[25]*, Maleenam*[25]*, Gugulabh*[30]*, Jatvabh*[30]

Shudha Shilajeet extraction and processing[35]*: -- Extraction/Shodhan*[1,30]*, – Then Bhawana*[30]

Shilajeet Bhasma nirman[1]*: - Ras Rattana Samuchaya have a reference of Shilajeet Bhasma nirman*[1] *with Manshila, Gandhak and Hartal.*

Table 11. *Shilajeet Shodhan (Processing)* methods

Sr. No.	Reference	Process Mentioned	*Dravya* used	Duration
1	*Charak Samhita Chikitsa 1/3/50)*[30]	*Bhawana (Method May be normal Bhawna or – dip and dry method).*	*Niryuh (Kwath) of; Vaat, Pitta, Kapha* pacifying *Dravya*	7days
2	*Sushrut Samhita*[32]	*Bhawana*	*Shalsaradi Gana*	*Not Mentioned* (NM)*
3	*Ras Tarangini*[31]	On Bright sunny day- Keep in sun for 3 hours-with hot water and Triphala Kwath- filter with cloth- Keep in iron pot - again keep in strong sun heat- Collect top layer formed.	With 2 times hot water and also ½ quantity of *Triphala Kwath/ Gomutra/ Bhringraj Svarasa.*	3 Hours
4	*Ayurvedic Formulary of India (AFI)*[37]	1. First Step: - Vigorously mixed with hot water-decanted- Concentrated to thick paste or solid amorphous surface. 2. Second Step: - Mixed with water + Triphala Kwatha - carefully boiled to dryness.	1. First Step: - Raw Shilajeet - ---Water-(Quantities NM*). 2. Second Step: - Above *Shilajeet* -1 part Water - 2 parts *Triphala Kwatha* - ½ part	NM* As required --
5	*Ras Ratna Samucchay*[1] *(3 Methods)*	*1. Wash (Prakshalan)* *2.Heating in Iron pot (Lohpatre).* *3.Fomentation (Svedana).*	*1. YavKshar; Amla Ras; Gomutra*.* *2.Dugdha; Triphala Kwath; Bhringraj Swaras** *3. Kshar;Amla; Guggul**	*1. NM** *2. NM** *3. Ghatika*
6	*Rasendra Sar Sangrah*[21]	Levigation (*Pishtam*)	*Godugdha; Triphala Kwath; Bhringraj Swaras*	1 day
7	*Yogratnakar*[25]	Dip-Levigation-Filter-Sun Heat	*Hot Water*	3 Hrs/ Total process 2 Months)
8	*Ras Paddhati*[38]	Dissolve- Settle- Put in Sun Heat- Decant-Dissolve residue again in Hot water-Further, process repeated 3 times.	Hot water (Iron Pot)	Process repeated 3 times
9	*Ras Tantra Saar Siddh Prayog Sangrah*[39] *(3 Methods)*	*1. First Method: - *AgniTapi with Triphala Medium* **2. Second Method: - *SuryaTapi* with *Triphala* Medium. (Boiling has been indicated in first stage of dissolving Raw *Shilajeet*) ***3. Third Method*: - *SuryaTapi* with Water medium.	*[Triphala kwath* made with (64 times water reduced to ¼). Use this *Kwatha* = 10* times in *Agnitapi* and 16** times of *Shilajatu* in *Suryatapi*] ***Third Method= Water only.	Raw *Shilajeet* to dip for 24 hours in Media.
10	*Ayu.Saar Sangrah*[40]	*AgniTapi with Triphala Medium*	Triphala 10 times;	Dip for 24 hours
11	*Sharangdhar Samhita*[41] *(2 Methods)*	*1.* Levigation in Sun Heat Dip-Levigation-Filter- Sun Heat (process completion takes 2 months)	*1. Cow Milk, Triphala Kwath,Bhringraj Swaras.* 2. Hot water	1. 1 day 2. 3 Hrs (Levigation)
12	*Rasendra Chintamani*[42]	1. Wash and Dissolve- Settle- Heating- Collect top layer formed. 2. Levigation	1. Hot Water 2. *Vaat, Pita, Kaph har- Kwath or Ras.*	1. NM* 2. 1 Week
13	*Ashtang Hridya*[43]	Wash and Dissolve – Dry - Levigation	Water; *Kwath for Levigation*	*Bhawna*-7 days

10. Research Scopes

Ras Shastra is a branch of *Ayurveda* dealing with drug innovation. By some special techniques like *shodhan, marana,* etc., the raw material of earthy origin is processed to make it compatible with the body to give medicinal outcomes. *Shilajeet* is also of earthy origin, moreover, it is a unique drug made compatible to the body primarily by the natural process inside the earth. The only work left to do for us is to extract it

Table 12. Experimental studies-*in Vivo/Vitro*, Clinical studies and uses

Sr.	Criteria	Observations
1.	Strong antioxidant activity[14]	2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity[14]. *Shilajeet* increases SOD an antioxidant enzyme significantly, Vitamin E and Vitamin C levels of blood ($p<0.01$[54].
2.	High ORAC index[33]	Andean *Shilajeet* in Chile shown, an ORAC index between 50 and 500 Trolox units/g[33]; Quite Higher than Noni and blueberries.
3.	Alzheimer[14] neurological treatments	Significant activity[46]. fulvic acid has strong preventing activity to self-aggregation into pathological filaments, a significant compound for prevention of Alzheimer's disease[33].
4.	Considerable radioprotective and antioxidant improving potential[14]	Research experimenting the exposure of X-ray radiation on Zebrafish, Danio rerio, by studying the morphological, behavioural, clinical symptoms, antioxidant levels and DNA damage of the fish[14].
5.	Antiviral activity[14]	Found reactive to human respiratory syncytial virus, herpes simplex 1and2, human cytomegalovirus, and vesicular stomatitis virus, human rotavirus[14].
6.	Improved blood glucose, insulin and glucose tolerance[14]	Possibly due to activation of hepatic and muscle insulin signalling pathways[14].
7.	Heat related syndrome in Tibetan medicine[2]	Water extract of *Shilajeet*[2]
8.	The antifungal activity[7]	Methanolic crude extract of *Shilajeet*[7]
9.	Toxicity Study[55]	91 days different dose level (500 to 5000mg/kg), repeated administration, four groups with control, albino rats' study, did not find any significate intergroup changes [55].
10.	Effects on blood chemistry of normal human[54]	In a safety study; 2 g of *Shilajeet* for 45 days, found not to produce significant change; in BP, Pulse and body weight and similarly no change was observed in haematological parameters[54]
11.	Lipid profile[54]	Decline in Serum Triglycerides, Serum cholesterol levels. also, improvement in HDL Cholesterol observed[54].
12.	The antioxidant activity; DPPH Radical-Scavenging Assay, Lipid Peroxidation Inhibitory Assay Reducing Power Assay[56].	Aqueous extract of *Shilajeet;* shows DPPH radical-scavenging activity (IC50 value =11.9µg/ml) equivalent to standard ascorbic acid[56]. Significant ($P<0.05$) lipid peroxidation inhibitory and anti-arthritic activities seen[56]. High phenolic content of *Shilajeet*[56].
13.	Comparative efficacy of *Shilajeet* and Gum *Guggul* in lipid profile study in wistar rats[57].	*Shilajeet* lower serum cholesterol, liver cholesterol, serum triglycerides and serum phospholipids of wistar rats by 39, 55, 47 and 25 per cent respectively[57].
14.	Degenerative Brain Disorder[56]. *Shilajeet* as Combination with Complex B Vitamins[58]	It was found, *Shilajeet,* fulvic acid and formula of *Shilajeet* with B complex vitamins, found as novel nutraceutical with significant effect in Brain Disorder of degenerative nature[58].
15.	Complexation of Furosemide with Fulvic Acid[59]	Furosemide and Fulvic Acid complex formation was successful[59].
16.	Complexing between aspirin and humic acid[58]	The solid inclusion complex formation was successful[60] and the complex was studied and found significant ($p < 0.05$) as anti-inflammatory and anti-ulcerogenic[60].
17.	Plant Growth[53]; Treatments of *Shilajeet* and Moringa leaf juice combination[53].	There was an increase in seed germination, seedling growth, water soluble protein and amylase activity[53].

from earthy mass and to do *Shodhan* and fortification with *Bhawana* (extraction, purification, and enhancing biocompatibility with the addition of synergistic drugs).

Shilajeet is one of the most commonly used drugs in *Ayurveda* and *Ras Shastra* and is being used extensively worldwide. However, the availability of genuine *Shilajeet* and its Identification is questionable due to lack of reference standards. Also, if we see the previous research data on *Shilajeet,* there are huge variations in findings with respect to analysis parameters.

11. Existing Information

- However, *Shilajeet* is a very common drug and used extensively in Indian medicine. Moreover, no identification, analysis and characterization data

is available in any official publications namely; Indian pharmacopeia, Ayurvedic pharmacopeia of India (API), Ayurvedic Formulary of India (AFI). Only the Ayurvedic Formulary of India (AFI)[37] Department of AYUSH, Govt. of India Publication has a translation of the *Shodhan* process[37].

- Moreover, tests in classical texts *Charak Samhita Chikitsa-1, Sushrut Samhita Chikitsa-13, Ras Rattan samuchay-2, Ras Tarangini-22, Ayurved Prakash-4*, etc. have detailed description of *Shilajeet* and its test to identify genuine *Shilajeet*. However, modern day analysis was not performed at that time. In today's context, a standard analysis protocol is required.
- A number of literary publications on *Shilajeet* have detailed reviews of information on *Shilajeet*[11,48], detailing the classical text information.
- Further, a number of research studies can be seen published, various previous studies cannot be compared and compiled to form conclusive data as types of samples in various studies vary *(shudh/ashudha),* most samples are commercial, rare samples are collected from a natural source by the researcher, in some studies origin and type of samples is unknown, only specific analysis of their interest has been done by various researchers previously and there is huge variation in analytical findings. However, none of the previous studies gave conclusive data on Characterisation.

So, a work with a large no of samples from the site of occurrence and commercially available samples is needed to get a data range of various parameters. Characterization of *Shilajeet* on the basis of *Ayurveda* classical tests and API protocol for Ras Material, elemental analysis and also Fulvic acid and Humic acid content is required, along with other organic and inorganic constituents that may be remarkably adding to its therapeutic and *Rasayana* effect. The availability and genuinity of raw samples must be studied by the professionals in the field. Moreover, there is a dependency on market only, for the availability of raw materials of *Ras Shastra* and many other raw drugs in *Ayurveda* and so many times quality and even identity of raw drug is compromised. Research work, from field to laboratory to field, is need of the day for its origin, changes taking place in side earth, its formation, sources, availability, extraction, identification, usability (*Grahyata*) and quality control and processing standardization, experimental and clinical studies for its potential as a health supplement, vitality enhancer, development of nutraceutical products and specific medicinal value in various diseases is worth investigating.

12. Need and Purpose of Working on *Shilajeet*

12.1 Commercial Value and Employment Opportunity

Shilajeet has a huge commercial value, this single drug and its products is a complete industry in itself. Today, if we see purified form of *Shilajeet* in market, it is sold minimum from Rs. 500 per 10gm and may go up to any cost as per the marketing strategy, packaging type and form. It is doing great commercially even if there is no standardization and standards available in any pharmacopeia of official publication. Standardization will further enhance its commercial value.

12.2 Natural product of Medicinal and Nutritional Value

Shilajeet is absolutely a natural product and has not been synthesized in the laboratory, it has a vast medicinal scope as discussed in various sections of this work, and a great nutritional supplement as is evident from its composition.

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