WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
Coden USA: WJPRAP Impact Factor 8.453
Volume 15, Issue 3, 483-499. Review Article ISSN 2277–7105

NATURAL PLANTS FOR IMMUNE SYSTEM ENHANCEMENT

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Article Received on 30 Dec. 2025,
Article Revised on 20 Jan. 2026,
Article Published on 01 Feb. 2026

https://doi.org/10.5281/zenodo.18428707

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How to cite this Article: [1]*Shaikh Sameer Ayub, [2]Mr. Shikare S. H., [3]Dr. Ganesh S. Tolsarwad. (2026) Natural Plants For Immune System Enhancement. World Journal of Pharmaceutical Research, 15(3), 483–499.

ABSTRACT

Herbal medicines have been extensively used in traditional systems of medicine for centuries to enhance immunity and maintain homeostasis. These natural remedies are rich in bioactive phytochemicals, which interact with various cellular and molecular pathways to modulate immune function. This review systematically explores the Immunomodulatory effects of selected herbal medicines, including Amla, Tulsi, Ashwagandha, Giloy, Turmeric, and Garlic. Detailed discussion is provided on their active constituents, such as polyphenols, alkaloids, flavonoids, and terpenoids, which contribute to antioxidant activity, cytokine regulation, and enhancement of both innate and adaptive immunity. The paper also examines clinical evidence supporting the use of these herbs in managing infections, chronic inflammatory conditions, and immune deficiencies. Additionally, it highlights the role of herbal formulations in reducing oxidative stress, improving gut microbiota, and promoting overall systemic health. Emerging trends, including nanoformulations, standardized extracts, and novel drug delivery systems, are discussed to improve bioavailability and therapeutic efficacy. Safety profiles, dosage considerations, and potential herb-drug interactions are carefully reviewed to ensure practical application in healthcare.

KEYWORDS: Herbal medicines, Immunomodulators, Phytochemicals, Immunity, Clinical studies. NDDS.

INTRODUCTION

Since ancient times, humans have relied on nature's bounty to combat infections and maintain health. In India, herbs such as Tulsi (Ocimum sanctum), Amla (Emblica officinal is), and Ashwagandha (With an lasomnifera) have been widely used in households for seasonal infections and immune support. Traditional Ayurvedic texts emphasize the importance of the seherbs in strengthening the body's defense system, which modern pharmacology now validates through experimental studies.

Immune system overview

The immune system is a complex network of cells, tissues, and organs that protects the body from pathogens, cancer cells, and toxins.

Innate immunity: First line of defense; includes macrophages, NK cells, dendritic cells, complement proteins.

Adaptive immunity: Specific defense; includes T-cells (Helper, Cytotoxic), B-cells (Antibodies), and memory cells.[1- 4]

Immunomodulators

Substances that enhance (immunostimulants)or suppress (immunosuppressant's) immune responses, Herbal Immunomodulators offer natural regulation of immune activity with minimal adverse effects.

Importance of Herbal Medicines

Bioactive Compounds: Flavonoids, terpenoids, polysaccharides, alkaloids

Advantages: Cost-effective, widely available, minimal toxicity

Role: Preventive healthcare, complementary therapy, immu ne support Herbal medicines are naturally derived plant-based preparations that have been used for centuries in traditional systems of medicine such as

- Ayurveda,
- Siddha,
- Unani,
- Traditional Chinese Medicine[5-6]

These herbal formulations contain phytoconstituents like alkaloids, flavonoids, tannins, terpenoids, and polyphenols, which exhibit multiple pharmacological activities beneficial for human health. The immune system plays a crucial role in protecting the body against infections, pathogens, toxins, and foreign substances.

It functions through a complex network of cells, tissues, and signaling molecules that work together to maintain internal balance and defense. However, due to modern lifestyle factors such as stress, pollution, poor diet, lack of sleep, and frequent infections, the immune system often becomes weakened or dysregulated, leading to various health disorders.

In this context, immunomodulators are substances that help in modifying or regulating the immune response. They can enhance immunity in cases of immune deficiency and suppress excessive immune reactions in conditions like allergies and autoimmune diseases. Conventional synthetic Immunomodulatory drugs are often associated with adverse effects and high toxicity, which limits their long-term use.

Therefore, attention has shifted towards herbal medicines as safe and effective immunomodulators.[7-10]

Medicinal plants such as

- Ashwagandha,
- Tulsi,
- Amla,
- Giloy, and Garlic

Have shown significant immunostimulants, antioxidant, anti-inflammatory, and adaptogenic properties. These herbs support the immune system by enhancing macrophage activity, stimulating lymphocyte proliferation, promoting cytokine production, and improving overall immune resistance. With growing global interest in natural and holistic healthcare, herbal immunomodulators are gaining importance in the prevention and management of diseases. They not only boost immunity but also help in improving vitality, stress tolerance, and overall quality of life.[11]

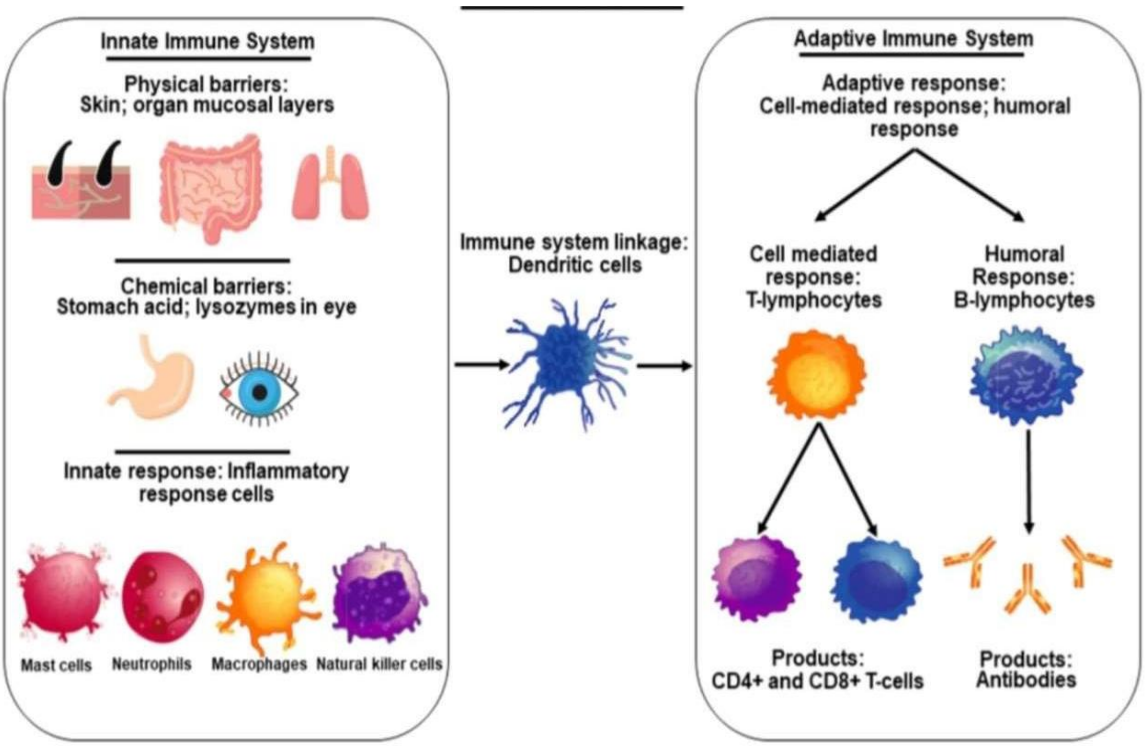

Fig. 1: Immune system overview.

2. LITERATURE REVIEW

1. Patwardhan B. et al. (2017) reported that herbal medicines such as Withania somnifera (Ashwagandha), Tinospora cordifolia (Giloy), and Ocimum sanctum (Tulsi) possess potent immunomodulatory and antioxidant properties. These herbs enhance both innate and adaptive immune responses by stimulating macrophage activity and regulating cytokine production.

2. Gupta A. and Choudhary N. (2018) investigated the phytochemical composition of Emblica officinalis (Amla) and confirmed the presence of bioactive compounds such as flavonoids, phenolics, and alkaloids, which contribute to antioxidant and anti-inflammatory activities, thus improving immune defense and reducing oxidative stress.

3. Kumar S. et al. (2020) discussed the clinical importance of polyherbal formulations containing Amla, Giloy, and Turmeric. Their findings suggest that the synergistic effect of these plants significantly improves immune system regulation, reduces inflammation, and promotes faster recovery from infections.

4. Sharma R. et al. (2021) highlighted the development of nano-formulations of herbal drugs to enhance bioavailability and targeted drug delivery. Nano-herbal systems containing

curcumin and Ashwagandha extracts demonstrated higher therapeutic efficacy in immune regulation compared to traditional formulations.

5. Singh D. and Patel M. (2023) reviewed herbal immunomodulators and concluded that phytochemicals like terpenoids and polyphenols play a vital role in modulating immune cell signaling pathways, offering potential use in chronic inflammatory diseases and autoimmune disorders.

6. Mehta K. et al. (2019) evaluated the immunomodulatory activity of Curcuma longa (Turmeric) and observed that curcumin enhances antibody response and modulates cytokine expression, thereby improving both innate and adaptive immunity.

7. Rao P. and Desai V. (2020) studied Withania somnifera (Ashwagandha) root extract and found significant stimulation of lymphocyte proliferation and increased natural killer (NK) cell activity, indicating strong immunostimulant potential.

8. Joshi A. et al. (2021) reported that Tinospora cordifolia (Giloy) polysaccharides enhance macrophage activation and nitric oxide production, contributing to improved pathogen clearance and resistance against infections.

9. Patil S. and Verma R. (2022) reviewed the antioxidant and anti-inflammatory effects of Ocimum sanctum (Tulsi) and Zingiber officinale (Ginger). Their findings emphasized their synergistic role in regulating immune response and protecting against oxidative stress.

3. AIM AND OBJECTIVES

Aim:- A review of natural plants for immune system enhancement.

OBJECTIVES

1. To understand the concept of immunomodulation and its importance in health.
2. To identify commonly used herbal medicines with Immunomodulators properties.
3. To explore the active phytochemicals responsible for immune enhancement.
4. To study the mechanism of action of selected herbs on the immune system.
5. To review scientific evidence and traditional uses of herbal Immunomodulators.
6. To analyze the potential benefits and limitations of using herbal medicines in
7. To study the concept of the immune system and understand the difference between innate and adaptive immunity.

8. To define and explain the role of immunomodulators in maintaining immune balance and disease prevention.
9. To explore various medicinal plants known for their Immunomodulatory properties such as Ashwagandha, Tulsi, Amla, Giloy, Turmeric, and Garlic.
10. To study the mechanism of action of selected herbs on various components of the immune system such as macrophages, T-cells, B-cells, and cytokines.
11. To review scientific research, clinical data, and traditional knowledge supporting the Immunomodulatory effects of herbal medicines.[12,13]

4. NEED OF THE STUDY

Increasing incidence of immune-related disorder requires safer and effective treatment options. Synthetic Immunomodulators drugs often cause side effects, creating a need for natural alternatives. Herbal medicines have been traditionally used for boosting immunity but lack scientifit documentation There is growing interest in exploring plant-based therapies for preventive healthcare. Understanding the Immunomodulators potential of herbs can support the development of safe complementary medicines. To promote awareness about the role of herbal medicines in enhancing body defense mechanisms. In recent years, there has been a noticeable rise in immune-related disorders such as recurrent infections, allergies, autoimmune diseases, and lifestyle-induced immunity weakening. Conventional synthetic Immunomodulatory drugs, although effective, are often associated with toxic side effects, high cost, and long-term dependency, making them unsuitable for prolonged use. This has created a strong need for safer, natural, and cost-effective alternatives to support immune health. Herbal medicines have been traditionally used in Ayurveda, Unani, Siddha, and folk medicine to improve resistance against diseases and strengthen the body's defense mechanism. However, despite their wide traditional acceptance, there is still a lack of scientific documentation and clinical validation of their Immunomodulatory effects. With the growing interest in plant-based preventive healthcare, it becomes essential.[14-15]

5. PLAN OF WORK

1. Selection of topic
2. Collection of literature
3. Identification of common herbal immunomodulators
4. Study of active phytochemical constituents
5. Compilation of traditional and scientific evidence

6. Analysis and discussion

7. Summary and conclusion preparation.[16,17]

6. MATERIALS AND METHODS

6.1 sources of data

1. Textbooks of Pharmacognosy, Pharmacology, and Herbal Medicine
2. Research papers from scientific journals
3. Online databases (PubMed, Google Scholar, ScienceDirect)
4. Ayurvedic classical literature for traditional reference ·
5. Textbooks of Pharmacognosy, Pharmacology, and Herbal Medicine.
6. Research papers published in peer-reviewed scientific journals.
7. Online databases such as PubMed, Google Scholar, and Science Direct.
8. Ayurvedic classical literature for traditional references.

INCLUSION AND EXCLUSION CRITERIA

Inclusion: Herbs with documented immune-Enhancing effects in traditional texts or modern Studies.

Exclusion: Herbs without adequate Documentation or insufficient scientific Evidence.

6.2 Reference herbs selected for study

1. Amla (Emblica officinal is)
2. Tulsi (Osmium sanctum)
3. Ashwagandha (Withania somnifera)
4. Giloy (Tinospora cordifolia)
5. Turmeric (Curcuma longa)
6. Garlic (Allium sativum)[18]

7. PHYTOCHEMICALS IN HERBAL MEDICINES

- Quercetin, Kaempferol- Anti-inflammatory, antioxidant

Terpenoids

- Cur cumin - Inhibits NF-KB, reducespro-inflammatory cytokines

Polysaccharides

- Beta-glucans - Stimulate macrophages, NK cells

Alkaloids

- Pipeline - Enhances bioavailability of co-administered[20]

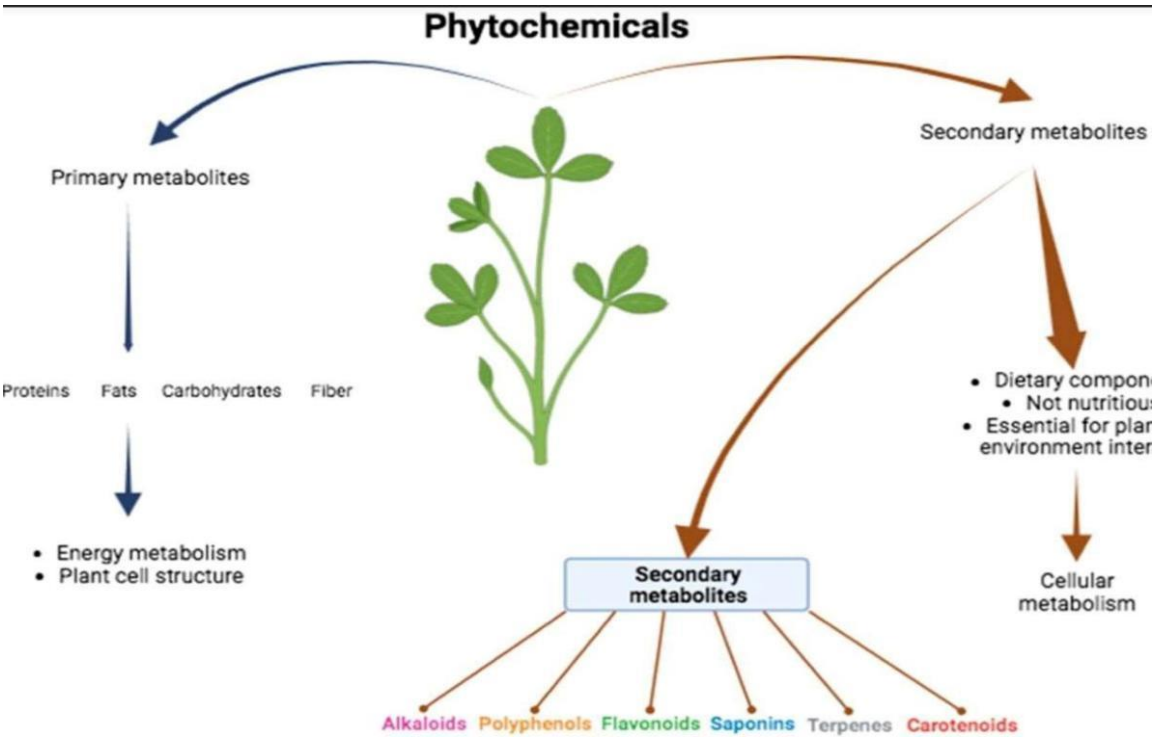

Fig. 2: Phytochemicals.

Table 1: Herbal plants and active phytochemicals.

PLANTS	ACTIVE COMPOUNDS	TARGET CELLS /ACTION
Amla	Vitamin c	Acts on macrophages & t cells
Tulsi	Eugenol	Modulates cytokines & activates t-cells
Ashwagandha	Withanolides	Stimulates nk cells & t-cells
Giloy	Alkaloids, tinosporaside	Enhances macrophages activity
Turmeric	curkumin	Modulate cytokine production & reduces inflammation
garlic	allaicin	Stimulates lymphocytes has antibacterial & antivirala action

8. MECHANISMS OF IMMUNOMODULATION

8.1 Cytokine modulation

IL-2, IL-6, TNF-a regulation IL-2 (Interleukin-2): Stimulates proliferation of T-lymphocytes. Enhances differentiation of cytotoxic T-cells and NK cells. Acts as a growth factor for immune cell expansion during infection.

- **IL-6 (Interleukin-6):** Promotes differentiation of B-cells into plasma cells, leading to increased antibody production, Induces acute-phase protein synthesis in the liver, which supports early immune defense.
- **TNF-α (Tumor Necrosis Factor-alpha):** Plays a role in inflammatory signaling and destruction of infected cells, Herbal agents help maintain TNFα levels within physiological limits to prevent chronic inflammation or autoimmunity.
- **Overall Effect:** Herbal immunomodulators maintain cytokine homeostasis, preventing excessive immune reaction while enhancing protective immune responses.

8.2 Immune Cell Activation

Enhanced macrophage cell, and T-cell activity.

- **Macrophage Activation:** Enhances phagocytosis (engulfing and destruction of pathogens). Increases release of nitric oxide (NO) and reactive oxygen species (ROS) which kill microbes, promotes antigen processing and presentation via MHC-II to activate T-cells.
- **T-Cell Activation:** Stimulates differentiation into Helper T-cells (Th1 & Th2), Th1 pathway enhances cell-mediated immunity, Th2 pathway supports humoral immunity (antibody production), Boosts secretion of IFN-γ, improving intracellular pathogen clearance.
- **NK Cell Modulation:** Increases cytotoxicity against tumor cells and virus-infected cells.
- **Overall Effect:** Immunomodulators strengthen both innate and adaptive immunity, improving pathogen clearance and immune surveillance.[21,22]

8.3 Anti-inflammatory pathways

- **NF**-KB inhibition COX-2 suppression NF-κB Inhibition:

NF-κB is a transcription factor that activates genes responsible for inflammation, cytokine release, and cell survival, Herbal agents suppress NF-κB translocation to the nucleus, reducing production of IL-1β, IL-6, and TNF-α, thus controlling excessive inflammation.

- **COX-2 Suppression:** COX-2 enzyme converts arachidonic acid into pro-inflammatory prostaglandins. Herbal bioactives inhibit COX-2 expression, reducing pain, redness, swelling, and chronic inflammatory damage.
- **Reduction of crp and ros:** Decreases circulating C-reactive proteins and oxidative stress markers, preventing tissue damage.

- **Overall Effect:** Maintains a balance between required inflammatory response and prevention of chronic inflammatory diseases like arthritis, asthma, and autoimmune disorders.

8.4 Adaptive immunity saport

Promotes antibody production and memary cell Activation

- Antibody Production: Stimulates B-lymphocyte proliferation and maturation into plasma cells, Enhances secretion of IgG, IgM, and IgA antibodies, improving long-term immunity.
- Memory Cell Formation: Promotes generation of memory T and B cells, allowing faster and stronger immune response during secondary exposure to pathogens.
- Immune Tolerance Regulation: Prevents autoimmune reactions by regulating T-regulatory cells (Tregs) to maintain self-tolerance.
- Lymphoid Organ Support: Improves function of spleen, thymus, and lymph nodes, which are primary sites for immune activation.
- Overall Effect: Enhances long-term immune memory and adaptive defense, crucial for vaccination response and lifelong protection.[23]

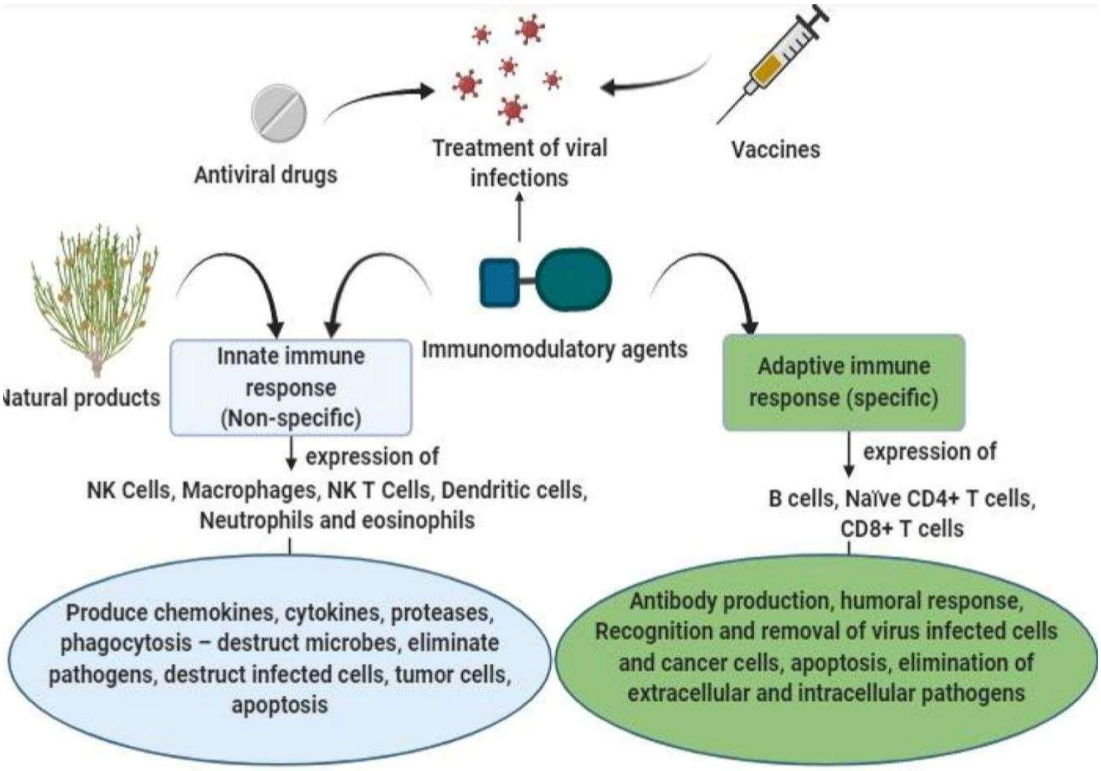

Fig. 3: Immune response pathway.

9: PROMINENT HERBAL IMMUNOMODULATORS

1. Amla (Emblica officinal) is Rich in Vitamin C & antioxidants, Enhances phagocytosis and T-cell function

- Active compounds: Vitamin C, Gallic acid, Ellagic acid, Emblicanin A & B.
- Additional Benefit: Supports spleen function, promoting immune cell maturation.

2. Tulsi (Ocimum sanctum), Anti-stress, antiviral, anti-inflammatory Modulates cytokine secretion

- Active Compounds: Eugenol, Ursolic acid, Rosmarinic acid.
- Additional Benefit: Acts as a bio-enhancer, increasing absorption of other herbal immunomodulators.

3. Ashwagandha (Withania somnifera) Adaptogen: reduces cortisol Enhances NK & T-cell activity,

- Active Compounds: Withanolides, Withaferin-A, Alkaloids
- Additional Benefit: Supports thyroid and adrenal glands, indirectly stabilizing immune performance.

4. Giloy (Tinospora cordifolia) Stimulates macrophages Increases antibody production

- Active Compounds: Berberine, Tinosporide, Cordifolioside.
- Additional Benefit: Detoxifies blood and lymphatic system, improving antigen clearance.

5. Turmeric (Curcuma longa) Cur cumin inhibits pro-inflammatory cytokines Enhances proliferation of immune cells

- Active Constituents: Cur cumin, Demethoxycurcumin, Bisdemethoxycurcumin.
- Additional Benefit: Acts as a natural COX-2 inhibitor, similar to NSAIDs but safer.

6. Garlic (Allium sativum) Stimulates lymphocytes. Antiviral and antibacterial properties[24,25]

- Active Compounds: Allicin, Alliin, Ajoene, S-allyl cysteine (SAC), Diallyl disulfide (DADS)
- Aditional Benifit: Antioxidant Activity, Anti-inflammatory Effect, Cardioprotective Benefits.

10. CLINICAL STUDIES AND EVIDENCE

Amla

- Increased WBC & antioxidant markers in elderly(2022)
- This indicates its strong potential as a natural immune rejuvenator in geriatric care (2022).

Tulsi

- Reduced incidence of upper respiratory tract infections (2021)
- This suggests Tulsi's role as a preventive herbal adaptogen for respiratory immunity (2021).

Ashwagandha

- Enhanced NK cell activity under stress (2020)
- This highlights its application in stress-induced immunosuppression and chronic fatigue cases (2020).

Giloy

- Improved antibody response post-vaccination (2019)
- Thus, it can be used as an adjunct therapy in post-vaccination and post-infection recovery (2019).

Turmeric

- Cur cumin supplementation reduced-price-inflammatory cytokines (2021)
- This proves its dual role in both immune enhancement and inflammation control (2021).

Garlic

- Decreased cold & flu episodes (2020)
- This supports its role as a daily immune protective agent with antimicrobial benefits (2020).[26,27]

Table 2: Herbal immunomodulators summary.

Plant	Compound	Target cells	Effect	Refrences
Amla	Vitamin c	Macrophages, T-cells	Phagocytosis antioxidant	Kumar et al.,2021
Tulsi	Eugenol	Cytokines, T-cells	Reduces inflammation	Sharma et al., 2021
Ashwagandha	Withanolides	NK & T - cells	Enhances cell - mediated immunity	Singh et al., 2020

Fig. 4: Herbal plants immuno modulators.

11: APPLICATIONS AND FUTURE PROSPECT

11.1 Preventive healthcare

- Elderly, children, immunocompromised
- Can be used in seasonal immunity support, especially during flu and viral outbreaks.
- Herbal immunomodulators can reduce hospital load by preventing minor infections at community level.
- Daily supplementation may enhance vaccine response in low-immunity populations.[28]

11.2 Complementary therapy

- Along with modern medicine.
- Can be administered alongside modern medicine to reduce drug side-effects and improve recovery.
- Beneficial in chronic illnesses like arthritis, diabetes, cancer recovery, autoimmune disorders.
- Supports chemotherapy patients by preventing immune suppression.
- Reduces dependency on long-term steroids and NSAIDs, lowering adverse drug reactions.[29]

11.3 Emerging research

- **Nano-formulations & Targeted Delivery (NDDS)**

1. Encapsulation of herbal extracts in nanoparticles/liposomes improves absorption and bioavailability.

Standardized Phytochemical Markers

2. Research is moving towards fixing dosage, purity, and bioactive concentration.

AI-based Herb Screening

3. Latest work includes using computational biology and AI to identify most potent herbal Combinations for immune modulation.[30]

Synergistic Herbal Combinations

4. Research on polyherbal formulations for multi-target immune boosting without toxicity.

Future scope

1. Clinical trials, standardization, global acceptance
2. Need for Clinical Trials under WHO-GCP Guidelines for global recognition.
3. Standardization and Quality Assurance of herbal products for export and medical prescription use.
4. Integration into National Immunity Programs and Public Health Policy.
5. Potential for global nutraceutical and pharmaceutical market expansion, boosting economic growth.[31]

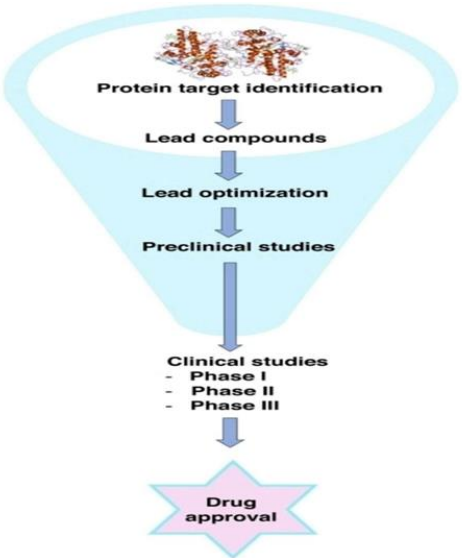

Fig. 5: Drug discovery and development process funnel.

12. CONCLUSION

Herbal medicines are safe, effective, and widely as immunomodulators.The diverse phytochemicals present in herbs such as Amla, Tulsi, Ashwagandha, Giloy, Turmeric, and Garlic. Hence, the phytochemicals present in the above herbal plants play a significant role in immune system enhancement. These herbs support immunity by modulating innate and adaptive immune responses, reducing inflammation, and enhancing antibody production. Advanced research and clinical validation will further establish their therapeutic value in modern healthcare and preventive medicine. The integration of herbal immunomodulators into contemporary treatment approaches may also reduce dependency on synthetic drugs and help minimize associated side effects. multiple mechanisms to maintain immune balance and improve resistance against infections.

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