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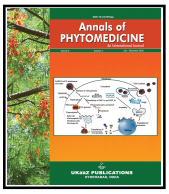

Special invited review article: Open access

Importance of vegetables as healthier diet in the management of COVID-19 pandemic

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Abstract

COVID-19, a viral outbreak has taken toll on millions of lives in a very short span of time. This spread can be mainly due to ease of travel. Remedy for viral infections is extremely difficult as they keep changing their characteristics often. Though, vaccines have been under study for coronavirus, none has been approved yet. Till then, nutritional supplement is the only way to protect the human body against such lethality. As per World Health reports, every year about 2.7 million deaths occur due to poor diet lacking in enough and essential dietary fibres, vitamins and minerals received from vegetables and fruits. Immune system must be improved and developed through proper dietary management. Recommended diet includes green, low fat, vegetarian foods to boost immunity. They contain variety of nutrients including vitamins, minerals, fibre and many phytochemicals. These secondary metabolites and phytochemicals constitute a major part in developing immunity. Phytochemicals are the most important element in the pharmaceutical and medical industry too. Intake of water, vitamins like A, C, B complex, minerals like zinc and magnesium and other micronutrients keep the infections at bay. Thus, including foods rich in these substances help to fight diseases including cancer, diabetes, cardiovascular disorders, *etc*. The nutrients from vegetables like tomato, onions, bell peppers, crucifiers, *etc*., and medicinal crops like turmeric, ginger and garlic combat against these viral infections.

1. Introduction

1.1 Coronavirus: Epidemiology and pathophysiology

COVID-19 is a world wide pandemic that is considered as 'once in a century pandemic' that has costed more than 1 million lives with approximately 50 million of people contracted this deadly virus. It is caused by severe acute respiratory syndrome virus (SARS-CoV2), virus originating from Wuhan, China (Zhu *et al.*, 2020). It is enveloped by a single stranded RNA of the coronavirus family. This family subdivided into four genera as alpha, beta, delta, and gamma; of which alpha and beta cause COVID-19 in humans (Weiss and Leibowitz, 2011). This viral infection affects the respiratory tract of humans leading to fever, cough, lung infection, *etc*., and eventually causing death in worst cases. Transmission of the virus occurs mainly through human contact *via* infected droplets from cough, sneeze, saliva and faeces matter. It is also proved that virus lives for up to 3 days in non living things that have been in contact with the virus (Li *et al.*., 2020).

The pathophysiology of the disease is described below. The virus primarily attacks the respiratory tract by creating an association with the epithelial cells of the lungs. Replication of the virus in the nucleus forms new viral proteins that increase the severity of the infection (Tang *et al.*, 2020). The main symptoms of COVID-19 are onset of fever, cough, breathing difficulty, anosmia and fatigue. In severe cases, pneumonia is developed with severe symptoms, causing acute respiratory disorders (Huang and Wang, 2020).

1.2 Coronavirus: Testing and treatment

Testing methods vary for different circumstances. Nucleic acid testing is considered as the gold-standard method for diagnosis stage. RT-PCR is used to identify and amplify the viral load in lesser time. Antigen test kits are developed that uses nasopharyngeal or oropharyngeal swabs to detect the viral load (Pan *et al*., 2020; Wölfel *et al*., 2020; Kim *et al*., 2011). These locations are chosen as they contain maximum quantity of virus. The specificity of the test is high whereas the sensitivity is low, leading to many false positive results. Antibody test kits are used to identify IgM and IgG antibodies and these data can be used to identify plasma donors (Wu *et al.*, 2020).

Treatment of COVID-19 involves various stages depending on the severity of the viral infection. Patients with asymptomatic illness and mild symptoms like fever, cough, fatigue, *etc*., needs to self-isolate themselves and requires no further clinical treatment until their condition worsens. Patients with moderate and severe illness suffering with different levels of breathing difficulty require medical supervision as their health deteriorates. Antiviral drugs, immunotherapy and oxygen therapy is applicable at this stage of disease. Critical illness includes disorders like acute respiratory distress syndrome (ARDS), cardiac distress, *etc*. At this stage, failure of multiorgans is seen. Various treatments and procedures are preferred. N95 respirators and other PPE (personal protective equipment) like gloves, masks, gown, eye protection, face shield,

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etc., are essential for the patients and those in contact with them. High flow nasal cannula oxygen, mechanical ventilation, norepinephrine, dexamethasone, *etc*., are recommended. Immunotherapy uses the antibodies of SARS-CoV2 or plasma for the treatment. Therapeutic treatment includes usage of antiviral drugs which are still under study. Favipiravir is one of the drugs approved by National Medical Products Administration of China. Production of vaccine for COVID-19 is very difficult as it usually takes many years to be out in market. Many vaccines have been developed and a few of them are under trial. None of the vaccine has been approved to be used against the virus yet (Corum *et al*., 2020). Thus, till the advent of a successful vaccine or therapy, the only possible way to keep us away from the diseases is undertaking nutritious way apart from social distancing and isolation.

1.3 Boosting immune system

Foods improving immunity of a person should be included in the diet. Plant based foods increases the immune system of the body. It improves the gut microflora and helps fight infections. Immune system is the most important working of human body against an infection; especially bacteria and virus. This system activates when a foreign body enters the body. To keep the immune system hale and healthy, nutrition is the topmost priority. Poor nutrition increases the infection and its susceptibility. Immune function decreases with age and depleting nutrition. Deficiency in vitamins, minerals, protein, omega-3-fatty acid, fibre, *etc*., reduces the capability of the immune system. This virus affects infants and old age people in larger proportion; whose immune system is weak (Patel, 2020). Micromanagement of diet is crucial to boost the immunity against COVID-19. Consumption of low fat, plant-based foods inflates the immunity. Studies show that vegetarians produce more white blood cells than non-vegetarians (Davison *et al.,* 2016). Canned foods with high salt content, junk foods, oily foods, carbonated drinks should be avoided in general. To keep the virus at bay, avoiding food from outside is essential. Disinfection process is highly required.

A recent trend of following 'Functional foods' for the improvement of overall health is increasing among the people. The health benefits of such foods are indispensable and inexhaustible. Vegetables and fruits are especially rich in all the essential nutrients like vitamins, minerals and other phytochemicals. These nutrients in general provide improvement in many health disorders like heart diseases, cancer, diabetes and cholesterol, immune dysfunction, *etc*. These nutrients provide protection against these diseases by following certain mechanisms that modify or change the foreign body's metabolism; thereby restricting their growth and replication. Constituents of water soluble vitamins are essential for emotional well being (Kaplan *et al.,* 2007). Constituents of fat soluble vitamins, especially beta carotene and its components are essential in providing protection for the body against oxidative stress, inflammatory responses, *etc*. (Miller, 2011).

The vegetables chosen for the discussion in this review paper are crucial and fundamental for boosting immunity. The goodness of these commonly available vegetables has discussed in detail. Beetroots are known for its disease preventing and health promoting nature. Bell peppers are rich in its antioxidant properties from phytochemicals. They are available throughout the world. Tomatoes are rich in lycopene content that is highly required to maintain the immune system healthy. They provide great radical scavenging property. Broccoli is one of the unexplored, most nutritious vegetables. It is abundant in vitamin A, C and iron that helps in boosting the immunity. Carrot is one of the vegetables that is ranked among top ten grown crops across the world, meaning it is highly consumed and easily available. It is of high commercial value due to the amount of nutrients present in them. Eggplants are ranked high as a nutrient rich vegetable with providing a variety of nutrients like fibre, vitamins, minerals and phenolic compounds. Apart from vegetables, a few immune boosting medicinal crops like ginger, garlic and turmeric are also discussed in this review. Ginger and turmeric are strong anti-inflammatory agents. They induce the functioning of immune cells. This study reveals many mechanism and processes of the vegetables that enhances their potential of becoming chief immune boosters.

2. Immunonutrition diet against COVID-19

Nutritional status of an individual determines the nutritional status of a nation. Many factors like age, sex, lifestyle, health, *etc*., determine the nutritional status. Various nutrients like zinc, magnesium, iron, vitamins A, B, C, E, *etc*., help increase the immunity. Foods that increase the immunity in general are fruits (apple, melon, papaya, *etc*.), vegetables (bell peppers, garlic, lime, ginger, broccoli, *etc*.), whole grains and nuts, *etc*. Some of the important components that boost immunity are discussed below:

2.1 Vitamin A

Vitamin A is composed of a chemical structure called retinol which is acquired by the diet as carotenoid or provitamin A (Tang, 2010). The most active form of retinol is retinoic acid. Vitamin A promotes the functioning of T-cells, which improves the immune response against many viral diseases (Weiss *et al*., 2015; Jayawardena *et al*., 2020). Vitamin A is also known for its antioxidative and antimicrobial properties. It induces the production of interleukins like IL-1and IL-1β against virus. It also has the capacity of pulmonary regeneration during its mechanism (Yang *et al*., 2015). Retinoid develop innate immunity *via* an interferon mechanism (Trottier, 2009). Animal studies indicate to increase the immune responses against COVID-19 virus through vitamin A supplements (Jee, 2013). Some good vegetable sources of vitamin A are carrots and sweet potatoes.

2.2 Vitamin B

Vitamin B is often referred as B complex in supplementations; which plays an important role in cell mechanisms and also involve in immune cells and improve the inflammation conditions (Spinas *et al*., 2015). Vitamin B1 and B3 induces the production of some or all of IL-1β, IL-1, IL-6, COX-2, and TNF-α. Vitamin B2 and B7 regulates inflammatory mechanisms. Vitamin B6 especially is involved in T cell mechanism. B6 and B12 play a key role in innate and adaptive immune responses. Computational studies suggest that proteins 3-C-like protease (M-pro) and a papain-like protease (PL-pro) on COVID virus are counteracted by vitamin B 12 through bindings and dockings (Kandeel and Al-Nazawi, 2020). Vitamin B complex is found in vegetables like potato, chilli peppers, green leafy vegetables, *etc*.

2.3 Vitamin C

Vitamin C (ascorbic acid) is associated with boosting immunity. It treats inflammations caused due to infections. It acts in phagocytosis and chemocytosis through T-lymphocyte mechanism. Vitamin C acts as antioxidant in lungs (Erol, 2020). 90 mg/day for men and 75 mg/day for women is the RDA. Vitamin C supports the immunity system of the body by reducing the time period of the disease and also its potency and severity. Vitamin C has antiviral activity to an extent; also aiding innate and adaptive immunity (Webb, 2007). Some of the good vegetable sources of this nutrient are bell peppers, spinach, cauliflower, eggplant, green vegetables like broccoli, mushrooms, *etc*., develop the immunity in human body.

2.4 Vitamin D

Vitamin D helps in constricting microbial infections. Since vitamin D's pathway consist of various steps, its potency is reduced many folds. Thus, vitamin D decreases the viral infection by declining its mortality (Pike and Christakos, 2017). Viruses usually destroy the gap junctions and promote viral infection growth and affect the cell. This is protected by vitamin D mechanisms. This is done in 3 ways, namely; adaptive immunity, physical barrier, and natural cellular immunity. Vitamin D turns into 25 (OH) D in the liver and 125 (OH) 2D (calcitriol) in kidney or any other organ. Studies show that 125 (OH) D restricted rotavirus, *in vitro* and *in vivo*. Similarly, vitamin D supplements controlled common cold and restricted dengue to a certain extent. Innate immunity of an organism is also improved by vitamin D as it introduces 125-dihdroxyvitamin D into antimicrobes which induces antimicrobial activity (Beard, Bearden and Striker, 2011). Vitamin D also induces the production of T-1 helper cells and T-2 helper cells. These in general encourages T regulatory cells, thereby suppressing the inflammatory responses. Less exposure to sunlight decreases the levels of 25 (OH) D. Vitamin D supplements also increases the generation of antioxidant and glutathione, which is an antimicrobial supplement recommended against COVID-19 (Holick, 2007). Many kinds of mushrooms are a good source of Vitamin D.

2.5 Vitamin E

Vitamin E is composed of many kinds of tocopherols; maintaining the overall health of a person, especially the immune system. These tocopherols act as antioxidant. It protects against bacterial and viral infections. It functions primarily by controlling the lipid peroxidation by protecting the PUFA in membranes (Liang *et al*., 2003). Vitamin E has positive effect in treating upper respiratory disorders. Supplementing vaccines along with vitamin E has supreme efficacy (Meydani, 1997). Good sources of vitamin E are green leafy vegetables like broccoli, asparagus and spinach. The complex of vitamin C and E have a great potential as immune boosters against virus.

2.6 Zinc and magnesium

Zinc is one of the most important minerals that aids in production of immune cells, in innate and adaptive responses (Wessels *et al.*, 2017). It also aids in T-cell function. Magnesium (Mg) also plays a key part in regulation of immune system. Mg is also involved in the respiratory and circulatory system; where it helps in the delivery of oxygen; thereby playing an important role in COVID-19. Mushrooms, green beans, asparagus and kale are good source of zinc. Spinach, okra and potatoes are good source of magnesium.

3. Vegetables boosting immunity

Vegetables contain a complex of nutrients like vitamins, minerals, fibre, phytochemicals, *etc*., they act as nutraceuticals improving the condition of entire body and all organs. Vegetables are very important in boosting immunity as they possess high antioxidant, anticarcinogenic properties. They fight against free radicals in body. Different vegetables possess different nutrients; therefore, all of them must be consumed on a regular basis. Micronutrients such as Vitamin C, carotenoids, *etc*., have a prime role as antioxidant, treating degenerative diseases, inflammatory disorders, some cancers, *etc*. (Raison and Miller, 2011). Some of the vegetables that boost the immunity against COVID-19 are discussed below:

3.1 Tomato (*Lycopersicon esculentum* Mill.)

Tomato is one of the major vegetables used in Indian diet (Figure 1). Since it is a non starchy vegetable, its high consumption regulates diabetes and cholesterol. Studies on animals and humans suggest that tomato rich diet increased HDL cholesterol by 15% and decreased the LDL cholesterol by 8% (Periago *et al*., 2008). Tomatoes contain all four carotenoids (alpha- and beta-carotene, lutein, and lycopene). Since all are present, the synergetic effect on body is huge. The brightest shade of tomatoes has maximum lycopene and beta-carotene in them (Figure 2). It has good antioxidant property and filled with vitamins and minerals that make them a powerful immune booster (Freeman and Reimers, 2010). Ascorbic acid is present in huge quantities in tomato after citrus crops. This improves the immunity in body. Vitamin C and A present in tomatoes make up for 40% and 15%, respectively of daily recommended intake of that vitamin (Bhowmik *et al*., 2012). Minerals like potassium, magnesium, iron and phosphorus are rich in tomatoes contributing to good functioning of nervous system and muscles. 8% of potassium and 7% of iron from RDA is found in tomatoes. Tomatoes are made up of phytochemicals like carotenoids consisting 60% of lycopene, 10% of phytoene, 10% neurosporene and 15% carotenes (Clinton, 1998). Lycopene accounts for the antioxidant property in them. These antioxidants neutralize the free radicals present in body that has the capacity to destroy the healthy functioning body cells. Lycopene is found mostly on the walls of the vegetable and the body absorbs it better when cooked in olive oil according to a study conducted by Ohio State University.

Apart from this goodness, they offer anti-inflammatory and anti-thrombotic functions (Shidfar *et al*., 2011). They also protect body from cardiovascular diseases, osteoporosis and skin diseases. The leaf, stem, roots of the plant have phenolic compounds like gallic acid, chlorogenic acid, ferulic acid, caffeic acid, rutin, and quercetin. These are said to have antiviral effects. Chlorogenic acid and coumaric acid present in tomatoes hinders the effect of nitrosamine, which reduces the risk of lung cancer; also, by rectifying the damage done by smoking (Bhowmik *et al*., 2012). Research conducted in the University of Montreal revealed that when people consumed diet with high quantities of tomato, it prevented pancreatic cancer. Vitamin K along with calcium present in tomatoes strengthen bone functioning. Researchers found that intake of certain amount of tomato per day reduce the risk of several cancers including prostrate, renal, stomach, lungs and breast. Studies conducted in France indicate that human intestinal cells absorb more carotenoids from tomato with peels rather than

without the latter. The major advantage of this fruit is that it does not lose its nutritional value while cooking, canning or any such processes. Also, its bioavailability increases after cooking contrasting to other vegetables, thereby making it easier and desirable to consume more.

Figure 1: Bunch of tomatoes.

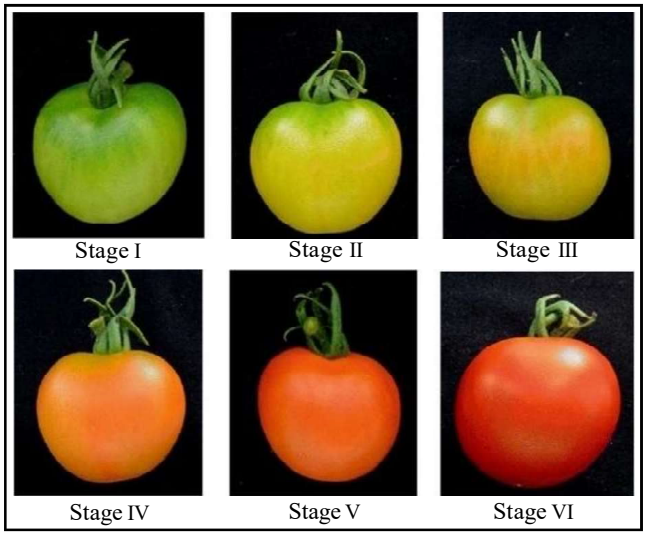

Figure 2: Ripening stages of tomato.
(**Source:** Gawande and Thengane, 2018)

3.2 Bell pepper (*Capsicum annum* L.)

Bell peppers, native of America are used medicinally for many uses (Figure 3). They are available in different colours: green, yellow, orange, red, *etc*. (Igbokwe *et al*., 2013). They possess compounds of interest like β-carotene and other important carotenoids; capsantine, capsorubin, and cryptocapsin (Deepa *et al*., 2006). These chemicals offer to destruct free radicals. Along with these are found other flavonoids like quercetin, luteolin, and capsaicinoids that prevent oxidative damage and provide antioxidant properties (Hasler, 1998). All the above mentioned phytochemicals contribute to preventing diseases like cancer, CVD, diabetes, *etc*. Carotenoids and flavonoids work as anti-inflammatory agent (Blanco-Rios *et al*., 2013). Of all the carotenoids, lycopene content is higher in peppers. It is rich in antioxidants and has chemotherapeutic and anti-inflammatory properties, antimutagenic properties (Sancho *et al*., 2002). One of the special properties of lycopene is that they cannot get converted into vitamin A; thus, available completely for free radical scavenging (Cruz *et al*., 2013). Research suggests that red bell peppers extract induced B-cell proliferation and, thus increases the immunoglobins concentration. Similarly, increase in T-cells and macrophages were seen (Moklesur *et al*., 2010). One research conducted in Japan found that the production of immunoglobins (IgM in B cells) increased by many folds when the specimen (mice) was introduced with the extracts of red bell peppers. This study also reveals that the active component of the pepper extract is a heat sensitive, non-protenious substance. Bell peppers are a very good source of vitamin A, C and K. They boost the immune system apart from being anticancerous and antioxidant (Bosland, 1996). About a cup of red bell peppers has 150% of vitamin C of RDA.

Vitamin C is the most important nutrient to boost immunity and fight microbes. Vitamin K helps against oxidative damage along with clotting mechanisms. Rich in vitamin C, bell peppers act as a strong immune boosting crop. Studies by many people suggest that the quantities of β-carotene are higher in red coloured varieties followed by orange, yellow and found least in green peppers (Marin *et al*., 2004) (Figure 4). The vitamin C content is higher at the initial stage of ripening of the vegetable and decreases due the course (Markus *et al*., 1999). Lycopene content is highest in red variety, followed by yellow and orange and lowest in green varieties. It is found that lycopene is nine times more in red peppers than in green peppers (Igbokwe *et al*., 2013). Antioxidant content is found higher in red peppers followed by green, orange and yellow (Sun *et al*., 2007). This concentration is dependent on the concentration of total phenols found in the peppers as the vegetable ripens. Bell peppers can be used to increase the antibody production and, thereby destroy infections caused by virus and bacteria.

Figure 3: Bell pepper.

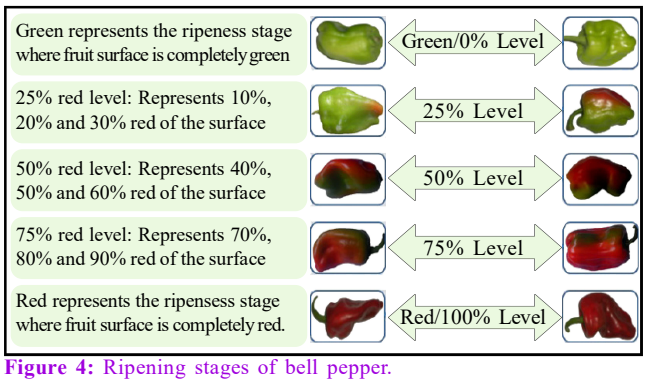

Figure 4: Ripening stages of bell pepper.
(**Source:** Hariri *et al*., 2014)

3.3 Carrot (*Daucus carota* L.)

To develop immune system, proteins and lipids play a major role in immune system which is gathered from legumes and such foods. But vitamins and minerals are gained only from vegetables. Such important nutrients are very rich in carrots (Table 1). Carrots belong to Apiacea family (Nguyen and Nguyen, 2015). They consist of stem and root, of which roots are the widely consumed part of the plant. Carrots are found in different colours like yellow, orange, white, purple, *etc*. (Figure 5). The most consumed orange carrots are rich in provitamin A and beta carotene (Dias, 2012). Red carrots are rich in lycopene. Purple carrots are rich in anthocyanins (Sun *et al*., 2009). Phenolic compounds and its role in immune system are indispensable. These aromatic groups comprise of phenolic acids, flavonoids, tannins, lignans, stilbenoids, and curcuminoids (Goncalves, 2013). They have high antioxidant property and play a vital role in defence mechanism (Tsao, 2010). Consumption of these phenolic groups has relation to antiageing, anti-inflammatory, anti-carcinogenic and antiproliferative effects (Soto-Vaca *et al*., 2012).

Apart from these effects, it also aids in the management of diabetes, BMI (body mass index) and cholesterol (Wright *et al*., 2013). Carrots are mainly known for their vitamin A concentration. One carrot has upto 400% of RDA of vitamin A. Carotenoids present in carrots is highly bioavailable, making it desirable for vitamin A supplementation (Van *et al*., 2000). Vitamin A restricts the entry of virus and bacteria into the respiratory tract by regulating the mucous membrane. It induces the release of WBC's and other immune cells into the body when a predator is identified. Vitamin C present in carrots also induces the immune cells and performs antioxidant reactions. Interferons, one of the most important immune cells are increased with vitamin C. Vitamin B6 is necessary for carrying information relating to immune responses that fights the infection. Vitamin E reverses ageing of cells, which increases the declining activity of immune cells. Minerals rich in carrots relating immunity are zinc, iron and copper. Zinc develops immune cells proliferation, iron backs up inflammatory process, copper increases production of WBS's. Carrots are rich in carotenoids, anthocyanin, flavonoids, polyacetylenes, *etc*. Carrot is made up of flavonoids, namely; kaempferol, quercetin and luteolin (Horbowicz *et al*., 2008). Carotenoids and anthocyanins are found in greater quantities. Carrots are rich in different types of carotenoids, namely; 'β-carotene (75%); α-carotene (23%); lutein (1.9%); and β-cryptoxanthin, lycopene, and zeaxanthin' (Soltoft *et al*., 2011). The main component in carrots is β-carotene, a phytonutrient that helps develop the immune system (Ghosh, 2020). β-carotene found in carrots inhibits the division of RNA of the virus inside the human body (Liu *et al*., 2010). It also acts an anti-inflammatory agent that increases leucocyte count and, thereby boosts immunity. Activation of lymphocytes, a type of immune cell is increased with higher intake of carrots (Wright *et al*., 2013). Polyacetylenes are a type of phytochemical found in carrots due to the presence of aliphatic C17-polyacetylenes of the falcarinol type (Christensen, 2011). These C-17 bonds provide resistance against breast and various cancers. Studies find that these compounds provide anticancerous, antibacterial, antifungal and anti-inflammatory effects (Baranska *et al*., 2013).

Figure 5: Carrots.

Table 1: Nutritional values of carrot

S.No.	Minerals	Values in mg/100 g	Vitamins	Values in mg/100 g	Macronutrients	Values in g/100 g
1	Potassium (K)	320.00	Choline (B4)	8.80	Carbohydrates	9.58
2	Sodium (Na)	69.00	Ascorbic acid (C)	5.90	Proteins	0.93
3	Phosphorus (P)	35.00	Niacin (B3)	0.983	Fat	0.24
4	Calcium (Ca)	33.00	Alpha tocopherol (E)	0.660	Energy	41 kcal
5	Magnesium (Mg)	12.00	Pantothenic acid (B5)	0.273	-	-
6	Iron (Fe)	0.30	Pyridoxine (B6)	0.138	-	-
7	Zinc (Zn)	0.24	Thiamine (B1)	0.066	-	-
8	Manganese (Mn)	0.143	Riboflavin (B2)	0.058	-	-
9	-	-	Retinol (A)	835.00 µg	-	-

(**Source:** Dias J.C., 2014).

3.4 Onion (*Allium cepa* L.)

Onion is one of the most used vegetable in everyday food. It is one of the oldest cultivated plants and is a native to central Asia (Figure 7). It is used not only for culinary purpose, but also for therapeutic purposes. Onion consists of 25 active compounds that are rich in medicinal value (Table 2). It is capable of stimulating immunity for cold, flu and other respiratory problems. Studies indicate that these compounds enhance the body's immune functions (Christy *et al*., 1996). It also has the ability to control diabetes, cholesterol and obesity. Platelet aggregation is inhibited which is involved in defence mechanism. Various cancers including breast, colon and ovarian, *etc*., are controlled due to onion extracts as they hinder replication and proliferation process of the cancer cells (Sanderson *et al*., 1999). Onions are so rich in flavonoids, fructans and organosulfur compounds that provide antimicrobial activity and antiviral activities (Goldman, 2020). Other nutrients like selenium, zinc and vitamins encourages it to

become immune booster (Agustin-Bunch, 2020). Studies show that viral infections like polio, rhinovirus, hepatitis C, ebola, SARS, *etc*., were affected by quercetin. Phytochemicals found in onions hinder the protein in virus. Flavonoids like sorhamnetin, kaempferol myricetin, and quercetin are present in onion that restricts the viral replication and distribution in body cells. Animal studies conducted by Tafteng *et al*. (2012) revealed that there is a proven positive correlation between onion extract and immune system. These extracts were fed to rats as pellets along with their regular diet. There was significant increase in CD4 cells and T cells due to the ingestion of the onion extract. Also, the WBC (white blood cells) count was drastically increased, proving enhanced functioning of immune system. Onions are rich in vitamins and minerals too. The iron content is abundant in iron that it could be used in treating anaemia. Also, used in the treatments of urinary infections and heart disease (Tripathi, 2006). When applied externally on body, it acts as antibacterial and antifungal. It is rich in calcium and chromium and other compound like allyl propyl disulfides, thiols, and isomers of allyl propyl disulphides that stimulates insulin aiding in controlling diabetes.

A compound found in onion called GPCS (2-L-glutamyltrans-s-1-propenyl-l-cysteine sulfoxide) inhibits the activity of osteoclasts that weakens bone functioning. Antimicrobial effects of onion against bacteria, virus and fungal infections are studied under various circumstances. The compound that provides antibacterial effect are organosulphur compounds as they inhibit the growth of both gram-positive and negative bacterial species such as *Baccilus, Streptococcus, etc*., and *Salmonella, E. coli, etc*., respectively (Škerget *et al*., 2009). Apart from onion extracts, onion peel extracts also showed restricting effect *Staphylococcus aureus* (Lee *et al*., 2011). Similarly, dehydrated onion when introduced into meat cuts inhibits enterobacteriaceae (Park *et al.*, 2008). Antiviral activity is also seen in onion due to the presence of compound, quercetin. This compound also enhances the bioavailability (Wu *et al*., 2005). It prevents and protects against deadly viruses such as retrovirus, parvovirus, influenza hepatitis virus, *etc*. (Goren *et al*., 2002). Not only onion but onion plant varieties such as shallots, garlic, leeks, *etc*., that possess this specific compound, Quercetin have antiviral effect. Antifungal effect is also found in onion by disrupting the cellular activities of fungi. Oxygen intake, growth, lipid and protein synthesis of fungi all are hindered by onion extract (Gupta, 2001).

Figure 7: Onions.

Table 2: Nutritional values of carrot

S.No.	Minerals	Values in mg/100 g	Vitamins	Values in mg/100 g	Macronutrients	Values in g/100 g
1	Potassium (K)	161.0	Folate (B9)	21.0 µg	Carbohydrates	10.27
2	Phosphorus (P)	32.0	Ascorbic acid (C)	8.1	Proteins	1.21
3	Calcium (Ca)	25.0	Pantothenic acid (B5)	0.135	Fat	0.11
4	Magnesium (Mg)	11.0	Pyridoxine (B6)	0.132	Sugars	4.66
5	Zinc (Zn)	0.19	Thiamin (B1)	0.051	Dietary fiber	1.9
6	Manganese (Mn)	0.142	Riboflavin (B2)	0.03	Water	98.02
7	Copper (Cu)	0.043	-	-	Energy	44.0 kcal

(**Source:** Rodrigues *et al.*, 2003).

3.5 Beetroot (*Beta vulgaris* L.)

Beetroot, a native of Africa and widely used in Europe, is used in daily diet in various forms as salad dressing, in borscht and also as normal vegetable by boiling (Figure 9). They provide abundant carbohydrate and starch content. It is also used as a food colouring agent in many food processing units. Protein and fibre content are also rich in beetroots. Fat content is very low contributing to low calorific value (Neelwarne and Halagur, 2013). It is rich in vitamin B complex, A, C and K (Kale *et al*., 2018) (Table 3). Beetroots possess phytochemicals like betalains, betacyanins, carotenoids and betaxanthins, flavonoids, polyphenols and saponins (Baiao *et al*., 2017). They also contain certain bioactive compounds like saponins, alkaloids and many amino acids like proline, valine, tyrosine, *etc*. Apart from these, beets are rich in minerals like potassium, sodium, iron, *etc*., that promote many heath factors (Babrykin *et al*., 2019). All the components present in beetroots provide them the antioxidant, antimicrobial and anti-inflammatory capacity (Jasmitha, 2018). These components vary according to different varieties of beetroots. Apart from varieties, different parts of the plant provide different quantities of the compounds. For example, carotenoids are found more in leaves than in tuber area (Lechner and Stoner, 2019). Betalain is a compound found in abundance in this particular vegetable. It is water soluble nitropigment that is found in epidermal tissues of the crop. This compound provides antioxidant, anti-inflammatory and anticancerous activities (Sun-Pan *et al*., 2006). Apart from these properties, they also prevent the human body from cardio-vascular diseases (CVD), neurodegenerative diseases, *etc*. (Khan, 2016). Studies and investigations on bioavailability of the beet extracts such as betalains *in vivo* indicate that the compound

is absorbed into circulation system without any change in their chemical form and are highly available in that manner, although the concentration absorbed is comparatively low to other compounds. Studies suggest that the high antioxidant property of beetroots is due to their radical scavenging activity (Wootton-Beard *et al*., 2011). Beetroots are rich in vitamins that increase the WBC (white blood cells). It has other important properties like detoxifying capacity preventing the body from cancer (Nangia, 2018). They also possess antimutagenic effects due to the presence of methyl-nitro-nitrosoguanidine (MNG) (Hussain *et al*., 2018). Antimicrobial and antiviral properties are also found in beetroots (Strack *et al*., 2003).

Figure 9: Beetroot.

Table 3: Nutritional values of onion

S.No.	Minerals	Values in mg/100 g	Vitamins	Values in mg/100 g	Macronutrients	Values in g/100 g
1	Potassium (K)	442.00	Folate (B9)	148 µg	Carbohydrates	13.0
2	Phosphorus (P)	54.00	Ascorbic acid (C)	6.7	Proteins	2.19
3	Calcium (Ca)	22.00	Pantothenic acid (B5)	0.211	Fat	0.23
4	Magnesium (Mg)	31.00	Pyridoxine (B6)	0.091	Sugars	9.19
5	Zinc (Zn)	0.480	Thiamin (B1)	0.042	Dietary fiber	3.8
6	Manganese (Mn)	0.447	Riboflavin (B2)	0.054	Water	149.11
7	Copper (Cu)	0.102	Niacin (B3)	0.454	Energy	58 kcal
8	Iron (Fe)	1.090	-	-	-	-
9	Sodium (Na)	106.00	-	-	-	-
10	Selenium (Se)	1.00 µg	-	-	-	-

(**Source:** Clifford *et al*., 2015).

3.6 Cucumber (*Cucumis sativus* L.)

Cucumbers are a native of Indian subcontinent (Figure 11). These vegetables are of gourd family with green outer cover and are known for its unique taste (Figure 12). Cucumbers are the fourth largest grown plant after tomato, onion and cabbage (Eifediyi and Remison, 2010). It has immense water content, approximately 96% of the vegetable (Vivek *et al*., 2017). Cucumber is rich in vitamin C, A and β-carotene. It also contains minerals like potassium, manganese, sodium and silicone (Table 4). It contains less antioxidant activity and other phenolic compounds when compared to other vegetables in discussion (Chu *et al*., 2002). But, this vegetable is very useful in maintaining hydration levels during viral infections. High water content aids in easy digestion by eliminating toxins from the body. This vegetable is also used in maintaining blood pressure and body mass index (Kashif *et al*., 2008). Lignans present in cucumber such as lariciresinol and secoisolariciresinol prevent many types of cancers including ovarian, breast, prostrate, *etc*. (Wang *et al*., 2007). Some of the phytonutrient present in cucumber are cucurbitacin A, B, C, D; flavonoids like quercetin, kaempferol, luteolin promote antioxidant and anti-inflammatory properties (Kumar *et al*., 2010). These cucurbitacin A, B, C, D are found to inhibit the cancer growth pathways in the body.

Animal studies conducted show the increase in scavenging of free radicals accounting for its antioxidant activity (Egbung *et al*., 2013). Cucumber extract is found to restrict the action of pro-inflammatory enzymes like cyclo-oxygensase 2 promoting anti-inflammatory properties. Tannins present in cucumbers also promote anti-inflammatory properties including analgesic properties (Ekeanyanwu *et al*., 2010). These tannins also possess antimicrobial properties by cell disruption mechanisms (Ibrahim *et al*., 2014). Studies suggest that cucumber possess good antimicrobial activity. Osugwu *et al*. (2015) reported that the extracts of *T. cucumerina* leaves made by ethanolic extraction show an inhibition activity against all human pathogenic microbes except *E.coli* and the same extract made by aqueous extraction method inhibited only a few a human pathogen including *S. aureus*, *P. aeruginosa* and *S. typhi*. The seed extracts of cucumber show antimicrobial activity against *Serratia marcescens*, *E.coli*, *Streptococcus thermophilous*, *Fusarium oxysporium* and *Trichoderma reesei* (Sood *et al*., 2012).

Figure 11: Cucumbers.

Figure 12: Cucumbers.

Table 4: Cucumber: Nutritional facts (per 100g) and nutrients (mg %)

Folates	7 µg	2%
Niacin	0.098 mg	<1%
Pantothenic acid	0.259 mg	5%
Pyridoxine	0.040 mg	3%
Riboflavin	0.033 mg	3%
Thiamin	0.027 mg	2%
Vitamin A	105 IU	3.5%
Vitamin C	2.8 mg	4.5%
Vitamin E	0.03 mg	0%
Vitamin K	16.4 mg	13.6%
Sodium	2 mg	0%
Potassium	147 mg	3%
Calcium	16 mg	1.6%
Iron	0.28 mg	3.5%
Magnesium	13 mg	3%
Manganese	0.079 mg	3.5%
Phosphorus	24 mg	3%
Zinc	0.20 mg	2%

3.7 Crucifiers

Crucifiers are a group of vegetables that include broccoli, cauliflower, sprouts, cabbage, turnip, artichoke, *etc*. In general, all these vegetables are rich in dietary fibre, vitamin A, B, C and minerals like iron, potassium, phosphorus, calcium, *etc*. The outer leaves of have more nutrients than the inner florets (Ulger *et al*., 2018). Artichokes can be consumed raw in salads. Sulforaphane found in artichokes induces the functioning of antioxidant enzymes which attacks free radicals and boost immunity in the body. Studies suggest that influenza virus is combated by vitamin C induced immune responses, promoting antiviral properties (Kim *et al*., 2013). Cauliflower possesses compounds like choline and glutathione that suppress virus (Morris *et al*., 2012). Vitamins K, C and manganese in cauliflower gives it a diminishing oxidative stress and keeps the body hale. Cauliflowers possess high antioxidant capacity and anti-inflammatory. They are composed of different types of phytochemicals like carotenoids and tocopherols and phenolic compounds, vitamins and minerals (Murillo and Mehta, 2001). They can be used to treat ailments like CVD, some cancers, neurodegenerative disorders, *etc.* Sulphur compound, glucosinolates found in cauliflower inhibit the carcinogenesis pathway restricting the growth of tumour cells (Xiaojiao and Kezhen, 2012). These crucifiers prevent breast, lung and stomach cancers. Phytochemicals like betacarotene, betacryptoxanthin, caffeic acid, cinnamic acid, ferulic acid, quercetin, rutin, and kaempferol present in cauliflowers aid in anti-inflammatory process by inhibiting the action of free radicals. Cabbages are known for its rich phytochemical content including vitamins (A, B complex, C, E and K) and minerals. They are low in fat content and, hence used by people looking to control body weight (Hasan and Solaiman, 2012). Cabbages are used to treat diseases and disorders like cancer, diabetes, *etc*. Autoimmune diseases like Alzheimer can also be treated due to its antioxidant property. Compounds like indole-3-carbinol and glucosinolates boost the immune system (Shama *et al*., 2012).

3.8 Broccoli (*Brassica oleracea* L.)

Broccoli is a native of Italy. It is one of the most nutritious crucifers with green core. It is used world wide for its high nutritional benefit (Table 5). It is rich in vitamins like A, C, B complex and minerals like iron, selenium and calcium (Mishra and Mukherjee, 2012). It possesses anticancer property due to the compound di-indolymethane. This compound also ensures proper functioning of the immune system (Shubha *et al*., 2020), thus promoting antiviral and antibacterial property of the vegetable. Antitumorous capacity is attributed by the presence of a compound known as glucoraphanin, sulphoraphane and indole-3-carbinol that disrupts the growth of cancer cell. Thus, it prevents breast, colon and rectal cancer (Phillip, 2011). β-carotene and lutein are also present in broccoli. Sulforaphane (SFN) is a major compound found in broccoli that provides anti-inflammatory property. Vitamin C present in broccoli is highly useful in boosting immunity and protecting the defence mechanism of the body (Jagadish *et al*., 2007). It also possesses antiviral property (Antonenko *et al*., 2013). Aryl hydrocarbon receptor (AhR), a protein that regulates intra epithelial lymphocytes that coordinates the proper functioning of immune cells is rich in these crucifiers.

Table 5: Nutritional values of broccoli

S.No.	Minerals	Values in mg/100 g	Vitamins	Values in mg/100 g	Macronutrients	Values in g/100 g
1	Potassium (K)	293.0	Folate (B9)	108 µg	Carbohydrates	7.18
2	Phosphorus (P)	67.0	Ascorbic acid (C)	64.9	Proteins	2.38
3	Calcium (Ca)	40.0	Pantothenic acid (B5)	616.0	Fat	0.41
4	Magnesium (Mg)	21.0	Pyridoxine (B6)	0.2	Sugars	1.39
5	Zinc (Zn)	0.45	Thiamin (B1)	0.063	Dietary fiber	3.3
6	Manganese (Mn)	0.194	Riboflavin (B2)	0.123	Water	89.25
7	Copper (Cu)	0.061	Phylloquinone (K)	141.1 µg	Energy	35 kcal
8	Iron (Fe)	0.67	Alpha tocopherol (E)	1.45	-	-
9	Selenium (Se)	1.6 µg	Choline	40.1	-	-
10	Sodium (Na)	41.0	Retinol (A)	77 µg	-	-

(**Source:** Liu *et al*., 2018).

3.9 Green leafy vegetables

Green leafy vegetables include lettuce, chards, moringa leaves, spinach, Amaranthus, *etc.* (Figure 14). They are rich in iron, fibre and calcium. Vitamins especially A, C and B are loaded in these varieties. Different parts of the plants offer different kinds of nutrient. Green leaves have high nutrient content, whereas thin leaves (spinach and moringa) have higher amount of vitamin. Spinach is loaded with vitamin C and A that reduces the risk of common cold (Hussein, 2020). It is also rich in minerals like magnesium, iron, calcium and manganese. It aids in digestive system working. It is also a mild laxative that clears the bowel system keeping the toxins away from human body system. It also has anti-inflammatory properties (De and De, 2020). *Moringa olifera* are a native of Indian subcontinent which is known for its exceptionally high nutrient content. They are rich in iron, zinc, magnesium, potassium and calcium. Vitamin A, B complex and C are found in abundance (Mbikay, 2012). *M. oleifera* has 7 times more vitamin C than orange, 10 times vitamin A than carrot, 17 times calcium than milk, 15 times potassium than bananas and 25 times iron than spinach. High fibre content is used in the treatment of colon cancer and low fat content is used in controlling diabetes (Oduro *et al.*, 2008).

Figure 14: Spinach.

Other important bioactive compound present is polyphenols (260 mg/100 g), quercetin (100 mg/100 g), kaempferol (34 mg/100 g) and β-carotene (34 mg/100 g) (Arabshahi *et al*., 2007). It also shows high antioxidant capacity restring free radicals from damaging the normal cellular function, thus preventing many disorders like diabetes (Cerf, 2013). It also shows anticancer properties through compounds like (Hermawan *et al*., 2012). Research studies suggest that Moringa leaves boost immunity especially in HIV patients as they possess antiretroviral property (Monera and Maponga, 2012). Extracts of these leaves are resistant to microbes including *Bacillus subtilis, Staphylococcus aureus and Vibrio cholera* (Viera *et al*., 2010). This is due to the presence of compounds pterygospermin, moringine and benzyl isothiocyanate. Overall, they are a good antidiabetic, antitumor, antioxidant, anti-inflammatory, antimicrobial food. In cabbage and lettuce, the outer cover of leaves contains more minerals and vitamins (Ulger *et al.*, 2018). These properties aid in boosting the immunity. Basella leaves also possess vitamins like A, B, C, E, K (Deb *et al*., 2018), along with antiviral property that can mainly target against COVID-19 (Lin *et al.*, 2009) (Figure 15).

Figure 15: Benefits of green leafy vegetables.
(**Source:** Singh *et al*., 2001)

3.10 Brinjal (*Solanum melongena* L.)

Brinjal is an Asian vegetable, also known as aubergine in European countries. It is available in many different shapes and colours (Figure 16). It is ranked among top 10 vegetables that have high radical scavenging capacity (Cao *et al.*, 1996). This is due to the high quantities of phytochemicals including chlorogenic acid and flavonoids including glucoside, nasunin and delphinidin (Cassidy *et al*., 2013). This works as anti-inflammatory and antiobesity agent. Apart from this benefit, extracts of brinjal also proves to be anticancerous (Afshari *et al*., 2016). It is loaded with phytonutrients that aid in curing diabetes and cholesterol as they possess very less calories (Caguiat and Hautea, 2014). The nutrients rich in brinjal are vitamins and minerals like iron, magnesium, calcium, *etc*., along with fibre and protein (Table 6). These minerals are important for bone functioning (Bhasker and Kumar, 2015). Brinjals are useful for treating many common ailments like piles, tooth ache, inflammation, throat pain, *etc.* (Mak, 2013).

Purple colour of the peels is due to the presence of a compound known as anthocyanin. They are proven to be effective against diabetes, CVD, *etc*. It also shows antioxidant properties (Casati *et al*., 2016). Glycoalkaloids found in brinjals possess anticancer feature especially against lung cancer (Shen *et al*., 2017). Since fibre is found in abundance, it removes toxins from thorax area and protects the body against stomach and colon cancer (Fraikue, 2016). Nasunin anthocyan, an antioxidant combats free radicals and protects cell membrane (Butu and Rodino, 2019). Higher phenol content was observed in brinjal which contribute to high antioxidant capacity (Santas *et al*., 2008). Similarly, high ascorbic acid content is also found in brinjal that attributes to boosting immune system. They also possess antiviral, antimicrobial and anticancerous activity. Peels of the vegetable contain DR2B and DR2C extracts that disrupt the replication process of virus restricting the disease (Di Sotto *et al*., 2018). Studies show that antimicrobial effect is found against certain microbes like *Escherichia coli*, *Staphylococcus aureus*, *Bacillus subtilis*, *Vibrio cholerae*, *Pseudomonas* sp. and *B. cereus* (Ahmed *et al.*, 2016).

Figure 16: Brinjal.

Table 6: Nutritional values of brinjal

S.No.	Minerals	Values in mg/100 g	Vitamins	Values in mg/100 g	Macronutrients	Values in g/100 g
1	Potassium (K)	229.0	Folate (B9)	22 µg	Carbohydrates	5.88
2	Phosphorus (P)	24.0	Ascorbic acid (C)	2.2	Proteins	0.98
3	Calcium (Ca)	9.0	Pantothenic acid (B5)	0.281	Fat	0.18
4	Magnesium (Mg)	14.0	Pyridoxine (B6)	0.084	Energy	25 kcal
5	Zinc (Zn)	0.36	Thiamin (B1)	0.039	-	-
6	Manganese (Mn)	0.232	Riboflavin (B2)	0.037	-	-
7	Copper (Cu)	0.081	Choline	6.9	-	-
8	Sodium (Na)	2.0	Niacin	0.649	-	-
9	Iron (Fe)	0.23	Phylloquinone (K)	3.5 µg	-	-
10	-	-	Alpha tocopherol (E)	0.3	-	-

(**Source:** Naeem and Ugur, 2019).

3.11 Elephant foot yam (*Amorphophallus campanulatus* (Roxb.) Bl.)

Elephant yams belong to Araceae family, with its maximum growth occurring in Asia and certain African countries (Figure 18). Tubers are usually rich in starch content and less in protein content. Micronutrients like minerals like iron, zinc, magnesium and calcium contribute to its healthy nature (Englberger *et al*., 2003). Zinc found in yams plays a vital role in boosting the immune system by interacting with the central and humoral immunity (Shankar and Prasad, 1998). Magnesium is used in maintaining proper functioning of central nervous system (CNS) (Hass and Levin, 2006). The root extract of this plant is used in Ayurvedic treatments for tumours, inflammations, asthma, *etc*., due to the presence of alkaloids, flavonoids and phenols (Singh *et al.*, 2017). These low fat, high nutritional content tuber is used for tumour, arthritis, *etc*. (Singh and Neeraj, 2012). Hypoglycaemic effect and low LDL content is found in these yams and, hence can be used in the treatment of diabetes and obesity, respectively (Reddy *et al*., 2013). High fibre content found can be used in the treatment of CVD (Gordon, 2002). Vitamins A and C present as alpha-tocopherol and ascorbic acids act as radical scavengers. Lycopene and Beta-carotene present improve their antioxidant properties. They protect the damage caused by reactive oxygen species and other free radicals (Figure 19). Components such as quercetin, 3, 5-diacetyltambulin, amblyone, salviasperano, *etc*., found in this vegetable gives it antioxidant, antitumor, *in vitro* cytotoxic, antibacterial, antifungal, anti-inflammatory, immunomodulatory properties (Patel *et al*., 2012).

Figure 18: Elephant foot yam.

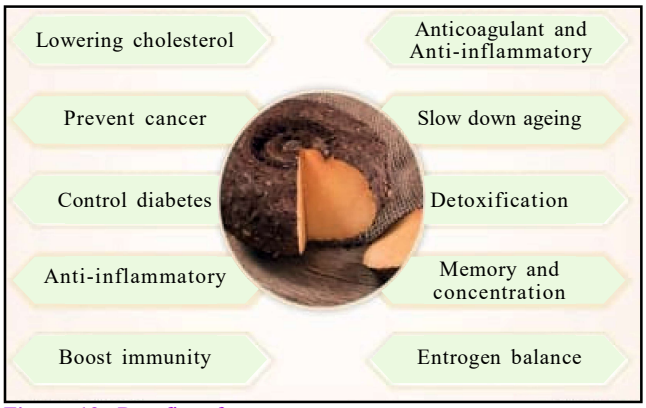

Figure 19: Benefits of yam.
(**Source:** Dufie *et al.*, 2013)

4. Medicinal crops

4.1 Turmeric (*Curcuma longa* L.)

One of the most used spices in Indian cooking, turmeric is a rhizome powder of a herb form ginger family. It is mainly grown in Asian countries and used in their cuisines. The major compound found in turmeric is curcuminoid due to which they impart yellow (Lampe *et al*., 1910). 12 g/day is considered as a safe limit for consumption. Turmeric is said to possess antioxidant activity along with antibacterial and antiviral activity (Srimal and Dhawan, 1973). It has high immune activity towards foreign bodies (Table 7). This is done by inducing immune response *via* T cells, B cells and other immune cells in the body. Studies suggest that curcumin initiate proliferation and activation of T cells (Ranjan *et al*., 2004). It also increases lymphocyte production and CD4+ cells which are an integral part of the immune system (Li and Liu, 2005). Animal studies with mice suggest that B-cells were activated in their mucosal line (Churchill *et al*., 2000). Curcumin decreases the release of ROS (reactive oxygen species) from macrophages (Joe and Lokesh, 1994). They also initiate phagocytosis *via* macrophages.

Natural killer cells (NK cells) are a type of immune cells that are stimulated by turmeric extracts. Rise in cytokine is the main concern in corona which is very easily tackled by turmeric (Hewlings and Kalman, 2017). Curcumin and turmeric extracts are mainly useful as they are able to differentiate between disease causing foreign bodies and other body cells, thus providing good treatment. Due to its high immune efficiency, they are used in the treatment of auto immune diseases. Alzheimer's is treated by down modulating the cytokine (Lim *et al*., 2001). Also used in the management of diabetes by controlling the blood sugar levels by increasing the antioxidant activity (Arun and Nalini, 2002). Turmeric is also in treating many such diseases and disorders like CVD, arthritis, scleroderma, *etc*.

Table 7: Nutritional values of turmeric

S.No.	Minerals	Values in mg/100 g	Vitamins	Values in mg/100 g	Macronutrients	Values in g/100 g
1	Potassium (K)	196.0	Alpha tocopherol (E)	0.42	Carbohydrates	6.31
2	Phosphorus (P)	28.0	Vitamin B, K, choline	Less than 2%	Proteins	0.91
3	Magnesium (Mg)	20.0	-	-	Fat	0.31
4	Zinc (Zn)	0.42	-	-	Dietary fiber	2.1
5	Manganese (Mn)	1.861	-	-	Water	1.21
6	Copper (Cu)	0.122	-	-	Energy	29 kcal
7	Iron (Fe)	5.17	-	-	-	-

(**Source:** Ikpaema *et al*., 2014).

4.2 Ginger (*Zingiber officinale* Rosc.)

Ginger is also a rhizome used in almost all cuisine over the whole world as a condiment realizing its health properties (Figure 21). They are rich in nutrients like vitamins and minerals and also in its antioxidant property. It is also used for its anti-inflammatory properties (Butt and Sultan, 2011). It is used to treat common ailments like cold and cough, CVD, asthma, allergies and diabetes, *etc*. It is also used in cancer treatment (Ahui *et al*., 2008). Animal studies done on rat indicate that there is slight increase in RBC and platelet count due to consumption of ginger extract (Tende *et al*., 2014). Other studies suggest an increase in immunoglobins IgG and IgM levels after ginger extract administration (Khalil and El-housiney, 2013). There was an increase in lymphocyte count and neutrophil count after consumption of ginger extract as per a study conducted with smokers and non-smokers. There was a good response with the non-smoker community to this ginger extract in accordance with immune cells and their functioning (Figure 22).

Figure 21: Ginger.

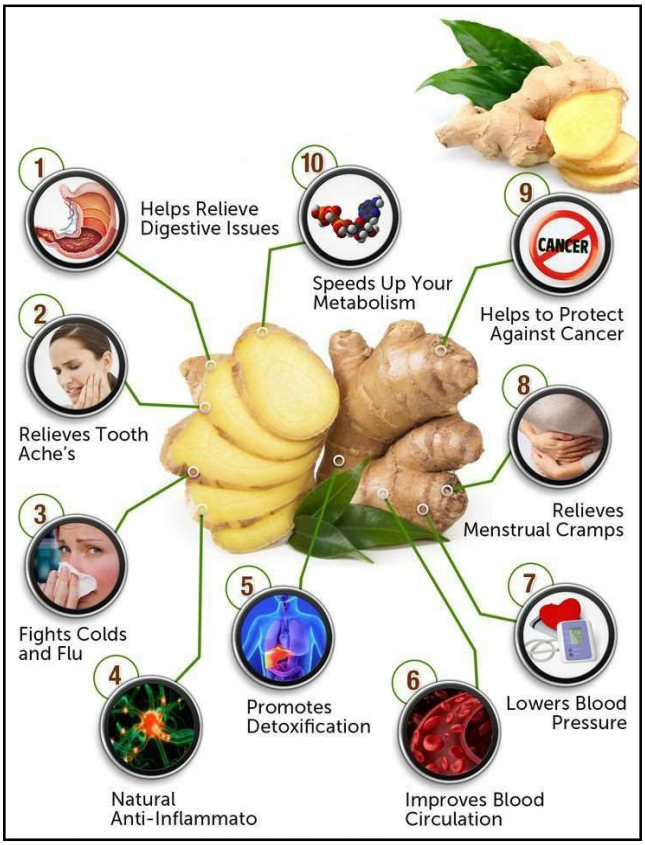

Figure 22: Health benefits of ginger.
(**Source:** Khan *et al*., 2019)

4.3 Garlic (*Allium sativum* L.)

Garlic is known for its health promoting properties and is used for many centuries as for its medicinal uses and also its culinary value. It is consumed as a whole bulb, paste and juice (Figure 23). It belongs to Alliaceae family. Garlic is low in proteins, fats and carbohydrates but rich in minerals and vitamins (Table 8). Due to low fat and carbohydrates, they are used for management of diabetes and obesity (Augusti, 1996). Allicin and disulphide compounds attribute this hypoglycaemic effect. Garlic extracts are useful in the treatment of cold and flu, respiratory ailments, cancer and also infections by microbes. High sulphur component in garlic interfere with the carcinogenesis mechanism, thereby establishing their anticancerous activity. It inhibits the proliferation of cancer cells, preventing breast cancer, colon cancer, *etc*. Garlic is known for many of its medicinal uses, especially its antiviral activity. Allicin exhibits antibacterial activity against *E. coli* and such bacteria; antifungal property against *Candida albicans* and such fungal species. These are attributed due to the presence of chemical compounds like alcohol dehydrogenase, RNA polymerase, *etc*. Animal studies done with rats reveal increase in CD4 T-cells in animals treated with garlic extract (Banerjee *et al*., 2002). This increases the immune stimulating properties (Tang *et al*., 1997). Activation of T-cells, lymphocytes and natural killer (NK) cells were found with administration of garlic extract boosting the immunity (Sumiyoshi, 1997). It is composed of many flavonoids and anthocyanins. Organosulfur compounds like quercetin inhibits RNA replication of virus (Kumar and Pandey, 2013). Studies show that viral infections like polio, rhinovirus, hepatitis C, Ebola, SARS, *etc*., were affected by quercetin.

Figure 23: Garlic.

Table 8: Nutritional values of garlic

S.No.	Minerals	Values in mg/100 g	Vitamins	Values in mg/100 g	Macronutrients	Values in g/100 g
1	Selenium (Se)	1.3 µg	Ascorbic acid (C)	2.8	Carbohydrates	2.98
2	Manganese (Mn)	0.15	Pyridoxine (B6)	0.111	Proteins	0.57
3	Copper (Cu)	0.027	Thiamin (B1)	0.018	Dietary fiber	0.2
4	-	-	-	-	Water	5.27
5	-	-	-	-	Energy	13 kcal

(**Source:** Ansary *et al*., 2020).

5. Conclusion

Many vegetables and fruits are rich in phytochemicals and other nutrients that are necessary to battle diseases. Vitamins, minerals, antioxidants are found in excess in various vegetables. Thus, a combined and balanced diet is recommended. Nutritional supplements are very much required to fight diseases apart from other therapies. Viral infections especially COVID-19 that is costing millions of lives.

COVID-19 has become a worldwide pandemic that is destabilizing human health in all possible direct and indirect ways. The nutritional status of a person is affected by various factors such as age, gender, lifestyle, *etc*. Thus, to maintain a hale environment, a robust immune system is essential. Micronutrients like vitamin A, B, C, *etc.,* along with mineral intake like zinc, iron contribute to the same. Many vegetables and fruits are rich in phytochemicals, antioxidants and other nutrients that are necessary to battle diseases. Vitamins, minerals, antioxidants are found in excess in various vegetables. Thus, a combined and balanced diet is recommended.

The working and functioning of the micronutrients and nutritional supplements to boost immunity and their defence mechanism against the harmful microorganisms are well explained in this work. Vegetables that provide these benefits such as tomato, onion, beetroot, *etc*., along with medicinal herbs like turmeric, ginger and garlic are studied. The nutraceutical and therapeutic value of these vegetables are very much required to fight diseases apart from other therapies. Viral infections, especially COVID that is costing millions of lives all over the world, must be prevented than cured. This is mainly done by boosting one's immunity. An appropriate diet with essential nutrients is required to handle such infections rather than vaccines. Apart from improving the diet, staying hydrated, staying active with physical exercises and de stressing oneself plays an important role in overcoming the diseases. Even after recovery of diseases, immunity is the key to a healthy life thereafter.

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Conflict of interest

The authors declare that there are no conflicts of interest relevant to this article.

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