Nanotechnology Applications in Medicinal Plants and their Bionanocomposites

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An Ayurvedic Approach

Edited by

Shivaji H. Pawar

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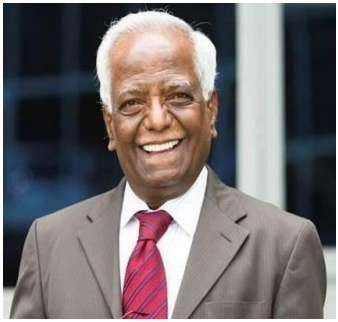

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Prof. Dr Shivaji. H. Pawar
Editor

PREFACE

Nanotechnology Applications in Medicinal Plants and their Bionanocomposites: An Ayurvedic Approach is an extensive collection of learned materials and new results focusing on advances in nanomaterials and nanotechnology for their applications in medicinal plants with a new approach by the contributing authors who are experts working in the fields of nanosciences, Ayurvedic, medicines, biological sciences, medical sciences, physics, chemistry biotechnology and engineering sciences.

This book is the first of its kind and is based on multi-faculty interdisciplinary research. The COVID-19 pandemic taught us the lesson of prioritising our efforts towards health cure applications. The research efforts on developments in nanomedicine for the detection, treatment and prevention of patients from severe/acute respiratory syndrome (SARS)-CoV-2 have helped to handle the pandemic situation. Recently, in the COVID-19 pandemic, both traditional medicines and modern synthetic medicines were used to treat patients. In the post-COVID era, many more patients treated with modern medicines have faced adverse side effects. Traditional medicines based on medicinal plants have no side effects but show slow recovery. The application of nanotechnology in medicinal plants to formulate nanomedicines has made it possible to overcome these drawbacks. The details of this advanced research are described in separate chapters of this book.

Further, nanotechnology applications in medicinal plants are of recent origin as compared to their traditional applications in *Ayurveda.* Nanotechnology offers immense opportunities for improvements in the quality of life through applications in nanomedicine and food systems. Nanotechnology-derived devices have also been explored in the areas of plant breeding and genetics. Additionally, the medicinal plant products and by-products can be utilised as a source for developing bionanocomposites. Nevertheless, the potential advantages of nanotechnology applications in the *Ayurveda* sector are still marginal and have not been commercialised to a significant extent, as compared to other industrial sectors. Researchers in the area of *Ayurveda* are being extensively pursued in quest for solutions to the medicinal plants and environmental challenges, such as sustainability, increased productivity, disease management and plant protection through innovative techniques for monitoring, assessing and

controlling plant growth practices. This book provides basic knowledge about the role of nanotechnology in developing sustainable *Ayurveda* and environment and eventually, in the welfare of human society at large in the near future.

In all, there are sixteen chapters in the book. The book begins with "Ayurveda from Ancient Age until the Age of Nanotechnology" and ends with "A New Perspective in Ayurveda with the Intersection of Nanotechnology and Medicinal Plants." The book chapters have covered various aspects of the interface between nanotechnology, Ayurveda, medicinal plants, bionanocomposites, bionanofortification, bhasma, drug delivery, mobile application, diseases like tuberculosis, COVID-19 and cancer.

Finally, in this fast technical age, this book will be a precious piece of information enriching the readers with basic and advanced knowledge of health care applications, giving fast results with no side effects.

I hope readers will find this book interesting and enlightening.

Prof. Dr Shivaji. H. Pawar
Editor

This book focuses on advances in nanomaterials and bionanocomposites for their applications in medicinal plants. Nanotechnology applications in medicinal plants are a recent addition to Ayurveda, the ancient Indian medical system. Nanotechnology offers immense opportunities for the improvement of quality of life through applications in nanomedicine and food systems. This book provides basic knowledge about the role of nanotechnology in developing a sustainable form of Ayurveda utilising bionanocomposites. It will be useful to students of nanosciences, Ayurvedic medicines, biological sciences, medical sciences, physics, chemistry, biotechnology and engineering sciences. The book is the first of its kind and is based on interdisciplinary research from a variety of experts in their fields.

CHAPTER 1

AYURVEDIC MEDICINES WITH INTERSECTION OF NANOTECHNOLOGY AND MEDICINAL PLANTS

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Abstract:

The COVID-19 pandemic taught us to prioritise our efforts towards healthcare applications. Research and developments in nanomedicine for the detection, treatment and prevention of SARS-CoV-2 have helped to handle the pandemic. However, patients have faced the side effects of those medicines used to treat COVID-19. In view of this, nowadays, researchers are moving towards a herbal approach to medical treatments for patients who have cancer. The present chapter is focused on a new perspective in Ayurveda with the intersection of nanotechnology and medicinal plants, explaining the traditional old Ayurvedic medicinal science and the development of bionanocomposites with medicinal plants. The properties of bionanocomposites are found to be sensitive to the shape, size, and quantum of nanoparticles embedded in the biomaterial. Thus, the engineering and monitoring of the preparative parameters of bionanocomposites are discussed in this chapter. Finally, an attempt has been made to give new dimensions to Ayurvedic bhasma in light of recent developments in nanoscience and nanotechnology.

Keywords: Bionanocomposites, Medicinal Plants, Healthcare Applications, Cancer, COVID-19

1. Introduction

Since the year 1000 CE, people have thought about using different kinds of plants to make medicines, and most of the drugs used today are still made from natural products that come from plants. The Egyptian "Ebers Papyrus" recorded the use of traditional medicines from 2900 BCE, which is one of the best-preserved records. It has 700 drugs made from plants. Both the traditional Chinese medicine and the Indian Ayurveda method were written down over a thousand years ago, around 1000 BCE. Amazingly, there are many different kinds of therapeutic plants all over the world. Around 70,000 plant species, from the smallest lichens to the tallest trees, have been shown to have the ability to treat different diseases. The WHO says that 21,000 plants can be used for medicinal purposes. Even today, traditional herbal practitioners are known to use the herbal medicine system in rural areas. They use about 2500 plants to treat basic illnesses. It is one of the best ways that Indian medicine has been offered. India is home to more than 100 plant families that are used for traditional medicine in different parts of the world. India has the best quality and largest amount of therapeutic plants, and it is the second largest exporter of these plants. It is one of the 12 major biodiversity hotspots in the world. It has 16 agro-climatic zones and a wide range of about 45,000 plants, of which 7,000 are known to be medicinal. Natural medicines have a lengthy history of use in the treatment of many human illnesses. The ongoing use of these medications has increased their influence on contemporary medical and healthcare services globally. The pharmaceutical industry is known to rely mostly on inorganic chemical libraries and high-throughput screening for the discovery of innovative medications. In order to produce novel medications based on natural products, wide interdisciplinary approaches were essential. One of the most significant scientific foundations for both the traditional and modern medical systems is regarded to be herbal medicine. Due to their higher cultural acceptability (Ambwani 2019), compatibility with the human body, and lack of negative side effects, natural product-based medicine is used by about 75–80% of the population in major developing nations.

Consequently, throughout the past few decades, major developing countries have significantly increased their research into and use of herbal medicines. The World Health Organisation (WHO) has said that the use of traditional medicines, including herbal remedies, is regarded as a therapeutic practice that first emerged hundreds of years ago and is still in use today. Herbal medication development is exclusively reliant on conventional medicine, which consists of therapeutic plant formulations.

According to historical evidence, herbal medicine has been used for over 5000 years in Syria, Egypt, China, and India. The *Rigveda, Atharvaveda, Charak Samhita*, *Sushruta Samhita* and *Kamboj* are some of the traditional Indian works on human medicine (2000). Since December 2019, everyone in the world has been affected by the COVID-19 outbreak. It has taught us that the most important thing is to focus on health cures instead of health studies. The most important thing was to treat the people who had SARS-CoV-2 and save their lives in any way possible. Recent research on nanomedicine, which is built on advances in nanoscience and nanotechnology, has helped the world deal with the recent pandemic by finding, treating, and preventing SARS-CoV-2 patients. Medicines used to help COVID-19 patients have side effects that the patients have to deal with. After treatment, the patients needed more care. (Rothan et al. 2020). The same is true for many other illnesses, such as multiple sclerosis, cancer, tuberculosis, and so on. Because of this, researchers are now moving away from using manufactured anti-cancer drugs and are attracted towards using natural herbs to treat diseases like cancer. The study of active chemicals that come from plants could help cure diseases in the future. These active compounds work directly or indirectly to treat illnesses that are hard to treat, like communicable and non-communicable diseases. One of the most interesting things scientists are looking into is how these active chemicals change into nanoforms (Ochwang'I DO et al. 2014). The nanocomposites of phytomolecules from saffron, clove, lavender, and red beetroot (graphene oxide, solid lipid nano, and nanoemulsion) may be able to lessen these harmful effects. In the near future, finding out how the molecules of these naturally made compounds and nanocomposites work to fight cancer could help more cancer patients. Besides, these chemicals and their bionanocomposites might be able to stop the dangerous COVID-19 virus. Because of this, researchers would find more potential drugs to help fight cancer and viruses. Synthetic drugs used to treat diseases can hurt the body. This makes medicinal plants more important and helpful (Faraat et al. 2012). Cancer is a terrible disease, and it is thought that 21 million people will have it by 2030. About 35,000 plant species that might help fight cancer have been researched by the National Cancer Institute (NCI) in the United States. Nanoscale drug delivery methods are important tools for improving the pharmacokinetics and bioavailability of both synthetic and naturally active compounds. Because they have vitamins or sugars, leaves, fruits, roots, seeds, and stems all can be used to make nanoparticles instead of chemicals that could be harmful. This is because nanoparticles can be made from plant products very well (Daniel et al. 2012). The qualities of nanoparticles and

nanocomposites depend on their sizes, which can affect how well they work as medicines. So, for bionanocomposites to have repeatable and reliable qualities and treatments, they need to be designed in an environment of medicinal plant extracts to make them biocompatible and less harmful to cells. (Mishra et al. 2011; Kumar et al. 2018) This may be the first time that something like this has been mentioned as a medical treatment for people with both communicable and non-communicable diseases to avoid the side effects of dangerous chemicals used in medicines.

2. Concepts of Ayurvedic Medicine

Ayurveda is a study of life that takes a whole-person approach to health and makes medicine specific to each person. It is one of the oldest medical systems and is made up of thousands of ideas and theories about medicine. Ayurveda is interesting because it can treat many long-term diseases that modern medicine can not do, like cancer, diabetes, arthritis, and asthma. Unfortunately, this valuable gift from our ancestors is falling behind because many of its ideas have not been proven scientifically. So, evidence-based research is very important for Ayurveda to be recognised and accepted around the world. There need to be improvements in how it is studied. Traditional Indian medicine, which is called Ayurveda, is built on a traditional medical system, just like traditional Chinese medicine, which was developed in China. Ayurveda has been around for about 3000 years, and it has been used to treat illness for a long time. The three basic ideas called doshas (vata, pitta, and kapha), come from the five main ideas of Indian thought. The doshas in Ayurveda can be thought of as control factors for the most basic physiological processes in living systems. Vata and its subdoshas control input/output processes and motions; pitta and its subdoshas control throughput, turnover, and energy; and kapha and its subdoshas control storage, structure, and lubrication. However, things like food, activity, the weather, and stress can stop or damage these processes. Ayurveda tries to get the body's functions back to normal by giving tips on what to eat and how to exercise, giving herbal preparations to put inside the body, giving purification treatments (Panchakarma), and surgery (shalya chikitsa). People's doshas can be changed by the food, spices, and healing plants they eat. Different ways that these elements affect doshas are by stabilising, disturbing, and supporting the good state of the body. To fully understand how food, spices, and medical plants can affect the body, one needs to know about how they work. In this chapter, what medicinal plants do and how they interact with nanoparticles will be discussed at length.

2.1 Ayurvedic Medicinal Plants

Ayurveda tries to analyse what is wrong with the patients before treating them with medicines, changing their food, or restricting their habits. In Ayurvedic treatment, plant-based preparations are used a lot. In a broad sense, anything in the world can be used as a possible medicine (Ochwang'I et al. 2014). Ayurvedic texts from the past warn against using substances that are not well known. (Faraat Ali et al. 2021). Ayurvedic pharmacopoeia can include any plant, animal, or mineral material, but only if it is fully understood in terms of its name, identity, properties, and uses. The texts also tell people not to abuse well-known medicines. They stress that even poisons can be used as medicine if they are used in the right way, while even the best medicines can be dangerous if they are used wrongly. In more than 3000 years, only about 1200 to 1500 of the nearly 10,000 plants used for medicine on the Indian subcontinent have been added to the official Ayurvedic pharmacopoeia. Before a plant is added to the Ayurvedic pharmacopoeia, it must be carefully studied (Faraat Ali et al. 2021). Approximately ninety per cent of Ayurvedic remedies are derived from plants. Food and seasonings have a weaker effect on the body than Ayurvedic herbs. These actions allow the plant to reverse pathophysiological processes and balance the doshas. Therefore, these plants should be utilised with caution. In Sanskrit, classical Ayurvedic concoctions derived from such plants are known as yoga. Yogas have evolved as a result of years of practical experience combining plants for maximum effect. Similarly, polyherbal combinations have proven more durable than single botanicals. The majority of Ayurvedic classical preparations consist of a combination of three to thirty plants. These ingredients are combined precisely so that the formula is balanced and repeatable. In these combinations, one or two of the plants will be active, while the others will play a supporting role. The supporting herbs will have distinct effects, functioning as catalysts to aid in absorption, transport and toxicity reduction. If the optimal combination is achieved, the outcome can be excellent, but such results are contingent on in-depth plant knowledge.

2.2 The Formulations and Actions of Ayurvedic Medicines:

Ayurvedic remedies consist primarily of botanical mixtures. In some regions of India, Ayurvedic preparations contain heavy metals. Traditional texts such as the *Charak Samhitha*, *Susrutha Samhitha* and *Ashtanga Samgraha* make no mention of the use of heavy metals; this is evidently a

later development. Heavy metals are toxic and are not permitted in modern pharmaceuticals at any level. In contrast, metals may be added to Ayurvedic preparations for their purported therapeutic effects to create rasausadhies (herbo-bio-min m etallic preparations). In Ayurveda, the use of metals and minerals as medicines is only recommended after purification *(*shodhana), at the prescribed low dose, with a specific vehicle *(anupana),* for a specific period, and with strict adherence to dietary, activity and environmental restrictions. Ayurveda also describes the toxic effects, complications and diseases that result from the ingestion of unprocessed or inadequately processed metallic preparations. Numerous Ayurvedic rasausadhies have been found to contain metals, and cases of toxicity due to the consumption of Ayurvedic herbs have been reported over the past decade, particularly those sold on the Internet (Balkrishna et al. 2021). Such metals are not present in unadulterated Ayurvedic herbal preparations (Beg et al.2017). According to traditional Ayurvedic texts, quality-assured Ayurvedic compounds are effective enough to combat disease. The plant elements selected are also crucial. The leaves, flowers, seeds, barks, roots, or epidermis of a plant are selected depending on the plants involved and the medical combinations in question. The particular combination selected is the result of extensive practical experience with the constituents required for maximum effect. The action mechanisms of polyherbal drugs and their extracts differ significantly from those of single substances and synthetic drugs. (Shi et al. 2017; Patel et al. 2021). Polyherbalism has its origins in the earliest pharmacological texts of Ayurveda, such as the *Charak Samhita*, *Susrutha Samhita*, and *Ashtanga Hrudaya*. The 1300 CE Ayurvedic text *Sarangdhar Samhita* emphasises the concept of polyherbalism within this ancient medical system. (Sheel et al. 2020). Most Ayurvedic formulations contain multiple herbs (Ciorîță et al. 2020; Jain 2020). Although the active phytochemical components of individual plants are well established, they are typically present in insufficient quantities to produce the desired therapeutic effects. (Jabir 2021). Recent research indicates that combining plants of differing potency increases their efficacy, both in comparison to the use of individual plants and to the aggregate of their individual effects. The term for this phenomenon is synergy. Some pharmacological actions from the active constituents of certain botanicals have been shown to be significant only when combined with the active constituents of other plants but not when used alone. (Jabir et al. 2021). Two proposed mechanisms explain these effects: pharmacokinetic synergy and pharmacodynamic synergy (Nandhini et al. 2019). The former is predicated on the perception that certain herbs can facilitate the assimilation, distribution, metabolism, and

elimination of other herbs. This refers to the synergistic effect of active constituents with similar therapeutic actions that target similar receptors or physiological systems. Multiple factors are responsible for the majority of maladies, resulting in both visible and invisible symptoms. A combination of herbs may simultaneously act on multiple targets to provide comprehensive alleviation (Karade et al. 2019). There is a misconception that natural Ayurvedic remedies are always safe; this is false. The *Charaka Samhita* notes that Ayurvedic remedies have negative side effects when improperly prepared and then utilised. (Meena et al. 2018). The *Charak Samhita* emphasises the factors to be considered when selecting formulation constituents, such as the habitat of the plants, the season in which they thrive, the prevalent harvesting conditions, the chosen methods of storage, and the chosen methods of pharmaceutical processing (Rokade et al. 2018). Herbs are natural substances, and their constituents may vary depending on their geographical location, climatic conditions, exposure to environmental hazards, harvesting methods, and collection protocols. These variables make it challenging to standardise or replicate the quality of the final product (Jamdade et al. 2019). The bioavailability of a nutrient is broadly defined as its absorption and utilisation (Aritonang et al. 2019). The bioavailability of herbal medication or its active constituents determines the degree and amount of absorption (Beg et al. 2017; Kikowska et al. 2018).

Due to the synergistic and antagonistic actions of a herb's constituents, the herb's chemical complexity can affect its bioavailability. A drug's hydrophobic properties, as well as the gut microflora, liver function, and chemical modifications produced by herbal constituents, determine its ability to cross the luminal wall. If herbal drugs are to affect the central nervous system, they must cross the blood-brain barrier. However, there is a paucity of literature on Indian herbs, particularly those with potential antioxidant-stimulating properties, on this crucial topic (Tahir et al. 2017). The synergistic interactions between botanicals can significantly influence their bioavailability. Long pepper, black pepper and ginger can all boost the bioavailability of certain substances. (Kganyago et al. 2018). Individual differences in gut microflora and hepatic activity also influence systemic absorption (Hashemi et al. 2020)

2.3 The Drug Administration in Ayurveda:

The administration of drugs differs between Ayurveda and modern medicine. Most medications in the latter category are synthetic, and their administration affects the stomach and intestines. Thus, the majority of

conventional medications are administered after sustenance. Ayurveda specifies the scheduling of medication administration based on the patient's nature, disease, and disease state. Ayurvedic preparations are also administered on an empty stomach. The latter preparations are slow-acting because they are derived from plants. The assimilation of Ayurvedic plant preparations is a normal function of the metabolic process. Ayurvedic preparations must be broken down for digestion in the gastrointestinal tract and must be metabolised in the stomach and intestine prior to entering the bloodstream and reaching the target organ to exert a therapeutic effect. For Ayurvedic physicians, the digestive fortitude of their patients is crucial. Before being assimilated as part of normal metabolism, Ayurvedic preparations must undergo numerous digestive processes. As a result, Ayurvedic physicians routinely analyse the metabolic state of their patients prior to treatment, aiming for optimal stability and minimal gastrointestinal harm. There are various forms of Ayurvedic medication, such as decoctions, powders, pastes, fermented products, tablets, and medicinal butters (ghees). The formats used, whether liquids, pastes, or tablets, are related to the efficacy of preparations.

2.4 The Need of Ayurvedic System of Medicine to Improve

Ayurvedic medicine is unquestionably more successful than allopathic treatment for the majority of chronic disorders. The bulk of the world's population, however, favours contemporary medicine since it can heal illnesses more quickly than Ayurvedic therapy, which makes Ayurveda less popular. The rising cost of healthcare in some countries and growing awareness of the danger of allopathic pharmaceuticals are driving an increasing number of individuals to look for alternatives. Ayurvedic scientists need to improve the core competency of Ayurveda without compromising its essential principles rather than competing with and leaning towards Western medicine. The following are some key factors for the decline of Ayurveda: A) Despite their enthusiasm, young Ayurvedic scholars lack clarity in their opinions regarding the future of the discipline. Additionally, they are unsure about how to share their important Ayurvedic research findings. B) For specialised research in Ayurveda, only a select few organisations have well-established research infrastructure. To perform advanced and high-quality research in Ayurveda, it is necessary to have experienced researchers who are familiar with modern technologies. C) Biomedical scientists are frequently unwilling to collaborate and are overly sceptical and prejudiced. D) Each year, over a

thousand postgraduate students in Ayurveda graduate and join the stream of academia and practice. Only a few of them opt to work as Ayurvedic researchers. E) Neither the Ayurvedic teachings nor the textbooks' addition of fresh research methodology have changed in the previous 50 years. Researchers in Ayurveda should seriously take into account the important factors listed above in order to advance it.

3. Intersection of Nanotechnology and Medicinal Plants:

3.1 Encouraging Interdisciplinary Research

There is a need to incorporate all basic sciences, including physics, chemistry, molecular biology, and biotechnology, along with ethnopharmacology, Ayurvedic drug discovery, pharmacoepidemiology, reverse pharmacology, and various other fields, for a better understanding of Ayurveda research and a more promising outcome. In recent years, the concept of multi-faculty interdisciplinary research has also been introduced to Ayurveda, primarily for integrative medicine. In Western nations, the multidimensional approach that combines traditional and contemporary medicines is expanding. It has been determined that the clinical efficacy of many traditional medications for a variety of diseases is superior to that of modern medicine. The Ayurvedic system of medicine is extremely safe and can help reduce the tremendous burden of mortality and morbidity caused by the various side effects of conventional drugs. This traditional method is also effective against diseases in which pathogens have developed antibiotic resistance. Thus, interdisciplinary research is crucial to combating the majority of chronic diseases.

3.2 Medicinal Plants and Phytochemicals:

Due to the harmful effects of synthetic drugs, researchers are increasingly turning to herbal medicine to treat ailments. The study of plant-derived active compounds may one day aid in the treatment of human diseases. These active compounds can be used directly or indirectly to treat difficult-to-treat diseases such as cancer. The nanoforms of these active compounds are one of the most intriguing aspects that scientists are investigating. Synthetic pharmaceuticals used to treat diseases can be harmful to the body, elevating the significance and utility of medicinal plants. The world has found a place for phytotherapy, and the use of plants has replaced the trend of using synthetic compounds. Aspirin, derived from willow bark; digoxin, derived from the opium poppy; and morphine,

derived from the opium poppy, are all traditional medicines derived from plants studied in clinical, pharmaceutical, and chemical contexts.

Herbal remedies are the earliest form of medicine. They have been used in traditional medicine in numerous countries for thousands of years. People have known for centuries that they are beneficial to our health because they have witnessed it for themselves (Mishra et al. 2011). Natural products are a significant source of drug compounds, and a number of modern pharmaceuticals are derived from traditional herbal medicine. The ancient Indians treated many ailments and disorders with various plant components (Ballabh et al. 2007). Studies have demonstrated the potent therapeutic qualities of the plant materials employed in the procedure. Additional research on the plant's crude extracts and compounds revealed that the extracts include secondary metabolites known as phytochemicals, including alkaloids, flavonoids, phenols, and chalcones. Numerous phytochemicals can neutralise viruses and germs as well as fight free radicals. Later studies demonstrated the usefulness of these plant components that were utilised to treat disease or infection.

A significant variety of phytochemicals can be utilised to cure retroviral infections, according to research in the scientific literature and encouraging biological testing. According to Behl et al. (2021), phytochemicals have recently been utilised to prevent viral infections like HIV, influenza, and the common cold. Several plants are beneficial to human health. These all are shown in Table 1.

Table 1: Summary of some published studies on medicinal plants used for human health from the below table. The notable thing is that the phytochemicals which are present in plants are used to cure different communicable and non-communicable diseases, including COVID-19.

	Medicinal plant		**Part of plant used**	**Phytochemicals for medicinal treatment**	**Phytochemicals for medicinal treatment**		**Citation**
	Botanical Name	*Common Name*			*Communicable*	*Non communicable*	
1.	Bletillastriata	Chinese ground orchid	Root	phenanthrenes	Anti-viral	-	Shi et al. 2017
2.	Abutilon Indicum	Indian Mallow	Leaves	Methoxycarbony l-2-phynylethyl 4 hydroxybenzami de	-	colon cancer	Jain et al. 2020
3.	Curcuma longa	turmeric	Root	polyphenol		Cancer diabatic infection	Anand et al. 2017
4.	Flacourtia Indica	ramontchi	Leaves	Phynolic compounds		Anti-cancer, antiproliferative	Nandhini et al. 2018
5.	Salvia Sclarea	Clary sage	the central part of the leaf blade	malondialdehyde e (MDA)		Antioxidant activity	Dobrikova et al. 2021
6.	Gardenia resinifera	Gummy gardenia	leaves			cytotoxic effects on human mesenchymal cell lines, proving them as a potential candidate for biomedical applications.	Karade et al. 2019

7.	OcimumTenuifloru m	Holy basil	leaves	hydroxyl functional groups		cancer and bacteria therapy	Meena et al. 2019
8.	Gloriosasuperba	gloriosa lily	tubers	alkaloids, flavonoids, glycosides, phenols, saponins, steroids, tannins, and terpenoid		Breast cancer	Rokade et al. 2018
9.	Gnidiaglauca	Fish Poison Bush.	leaves	5-methoxyseselin, suberin, xanthyletinxanthoxyletin		anti-diabetic	Jamdade et al. 2019.
10.	Impatiens balsamina and Lantana camara)	***garden balsam***	leaves	Essential oil, phenols, sesquiterpenoids tannins	Antimicrobial, antibacterial		Aritonang et al. 2019
11.	Cayratiapedata		leaves	Terpenoids, flavonoids, alkaloids, fatty acids, phenolic compounds, aldehyde	antibacterial, antimicrobial, antityrosinase, and antibiofilm	anti-cancer	Jayachandran et al. 2021
12.	Eclipta alba		leaves	a-terpineol, cadinene, linolenic acid, methyl linoleate and myristic acid amide	antibacterial, antifungal, anti-viral activities		KshamaRai et al. 2020
13.	Pongamiapinnata	Seashore mempar	seeds	pongaflavanol, tunictachalcone, glybanchalcone,	antibacterial		Beg et al. 2017
14	Azadirachtaindica	neem	leaves		malaria, rheumatism, skin diseases, ulcers, respiratory tract infections, diarrhoea		Appiah et al. 2018

15	Eryngium planum	Sea holly	fruits and isolated seeds	triterpenoids saponins, phenolic acids, coumarins, flavonoids, acetylenes, and essential oil	anti-infammatory, diuretic, expectorant		Kikowska et al. 2018
16	Taraxacumlaevigat um		whole plant	terpenoids, phenols, alkaloids, flavonoids, quinines, tannins etc	antibacterial		Tahir et al. 2017
17	Monsoniaburkenea		leaves	phenolic acids, flavonoids, tannins	antibacterial		Kganyago et al. 2018
18	Teucriumpolium	Feltygermand e-r	leaves	proteins, peptides, polysaccharides, phenolics, enzymes, and vitamins	Antibacterial, anti-ulcer, anti-inflammatory, antispasmodic, antihypertensive, antinociceptive		Hashemi et al. 2020
19	Lippiaadoensis	kosearut	leaves		antibacterial antimicrobial		Demissie et al. 2020
20	Memecylonumbell atumBurm	ironwood	leaves	4-N-methyl benzoic acid	Antimicrobial, anti-tumour		AlSalhi et al. 2019
21	Papaversomniferu m	Opium poppy	pod	essential alkaloids	Antibacterial, anti-diabetic		Wali et al. 2019
22	insulin plant	Costusigneus	roots, leaves, stems, seeds, and fruits		antibacterial antimicrobial	anti-cancer	Joghee et al. 2018
23	Nervaliazeylanica		leaves	phenols, alkaloids, flavonoids, saponins, and tannins	antimicrobial		Vijayan et al. 2018

24	Indigoferatinctoria		leaves	alkaloids, amino acids, flavonoids, saponins, steroids, glycosides, carbohydrates, tannins, phenolic group	Antimicrobial	anti-cancer	Vijayan et al. 2017
25	Buddlejaglobosa	orange-ball- tree		Phenolic compounds, terpenoids, flavonoids, alkaloids, polysaccharides, proteins, enzymes, and amino acids.	antimicrobial		Carmona et al. 2017
26	Citrullus colocynth	bitter apple	fruit pulp and seeds		antimicrobial activity		Farouk et al. 2023
27	Viscum album L.	European mistletoe	leaves	carbohydrate or phenol contamination		Cancer and cardiovascular disease	Xie et al. 2018
28	Gmelinaarborea	Gamhar	fruit	polysaccharides, polyphenols, aldehydes, ketones, proteins/enzymes, amino acids		Diabetes	Saha et al. 2017
29	Berberisbalochistan ica	Berberisbaloc histanica	leaves	2,2-diphenyl-1-picrylhydrazy	Antibacterial activity		Uddin et al. 2021
30	Eupatorium Odoratum	siam weed	leaves	protein, biotin, ascorbic acid, steroids, flavonoids and various polyphenolic compounds	Antibacterialantimicrobial		Roy et al. 2019

31	Bromeliakaratas	Ananaspingou nin		phenolic acid		Diabetes	Mata-Torres et al. 2020
32	D. pentagyna,	Dilleniaindica	leaves	palmitic acid, vitamin E, palmitamide	antimicrobial	anti-tumour	Thooptianrat et al. 2022
33	W. ugandensis	simply greenheart tree	stem bark	-		antimaleria	Schultz et al. 2020
34	Ziziphusnummulari a	Wild jujube	leaves	polyphenols, alkaloids, flavonoids	antibacterial, antifungalanti-cancer		Padaliaa et al. 2021
35	obtusifolia	Sicklepod		phenolics, alkaloids, tannins, flavonoids, saponins and steroids	Anti-microbial		Moglad et al.
36	Kaempferiaparviflo ra rhizome	black ginger		Volatile oil, phenolic glycosides and numerous flavonoids.	anti-microbial	anti-cancer activities	Varghese et al. 2021
37	Malvasylvestris	Mallow			antimicrobial	anti-cancer	Mousavi et al. 2019
38	Costusspeciosus rhizome	setawartawar		phenols, carbohydrates, glycosides, vitamin C, vitamin E, flavonoids, saponins, and alkaloids.	antibacterial, antifungal, analgesic, antipyretic, antidiuretic, larvicidal,		Vijayana et al. 2019.1
39	Gossypiumhirsutum	Mexican cotton	leaves			Cancer	Kanipandiana et al. 2019
40	Capparisspinosa a	Caper bush	Fruitroots	ethanolic, ethyl acetate and methanolic	antimicrobial		Hongxia Zhang et al. 2018
41	Calotropisgigentea	Crown flower	flower		anti-bacterial		Vermaa et al. 2018

42	Bauhinia purpurea	Bauhinia variegate	leaves	glycosides, saponins, phenolic compounds, tannins, flavonoids, fixed oils, fats, and phytost	Antimicrobial	Anti-cancer	Vijayan et al. 2019
43	Cissusarnotiana	Treebind	leaves		Antibacterial antimicrobial		Rajeshkumar et al. 2019
44	Vacciniummyrtillu s l	bilberry	leaves	phenolic acids, tannins,		Diabetes	Adić et al. 2019
45	Hydnocarpuspenta ndra	Jangali almond	leaves	phytochemicals like tannins, flavonoids, alkaloids, steroids, saponins, etc	antimicrobial and anti-Larvicidal activities		Shyam et al. (2019)
46	Selaginellamyosuru s	Lycopodiopsi da	whole plant	flavonoids, saponins, steroids, terpenoids, tannins, or phenols,	Antimicrobial, anti-viral, or antitumoral potential.		Inder et al. 2017
47	Justicia pectoralis	fresh cut	leaves	flavonoids, steroids, triterpenoids and alkaloids		Antiasthmatic	
48	Gnaphaliumpolycaulo n	many stem cudweed	leaves	phytoconstituent s such as flavonoids, phenolic glycosides, diterpenes, triterpenes, and phytosterols	antimicrobial,		Shanmugapriy a et al. 2019
49	Millettiapinnata	Indian beech	flower	Flavonoids, terpenoids, phenols, saponins, alkaloids, and vitamins	antibacterial		

50	Suaedamaritima	herbaceous seepweed	leaves	Phenylpropanoid s		anti-proliferative, anti-cancer	Rajendran et al. 2016
51	Ginger	Zingiberoffici nale	leaves, stem, root, bark, seed, fruit, pulp, peel, flower and plant nectare (honey)	flavonoids and their functional group	antimicrobial antibacterial		Mehata et al. 2021
52	Commiphorawighti i	Indian bdellium-tree	leaves	diterpenoids, triterpenoids, steroids, long-chain aliphatic tetrols, aliphatic esters, ferulates, lignans, carbohydrates, a	anti-inflammatory		Uzma et al. 2022
53	Orostachys cartilaginous	O. furusei	leaves	secondary metabolites		antioxidant	Hao et al. 2020
54	Justiciaadhatodapla n	Malabar nut	leaves	polysaccharides, Alkaloids, flavonoids, proteins etc	Anti-microbial		Rajalekshmi et al. 2020
55	Scutellariaviscidula	Bicolor Skullcap	Roots stems, and leaves	phenylpropanoid		Antioxidant	Chengke et al.
56	Camellia sinensis L	Green Tea	leaves	polyphenols	antimicrobial		Masooleh et al. 2018
57	Acanthospermuma ustrale	Loef	leaves	phenolic and favonoid	antimicrobial and cytotoxic activity		Mussin et al. 2021

58	Cassia fistula	Golden Shower Tree	leaves	proteins, vitamins, coenzymes-based intermediates, phenols, flavonoids, and carbohydrates	antibacterial		Naseer et al. 2020
59	Eucalyptus globulus	Guduchi	leaves	penicillin-binding protein	antibacterial antimicrobial		Masood et al. 2021
60	Anselliaafricana	Leopard orchid	leaves	phenolic acids such as hydroxybenzoic and hydroxycinnamic acids	antibacterial		Bhattacharyya et al. 2019
61	Tinosporacordifolia	Guduchi	whole plant	alkaloids, cardiac glycosides, tannins and flavonoids	antioxidant		Satija et al. 2020
62	Catharanthusroseus	Madagascar periwinkle		secondary metabolites		anti-cancer activity	Akther et al. 2019
63	Tobacco	Nicotianataba cum	leaves	nicotine, tobacco alkaloid		Diabetes or chronic pain	Berlowitz et al. 2020
64	Justiciaspicigera						
65	Phyla dulcis	Honeycomb	leaves	Hernandulcin	Antimicrobial Antibacterial Antioxidant Antibiofilm		Carson et al. 2020