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# Potential mechanisms of antioxidants derived from horticultural crops against covid-19

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**Abstract**

Since the end of 2019, the covid-19 is critically overhanging general health and called as pandemic by World Health Organization. Alternative approaches are very important for its control along with specific drugs for covid-19. Hence, the main objective of the present article is to provide an overview on the function of horticultural crops enriched with antioxidants as a possible alternative opportunity in combating the covid-19. Natural antioxidants such as vitamins, bioactive molecules, various polyphenols and some of micro nutrients have promising abilities for being used as antiviral agents. This promising feature is accompanied with its effect on decreasing the levels of ROS in infected cells, inhibiting replication of several strains of different viruses and preventing the proliferation of cancer cells. Results highlighted the anti-viral effects of different antioxidants which can be summarized in three groups; 1) polyphenols with anti-inflammatory and anti-allergy effects; 2) vitamins with inhibitory effects on oxidation processes, preserving the epithelium and improving immune function in the elderly and 3) minerals effecting on the formation of antibodies and improving immune system. According to these comprehensive facts of the review, antioxidants propose promising goals for improving oxygenation rates and glutathione levels, decreasing sodium intake and blood pressure, strengthening immune response and prevention of the chronic human diseases.

**Keywords;** Coronavirus, Fresh Fruits and Vegetables, Anti-Inflammatory, Bioactive Compounds, Immunity

## INTRODUCTION

When the calendars showing December 2019, the most important outbreak of the 21st century had appeared in Wuhan, China, with the name of Corona Virus illness, induced by the Severe Acute Respiratory Syndrome Coronavirus 2. Then, it was called as covid-19 by World Health Organization and has received a lot of consideration because of widespread infection of the mentioned new strain all over the world (Ho et al., 2020). With the help of the huge travelling options in the 21st century, the number of positive SARS-CoV-2 infections had a tremendous increase all over the world, and then it was called as pandemic in March 2020 by WHO. As of 9 February 2021, Covid-19 has reported to cause the death of more than 2.3 M people, with more than 107 M people infected worldwide (Anonim, 2021). The family of this covid-19 is called as Coronaviruses (CoVs), which its main characteristics are the enveloped positive-sense RNA and club-like spikes (Xian et al., 2020). It is known that this family had single-stranded RNA, contaminating animals and humans, and cause to respiratory, gastrointestinal, hepatic, and neurologic maladies (Dhama et al., 2020). The severity of this disease is enhanced with the increase in oxidation and inflammation, mainly in the presence of persistent diseases. Active oxygen species (AOS) induced free radicals cause the oxidation and is specified as a disorder in the equilibrium between the level of AOS and antioxidative barriers (Reshi et al., 2014). Results imply that covid-19 participates with the hemoglobin durability and leads the prohibition of heme transformation following great iron distribution. Progression of the malady may cause to a relevant iron dysmetabolism and ferroptosis following by hypoxia and enhancement cell oxidation conditions (Cavezzi et al., 2020).

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The first Corona Virus vaccines had been approved for emergency use after December 2020. However, since it is still very difficult for everyone to reach vaccine and the effectiveness of the vaccines are under debate, the application of broad-spectrum antibiotics along with famously antivirals and corticosteroids are advised. Use of herbs and traditional remedies, established upon the natural and organic substances are a method of treatment, too. Active compounds of different natural products can be used against coronavirus but it is clear that the amount of their effectiveness must be tested *in vivo* and it should also be combined with other chemical treatments. The oxidative stress caused by covid-19 was reported to cause damages on the nucleic acids, which might likely decrease the efficiency of Corona Virus vaccines (Bakadia et al., 2021). Recently World Health Organization and participants "effort altogether on the response - tracking the pandemic, talking to crucial intermediation, by distribution of essential pharmaceutical stocks to those in need- they are racing to expand and spread secure and efficient vaccines".

According to recent available information, vaccines trains human body against viruses/infections and prepare body's natural defenses by activating the immune system. Therefore, the body becomes ready for infections and whenever it is infected by the maladies-inducing agents later, the body might directly respond and prevent itself from illness. Together with an effective vaccine, it is also important to include foods enriched with antioxidants in the diet and strengthen the immune system as well as to continue the essential public health actions to suppress transmission and reduce mortality. After this huge pandemic, a global recession occurred where public health measures also strengthen to reduce the rate of viral transmission; and these together caused an alteration in the consumer behavior. This caused an increase in the consumption of nutraceuticals and functional foods especially in the developed countries where the consumers have ability to reach those foods (Aday & Aday, 2020). Moreover, existence of minerals and antioxidants derived from horticultural crops are more important in order to induce immune system of the human. Hereafter, United Nations Food and Agriculture Organization (FAO) called the year 2021 as international year of fruits and vegetable in order to emphasize fruits and vegetables as dietary essentials. Therefore, the goal of the present work is to investigate the mode of action of antioxidants and phytochemicals of horticultural crops including fruits, vegetables and medicinal plants in combating covid-19. Our review focuses on the effect of weak body immunity in countering with Corona Virus and then the mode of action of antioxidants derived from horticultural commodities in strengthening the immune system of the body and combating with covid-19.

## MALNUTRITION AND WEAK IMMUNE SYSTEM

Homeostasis is the case of steady internal, physical, and chemical situations preserved by living organisms and the nutrition is very determinant for the maintenance of homeostasis, including immune function (Childs et al., 2019). The immune system has known for several centuries to be related with nutrition. Thus, malnutrition is accepted as the primary cause of immunodeficiency. Several previous review works have indicated the effect of nutritional deficiencies on weakened immune responses and increased mortality, especially in the elderly people. In common situation of the Corona Virus pandemic, nutrition related guarded system induction and strengthening are very important. Although some vaccines got emergency application, it is still absent in the worldwide use, and its efficacy and longevity are not well-known, the "nutritional status-immune response" of individuals is still very important (Romano et al., 2020). Thus, malnutrition is considered as an important agent in the incidence of viral disease, which causes to increase in the rate of infected people and the risk of mortality and malady especially in the elderly. Besides to that, Damage to human homeostasis due to viral infection increases the need for various nutrients and vitamins, including zinc, selenium, vitamins A, B, and C (Gombart et al., 2020). In fact, maintaining variety, balance and proportion in nutrient intake helps the body's general health, including strengthening the immune system. The results of several studies indicate that micronutrient deficiencies lead to poor performance of the safety system, especially in terms of safety performance, mediator cells, phagocytic function, production of cytokines, antibody reactions, etc. In fact, nutrient deficiencies are the most important reason for the worldwide weakness of the human body immunity (Chandra, 1999). On the other hand, malnutrition increases capacity to opportunistic microorganisms and reduce the effectiveness of drug treatments (Katona and Katona-Apte, 2008). Therefore, a balanced diet which is supplemented with horticultural antioxidants and phytochemicals will be more essential in improving the effect of drug treatments and also increasing the immune factors in people infected with the corona virus. In this case, along with the effective chemical drugs against SARS-CoV-2, it is necessary to find natural drugs as a supplementary approach to cope and prevent the spread of the virus.

## CLINICAL FEATURES

A broad-spectrum study on the clinical appearance of Corona Virus, such as infection without specific signs, mild upper respiratory and pulmonary alveolar collapses, together cause severe infections which stops oxygen exchange (Soto et al., 2020) with respiratory failure, and where it results with moderate to intensive care requirement (Dhama et al., 2020). The infection symptoms of covid-19 usually vary depending on the time of the beginning of the malady and the patients may have "malaise, headache, sore throat, runny nose, and tachypnea, as well as fatigue, anorexia, myalgia, and sputum production during the disease period. In addition, they may develop mild-to-severe respiratory problems, with symptoms such as fever, cough, and dyspnea". The mentioned malady has an intense transmission capacity by aspiration of epidemic aerosols and principally needs to an incubation period of 3-14 days, which case to maladies varying from the asymptomatic to fatal consequences (Yang et al., 2020). Current knowledge also suggests that the intensity of Corona Virus infection generally depending on the lymphocytopenia, and the patients who died from Corona Virus had lower lymphocyte counts in comparison with survivors (Yang et al., 2020). Patients also noted to exhibit symptoms of significant systemic inflammation, such as increasing in the levels of C-reactive protein (CRP), the rate of erythrocyte sedimentation (ESR), procalcitonin, chest CT score, and decrease in lymphocyte (LY) count. Chest CT score had positive correlation with white blood cell (WBC) count, CRP, ESR, procalcitonin, and

abnormal coagulation function, a negative correlation with LY count and some patients had lymphocytopenia at the reception time (Zhang et al., 2020).

## ANTIOXIDANTS

Antioxidants are compounds produced by aerobic microorganisms that keep the amount of active oxygen species (AOS) in plant organelles at low concentrations (base concentrations), although they may be participated in signal transmission cascades, preventing the incidence of oxidative stress and cytotoxicity symptoms (Mittler et al., 2004). The production site of various antioxidant compounds inside the cell is summarized in Table 1. During optimum growing conditions, the level of AOS production in plant organelles is little, about 240 micromoles per second of superoxide anion, and in the basal state 0.5 micromoles of hydrogen peroxide in chloroplasts, which are usually in equilibrium with the amount of anti-oxidant molecules (Racchi, 2013). However, biotic and abiotic stresses increase the level of reactive oxygen species (ROS) in the body and an unregulated cell oxidation may be induced. Application of exogenous protective compounds called antioxidants can prevent or delay oxidative stress. Epidemiological investigations have also recommended that using fresh fruits and vegetables in daily diet, having phenolic and non-phenolic antioxidants has a negative correlation risk with chronic diseases (Naska and Trichopoulou, 2014).

**Table 1.** Resources of the essential antioxidant in plant different organelles.

| Organelle | Essential antioxidants |
|---|---|
| **Chloroplast** | Ascorbate peroxidase, Glutathione reductase, Glutathione peroxidase, Monodehydroascorbate reductase, dehydroascorbate reductase, Cu/ZnSOD, FeSOD, Ascorbate, Glutathione, Carotenoids,α-Tocopherol |
| **Mitochondrion** | MnSOD, Ascorbate peroxidase, Monodehydroascorbate reductase, dehydroascorbate reductase, Glutathione reductase, Glutathione peroxidase, Ascorbate, Glutathione |
| **Cytosol** | Ascorbate peroxidase, Monodehydroascorbate reductase, dehydroascorbate reductase, Glutathione reductase, Glutathione peroxidase, Cu/ZnSOD, Ascorbate, Glutathione |
| **Vacuole** | Ascorbate, Glutathione, Flavonoids |
| **Nucleus** | Ascorbate, Glutathione |
| **Peroxisome** | Catalase, Ascorbate peroxidase, Ascorbate |
| **Apoplast** | Peroxidase, Ascorbate |

Reference: adopted from Racchi (2013)

According to Halliwell and Gatridge (2007), the ways of antioxidants function are 1) to prevent ROS formation either by inhibiting enzymatic defense or by chelating important elements in production of free reactive oxygen species; 2) Elimination of ROS and increasing the expression of antioxidant defense mechanisms. Furthermore, the antioxidant potency is very important in which infers to biologically useful properties of fresh fruit and vegetables. The importance of the study of antioxidant compounds in horticultural commodities include 1) Antioxidant compounds protect fruit tissue against toxic ROS and therefore make products tolerant against stress (Van Breusegemet al., 2008); 2) Due to the presence of these compounds, fruits have a high nutritional value in human and animal nutrition; 3) Many fruits are perishable and after harvest, have a relatively short shelf life that causes many changes in their texture, color and aroma. These changes are sometimes associated with a decrease in antioxidant compounds (Stevens et al., 2008); 4) Antioxidant compounds are involved in reducing the growth and yield of agricultural products. According to the localization of antioxidants in the tissue, they can be subdivided into three categories;

1) Intracellular antioxidants functioning inside the cells: Enzymes such as catalase, glutathione peroxidase, glutathione reductase, superoxide dismutase and ceruloplasmin.

2) Antioxidants in the cell membranes: Small molecules such as ascorbate, uric acid, glutathione, α tocopherol, β-carotene and vitamin E.

3) Extracellular antioxidants present in the extracellular liquids: Proteins like albumin, transferrin and metallothioneins (Khavinson et al., 2003).

## THE EFFECT OF ANTIOXIDANTS ON IMMUNE SYSTEM

Viral diseases are required to have the prevention of viral replication followed by cell survival. Therefore, medicines with antioxidants, which have anti-virus effects, are promising. The results of curing with antioxidants in sepsis, acute respiratory disease syndrome and acute lung injury are known but treatment with antioxidants has not been yet examined in covid-19. Soto et al. (2020) suggested that antioxidants improve oxygenation ratio, level of glutathione and make the immune system of patients to be stronger. This then help to diminish the necessity for mechanical ventilation or reduce the time required for that. In general, they can reduce mortality rates in acute lung injury/acute respiratory distress syndromes and finally will help the patients affected by covid-19. At the corona virus patients, the elevation of blood pressure (BP) level was also reported (Smyth et al., 2019). Thus, consumption of potassium-rich fruits and vegetables including

sweet potatoes, avocados, spinach, beans, bananas and also coffee can likely regulate the BP. The mechanism of potassium is mainly associated with decrease in $Na^+$ intake which is a secure basis to have low blood pressure (McDonough et al., 2017).

According to the published literature information, it is clear that deficiency of one or more of some micronutrients and vitamin (i.e. Zn, vitamin A, C and E) compromises the immune response, and makes the individuals more susceptible to infections by virus and to a worse maladies anticipation (Ayseli et al., 2020). Therefore, during the covid-19 pandemic, enrichment the body with optimum intake of Zn and vitamins C and D may express a promising medicinal tool against the viral infections and incidence of the inflammatory diseases (Name et al., 2020). In general, using any of these vitamins is not mandatory and is not a major treatment for the mentioned disease in this paper but it can be used as adjunctive therapy.

For example, vitamin C is one of the most potent antioxidants which is able to donate electrons. That is biosynthesized inside the mitochondria and transported to other parts of the cell through a proton-electrochemical gradient. Vitamin C characteristics of the horticultural crops are very important for the consumers and producers too. Ascorbic acid or vitamin C may cause immune system to be stronger and the skin to be firmer by supporting the epithelial barrier against the entrance of pathogenic microorganisms and improve the adaptive immune systems (Carr and Maggini, 2017). Vitamin C also protects the host cells from phagocytes against free radicals.

In common colds and other infections, the ratio of vitamin C is reduced in the plasma, leukocytes and urine. A study in mice showed deficiency of vitamin C at the time of influenza injuries more in the lungs (Li et al., 2006). The effect of ascorbic acid in strengthening immune system is related to its accumulation in phagocytic cells such as Neutrophils. The mentioned situation can improve chemotaxis condition, phagocytosis and finally eliminates bacteria and viruses. In a study the chick embryo tracheal organ cultures were infected by coronavirus. The results showed that exposure of infected culture to ascorbate make that to be more resistant against coronavirus (Atherton et al., 1978). On the other hand, vitamin C acts as an antihistamine and inhibits symptoms such as sneezing, itchy nose, runny nose and prevents nasal congestion and swelling of the sinuses or even pneumonia (Field et al, 2002). The most common infection site in covid-19 is lower respiratory tract, so this vitamin can be used as a potentially effective option in treatment of respiratory infections caused by covid-19. Vitamin C-rich fruits that include 12 mg or more vitamin C per reference amount are qualified to carry the label "rich in vitamin C". Here there are some fruits with different levels of vitamin C including oranges (53.2 mg 100g $FW^{-1}$), tomatoes (13.7 mg 100g $FW^{-1}$), pineapple (47.8 mg 100g $FW^{-1}$), apple (4.6 mg 100g $FW^{-1}$), bananas (8.7 mg 100g $FW^{-1}$), strawberry (80 mg 100g $FW^{-1}$), melons (10-29 mg 100g $FW^{-1}$) and grapes (3.2 mg 100g $FW^{-1}$) (Fenech et al., 2019). However, an average requirement (AR) of 90 mg/day for men and 80 mg/day for women had been established by the European Food Safety Authority (EFSA Panel on Dietetic Products and Nutrition and Allergies [NDA], 2013).

Polyphenols have pharmacological activities including antioxidant activity, anti-inflammatory characteristics, anticancer characteristics, antibacterial properties, antifungal activities and antiviral characteristics too. Antiviral activity of flavonoids such as luteolin, apigenin, amentoflavone, quercetin, epigallocatechin gallate and gallocatechin gallate is due to preventing of the proteolytic activity of SARS-Cov 3C-like protease, which is the important key in viral replication (Solnier & Fladerer, 2020). Polyphenols also have other activities such as inhibition of lipid-peroxidation, capillary permeability and fragility, cyclo-oxygenase, and lipoxygenase enzyme activity (Rusznyak and Szent-Gyorgyi, 1936). Phenolics are reported to contribute to the antioxidant complement of several colorful (red, purple or blue) fruit species such as Blackberry, Raspberry and Jostaberry with 426.2, 129.2 and 125.4 mg $100g^{-1}$ FW, respectively (Okatan, 2020).

In several berries, the amount of antioxidant capacity (which is measured as oxygen radical absorbing capacity called ORAC) has been noted to have a positive relationship with the amount of their anthocyanin and total phenolic (Kalt et al., 2001). Since antioxidant capacity, as a result of phenolic compounds, can be decreased during different processing procedures of fruits (i.e. cutting or freezing), it is better to be consumed as raw (without processing). The mode of function of some effects of polyphenolic compounds is not completely demonstrated. A total knowledge of some variables of polyphenol bioavailability; such as the kinetics of adsorption, accumulation and elimination, will comfort the pattern of this projects. In addition to the fruits and vegetables, using of medicinal plants and herbs is going to be common in different societies due to their richness in antioxidants compounds. Some of the antioxidant derived from fruits and vegetables and also herbs are illustrated in Tables 2 and 3, respectively.

**Table 2.** The amount of antioxidants in some horticultural commodities.

| Horticultural commodity | Antioxidant level (mmol 100g $FW^{-1}$) | References |
|---|---|---|
| Pecan | 10.6 | Raman, 2018 |
| Blueberry | 9.2 | Raman, 2018 |
| Strawberry | 5.4 | Raman, 2018 |
| Artichokes | 4.7 | Raman, 2018 |
| Raspberries | 4 | Raman, 2018 |
| Kale | 2.7 | Raman, 2018 |
| Red cabbage | 2.2 | Raman, 2018 |
| Beans | 2 | Raman, 2018 |
| Beet | 1.7 | Raman, 2018 |
| Spinach | 0.9 | Raman, 2018 |
| Berries and berry products | 37.08 | Carlsen et al., 2010 |
| Fruit and fruit juices | 2.36 | Carlsen et al., 2010 |
| Grains | 0.73 | Carlsen et al., 2010 |
| Herbal/traditional plant | 120.18 | Carlsen et al., 2010 |
| Legumes | 1.18 | Carlsen et al., 2010 |
| Nuts and seeds | 15.83 | Carlsen et al., 2010 |
| Vegetables | 1.50 | Carlsen et al., 2010 |

**Table 3.** Antioxidants isolated from some herbal spices.

| Spice | Antioxidants | References |
|---|---|---|
| Rosemary | Carnosic acid, carnosol, rosemarinic acid, rosmanol | Shyjala and Peter, 2004 |
| Sage | Carnosol, carnosic acid, rosmanol, rosmarinic acid | Shyjala and Peter, 2004 |
| Oregano | Derivatives of phenolic acid, flavonoids, tocopherols | Shyjala and Peter, 2004 |
| Thyme | Carvacrol thymol, *p*-cymene, caryophyllene, carvone, borneol | Shyjala and Peter, 2004 |
| Summer savory | Rosmarinic acid, carnosol, carvacrol, thymol | Shyjala and Peter, 2004 |
| Marjoram | Flavonoids | Shyjala and Peter, 2004 |
| Allspice | Pimentol | Shyjala and Peter, 2004 |
| Tumeric | Curcumin | Tsao, 2015 |
| Red pepper | Capsaicin | Tsao, 2015 |
| Chilli pepper | Capsaicin, capsaicinol | Tsao, 2015 |
| Clove | Eugenol | Tsao, 2015 |
| Tumeric | Curcumin | Tsao, 2015 |

## MODE OF ACTION OF SOME HORTICULTURAL COMMODITIES AGAINST COVID-19

Berries are very important fruits in terms of their unique color, taste and flavor, high contents of minerals and vitamins and a wide variety of uses in the food industry. They have different types of phytochemicals in different levels including phenol, antioxidant, anthocyanin and ascorbic acids (Okatan, 2020). Phenolic compounds, mainly anthocyanins, in the berries give high antioxidant capacity to the fruits (Gündeşli et al., 2019). Regarding to a FRAP analysis; berries have maximum 9.2 mmol of antioxidants per 100 grams. The positive effects of berries on human health can be summarized as neutralizing the detrimental effects of ROS, reducing inflammation and altering the expression of some genes. Similarly, Raman (2008) also noted that the anthocyanins of blueberries help to reduce the risks of cardiovascular diseases, lowers LDL cholesterol levels and blood pressure. One of the most popular species of the berries is strawberry. The strawberry fruits are characterized with their sweet taste, versatile and rich source of vitamin C and antioxidants. Strawberries are reported to provide maximum 5.4 mmol of antioxidants per 100 grams (Raman, 2018). Similar to general group of berries, strawberries also contain anthocyanins, which give the red color to the fruits.

One of the common signs of covid-19 is fever. Fever increases both energy and micronutrient requirements (Muller at al., 2003). Citrus fruits are known to contain high levels of flavonoids and vitamin C. These phytochemicals decrease inflammation and boost immunity, which may help to fight fever, and indirectly help to fight with covid-19. On the other hand, vitamin A preserves the entirety of the epithelium in the respiratory and gastrointestinal tracts. For example, Scrimshaw et al. (1968) reported that "no deficiency in nutrients except for vitamin A has more positive correlation with encountering to infectious diseases". Another important ROS scavenger is vitamin E. The best way to strengthen the immunity system in elderly is dilation in hypersensitivity skin response and production of antibody after vaccination. In a previous work, it was noted that the vitamin E improves the resistance of elderly mice body to influenza virus infection and reduces the risk of acquiring upper respiratory infections in nursing home residents. Vitamin E also has an inhibitory effect on lipid peroxidation (Meydani et al., 2005). Current knowledge with the citrus fruits also recommends that the hesperidin and ascorbic acid derived from citruses can prevent

infectious diseases, including covid-19 by counteracting the cell damaging effects of the reactive oxygen species triggered by viral infections and inflammation. Similarly, Bellavite and Donzelli (2020) suggested that the citrus fruits can have a potential to be used as medicine against severe acute respiratory syndrome coronavirus. Besides to that, there are some other important fruits like oranges, kiwi, papaya and guava and some vegetables like spinach, bell pepper, eggplant, beetroots and cauliflower that are recognized to be high in vitamin C and are supporting for immune system. Overall, the existing literature suggests that these products are important to be included in diet. Spirulina and curcumin, as they are rich in vitamin C and minerals, have the most effects on strengthening immunity of elderly people (Erol, 2020). The presence of minerals in fruits and vegetables in connection with their roles in preventing infectious diseases and strengthening the immune system is related to their involvement in the formation of antibodies against pathogens (Katona and Katona-Apte, 2008). Garlic, ginger, turmeric, acid lime, aonla, spinach, broccoli etc. must be included in human diet to boost up the immune system and protect body against infectious diseases because they are the most potent anti-viral items (De and De, 2020).

It was recently noted by Wagner et al. (2020) that lymphocytopenia could be an easily obtained, useful, early and prognostic agent in assigning the clinical cycle and the intensity of covid-19 in patients. In this regard, some of minerals such as Zn is known to decrease T and B lymphocytes counts; and represses delayed hypersensitivity, cytotoxic activity and antibody production (Fawzi, 2004). Besides, potassium, zinc and magnesium supplementation either reduce the incidence of and inhibition of mortality induced by pneumonia or can effect on diarrhea (Katona and Katona-Apte, 2008). Moreover, banana is a horticultural commodity full of energy, carbohydrate, fat, protein, vitamin A, vitamin B, and vitamin C, K, P, Ca and Fe. Bananas are good anti-oxidants that are able to cure infection, slow the aging process, promote heart health, improve digestion, promote mental relaxation, support menstrual health, regulate blood sugar and cure anaemia (De and De, 2020). Results of some literatures about the effect of special antioxidants derived from horticultural crops and medicinal plants on pathogen and also the way of their function are summarized in Tables 4 and 5, respectively.

**Table 4.** Some of horticultural crops, their antiviral compounds and effects on immune system

| Horticultural crops | Active compounds | Type of virus | The way of effect on pathogens | Reference |
|---|---|---|---|---|
| Green Tea | Epigallo catechin gallate, epicatechin gallate and gallocatechin-3-gallate | SARS-CoV-2 and influenza | anti-inflammatory and antiseptic | Ghosh et al., 2020; Matsumoto et al., 2005 |
| Red Grape and berries | Resveratrol (3,5,4-trihydroxy-trans-stilbene) | MERS-CoV | Reduced expression of viral nucleocapsid protein. | Burns et al., 2002; salehi et al., 2018 |
| Mexican Oregano | Luteolin (3′,4′,5,7-tetrahydroxyflavone) | SARS-CoV | inhibition of the proteolytic activity of SARS-CoV 3C-like protease | Solnier & Fladerer, 2020 |
| Soybeans | Daidzein (7-hydroxy-3-(4-hydroxyphenyl)-4H-chromen-4-one) | SARS-CoV | inhibition of the proteolytic activity of SARS-CoV 3C-like protease | Solnier & Fladerer, 2020 |
| Citrus | Quercetin (3,3',4',5,7-pentahydroxyflavone) | SARS-CoV | inhibition of the proteolytic activity of SARS-CoV 3C-like protease | Solnier & Fladerer, 2020 |
| Parsly | Apigenin (4′, 5, 7,-trihydroxyflavone) | SARS-CoV | inhibition of the proteolytic activity of SARS-CoV 3C-like protease | Solnier & Fladerer, 2020 |
| Ginkgo | Amentoflavone (bis-apigenin coupled at 8 and 3' positions, or 3′,8″-biapigenin) | SARS-CoV | inhibition of the proteolytic activity of SARS-CoV 3C-like protease | Solnier & Fladerer, 2020 |

**Table 5.** Medicinal plants and their antiviral effective material

| Plant | Extracted effective material | Mode of action | Activity | Reference |
|---|---|---|---|---|
| *Humulus lupulus* L. (Cannabaceae) | Hydroalcoholic | inhibited replication of various viral strains | anti-influenza | Di sotto et al., 2018 |
| Cibotium barometz, Gentiana scabra, Dioscorea batatas, Cassia tora and Taxillus chinensis | | cytopathogenic effect (CPE) on Vero E6 cells under in vitro conditions | SARS-CoV | Wen et al., 2013 |
| *Curcuma longa* (Zingiberaceae) | Curcumin | inhibits the production of pro-inflammatory cytokines | anti-SARS-CoV-2 | Fadus et al., 2017; Manoraran et al., 2020 |
| Grape, peanut, red wine and mulberry | Resveratrol | inhibited Middle East Respiratory Syndrome Coronavirus () replication | MERS-CoV | Lin et al., 2017 |
| Citrus | Hesperidin and vitamin C | binding to SARS-CoV-2 proteins | SARS-CoV-2 | Bellavite, & Donzelli, 2020 |
| Cinnamon | Cinnamaldehyde | inhibits the TNF-α-induced inflammation through suppression of NF-κB activation | SARS-CoV-2 | Lee et al., 2018 |

## CONCLUSION

In the present review, we had tried to describe the antiviral properties of some phytochemicals and antioxidants of horticultural crops. On the other hand, the effects of bioactive components of fruits and vegetables and their nutritional values were reviewed to supply a reference material for combating covid-19. Corona virus is a drastic and dangerous infectious malady. The disease is mostly spread through respiratory droplets of the people to be in direct contact with each other. Regarding the covid-19 pandemic, minerals and bioactive substances that are able to improve the body immunity to prevent or decrease the danger of drastic advance and prognosis of this infectious disease become related. Although the effect of zinc and vitamins C and D similar with antioxidants in the response of body immunity to infectious disease are unavoidable but also the need to use chemical drugs and vaccinations to suppress the rapid spread of corona virus is still essential. In this way, World Health Organization is in cooperation with scientists, business, and global health organizations through the ACT accelerator to enhance the pandemic response. Although there is a global effort to develop an effective vaccine against covid-19, basic and essential public health actions must be taken to prevent the spread of the mentioned disease and to decrease its mortality. Vaccines, in general, save a lot of people each year by improving and strengthening the human body's immunity system and to find and combat the infectious microorganisms they target.

Adding of horticultural commodities into the diet causes to keep the role of antioxidants in body defense pathway. Vitamin C can lead to strengthening immune system and protection against infection caused by corona virus. Since the exact mechanism of covid-19 has not been fully elucidated and no specific drug has been developed for it, control could be mainly achieved by the dietary supplemented with antioxidants as well as the interruption of the transmission cycle. Different kinds of antioxidants are able to increase immune system function, decrease secretion of inflammatory cytokines, reduce oxidative stress and increase the body's antioxidant power, prevent lipid peroxidation, maintain cell membrane integrity, maintain strong connections between cells, prevent changes in the virus genome and improve chemotaxis and phagocytosis. Review of the existing literature suggest that consuming common fruits and vegetables, which have high antioxidants, anthocyanin, nutrient and vitamin contents may contribute much more to the reduction of ROS and help to fight against covid-19.

## CONFLICT OF INTEREST

Author declare no conflict of interest.

## REFERENCES


Anonim. (2021). Coronavirus cases. https://www.worldometers.info/coronavirus/

Aday, S and M. S. Aday. (2020). Impacts of COVID-19 on food supply chain. Food Quality and Safety.

Atherton, J. G., C. C. Kratzing and A. Fisher. (1978). "The effect of ascorbic acid on infection of chick-embryo ciliated tracheal organ cultures by coronavirus." Archives of virology, 56 (3), 195-199.

Ayseli, Y.I., N. Aytekin, D. Buyukkayhan, I. Aslan and M. T. Ayseli. (2020). Food policy, nutrition and nutraceuticals in the prevention and management of COVID-19: Advice for healthcare professionals. Trends in Food Science and Technology, 105, 186–199.

Bakadia, B. M., B. O. O Boni, A. A. Q. Ahmed and G. Yang. (2021). The impact of oxidative stress damage induced by the environmental stressors on COVID-19. Life sciences, 264, 118653.

Bellavite, P and A. Donzelli, 2020. Hesperidin and SARS-CoV-2: New Light on the Healthy Function of Citrus Fruits. Antioxidants, 9(8), 742. doi:10.3390/antiox9080742

Burns, J., T. Yokota, H. Ashihara, M. E. Lean and A. Crozier. (2002). Plant foods and herbal sources of resveratrol.

Journal of Agricultural and Food Chemistry, 50(11), 3337–3340.

Carlsen, M. H., B. L. Halvorsen, K. Holte, S. K. Bøhn, S. Dragland, L. Sampson and R. Blomhoff. (2010). The total antioxidant content of more than 3100 foods, beverages, spices, herbs and supplements used worldwide. Nutrition Journal, 9(1). doi:10.1186/1475-2891-9-3

Carr, A.C and S. Maggini. (2017).Vitamin C and Immune Function. Nutrients, 9, 1211. doi: 10.3390/nu9111211

Cavezzi, A., E. Troiani and S. Corrao. (2020). COVID-19: Hemoglobin, iron, and hypoxia beyond inflammation. A narrative review. Clinics and Practice, 10 (2), 1271.https://doi.org/10.4081/cp.2020.1271

Chandra, R. K, 1999. Nutrition and immunology: from the clinic to cellular biology and back again. Proceedings of the Nutrition Society, 58(3), 681-693.

Childs, C.E., P.C. Calder and E.A. Miles. (2019). Diet and immune function. Nutrients, 11, 1933. doi: 10.3390/nu11081933

De, L. C and T. De. (2020). Protective Foods to Develop Immu-nity of Individuals against COVID 19. Reaserch today, 2(5), 287-290.

Dhama, K., S. Khan, R. Tiwari, S. Sircar, S. Bhat and Y. S. Malik. (2020). Coronavirus disease 2019-COVID-19. Clinical Microbiology Reviews, 33, e00028– 20. doi: 10.1128/CMR.00028-20

Di Sotto, A., P. Checconi, I. Celestino, M. Locatelli, S. Carissimi, M. De Angelis, V. Rossi, D. Limongi, C. Toniolo, L. Martinoli, S. Di Giacomo, A.T. Palamara and L. Nencioni. (2018). Antiviral and antioxidant activity of a hydroalcoholic extract from Humulus lupulus L. Oxidative Medicine and Cellular Longevity, https://doi.org/10.1155/ 2018/5919237

Efsa Panel on Dietetic Products and Nutrition and Allergies [NDA]. (2013). Scientific opinion on dietary reference values for vitamin C. European Food Safety Authority journal, 11, 3418. doi: 10.2903/j.efsa.2013.3418

Erol, A. (2020) . High-dose intravenous vitamin C treatment for COVID-19.

Fadus, M. C., C. Lau, J. Bikhchandani and H. T. Lynch. (2017). Curcumin: An age-old anti-inflammatory and anti-neoplastic agent. Journal of Traditional and Complementary Medicine, 7(3), 339–346.

Fawzi, W and G. Msamanga. (2004). Micronutrients and adverse pregnancy outcomes in the context of HIV infection. Nutrition Reviews, 62, 269–75.

Fenech, M., I. Amaya, V. Valpuesta and M. A. Botella. (2019). Vitamin C Content in Fruits: Biosynthesis and Regulation. Front. Plant Science, 24 https://doi.org/10.3389/fpls.2018.02006

Field, C.J., I. R. Johnson and P.D. Schley. (2002). Nutrients and their role in host resistance to infection. Journal of leukocyte biology, 71(1), 16-32.

Ghosh, R., A. Chakraborty, A. Biswas and S. Chowdhuri. (2020). Evaluation of green tea polyphenols as novel corona virus (SARS CoV-2) main protease (Mpro) inhibitors – An in silico docking and molecular dynamics simulation study. Journal of Biomolecular Structure and Dynamics, 1–13. https://doi.org/10.1080/07391102.2020. 1779818.

Gombart, A.F., A. Pierre and S. Maggini. (2020). A review of micronutrients and the immune system-working in harmony to reduce the risk of infection. Nutrients, 12(1), 236. doi: 10.3390/nu12010236

Gündeşli, M. A., N. Korkmaz and V. Okatan. (2019). Polyphenol content and antioxidant capacity of berries: A review. International Journal of Agriculture, Forestry and Life Sciences, 3(2), 350–361.

Halliwell, B and J.M.C. Gutteridge. (2007). Free Radicals in Biology and Medicine, 4th ed.; Oxford University Press: Oxford, UK.

Ho, L. T. F., K. K. H. Chan, V. C. H. Chung and T. H. Leung. (2020). Highlights of traditional Chinese medicine frontline expert advice in the China national guideline for COVID-19. European Journal of Integrative Medicine, 101116. https://doi.org/10. 1016/j.eujim.2020.101116.

Katona, P and J. Katona-Apte. (2008). The Interaction between Nutrition and Infection. Clinical Infectious Diseases, 46(10), 1582–1588. doi:10.1086/587658

Khavinson, V. K. H., V. A. Barinov, A. V. Arutyunyan and V. V. Malinin. (2003). Svobodnoradikal'noe okislenie i starenie (Free Radical Oxidation and Senescence), St. Petersburg: Nauka.

Koca, I and B. Karadeniz. (2009). Antioxidant properties of blackberry and blueberry fruits grown in the Black Sea Region of Turkey. Scientia Horticulturae, 121(4), 447–450. doi:10.1016/j.scienta.2009.03.015

Lee, S.C., S.Y. Wang, C.C. Li and C.T. Liu. (2018). Anti-inflammatory effect of cinnamaldehyde and linalool from the leaf essential oil of Cinnamomum osmophloeum Kanehira in endotoxin-induced mice. Journal of food and drug analysis, 26(1), 211-220.

Lee, S. K and A. A. Kader. (2000). Preharvest and postharvest factors influencing vitamin C content of horticultural crops. Postharvest Biology and Technology, 20(3), 207–220. doi:10.1016/s0925-5214(00)00133-2

Li, W., N. Maeda and M. A. Beck. (2006). Vitamin C deficiency increases the lung pathology of influenza Virus– Infected gulo−/− mice. The Journal of nutrition, 136(10), 2611-6.

Lin, S.C., C. T. Ho, W. H. Chuo, S. Li, T. T. Wang and C.C. Lin. (2017). Effective inhibition of MERS-CoV infection by resveratrol. BMC Infectious Diseases, 17, 144-154.

Lv, Q., P. Zhang, P. Quan, M. Cui, T. Liu, Y. Yin and G. Chi. (2020). Quercetin, a pneumolysin inhibitor, protects mice against Streptococcus pneumoniae infection. Microbial Pathogenesis, 140, 103934. https://doi.org/10.1016/j.micpath.2019. 103934.

Manoharan, Y., V. Haridas, K. C. Vasanthakumar, S. Muthu, F. F. Thavoorullah and P. Shetty. (2020). Curcumin: A wonder drug as a preventive measure for COVID19 management. Indian Journal of Clinical Biochemistry, 35(3), 373–375.

Matsumoto, M., T. Mukai, S. Furukawa and H. Ohori. (2005). Inhibitory effects of epigallocatechin gallate on the propagation of bovine coronavirus in Madin-Darby bovine kidney cells. Animal Science Journal, 76(5), 507–512. https://doi.org/10.1111/j. 1740-0929.2005.00297.

Mcdonough, A. A., L. C. Veiras, C. A. Guevara and D. L. Ralph. (2017). Cardiovascular benefits associated with higher dietary K vs. lower dietary Na evidence from population and mechanistic studies. American Journal of Physiology - Endocrinology and Metabolism, 312 (4): E348 DOI: 10.1152/ajpendo.00453.2016

Meydani, S.N., S.N. Han and D. Wu. (2005). Vitamin E and immune response in the aged: molecular mechanisms and clinical implications. Immunological Reviews, 205, 269–84.

Mittler, R., S. Vanderauwera, M. Gollery and F. Van-Breusegem. (2004). Reactive oxygen gene network of plants.Trends in Plant Science, 9, 490–498.

Muller, O., M. Garenne, B. Kouyate´ and H. Becher. (2003). The association between protein-energy malnutrition, malaria morbidity and all-cause mortality in West African children. Tropical Medicine & International Health, 8, 507–11.

Name, J. J., A. C. R. Souza, A. R. Vasconcelos, P. S. Prado and C. P. M. Pereira. (2020). Zinc, Vitamin D and Vitamin C: Perspectives for COVID-19 with a Focus on Physical Tissue Barrier Integrity. Frontiers in nutrition, 7, 295. https://doi.org/10.3389/fnut.2020.606398

Naska, A and A. Trichopoulou. (2014). Back to the future: the Mediterranean diet paradigm. Nutrition, Metabolism & Cardiovascular Di seases, 24, 216–219. doi: 10.1016/j.numecd.2013.11.007

Okatan, V. (2020) . Antioxidant properties and phenolic profile of the most widely appreciated cultivated berry species: A comparative study. Folia horticulture, 32(1), 79–85.

Racchi, M. L. (2013). Antioxidant Defenses in Plants with Attention to Prunus and Citrus spp. Antioxidants, 2, 340-369; doi:10.3390/antiox2040340

Raman, R. 2018. https://www.healthline.com/nutrition/foods-high-in-antioxidants

Reshi, M.L., Y.C. Su and J. R. Hong. (2014). RNA viruses: ROS-mediated cell death. International Journal of Cell Biology, 467452, https://doi.org/10.1155/2014/467452.

Romano, L., F. Bilotta, M. Dauri, S. Macheda, A. Pujia and G. L. De Santis. (2020). Short report - medical nutrition therapy for critically ill patients with COVID-19. European Review for Medical and Pharmacological Sciences, 24, 4035–9.

Tsao, R. (2015). Synergistic interactions between antioxidants used in food preservation. In Handbook of antioxidants for food preservation. 335-347. Wood head Publishing.

Rusznyak, S.P and A. Szent-Gyorgyi. (1936) . Vitamin P as Flavonoids. Nature, 138, 27.

Salehi, B., A. P. Mishra, M. Nigam, B. Sener, M. Kilic and M. Sharifi-Rad, 2018. Resveratrol: A double-edged sword in health benefits. Biomedicines, 6(3), 91.

Scrimshaw, N and C. Taylor. (1968). Gordon J. Interactions of nutrition and infection. Monograph series no. 37. Geneva, Switzerland: World Health Organization.

Shylaja, M.R and K.V. Peter. (2004). The functional role of herbal spices. In Handbook of Herbs and Spices. 2.

Smyth, L.J., M. Cañadas-Garre, R.C. Cappa, A.P. Maxwell and A.J. Mcknight. (2019). Genetic associations between genes in the renin-angiotensin-aldosterone system and renal disease: A systematic review and meta-analysis. British Medical Journal Open, 9, 026777.

Soto, M. E., V. Guarner-Lans, E. Soria-Castro, L. Manzano Pech and I. Pérez-Torres. (2020). Is antioxidant therapy a useful complementary measure for Covid-19 treatment: An algorithm for its application. Medicina, 56(8), 386.

Stevens, R., D. Page, B. Gouble, C. Garchery, D. Zamir and M. Causse. (2008). Tomato fruit ascorbic acid content is linked with mono dehydro ascorbate reductase activity and tolerance to chilling stress. Plant, Cell and Environment, 31, 1086–1096.

Van Breusegem, F., J. Bailey-Serres and R. Mittler. (2008). Unraveling the tapestry of networks involving reactive oxygen species in plants. Plant Physiology, 147, 978–984.

Wagner, J., A. Dupont, S. Larson, B. Cash and A. Farooq. (2020). Absolute lymphocyte count is a prognostic marker in Covid-19: A retrospective cohort review. International Journal of Laboratory Hematology, doi:10.1111/ijlh.13288

Wen, C. C., L. F. Shyur, J. T. Jan, P. H. Liang, C. J. Kuo, P. Arulselvan and N. S. Yang. (2011). Traditional chinese medicine herbal extracts of cibotium barometz, gentian scabra, dioscorea batatas, cassia tora, and taxillus chinensis inhibit sars-cov replication. Journal of Traditional and Complementary Medicine, 1(1), 41–50. https://doi.org/ 10.1016/S2225-4110(16)30055-4.

Xian, Y., J. Zhang, Z. Bian, H. Zhou, Z. Zhang, Z. Lin and H. Xu. (2020). Bioactive natural compounds against human coronaviruses: a review and perspective. Acta Pharmaceutica Sinica. 10, 1163–1174.

Yang, X., Y. Yu, J. Xu, H. Shu, J. Xia, H. Liu, Y. Wu, L. Zhang, Z. Yu and M. Fang. (2020). Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: A single-centered, retrospective, observational study. The Lancet Respiratory Medicine, 8, 475–481.

Yang, Y., Q. Lu, M. Liu, Y. Wang, A. Zhang and N. Jalali. (2020). Epidemiological and clinical features of the 2019 novel coronavirus outbreak in China. Medrxiv, 2020

Zhang, J., G. Meng, W. Li, B. Shi, H. Dong, Z. Su and P. Gao. (2020). Relationship of chest CT score with clinical characteristics of 108 patients hospitalized with COVID-19 in Wuhan, China. Respiratory Research, 21(1), 1-11.