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Yashada (Zinc): A Brief Insight to Its Sources, History, Archaeology, Extraction and Therapeutic Uses

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ABSTRACT

In Ayurveda, Aushada (Medicines) stands second in chikitsa padachatustayam (4 pillars of treatment) after Bhishak (Vaidya). Aushada plays an important role in treating any diseases, in fact aushada act as weapon for any Vaidya for treating the diseases of any origin. Rasashastra is an ocean of science, contains Herbo-metallic preparations which helps not only treating the disease but also helps in stabilizing the body (sthirikaratwa of deha) as metals are derived from earth crust which is a parthiva Dravya which in turn helps in stability of deha(body). Among metals, Zinc is the most commonly used and cost-effective drug where its usage is also pronounced even at the recent pandemic situation along with other supplements and so to give the quality medicine, it's a need of an hour to know about its source, availability in ores, extraction from mines, test for Genuity as per ayurveda and contemporary sciences. This article helps the wise vaidyas (physicians), Ayurvedic pharmaceutics in collecting genuine zinc from the genuine source along with confirmatory test as per ayurvedic literatures and contemporary science which benefits the society by providing quality medicine from the quality raw drug collection practices.

INTRODUCTION:

Rasashastra in *Ayurveda* is a branch, which processes various raw minerals, metals, gemstones and animal products into therapeutically potent medicaments. The pharmaceutical processing of these raw materials makes it essential to understand the knowledge of geology and metallurgical processes.

Metallic preparations are the important part of *rasaushadhis* (Herbo-mineral preparations), which are very well known for their small dose, better palatability and quicker action. Metal zinc is placed in *putiloha varga* (A category of metals that has a foul smell on melting). A detailed description of *Yashada* is available in the 13th-century book known as *Ayurveda Prakash*, written by *Madhav Upadhyay*.[1] While much before this time utensils, weapons and artefacts of *Pittala* or *Riti* (Brass), which is an alloy of *yashada* (Zinc) and *tamra* (Copper) were in use. From the bronze age or chalcolithic age, *pittala* metal is *mishra loha* (alloy) made up of *Yashada* (Zinc) and *Tamra* (Copper). The beginning of the use of copper and brass tools, medical devices and surgical instruments are exclusively found in practice from the vedic and *samhita* periods. Thus, it is quite an amazing fact that brass has a much longer history than zinc which is evident in most of the modern textbooks of *rasa shastra*. In fact, brass has a much longer evident based history than zinc. Brass is produced either by smelting copper ores containing zinc or copper and zinc ore in reduced condition or by mixing copper and zinc metals.

Base metal zinc is a non-ferrous chemical element with the symbol Zn and atomic number 30. In the absence of oxidation, it appears silvery blue. Smithsonite, calamine, zincite, wilkmite, and franklinite are some of its mineral forms, as well as sphalerite or zinc mix. In nature, zinc occurs as a metallic element, but it can only be obtained in pure form by smelting zinc-containing ores.[2]

As zinc is crucial for preserving human society's health. Understanding zinc's origin, history, extraction process and medical applications is a need of an hour.

Sources of zinc:

Zinc, due to its resistance to corrosion and capacity to make alloys with other metals, zinc, a bluish-white metallic element, is widely utilized in a variety of industries. It is a crucial mineral for human health and is engaged in a wide range of biological activities.

The main sources of zinc are**:** sphalerite (zinc sulphide), smithsonite (zinc carbonate), hemimorphite (zinc silicate), and zincite (zinc oxide). These ores are mined across the globe, notably in Australia, China, Peru, the US, and Canada.[3] In India, it is found in Bihar, Rajasthan, Punjab, Kashmir, Madya Pradesh and Tamil Nadu. Silver and occasionally gold are coupled with lead in combined zinc-lead ores, which account for over half of all zinc production. Many ores have zinc concentrations between 2 and 10%.[4]

Table 1: Ores & their chemical formulae of zinc [3]

Sl. No.	Forms	Nomenclature and availability	Chemical formula
1.	Element	Native zinc	Zn
2.	Oxides	Zincite Franklinite	ZnO (Fe, Zn, Mn) (Fe, Mn)$_2O_4$
3.	Sulphides	Blende (UK)/Sphalerite (USA)	ZnS
4.	Carbonate	Calamine (UK)/ Smith stone (USA)	$ZnCO_3$
5.	Basic Carbonate	Hydrozincite	$Zn_5(OH)_6(CO_3)_2$
6.	Silicates	Willemite hemimorphite	Zn_2SiO_4 $Zn_4\ Si_2O_7\ (OH)_2.\ H_2O$
7.	Sulphate	Goslarite	$ZnSO_4.7H_2O$

History and archaeological evidences of zinc:

Zinc has a long history, and India has benefited much from its use in its material culture. However, the use of zinc dates back fairly far to the copper-zinc alloy known as brass.[5] It is interesting to note that northern India provided the majority of the brass used as currency from the second century BC to the fourth century AD. According to reports of brass work found at Lothal and Atranjikhera, zinc was discovered in India between the fourth and fifth centuries before Christ. When zinc was finally isolated, it was actually a late addition to the list of metals that were readily available. Prior to being used industrially, the zinc that was used to make brass was actually present in the form of calamine, a substance that contains zinc.[6]

Brasses with up to 25% zinc have been found in contexts from China's fifth and third millennia BC. Since the last quarter of the third century BC, when China's Han Dynasty was at its height, the Chinese have been employing zinc and brass. According to Craddock and

Zhou, Buddhism may have brought zinc to China around 2000 years ago. The Tan dynasty (619-917 AD)'s Buddhist literature contains the oldest known literary reference to brass being referred to as tutty.[7]

In the early centuries of the Christian era, at least before the third century AD in China, brass was not a prevalent material. Previous studies examining coins from the third century BC to the late nineteenth century AD indicate that the amount of zinc unexpectedly jumped by 20% or even up to 28% in the brasses of China's early seventeenth century AD. According to Chinese literature and archaeological findings, China did not employ metallic zinc until the 16th century AD.[7]

India holds the distinction of being the first country to develop distillation technology for the production of pure zinc. Although there are several zinc ore resources around the nation, the largest ones are in the Aravalli's. The pre-cambrian metamorphic rocks that make up the Aravalli's range in southern Rajasthan are made up of craggy and beautiful hills that are rich in zinc ore in the form of sphalerite veins in addition to galena and copper containing deposits. The zinc mines of Zawar were initially documented by Abul Fazal in his well-known book *Ain-i-Akbari* in 1956. Incredibly convincing evidence for zinc mining and smelting furnaces, as well as prehistoric smelting retorts from the dam fill at Zawar, were found in 1983 by archaeometallurgical research conducted there in conjunction with Hindustan Zinc Limited, Udaipur.[8]

Chinese knowledge of zinc extraction dates back to at least the Ming era (1368–1644), when calamine was heated in a clay jar with a tight lid to produce "metallic zinc," according to a text on metals.

As a result, China was able to export zinc in growing amounts by the Mughal era. It appears that Chinese zinc was originally introduced to India by the Portuguese. The Zawar mines were reportedly unable to fully satisfy India's growing zinc demand. The Zawar mines were eventually closed in the eighteenth century due to the massive amounts of zinc imported from China that rendered them unprofitable. These mines are thought to have been abandoned as a result of political unrest in Mewar and frequent Mughal, Pindari, and Maratha invasions in the 18th century.[9]

Literary Evidences in Ayurveda:

In favour of the extraction of zinc, Prafulla Chandra Ray quotes a verse from the 12th-century book *Rasarnava*. The next references he cites are to *Rasaprakash sudhakara* of Yashodhara (twelfth-thirteenth century); *Rasachintamani* of Madanantadeva (tenth-twelfth century); *Rasakalpa* (*Rudrayamala tantra*) (tenth- twelfth century); *Rasaratnasamuccaya* by Vagbhata (twelfth-fourteenth century) and *Dhatukriya or Dhatumanjari* (*Rudrayamala Tantra*) (of uncertain age).[10]

It should be noticed that Sanskrit literature begins to include more and more allusions to the extraction of zinc from the twelfth to the thirteenth century onward; this is consistent with both literary and archaeological evidence.[10]

Extraction of zinc from its ores:[11,12]

Zinc sulphide (ZnS) ore, also referred to as sphalerite, is the most crucial raw material for the manufacturing of zinc. Zinc silicate and zinc carbonates, often known as Calamine and Smithsonite, come next in importance. Sulfide ores are the primary source of zinc production in the globe. Pyro-metallurgical and hydro-metallurgical processes are two categories for methods used to extract zinc from its ores.

Zinc extracting process

Pyro-metallurgical processes	**Hydro-metallurgical processes**
15-20% of zinc production	80% of zinc production

A. Pyro-metallurgical processes: The pyro-metallurgical pathway currently accounts for between 15 and 20% of the world's zinc production. Due to excessive power consumption and poor recovery, the production of zinc using the horizontal, vertical, and electrothermal retort techniques is becoming negligible. Imperial Smelting Process (ISP) is the only significant pyrometallurgical procedure at the moment.

1. Retort Process:

In the horizontal retort furnace, coke and dead-roasted zinc oxide are melted. By reducing zinc with CO, zinc is created at a temperature of roughly 1000°C in gaseous form. In a reducing environment, the generated zinc vapour is condensed. Therefore, zinc oxide reduction with coke is carried out inside a retort that is typically heated outside and inhibits oxidation of CO to CO_2. In a liquid zinc bath, the zinc vapour is gathered. Both vertical and horizontal retorts use the same producing principle.

2. Imperial Smelting Process:

At the moment, the imperial smelting process accounts for 8–10% of the world's main zinc production. Using complicated lead-zinc concentrates or a mixture of lead and zinc concentrates as the raw material, the process simultaneously produces lead bullion and zinc metal. In order to reduce the PbO-ZnO mixture simultaneously, warmed coke and lime stone are added to the ZnO and PbO sinter mix in the ISF. At the furnace's hearth, liquid lead bullion is gathered, and zinc vapour is quickly condensed at the top by liquid lead sprayed at 600°C. Zinc metal separates from lead due to the different solubilities of the two molten metals with gradual cooling up to 400°C.

B. Hydro-metallurgical processes:

The Hydrometallurgical process is a continuous process which includes Roasting, Leaching and Electrowinning. The standard roast-leach-electrowinning (RLE) hydrometallurgical pathway accounts for around 80% of the world's total zinc output. The easily leachable zinc oxide is created initially from the zinc sulphide mineral.

Roasting:

$$2\ ZnS + 3\ O_2 \longrightarrow 2\ ZnO + 2SO_2\uparrow$$

The zinc sulphides in the concentrates are changed into zinc oxide, or calcine, during roasting. Around 950° C is the operating temperature of a roasting furnace, which produces enough heat to make the process autogenous. Additionally, the roasting process produces sulphur dioxide-rich waste gases, which are later transformed into sulfuric acid through a contact process.

Leaching:

$ZnO + H_2SO_4 \longrightarrow ZnSO_4 + H_2O$

The primary goal of the leaching procedure is to convert the zinc oxide present in the roasted calcine material into zinc sulphate prior to the electrolysis stage by dissolving it with sulfuric acid. Most of the zinc in roasting calcine (about 90%) exists as zinc oxide, whereas the remaining 10% is zinc ferrite, from which zinc dissolution necessitates more potent acidic conditions. The leach residue is refined further to recover valuable metals. Goethite, jarosite, or haematite, which are typically kept in ponds, are used to extract the dissolved iron from the zinc sulphate solution.

Purification:

The leach solution is then purified to get rid of dissolved contaminants including cadmium, copper, nickel, or cobalt that could also interfere with the electrolysis process. By incorporating zinc dust into the solution, these contaminants are eliminated through cementation. The purified zinc sulphate solution is sent to the zinc electrowinning cell house.

Electrowinning:

$Zn^{+2} + 2\ e^{-} \longrightarrow$ Zn (Deposited over aluminium cathode)

Through the process of electrolysis, zinc metal is extracted from the purified solution. On aluminium cathodes, the zinc that has been deposited is periodically removed. Special High Grade (SHG) zinc, which contains 99.995% zinc, is created using the electrolysis process. This zinc is then melted in an induction furnace and cast into commercially viable products.[11,12]

Test for genuine zinc and its characteristics:

The Quality medicine comes from Quality and authentic source. In respect to zinc encrustation is the sign of genuine zinc. The encrustation produced by heating zinc minerals on charcoal turns yellow when heated and white when cooled. When this encrustation is soaked with cobalt nitrate and heated to a high temperature, it takes on a delicate green hue.[13]

Zinc is a blue to grey metallic element, having 419.5C melting Point. It possesses good resistance to atmospheric corrosion. It is soluble in copper and has the density of 7.133.[14] The alloy of copper and zinc is brass where 67% of copper and 33% of zinc present in it.[15]

Uses of zinc in human health:

Zn is such an essential nutrient in human health that even a minor deficiency can have a severe consequence. Zinc is a necessary element that the body uses for many different processes since it is a cofactor in the creation of several enzymes, DNA, and RNA.[16] Many metal-proteins and enzymes contain it as a component. Metal-proteins and associated enzymes are necessary for it to perform certain tasks in cells and tissues.[17] Zinc is actually the sole naturally occurring lymphocytic mitogen. Of the total zinc in our body, 85% is found in our muscles and bones, 11% is found in our skin and liver, and the remaining zinc is found in many other tissues. The prostate and the area around the eyes have the highest quantity of zinc. The average adult body contains between 1.4 and 2.3 g of zinc.[16]

A normal adult need roughly 10–20 mg of zinc per day, while a pregnant woman needs 20–25 mg daily to supply additional zinc for the developing fetus.[8] In the small intestine, fibre, phytic acid, calcium, and copper reduce zinc absorption, whereas glucose, amino acids, peptides, and other chelating substances promote zinc absorption.[17]

Source of zinc in human body:

The source of metal required by cells is plasma zinc. The brain's hippocampal and cerebral cortex contain the greatest concentrations of zinc. Pregnancy, the use of oral contraceptives, catabolic conditions like burns, trauma, or surgery, as well as haemolytic and sickle cell anaemia, all result in a drop in plasma zinc levels. Acute myocardial infarction infections, cancer, hepatitis, and numerous other illnesses all cause a reduction in plasma zinc.[17]

In humans, zinc deficiency results in anorexia, appetite loss, loss of taste and smell, and other symptoms. It can also compromise the immune system, leading to anaemia and arteriosclerosis. Poor platelet aggregation, a reduction in T cell count, and a diminished T-lymphocyte response to phytoestrogens are the causes of poor haemostasis in cases of zinc deficiency.[16]

Zinc and Ayurvedic Perspective:

Zinc is used in Ayurvedic therapeutics as *Yashada Bhasma* (Zinc calyx) having *Kashaya* (astringent), *katu* (pungent) in rasa (taste), *sheeta veerya* (cold in potency). Externally it is widely indicated in different type of *netra rogas* (eye diseases). Internally it helps in managing *kapha-pitta* vitiated diseases, improves physical strength, virility and intellect. Indicated in Anaemia, Diabetes Mellitus, Cough, Bronchial asthma, Tuberculosis, Metrorrhagia, Parkinson and specially helps in pacify *vata dosha* and beneficial in neuro-musculoskeletal disorders.[18]

Discussion:

In the field of *Ayurveda*, Zinc is known as *Yashada* or *Jashada*. It is widely accepted and clinically utilized in the field of *Ayurveda* in the form of *yashada bhasma* / *jashada bhasma* for the management of one of the burning issues in the society is Diabetes mellitus and also scientifically proven for the same.[19]

As zinc is one of the base metals which is essential for the body which is widely practiced in the field of *Ayurveda*, it is a need of an hour for an ayurvedic manufactures and for a wise vaidya to know about its Genuity through the knowledge of sourcing, availability and production of zinc to prepare a good quality medicine.

In *Ayurveda*, the genuity of the drugs is assessed depending on the *grahya lakshanas* and *agrahya lakshanas* mentioned in the *Rasashastra* textbooks. Particularly, for *yashada*, the *grahya lakshanas* are heavy, smooth, soft, clear, quickly melts and shiny edges on cutting are used for medicinal purpose and the *agrahya lakshanas* are hard, rough, dull, light in weight, dirty and one which takes long time for melting are not suitable for preparing medicines. [20]

Conclusion:

Therefore, the samples collected for preparing medicines are to be selected based on *grahya lakshanas* and also it is to be checked for test for genunity of zinc with respect to contemporary methods as mentioned earlier. To get a quality zinc according to the source, categorization need to be done and standardize according to the quality mentioned in ayurvedic texts followed by contemporary methods.

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