

Ayurvedic Medicine: A Traditional Medical System and Its Heavy Metal Poisoning

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Ayurveda is one of the oldest and most widely practiced traditional medical systems in the world. The ancient knowledge in this traditional medical system has yet to be fully explored. The interaction of rich knowledge from various traditional systems of medicine can open new pathways in the herbal drug discovery process. Apart from other hurdles in discovering plant-based medicines, the lack of knowledge of the differences and similarities between the theoretical doctrines of these systems is the greatest impediment to their convergence. *Rasashastra* is an Ayurvedic medicine section that deals with formulations that include minerals/metals, particularly *Parad* (mercury). According to the Ayurvedic Formulary of India, the most widely used heavy metals are mercury, arsenic, and lead. However, contemporary scientists are concerned about the use of heavy metals in Ayurvedic preparation. In this review article, we will discuss Ayurvedic medicine and the toxic effects of heavy metals.

Key Words: *Ayurvedic Medicine; Heavy Metals; Herbal Medicine; Mercury*

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INTRODUCTION

Contemporary medications, also known as modern chemical medicines or pharmaceutical products, and traditional medicines, which are manufactured by conventional methods, are also widely used to effectively treat a variety of medical conditions.¹ However, the risks associated with the use of contemporary medications have led millions of people throughout the world to turn to herbal and traditional medicines as alternative healing agents. Long-term use of modern medicine in chronic diseases has several negative consequences that most patients prefer to avoid, therefore they turn to traditional medicines.¹ Many plants and their extracts found in traditional remedies have been demonstrated to exhibit a variety of biological functions.² In the Indian system of medicine, there are over 300 formulations for treating jaundice and chronic liver diseases.³ Approximately 600 commercial traditional medicines with hepatoprotective properties are sold all over the world. Because of the enormous benefits, the majority of the world's population relies on them in some form for various health benefits. According to World Health Organization

research, traditional medicine is used as the major source of healthcare by 65% to 80% of the world's population.⁴

Ayurveda is a traditional medical system with historical roots in the Indian subcontinent. Ayurveda is recognized as a medical system in India, Sri Lanka, Pakistan, Nepal, the UAE, Oman, Bangladesh, Saudi Arabia, Hungary, Bahrain, Malaysia, Serbia, Mauritius, Tanzania, Cuba, Switzerland, and Brazil, while only five countries of the European Union (EU) regulate its practices.⁵ Ayurveda focuses on disease prevention rather than disease therapy.⁶ Its origins can be traced back to the Indian subcontinent and has been practiced for more than 3,000 years. The phrase "Ayurveda" is a combination of two Sanskrit words: "Ayur," which means "life," and "Veda," which means "knowledge or science." As a result, Ayurveda is translated as the "science of life." Ayurveda is based on the notion of keeping the interconnected relationships between the body and the mind in balance. It teaches the patients the value of knowing their body and mind and living in close interaction with nature.

Scientists have identified various bioactive substances in therapeutic plants used in Ayurveda. *Rauwolfia* alkaloids for hypertension, Guggulsterons as hypolipidemic

agents, *Mucuna pruriens* for Parkinson's disease, Picnosides for hepatic protection, Piperidines as bioavailability enhancers, Baccosides for mental retention, Psoralens for vitiligo, Phyllanthins as antivirals, Berberine, Curcumin for controlling infections, inflammation, and cancer, and Shatavarin and Withanolides as adjuvants and immunomodulators.⁵ Several Ayurvedic medications and formulations were also explored using a reverse pharmacology technique during the COVID-19 pandemic.⁵ Ayush-64, an Ayurvedic formulation used to treat malaria, has been repurposed as an adjuvant treatment for mild to moderate COVID-19.⁷ Anu Taila, a traditional Ayurvedic compound used for intranasal administration, demonstrated preventive potential with strong antiviral effectiveness, viral load decrease, and virus entry barrier.⁸ In a randomized controlled multicenter clinical trial, *Withania somnifera* (*Ashwagandha*) was found to be more effective and safer than hydroxychloroquine for COVID-19 prevention.⁹

Trace minerals such as zinc, gold, silver, iron, copper, magnesium, manganese, and chromium are required for particular biochemical reactions in the human body; yet they can be harmful at high levels of exposure.¹⁰ Heavy metals such as lead, arsenic, mercury, and cadmium are xenobiotics that can induce toxicity even at low doses.¹¹⁻¹⁴ Metals (*bhasmas*) are highlighted as needed for appropriate biological functioning in *Rasa Shastra* Ayurveda, hence they are purposely implemented after "purification" (*suddha*) in the formulations. However, numerous recent research articles have shown that herbal medications are contaminated with lethal amounts of heavy metals. According to a study, 42 of 43 Ayurvedic remedies were randomly selected for analysis, and heavy metals such as mercury, lead, arsenic, and chromium were found in most of the formulations.¹⁰ Heavy metals are widely present in Ayurvedic remedies which affect negatively in the body.¹⁰

HISTORY

Ayurvedic literature has a comprehensive documentation of medicinal plants. The period of documentation can be categorized into four distinct phases. They are the Vedic period, The Classical period, the Medieval period, and the Modern period.¹⁵

1. Vedic period (circa 4000-1500 BCE)

The earliest references to Ayurveda can be found in the *Vedas*, the oldest sacred texts of India.¹⁶ The *Rigveda*, one of the oldest *Vedas*, mentions various medicinal plants and healing practices.

2. The classical period (circa 1500 BCE-700 CE)

The foundational text of Ayurveda, the "*Charaka Samhita*," is attributed to the sage *Charaka* and is believed to have been written during this period.¹⁷ It covers a wide range of medical knowledge, including anatomy, diagnosis, and treatment. Another important text from this period is the "*Sushruta Samhita*," attributed to the sage *Sushruta*. It fo-

cuses primarily on surgical techniques.

3. Medieval and post-Medieval periods (circa 700-1500 CE)

During this time, Ayurveda continued to develop and spread. The "*Ashtanga Hridaya*," written by Vagbhata, is a significant text from this period, summarizing earlier Ayurvedic knowledge. Ayurveda received patronage from Indian rulers, including the Mughal emperors, which led to further advancements in the field.

4. Modern period (15th century-present)

The colonial period saw a decline in Ayurveda's popularity as Western medicine gained prominence. In the 20th century, there was a resurgence of interest in Ayurveda, with efforts to promote indigenous medical systems in India. Modern research and integration of Ayurveda with conventional medicine have become more prevalent.

BASIC DOCTRINE PRINCIPLES

Ayurveda, the ancient system of medicine in India, is based on a set of fundamental principles and doctrines that guide its understanding of health, disease, and treatment. These principles form the core of Ayurvedic philosophy and practice. Here are the basic doctrine principles of Ayurveda:

1. Panchamahabhutas (five elements)

Ayurveda views the universe and all matter as composed of five fundamental elements: Earth (*Prithvi*), Water (*Jala*), Fire (*Agni*), Air (*Vayu*), and Ether (*Akasha*).^{18,19} These five elements (earth, water, fire, air, and ether) manifest themselves in the human body and influence health.

2. Tridosha (three doshas)

Ayurveda categorizes individuals into three primary constitutional types, or *doshas* (faults or defects): *Vata*, *Pitta*, and *Kapha*.¹⁸ These *doshas* are related to different combinations of the five elements (earth, water, fire, air, and ether) and influence an individual's physical, mental, and emotional characteristics. *Vata* is associated with air and ether, *Pitta* with fire and water, and *Kapha* with earth and water.¹⁸ Health is believed to depend on the balance of these *doshas*, while imbalances can lead to disease.

3. Sapta dhatus (seven tissues)

Ayurveda recognizes seven essential tissues (*Sapta Dhatus*) in the human body, which are sequentially formed from the food we eat.¹⁸ These *dhatus* are:

- I. *Rakta Dhatu*: blood
- II. *Mamsa Dhatu*: muscles
- III. *Meda Dhatu*: fat
- IV. *Asthi Dhatu*: bone
- V. *Majja Dhatu*: bone marrow
- VI. *Shukra Dhatu*: reproductive fluid or semen

4. *Agni* (digestive fire)

Agni represents the digestive fire within the body responsible for breaking down and assimilating nutrients from food. Balanced *Agni* is essential for proper digestion, metabolism, and overall health. Ayurveda emphasizes maintaining *Agni* for optimal well-being.

5. *Malas* (waste products)

Malas describes the nature of waste products and their importance in maintaining health. Ayurveda recognizes three primary waste products: *Malas* (feces), *Mutra* (urine), and *Sweda* (sweat). Proper elimination of waste is crucial for maintaining health, as waste accumulation can lead to disease.

6. *Prakriti* (constitution)

Each individual has a unique constitution or *Prakriti*, which is determined by their dominant *dosha* or combination of *doshas* at birth. Understanding one's *Prakriti* helps tailor lifestyle, diet, and treatment to maintain balance and prevent illness.

7. *Vikriti* (imbalance)

Vikriti refers to the current state of imbalance in an individual's *doshas*, which may differ from their *Prakriti*. Identifying and addressing *Vikriti* is central to Ayurvedic diagnosis and treatment.

8. *Dinacharya* and *ritucharya* (daily and seasonal routines)

Ayurveda emphasizes the importance of daily and seasonal routines for maintaining balance and promoting health. These routines include practices related to diet, exercise, sleep, and self-care that are customized according to one's constitution and the season.

9. *Ahara* (diet) and *aushadha* (herbs and medicines)

Ayurveda places great importance on diet as a means of maintaining health and treating imbalances. Herbal remedies and medicines are used to restore balance and promote healing, often tailored to an individual's constitution.

10. *Srotas* (channels)

The body's channels or pathways through which various substances flow are called *Srotas* which play an important role in the transportation of nutrients, energy, and waste in the body. There are both physical and subtle *Srotas* and keeping them clear and functional is essential for overall health. *Srotas* are the physiological channels through which substances flow in the body.

TOXICOLOGICAL ASPECTS

Ayurvedic medicine, like any other system of medicine, has its principles and practices related to toxicology. Ayurveda emphasizes the use of natural substances, including herbs, minerals, and animal products, in healing

and wellness. However, it also acknowledges the potential for toxicity in certain substances and provides guidelines for their safe use. Here are some key aspects of toxicology in Ayurvedic medicine:

1. Herbal toxicology

Ayurveda uses a wide range of herbs and plants for medicinal purposes. Some herbs, if not used appropriately, can show toxic effects (Table 1).²⁰⁻³⁶ Ayurvedic texts classify herbs according to their safety and potential toxicity. The "Bhavaprakasha Nighantu" and other Ayurvedic pharmacopeias provide information about the toxicity, dosage, and contraindications of various herbs.³⁷

2. Individual tolerance and constitution

Ayurvedic practitioners consider the constitution of an individual (*Prakriti*) and current imbalance (*Vikriti*) when prescribing treatments. Some substances that may be well-tolerated by one person could be harmful to another. Ayurvedic practitioners must assess a patient's constitution and susceptibility to potential toxicity.

3. Mineral and metal-based medicines

While Ayurveda often emphasizes the use of natural remedies and herbs, some Ayurvedic medicines may contain ingredients and heavy metals like mercury, lead, and arsenic that can be harmful to the liver, and kidney if not properly prepared, prescribed, or used.¹⁰

Rasa Shastra is an Ayurvedic branch that deals with formulations incorporating medications of metal/mineral origin. This branch covers their genesis, variations, physical and chemical characteristics, medicinal properties, and applications. As a result, this field is also known as 'Ayurvedic Pharmaceuticals'. *Rasa Shastra* is the study of metals such as gold, mercury, silver, copper, iron, tin, lead, and zinc, which are also traditionally known as *Swarna*, *Parada* or *Rasa*, *Rajata*, *Tamra*, *Lauha*, *Vanga*, *Naga*, and *Yasada*, respectively.³⁸ These metals are necessary components of the human body and play an important role in human physiology. According to the Ayurvedic Formulary of India, mercury and lead are the most used heavy metals.³⁸

Heavy metals can interfere with the normal physiological function of organs such as the brain, kidney, liver, and blood.³⁹ Toxicity from heavy metals can have immediate or long-term repercussions. Long-term heavy metal exposure, among other things, can cause degenerative processes comparable to Parkinson's disease, multiple sclerosis, muscular dystrophy, and Alzheimer's disease. Ayurvedic herbal medicine products (HMPs) contain herbs, minerals, and metals.³⁹ In the United States and overseas, at least 55 cases of heavy metal intoxication related to Ayurvedic HMPs in adults and children have been reported since 1978.⁴⁰

1) Mercury (*Parad*): There is a specialized branch of Ayurveda that is known as *Rasa Shastra*. Here, the term *Rasa* is a synonym of Mercury and *Shastra* means book or science; therefore, the word *Rasa Shastra* means the

TABLE 1. Name of some Ayurvedic medicines that contain mercury and possible toxicity (study conducted in animals)

Ayurvedic medicines	Medicinal purposes	Study period (days)	Possible toxicity
Naradiya Laksmivilasa Rasa	Diabetes, obesity, rheumatoid arthritis	32	Hepatotoxicity ^{20,21}
Siddha Makardhwaja	Tonic and rejuvenator	28	Hepatotoxicity ²²⁻²⁴
Swalpo Chandrodoy Makardhwaj	Geriatric rejuvenator	32	Kidney, spleen ²⁵
Chandrangshu Ras	Vulvodynia	32 ²⁶	
Chintamanichaturmukh Ras	Vertigo		Hepatotoxicity ²⁷
Rasaraj Ras	Hemiplegia	28	Hepatotoxicity ²⁸
Pijusaballi Rasa	Edema	28	Kidney ^{29,30}
Karpur Ras	Diarrhea	28	Liver, kidney ³¹
Yogendra Ras	Epilepsy	28	Liver, kidney ³²
Makardhwaja	Anti-aging and aphrodisiac	28	Abnormalities in luteinizing hormone, progesterone, anemia ³³⁻³⁵
Vata Gajendra Singha	Rheumatoid arthritis	28	Abnormalities in blood parameters ³⁶

“Science of Mercury”.⁴¹ The evolution of *Rasa Shastra* as a specialized branch is traced to the great Buddhist Sage Naagaarjuna who is considered as ‘Father of *Rasa Shastra*’.⁴¹ It is believed to have begun to take on its full form with scientific documentation and classification during the eighth century. Additionally, Naagaarjuna is renowned for his great skill in handling mercury for alchemical and medicinal purposes.

The fact that this branch’s name comes from *Parad* (*Rasa* in *Rasa-Shastra*), suggests that medical professionals of that period placed an intense emphasis on using *Parad* or *Rasa* in medicinal uses. *Rasa Shastra* has existed since the Vedic period.⁴² It has also been reported that Buddhist sages were the first to use mercury and are believed to be one of the creators of treatment by using metals and minerals in their appropriate form.⁴² In addition to other metals, several medications used in *Rasayana chikitsa* (rejuvenation therapy) contain *Parad*. These are classified as *Rasaousadhies*.⁴³ Since *Rasaousadhies* are effective in small doses and give quick relief as compared to pure herbal formulations, they have gained tremendous significance.⁴³

The medication by *Parad* is quite effective. It is one of the crucial foundational components of *Rasa-Ousadhies*. When processed appropriately, it balances the three *doshas* (*vata*, *pitta*, and *kapha*) in the body. It has a soothing impact on our bodies, preventing illness consequently. Some of its effects include *vrishya* (an aphrodisiac), *balya* (a tonic), *snigdha*, *rasayana* (to revitalize), *vrana shodhana* and *ropana* (to treat wounds), *krimighna* (an antibiotic), and *yogavahi*.⁴⁴ When used with *Parad*, several plants’ therapeutic effects are enhanced. It aids in mental stability and is regarded as the most effective disease-eradicator. Suitable carriers for preparations containing *Parad* include sugar, amla powder, ginger, and lemon juice.⁴⁴ It is the metal in a liquid state which makes it unsuitable for use. To overcome this problem, scholars have mentioned certain procedures called *Rasa-Bandha* (mercurial bonds).

At the same time, Mercury (*Parad*) alone has been termed as a highly toxic and poisonous material and carries eight

natural toxins within; those may cause certain negative effects; such as *Naag dosha*: wound, *Bang dosha*: eruption in skin, *Agni dosha*: burning in body, *Mal dosha*: stiffness all around, *Chapalya dosha*: loss of virility and sexual power, *Vish dosha*: death, *Giri dosha*: boils all over body and *Asahyagni dosha*: Maniac depression. There is always great emphasis that all such *doshas* of mercury should be eliminated first by performing various processing steps and then only processed mercury should be used for human consumption.

If mercury is not properly extracted and purified, it can be hazardous to the liver and other organs. Methylmercury (MeHg) at high concentrations can cause a range of diseases, including delayed growth and development, decreased reproductive success, liver dysfunction, and kidney damage.⁴⁵ MeHg can also have negative impacts on prenatal growth, brain function, the cardiovascular system, and immunological function in adults and children.⁴⁵

2) Arsenic: Arsenic is derived from the Greek word *arsenikon* meaning “potent”. It has been employed as a poison and a medicinal agent since ancient times. *Susruta* described arsenical compounds (Phenasma) as metallic poison before the year 2000 B.C. Charak Samhita (400 BC) describes the external usage of Orpiment and Realgar in skin ailments. However, the extensive usage of arsenic in Ayurveda was discovered around the eighth century, following the establishment of *Rasa Sastra*, as various arsenic compounds are found in treatments. Arsenicals are also used in the Siddha and Unani systems of medicine in India.

Haritala (Orpiment), Manashila (Realgar) and Gouripasana (White arsenic) are the three commonly used Arsenicals in Ayurveda for wide range of diseases (Table 2).⁴⁶ Haritala (Orpiment) and Manashila (Realgar) come under Uparasa and Gouripasana (White arsenic) comes under *Sadharana Rasa* as per the Ayurveda *Rasa sastra* (Alchemy). Malla sindura and *Rasa Manikyaa* are two derivatives of White arsenic and Orpiment respectively used in certain cases of cancer by contemporary Ayurveda Practitioners.

TABLE 2. Some Ayurvedic medicines containing Arsenic compounds

Ayurveda drug	Arsenic compounds	Medicinal pupose
Kasturivarava rasa	Haritala (orpiment) As ₂ S ₃	Fever
Vatagajankusa rasa	Haritala (orpiment) As ₂ S ₃	Neuro-muscular diseases
Tala Sindura rasa	Haritala (orpiment)As ₂ S ₃	Fever, cough, skin desease
Tala bhasma	Haritala (orpiment) As ₂ S ₃	Syphilis, gout, herpes
Krimihara rasa	Manashila (realgar) As ₂ S ₃	Intestinal worms
Gulma Kalanal Ras	Manashila (realgar) As ₂ S ₃	Abdominal conditions
Smriti sagar ras	Manashila (realgar) As ₂ S ₃	Epilepsy and neurological diseases
Kalanala Rasa	Gouripasana As ₂ O ₃	Abdominal conditions
Nityodita rasa	Gouripasana As ₂ O ₃	Gout, elephantiasis, tumors, obesity
Mallasindura	Gouripasana As ₂ O ₃	Asthma

All arsenical compounds used in Ayurveda drugs are absorbed through the gastrointestinal system.⁴⁷ Arsenical compounds have been used to regulate the blood counts of patients with hematological malignancies. There has been some observation of current Ayurvedic practitioners treating various solid tumors, such as nasal polyps, hemorrhoids, and elephantiasis.⁴⁸ It may be due to the induction of apoptosis. The mechanism of arsenic-induced cell death is well understood in the application of As₂O₃, which is a potent cytotoxic and antitumor activity in vitro and vivo. Elevation of reactive oxygen species is a crucial early cellular event that happens after As₂O₃ therapy of target cells.⁴⁹ Arsenic-containing chemicals are also effective modulators of the thioredoxin system, including thioredoxin, thioredoxin reductase, and NADPH. Some heavy metals, such as arsenic, are directly hepatotoxic, causing liver cell destruction and compromising overall liver function. Gauripasana (Arsenic trioxides) is a highly toxic compound than harital and manashila.⁵⁰

3) Lead: Lead is a natural metal present in water and soil. Human exposure comes primarily through diet, air, drinking water, and ingestion of paint particles in the air, as well as occasionally through medicine. Even though lead has medicinal benefits, it is considered an unsafe metal in Ayurveda. Ayurvedic medications have been found to contain high levels of lead as well as other heavy metals, which constitute serious health risks.⁵¹ According to one investigation, lead was identified in 65% of 252 Ayurvedic medicines mixed with mercury.⁵¹

Lead accumulates in the brain, spleen, kidneys, liver, and lungs, as well as in blood, bone, and soft tissues.⁵² Lead in blood has a half-life of 30 days in people with normal renal function and a longer half-life in people with renal insufficiency.⁵² Excess lead, like other heavy metals, causes the creation of free radicals, which causes oxidative damage to biological components such as DNA and cell membranes.⁵³ Lead inhibits DNA transcription, and vitamin D enzymatic production that maintains cell membrane integrity.

SAFETY CONCERN

The safety of medications and therapies has always been a top emphasis in the Ayurvedic system. Ayurveda takes pleasure in claiming to be the *suddha* (pure) approach to treatment that defines ailments without causing new ones. A medication or medicine that cures one sickness but causes another is deemed *asuddha* or impure. The presence of bioactive plant components and other heavy metals such as mercury, lead, and arsenic are directly associated with the toxicity of medicinal plants and ayurvedic medicinal preparations. When it comes to heterogeneous, complex mixes of herbs and heavy metals, the situation becomes much more complicated. Several chronic studies in rats have found that only plant-based Ayurveda medicines have long-term negative effects on organs such as the liver, kidney, and spleen and glycemic index.⁵⁴⁻⁵⁶ Chronic studies have also found that Ayurvedic drugs elevated blood glucose levels in rats, which could lead to additional complications in diabetic patients.⁵⁷ There are many examples of toxic endogenous compounds in the plant kingdom such as pyrrolizidine alkaloids (hepatotoxic, genotoxic, cytotoxic, phototoxic), furan derivatives (hepatotoxic, possible carcinogenic), epoxy-diterpenoids (hepatotoxic), anthraquinones (hepatotoxic), bis-benzylisoquinoline alkaloids (pulmonary toxicity), alkenylbenzenes (genotoxic, carcinogenic), ginkgolic acids (embryotoxic, cytotoxic, neurotoxic).⁵⁸

Ayurvedic treatments are frequently made by various manufacturers without any regulations or safety concerns, and there may be a lack of uniformity in terms of the components utilized and their concentrations. This discrepancy can lead to variances in product potency and safety. Ayurvedic medications, unlike modern pharmaceuticals or contemporary medicines, frequently lack standardized manufacturing processes and quality control. As a result, the potency and safety of products from different manufacturers may differ. Various metals used in Ayurvedic medicine, including zinc, copper, and iron, have various therapeutic benefits in humans, but excessive doses of these metals can be fatal.⁵⁹ Toxic concerns are increasingly serious due to insufficient Ayurvedic drug safety studies. Many Ayurvedic treatments have not been subjected to rigorous scientific

testing to determine their safety and efficacy. It can be difficult to identify potential hazardous ingredients in these medicines without thorough scientific investigation and robust clinical trials.

Ayurvedic preparations or formulations should be strictly regulated by authorities.⁶⁰ The government should introduce restrictions to prohibit direct access or over-the-counter purchases of Ayurvedic medicines. Clinicians or physicians should prescribe validated or authentic Ayurvedic remedies while also discussing drug dosage and toxicity with patients. Furthermore, heavy metal-containing ayurvedic medicine should be thoroughly evaluated to ensure the standard quality of the drug. Ayurvedic physiology, pathology, pharmacology (both basic and clinical), and medicines all require fundamental research. The government should devise a timetable for the gradual advance of Ayurvedic education and research. Science-based approaches to Ayurveda education, such as traditional Chinese medicine, can be encouraged, used, and instilled. It is commendable that China has almost 95% Department of Traditional Medicine in its government hospitals. That is why their ancient medicinal system has gained global renown and is widely accepted.⁶¹ Youyou Tu was awarded the Nobel Prize in Medicine for inventing Artemisinin, a medicine that has drastically reduced malaria fatality rates based on a traditional Chinese medicine cure.⁶¹ Similar strategies may be implemented in the healthcare system to promote the development of Ayurveda.

There are currently more than 600 different Ayurvedic preparations available for children and adults as herbal remedies to treat a variety of illnesses such as the common cold, diabetes, infertility, cardiovascular problems, psychiatric disorders, respiratory problems, rashes, and pain.⁶² A thorough examination of 193 Ayurvedic remedies indicated the presence of heavy metals in 20% of the products examined.⁶² Many of these drugs are produced in both India and the United States. Because they are promoted as supplements, they are not regulated by the United States Food and Drug Administration and are widely available in health food stores and on the internet. Over 20% of the Ayurvedic medicines manufactured and supplied by US and Indian corporations are thought to include harmful metals such as lead, mercury, and/or arsenic.⁵¹

QUALITY CONTROL

Quality control in Ayurvedic medicine requires understanding what is in the plant's chemical components, what happens during manufacturing, and doing chemical and biological inspections before the finished product is sent to the client.⁶³ The globe is raising serious concerns about the adulteration and contamination of traditional medicines. Furthermore, adulterants may be found in low-cost tree products with comparable biochemical or pharmacological component effects.⁶⁴ All essential information about horticulture-related items should be carefully evaluated while developing medications to account for empirical and batch-

to-batch variation. Based on the numerous standards outlined in the Ayurvedic Pharmacopoeia, it is critical to assess the description and analytical specifications of Ayurvedic formulations.⁶⁵ Standardization methods should be used for all aspects of Ayurvedic medicine consistency, such as proper sample recognition, organoleptic analysis, volatile substance, pharmacognostic analysis, quantitative analysis, microbial load, xenobiotic, toxicity evaluation, phytochemical evaluation, and biochemical activity.⁶⁵ Analytical parameters such as moisture content, ash values, extractive values, heavy metals, pesticide residues, and aflatoxins may help evaluate the quality of herbal raw materials. Various chromatographic techniques are frequently used to detect and maintain the quality of herbal medications or products. Though there are various chromatographic ways to segregation, the common thread is compound isolation through the use of mobile and stationary phase changes. Chromatographic techniques include GC, HPTLC, HPLC, HPLC-MS, GC-MS, NMR, and TLC, among others.⁶⁶ All of these procedures may help to assess the phytoconstituents contained in complicated Ayurvedic medicines.

DISCUSSION

Ayurveda has a long history, however, there were several drawbacks in approaches to it that hampered its expansion, like the Western medical system. In most of the cases, the active components of the herbal medications provided were unknown, and many drugs still require further investigation for active constituent characterization and mechanism of action elucidation. Ayurveda medications continue to have downsides despite decades of using modern scientific techniques for drug analysis. Heavy metal adjuvants are routinely added to Ayurvedic medicines for their alleged therapeutic effects and to boost effectiveness. Lead, arsenic, and mercury are three heavy metals commonly found in Ayurvedic treatments. The current study indicated that users of Ayurvedic remedies may be at risk of heavy metal toxicity and urged for obligatory testing for hazardous heavy metals in Ayurvedic goods.

CONFLICT OF INTEREST STATEMENT

None declared.

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