

# Plant Extracts as Functional Ingredients: Bioactive Compound and Their Role in Immunity

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**Abstract** – Plants extract have long been acknowledged for their capacity to improve human immunity and combat a broad spectrum of infectious diseases. When incorporated into foods as functional ingredient, the antiviral and immunity-enhancing attributes of these plant extracts have exhibited considerable therapeutic value by lowering mortality rates and limiting the transmission of viral infections. Plant extracts such as tulsi, giloy, turmeric, ashwagandha, mulethi, black pepper, and ginger are widely utilized for their immunomodulatory effects. This review summarizes current research on the effectiveness of these plant extracts in supporting immunity against viral and bacterial infections.

**Key Words:** *Immunity, Tulsi, Giloy, Ashwagandha, Turmeric, Mulethi.*

## 1. INTRODUCTION

The human immune system depends on a complex network of biological processes to protect the body from pathogens, oxidative stress, and inflammation. As interest in functional foods and health-promoting diets grows, plant-derived bioactive compounds have gained attention as natural agents for immune support. Medicinal and culinary plants contain a variety of phytochemicals, including alkaloids, flavonoids, polyphenols, terpenoids, and glycosides, many of which have demonstrated measurable effects on immune cell activity, cytokine regulation, and inflammatory pathways (Srivastava et al., 2020).

Tulsi, giloy, turmeric, ashwagandha, and mulethi have been essential to human diets for centuries, commonly consumed as herbal teas, decoctions, fortified milk, and spice-based preparations. Their bioactive compounds, including curcumin, withanolides, glycyrrhizin, eugenol, and ursolic acid, are currently the focus of research in food science and nutrition. Studies have shown these compounds' abilities to enhance T-cell and Natural Killer cell activity, support antiviral defense mechanisms, and reduce pro-inflammatory responses (Mondal et al., 2010; Moghadamtousi et al., 2014; Shree et al., 2020). This review evaluates the scientific evidence for the immunomodulatory attributes of these five plants and their bioactive constituents, intending to establish their value as functional ingredients in foods and beverages that support immunity.

## 2. LATEST RESEARCH ON PLANT EXTRACTS TO PROVIDE IMMUNITY AGAINST VIRAL AND BACTERIAL INFECTIONS

Numerous studies have investigated the antiviral, antibiotic, and antimalarial properties of plant extracts, supporting their potential use in treating viral diseases and enhancing the human immune system. Significant research has focused on how extracts from tulsi, giloy, ashwagandha, turmeric, and mulethi can improve immunity against various viral and bacterial infections.

### 2.1 Tulsi

Tulsi (holy basil), also known by its scientific name *Ocimum sanctum* or *O. sanctum*, is a sacred herb that has been widely used for the treatment of various diseases since times immemorial (Kushwah et al., 2020). It has many therapeutic effects such as antiviral, antibiotic, antibacterial, anti-inflammatory, anti-diabetic, anti-carcinogenic, and immunity enhancing properties as demonstrated in various in-vivo and in-vitro studies (Srivastava et al., 2020). Ayurveda denotes tulsi as 'Elixir of life', an attribution owing to its fast-healing ability and capability for curing many ailments like asthma, bronchitis, pyrexia, microbial infections, skin diseases, gastric disorders, etc. (Nadkarni and Krishnarao, 1954).

Being known as an effective medicine for pneumonia treatment, it also has empirical data supporting antiviral properties against both DNA viruses such as hepatitis, herpes, and adenoviruses, as well as RNA viruses like enteroviruses 71 and coxsackievirus CVB1 (Chiang et al., 2005). Human immune response is also strengthened by

tulsi through enhancement of both cellular and humoral immunity (Mukherjee et al., 2005). The main antiviral phytochemicals found in tulsi are ursolic acid, eugenol, and apigenin (Prakash and Gupta, 2005).

In a molecular docking study, three compounds namely Vicenin, Isorientin, and Ursolic acid showed significant binding affinity for viral main protease targets (Shree et al., 2020). In another study, the immunomodulatory effects of tulsi were analyzed by administering 300 ml of ethanolic tulsi extract to 24 healthy persons. After 4 weeks, an enhancement in the number of two immune cells, namely T-cells and Natural Killer cells, was observed. These cells help the human body fight against various infections including those caused by viruses and bacteria (Mondal et al., 2010; Brahmabhatt, 2020). Consumption of herbal tea was supported by a study in which the probable pathway for this formulation as an immunity booster was identified (Khanal et al., 2020).

## 2.2 Giloy

The scientific name of giloy or guduchi is *Tinospora cordifolia* (*T. cordifolia*) (Shree et al., 2020). Many biologically important phytochemicals of giloy, such as alkaloids, steroids, lactones, glycosides, diterpenes, aliphatic compounds, and phenolics, have demonstrated immunomodulatory activities in humans (Srivastava et al., 2020; Singh and Saxena, 2020). It contributes to human health in numerous ways, including anti-inflammatory, anti-stress, anti-periodic, anti-allergic, anti-spasmodic, anti-diabetic, anti-microbial, wound healing, and blood purifying properties, which aid digestion and boost immunity (Srivastava et al., 2020). Giloy has broad-spectrum antimicrobial effects against many strains like *Escherichia coli*, *Staphylococcus aureus*, *Salmonella typhi*, *Salmonella typhimurium*, and *Enterobacter aerogenes* (Saha and Ghosh, 2012).

Molecular docking studies have found that tinocordiside, a phytochemical in *T. cordifolia*, may help inhibit viral entry into host cells by decreasing binding energies at key receptor sites (Balakrishna et al., 2020; Shree et al., 2020). Further, berberine, another phytochemical from *T. cordifolia*, has demonstrated lower binding energy compared to many other compounds studied, with simulation results revealing its capability as an effective inhibitor of viral replication (Chaudhary, 2020). Its protective role against nephrotoxicity is also ascribed to its alkaloid content, including tinosporin, tetrahydropalmatine, choline, palmatine, and magnoflorine (Srivastava et al., 2020).

## 2.3 Ashwagandha

Ashwagandha, also known by its scientific name *Withania somnifera*, is a very prominent herb in Ayurveda (Srivastava et al., 2020). A number of therapeutic uses of ashwagandha are described in various Ayurveda treatises. It is reported to be tonic, narcotic, diuretic, anthelmintic, astringent, thermogenic, and stimulant (Varma et al., 2020). It contains phytochemicals namely withanolides, which include triterpenelactones-withanolides, withaferin A & D, steroidal lactones, alkaloids, tropine, and cuscohygrine. Along with withanolides, these bioactive compounds possess anti-inflammatory and analgesic properties (Srivastava et al., 2020).

Molecular docking studies have identified several phytochemicals in ashwagandha, including Withanoside V, Somniferine, Withanolide R, and 2,3-Dihydrowithaferin A, that show strong binding affinity for viral protease and spike protein targets, restraining viral action and preventing replication (Shree et al., 2020; Parida et al., 2020). Withanone in particular has been reported to reduce binding energies at key viral receptor sites, potentially blocking viral entry into host cells (Srivastava et al., 2020). Tripathi et al. (2020) further concluded through molecular docking and simulation studies that Withanoside V is a potential inhibitor of viral main protease activity.

The immunomodulatory impact of ashwagandha was assessed in a study where its extract was incorporated into mice models, with results showing a significant increase in platelet count. A group of 37 underweight subjects treated with ashwagandha extract for one month showed significant improvement in physical strength, lung and heart functioning, and memory (Chudasama, 2015). Straugn and Karak (2020) also concluded that Withaferin A showed strong potential as an effective therapeutic agent against viral infections.

## 2.4 Turmeric

Turmeric is a very common spice used in almost every Indian household. It is scientifically identified as *Curcuma longa* (Srivastava et al., 2020). Apart from cooking purposes, it has been widely used in many traditional medicine systems like Unani, Ayurveda, and Siddha since times immemorial (Gopinath et al., 2018). Carbohydrate, protein, fat, mineral, fibre, essential oils, and curcuminoids are the main constituents found in powdered turmeric. Diarylheptanoids such as curcumin, demethoxycurcumin, and bisdemethoxycurcumin are the phytochemicals present in turmeric (Srivastava et al., 2020).

According to Rajagopal et al. (2020), turmeric possesses many health benefits including inhibition of platelet aggregation, anti-diabetic, anti-tumor, anti-oxidant, anti-inflammatory, and gastro-protective effects. It also helps in naturally cleaning the respiratory tract (Srivastava et al., 2020). Curcumin has shown effectiveness against many viruses including influenza A virus, HIV, enterovirus 71 (EV71), herpes simplex virus (HSV), hepatitis C virus (HCV), and human papillomavirus (HPV) (Moghadamtousi et al., 2014; Praditya et al., 2019; Qin et al., 2014). Interference by curcumin with important steps in the viral replication cycle, such as viral attachment and genome replication, is considered the mechanism underlying its antiviral activity (Mounce et al., 2017; Zorofchian Moghadamtousi et al., 2014).

Curcumin is also said to suppress the inflammatory process through reducing cytokine production, which may similarly help prevent lung injury associated with severe respiratory infections (Ciavarella, 2020).

### 2.5 Mulethi

*Glycyrrhiza glabra* is commonly known as mulethi or liquorice. It is widely used for treating various ailments because of its abundant medicinal properties (Damle, 2014). It is antiviral, anti-inflammatory, antibacterial, anti-fungal, anti-diabetic, and anti-ulcer in nature (Srivastava et al., 2020). Glycyrrhizin is the main component of liquorice root; it is sweet in taste and is also known as glycyrrhizic acid or glycyrrhizinic acid. The root of mulethi is reported to contain many medicinal properties and is used to treat various diseases like cough, cold, and asthma (Damle, 2014).

Glycyrrhizin is a saponin reported to show significant effects against viral replication (Cinatl et al., 2003; Prasad et al., 2020; Pandit & Singh, 2020). Research has further confirmed antiviral activity through plaque reduction assays (Chen et al., 2004). In a clinical study, six active compounds including pyrazofurin, 6-azauridine, mycophenolic acid, ribavirin, and glycyrrhizin were tested against viral isolates, with glycyrrhizin showing the most significant inhibition of viral replication among all compounds studied (Bailey et al., 2020). Srivastava et al. (2020) also analysed antiviral activities of fifteen glycyrrhizin derivatives and found that conjugates and amides with two amino acid residues and thirty free -COOH functional groups showed a significant increase in antiviral activity.

### 3. CONCLUSIONS

Plant extracts from tulsi, giloy, ashwagandha, turmeric, and mulethi represent a rich source of bioactive compounds, including curcumin, withanolides, glycyrrhizin, eugenol, and ursolic acid, with thoroughly documented immunomodulatory properties. The evidence reviewed here shows that these compounds actively boost immune cell activity, regulate inflammatory responses, and support the body's natural defence mechanisms. Their long history in traditional diets, consumed via teas, decoctions, spice preparations, and fortified beverages, reflects a natural understanding of their health benefits that modern food science is now beginning to validate systematically. Incorporating these plant extracts as functional ingredients in food and beverage products delivers a practical, accessible, and evidence-based approach to supporting immunity at a population level. As consumer demand for functional and health-promoting foods continues to grow, these botanicals provide considerable opportunity for innovation in food product development.

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