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Review

Potential of Nutritious Indian Medicinal Plants to Boost Immunity in the Aftermath of Pandemics: A SWOC Analysis

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Abstract

The world has suffered a lot during the COVID-19 pandemic, for which nobody was prepared. Due to the lack of appropriate treatment, Indian medicinal plants have alleviated the burden due to their diverse health benefits. It has been observed that certain medicinal plants can effectively enhance immunity against microorganisms and viruses. Numerous scientific studies have supported the above claims. This paper presents the SWOC analysis of Indian medicinal plants for their immunity-enhancing effects so that the medicinal plants industry is better prepared to prevent or tackle the rebound of any pandemic-like situation in the future.

Keywords

Analysis; herbs; immunity; pandemic; medicinal plants

1. Introduction

The shift from hunting-gathering to agrarian societies and then to globalized trading societies has favored the spread of infections across the continents and within the population. Increasing trade and interlinking between different communities have facilitated the transmission of infectious pathogens and the development of new resistant strains of infectious microorganisms. The outbreak of infectious diseases has had long-lasting impacts on societies. These impacts include social, political, economic, and environmental impacts. Sometimes, these are so harsh that they wipe out a large section of the population, thereby destroying the entire gene pool of a developed civilization [1].

The world has faced pandemics throughout history, and the most destructive of them was the "Spanish flu" of 1918, which killed a large number of people in the shortest period. Other historically documented pandemics include the "Plague of Athens," "The Black Death," and" The White Plague, "among others [2]. In the early stages, before 1959, most studies were centered on animal models, with minimal consideration given to the influence of nutrition on individual immunity. Later on, with the availability of sophisticated tools and techniques, researchers started focusing on the malnutrition-infection cycle and the underlying mechanisms [3]. Studies on people with deficiencies and experimental research indicate that proper dietary intake of vitamins and minerals is essential for boosting immunity and lowering the risk of contracting several diseases [4].

Examples of 21st-century pandemics include the H1N1 influenza, Nipah and Ebola viruses, and Swine flu [2]. COVID-19, triggered by SARS-CoV-2, is the most recent epidemic that has shaken the entire world [5]. It was discovered for the first time in December 2019 in Wuhan, China. It then spreads from person to person via respiratory mucus droplet transmission and contact. It merely took around three months for COVID-19 to spread worldwide, and on March 11, 2020, the World Health Organization proclaimed COVID-19 a "public health emergency of international concern" i.e., a pandemic [6-8]. Directly and indirectly, the pandemic has heightened the burden of malnutrition worldwide, particularly evident in developing and underdeveloped countries. The COVID-19-related restrictions have changed the lifestyle and eating habits of all individuals. Due to a lack of physical activity and unhealthy food, the immunity of individuals against the virus decreased, and morbidity increased [9].

With the spread of COVID infection, the potential search for the underlying causes responsible for the susceptibility to infection has geared up. The immunity against the infection has been widely documented as being directly linked to the nutritional status of the individuals [10]. Along with infection susceptibility, the nutrition and diet of an individual influence the progression, severity, and aftereffects of the disease [11]. It has been widely proven that nutrition plays an important role in boosting immunity. Nutritional deficiencies especially, of iron, protein, and micronutrients like zinc, selenium, etc. lead to impaired antibody formation and a reduction in the number of immunoglobulins, interferons, and T cells. It further leads to an increase in morbidity and mortality due to infection [12]. Butler *et al.* (2020) studied the impact of nutrition on COVID-19 susceptibility and its consequences in the long term. They recommended avoiding the so-called 'Western diet' since it is high in saturated fats, sugars, and processed carbohydrates, lowering immunity and making individuals unhealthy [13].

In the lack of appropriate therapy and the absence of a vaccine, the nutraceuticals, functional foods, and herbal alternatives made an attractive hypothesis to boost individuals' immunity and

alleviate the pandemic's burden. Many research and review articles appeared to support the proposed hypothesis describing the beneficial role of Indian medicinal plants in preventing and treating diseases [13-26]. The present review studies certain nutritious, medicinal plants widely consumed during the pandemic to boost the population's immunity. A SWOC analysis of the Indian medicinal plants sector will also be conducted to assess the various strengths, weaknesses, opportunities, and challenges related to the topic.

2. Medicinal Plants to Enhance Immunity and Prevent Infections

The United Nations Environment Program's World Conservation Monitoring Centre has recognized India as one of the seventeen megadiverse countries. It harbors about 7-8% of the total recorded species in the world [27]. The WHO has identified over 21,000 plant species with the potential for use as medicinal plants. Moreover, it has been reported that 80% of the global population relies on herbal medicine as their primary form of healthcare [28]. Since ancient times, medicinal plants have been acknowledged for their capacity to prevent and treat various diseases. In comparison to synthetic drugs, herbal medications are less toxic, more environment-friendly, readily accessible, and have been used for generations [29]. Also, many unexplored and neglected plant species contain the potential for immunomodulation that can be utilized as food to variegate the human diet and enhance immunity power [30].

An abundance of data suggests that phytoconstituents in medicinal plants can help boost the immune system [4, 23, 31-34]. Medicinal plants can induce or inhibit specific immunological activities to regain a proper immune response to illness [33]. Immunostimulatory compounds derived from plants can boost immune response and prevent immune-depleting illnesses from viruses like HIV. Moreover, plant-based substances can regulate the immune system and reduce an overactive reaction, which is observed in type-1 hypersensitivity diseases such as allergic rhinitis and asthma [35].

Even during the recent pandemic, traditional medicinal plants appeared to be a savior when no allopathic medicine was available against the coronavirus. A decoction of plants tulsi (*Ocimum sanctum*), cinnamon (*Cinnamomum zeylanicum*), black pepper (*Piper nigrum*), ginger (*Zingiber officinale*), and grapevine (*Vitis vinifera*) was recommended by the Ministry of AYUSH during the pandemic [31, 36]. Along with these, a large number of nutritious medicinal plants have been consumed for prevention and treatment of infections since ancient times like Andrographis (*Andrographis paniculata*), giloy (*Tinospora cordifolia*), turmeric (*Curcuma longa*), neem (*Azadirachata indica*), licorice (*Glycyrrhiza glabra*), moringa (*Moringa oleifera*), cardamom (*Elettaria cardamomum*) and many more. Khatabi *et al.* (2023) studied a nutritious, medicinal plant commonly used in food preparations in India, *Coriandrum sativum,* to prevent colorectal cancer. In-*silico* studies of its constituents, rutin, and gallocatechin, have found them to have good therapeutic effects [37]. Aanouz *et al.* (2021) studied 67 Moroccan plants by molecular docking for their inhibitory potential against SARS CoV-2 main protease. Of these, three compounds, β-Eudesmol from *Lauris nobilis*, digitoxigenin from *Nerium oleander,* and crocin from *Crocus sativus*, were potent inhibitors of SARS-CoV-2 main protease [32].

Researchers have identified more than 1000 medicinal plants that can be utilized to enhance the immunity of the population owing to their high nutritional contents [30]. Medicinal plants are well known to produce several secondary metabolites, including alkaloids, glycosides, tannins,

flavonoids, terpenoids, polyphenols, and others. These secondary metabolites perform various tasks, including defense against invading pathogens and microbes, thereby enhancing the immunity of individuals [38]. However, many of these plants have remained underutilized. Also, these plants are locally available, affordable, non-toxic, and without side effects. Herbs containing active principles known for enhancing immunity can be utilized to combat the spread of infections and diseases within large segments of the population. With the utilization of newer tools and technology, the active principles of plants can be extracted effectively [39]. Further, the active principles of herbal medicine can be molded into a suitable formulation and utilized as a potent, nutritious herbal medication.

3. SWOC Analysis of Indian Medicinal Plants

SWOC analysis is a strategic planning tool for Strengths, Weaknesses, Opportunities, and Challenges. It aids in comprehending the diverse perspectives on the issue. The strengths and opportunities of Indian medicinal plants are enormous owing to the evidence of their traditional use over the past centuries. Along with the positives, the sector possesses some weaknesses and challenges that can be overcome with proper strategic planning.

3.1 Strengths

India is known for its rich biodiversity, with a wide range of plant species that possess medicinal properties. The country's diverse climate and geographical conditions make it suitable for the flourishing of a diverse flora, which includes a wide variety of medicinal plants with immune-boosting and infection-fighting properties. Approximately 7,500 of India's 17,000 higher plant species are utilized for medicinal purposes. This ratio of medicinal plants utilized for medicinal purposes is the highest in any nation worldwide for its current flora [40].

Traditional systems of medicine in India, such as Ayurveda, Siddha, and Unani, have a long history of documenting information regarding the use of medicinal plants to boost immunity. This traditional knowledge base provides valuable insights into the selection, preparation, and utilization of medicinal plants for immune support. According to Wealth of India, various plant extracts and parts have been historically utilized as folk medicine to cure various infections [41]. Also, due to the inefficiency of modern therapies for controlling chronic diseases and the very significant adverse effects they render, the utilization of traditional remedies has been increasing in recent years. Numerous modern drugs and their synthetic counterparts are derived from the prototype compounds found in the secondary metabolites of plant production. Examples include paclitaxel derived from the Taxus plant, vincristine extracted from Vinca, and reserpine isolated from Rauwolfia. The Indian medicinal plant industry provides various ayurvedic medicines targeting immune system wellness. These preparations frequently include various medicinal herbs, strengthening their immune-boosting properties synergistically. Such preparations are commonly available and have been used to promote immunity for generations.

Currently, farmers' cultivation of herbs and medicinal plants on their land is promoted by the Government of India by providing subsidies through a centrally sponsored scheme of the 'National AYUSH Mission.' Also, a scheme on 'Conservation, Development and Sustainable Management of Medicinal Plants' promotes *in-situ* and *ex-situ* conservation of medicinal plants by various Government and Non-Government organizations [42].

The global demand for natural and plant-based immune-boosting therapies is growing significantly. The Indian medicinal plant sector is well-positioned to meet this need by offering high-quality herbal products and extracts with immune-boosting qualities. There has recently been a boom in scholarly interest in Indian medicinal herbs. Many Indian research institutions and universities are investigating these plants' therapeutic qualities, especially their immune-boosting properties. This research validates conventional claims and gives a scientific basis for their usage [43].

Sustainable cultivation and harvesting methods are actively being promoted by numerous organizations and stakeholders in the Indian medicinal plant industry. This protects the ecosystem while ensuring long-term accessibility to medicinal herbs. The potency and quality of medicinal plants are preserved through sustainable practices, increasing their ability to strengthen the immune system.

Intellectuals around the world as well as in India strongly value the unique advantages of Indian medicinal plants. As a result, there is a rise in demand for herbal medications. Global demand for herbal supplements and natural therapies is rising, creating a market for traditional Indian plants and related products [44].

Overall, the strengths of the Indian medicinal plant sector, including its biodiversity, traditional knowledge, scientific research, ayurvedic formulations, global demand, and sustainable practices, contribute to its potential for boosting immunity against infections.

3.2 Weaknesses

Although the Indian medicinal plant sector has many strengths, it also has weaknesses that may limit its potential to boost defense against infections effectively. The use of herbal medicine has increased dramatically over the last two decades, but research data is still scarce. The biggest threat to consumer health may arise from adulteration and substitution, which could result from increased demand for herbal medicines. Herbal drugs are considered safe, but still, there is some data available that reports the risk of toxicity for long-term use. A study by Hoenerhoff *et al.* (2013) reports hepatocellular carcinoma in mice treated with *Ginkgo biloba* extract for two years [45]. Studies have also reported oral carcinoma by Areca catechu and Piper betle and mutagenicity by *Senna alata* [46, 47]. Moreover, some herbs are reported to interact with conventional drugs, potentially leading to undesirable effects. For instance, Allium sativum interacts with saquinavir, Silybum marianum with metronidazole and losartan [48, 49]. While traditional knowledge exists, there is a need for more extensive clinical trials and rigorous scientific studies to validate the safety and efficacy of Indian medicinal plants. This gap may hinder their acceptance in mainstream medicine and limit their use [50].

It is critical to standardize quality control measures and dosage standards for medicinal plants to ensure consistent efficacy and safety. Herbal product potency and efficacy can vary due to variances in cultivation, processing, and formulation practices. Many Indian medicinal herbs lack this standardization at present. The regulatory control of herbal products in the Indian medicinal plant sector also seems inconsistent. Finding and recognizing high-quality herbal medicines is a crucial challenge for regulatory authorities since interspecies variations and confusing vernacular names can result in misidentification and adulteration of the raw materials during the preparation of medicines [51].

While there is a wealth of information about medicinal plants in traditional medical systems such as Ayurveda, access to these treatments and healthcare professionals skilled in their use may be limited in certain areas. This lack of accessibility may constrain medicinal plants' broad adoption and application for strengthening immunity. India's cultural and geographic setting significantly influenced the historical usage of medicinal herbs. Some treatments might only work in certain localities or communities, which restricts their application to those places. This may make it more difficult for plant-based immune-boosting techniques to be scaled up and widely used [52].

Collaborative efforts from regulatory agencies, researchers, medical experts, and producers of herbal products are required to address these problems. To fully realize the promise of the Indian medicinal plant industry in enhancing immunity against infections, standardization, research investment, better regulation, sustainable agricultural practices, and expanded accessibility are necessary.

3.3 Opportunities

The COVID-19 pandemic has highlighted the need for a robust immune system. This rising emphasis on immune health allows the Indian medicinal plant business to provide natural and effective immune-support medicines. Due to the growing need for therapeutic use and nutritional dietary supplements, herbal medicine has abundant opportunities. Since India has an abundance of biodiversity, it is possible to cultivate therapeutic plants and export plant material to boost the country's economy [53].

Integrating traditional medical systems, such as Ayurveda, with modern treatment can result in synergistic immunological health approaches. Collaboration in research and clinical investigations between traditional medicine practitioners and modern medical professionals can validate the efficacy of Indian medicinal plants and investigate their potential in conjunction with conventional medicines [54]. There are more than 10,000 industrialized units in India, which earn a net income of about 1 billion US dollars from medicinal plants [55]. The Indian medicinal plant industry can concentrate on creating standardized formulations and conducting proper clinical trials that ensure consistent quality, potency, and efficacy. Standardization aids in the establishment of dependable dose recommendations and increases consumer trust. Creating evidence-based protocols for preparing and administering herbal treatments can help increase their acceptance and effectiveness in boosting immunity. For Indian medicinal plants to fully realize their potential for enhancing immunity, continued investment in research and development is essential [56].

The market for medicinal plants in India has the chance to grow and meet the rising demand for herbal immune-boosting treatments worldwide. Indian herbal products can benefit from export opportunities and contribute to the global healthcare market by maintaining high-quality standards and adhering to international laws. By capitalizing on these opportunities, the Indian medicinal plant sector can further enhance its contribution to boosting immunity against infections and strengthen its position in the global healthcare industry [57].

India is the appropriate place for research organizations and universities to undertake fundamental and application-oriented research on this topic due to its huge richness of knowledge on medicinal plants and herbs. Central Council for Indian Medicine (CCIM), Council for Scientific and Industrial Research (CSIR), and many other such government and private organizations are engaged actively in promoting education, research, and training on the Indian system of Medicine [58]. In

reality, research on medicinal plants, including the beneficial aspects of both traditions and technologies, may surpass information technology and biotechnology in the coming years as the sector with the most sustainable development.

3.4 Challenges

Nevertheless, despite the inherent positive aspects, vast resource base, and immense commercial potential of medicinal plants, many hurdles prevent this industry's development [59]. Price volatility, restrictions on quality, competition from synthetics, inappropriate collection and storage methods resulting in low levels of active ingredients, non-compliance with import laws and regulations by the exporters, erratic supply, and suppliers with asymmetric information about the world trade are just a few of the factors that affect the Indian medicinal plants sector [44, 59]. In India, the Drug and Cosmetic Act of 1940 and Rules of 1945 were amended several times to regulate unconventional and traditional medicines. Also, in 2014, a separate ministry named AYUSH was set up to promote and implement regulatory guidelines. However, inadequate quality control monitoring, safety, and toxicological assessment is still challenging for the Indian medicinal plants sector [60].

The overuse of medicinal plants causes the depletion of natural resources. Sustainable cultivation, harvesting, and conservation techniques must guarantee these plants' ongoing availability. Also, the quality control technique for herbals is time-consuming due to their inherent characteristics of containing multiple bioactive components [61]. Following WHO recommendations, quality assurance institutions regulate good manufacturing practices (GMP) for herbal products. Various legislative and government agencies have been established to oversee the production and marketing of herbs in India. However, challenges related to purity, adulteration, and ineffective agricultural and post-harvesting processes remain [62].

A challenge in medicinal plants is defending intellectual property rights related to traditional knowledge and tackling biopiracy. Growing worldwide competition, coupled with inadequate administration and control, has allowed competitors to dominate the global market, as witnessed in the US patent for curcumin, derived from the Indian native plant *Curcuma longa* and used to treat wounds and infections [63]. Therefore, legal frameworks must be established to protect the interests of traditional medicine practitioners and local communities.

A key challenge under the Biodiversity Act is the protection of overharvesting of medicinal plants. An overuse of plants for the prevention and treatment of infections may cause a burden on biodiversity. Thus, using traditional herbal remedies must align with the sustainability principle [64]. It is crucial to inform and raise consumer awareness and change medical practitioners' perceptions about the potential of Indian medicinal plants to strengthen immunity. It could take a concentrated effort to overcome skepticism and establish trust in the effectiveness of herbal treatments.

Overall, Indian medicinal plants have significant potential for enhancing immunity and preventing infections. However, addressing the weaknesses and challenges through scientific validation, standardization, collaborative research, and sustainable practices is essential to fully harnessing their benefits. Table 1 summarizes the SWOC analysis of Indian medicinal plants.

Table 1 SWOC analysis of Indian medicinal plants.

STRENGTHS	**WEAKNESSES**
Rich biodiversity	Lack of scientific validation
Traditional knowledge	Limited standardization
Established market	Lack of regulations
A strong base of research and development	Limited accessibility
Well-established pharmaceutical industry	Cultural and geographic limitations
OPPORTUNITIES	**CHALLENGES**
Increased focus on immune health	Meeting regulatory requirements
Increasing global interest and demand	Intellectual Property Rights
Integrated medicine	Conservation and sustainability
Development of standardized formulations	Changing consumer perceptions
Export opportunities	Changing medical practitioners' perception

4. Conclusion

India has traditionally been known as a rich depository of herbal plants, and the knowledge and practice of different herbal medicine forms are considered "living traditions." These traditional medicinal plants were utilized on a wide scale during the pandemic for the prevention and treatment of coronavirus infection. This paper highlighted the high potential of nutritious herbs to boost immunity and tackle similar health problems in the future. Numerous scientific studies have suggested that traditional plants are a great source of phytoconstituents with rich nutritional values and can exert pharmacological actions ranging from symptomatic reliefs to targeted mechanisms. The Indian medicinal plant industry can significantly strengthen immunity during pandemics by exploiting its strengths, resolving weaknesses, capturing opportunities, and overcoming challenges. The sector's potential can be further increased through ongoing research, standardization, and cooperation between traditional and modern medical systems.

Author Contributions

SD: Conceptualization, Writing-original draft, validation. MG Conceptualization, Writing-review & editing, Supervision. Both the authors read and approved the submitted version.

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Competing Interests

The authors have declared that no competing interests exist.

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