ORIGINAL ARTICLE

Dietary Foods to Strengthen Immunity During Pandemic: A Composite Review

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ABSTRACT The host defenses require an adequate quantity and balance of nutrients to function properly. Protein and certain micronutrient deficits have long been linked to immune dysfunction, and a proper diet of iron, zinc and some minerals, vitamins A, D, E, B6, B12, antioxidants, and phenolic substances is critical for immune function regulation. There is a complex interaction between nutrients and immune system. Some non-nutrients have also demonstrated potential immunity boosting actions. As a result, this review offers a broad overview of immune system function and the primary bioactive chemicals found in plant- based meals that contribute to the development of host immunity. This review also includes recent findings and research on the therapeutic benefits associated with improving immune response through the consumption of a variety of foods from various groups, such as vegetables, fruits, nuts and seeds with high nutritive values, all of which demonstrate their specific immune-boosting functions by revitalizing the body for a healthy lifestyle.

Keywords: Immunity boosting, Bioactive compounds, Plant-based foods, Nutrients

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Submited: 22-Feb-2022 **Accepted:** 20-Jun-2022 **Published:** 26-Jul-2022

INTRODUCTION

Vitamins, minerals, fatty acids, a few polysaccharides, and some non-nutrients (i.e., polyphenols) included in foods have demonstrated therapeutic potential

and can boost people's immunity (Thirumdas *et al.*, 2021). Immunity refers to the host's total ability to combat disease-causing germs, which is imparted through the immune system. Types of immunity include: innate immunity and acquired immunity. Innate immunity is a sort of non-specific defense that is present at birth. This is done by erecting physical, cellular, physiological, and chemical barriers to prevent external agents from entering our bodies (Lockyer *et al.*, 2020). On the other hand, acquired immunity is pathogen specific and memory based. This means that when our body comes into contact with a pathogen for the first time, it creates a low-intensity initial reaction, also known as primary response or humoral immune response. A secondary or anamnestic reaction, also known as a cell-mediated immune response, is elicited by a subsequent encounter with the same pathogen. B-lymphocytes and T-lymphocytes, two different types of lymphocytes found in our blood, are involved in both primary and secondary immune responses. The good impacts on immunity are directly proportionate to optimistic thinking and favorable thoughts have a direct relationship with the positive impacts on immunity that can be achieved by regulating or lowering stress levels (Shankar *et al.*, 2020). Phenolic substances are the major group of bioactive compounds and includes flavonoids (flavanones, flavones, flavanols, flavonols, anthocyanins, isoflavonoids) stilbenes and phenolic acids.

Access this article online
Website: www.ijfans.org
DOI: 10.4103/ijfans_118-22

IMMUNITY BOOSTING FRUITS AND THEIR BIOACTIVE COMPOUNDS

Blueberries (*Cyanococcus*)

Flavonoids (anthocyanin, flavanols, flavonols), hydroxycinnamic acids and tannins (nonflavonoids), are all found in blueberries. There are also significant levels of ascorbic acid, vitamin K, vitamin B9, and magnesium. Anthocyanin, along with other polyphenols found in

How to cite this article: S Rabia Farheen, Saiyyad Alamdar Husain and Murad Husain. Dietary Foods to Strengthen Immunity During Pandemic: A Composite Review. Int J Food Nutr Sci 2022; 11:1-5.

blueberries, plays an antioxidant role in diabetes, antiaging, hypertension, hyperlipidemia, bone, eye, and cancer prevention (Banerjee *et al.*, 2020). Kim *et al.* (2021) studied bioconversion material made from black rice and blueberry extracts using *Lactobacillus plantarum* concluding its efficient anti-inflammatory properties and may help activate macrophages to improve immunological function.

Citrus Fruits (Citrus)

Hesperetin, the most important orange flavone, is found in the fruit in a glycosylated form as hesperidin, which is found mostly in the peel and white section (albedo) of citrus fruits, and eating the whole fruits allows for a higher intake than drinking the juice (Bellavite *et al.*, 2020). According to research conducted by Lee *et al.* (2011). The findings indicate that Citrus unshiu (Satsuma mandarin, SM) is a citrus fruit whose content and peel extracts have anti-tumor characteristics in a tumor-bearing mouse model, and that the mechanism involves the anti-tumor effects of SM extracts is via enhancing immune-mediated anti-tumor attributes by bolstering cytokines such as TNF- and IFN-Amla (Indian gooseberry), which contains bioavailable flavonoids like rutin and quercetin, is good for overall immunity since it reinvigorates and rejuvenates the body (Ara *et al.*, 2020).

Kiwi Fruit (*Actinidia deliciosa*)

Kiwi fruits have numerous medicinal properties, and it is one of the most important immune-boosting fruits due to its high antioxidant activity, which includes vitamins and phytochemicals known as flavonoids, which aid in the neutralization of unstable molecules known as free radicals, which are linked to chronic disease and ageing (Khalua *et al.*, 2020). Kiwifruit has been proven to influence a number of oxidative stress biomarkers and positive immunological responses, thereby lowering the occurrence and severity of upper respiratory tract infection symptoms, and may be more effective than vitamin C supple-mentation alone (Skinner *et al.*, 2013).

Pineapple (*Ananas comosus*)

Vitamin C is a potent antioxidant which is abundantly present in pineapple, aids in the synthesis of collagen in bones, blood vessels, cartilage, and muscle, as well as iron absorption, thereby increasing immunity (Hossain *et al.*, 2015). Bromelain, found in pineapples, inhibits cyclooxygenase, modifies prostaglandins and thromboxane, and hydrolyzes bradykinin, and exerts important immunomodulatory actions (Kritis *et al.*, 2020).

Avocado (*Persea americana*)

Avocados are high in carbohydrate, protein, monounsaturated fatty acids, dietary fibre, minerals, and vitamins, and they can help to enhance immune systems by acting as an antioxidant and anti-inflammatory agent (Gargi *et al.*, 2019). Avocado seed has 72% of the antioxidants found in the whole avocado and avocado seed oil is also full of antioxidants namely, lutein and zeaxanthin, lowers cholesterol and helps fight off disease and increases the responsiveness of humoral immune system (Chaudhary *et al.*, 2015).

IMMUNITY BOOSTING VEGETABLES AND THEIR BIOACTIVE COMPOUNDS

Spinach (*Spinacia oleracea*)

With inhibitory concentrations of 3.03 g/mL, 6.03 g/mL, and 3.046 g/mL for OH-scavenging, 2-diphenylpicrylhydrazyl (DPPH) inhibition, and amylase inhibition, respectively, methanolic extract of spinach revealed antioxidant activity and antidiabetic action (Vyas *et al.*, 2017). Spinach is high in carotene, folic acid, and vitamin C, which helps to enhance the immune system. In terms of boosting haemoglobin, spinach is seen to be a healthy green vegetable (Jankar *et al.*, 2020).

Broccoli (*Brassica oleracea var. italica*)

Broccoli includes anti-cancer and immune-boosting capabilities and its isothiocyanates, such as sulforaphane and indole-3-carbinol, increase detoxification enzymes and function as antioxidants, lowering estrogen levels and lowering the risk of breast and uterus cancer (Adak, 2020). Broccoli is high in iron, phosphorus, vitamins A and C, and riboflavin, as well as being one of the best sources of glucosinolates (Ashok *et al.*, 2020). According to Arshad *et al.* (2020), broccoli includes the potent antioxidant glutathione, as well as the bioflavonoid quercetin, which has been shown to protect against a variety of infections in tests.

Moringa (*Moringa oleifera*)

Several studies on the antiviral activity of the *M. oleifera* plant, a prominent bioprospective aspirant, have been published, and the plant is known to be used in many traditional medicines and pharmacopoeias to treat a variety of immunity disorder such as celiac disease, addison disease and so on (Biswas *et al.*, 2020). Kaempferol, pterygospermin, morphine, quercetin, and apigenin-7-rutinoside are some of the Moringa components that help enhance immunity (Fajri, 2021). Individuals who suffer from malnutrition and have a weakened immune system have long been treated with moringa soup consumption to in- crease their immunity (Bhattacharjee, 2020). According to the findings, Soni *et al.* (2021) concluded that fortifying pasta with Moringa oleifera leaf powder can work as a natural immune booster and minimize the risk of microbial illnesses.

Sweet Potato (*Ipomoea batatas*)

The minerals are moderately present in Sweet Potato, but iron was reported in good concentrations; lutein and zeaxanthin are in good concentrations; and among all, elevated the quantities of a-carotenoid and b-carotenoid, which are good sources for immunity building, were reported, as well as phenolic acids, such as CGA, CA, 4, 5-; 3, 5-; 3, 4-diCQA isomers, in good proportions (Neela *et al.*, 2019). Mice given purified sweet potato polysaccharide for 7 days showed significant increases in lymphocyte proliferation, natural killer cell activity, hemolytic activity, serum IgG concentrations, and immunological indices, implying that purified sweet potato polysaccharide boosts immunity and can be utilised as a biological response modulator. (Panda *et al.*, 2012).

IMMUNITY BOOSTING NUTS AND SEEDS AND THEIR BIOACTIVE COMPOUNDS

Almond (Prunus dulcis)

A daily intake of 45 g of almonds can help lower dyslipidemia, one of the most major risk factors for cardiovascular disease and almonds have also been shown in several well-conducted clinical studies to reduce low density lipoprotein cholesterol, which is a known risk factor for cardiovascular disease and studies have also analyzed the effect of almonds on high density lipoprotein cholesterol (HDL-C), and it has been found that intake of almonds has helped consistently improve HDL-C levels (Kalita *et al.*, 2018). The kernels are high in fat (mono-unsaturated fatty acids and poly-unsaturated fatty acids), carbohydrates (fibre, etc.), proteins, vitamins (vitamin E, vitamin B, etc.), minerals (copper, calcium, magnesium, etc.), and a variety of bioactive substances (phytosterols, polyphenols, etc.)and are used as a natural antioxidant, anti-inflammatory and promotes leukocytes production (Barreca *et al.*, 2020).

Walnut (*Juglans regia*)

In comparison to the normal control mice, those supplemented with different doses of walnut proteins showed enhanced immune indices, including organ index, spleen lymphocyte proliferation, macrophage activity, number of CD4+ and CD8+ T cells, immunoglobulin A (IgA) and secretory IgA content, and messenger RNA and protein expression levels of cytokine factors and their results revealed that these walnut proteins may have positive effects on the immune system and perform their immunomodulatory functions and these findings support the use of walnut proteins as nutritional sources to enhance the immune system (Li *et al.*, 2018). Mao *et al.* (2020) showed that walnut oligopeptides could significantly improve humoral and cell-mediated immune responses, macrophage phagocytosis and natural killer cell activity, increased T and Th cells percent ages, Interleukin (IL)-2, IL-12, IL-10,as well as immunoglobulin (Ig)A, IgG, IgM and intestinally produced IgA production and granulocyte–macrophage colony stimulating factor secretion, all attributed to these advances and each one of these above indicated that walnut oligopeptides could be a promising immunomodulatory dietary supplement at dosages ranging from 110 to 440 mg/kg of body weight.

Brazil Nut (*Bertholletia excelsa*)

Brazil nut (Bertholletia excelsa) possess phenolics and flavonoids in both free and bound forms and are abundant in tocopherol, phytosterols, and squalene and bountiful source of selenium with the concentration of 19.91 g/g (Yang, 2009). The brazil nut oil has a high nutritional value based on the measurement of the key important fatty acids, particularly unsaturated (75%) and monounsaturated fatty acids, primarily oleic and linoleic acids. consequently, Brazil nut is of high nutritional and functional relevance as a source of vital fatty acids, that stimulates T cytotoxic cells (Santos *et al.*, 2013).

Pistachio (*Pistacia vera*)

These are high in vitamin B6, which is necessary for a healthy immune response, encourages blood circulation by assisting in the transport of oxygen through the arteries to cells, and aids in the maintenance of lymphoid glands such as the thymus, spleen, and lymphatic system, all of which can aid in the production of white blood cells that help the body fight against infections (De, 2020). Pistachios are high in copper, manganese, vitamin, thiamin, potassium, phosphorous, chromium, vitamin E and K, riboflavin, folate, magnesium, iron, zinc, and selenium, as well as lutein and zeaxanthin (xanthophyll carotenoids) and phenolic compounds such as anthocyanins, flavonoids, and proanthocyanidins, and have immunomodulatory effects (Higgs *et al.*, 2021).

Pumpkin Seeds (*Cucurbita pepo. L*)

P-hydroxybenzoic acid is the most prevalent phenolic acid in pumpkin seeds, but other phenolics such as caffeic, p-coumaric, ferulic, sinapic, protocatechuic, vanillic, syringic acid, and p-hydroxybenzaldehyde are also found (Krimer *et al.*, 2020). Dehusked pumpkin seeds supplements blood iron levels, and dramatically improves blood iron levels by elevating serum iron, elevating transferrin saturation percent, and decrease in TIBC (Dowidar *et al.*, 2020). Pumpkin seeds include bioactive chemicals that have anthelmintic, antidiabetic, antidepressant, antioxidant, anticancer, and cytoprotective properties, as well as increasing immunoglobulin levels (Dotto *et al.*, 2020).

Sesame Seeds (*Sesamum indicum*)

Sesame seeds include considerable levels of phenolics, flavonoids, nutrients, and minerals, as well as sesamin, a bioactive molecule with significant antioxidant potential (Dravie *et al.*, 2020). Lipid-soluble lignans such as sesamolin, sesamin and sesaminol, are the most abundant, followed by pinoresinol diglycoside. Participants in a trial were given interferon (IFN)- 1a with or without 0.5 mL/kg/day sesame oil consumption. In comparison to the control group, the sesame-oil supplemented group did not improve on the Expanded Disability Status Scale (EDSS). Sesame oil, on the other hand, lowered IFN- and TNF-in peripheral blood mononuclear cells, thereby enhancing immune response (Alasalvar *et al.*, 2021).

CONCLUSION

There is significant epidemiologic evidence that fruits and vegetables play a preventive effect in cancer prevention. Fruits and vegetables may also play a protective function in the prevention of coronary heart disease by increasing human lymphocytes, which are associated to humoral immunity, according to current scientific findings. The information reviewed adds to the case for in- creasing eating of a wide range of foods. The information reviewed adds to the case for increasing eating of a wide range of fruits, vegetables, cereals and pulses, nuts and seeds, herbs and spices, and therapeutic microbes. This review focused on certain vegetarian foods from diverse groups that have the strongest immune-boosting properties. It's also been related to new scientific findings that back up the claims. Finally, each food has its own therapeutic effects, so including as many foods as possible in a balanced diet will boost immunity, exhibit antibacterial, antiviral, anticancer, anti-inflammatory, immunosuppressive, cardiovascular, antioxidant, and antidiabetic effects, and equip the body to maintain good health and fight diseases while remaining happy.

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