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INTEGRATION OF NANOTECHNOLOGY IN INDIAN TRADITIONAL MEDICINES CURRENT STATUS AND FUTURE TREND

Ayesha Nazeer, Faisal Ahmad and Shamim Ahmad*

508, BWT, Eros Garden, Charmwood Village, Faridabad, Haryana, India.

***Corresponding Author: Shamim Ahmad**

508, BWT, Eros Garden, Charmwood Village, Faridabad, Haryana, India.

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ABSTRACT

The ancient Indian systems of medicine, including Ayurveda, Unani, and Siddha, have since long been utilizing natural materials and traditional processing techniques that can be considered early forms of nanomedicine. Concepts like Bhasmas in Ayurveda, which are nanoparticulate herbo-mineral-metallic preparations, demonstrate the inherent understanding of the benefits of reducing particle size to enhance bioavailability and therapeutic efficacy. With the advent of modern nanotechnology, there is a growing interest in scientifically validating and integrating these traditional practices with cutting-edge nanomedicine approaches. Analytical techniques like electron microscopy and spectroscopy have confirmed the presence of nanoparticles in traditional Bhasmas, providing a scientific basis for their enhanced bioavailability, targeted delivery, and improved safety profile compared to raw metals and minerals. Furthermore, the traditional Ayurvedic processes of Shodhana (purification), Bhavana (levigation), and Marana (incineration) can be viewed as early forms of nanoparticle engineering, transforming raw materials into stable, biocompatible, and therapeutically potent nanomedicines. Optimizing and standardizing these traditional methods using modern scientific principles holds great promise for developing safe and effective Ayurvedic nanomedicines. The integration of nanotechnology with Indian traditional medicine systems can also help address some of the key challenges faced by the widespread acceptance of these ancient practices, such as lack of scientific validation, standardization, and regulatory frameworks. By combining traditional wisdom with modern scientific understanding, a synergistic approach can be developed to harness the full potential of nanomedicine for improving human health and wellness. This review discusses the current state of research on the integration of nanotechnology in Indian traditional medicine systems, highlighting the key opportunities, challenges, and future directions in this emerging field of study.

KEYWORDS: Nanotechnology, Nanoparticles, Bhasmas, Kushtas, Unani, Ayurveda, Siddha Medicines, Nanomedicines, Nano-herbal Medicines.

1. INTRODUCTION

The traditional Indian medicine systems of Ayurveda, Siddha, and Unani have a rich history spanning thousands of years. These holistic approaches to healthcare utilize a diverse range of natural substances, including herbs, minerals, and even metals, in their formulations. However, the inherent complexity and variable bioavailability of many traditional ingredients have posed challenges in terms of standardization and therapeutic efficacy.

In recent years, the integration of nanotechnology has emerged as a promising avenue to address these limitations and enhance the potential of Ayurvedic, Siddha, and Unani medicines. Nanoscale formulations can improve the solubility, stability, and targeted delivery of active compounds, potentially leading to improved bioavailability and therapeutic outcomes.

This review aims to explore the current status of nanotechnology applications in traditional Indian medicine systems, highlighting the key developments, challenges, and future prospects. By examining case studies and research trends, it will provide insights into how the convergence of ancient wisdom and modern science can pave the way for more effective and evidence-based traditional medicine practices.

The integration of nanotechnology in Ayurveda, Siddha, and Unani medicines holds the potential to revolutionize the way these traditional systems are perceived and utilized, bridging the gap between traditional knowledge and contemporary scientific understanding. As this field continues to evolve, it is crucial to explore the opportunities and address the regulatory, safety, and ethical considerations to ensure the responsible and

sustainable integration of these innovative approaches [Liu, et al, **2008**; WP-19; WP-23].

The traditional Indian medicine systems have a rich history spanning thousands of years. These holistic approaches utilize a diverse range of natural substances, including herbs, minerals, and even metals, in their formulations. However, the inherent complexity and variable bioavailability of many traditional ingredients have posed challenges in terms of standardization and therapeutic efficacy.

In recent years, the integration of nanotechnology has emerged as a promising avenue to address these limitations and enhance the potential of Ayurvedic, Siddha, and Unani medicines. Nanoscale formulations can improve the solubility, stability, and targeted delivery of active compounds, potentially leading to improved bioavailability and therapeutic outcomes.

Currently, researchers have explored various nanotechnology-based approaches to improve the delivery and efficacy of traditional Indian medicine formulations:
Metallic nanoparticles, such as those made from gold, silver, and copper, have been developed using Ayurvedic and Unani methods. These nanoparticles, once surface modified appropriately, can enhance the bioavailability and therapeutic potential of the traditional preparations. Nanoscale emulsions and suspensions of Ayurvedic and Siddha herbal extracts have shown improved solubility, stability, and permeability compared to their bulk counterparts. Ayurvedic and Unani active compounds have been encapsulated in nanofibers and nanocarriers, such as liposomes and polymeric nanoparticles, to enhance their targeted delivery to enhance their therapeutic efficacy. Researchers are exploring the use of nanobiosensors to monitor the quality and consistency of traditional Indian medicine formulations, improving standardization and quality control.

The integration of nanotechnology in Ayurvedic, Siddha, and Unani medicines holds significant promise for the future as described below.

Nanoscale formulations can enhance the solubility, stability, and targeted delivery of active compounds, leading to better therapeutic outcomes. Nanobiosensors and advanced analytical techniques can help establish quality standards and ensure the consistency of traditional medicine preparations. Nanomedicine approaches can enable the development of customized traditional medicine formulations tailored to individual patient needs also known as personalized medicines. The convergence of ancient wisdom and modern science can pave the way for more evidence-based and integrated healthcare solutions.

However, the successful integration of nanotechnology in traditional Indian medicine systems will require addressing regulatory, safety, and ethical considerations to ensure the responsible and sustainable development of these innovative approaches [Sharma, et al, **2014;** Srivastava, et al, **2015;** Akhtar, et al, **2016;** Jain, et al, **2016;** Ansari, et al, **2017;** Rajamanickam, et al, **2018;** Sharma, et al, **2019**].

2. Integrating nanotechnology into indian traditional medicines

Nanoscale formulations can enhance the solubility, stability, and targeted delivery of active compounds from Ayurvedic herbs and minerals. This can lead to improved absorption and bioavailability, potentially enhancing the therapeutic efficacy of traditional Ayurvedic preparations.

Metals and minerals are important ingredients in many Ayurvedic formulations. Nanoparticles made from substances like gold, silver, copper, and zinc can help improve the delivery and therapeutic potential of these metallic ingredients.

Advanced analytical techniques using nanobiosensors can help establish quality standards and ensure the consistency of Ayurvedic preparations. This can improve the safety and efficacy of these traditional medicines.

Nanomedicine approaches can enable the development of customized Ayurvedic formulations tailored to individual patient needs, based on their specific health conditions and genetic profile.

The integration of nanotechnology with Ayurvedic principles can help bridge the gap between traditional knowledge and contemporary scientific understanding. This convergence can pave the way for more evidence-based and integrated healthcare solutions.

However, the successful adoption of nanotechnology in Ayurveda will require addressing regulatory, safety, and ethical considerations to ensure the responsible and sustainable development of these innovative approaches. Proper quality control and safety testing are crucial to minimize the risks of contamination or toxicity [Liu, et al, **2008**; Doshi, et al, **2019**].

Ayurvedic preparations have traditionally been using mercury compounds like cinnabar (mercury sulphide) as ingredients. However, the presence of toxic heavy metals like mercury in Ayurvedic medicines has raised significant safety concerns. Studies have found that some Ayurvedic products contain mercury, lead, and arsenic at levels far exceeding safe limits.

Nanotechnology can be used to develop nanoparticle formulations of Ayurvedic ingredients, including mercury-containing compounds. Nanoscale processing and encapsulation of mercury compounds may help improve their stability, bioavailability, and reduce toxicity. For example, research has shown that mercury

nanoparticles prepared using Ayurvedic methods can have lower toxicity compared to bulk mercury.

While nanotechnology shows promise, more rigorous research is needed to fully understand the safety and efficacy of nanoformulations containing mercury. Proper standardization, quality control, and regulatory oversight are crucial to ensure the safety of any Ayurvedic products, including those using nanotechnology. Improper manufacturing practices can still lead to contamination and toxicity, even with the use of nanotechnology.

Ayurveda emphasizes a holistic approach to health, not just the use of individual ingredients. Integrating nanotechnology with Ayurvedic principles may help enhance the safety and efficacy of traditional preparations, but should be done cautiously and in alignment with Ayurvedic philosophy.

Nanotechnology has the potential to help reduce the toxicity of mercury in some Ayurvedic preparations, but more research and rigorous quality control measures are needed to ensure the safe and responsible integration of these innovative approaches. A holistic, evidence-based approach is crucial for the successful convergence of traditional Indian medicine and modern science [Liu, et al, **2008**; Doshi, et al, **2019**; WP-18; WP-19].

Based on the search results, the use of mercury in Ayurvedic medicines is a complex and controversial issue, impacted by international regulations:
Mercury is a well-known toxic heavy metal that can have severe negative health effects. The presence of mercury, as well as other heavy metals like lead and arsenic, has been found in some Ayurvedic preparations, raising significant public health concerns.

International bodies like the United Nations Environmental Programme (UNEP) and regulatory authorities in the US and EU are working to ban the trade and use of mercury globally.

The "Minamata Convention" aims to restrict the use of mercury, which is recognized as a chemical of global concern due to its persistence in the environment and negative health impacts.

Traditionally, mercury has been used in certain Ayurvedic preparations, such as Rasa Shastra, based on the belief that it can have therapeutic benefits when properly processed. However, the international regulations and bans on mercury are posing challenges for the continued use of mercury containing Ayurvedic medicines.

Some Ayurvedic experts argue that the use of mercury in traditional Ayurvedic medicines should be exempt from the international regulations, as the mercury is processed and transformed into a non-toxic form. There are calls for rational regulations that allow the continued use of mercury in Ayurveda, while ensuring proper quality control and safety measures.

Regardless of the traditional use of mercury in Ayurveda, proper manufacturing practices, quality control, and safety testing are crucial to minimize the risks of mercury contamination and toxicity. Unregulated and improper preparation of mercury containing Ayurvedic medicines can lead to serious health issues, as evidenced by some reported cases of mercury poisoning.

The international regulations on mercury pose significant challenges for the traditional use of mercury in Ayurvedic medicines. While some Ayurvedic experts argue for exemptions, the overarching need is there for robust quality control, safety testing, and regulatory oversight to ensure the safe and responsible integration of mercury based Ayurvedic preparations [Liu, et al, **2008**; Doshi, et al, **2019]**.

3. *General background information*

Unani, Ayurved, and Siddh are the three most widely practiced traditional medicine systems in India. While they share some similarities, there are also key differences in their origins, philosophies, and approaches to formulations:
Unani system of medicine originated in ancient Greece, later adapted, and developed in the Middle East and South Asia. Unani is based on the concept of four humors (blood, phlegm, yellow bile, black bile) and their balance. Unani medicines use herbal, mineral, and animal-derived substances in its formulations including oral medicines, topical applications, and manipulative therapies.

Ayurvedic system of medicine emphasizes balance between the three doshas (vata, pitta, kapha) in the body and uses herbs, minerals, metals, and animal products in its formulations those including oral medicines, topical applications, dietary regimens, yoga, and meditation.

Siddh system of medicine originated in ancient Tamil Nadu, India. It focuses on spiritual and supernatural aspects along with physical health and uses herbs, minerals, metals, animal products, and even gems in its formulations including oral medicines, topical applications, and spiritual practices.

3.1. Similarities and Differences

All the three systems have a holistic approach to health and disease relying heavily on herbal formulations as the mainstay of treatment incorporating the dietary regimens and lifestyle modifications as part of therapy. They aim to restore balance in the body, mind, and spirit.

The Unani system came from ancient Greece while Ayurved and Siddh are indigenous to India.

Siddh places more emphasis on spiritual aspects compared to Unani and Ayurved. Ayurved and Siddh use more metals and minerals compared to Unani whereas the Unani system uses more animal-derived substances while Ayurveda and Siddha avoid them.

While Unani, Ayurved and Siddh share the common goal of restoring health through natural means, they differ in their philosophical foundations, specific approaches, and choice of ingredients in their formulations. All three systems continue to be widely practiced in India and other parts of the world.

3.2 Intercomparison of Ayurveda, Siddha and Unani systems

Siddha has a stronger spiritual focus compared to the more physical/humoral approach of Unani and the balance of doshas in Ayurveda.

Siddha and Ayurveda use more metals, minerals, and animal products compared to the predominantly herbal Unani formulations.

Siddha incorporates spiritual practices, Unani uses more manipulative therapies, while Ayurveda emphasizes herbal remedies, diet, and lifestyle.

Ayurveda is indigenous to India, Siddha to Tamil Nadu, and Unani has its roots in ancient Greece.

Overall, while all three systems share the common goal of restoring health through natural means, they differ in their philosophical underpinnings, specific therapeutic approaches, and choice of ingredients in their formulations [WP-01; WP-03; WP-06; WP-07; WP-08].

3.3 Preventive healthcare approaches in traditional system of medicines

All three systems take a holistic approach to health and disease prevention emphasizing the role of diet, lifestyle, and environment in maintaining balance and preventing illness by using natural substances like herbs, minerals, and animal products in the related preventive therapies.

Siddha has a stronger spiritual focus compared to the humoral approach of Unani and the dosha balance in Ayurveda. Siddha and Ayurveda use more metals, minerals, and animal products compared to the predominantly herbal Unani formulations. Ayurveda has a more developed system of daily and seasonal regimens for prevention.

While the three systems differ in their philosophical foundations and specific approaches, they share the common goal of maintaining health and preventing disease through natural means. Their preventive healthcare strategies emphasize the interconnectedness of the body, mind, and environment [Shiva, et al, **2022;** WP-03; WP-08; WP-09; WP-10].

3.4 Inclusion of Diet and Exercise - Unani, Ayurveda and Siddha Methods

Unani focuses on maintaining the balance of the four humors through dietary modifications involving specific foods, spices, and cooking methods based on one's temperament. It prescribes physical therapies like exercise, massage, and fomentation to promote health and mostly involves herbal, mineral, and animal-derived substances in its formulations.

Ayurveda emphasizes a Sattvic diet - fresh, seasonal, vegetarian foods that promote balance of the three doshas (vata, pitta, kapha). Recommends specific dietary guidelines based on one's dominant dosha to maintain balance by incorporating yoga, pranayama (breathing exercises), and meditation as integral parts of the lifestyle to promote daily and seasonal routine routines to align with natural cycles.

Siddha system follows the concept of do's and don'ts based on diet and lifestyle rules while using herbal, mineral, and animal-based preparations as part of the dietary regimen along with incorporation of Pranayama (yogic breathing) and Varmam (energy point stimulation) practices – all leading to the balance between the three humors through diet and lifestyle.

All the three systems take a holistic approach to health, integrating diet, lifestyle, and physical practices while emphasizing the importance of maintaining balance and harmony in the body, mind, and environment.

Ayurveda has a more developed system of daily and seasonal routines compared to Siddha and Unani. Siddha incorporates more spiritual and mystical elements in its dietary and lifestyle recommendations. Unani places greater emphasis on the humoral theory and physical therapies compared to the other two.

Overall, while the three traditional medicine systems have distinct philosophical foundations, they share the common goal of promoting health and preventing disease through a synergistic approach to diet, exercise, and lifestyle modifications [Thas, **2008;** WP-08; WP-09; WP-10; WP-11].

2.5Variety of Solid, Liquid and Viscous dosage forms

Unani system deploys Tablets (Qurs), Pills (Habb), Powders (Safoof), Lozenges (Mulaiyan).

Ayurveda has Tablets (Vati), Pills (Gutika), Powders (Churna), and Granules (Avaleha) compared to Siddha providing Tablets (Kattu), Pills (Kuligai), Powders (Choornam), and Pastes (Karpam).

Liquid dosages of Unani are in the form of Decoctions (Joshanda), Infusions (Naqoo'), Syrups (Sharbat), and Juices (Aarak); Ayurveda offers Decoctions (Kwatha), Infusions (Phanta), Syrups (Arishta, Asava), and Juices (Swarasa); and Siddha formulations are provided in the

form of Decoctions (Kudineer), Infusions (Ilagam), Syrups (Thylam), and Juices (Pazham).

Viscous/Semi-Solid Dosage Forms in Unani are Liniments (Marham), Ointments (Zimad), Pastes (Laooq), and Medicated Oils (Roghan); Ayurveda offers Liniments (Lepa), Ointments (Ghrita), Pastes (Kalka), and Medicated Oils (Taila) whereas Siddha formulations are available as Liniments (Poochu), Ointments (Ennai), Pastes (Karpam), and Medicated Oils (Ennai).

All the three systems are very well known to utilize a wide range of solid, liquid, and viscous dosage forms. Decoctions, infusions, syrups, and medicated oils are common across the three traditions. Powders, tablets/pills, and pastes/liniments are also widely used. Unani has a stronger emphasis on animal-derived substances in some formulations. Siddha incorporates more spiritual and alchemical elements in its preparations. Ayurveda has a more developed system of classifying and preparing its dosage forms.

Overall, the traditional Indian medicine systems demonstrate a rich diversity in their pharmaceutical preparations, drawing upon the unique strengths and characteristics of solid, liquid, and viscous dosage forms to address a wide range of health conditions [Ansari, et al, **2019;** Fazil, M., and Nikhat, **2022**; REP-01; REP-02; WP-09].

3.6 Commonest forms of ayurvedic medicines

Solid Dosage Forms contain mostly in the form of Tablets (Vati), Pills (Gutika), Powders (Churna), and Granules (Avaleha). Liquid Dosage Forms contain Decoctions (Kwatha), Infusions (Phanta); Syrups (Arishta, Asava), and Juices (Swarasa). Viscous/Semi-Solid Dosage Forms contain Liniments (Lepa), Ointments (Ghrita), Pastes (Kalka) and Medicated Oils (Taila).

The Ayurvedic medicines utilize a wide range of solid, liquid, and viscous/semi-solid dosage forms to deliver the herbal, mineral, and other natural ingredients. These diverse formulations allow the practitioners to address a variety of health conditions and administer the medicines through different routes accordingly.

Solid forms like tablets, pills, and powders are commonly used. Liquid forms like decoctions, infusions, and syrups are also widely employed. Viscous/semi-solid forms such as liniments, ointments, and medicated oils are important for topical applications. The choice of dosage form depends on factors like the nature of the ingredients, the intended route of administration, and the desired therapeutic effect. Overall, the Ayurvedic system demonstrates a rich diversity in its pharmaceutical preparations, drawing upon the unique strengths of various solid, liquid, and viscous dosage forms to deliver natural, holistic treatments [WP-10; WP-13; WP-14; WP-15; WP-16].

3.7 Ayurvedic dosages

Ayurveda has specific dosage guidelines based on the patient's age and life stage. For example, the first month of life, the dose is 1 ratti (approximately 125 mg) which is then increased by 1 ratti every month up to 12 months. Doses are then increased by 1 masa (approximately 900 mg) every year up to 16 years of age.

Ayurvedic practitioners assess the patient's predominant dosha (vata, pitta, kapha) and body constitution to determine the appropriate dosage. Patients with different prakriti may require varying doses of the same medicine.

The nature and severity of the disease or health condition are also factored in when deciding the dosage. Acute conditions may require higher doses compared to chronic or milder ailments.

Ayurvedic medicines come in various potencies and concentrations, which the practitioner must consider when prescribing them. Stronger formulations like bhasmas (calcined minerals) may require smaller doses compared to simpler herbal preparations.

The practitioner evaluates the patient's agni (digestive fire) and adjusts the dose accordingly. Patients with weaker digestion may require smaller, more frequent doses.

Ayurvedic texts recommend adjusting doses based on the season and environmental factors.

In essence, Ayurvedic practitioners use a holistic, patient-centric approach, considering factors like age, constitution, disease state, formulation strength, and digestive capacity to determine the appropriate dosage for each individual. This personalized approach is a key tenet of Ayurvedic healthcare [Shipra, and Goyal, **2019;** Brahmankar, et al, **2021;** WP-17].

4. Metals and Minerals in traditional indian medicines

Ayurvedic preparations may contain metals, minerals, and gems as ingredients. Examples include lead, mercury, and arsenic, which have been found in some Ayurvedic products. The presence of these heavy metals in Ayurvedic medicines is a major safety concern, as they can lead to toxic effects if not properly processed and used. Ayurvedic texts describe methods for purifying and processing these metals and minerals, but improper preparation can result in contamination.

The Unani system also incorporates the use of metals and minerals in its formulations, though to a lesser extent compared to Ayurveda. Common Unani mineral ingredients include sulphur, iron, copper, and zinc. The Unani approach emphasizes the proper processing and purification of these mineral substances to ensure safety and efficacy.

The Siddha system places a stronger emphasis on the use of metals, minerals, and even gems in its preparations. Siddha practitioners utilize a wide range of metallic substances, including mercury, lead, gold, silver, and others. Like Ayurveda, the Siddha system has traditional methods for purifying and processing these materials, but improper preparation can lead to toxicity concerns.

It's important to note that the use of metals and minerals in traditional Indian medicines is based on their philosophical principles and historical practices. However, the presence of heavy metals like lead, mercury, and arsenic in some commercially available products is a major safety issue that has been highlighted in recent studies.

Proper manufacturing practices, quality control, and adherence to safety guidelines are crucial when incorporating metals and minerals into Ayurvedic, Unani, and Siddha formulations. Consumers should exercise caution and consult qualified practitioners before using any traditional Indian medicines, especially those containing metallic ingredients [Fazil, and Nikhat, **2022;** WP-03; WP-07; WP-18; WP-19].

4.1 Some specific metals used in traditional indian medicines

Ayurvedic preparations may contain metals, minerals, and gems as ingredients. Examples include lead, mercury, and arsenic, which have been found in some Ayurvedic products.

The Unani system also incorporates the use of metals and minerals in its formulations, though to a lesser extent compared to Ayurveda. Common Unani mineral ingredients include sulphur, iron, copper, and zinc. Siddha Medicine system places a stronger emphasis on the use of metals, minerals, and even gems in its preparations. Siddha practitioners utilize a wide range of metallic substances, including mercury, lead, gold, silver, and others.

However, the presence of heavy metals like lead, mercury, and arsenic in some commercially available Ayurvedic and Siddha products is a major safety issue that has been highlighted in recent studies. Improper processing and purification of these metallic substances can lead to toxic effects if not done properly.

It's important to note that the use of metals and minerals in traditional Indian medicines is based on their philosophical principles and historical practices. But proper manufacturing practices, quality control, and adherence to safety guidelines are crucial when incorporating these ingredients into Ayurvedic, Unani, and Siddha formulations to ensure safety [Ansari, et al, **2019,** WP-13; WP-16; WP-18; WP-19].

4.2 Commonest Metals and Minerals in Ayurvedic Medicines

Mercury is one of the most widely used metals in Ayurvedic preparations. It is used in various forms like Rasasindura, Kajjali, and Rasa Parpati. Mercury is believed to have rejuvenating and detoxifying properties in Ayurveda.

Sulphur is another important mineral used extensively in Ayurvedic medicines. It is used in the form of Gandhaka Rasayana and Gandhaka Malahara for various skin and respiratory conditions.

Iron is used in the form of Bhasmas (calcined metals/minerals) is commonly used in Ayurvedic formulations. Examples include Mandura Bhasma and Lauha Bhasma, which are used for anaemia and other blood disorders.

Copper is used in the form of Tamra Bhasma for conditions like anaemia, arthritis, and skin diseases.

Zinc is used in the form of Yasada Bhasma for treating conditions like diabetes, sexual disorders, and skin diseases.

Lead is used in the form of Sisa Bhasma has been used traditionally, but its use is controversial due to potential toxicity.

Arsenic has been used in some Ayurvedic preparations, but their use is also controversial and potentially harmful.

It's important to note that the use of heavy metals and minerals in Ayurvedic medicines has raised safety concerns, and proper processing and purification methods are crucial to minimize the risk of toxicity. Regulatory bodies have also placed restrictions on the use of certain metals in Ayurvedic products. [DOS-01; Kannan, et al, **2022;** Thas, **2008;** WP-11; WP-19].

4.3 Potential benefits of metals in ayurvedic medicines

Metals like iron, copper, and zinc are essential minerals that can provide nutritional benefits when used in appropriate amounts. Certain processed forms of metals like bhasmas (calcined metals/minerals) are believed to have rejuvenating and detoxifying properties in Ayurveda. Ayurvedic texts describe methods for purifying and processing metals to make them safe for medicinal use.

However, there are also significant risks and drawbacks as listed below.

Some Ayurvedic preparations have been found to contain toxic metals like lead, mercury, and arsenic in unsafe concentrations. Consuming Ayurvedic medicines containing heavy metals can lead to lead poisoning, mercury poisoning, and other toxic effects. A 2015

survey found that 40% of people using Ayurvedic preparations had elevated blood lead levels, and 25% of supplements tested had high lead levels. The U.S. Food and Drug Administration (FDA) has raised concerns about the potential health risks associated with the presence of metals in certain Ayurvedic products. While the traditional Ayurvedic processes like Shodhana (purification) and Marana (incineration) aim to transform raw metals and minerals into safe, bioavailable forms, improper implementation of these methods can still result in contamination and toxicity.

It is worth noting that while metals have a place in traditional Ayurvedic formulations, the risks of toxicity from improper use or contamination outweigh the potential benefits. More research is needed to establish safe and effective protocols for incorporating metals into Ayurvedic medicines. Consumers should exercise caution and consult qualified practitioners before using any Ayurvedic products containing metals [WP-07; WP-10; WP-14; WP-16; WP-18].

4.4 Arsenic in Ayurvedic Medicines - Significant negative health effects

Several studies have found that some Ayurvedic medicines contain unsafe levels of lead. Consuming these lead contaminated Ayurvedic products can lead to lead poisoning, which can cause neurological problems, developmental delays, and other serious health issues. A 2015 case report linked elevated blood lead levels in a woman to Ayurvedic preparations purchased online.

Some Ayurvedic medicines have been found to contain mercury, which is a highly toxic heavy metal. Exposure to mercury through Ayurvedic products can result in mercury poisoning, leading to symptoms like tremors, emotional changes, insomnia, and cognitive and motor dysfunction. A 2015 survey found that 38% of Ayurvedic products tested contained mercury, with some having concentrations thousands of times higher than the safe daily limit.

Certain Ayurvedic preparations have been reported to contain unsafe levels of arsenic, another highly toxic substance. Consuming arsenic contaminated Ayurvedic medicines can cause arsenic poisoning, which can lead to nausea, vomiting, diarrheal, and even cancer. The 2015 survey mentioned earlier found that 32% of Ayurvedic products tested contained arsenic, with some exceeding safe intake levels by thousands of times.

The presence of these heavy metals in some Ayurvedic products is a major public health concern, as they can have severe and long-lasting negative effects on the human body. Proper regulation, quality control, and safety testing of Ayurvedic medicines are crucial to protect consumers from potential toxic exposures.

Consumers should exercise caution when using Ayurvedic preparations and consult qualified practitioners to ensure the safety and quality of the products. It is also important to disclose the use of any Ayurvedic medicines to one's conventional healthcare providers to monitor for potential interactions or adverse effects [WP-03; WP-07; WP-10; WP-14; WP-18].

4.5 Major Safety Concern - Using arsenic, Lead and Mercury

A 2015 survey found that 32% of Ayurvedic products tested contained arsenic, with some exceeding safe intake levels by thousands of times. Consuming Ayurvedic medicines contaminated with arsenic can cause arsenic poisoning, leading to nausea, vomiting, diarrhoea, and even cancer. The U.S. Food and Drug Administration (FDA) has raised concerns about the potential health risks associated with the presence of metals in certain Ayurvedic products. A case report published in 2015 highlighted the potential dangers, linking elevated blood lead levels in a woman to Ayurvedic preparations she had purchased online.

Proper regulation, quality control, and safety testing of Ayurvedic medicines are crucial to protect consumers from potential toxic exposures. Ayurvedic practitioners do not intentionally use arsenic or other heavy metals in their treatments. The contamination likely occurs due to improper manufacturing practices and lack of stringent quality control measures.

Consumers should exercise caution when using Ayurvedic preparations and consult qualified practitioners to ensure the safety and quality of the products. It is also important to disclose the use of any Ayurvedic medicines to one's conventional healthcare providers to monitor for potential interactions or adverse effects [WP-07;WP-10; WP-14]

4.6 Training of Ayurvedic practitioners to use potentially toxic substances

In India, Ayurvedic practitioners undergo state-recognized, institutionalized training.

However, Ayurvedic practitioners are not licensed in the United States, and there is no national standard for Ayurvedic training or certification.

Some Ayurvedic preparations have been found to contain toxic substances like lead, mercury, and arsenic.

This contamination likely occurs due to improper manufacturing practices and lack of stringent quality control measures, rather than intentional use by Ayurvedic practitioners.

Ayurvedic medicines are regulated as dietary supplements in the United States, rather than as drugs. This means they are not required to meet the same safety and efficacy standards as conventional medicines.

Consumers should exercise caution when using Ayurvedic preparations and consult qualified practitioners to ensure the safety and quality of the products. It is important to disclose the use of any Ayurvedic medicines to one's conventional healthcare providers to monitor for potential interactions or adverse effects.

It is thus noted that while Ayurvedic practitioners in India receive formal training, the lack of consistent regulation and safety standards, especially in the United States, means that the use of potentially toxic substances in Ayurvedic medicines is a significant concern. Proper quality control, safety testing, and oversight are crucial to ensure the safe use of Ayurvedic treatments [WP-03; WP-10; WP-19].

4.7 The Commonest Toxic Substances in Ayurvedic Medicines

Lead

A 2015 survey found that 40% of people using Ayurvedic preparations had elevated blood lead levels. About 25% of Ayurvedic supplements tested had high levels of lead. A 2015 case report linked elevated blood lead levels in a woman to Ayurvedic preparations purchased online.

Mercury

The 2015 survey mentioned above found that 25% of Ayurvedic products tested contained high levels of mercury.

Arsenic

Rarely, Ayurvedic products may cause arsenic poisoning. A 2011 study found that some traditional Indian medicines contain bio-accessible arsenic.

It's important to note that the presence of these heavy metals in some Ayurvedic products is likely due to contamination from improper manufacturing practices, rather than intentional inclusion by Ayurvedic practitioners.

The U.S. FDA warns that the presence of metals in some Ayurvedic products makes them potentially harmful. Ayurvedic medicines are regulated as dietary supplements in the United States, so they are not required to meet the same safety and efficacy standards as conventional drugs.

Consumers should exercise caution when using Ayurvedic preparations and consult qualified practitioners to ensure the safety and quality of the products. Disclosing the use of Ayurvedic medicines to conventional healthcare providers is also important to monitor for potential interactions or adverse effects as discussed by a number of researchers included in the enclosed references [Brahmankar, et al, 2021; Wp-03; WP-07; WP-14].

5. *Bhasmas and Kushtas*

These are two important mineral-based preparations used in Ayurvedic and Unani medicine systems, respectively. However, their use has raised some concerns regarding potential toxicity issues as listed below.

Bhasmas are calcined or incinerated metallic and mineral preparations used in Ayurvedic medicine. They are believed to have enhanced therapeutic properties compared to the raw metals/minerals. Common Bhasmas include those made from gold, silver, copper, iron, lead, mercury, and others. Bhasmas are prepared using specialized Ayurvedic methods involving purification, calcination, and trituration. Potential Advantages: Improved bioavailability, enhanced therapeutic efficacy, and reduced toxicity compared to raw metals.

Some Bhasmas may contain residual heavy metals like lead, mercury, and arsenic if not properly processed, leading to potential toxicity.

Kushtas are calcined or sublimated mineral preparations used in Unani medicine. They are believed to have potent medicinal properties when properly processed. Common Kushtas include those made from metals, minerals, and gems like gold, silver, copper, iron, lead, mercury, and others. Kushtas are prepared using specialized Unani methods involving purification, calcination, and sublimation.

Improved bioavailability, enhanced therapeutic efficacy, and reduced toxicity compared to raw minerals. Toxicity Concerns may arise from improper processing of Kushtas, which can lead to the presence of toxic heavy metals, posing safety risks.

The following considerations are necessary during Bhasmas and Kushta formulations.

Proper manufacturing practices, quality control, and safety testing are crucial to minimize the risks of heavy metal contamination in Bhasmas and Kushtas. Regulatory oversight and adherence to safety guidelines are important to ensure the safe use of these mineral-based preparations. Consumers should exercise caution and consult qualified practitioners before using Bhasmas, Kushtas, or any Ayurvedic/Unani products containing metals or minerals.

While Bhasmas and Kushtas are believed to have therapeutic advantages when properly prepared, their potential for heavy metal contamination is a significant safety concern that needs to be addressed through rigorous quality control and regulation as discussed by many reported in the enclosed references [Fazil, and Nikhat, **2022;** WP-07; WP-16; WP-18; WP-19].

5.1 Bhasmas and Kushtas - Comparison

Both Bhasmas and Kushtas are believed to have enhanced therapeutic properties compared to raw

metals/minerals due to specialized processing methods. Bhasmas are prepared using Ayurvedic methods like purification, calcination, and trituration, which are thought to improve bioavailability and efficacy. Kushtas are prepared using Unani methods like purification, calcination, and sublimation, which also aim to enhance potency. However, there is limited high-quality clinical evidence directly comparing the efficacy of Bhasmas vs Kushtas.

The main safety concern with both Bhasmas and Kushtas is the potential for heavy metal contamination if not properly processed. Some Bhasmas have been found to contain residual lead, mercury, or arsenic, which can lead to toxicity if not removed.

Similarly, improper preparation of Kushtas can also result in the presence of toxic heavy metals. Rigorous quality control and adherence to safety guidelines is crucial for both Bhasmas and Kushtas to minimize the risks of heavy metal contamination.

Bhasmas are more widely used in India compared to Kushtas, which are more common in the Unani tradition. Both systems have traditional methods for purifying metals/minerals, but modern analytical techniques are also important for ensuring safety. More research is needed on the comparative efficacy, safety, and quality control of Bhasmas vs Kushtas.

While Bhasmas and Kushtas are believed to have therapeutic advantages over raw minerals, their safety depends heavily on proper manufacturing practices to remove heavy metals. Consumers should exercise caution and consult qualified practitioners when using either Bhasmas or Kushtas [Fazil, and Nikhat, **2022;** WP-20; WP-21; WP-22; WP-23].

5.2 Bhasmas and Kushtas - Primary Ingredients

Bhasmas are calcined or incinerated metallic and mineral preparations used in Ayurvedic medicine. Common Bhasmas include those made from metals and minerals like gold, silver, copper, iron, lead, mercury, and others.

Kushtas are calcined or sublimated mineral preparations used in Unani medicine. Common Kushtas include those made from metals, minerals, and gems like gold, silver, copper, iron, lead, mercury, and others.

Both Bhasmas and Kushtas utilize a variety of metals, minerals, and sometimes even gems as their primary ingredients. The ingredients commonly used in both systems include gold, silver, copper, iron, lead, mercury, and others.

Bhasmas are prepared using specialized Ayurvedic methods involving purification, calcination, and trituration. Kushtas are prepared using Unani methods like purification, calcination, and sublimation.

These specialized processing techniques are believed to enhance the therapeutic properties and reduce the toxicity of the mineral ingredients in both Ayurvedic and Unani traditions. However, improper processing can still lead to the presence of toxic heavy metals in the final products.

Overall, the primary ingredients in both Bhasmas and Kushtas are various metals, minerals, and sometimes gems, with the key distinction being the traditional preparation methods used in the respective medical systems [Brahmankar, et al, **2021**; Fazil, and Nikhat, **2022**; WP-16; WP-18; WP-20].

5.2 Key hurdles in acceptance of nanotechnology in traditional indian systems of medicine

Many traditional Bhasmas have been used for centuries, but their exact composition, particle size, and mechanisms of action are not fully scientifically validated using modern analytical techniques. This makes it challenging to standardize and regulate their production using nanotechnology.

The regulatory framework for evaluating the safety and efficacy of nanomedicines derived from traditional preparations is still evolving. Existing regulations may not adequately address the unique properties of nanoparticles. Intellectual property rights and patenting of traditional knowledge is a sensitive issue that needs to be carefully navigated.

There is a general lack of awareness about the potential of nanotechnology among practitioners of traditional medicines. More training and capacity building is needed to integrate modern science with traditional knowledge.
Some practitioners may be resistant to adopting new nanotechnology-based methods, preferring to stick to traditional preparation techniques that have worked for centuries. Overcoming this inertia is a challenge.

Developing standardized nanomedicines may increase the cost of traditional preparations, making them less affordable for the masses. Ensuring affordability and accessibility is crucial for their widespread adoption.

While traditional preparations are believed to be safe, the use of engineered nanoparticles may raise new toxicity concerns that need to be rigorously evaluated for demonstrating the safety of nanomedicines.

In essence while nanotechnology offers immense potential to modernize traditional medicine, overcoming the hurdles of scientific validation, regulation, awareness, resistance to change, affordability, and toxicity concerns is crucial for its widespread acceptance and integration. A collaborative approach between traditional practitioners, modern scientists, and regulators is the need of the hour [Sharma, et al, **2016;** Valikarimwala, et al, **2021;** Chauhan, et al, **2024**].

6. Ways to integrate ayurvedic practices with nanotechnology

Techniques used in Ayurveda like Shodhana (purification), Bhavana (levigation), and Marana (incineration) to prepare Bhasmas can be studied using modern analytical techniques. It has been shown that these processes help reduce particle sizes and produce nanoparticles, supporting the idea that ancient Ayurvedic preparation methods are an early form of nanomedicine.

Integrating nanotechnology can help to standardize the composition, particle size, and quality of Bhasmas which traditionally relied on subjective methods. Modern analytical tools like electron microscopy, X-ray diffraction, and spectroscopy can be used to characterize the nanoparticles in Bhasmas.

The small size and large surface area of nanoparticles can improve the solubility, absorption, and bioavailability of Ayurvedic drugs, enhancing their therapeutic efficacy. Nanoparticle-based drug delivery systems can help target the active ingredients to specific sites in the body.

Nanotechnology can help reduce the toxicity of Ayurvedic preparations by converting toxic substances into non-toxic nanoparticles through processes like Marana. Rigorous safety evaluation of Ayurvedic nanomedicines using modern toxicological methods is needed to address the basic concerns.

Adopting green nanotechnology approaches can help modernize the manufacturing of Ayurvedic medicines in a more controlled, scalable, and environmentally friendly manner. Combining the strengths of Ayurveda and modern medicine, such as using Ayurvedic preparations as adjuvants with conventional drugs, can provide synergistic benefits.

Thus, a collaborative approach between Ayurvedic practitioners, modern scientists, and regulators is needed to integrate traditional knowledge with cutting-edge nanotechnology. This can help validate, standardize, and modernize Ayurvedic practices while preserving their core principles and benefits [Valikarimwala, et al, **2021;** Chauhan, et al, **2024].**

6.1 Nanotechnology and Improved efficacies of ayurvedic treatments

Modern analytical techniques like electron microscopy, X-ray diffraction, and spectroscopy can be used to characterize the nanoparticles present in traditional Bhasmas. This helps validate and standardize their composition and quality. The small size and large surface area of nanoparticles can enhance the solubility, absorption, and bioavailability of Ayurvedic drugs, improving their therapeutic efficacy. Nanoparticle-based drug delivery systems can help target the active ingredients to specific sites in the body.

Traditional processes like Shodhana (Purification) and Marana (Incineration) can convert toxic substances into non-toxic nanoparticles, reducing the toxicity of Bhasmas. Rigorous safety evaluation of Ayurvedic nanomedicines using modern toxicological methods can address concerns about their safety.

Adopting green nanotechnology approaches can help modernize the manufacturing of Ayurvedic medicines in a more controlled, scalable, and environmentally friendly manner.

Combining the strengths of Ayurveda and modern medicine, such as using Ayurvedic preparations as adjuvants with conventional drugs, can provide synergistic benefits.

It is quite evident that the integration of nanotechnology with traditional Ayurvedic practices can help validate, standardize, and enhance the effectiveness of Ayurvedic treatments, while also addressing concerns about toxicity and modernizing their manufacturing processes. This collaborative approach can lead to the development of more effective and safer Ayurvedic nanomedicines [Sharma, et al, **2016;** Valikarimwala, et al, **2021**; Chauhan, et al, **2024].**

6.2 Traditional Bhasmas - Significantly enhancing therapeutic benefits

Bhasmas typically contain particles in the size range of 5-50 nm, which is in the nanoscale range. This small size enhances their bioavailability, absorption, and targeted delivery in the body. The traditional preparation methods like Shodhana (purification) and Marana (incineration) help reduce the toxicity of metals and minerals by converting them into stable, biocompatible forms. Bhasmas are integrated with organic molecules during preparation, forming organo-metallic/organo-mineral complexes. This improves their stability, functionality, and therapeutic efficacy.

The concept of Yogavahi in Ayurveda refers to the ability of Bhasmas to act as carriers, enhancing the bioavailability and targeted delivery of other drugs. Bhasmas are prescribed in minute doses (15-250 mg/day) and are considered readily absorbable, adaptable, and assimilable. They are also believed to spread quickly in the body and act fast. Many Bhasmas are attributed with Rasayana properties, meaning they have immunomodulatory and anti-aging effects. This is an important therapeutic benefit.

It is noted that the unique nanoscale size, biocompatibility, stability, targeted delivery, and rapid absorption of Bhasmas, along with their immunomodulatory and anti-aging properties, contribute to their effectiveness as therapeutic agents in Ayurvedic medicine. These properties are similar to the benefits of modern nanomedicines [Sharma, and Prajapati, **2016;** Deng, et al, **2021**; Wahnou, et al, **2023**].

6.3 Process of Marana for Improved Bioavailability

The Marana process helps reduce the particle size of metals and minerals to the sub-micron and nano domain. This greatly increases their surface area to volume ratio, enhancing bioavailability and absorption in the body. During Marana, the metals and minerals get converted into organometallic compounds by conjugating with organic molecules. These organo-metallic complexes are more easily assimilable by the biological system compared to the raw metals.

The Marana process helps improve the stability and solubility of the metal/mineral preparations, making them more bioavailable. The incineration at high temperatures also helps remove impurities.

The transformation during Marana leads to changes in the electrical, thermal, chemical, and biological characteristics of the metals/minerals. This alters their behaviour and makes them more suitable for biological applications.

Analysis has shown that some Ayurvedic Bhasmas prepared by Marana, like Swarna Bhasma and Naga Bhasma, contain nanoparticles. The nanoscale size further enhances their bioavailability and therapeutic effects.

In essence, the Marana process helps convert metals and minerals into stable, soluble, and biocompatible nanoparticles and organometallic complexes, making them highly bioavailable for therapeutic applications. This ancient process can be considered an early form of nanomedicine [WP-25; WP-26].

6.4 Marana Process - Conversion of Metals and Minerals into Bioavailable NPs

The raw metals or minerals are first purified through various processes like washing, heating, quenching in specific liquids, etc. This helps remove impurities and toxins. The purified metals/minerals are ground into a fine powder using a mortar and pestle. This mechanical grinding helps reduce the particle size.

The fine powder is then subjected to high temperature incineration in a closed crucible. This process is repeated multiple times, with the addition of specific herbal juices or decoctions between each incineration.

The incineration at high temperatures (around 500-800°C) helps convert the metals/minerals into their oxide forms and further reduces the particle size to the nano range (5-50 nm). After each round of incineration, the crucible is quenched in a specific liquid medium like cow's milk, buttermilk, fruit juices, etc. This helps stabilize the nanoparticles. The incinerated material is then triturated with herbal juices or decoctions using a mortar and pestle. This helps convert the metal oxides into organometallic complexes. The triturated material undergoes repeated levigation with specific herbal juices or decoctions. This helps further reduce the particle size and improve the bioavailability.

Through these systematic steps of purification, size reduction, incineration, quenching, trituration and levigation, the Marana process transforms the raw metals/minerals into stable, biocompatible, and bioavailable nanoparticulate forms known as Bhasmas in Ayurveda. The resulting Bhasmas are considered safe and effective therapeutic agents [Sharma, and Prajapati, **2016;** Phan, and Haes, **2019;** WP-27].

6.5 Modern Adaptations and Validations - Marana Process

Techniques like electron microscopy, X-ray diffraction, and spectroscopy are being used to characterize the nanoparticles present in Bhasmas prepared by the Marana process. This helps validate their composition and size.

The enhanced bioavailability and absorption of Bhasmas compared to raw metals/minerals is being scientifically evaluated using modern pharmacokinetic and pharmacodynamic studies.

Rigorous safety evaluation of Bhasmas is being carried out using modern toxicological methods to address concerns about their safety and to validate their traditional use as safe medicines.

The Rasayana properties attributed to Bhasmas, like immunomodulation and anti-aging effects, are being scientifically investigated using modern biological assays and animal models. Efforts are being made to develop standardized manufacturing protocols for Bhasmas to ensure consistent quality, safety, and efficacy. This involves optimizing the traditional Marana process parameters.

The nanoparticulate nature of Bhasmas is being exploited by integrating them with modern drug delivery systems like nanoparticles and liposomes, to further enhance their therapeutic potential.

It is noted that while the traditional Marana process remains the foundation, modern scientific tools and techniques are being employed to validate, optimize, and integrate this ancient knowledge with contemporary medicine and drug delivery approaches. This synergistic integration of traditional wisdom with modern science holds great promise for developing safe and effective nanomedicines [Sharma, et al, **2016**, Phan and Haes, **2019**, WP-27].

6.6 Marana Process - Steps and Principles

The Marana process includes the following steps e.g., purification (Shodhana) of the raw metals/minerals; size reduction (Bhavana) through grinding; incineration (Marana) at high temperatures (around 500-800°C); quenching (Gaja-Puta) in specific liquid media;

trituration (Mardana) with herbal juices or decoctions and levigation (Bhavana) with more herbal liquids.

These systematic steps have been the foundation of the traditional Marana process used in Ayurveda for centuries to transform raw metals and minerals into bioavailable, nanoparticulate Bhasma preparations.

The modern scientific research has mainly focused on the followings.
Characterizing the nanoparticles in Bhasmas using advanced analytical techniques. Studying the improved bioavailability, absorption, and therapeutic efficacy of Bhasmas. Evaluating the safety and toxicity profile of Bhasmas. Developing standardized manufacturing protocols for consistent quality.

However, the core Marana process itself does not seem to have undergone any major changes or introduction of new materials. The traditional Ayurvedic knowledge and techniques are being validated and integrated with modern scientific understanding, but the fundamental principles of the Marana process remain the same.

The reported investigations do not indicate any significant departures from the classical Marana methodology. The focus appears to be on optimizing and standardizing the traditional process rather than introducing entirely new materials or techniques [Phan and Haes, **2019**; Sharma and Prajapati, **2016].**

6.7 Integration of nanotechnology

Nanotechnology has immense potential to enhance the efficacy and therapeutic potential of traditional medicines like Unani, Ayurvedic, and Siddha formulations. Some key future contributions of nanotechnology in this area are highlighted below.

Nanoparticle-based delivery systems can significantly improve the solubility, stability, and bioavailability of active phytochemical ingredients in herbal medicines. Nanoparticles can also enable targeted delivery to specific tissues or cells, increasing the therapeutic index and reducing side effects.

By formulating herbal extracts and active compounds into nanoparticles, their pharmacological activity can be enhanced. Nanotechnology-based delivery systems have been shown to increase the potency of herbal medicines against various diseases.

Many herbal medicines suffer from limitations like poor solubility, low stability, and rapid degradation. Nanoparticle-based approaches can help overcome these challenges and improve the clinical applicability of traditional medicines.

The integration of Ayurvedic principles and practices with modern nanotechnology has the potential to produce highly effective and safe medicines to treat various life-threatening diseases. This synergistic approach can leverage the strengths of both traditional and modern medicine.

Nanoparticle-based Ayurvedic and Unani formulations can enable better quality control and standardization compared to conventional preparations. The precise control over particle size, composition, and drug loading achievable with nanotechnology can ensure batch-to-batch consistency.

However, some challenges remain, such as the high costs of nanoparticle manufacturing, difficulties in scaling up, and the need for more data on the safety and toxicity of nanoparticle-based herbal formulations. As research continues, these challenges will likely be addressed, paving the way for the widespread adoption of nanotechnology in traditional medicine systems [Kaur, et al, **2018**; Valikarimwala, et al, **2021;** Dewi, et al, **2022].**

6.8 Nanotechnology Integration - Enhanced efficacy of unani formulations

Nanoparticles made from various materials like polymers, metals, and silica have been explored to improve the solubility, stability, and targeted delivery of active phytochemicals in Unani medicines. Polymer nanoparticles in particular have been highlighted as a way to overcome the poor bioavailability often seen with herbal drugs.

Nano-emulsion technology has been specifically investigated for use in Unani liquid dosage forms like Jushanda, Khasanda, Haleeb, and Sharbat. Nanoemulsions can enhance the solubility and absorption of herbal actives. Antifungal efficacy and drug release studies have been performed on nano-emulsion formulations containing Unani plant extracts like Pelargonium, lavender, tea tree, and Kaempferia.

More broadly, nanostructured formulations are being used to make Unani medicines more soluble, effective, and safe. The integration of nanotechnology with traditional Unani drugs is seen as a way to improve their bioavailability and therapeutic potential.

While these results are promising, more research is still needed to fully characterize the toxicity profiles and optimize the synthesis of these nanostructures for Unani applications. Overcoming challenges like high manufacturing costs and scalability will also be important for translating these nano-enabled Unani formulations to the clinic. But the initial findings suggest nanotechnology has significant potential to enhance the efficacy of traditional Unani medicines [Mirza, et al, **2014;** Sultana, et al, **2015;** Sapra, **2021;** Jayakodi, et al, **2022].**

6.9 Nanostructures Enhancing Bioavailability and Efficacy

The search results highlight nano-emulsion technology as a particularly effective approach for improving the delivery of Unani liquid dosage forms like Jushanda, Khasanda, Haleeb, and Sharbat. Nanoemulsions can enhance the solubility and absorption of herbal active ingredients in these traditional Unani preparations. Antifungal efficacy and drug release studies have been performed on nano-emulsion formulations containing Unani plant extracts like Pelargonium, lavender, tea tree, and Kaempferia.

Polymer-based nanoparticles have also been explored as a way to overcome the poor bioavailability often seen with herbal drugs used in Unani medicine. These nanoparticles can improve the solubility, stability, and targeted delivery of active phytochemicals.

More broadly, the search results indicate that various nanostructured formulations are being investigated to make Unani medicines more soluble, effective, and safe. This includes approaches like metallic nanoparticles and magnetic nanoparticles.

While these nanostructure-based strategies show promise, the search results also note that more research is still needed to fully characterize their toxicity profiles and optimize their synthesis for Unani applications. Overcoming challenges like high manufacturing costs and scalability will also be important for translating these nano-enabled Unani formulations to the clinic. But the initial findings suggest nano-emulsions, polymer nanoparticles, and other nanostructures have significant potential to enhance the bioavailability and therapeutic efficacy of traditional Unani medicines [Mirza, et al, **2014;** Mirza, et al, **2015;** Sultana, et al, **2015;** Pachuau, **2019;** Sapra, **2021].**

6.9.1 Benefits of Nano-emulsions in Liquid Unani Medicines

The search results indicate that nano emulsions can significantly enhance the solubility and absorption of herbal active ingredients used in traditional Unani liquid dosage forms like Jushanda, Khasanda, Haleeb, and Sharbat. The nano-scale size and high surface area of nano-emulsions help overcome the poor bioavailability often seen with crude herbal extracts. Nanoemulsions can protect Unani herbal actives from hydrolysis, oxidation, and other degradation processes. This helps improve the shelf-life and stability of these traditional liquid preparations.

The search results suggest nano-emulsion technology allows for more targeted delivery of Unani phytochemicals to specific tissues or cells. This can improve the therapeutic efficacy and reduce side effects compared to conventional Unani liquid formulations.

The small droplet size and homogeneous nature of nano-emulsions can make Unani liquid medicines more palatable and easier to administer, especially for geriatric or paediatric patients.

The search indicates that nano-emulsion technology can be judiciously integrated with the traditional Unani preparation methods and formulations described in ancient texts like the Qrabadeen.

Overall, the search results highlight nano-emulsions as a promising nanotechnology approach to enhance the bioavailability, stability, and therapeutic potential of Unani liquid herbal medicines. Further research is still needed to fully optimize these nano-enabled Unani formulations, but the initial findings are quite promising [Mirza, et al, **2015;** Sultana, **2015;** Mathialagan, et al, **2020;** Sapra, **2021].**

6.9.2 Challenges - Nano-emulsions preparation for unani herbal medicines

The research results highlight that many Unani herbal actives are thermolabile, meaning they are sensitive to heat. Traditional hot emulsification methods for making nano-emulsions can degrade or alter these heat-sensitive compounds, reducing their stability and efficacy and poses a major challenge.

The search indicates that while laboratory-scale nano-emulsion production is feasible, scaling up the manufacturing process can be difficult. Techniques like micro-fluidization and ultrasonication that are used to make nano-emulsions are complex, expensive, and not easily scalable for commercial production.

Nanoemulsions typically require high concentrations of surfactants to achieve the small droplet sizes. Finding the right balance of surfactants that are compatible with Unani formulations and provide long-term stability is an ongoing challenge.

The search results note that there is a general lack of standardization in the production of nano-emulsion-based Unani medicines. Defining the critical quality attributes and process parameters required for consistent, high-quality nano-emulsions is an area that needs more research.

While the potential benefits of nano-emulsions for Unani medicines are recognized, the search results indicate that more clinical data is needed to fully characterize the safety profiles and therapeutic efficacy of these nano-enabled formulations.

Overall, the key challenges seem to be centred around overcoming the thermolability of Unani actives, developing scalable and cost-effective manufacturing processes, and generating robust safety and efficacy data to support the widespread adoption of nano-emulsion technology in traditional Unani medicine. Addressing

these challenges will be crucial for realizing the full potential of this approach [Mirza, et al, **2015;** Sultana, et al, **2015;** Sapra, **2021;** Bhatt, et al, **2024].**

6.9.3 Stability of Nano-emulsions in unani herbal formulations

The search results highlight that many Unani herbal actives are thermolabile, meaning they are sensitive to heat. The high temperatures often used in traditional nano-emulsion preparation methods can degrade or alter these heat-sensitive compounds, negatively impacting their stability and efficacy.

The choice of surfactant and its concentration is critical for the long-term stability of Unani nano-emulsions. The search indicates that finding the right balance of surfactants that are compatible with Unani formulations and provide adequate emulsion stability is an important challenge.

The search results suggest that the introduction of salts, like sodium chloride, can affect the stability of Unani nano-emulsions if the salt concentration exceeds a certain resistance limit. Maintaining the optimal salt levels is important for preserving nano-emulsion stability.

The search highlights the need to evaluate the stability of Unani nano-emulsions under different storage temperatures, such as refrigeration (5°C) and room temperature (25°C). Maintaining the appropriate storage conditions is crucial for ensuring the long-term physical and chemical stability of these nano-enabled herbal formulations.

The search results indicate that parameters like droplet size and size distribution can impact the stability of Unani nano-emulsions. Maintaining a consistent, homogeneous nano-emulsion with the desired droplet characteristics is important for preserving stability.

Overall, the key factors seem to be cantered around overcoming the thermolability of Unani herbal actives, optimizing the surfactant system, controlling salt levels, and maintaining appropriate storage conditions - all of which are critical for ensuring the long-term stability of nano-emulsion-based Unani formulations. Addressing these stability challenges will be crucial for the successful development and commercialization of these nano-enabled traditional medicines.

6.9.4Unani Herbal Medicine - Benefit from Nano-emulsion Technology

The search results highlight growing interest in preparing essential oils like curcumin, eucalyptus oil, and lemon oil as nano-emulsions for Unani formulations. The small droplet size and high surface area of nano-emulsions can enhance the solubility, stability, and absorption of these lipophilic herbal actives.

Many Unani herbal actives are thermolabile, meaning they are sensitive to heat. Traditional methods of preparing nano-emulsions often involve high temperatures that can degrade these heat-sensitive compounds. Developing nano-emulsion techniques that avoid high temperatures is crucial for preserving the stability and efficacy of these Unani herbal ingredients.

The search results indicate that nano-emulsion technology has significant potential to improve the solubility and bioavailability of Unani herbal medicines that suffer from poor aqueous solubility. The nano-scale size and large surface area of nano-emulsions can enhance the absorption of these lipophilic compounds.

While the search results do not specify exact herbs, they suggest that Unani medicines containing essential oils, thermolabile compounds, or poorly soluble actives are likely to benefit most from nano-emulsion formulation approaches. Developing appropriate nano-emulsion preparation methods that avoid heat degradation and optimize solubility will be key for realizing the full potential of this technology for enhancing the delivery of these types of Unani herbal ingredients.

7. Unani Herbal Medicine - formulated into Nano emulsions

The research results highlight growing interest in preparing essential oils like curcumin, eucalyptus oil, and lemon oil as nano-emulsions for Unani formulations. The small droplet size and high surface area of nano-emulsions can enhance the solubility, stability, and absorption of these lipophilic herbal actives.

Curcumin, a compound found in turmeric, is commonly used in Unani medicine. Nanoemulsions of curcumin have been developed to improve its solubility and bioavailability compared to the crude extract.

Quercetin is another Unani herbal compound that has been nano-emulsified to enhance its therapeutic potential.

Silybin, derived from milk thistle, is an Unani hepatoprotective agent that has been formulated into nano-emulsions.

Extracts from the Ginkgo biloba tree are used in Unani medicine. Nanoemulsions of Ginkgo have been investigated to improve the delivery of its active constituents.

While the research results do not provide an exhaustive list, they suggest that essential oils, curcumin, quercetin, silybin, and Ginkgo are some of the more commonly nano-emulsified Unani herbs. Developing appropriate nano-emulsion preparation methods that optimize solubility, and stability will be key for realizing the full potential of this technology for enhancing the delivery of these Unani herbal ingredients [Mirza, et al, **2014;**

Mirza, et al, **2015**; Ansari, et al, **2019;** Sapra, **2021;** Fazil, and Nikhat, **2022].**

7.1 Indian Regulatory Guidelines for Nano-emulsified Unani Drugs

The Drugs and Cosmetics Act 1940 and Rules 1945 provide the regulatory framework for Ayurvedic, Siddha and Unani (ASU) drugs in India, including nano-emulsified formulations.

The Part XVII of the Drugs and Cosmetics Rules 1945 deals with labelling, packing and limit of alcohol in Ayurveda, Siddha, and Unani drugs.

The Part XVIII of the Drugs and Cosmetics Rules 1945 covers provisions related to Government Analysts and Drugs Inspectors for ASU drugs.

The Chapter IV-A of the Drugs and Cosmetics Act 1940 provides various regulatory and prosecution provisions to be followed for Ayurveda, Siddha, and Unani drugs.

The Part XVI and Part XVI-A of the Drugs and Cosmetics Rules 1945 deal with the manufacture for sale of Ayurvedic, Siddha and Unani drugs, including approval of institutions for carrying out tests on ASU drugs and raw materials on behalf of manufacturers.

While nano-emulsion technology is a relatively new approach, the existing regulatory framework under the Drugs and Cosmetics Act and Rules does provide guidelines for the manufacture, testing and sale of nano-emulsified Unani formulations in India. Adherence to these regulations is crucial for ensuring the quality, safety, and efficacy of nano-enabled Unani medicines [Mirza, et al, **2015**; REP-01; REP-02; Sapra, **2021].**

7.2 Manufacturing Guidelines for Nano-emulsified unani drugs in india

The Drugs and Cosmetics Act 1940 and Rules 1945 provide the overall regulatory framework for Ayurvedic, Siddha and Unani (ASU) drugs, including nano-emulsified Unani formulations.

The Part XVI and Part XVI-A of the Drugs and Cosmetics Rules 1945 deal with the manufacture for sale of Ayurvedic, Siddha and Unani drugs. This includes requirements for approval of institutions to carry out testing of ASU drugs and raw materials on behalf of manufacturers.

The Part XVII of the Drugs and Cosmetics Rules 1945 covers the labelling, packing and limit of alcohol in Ayurveda, Siddha, and Unani drugs. Specific guidelines for labelling and packaging of nano-emulsified Unani formulations must be followed.

The Part XVIII of the Drugs and Cosmetics Rules 1945 provides details on the roles and responsibilities of government analysts and drug inspectors for ASU drugs. This ensures quality control and enforcement of regulations for nano-emulsified Unani medicines.

The Chapter IV-A of the Drugs and Cosmetics Act 1940 outlines various regulatory and prosecution provisions to be followed for Ayurveda, Siddha, and Unani drugs.

While the existing regulatory framework does not have specific guidelines for nano-emulsified Unani drugs, the general provisions under the Drugs and Cosmetics Act and Rules apply. Adherence to these regulations is crucial for the manufacture, testing, and sale of nano-enabled Unani formulations in India [Mirza, et al, **2015;** REP-01; REP-02; Sapra, **2021**].

7.3Environmental Considerations in Manufacturing of Nano-emulsified Unani Drugs

The manufacturing of nano-emulsions can generate various types of waste, including chemical waste, solvent waste, and packaging materials. Proper waste management protocols need to be in place to ensure safe disposal and minimize environmental impact. Many nano-emulsion preparation methods involve the use of organic solvents. Efforts should be made to minimize solvent use, implement solvent recovery systems, and choose environmentally friendly solvents where possible. Certain nano-emulsion manufacturing techniques, like high-pressure homogenization, can be energy-intensive. Optimizing the processes to reduce energy consumption and improve energy efficiency is important from an environmental standpoint. The preparation of nano-emulsions may require significant amounts of water. Implementing water conservation measures, recycling water, and ensuring proper wastewater treatment are crucial environmental considerations. Volatile organic compounds (VOCs) or other airborne emissions generated during nano-emulsion manufacturing should be properly contained and treated to maintain air quality standards.

Protecting workers involved in the production of nano-emulsified Unani drugs from potential exposure to nanomaterials is an important environmental and health consideration.

While the research results do not provide detailed guidelines, they highlight the need for Unani drug manufacturers to have comprehensive environmental management systems in place. This includes waste handling, solvent use, energy efficiency, water conservation, emissions control, and occupational safety protocols. Adhering to relevant environmental regulations and adopting green manufacturing practices will be crucial for the sustainable production of nano-emulsified Unani medicines [Mirza, et al, **2015;** Mirza, et al, **2015**; REP-01; Sapra, **2021;** Mazayen, et al, **2022**].

8. General Conclusions

The integration of nanotechnology with traditional Indian medicine systems like Ayurveda, Siddha, and

Unani holds significant promise for enhancing the safety, efficacy, and standardization of these ancient practices. However, it also presents unique challenges and considerations:
Nanoparticle formulations of herbal extracts and mineral ingredients can improve solubility, stability, and targeted delivery, potentially enhancing bioavailability and therapeutic efficacy.

Nanoscale processing of metals like mercury may help reduce toxicity compared to traditional preparations, if done properly. Advanced analytical techniques using nanobiosensors can aid in quality control and standardization of traditional medicine formulations.

Challenges and Considerations
Improper manufacturing practices can still lead to contamination and toxicity, even with the use of nanotechnology. Rigorous quality control is crucial. The presence of heavy metals like mercury, lead, and arsenic in some traditional medicine products is a major safety concern that needs to be addressed. International regulations like the Minamata Convention aim to restrict the use of mercury globally, posing challenges for traditional medicines that incorporate mercury-containing substances like cinnabar. A holistic, evidence-based approach is needed to integrate nanotechnology with traditional Indian medicine principles in a responsible manner.

Regulatory oversight
Ayurvedic, Siddha, and Unani medicines are regulated differently in various countries. In India, they are included under the Department of AYUSH, while in the US they are regulated as dietary supplements. Proper regulatory oversight, quality control, and safety testing are crucial to ensure the safe and effective integration of nanotechnology with traditional Indian medicines.

While the integration of nanotechnology with traditional Indian medicine systems holds significant potential, it must be approached cautiously and responsibly. Rigorous research, quality control, and regulatory oversight are needed to address safety concerns, ensure efficacy, and preserve the core principles of these ancient healing traditions. A collaborative, evidence-based approach that combines traditional wisdom with modern science can lead to innovative and sustainable healthcare solutions [Liu, et al, **2008;** Doshi, et al, **2019;** WP-20; WP-23].

Potential Risks/Concerns – Proposed Integration
Some traditional Indian medicines have been found to contain toxic heavy metals like lead, mercury, and arsenic, even before the integration of nanotechnology. Improper manufacturing practices and lack of quality control can lead to contamination of nanoparticle formulations with these toxic substances, posing health risks. A 2015 survey found that 40% of people using Ayurvedic preparations had elevated blood lead levels, and 25% of supplements tested had high lead levels. Ayurvedic medicines are regulated as dietary supplements in the United States, rather than as drugs. This means they are not required to meet the same safety and efficacy standards as conventional medicines. The lack of consistent regulation and safety standards, especially in the US, means that the use of potentially toxic substances in nanoparticle based Ayurvedic medicines is a significant concern.

The integration of nanotechnology may make traditional Indian medicines seem more "modern" and "scientific", potentially leading to overuse or misuse by consumers. Nanoparticle formulations could be perceived as more effective, leading to reduced use of conventional medicines or delays in seeking appropriate medical care.

The integration of nanotechnology with traditional Indian medicines should be done in a way that respects and preserves the core principles and philosophies of these ancient healing systems. There are concerns that the use of advanced technologies like nanotechnology may alter or undermine the traditional knowledge and practices.

More rigorous research is needed to establish the safety and efficacy of nanoparticle-based traditional Indian medicines. Proper manufacturing practices, quality control, and safety testing are crucial to minimize the risks of contamination and toxicity.

It is noted that the integration of nanotechnology with traditional Indian medicines holds promise, it also presents significant risks and challenges that need to be carefully addressed through robust regulation, quality control, and safety measures. A cautious, evidence-based approach that preserves the core principles of these ancient healing traditions is essential [Doshi, et al, **2019; WP**-04**; WP**-07**; WP**-14].

Based on the results from published records, there do not appear to be any specific examples of traditional Indian medicines (Ayurvedic, Siddha, or Unani) that have been commercially reformulated using nanotechnology and entered the market.

9. REFERENCES

1. Akhtar, F., et al. Unani-based curcumin nanoparticles for treatment of rheumatoid arthritis: Preparation and in vivo evaluation. J. Ethnopharmacology, 2016; 179: 301-307.
2. Ansari, A.P., Dar, P.A., and Ahmed, N.Z. Scientific Basis of Some Common Medicinal Plants used in Unani Medicine: A Rational Approach. In book: Research Trends in Medicinal Plants Sciences, Publisher: AkiNik Publications, January, 2019; 3.
3. Ansari, S. H., et al. Unani-based copper nanoparticles: Synthesis, characterization, and antimicrobial activity. J. Traditional and Complementary Medicine, 2017; 7(3): 273-278.

4. Bhatt, P., Bhatt, T., Jain, V., Jain, R., and Bigoniya, P. Nanoemulsion through cold emulsification: An advanced cold manufacturing process for a stable and advanced drug delivery system. J. Applied Pharmaceutical Science, 2024; 14(05): 012-021.
5. Brahmankar, R., Baruah, H., Munishwar, N., and Raghuveer. Insight into traditional dosage forms in light of Ayurvedic pharmaceutics. Int. J. Pharmaceutical Research, 2021; 13(2): 3925.
6. Chauhan, Y.S., Chahar, D.S., Lal, R., and Sharma, S. Role of Nanotechnology in Ayurvedic Drug Development. wjpmr, 2024; 10(4): 120-2.
7. Deng, Z., Kalin, G.T., Shi, D., and Kalinichenko, V.V. Nanoparticle Delivery Systems with Cell-Specific Targeting for Pulmonary Diseases. Am. J. Respir. Cell Mol. Biol, 2021; 64(3): 292-307.
8. Dewi, M.K., Chaerunisaa, A.Y., Muhaimin, M., and Joni, I.M. Improved Activity of Herbal Medicines through Nanotechnology. Nanomaterials (Basel), 2022; 12(22): 4073.
9. DOS-01; SIDDHA SYSTEM OF MEDICINE, The Science of Holistic Health, Ministry of Ministry of Ayurveda, Yoga, Unani, Siddha, and Homoeopathy (AYUSH) Government of India, Ministry of Ayurveda, Yoga & Naturopathy, Unani, Siddha, and Homoeopathy (AYUSH), Government of India, 2019.
10. Doshi, M., Annigeri, R.A., Kowdle, P.C., Subba Rao, B., and Varman, M. Membranous nephropathy due to chronic mercury poisoning from traditional Indian medicines: report of five cases, *Clinical Kidney J*, 2019; 12(2): 239–244.
11. Fazil, M., and Nikhat, S. Therapeutic and palliative role of a Unani herbal decoction in COVID-19 and similar respiratory viral illnesses: Phytochemical & pharmacological perspective. J Ethnopharmacol, 2022; 297: 115526.
12. Hazarika, H., Krishnatreyya, H., Chattopadhyay, P., Saha, A., Pathak, Y.V., and Zaman, M.K. Nanoemulsion Delivery of Herbal Products: Prospects and Challenges. In book: Nano Medicine and Nano Safety, 2020, DOI: 10.1007/978-981-15-6255-6_11
13. Jain, S., et al. Nano-emulsion-based hydrogel formulation of Withania somnifera for topical delivery. Pharmaceutical Development and Technology, 2016; 21(4): 442-453.
14. Jayakodi, S., Kim, H., Menon, S., Shanmugam, V.K., Choi, I., Sekhar, M.R., Bhaskar, R., and Han, S.S. Preparation of Novel Nanoformulation to Enhance Efficacy in the Treatment of Cardiovascular Disease. *Biomimetics*, 2022; *7*: 189.
15. Kannan, M., Sathiyarajeswaran, P., Sasikumar, D., Geetha, A., Mohanapriya, M., Vinod, N.P., Manickam, P., Kanakavalli, K., Parthibhan, P., Pitchiah Kumar, M., Kannan, R., and Sivaraman, G. Safety and efficacy of a Siddha Medicine fixed regimen for the treatment of asymptomatic and mild COVID-19 patients. J. Ayurveda Integr. Med, 2022; 13(3): 100589.
16. Kaur, H., Yadav, P., Prajapati, P.K., Khatik, G., Haque, A., Vyas, M., and Verma, S. Application of nanotechnology for Ayurvedic drugs and formulations. Drug Invention Today, 2018; 10(5).
17. Liu, J., Shi, J.Z., Yu, L.M., Goyer, R.A., and Waalkes, M.P. Mercury in traditional medicines: is cinnabar toxicologically similar to common mercurials? Exp. Biol. Med. (Maywood), 2008; 233(7): 810-7.
18. Mathialagan, V., Sugumaran, A., and Narayanaswamy, D. Nano-emulsion: Importance in Pharmaceutical Nanotechnology, 2020; 3(4): 2005-10.
19. Mazayen, Z.M., Ghoneim, A.M., Elbatanony, R.S., *et al*, Pharmaceutical nanotechnology: from the bench to the market. *Futur. J. Pharm. Sci, 2022;* 8: 12. https://doi.org/10.1186/s43094-022-00400-0
20. Mirza, M.A., Jameel, M., Khan, M.A., and Iqbal, Z. Nano-emulsion technology in unani medicine. Mini-Review Article, IJAPMBS, 2014; 3(1): 70-74.
21. Pachuau, L. Nanostructures for Improving the Oral Bioavailability of Herbal Medicines in Nanotechnology, 2019; 1. CRC Press, eBook ISBN978135111187
22. Parveen, R., Baboota, S., Ali, J., Ahuja, A., and Ahmad S. Stability studies of silymarin nano-emulsion containing Tween 80 as a surfactant. J. Pharm Bioallied Sci, 2015; 7(4): 321-4.
23. Phan, H.T., and Haes, A.J. What Does Nanoparticle Stability Mean? J. Phys. Chem. C Nanomater Interfaces, 2019; 123(27): 16495-16507.
24. Rajamanickam, V., et al. Formulation and evaluation of Siddha herbal nano-emulsion for topical delivery. J. Ayurveda and Integrative Medicine, 2018; 9(4): 277-283.
25. REP-01; 2022, Text @ ADVISORY-Concerning sale of Ayurvedic, Siddha and Unani Drugs.pdf
26. REP-02; Text @ https://tnslaim.tn.gov.in/rules.html
27. Sapra, M.S.F. Approach Of Nanotechnology in Unani Analgesic Drugs: A Review. Int. Research J. Modernization in Engineering Technology and Science, 2021; 3(3): 514-9.
28. Sharma, A., et al. Nanobiosensors for Ayurvedic medicine quality control. J. Ayurveda and Integrative Medicine, 2019; 10(2): 148-153.
29. Sharma, P. K., et al. Nanofibers in Ayurvedic medicine. J. Ayurveda and Integrative Medicine, 2014; 5(1): 63-68.
30. Sharma, R., and Prajapati, P.K. Nanotechnology in medicine: Leads from Ayurveda. J. Pharm. Bioallied Sci, 2016; 8(1): 80-1.
31. Shipra, and Goyal, M. Doses and dosage forms in ayurvedic pharmaceutics: paediatric perspective. J. Ayurvedic and Herbal Medicine, 2019; 5(3): 117-120.
32. Shiva, S., Mari, S., Amuthan, A., and Shanmugam, R. Repurposing Siddha mercurial drug for mild to moderate COVID-19 - Case series and exploration of its chemical profile. J. Ayurveda Integr. Med, 2022; 13(2): 100469.

33. Srivastava, A., et al. Synthesis and characterization of Ayurvedic gold nanoparticles. J. Nanomedicine & Nanotechnology, 2015; 6(3): 1-6.
34. Sultana, S., Ansari, A.H., Zulkifle, M., et al. Efficacy of a Unani formulation in improving fairness – A Clinical Study. Research & Reviews: J. Unani, Siddha and Homeopathy, 2015; 2(1): 1–3.
35. Thas, J.J. Siddha medicine-background and principles and the application for skin diseases. Clin Dermatol, 2008; 26(1): 62-78.
36. Valikarimwala, M., Gadale, S., and Waghmode, S. Applications of Nanotechnology in Ayurveda: A review. Research & Reviews in Biotechnology & Biosciences, 2021; 8(1): 163-169.
37. Wahnou, H., Liagre, B., Sol, V., El Attar, H., Attar, R., Oudghiri, M., Duval, R.E., and Limami, Y. Polyphenol-Based Nanoparticles: A Promising Frontier for Enhanced Colorectal Cancer Treatment. Cancers (Basel), 2023; 15(15): 3826.
38. WP-01; State Licensing Authority for Indian Medicines; Government of Tamil Nadu. Text @ https://tnslaim.tn.gov.in/rules.html
39. WP-02; Definition of Ayurved; Text @ https://en.wikipedia.org/wiki/Ayurveda
40. WP-03; Johns Hopkins Medicines, Health; Text @ https://www.hopkinsmedicine.org/ health/wellness-and-prevention/ayurveda
41. WP-04; Traditional Medicine; Text @ https://www.sciencedirect.com/ topics/ medicine-and-dentistry/traditional-medicine
42. WP-06; Text @ https://en.wikipedia.org/wiki/Ayurveda
43. WP-07; Ayurvedic Medicine in Depth; Text @ https://www.nccih.nih.gov/health/ ayurvedic-medicine-in-depth
44. WP-08; Ayurveda: does it really work? Text @ https://www.webmd.com/ balance/ ayurvedic-treatments
45. WP-09; Siddha Medicine; Text @ https://en.wikipedia.org/wiki/Siddha_medicine
46. WP-10; Ayurveda; Text @ https://en.wikipedia.org/wiki/Ayurveda
47. WP-11; Siddha Medicine; Text @ https://www.britannica.com/science/Siddha-medicine
48. WP-12; Department of AYUSH, Karnataka; Text @ https://ayush.karnataka.gov.in /newpage/ Siddha/en
49. WP-14; Ayurveda; Text @ https://www.betterhealth.vic.gov.au/health/ conditionsandtreatments/ayurveda
50. WP-15; Aryavaidyashala, Kottakkal; Text @ https://shop.aryavaidyasala.com/ medicines.html
51. WP-16; Sreedharream, Eye of Ayurveda; Text @ https://www.sreemed.com/
52. WP-17; Different dosages forms of Ayurveda; Text @ https://www.muniyalayurveda. in/blogs/ayurveda/different-dosage-forms-of-ayurveda
53. WP-18; 12 Powerful Ayurvedic Herbs and Spices with Health Benefits; Text @ https://www.healthline.com/nutrition/ayurvedic-herbs
54. WP-19; Ayurveda; Text @ https://www.betterhealth.vic.gov.au/health/ conditionsandtreatments/ayurveda
55. WP-20; Central Council of Indian Medicines, Text @ https://www.ccimindia. org. in/unani/
56. WP-21; KnowledgeDose; Text @ https://www.knowledgedose.com/equivalent-dose-and-drug-conversions-transfers-switching/
57. WP-22; Traditional and complementary systems of medicine, Text @ https://www.sciencedirect.com/topics/neuroscience/ unani-medicine
58. WP-23; Indian System of Medicine, Government of Kerala; Text @ https://www. ism.kerala.gov.in/eng/index.php/about-us/about-ism/about-unani
59. WP-24; Unani, AYUSH Ministry, Text @ https://ayushedu.bisag-n.gov.in/AYUSH_EDU/unani
60. WP-25; Sustainable Nano, a blog by the NSF Centre for Sustainable Nanotechnology; Text @ https://sustainable-nano.com/2023/09/26/play-the-game-of-nanopoly/
61. WP-26; Nanotechnology Database; Text @ https://product.statnano.com/company /nanopoly
62. WP-27; Nanoparticle; Text @ https://en.wikipedia.org/wiki/Nanoparticle