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Plant-Based methods for boosting immunity

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Abstract:
The immune system plays a crucial role in defending the body against many diseases and infections. While there are several ways to strengthen the immune system, a plant-based diet is particularly effective. The immune system can be strengthened by eating a diet high in minerals, antioxidants, and other chemicals found in plants. Some of the most effective plant-based methods for boosting immunity include consuming foods such as strawberries, nuts, seeds, grapes, citrus fruits, green vegetables, and legumes. These foods are a good source of rich zinc, vitamin C, vitamin D, and other essential nutrients for optimal immune system function. Additionally, herbs and spices like ginger, turmeric, and garlic have been shown to have potent immune-boosting properties. Aside from diet, other plant-based methods for boosting immunity include regular exercise, getting adequate sleep, managing stress, and staying hydrated. These practices can help reduce inflammation, improve circulation, and support overall immune system function. Furthermore, incorporating plant-based methods for boosting immunity into our lifestyle can help us stay healthy and ward off diseases. With a balanced and nutrient-rich diet, regular exercise, and healthy lifestyle habits, they can keep your immune system functioning at its best.

Keywords: Immune system, Vitamins, Nutrients, Antioxidants, Stress management, Inflammation.

1. Introduction

The immune system is responsible for protecting the body against dangerous foreign invaders such as viruses and bacteria that are harmful as well as eradicating malignant cells when they develop inside the body. A network of unique cells, proteins, tissues, or organs makes up the immune system *(Martinon et al., 2009)*. Having a strong immune system is crucial to fend off various harmful illnesses. While immunity cannot be developed in one day or an entire week, eating a well-nutritious diet to maintain good mental and physical health causes our immune systems to become stronger on their own *(Arshad et al., 2020a)*. If the immune system is low, people have a high risk of infection and many other diseases like heart disease, diabetes, etc. *(Arshad et al., 2020a)*. Even the outcome of COVID-19 is that people with poor immunity report early death and increase progress of COVID-19 *(Li et al., 2020)*. There are many immunity boosters that are basically responsible for beating off outside or foreign invaders and damaging cells within the body that are cancerous or carcinogenic in nature. Our environment contains a variety of things that improve our immunity, including foods that we ate, plants that have medicinal properties, and other things *(JPAR-2102-RSA-000196 Ms. Priyanka (2), 2021)*. The World health organization (WHO) asserted herbal medicines that are also used to boost the immune system or improve primary health. Herbs such as black cumin, garlic, and licorice are included in food that will improve immunity as well as gut microbiota. Furthermore, medicinal plants are a rich source of carotenoids, flavonoids, or vitamins that improves the immune system *(Khodadadi, 2015)*. Amines such as vitamin A, vit. C, vit. E, vit. B6 and nutrients like Fe, Ca, Mg, Cu etc. and some amino acids are essential to boost our immunity obtained from plants *(Ibrahim & El-Sayed, 2016; Jafari et al., 2019; Moriguchi & Kaneyasu, 2003; Shah Alam et al., 2020)*. Therapeutic uses of medicinal plants include the management of autoimmune disorders, neurological, metabolic, and infectious conditions

(Abd El-Ghani & Abd El-Ghani, 2016; Dhama et al., 2019). Derivatization, characterization, and validation of bioactive compounds found in plants alkaloids, flavonoids, tannins, glycosides, and saponins is now possible with technological and methodological methods *(Pralhad Ingle et al., 2017)*. Natural products which are obtained from plants and investigated in many studies are used as first-line of defense or also increase the immune system against infection *(Vandebroek et al., 2020)*. If delicately explored, medicinal herbs with beneficial immunomodulatory abilities have the possibility to decrease the effects of infection as well as offer significant medicinal benefits *(Kulyar et al., 2021)*. The numerous immunity boosters and immune system mechanisms in the human body are discussed in this article review. The main goal of this review is to teach readers about all types of nutrients and immunity boosters that can be found in nature and their surroundings.

2. Immune system: Importance and types

In order to protect the body from hazardous pathogens including parasites, viruses, and bacteria, the immune system is a complicated collection of tissues, cells, and organs *(Calder & Kew, 2002)*. Beneficial living bacteria that reside in the stomach and protect the body from numerous diseases are an essential component of the immune system. When the immune system response is weak or low it becomes an invitation for infections like viruses *(Arshad et al., 2020b)*. Dysregulation in the immune system can also lead to the development of numerous diseases, emphasizing the crucial role of the immune system, which is both highly sophisticated and vital for preserving health. Two fundamental parts of the immune system are the innate immune system and the adaptive immune system *(Clark & Kupper, 2005)*. Exterior defenses including the layers of skin and mucous membranes, nonspecific phagocytic leukocytes, or serum protein levels are all components of the innate system *(Masters & De Nardo, 2014)*. The adaptive system, which is composed of B and T cells, is where pathogens that manage to get past these early outer barriers eventually encounter *(Parkin & Cohen, 2001)*. Cells that can identify particular bacteria are produced when this system is active. The adaptive system, in contrast to the innate system, develops gradually but shows memory and responds faster with successive exposure, leading to more effective adaptive defense mechanisms with each ongoing exposure to that particular pathogen *(Brolinson & Elliott, 2007)*. These two components work in combination to create a powerful barrier that prevents the development and longevity of infectious pathogens. For maintaining good health and avoiding infections and illness a strong and healthy immune system is crucial.

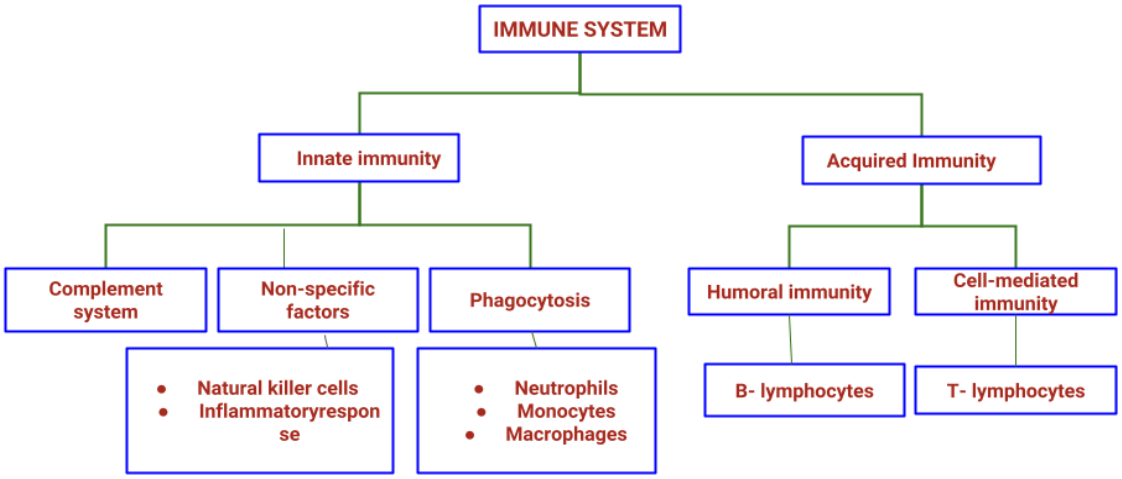


Figure: 1. Components of the immune system

2.1. **Innate and acquired immunity**

The barrier mechanisms and the cells involved in recognizing the molecular patterns on bacteria referred to as microbe-associated molecular patterns (MAMPs), and then destroying those germs, are included in innate also known as natural immunity. The cell walls lipopolysaccharides of Gram-negative microbes and peptidoglycans, which are components of Gram-positive bacteria are examples of MAMPs *(Erbs & Newman, 2012)*. Pattern recognition receptors, that is toll-like receptors are just one type among many others, that can recognize these common structural traits *(Boller & Felix, 2009)*. Following recognition, a typical response would be to engulf the bacterium carrying the MAMPs via the process of phagocytosis, followed by the organism's death inside lysosomes by its so-called respiratory burst, which produces harmful reactive oxygen species. Phagocytic cells that include neutrophils, macrophages, monocytes, and dendritic cells make the environment unfavorable for the invasive bacteria, this process also initiates the inflammatory response as well. Isolated MAMPs can initiate the inflammatory response, not just microbes that carry MAMPs *(Calder et al., 2009)*. Antigen-specific helper T cells are "presented" with components of the absorbed microorganisms that are visible on the surface of the phagocytes (also known as "antigen-presenting cells"). Aspects of acquired immunity, which is often referred to as adaptive immunity, include antigen recognition and effector activities that are unique to a given antigen, such as T cell proliferation, cytotoxic T cell, the killing of virally infected cells, and antibody generation by B cells (*Bonilla & Oettgen, 2010)*. Humoral immunity, that includes B cells or antibody generation, and other one is cell-mediated immunity, that includes T cells are two sub-categories of acquired immunity. Many kinds of T cells are present, each having a unique function in the immune response *(Miles & Calder, 2021)*.

The adaptive system, in contrast to the innate system, develops gradually but displays memory and responds more quickly to future exposure, leading to an effective adaptive defence mechanism with each subsequent contact with that particular pathogen *(Sofia Ygberg, 2011)*. These two factors work together to create a strong barrier that prevents the development and long-term survival of infectious pathogens *(Nicholson, 2016)*.

2.2. Mechanism of immunity during infection

There are three different types of immunity known to us i.e., Innate immunity (quick response), adaptive immunity (delayed response), and passive immunity *(Marshall et al., 2018)*. In continuation, passive immunity can be categorized as immunity acquired from the mother's side (known as natural immunity), and another kind that was acquired from medication is known as artificial immunity *(Davidson et al., 1989)*. When the body is impacted by viruses or bacteria for the first time, the skin and inflammation responses are triggered, indicating the initiation of immune system activity. However, during the COVID-19 pandemic, this immune system response has been compromised, leading to the possibility of infection in our bodies *(Chaussabel et al., 2010)*. Furthermore, antibody-mediated defenses were triggered by virus-induced immunological reactions. The T cells play a significant role in supporting the maturation of B cells into plasma cells, which subsequently generate targeted antibodies against viral antigens. An antibody possessing neutralizing properties proves highly effective in fully preventing the virus from entering host cells, thereby averting infection *(Murin et al., 2019)*. In addition, it assumes a crucial defensive role during later stages of infection, contributing to the prevention of recurring infections. The cellular immune response mediated by T lymphocytes is evident within infected cells. Different cells possess distinct functions within this response, where Helper T cells oversee the overall adaptive immune response, while cytotoxic T cells play a vital role in eliminating and purging virally infected cells *(Kumar et al., 2020)*.

For maintaining good health or avoiding infections a strong immune system is playing a very crucial and essential role. It can recognize or eliminate pathogens very quickly when the immune system is functioning properly and preventing them from causing serious harm to our body *(Sahoo et al., 2015).* On the other hand, a weakened immune system, can increase the risk of infections and diseases or make it more difficult for the body to recover and people may be more susceptible to infections such as the flu, colds, pneumonia and chronic conditions including cardiovascular disease, diabetes, and tumors. According to the World Health Organization, the vital source for healthy life is consuming a well-balanced diet that is essential to maintain a strong immune system. In context of the same vitamins and minerals serve as critical sources of nutrients in achieving this goal. Different roles of vitamins are recognized in the immune system such that water-soluble vitamin B, which is recognized for its ability to provide protection against viral and bacterial infections, while vitamin C is known to safeguard against flu-like symptoms *(Wessling-Resnick, 2018).* Insufficient vitamin D and vitamin E can lead to coronavirus infection *(Jayaweera et al., 2019)* and it can be obtained from sunlight whereas vitamin E can be obtained from plant products like oil, seeds, and fruits. Some minerals also cause great impact on immune system as insufficient or excess of amount iron can lead to very risky conditions *(Jin et al., 2020; Maares & Haase, 2016).* The disease is more able to take root as the body ages as compared to when it was younger.

3. Immunodeficiency

When the immune system is compromised, a disease or ailment known as immune deficiency can develop *(Fitzgerald, 1991)*. Due to its effects on phagocyte activities, cytokine generation, immunoglobulin A secretion, and cell-mediated immune responses, malnutrition is the most frequent cause of manganese, zinc, vitamins, or folic acid deficiencies can have a substantial impact on how the immune system reacts to infections *(Ali, 2020; Galmés et al., 2020; Zemb et al., 2020).* Therefore, dietary status, as a changeable element, is crucial to the integrity and proper operation of the immune system. Primary immune deficiency is when person born with a compromised immune system. Some examples of primary immune disorders - Severe combined immunodeficiency -This is an example of an immune disease that develops at birth. The danger of viral, microbial, and fungal infections in children is constant. This disorder is also known as "bubble boy disease" *(De La Morena & Nelson, 2014)*. The basic immunological deficiency diseases called common variable immunodeficiency that is characterized by insufficient levels of restrictive antibodies and greater chance of infections *(Cunningham-Rundles, 2001).* When your body is weakened by an external factor, such as a chemical or virus, secondary immunodeficiency problems develop. Examples of these disorders are AIDS - HIV is an acquired virus that causes AIDS by killing important white blood cells and weakening the body's immune system. Serious infections that the majority of individuals are susceptible to emerge in AIDS/HIV patients. Such infections are commonly referred to as "opportunistic infections" as they attack on immunity systems that are generally weakened *("Immunodeficiency Disorders," 2023)*. Many such examples also include viral hepatitis or multiple myeloma etc. Autoimmune diseases, instead of attacking outside invaders, the immune system occasionally targets its own tissues and organs. An illustration of an autoimmune disease is type I diabetes *(Utoimmune et al., 2001).* In type 1 diabetes : Insulin release or produce by the pancreatic cells from where immune system attacks. Insulin removes sugar from the blood *(Ye et al., 2017).* Rheumatic arthritis causes the joints to swell and deform as a result of the arthritis. Some people with rheumatoid arthritis also have lupus, an autoimmune disease that affects various organs including the skin, the kidneys, and lungs (*Khurana & Berney, 2005).* Patients with lupus have many auto-antibodies in their blood samples, all of distinct types. Those with weakened immune systems may be more susceptible to: Organ inflammation inside the body, autoimmune condition, digestive problems such

as nausea or diarrhea, fatal blood disorder, & developmental or growth deficits in young children's *("2021 in Conversation: The Year in Medical Research," 2021).*

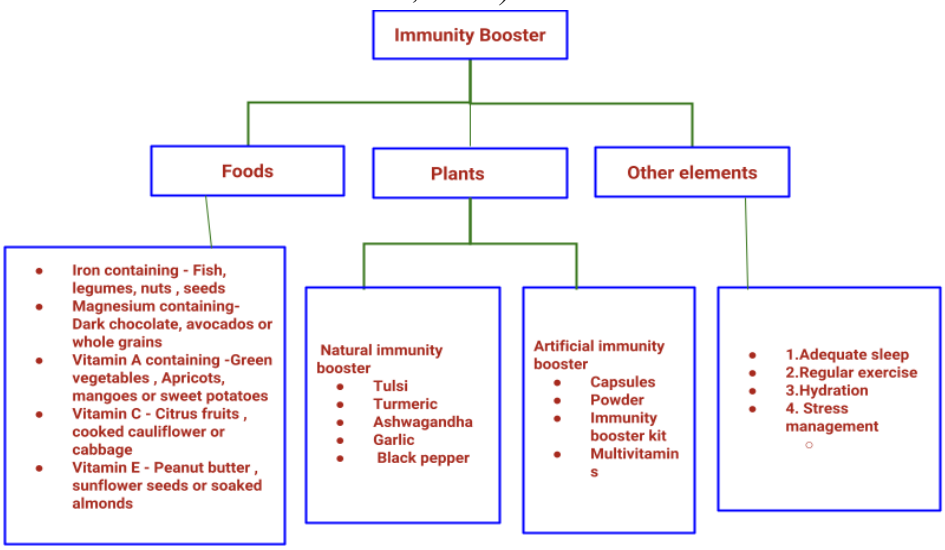


Fig.2. Immunity booster

4. Immunity booster

Development of strong immunity does not happen in a day; it takes time to enhance our immune system. To boost up the immunity in two ways by artificial or natural pathways for developing active defenses against invasive microorganisms. To fight against diseases, choosing a healthy lifestyle is your first preferences is to boost immunity. A few healthy changes to your routine and diet can be a great immunity booster.

Our country is rich with many medicinal plants that help to fight a wide range of various types of diseases. Medicinally important plants enhance our immunity stated by ancient medicine systems such as Ayurveda, Siddha and Unani.

In context of natural system of boosting immunity, there are many medicinal plants which do not have any side-effects in it.

4.1MEDICINAL PLANTS AS AN IMMUNITY BOOSTER

4.1.1 *Ocimum sanctum*:

Which is commonly known as Tulsi, it not only helps to increase the immune system but also helps to cure various types of ailments. Bioactive compound of Tulsi is oleanolic acid that is found in leaves and flowers. Many antioxidants, antiviral, antifungal and vitamin C properties are also present *(Gautam et al., 2022).* Consumption of Tulsi can be directly or indirectly like Tulsi tea (helps to cure throat and cold problems), secondary metabolites also present in the leaves of Tulsi. Terpenoids widely extracted from Tulsi plants *(Ghoke et al., 2018).*

4.1.2 *Curcuma longa*:

It is also known as Turmeric, in South- East Asia, it is used as a spice and in ayurveda its main ingredients which is found in its roots is curcumin – a bioactive compound *(Rajkumar, 2020; Soni et al., 2020).* It also has anti -tumor or anti-inflammatory properties. Depression and mental health can negatively affect the immune system *(Rajkumar, 2020; Zalachoras et al., 2020).* Immunity or depression either one of its targeting may challenge the inadequacy, drug hold dual acting promise to enhance or improve health. It also inhibits the replication of many viruses like zika virus, dengue virus, hepatitis B.

4.1.3 *Withania somnifera:*

Its scientific name is Ashwagandha (another name is Indian Ginseng) is a small shrub, red berries and pale green flowers. Leaves and roots are the parts which are used as roots and can be consumed in many ways like powdered and dried. It helps to improve brain function or help to fight against diseases by improving immunity, reducing depression, blood sugar levels, cortisol levels and also inhibiting colon, brain, breast, lung cancers etc. *(Dutta et al., 2019).* It is used to treat both non-infectious or infectious disorders *(Cai et al., 2015) (Palliyaguru et al., 2016)* and has been proven to strengthen the immune system *(Muralikrishnan et al., 2010)*. Hence, an effort was made to determine how this agent might be used by COVID-19 management.

4.1.4 Allium sativum:

It is commonly known as Garlic and have many health benefits. Have anti-inflammatory, anti-tumor, antimutagenic properties and is also very rich source of vitamin B2, B1, B6 and B6, zinc, sodium, magnesium and calcium and natural source of sulfur-containing compounds. In Garlic, allicin is present which help to boost immunity *(Shang et al., 2019)*. This is one of the body's active immune system leaders that boosts immunity by making killer cells and macrophage cells more active. Foods such as garlic should clearly relieve or reduce the immune pressure to which our immune system retains, often due to smoke, lack of nutrition, mental stress, chemical pollution or physical injuries l *(Salman et al., 1991)*.

4.1.5 Piper nigrum:

It is commonly known as Black pepper. It is used in veterinary and human medicine in India for gastrointestinal disorders and nose-ear, throat and menstrual disorders and reported antioxidant effects *(Takooree et al., 2019)*. Active compounds which are piperine are important to stimulate leukocytes, increasing resistance to various pathogens. Severe acute respiratory syndrome that is SARS coronavirus when world is trying to fight against the coronavirus and scientists work ruthlessly to find vaccines against SARS-CoV-2 which is a causal organism, there are few medicinal plants that strengthen resistance with natural products to prevent this infection *(Singh et al., 2021).* Piperanine and Piperdardine are two bioactive compounds that are derived from black pepper and can be used and are very effective against COVID -19.

4.1.6 Phyllanthus emblica:

Its common name is Amla and Indian gooseberry belongs to family Euphorbiaceae. It contains a lot of vitamin C (another well-known name is Ascorbic acid). It helps to reduce cholesterol and help to maintain diabetes and contain ellagic acid, minerals, vitamins, flavonoids, fixed oils and gallic acid *(Variya et al., 2016).* By encouraging the growth of phagocytes, which are specialized immune cells that aid is sucking up dangerous invaders. Vitamin C may also help strengthen your immune system. It might also result in the development of antibodies that will protect from allergic reactions caused in our body *(Choudhary & Grover, 2019).*

4.1.7 Moringa *oleifera:*

The moringa oleifera tree is a distinct option for enhancing the immune system *(Razis et al., 2014).* It has many different pharmacological and therapeutic uses in medicine. This tree is dense nutrient, affordable and accessible**.** Native Americans revere and employ this magic tree, an old tree, as part of their traditional medicine to treat a variety of illnesses affecting the immunological, digestive, central neurological, cardiovascular system *(Posmontier, 2011)*. Niaziminin B, an immunomodulator, is present in the leaves of *Moringa* oleifera *(Nfambi et al., 2015).* The immune system can be strengthened with the help of leaf extract *(Obi et al., 2018).* It also has antiviral properties which has long been used to treat a variety of respiratory

illnesses. A natural approach to treating COVID-19 may be successful with *Moringa oleifera (Rastogi et al., 2022).*

4.1.8 *Tinospora cordifolia*:

It is commonly known as Giloy, prior to a few months ago, when a novel coronavirus infection (COVID-19) was rapidly spreading over the globe. People have been advised that the only methods they can stay safe and healthy are to have a strong and healthy immunity and avoid getting the virus because at that time neither a specific vaccination nor a treatment for it *(AGRICULTURE & FOOD: E-NEWSLETTER, 2020).* A strong immunity system is essential for the prevention, since Giloy is known as the ultimate immune booster and is packed with antioxidants that aid in body detoxification and immunity improvement, it is a completely natural medicine that has no side effects in healthy individuals *(Srivastava et al., 2021).*

Table1. Medicinal plants, bioactive compound and its role

S. No	Plant name	Botanical name	Native place	Bioactive compound	Part used	Role	References
1.	Garlic	*Allium sativum*	Middle east	Allicin	Leaves, flowers	• Anti-inflammatory • Immunomodulatory • Antitumor	*(Shang et al., 2019)*
2.	Ashwagandha	*Withania somnifera*	India, middle east, parts of Africa	Withanoside	Root, leaves	• Antioxidant properties • Protect body against diseases by improving the cell mediated immunity • Antitumor	*(Dutta et al., 2019*)
3.	Amla	*Phyllanthus emblica*	Tropical and southern Asia	Ascorbic acid	Fruit	• Diabetes • Reducing cholesterol • To fight against cancer	*(Variya et al., 2016)*
4.	Tulsi	*Ocimum sanctum*	Indian sub – continent	Oleanolic acid	Leaves, flowers	• Antiseptic • Antiviral • To boost immunity • Antimicrobial	*(Ghoke et al., 2018)*

5.	Turmeric	*Curcuma longa*	South Asia	Curcumin	Rhizome	• Anti-inflammatory • Immunomodulatory agent • Antitumor • Antibacterial	*(Giordano & Tommonaro, 2019)*
6.	Neem	*Azadirachta indica*	Assam and Burma	Azarirachtin	Leaves, roots, bark	• Antibacterial • Antifungal • Boosting both cells mediated immune system and the lymphocytic cell	*(Gupta et al.,2017)*[1]

5 ARTIFICIAL IMMUNITY BOOSTER

Artificial immune- boosting drugs usually work faster, but may have short term immunization. Immunity can boost in an artificial form, they are

Sustainable snacks are mostly available and are common mainly based on carbohydrates and high fructose corn syrup and cheap quality proteins *(Amrein et al., 2021; Hussain Raja et al., 2014)*. Unhealthy snacks are a major factor for many diseases obtained or induced by antigen- containing vaccines, nutritional supplements, drugs etc. like heart attack, diabetic and *cancer ("Monitoring Health for the SDGs," 2018)*. The purpose of this study was to produce high nutrition protein-based chicken and also improve the microbial and lipid stability with the help of solanum nigrum, a shelf stable snack and immune booster *(Sudha Rani et al., 2017)*. Ratio of saturated to unsaturated fatty acid of chicken meat and is the source of fatty acid that is polyunsaturated or also the main source of bioavailability animal protein *(Kaur et al., 2017)*. The medicinal plant of solanum nigrum also referred to as "European black nightshade" or "black nightshade," is a member of the Solanaceae family, it is the source of therapeutic drugs and consumed as leafy vegetable or fruit *(Chhon et al., 2020)*. *Solanum nigrum* extract has medicinal qualities such as antibacterial, anti-inflammatory and anti-cancer and it includes a variety of phytochemicals including terpenoids, alkaloids, flavonoids, anthocyanin and polyphenols *(Sudha Rani et al., 2017)*. Plant extract has been shown to exhibit antibacterial properties against spoilage and pathogenic bacteria *(Sudha Rani et al., 2017; Le Son & Yen, 2014)* and to have strong immune-stimulating impacts *(Sudha Rani et al., 2017)*.

1. Spirulina is an organism that mostly grows in salt and freshwater. It is a single celled microbe commonly known as blue green algae. It is combined with minerals and vitamins and strong anti-inflammatory or antioxidant properties that prevent it from various allergies and infections. Spirulina powder improves the overall immune system and helps protect against cell damage in the body.
2. Active Turmeric Capsules (60 Capsules) - It is a natural antioxidant that acts as a regulator of immune response. These active turmeric capsules as a dietary supplement to boost immunity.
3. Moringa capsules - are excellent antioxidants, act as immunity booster or prevent cells from damage. These capsules are made from leaf extract and are rich in vitamin c, fiber, magnesium, or vitamin A etc. Different brands of products and supplements that strengthen the immune system *(Wagner et al., 2020)*.

- Immune System Booster Kit - Chirayu Pharmaceuticals: This line of immune boosters is designed to promote overall health and wellness. The pack contains Lungs Care syrup, Respiscan tablets, Giloy powder or Fitness Malt Tonic *(Khabour & Hassanein, 2021).*
- Ayurvedic Chyawanprash Pills for Immunity and Energy- Formulated with the extract of 21 ingredients of Chyawanprash, these multivitamin capsules are mainly designed for the modern lifestyle.
- Cipla Immune Boosters-This is completely available in vegetarian form and is ideal for children aged 7 and up. It was developed to support the development of children's immunity. It is available in the form of chocolate, so it is suitable for the taste of children.

6. Mechanism of boosting immunity:

The best defence against viruses is the immune system. Additionally, certain nutrients and tracing elements, such as iron, selenium, vitamin B12 or B6, E, D, C, D, E are used to strengthen our immunity *(Cameron et al., 2008).*

6.1.1 Vitamin C:

Cells, tissues, organs and chemicals are a complex network that form immune system that has evolved to protect or prevent the host from a wide range of pathogens including microbes, parasites *(Parkin2001, n.d.).* Numerous immune system functions, particularly immune cell function, have been linked to vitamin C over the course of more than 50 years of research *(Maggini et al., 2007; Webb & Villamor, 2007)*. Clinical experiments have shown that high vitamin C concentrations are useful in fighting off the common cold *(Ran et al., 2018)*. Scurvy, which can be fatal, is caused by a severe vitamin C shortage. Scurvy patients are particularly vulnerable to pneumonia and other potentially fatal infections *(Hemilä, 2017).* The major role of the skin is to protect the body from viruses and other external disturbances, among its many other vital duties. Vitamin C concentrations in skin are millimolar, with the epidermis containing larger amounts than the dermis (*McArdle et al., 2002; Rhie et al., 2001; Shindo et al., 1994)*. Because of its antioxidant qualities and contribution to the manufacture of collagen, which is necessary for the stabilization of epithelial barriers, vitamin C modulates the immune system *(Jacob et al., 1991)*. In addition to having an immunostimulatory impact on lymphocyte cells, it contributes to phagocytic activity *(Thomas & Holt, 1978).* Leukocytes contain a significant amount of vitamin C, which is quickly used during infection *(Anderson et al., 1980; Levine et al., 1996a)*. Leukocytes have a significant role in the healing of wounds, particularly neutrophils and macrophages generated from monocytes *(Martin & Leibovich, 2005)*. Neutrophils move to the wound site during the initial inflammatory phase to sterilize it by releasing antimicrobial proteins and reactive oxygen species (ROS) *(Wilgus et al., 2013).* To combat the exceptionally high levels of oxidative stress to which neutrophils are subjected as a result of reactive oxygen species generation, neutrophils must have high quantities of vitamin C *(Levine et al., 1996b; Levy et al., 1996)*. To kill germs, ROS are produced during the respiratory burst to kill infection and their production is increased during an inflammatory reaction. However, in long-lasting wounds that refuse to heal, like those found in diabetics, neutrophils continue to persist and instead undergo necrotic cell death, that extend the inflammatory response and prevent wound healing *(Wilgus et al., 2013)*. Many crucial aspects of neutrophils function, including movement in responses to inflammatory mediators (chemotaxis-Chemotaxis or chemokinesis are two terms used to describe different types of neutrophil movement or migration in response to chemical stimuli.),microbe death and phagocytosis[After migrating to the infection site, neutrophils move on to engulf the invasive pathogen], and apoptosis[The process of

programmed cell death occurs in neutrophils] *(Fox et al., 2010)* and clearance by macrophages, are thought to be influenced by vitamin C.

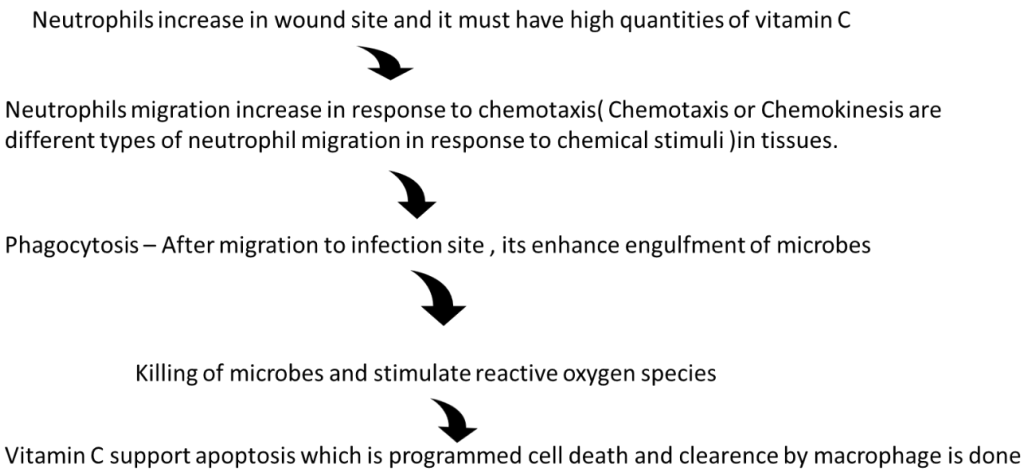


Fig.3. Vitamin C role in phagocytic function

6.1.2 Vitamin D:

Vitamin D which is fat soluble and is necessary for well-being and proper functioning of immune system. By sun exposure or consuming enough vitamin D-rich food one can achieve appropriate levels of vitamin D in the body. Smoking, age, being overweight, and having a chronic illness like high blood pressure or diabetes are the factors due to deficiency of vitamin D *(Siuka et al., 2020).* The prevalence of deficiency of vitamin D is still high; a study of teenagers in many European nations concluded that vitamin D amounts in 80% of participants were insufficient. Additionally, more than 40% were deemed deficient *(González-Gross et al., 2012).*

Additionally, a case study with 10 COVID-19 patients was carried out in Indonesia *(Pinzon et al., 2020).* Nine individuals exhibited vitamin D insufficiency, and one had inadequate vitamin D levels, according to blood analysis. Therefore, no patient in the study had sufficient amounts of vitamin D. This suggests that lack of vitamin D may increase the chance of contracting a virus. The main form of vitamin D seen in serum, 25-hydroxyvitamin D (25D), is main metabolite of vitamin D that is typically tested. 25-hydroxylation of dietary or cutaneous vitamin D, which is mostly catalyze by CYP2R1 as well as other enzymes, produces 25D *(Cheng et al., 2004; Zhu et al., 2013)*. The special 1α-hydroxylase CYP27B1 produces the metabolite 1,25-dihydroxyvitamin D (1,25D) the active form of vitamin D in peripheral tissues in a controlled way *(Zehnder et al., 2001).* A number of immunological inputs affect the expression of CYP27B1 in immune cells. Local synthesis of 1,25D from circulating 25D occurs in monocytic cells and is regulated by signaling from pattern recognition receptors. Almost 2000 study by Mathieu and colleagues that demonstrated that induction of interferon and bacterial lipopolysaccharide (LPS) will help in murine Cyp27b1 expression, there were the first convincing evidence for the significance of 1,25D signaling in innate immunity which is a T cell cytokine released by proinflammatory Th1 cells (*Overberg et al., 2000)*. In innate immunity defense, 25D controls the production of numerous genes, including those encoding chemokines, cytokines, pattern recognition receptors and antimicrobial peptides, when coupled to the vitamin D receptor (VDR). There are some transmembrane or intracellular or proteins known as Pattern recognition receptors (PRRs) that detect endogenous danger-associated chemicals such extracellular ATP, cytoplasmic or endosomal DNA, RNA as well as patterns which were specific to microorganisms

(Spychalowicz et al., 2012). As a result, they are the innate immune system's "first responders as ligand binding to PRRs causes a series of signaling processes to be triggered, alerting the cell to an infection. Additionally, 1,25D prevents an overactive immune response by reducing the synthesis of cytokines that promote inflammation, such as IL-6. Furthermore, 1,25D can cause autophagy, which enhances bacterial killing.

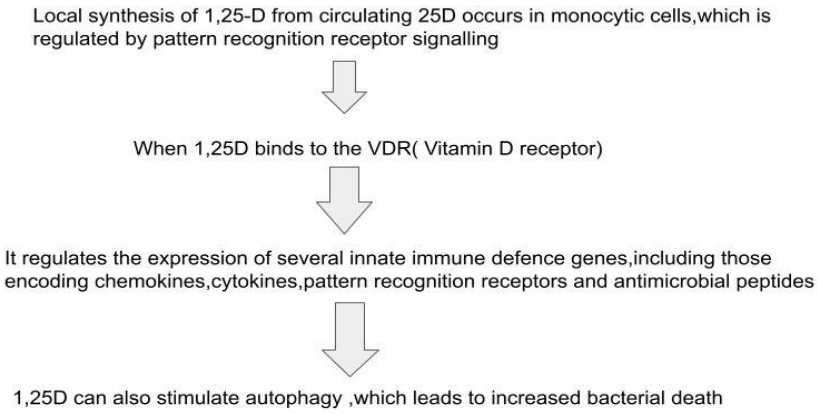
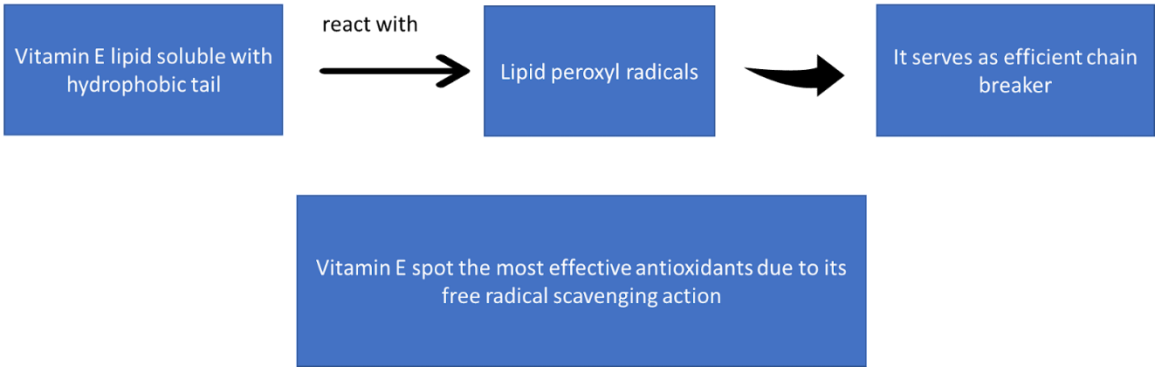


Fig.4. Mechanism of Vitamin D in bacterial infection

6.1.3 Vitamin E:

Vitamin E is a rich source of antioxidants and maintains the overall health by preventing it from viruses, infection and bacteria. Vitamin E tends to assemble inside lipid membranes because it is a lipid-soluble molecule with a hydrophobic tail. Lipid peroxyl radicals react with it significantly more quickly than they can with neighboring fatty acid side chains, since it serves as the most significant chain breaker there. Due to its effectiveness in avoiding oxidative damage through its free-radical scavenging action, vitamin E holds the top spot among the antioxidants studied in mouse influenza virus infections, and in multitarget influenza therapy it may be suggested as a component *(Lindschinger et al., 2019)*.



6.1.4 Magnesium and Zinc:

The average person's body has 2 milligrams of zinc. It is well absorbed in meat, fish, nuts, legumes, and eggs, but it is not totally absorbed in grains *(west, 2018)*. For immune cells to operate, zinc is essential for the production and stability of DNA, RNA, and proteins as well as for cell development and differentiation and the protection of antioxidant *(Iwata et al., 2004)*. A severe effect of zinc deficiency on the bone marrow is the reduction of immune cell progenitors *(Fraker et al., 1993)*. Cytokines production by monocytes and t-cells depends on zinc. Therefore, it is crucial for the immune system to work at its best. Magnesium, a mineral that is very important for the immune system. It is an important source of energy in our cells that cannot function properly. Innate immunity, including phagocytosis, the production of naturally occurring killer cells and respiratory bursts is all impacted by zinc deficiency *(Fraker et al., 1993)*. Significant consequences of zinc deficiency also have an impact on acquired immunity, which results in reductions in T-cell circulation and functioning.

Iron /Zinc /copper - contain or increase - Neutrophils or Selenoproteins - Immunity Boost

6.1.5 Vitamin B:

Health, as well as the prevention and treatment of various illnesses, are all correlated with appropriate diet. The nutrition equation includes getting the necessary vitamin intake each day, and B vitamins are crucial for preventive care. Diary or meats, whole or enriched grains, green vegetables a healthy metabolism is aided by vitamin B and these are also connected to a reduced risk of vitamin B complex which comprises 8 water soluble constituents are riboflavin (B2), thiamine (B1), niacin (B3), biotin (B7), pyridoxine (B6), Cobalamin (B12), folic acid (B9), pantothenic acid (B5) *(Brown & Beier, 2018)*. Among all those vitamins, especially, B6, B9, and B12, play a role in our body's initial response after it detects a disease. They accomplish this by affecting "natural killer" cell development and activity. Natural killer cells function by inducing apoptosis, or the death of infected cells, in order to "implode" the infected cells *(Malouf & Grimley Evans, 2003)*.

Vitamins A, B6, B9, B12, C, D -Protect or development/formation - Antibodies or Antioxidants - Immunity Boost

Table2. Sources of vitamins and nutrients

Minerals and vitamins	Sources	References
Zinc	Sea foods and nuts	*(Charan et al., 2012)*
Iron	Raspberry, apple, legumes	*(Khanna et al., 2021)*
Selenium	Sea food, diary, fruits and vegetables	*(Chung et al., 2020)*
Vitamin A	Mango, sweet potatoes, pumpkins	*(Suresha & Vasudevan, 1994)*
Vitamin C	Broccoli or citrus fruits such as lemon, oranges, tomatoes	*(Rasmussen et al., 1994)*
Vitamin D	Egg yolk, red meat, fishes	*(Rasmussen et al., 1994)*
Vitamin E	Vegetables, sunflower seeds, nuts	*(Anywar et al., 2020)*

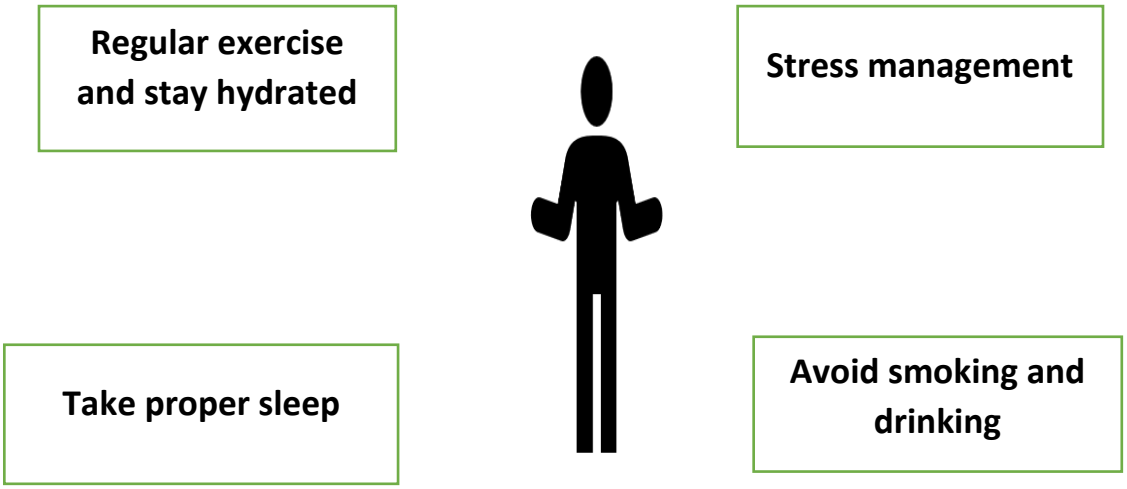
7. Immune suppressing agent:

Alcoholic and caffeinated beverages- The ability of your immune system to combat infection and get rid of aberrant or damaged cells can be harmed by drinking alcohol and coffee. Omega-6 fatty acid-rich foods - our body needs both omega- 3 and omega- 6 fats to function correctly *(Alagawany et al., 2019).* While diets high in omega-3 fast suppress the production of those proteins and promote immune function, diets high in omega-6 fats tend to suppress the expression of pro-inflammatory proteins, which may harm immune function. A heightened immunological response, increased gut inflammation, and changed gut flora composition have all been linked to some artificial sweeteners. Sucralose and Saccharin, two artificial sweeteners, have been associated with bacterial imbalances in the stomach. The immune system may suffer if artificial sweeteners are used excessively. *(10 Foods That Can Boost Your Immunity and 3 Of Your Favorites That Can Hurt," 2022).*

8. Other Methods for Boosting Immunity

A. Regular Exercise: Exercise frequently; even light exercise will help the body to release toxins or it improves metabolism to boost immunity It can also avoid blood clots, which have been described as a symptom in certain COVID-19 patients *(Clerkin et al., 2020)*. Physical activity generally improves immune function response, strengthens antioxidative capacity, lowers the level of oxidative stress, and boosts the effectiveness of energy generation, which lowers the incidence of inflammatory disorders *(Nieman & Wentz, 2019).*

B. Adequate Sleep: It requires at least 7 to 8 hours of sleep per day and is the best way to develop immunity. Lack of sleep impair brain activity and will make you tired. If body wouldn't be able to rest properly which will affect other body functions that directly affect immunity *(Kamdar et al., 2016).* Also, during the Spanish Flu Pandemic, doctors believed that sleep was extremely crucial to their patients' recovery.



C. Stress Management: (Distress yourself) Try to avoid all forms of stress; there are some frequent stress-relieving activities we can engage in; and stress is known to have a negative impact on immunity *(Salleh, 2008).*

D. Hydration: Keep hydrated by drinking up to 8 to 10 glasses a day. This will help to reduce toxins in the body, flush them out, and reduce the risk of getting flu infection. People may also utilize coconut water and juices produced from citrus fruits to stay hydrated. These drinks are rich in vitamins and minerals *(Alkhatib, 2020)*.

E. Reduction of Inflammation

F. Practice yoga or meditation: Being under a lot of stress can cause the release of the hormone cortisol, which will impair your ability to react to your immediate environment and make you more susceptible to infections, which will cause anxiety (*Bae et al., 2019).* Meditation can reduce stress, and it has been proven that yoga or meditation can calm all the nerves.

G. Avoid smoking, drinking alcohol, and other supplements or substances: These behaviours weaken the body's immune system and increase the risk of respiratory illnesses. They also destroy the cells that line the respiratory tract, which are essential for fighting viruses that enter through nasal orifices. In addition, heavy drinkers are more likely to experience a condition called acute respiratory distress syndrome *(Shifa Nizami & Mujeeb Uddin, 2020)*.

9. Discussion:

The aim of this review article was to evaluate the effectiveness of various immunity boosters in enhancing the immune response and preventing or managing infectious diseases. The immune system plays a crucial role in defending the body against pathogens and maintaining overall health. With the increasing prevalence of infectious diseases and the desire for improved health and well-being, the use of immunity boosters has gained significant attention.

The findings of this review indicate that several immunity boosters have shown promise in enhancing immune function. One such booster is vitamin C, which has been extensively studied for its immune-enhancing properties. Vitamin C acts as an antioxidant and helps stimulate the production of white blood cells, which are vital for immune defense. Numerous studies have demonstrated that vitamin C supplementation can reduce the duration and severity of respiratory tract infections, such as the common cold. Another immunity booster that has gained popularity is vitamin D. This vitamin plays a crucial role in modulating the immune response and has been linked to a decreased risk of respiratory tract infections. Several studies have reported that individuals with low vitamin D levels are more susceptible to infections, and vitamin D supplementation can help reduce the risk and severity of these infections. However, more research is needed to determine the optimal dosage and duration of supplementation for maximum immune benefits. The aim of this review article was to evaluate the effectiveness of various immunity boosters in enhancing the immune response and preventing or managing infectious diseases. The immune system plays a crucial role in defending the body against pathogens and maintaining overall health. With the increasing prevalence of infectious diseases and the desire for improved health and well-being, the use of immunity boosters has gained significant attention.

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supplementation can reduce the duration and severity of respiratory tract infections, such as the common cold. Probiotics are another category of immunity boosters that have shown promising results. These live microorganisms help maintain a healthy gut microbiota, which plays a vital role in immune function. Studies have indicated that certain strains of probiotics can enhance immune response and reduce the incidence and severity of respiratory and gastrointestinal infections. However, further research is required to determine the specific strains, dosages, and duration of supplementation that are most effective.

In addition to these specific immunity boosters, maintaining a healthy lifestyle is essential for overall immune health. Regular exercise, adequate sleep, stress management, and a balanced diet rich in fruits, vegetables, and other nutrient-dense foods are crucial for optimal immune function. These lifestyle factors contribute to a strong immune system and can enhance the effectiveness of immunity boosters. It is important to note that while immunity boosters can provide support for immune function, they should not be considered as standalone treatments or preventive measures against infectious diseases. Vaccinations, proper hygiene practices, and adherence to public health guidelines remain the primary methods for disease prevention.

10. Conclusion

In conclusion, this review highlights the potential benefits of various immunity boosters in enhancing immune response and preventing or managing infectious diseases.Plant-based methods effectively boost the immune system due to their high nutrient content and immune-boosting properties.Consuming a variety of plant-based foods, such as citrus fruits, leafy vegetables, berries, nuts, seeds, and legumes, can provide the body with essential vitamins and minerals that support optimal immune system function. Vitamin C, vitamin D, and probiotics have shown promise in strengthening immune function, but further research is needed to optimize their use. Additionally, maintaining a healthy lifestyle is crucial for overall immune health. It is important to approach immunity boosters as adjunctive measures rather than sole solutions, and public health measures should still be prioritized for disease prevention.

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