

## REVIEW ARTICLE

# A Review of Dietary Suggestions During COVID-19

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**Abstract:** This review aims to focus on plant-based foods that improve immunity against COVID-19 in all age groups. The World Health Organization (WHO) has declared COVID-19 a global pandemic, and thousands of infections and deaths are being reported every day. This article reviews the properties of bioactive ingredients in foods and herbs to support the human immune system. Many traditional foods can boost immunity along with some antiviral effects. Using lots of vitamins C, D and E and bioactive ingredients like turmeric, ginger, cinnamon, garlic, neem, amla and probiotic yogurt, as well as minerals like zinc and magnesium, these foods can boost the immune response against COVID-19. In addition, certain dietary patterns, such as the Mediterranean diet, have been associated with improved immune function and reduced inflammation. In conclusion, a nutrient-rich diet featuring herbal products and specific vitamins and minerals plays a key role in improving the immune response against COVID-19.

**Keywords:** COVID-19; Nutritional Requirement; Immunity; Natural Products; Vitamins.

## 1. Introduction

The human body is a remarkable fortress, equipped with sophisticated defense mechanisms to protect against a myriad of potential threats. At the forefront of this defense system is the immune system, a complex network of cells, tissues, and organs working in harmony to safeguard our health. This intricate system is composed of two main branches: innate immunity, which provides a rapid, non-specific response to invaders, and acquired immunity, which develops over time and offers targeted protection against specific pathogens. The immune system's primary function is to identify and eliminate foreign organisms such as bacteria, viruses, fungi, and other microbes that could potentially cause harm to the body. When functioning optimally, this biological security force effectively prevents illness by neutralizing or destroying these invaders before they can establish a foothold and cause disease. However, the immune system is not infallible. Various factors, including stress, poor nutrition, lack of sleep, and certain medical conditions, can compromise its effectiveness, leaving individuals more susceptible to infections and illnesses.

The critical role of a robust immune system has been brought into sharp focus by the ongoing COVID-19 pandemic. This global health crisis, precipitated by the novel coronavirus SARS-CoV-2, has underscored the importance of immune health in combating infectious diseases. First observed in December 2019, COVID-19 rapidly spread across the globe, prompting the World Health Organization (WHO) to declare it a pandemic in March 2020 [4]. The virus has since affected millions of people worldwide, causing significant morbidity and mortality. Research has shown that individuals with weakened immune systems are particularly vulnerable to severe COVID-19 infections [3]. This heightened risk extends to specific demographic groups, notably children and the elderly, for whom the consequences of infection can be especially dire, potentially leading to fatal outcomes [3]. The virus's impact on these populations highlights the crucial need for strategies to bolster immune function across all age groups. The clinical presentation of COVID-19 can vary widely among individuals. Typically, symptoms manifest within 5 to 6 days of infection, although in some cases, the incubation period may extend up to 14 days. Common symptoms include sore throat, persistent cough, shortness of breath, fever, and body aches [5]. However, the disease can also progress to more severe manifestations, including acute respiratory distress syndrome (ARDS), multi-organ failure, and other life-threatening complications.

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As the scientific community races to develop effective treatments and vaccines for COVID-19, the importance of preventive measures and immune support cannot be overstated. In the absence of a definitive cure or widely available vaccine, focusing on strategies to enhance immune function has emerged as a critical approach to mitigating the impact of the virus. Among these strategies, dietary interventions have garnered significant attention for their potential to bolster the body's natural defenses. The relationship between nutrition and immune function is well-established in scientific literature. Certain foods and nutrients have been shown to enhance the immune system's capacity to combat viral infections. These immune-boosting foods typically contain high concentrations of vitamins, minerals, and other bioactive compounds that support various aspects of immune function. For instance, foods rich in vitamin C, such as citrus fruits and bell peppers, can stimulate the production and activity of white blood cells, key players in the immune response. Hydration also plays a crucial role in maintaining optimal immune function. Adequate water intake helps keep mucous membranes moist, enhancing their ability to trap and eliminate pathogens. Furthermore, proper hydration supports the regulation of body temperature, which is essential for optimal immune cell function [6]. The importance of staying well-hydrated cannot be overstated, particularly in the context of respiratory infections like COVID-19. This review aims to explore and elucidate the potential role of immune-boosting diets during the COVID-19 pandemic. It will examine a range of foods and nutrients that have demonstrated immune-enhancing properties, with a particular focus on their potential applications in the current global health crisis. Among the foods to be discussed are those rich in antioxidants, which play a crucial role in mitigating oxidative stress caused by reactive oxygen species (ROS) [7]. These include curcumin-containing foods, papaya, various mushroom species, certain cereals, sunflower seeds, and almonds.

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## 2. Dietary suggestions during COVID-19

### 2.1. Vitamin C

Vitamin C is beneficial for improving immunity in all age groups, including children and the elderly, primarily through its effects on neutrophils [8]. Fruits and vegetables like papaya, kiwi, guava, oranges, spinach, mushrooms, and beets are excellent sources of vitamin C [6]. Spirulina and curcumin, rich in minerals and vitamin C, are particularly recommended for elderly individuals [9]. Vitamin C deficiency can lead to scurvy. During infections, activated phagocytes release oxidizing agents, or reactive oxygen species (ROS), which help deactivate or destroy viruses and bacteria [10]. However, many ROS can damage host cells and contribute to the pathogenesis of infections [11]. As an antioxidant, vitamin C becomes particularly important during oxidative stress [11]. It also stimulates antibody formation, enhancing the immune system.

### 2.2. Vitamin D

The skin contains provitamin D<sub>3</sub> (7-dehydrocholesterol), which is converted to vitamin D<sub>3</sub> (cholecalciferol) upon exposure to UVB radiation from sunlight. Vitamin D<sub>3</sub> from the skin and dietary sources (D<sub>3</sub> and D<sub>2</sub>/ergocalciferol) is then converted to 25-hydroxyvitamin D<sub>3</sub> (calcitriol) in the liver, and further converted to 1,25-dihydroxyvitamin D<sub>3</sub> (calcitriol) in the kidneys and other organs [12]. Vitamin D is a potent immunomodulator [13]. Immune cells like T and B lymphocytes, monocytes, and macrophages express vitamin D receptors and can convert 25-hydroxyvitamin D<sub>3</sub> to 1,25-dihydroxyvitamin D<sub>3</sub> [14]. Respiratory epithelial cells also express vitamin D receptors, suggesting a protective role against viral respiratory tract infections [15]. Exogenous vitamin D has been shown to improve antiviral defense in rhinovirus-infected bronchial epithelial cells by inducing interferon-stimulated genes [16]. Vitamin D supplementation enhances protective effects in patients with acute respiratory tract infections [17]. Fortified cereals and natural sunlight are good sources of vitamin D.

### 2.3. Vitamin E

Vitamin E is an essential nutrient for maintaining immunity and overall health in the elderly population. As a powerful antioxidant, it helps protect against various bacterial and viral infections [18]. Sunflower seeds, soaked almonds, and peanut butter are good sources of vitamin E to meet daily requirements [6]. Vitamin E primarily acts as a radical peroxyl scavenger, protecting lipoproteins and polyunsaturated fats in plasma membranes [19]. F<sub>2</sub>-isoprostanes promote oxidative lipid destruction by producing free radicals, but vitamin E supplementation has been shown to decrease free radical emission. While vitamin E supplementation raises plasma tocopherol levels, it does not affect athletic muscle damage [20].

### 2.4. Vitamin A

Vitamin A helps regulate the immune system and protects against infection by maintaining the health of tissues. Carrots, broccoli, red bell peppers, and sweet potatoes are rich sources of vitamin A [21]. Vitamin A deficiency has been associated with increased susceptibility to infections, particularly in the respiratory and gastrointestinal tracts [22]. Retinoic acid, a metabolite of vitamin A, plays a crucial role in the development and differentiation of immune cells, such as T cells and B cells [23].

## 2.5. Vitamin B Complex

B vitamins, particularly vitamin B6, are essential for maintaining optimal immune system function. Fortified cereals like corn flakes, wheat flakes, rice, and poha are good sources of vitamin B in the daily diet. Vitamin B6 is involved in the production of antibodies and cytokines, which are important for immune response [24]. Deficiency in vitamin B6 has been linked to impaired lymphocyte proliferation and decreased antibody production [25]. Other B vitamins, such as vitamin B12 and folate, also support immune function by their involvement in DNA synthesis and cell division [26].

## 2.6. Iron

Iron plays a significant role in many immune system processes by helping the body carry oxygen to cells. It comes in different forms, with heme iron being more easily absorbed by the body. Red meat (in moderation), chicken, beans, and broccoli are good sources of iron. Iron deficiency can impair immune function, particularly cell-mediated immunity, by affecting the growth and differentiation of immune cells [27]. However, excessive iron can also be detrimental, as it may promote the growth of certain pathogens [28]. Maintaining optimal iron levels through a balanced diet is crucial for a well-functioning immune system.

## 2.7. Zinc and magnesium

Zinc has an immunomodulatory effect and may play a role in the treatment of COVID-19. The combination of  $Zn^{2+}$  cations with the zinc ionophore pyrithione inhibits the activity of SARS-coronavirus RNA polymerase, reducing its replication [29]. Zinc is involved in the development and function of immune cells, including neutrophils, monocytes, and natural killer cells [30]. Magnesium, an electrolyte, strengthens lymphocytes and natural killer cells in the immune system. It also acts as a major source of energy (ATP) for cells. Whole grains, black beans, and dark chocolate are magnesium-rich foods.

## 2.8. Selenium

Selenium has a powerful effect on the immune system and is important for preventing infections. Animal foods like seafood, meat, liver, poultry, and cottage cheese are the best sources of selenium. Selenium is incorporated into selenoproteins, which have antioxidant and anti-inflammatory properties [31]. Selenoproteins help regulate immune cell function and protect against oxidative stress [32]. Adequate selenium intake is necessary for optimal immune response, as deficiency has been associated with increased susceptibility to infections [33].

## 2.9. Folate/Folic Acid

Folate is the natural form of the vitamin, while folic acid is the synthetic form often added to foods due to its health benefits. Beans, lentils, leafy green vegetables, and avocado are good sources of folate. Enriched pasta, bread, and rice provide folic acid [6]. Folate is essential for DNA synthesis and cell division, which are crucial for immune cell proliferation [34]. Deficiency in folate can impair immune function by reducing the production of antibodies and cytokines [35]. Adequate folate intake supports the maintenance of a healthy immune system.

## 2.10. Propolis

Propolis, a resin-like material produced by honeybees for use as a sealant in hives, has impressive immune-enhancing effects. Propolis contains flavonoids and phenolic compounds that possess antioxidant, anti-inflammatory, and antimicrobial properties [36]. These compounds can modulate immune cell function and cytokine production, promoting a balanced immune response [37]. Propolis has been shown to stimulate antibody production and enhance the activity of natural killer cells [38].

## 2.11. Turmeric

Curcumin, the bioactive compound in turmeric, acts as an anti-inflammatory agent [39]. Turmeric combined with ginger provides anti-inflammatory and digestive benefits, while turmeric with mushrooms offers anti-inflammatory and immune-boosting effects. Turmeric and ashwagandha together have anti-inflammatory and stress-relieving properties. Curcumin is recognized worldwide for its multiple potential health benefits and is used in various forms, such as in Indian curries. The anti-inflammatory and antioxidant properties of curcumin make it particularly beneficial during the COVID-19 pandemic.

## 2.12. Kasuri Methi (Fenugreek)

This lesser-known spice not only adds amazing flavor to dishes but is also an excellent source of fiber. It is known to be effective in decreasing cholesterol and inflammation in the body. Drinking fenugreek water on an empty stomach can help boost immunity [40]. Fenugreek contains saponins, which have immunomodulatory effects and can stimulate the production of antibodies [41]. The fiber content in fenugreek also supports gut health, which is closely linked to immune function [42].

### 2.13. Ginger

Ginger is well-known for its health-promoting properties, including its ability to treat a wide range of diseases through immunonutrition and anti-inflammatory responses [43]. Gingerol, a key compound in ginger, has antiviral and anti-inflammatory effects. During the COVID-19 pandemic, consuming ginger in the form of ginger water, ginger tea, or lemon ginger can be highly beneficial.

### 2.14. Coriander Powder

Coriander powder is excellent for relieving flatulence and aiding in better digestion by facilitating bowel movement. This is likely why it has been extensively used in cooking since ancient times. Good gut health not only protects against colds and viruses but also promotes faster recovery from infections. Coriander contains antioxidants and antimicrobial compounds that can support immune function [44]. The essential oils in coriander have been shown to exhibit antibacterial and antifungal properties [45].

### 2.15. Mushrooms

Mushrooms are high in selenium and B vitamins like riboflavin and niacin, which are essential for optimal immune system function [46]. They are also rich in polysaccharides, sugar-like molecules that enhance immune function. Beta-glucans, a type of polysaccharide found in mushrooms, have been shown to stimulate the activity of macrophages and natural killer cells [47]. Different types of mushrooms, such as shiitake, maitake, and reishi, have been studied for their immunomodulatory effects [48].

### 2.16. Cinnamon

Cinnamon is a potent immune booster due to its antibacterial, antioxidant, and anti-inflammatory properties, which help reduce infections and strengthen immunity [49]. Soaking a cinnamon stick in water overnight and drinking it the next morning may offer protection against coronavirus [50]. Cinnamon can be consumed as cinnamon tea, cinnamon water, in smoothies, or sprinkled on breakfast cereals. Cinnamaldehyde, a compound found in cinnamon, has been shown to inhibit the growth of various bacteria and fungi [51].

### 2.17. Astragalus

Astragalus is an herb whose root is used in medicine. It is typically used to strengthen the immune system and treat common colds, upper respiratory tract infections, and seasonal allergies. Astragalus is also known to fight against bacteria and viruses. While more research is needed to confirm its effectiveness against illnesses, taking 160mg of Astragalus root extract orally daily for 3-6 weeks has been found to decrease symptoms of seasonal allergies such as runny nose, itching, and sneezing. Astragalus contains polysaccharides and saponins that have immunomodulatory effects, stimulating the production of immune cells and cytokines [52].

### 2.18. Licorice Root

Licorice root, when used as a gargle, may help soothe sore throat pain, a common symptom of coronavirus. It also helps loosen congestion and reduce inflammation. Chewing a piece of licorice root or drinking it as tea can provide these benefits. Glycyrrhizin, a compound found in licorice root, has antiviral and anti-inflammatory properties [53]. It has been shown to inhibit the growth and replication of several viruses, including SARS-CoV [54].

### 2.19. Garlic

Garlic boosts immune power and helps reduce stress. It is a functional food known for its immunomodulatory, anti-inflammatory, antimutagenic, and antitumor properties [55]. Garlic may be an acceptable preventive measure against COVID-19 infection by boosting immune system cells. Allicin, a sulfur compound found in garlic, has been shown to have antiviral and antimicrobial effects [56]. Garlic also contains selenium, which supports immune function [57].

### 2.20. Garam Masala

This blend of whole spices is full of antioxidants that help boost digestion, fight inflammation in the body, and keep immunity at an optimum level. It also combats bloating and flatulence. To ensure maximum benefits, garam masala should include the following spices: coriander, turmeric, chili, fennel, black pepper, cumin, salt, ginger powder, mustard, green chili powder, fenugreek (leaves), cinnamon, cloves, and cardamom. The combination of these spices provides a synergistic effect, offering anti-inflammatory, antimicrobial, and immunomodulatory properties [58].

### 2.21. Neem

Neem boosts the immune system and lowers the risk of cancer and cardiovascular diseases. It has antibacterial and antiviral properties, purifying and cleansing the blood of harmful toxins [59]. Neem leaf extract has been shown to stimulate the production of immune cells and enhance their activity [60]. The compounds in neem, such as nimbin and nimbolide, have anti-inflammatory and antioxidant effects that support immune function [61].

## 2.22. Yogurt

Probiotics in yogurt are useful for controlling respiratory infections. They can lessen the impact of respiratory infections caused by the coronavirus [62]. Probiotics help maintain a healthy gut microbiome, which is closely linked to immune function [63]. The beneficial bacteria in yogurt, such as *Lactobacillus* and *Bifidobacterium*, have been shown to enhance immune response by stimulating the production of antibodies and cytokines [64].

## 2.23. Black Pepper

Black pepper is both an antioxidant and an antibacterial agent, contributing significantly to overall wellness. It also contains vitamin C, which naturally boosts immunity and acts as an excellent antibiotic. Piperine, the active compound in black pepper, has been shown to have immunomodulatory effects [65]. It can stimulate the activity of immune cells and enhance the production of antibodies [66]. Black pepper also has anti-inflammatory properties that can help alleviate symptoms associated with respiratory infections [67].

**Table 1. Summary of dietary sources and their effects**

Nutrient/Compound	Source	Immune Function	References
Vitamin C	Citrus fruits, kiwi, broccoli, bell peppers	Antioxidant, supports cellular functions of innate and adaptive immunity	8
Vitamin D	Sunlight, fatty fish, egg yolks, fortified foods	Modulates innate and adaptive immunity, enhances antiviral activity	12-17
Vitamin E	Nuts, seeds, vegetable oils, leafy greens	Antioxidant, regulates T cell function	18-20
Vitamin A	Sweet potato, carrots, spinach, milk	Supports T cell differentiation and function	22, 23
Vitamin B6	Poultry, fish, potatoes, non-citrus fruits	Maintains T cell populations and function	24, 25
Vitamin B12	Meat, fish, dairy products, fortified foods	Augments CD8+ T cells and NK cell activity	26
Iron	Red meat, poultry, fish, beans, lentils	Essential for immune cell proliferation and differentiation	27, 28
Zinc	Oysters, red meat, poultry, beans, nuts	Inhibits viral replication, supports immune cell function	29, 30
Selenium	Brazil nuts, seafood, meat, poultry	Regulates inflammation and immune response	31-33
Folate	Leafy greens, legumes, fortified foods	Supports proliferation of CD8+ T cells and NK cell cytotoxicity	34, 35
Propolis	Bee product	Immunomodulatory and anti-inflammatory properties	36-38
Curcumin	Turmeric	Immunomodulatory and anti-inflammatory properties	39
Fenugreek	Fenugreek seeds	Immunomodulatory and antioxidant properties	40-42
Ginger	Ginger root	Anti-oxidative and anti-inflammatory properties	43
Coriander	Coriander seeds and leaves	Immunomodulatory and anti-inflammatory properties	44, 45
Mushrooms	Various edible mushrooms	Immunomodulatory, anticancer, and oncoimmunological activities	46-48
Cinnamon	Cinnamon bark	Antimicrobial and immunomodulatory properties	49-51
Chokeberry	Chokeberry fruit	Reduces inflammation and modulates iron metabolism	52
Licorice	Licorice root	Antiviral and antimicrobial activities	53, 54
Garlic	Garlic cloves	Immunomodulatory and anti-inflammatory properties	55-57

Indian spices	Various spices used in Indian cuisine	Cardioprotective and immunomodulatory properties	58
Neem	Neem leaves	Immunomodulatory and anti-inflammatory properties	59-61
Probiotics	Fermented foods, supplements	Supports immune health and may prevent respiratory infections	62-64
Black pepper	Black peppercorns	Potential immunomodulatory and anti-cancer activities	65
Cardamom	Cardamom pods	Potential immunomodulatory and anti-cancer activities	65
Carvacrol	Oregano, thyme	Modulates cytokine levels and improves lung function	67

### 3. Conclusion

Exploring and analyzing the origins of immunity reveals evolutionary and developmental ties to diet and nutrition. Foods are capable of influencing immune system function, and this is particularly important during the COVID-19 global pandemic, where individuals with weakened immune systems are at higher risk. Foods containing bioactive ingredients like curcumin (turmeric), gingerol (ginger), cinnamon, garlic, black pepper, and neem have antiviral, anti-inflammatory, and immunomodulatory properties. Amla increases the body's white blood cells, while probiotics (yogurt) are useful for controlling respiratory problems. Various vitamins like C, D, and E also improve immunity. In conclusion, a plant-based diet rich in these immune-boosting foods plays a vital role in enhancing people's immunity to control COVID-19. However, it is important to note that while a healthy diet supports immune function, it should be used in conjunction with other preventive measures such as social distancing.

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