**IMPACT OF TOMATO MINERALS AND VITAMINS ON HUMAN HEALTH**

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**Abstract**

Tomato is a wonder fruit that is having extraordinary benefits for human health. Tomato is a significant source of vitamins and minerals like calcium, magnesium, potassium, vitamin C, E, A, Lycopene and carotenoids. Tomato keeps people in good health and lowers the risk of health problems like cardiovascular, cancer, diabetes, and hypertension. Lycopene serves as an antioxidant that quenches dangerous free radicals and protects against damage to DNA and cell structure. Minerals present in tomatoes make the bones healthier and improve skeletal muscle contraction. Fluoride present in tomatoes is useful for children's dental caries. In the past few decades, different studies suggested that there is a direct relationship between the consumption of bioactive compounds existing in tomatoes and reducing the risk of suffering from different types of cancers. This review article focuses on the role of tomato minerals and vitamins on human health that not only protect from different diseases but also improve the immune system of the body. The immune system gained more importance during recent coronavirus 2019 (COVID-19) circumstances. Having a good immune system resulted in a low risk of coronavirus attacks.

**Keywords:**Solanum lycopersicum L.; minerals; vitamins; cancer; antioxidant; COVID-19

**Introduction**

 There is no doubt that tomatoes (*Solanum lycopersicum* L.) are it is a member of the *Solanaceae* family and is one of the most popular fruits on the planet. Western South and Central America are the origins of this species ([Adejuwon, 2017](#_ENREF_2)), Even though it is characterized as a vegetable, if we see towards botanical terminology, the tomato is a vine born fruit ([Nasir et al., 2015](#_ENREF_37)). It has red, pink, yellow, white and green colors ([Adejuwon, 2017](#_ENREF_2)), which contain different nutritional values. Tomato is worldwide known as a “Protective Food” as this is an excellent a potent chemo protectant and antioxidant, as well as a source of minerals, vitamins, organic acids, and antioxidants ([Dagade et al., 2015](#_ENREF_14)). These compounds play a key role in human health, such as vitamin C, vitamin A, folate, potassium etc. Additionally, tomatoes contain lycopene, flavonoids, beta-carotene, and phenols important for health ([Al Said et al., 2014](#_ENREF_3)). That plays an important role against different diseases which includes obesity, high blood pressure, heart disease and diabetes. Lycopene serves as an antioxidant that quenches dangerous free radicals and protects DNA damage and cell structure. It also works as an anti-inflammatory, cholesterol-lowering and anticoagulant agent ([Al Said et al., 2014](#_ENREF_3)). Due to the remarkable role of tomatoes, there is a need to emphasise on formulation of a breeding programme for the development of cultivars rich in minerals, vitamins and antioxidants.

**Minerals**

Calcium

The most stored nutritional component in the human body is Calcium. Teeth and bones stored more than 99% (1.2-1.4 kg) of calcium and <1% is found in extracellular serum calcium. An average absorption rate of supplemented calcium in food in adults is 30%. The calcium absorption rate varies with the body changes, for example, a higher amount of calcium is required to grow a fetus during pregnancy so, the absorption rate of calcium increases. It dispersed throughout the tissue compartment of the human body. Different studies confirmed the involvement of calcium in proper body movement and function including, intracellular signaling, and hormonal secretion. The functions of each of these minerals could be reviewed separately, but they together demonstrate how important calcium is to the human body. A severe change in human body function is caused by the change in serum calcium. Because of its relationship with nerve transmission and intracellular signaling, hypocalcemia has been linked with an increased risk of seizures ([Health, 2013](#_ENREF_22)). Tomato contains a considerable amount of calcium; a 100g of tomato contains 7-10 mg of calcium that is vital in consolidation and performing minor repairs of bones as well as the bone tissue ([Bhowmik et al., 2012](#_ENREF_8)).

Magnesium

Our bodies rely on magnesium (Mg2+) for many functions. Several fundamental functions are regulated by magnesium; Muscle contractions, neuromuscular transmission, glycemic regulation, myocardial contractions, and blood pressure are all part of this process ([Bertinato et al., 2015](#_ENREF_7); [Gröber et al., 2015](#_ENREF_19)). In addition to its role in energy production, magnesium is also crucial to active transmembrane transport, nuclear material synthesis, and bone development. Aside from its role in energy production, magnesium is also crucial for active transmembrane transport of other ions, the production of nuclear materials, and bone formation ([Gröber et al., 2015](#_ENREF_19)). Furthermore, many diseases are associated with the deficiency of magnesium. Additionally, recent past studies have confirmed the valuable effects of magnesium supplementation. A hundred grams of tomato contains 11 mg of magnesium that can help cure the patient of hypomagnesaemia. Hypomagnesaemia is the combination of different diseases characterized by low magnesium intake that has been implicated in a broad range of cardio-metabolic conditions, including diabetes, hypertension, and cardiovascular disease ([Hruby and McKeown, 2016](#_ENREF_25)). Tomato is also a cure for another health condition called “Acidosis” is resulted in muscle fatigue, breathing issue, depression and hormonal changes. Humans maintain an alkaline balance with pH by incorporating different alkaline minerals like Ca2+, Na+, K+ and Mg2 and daily intake of a healthy diet maintained this balance naturally in ours. Tomatoes are excellent sources of Ca2+, Mg2+, and K+ and can aid in preventing acidosis ([Bhowmik et al., 2012](#_ENREF_8)).

Potassium

Potassium naturally presents in many foods and helps to maintain the body fluid inside of cells. Furthermore, it is important for heart function, muscle contraction, and digestion.. The optimum plasma level in adults lies at 3.5 to 5.0 mEq/L, maintained by 80 to 200 mEq per day on average dietary intake. It has been observed that the optimum intake, less need, and maximum tolerance are similar for both potassium and sodium ([Pohl et al., 2013](#_ENREF_39)). The deficiency of potassium causes diarrhoea, vomiting, acidosis and severe sweating. The recommended daily dietary dose of potassium for an adult is between 1875-5625 mg. Dagade et al. recommended that daily consumption of two to three tomatoes would fulfill the RDA of an adult so that this can decrease the risk of hypertension well as avoid muscle weakness, abdominal pain, cardiac problems, distension and respiratory failure ([Dagade et al., 2015](#_ENREF_14)). Our daily diet is low in K+ so a single cup of tomato juice can provide 534 mg of potassium and a half cup contains 454 mg of potassium ([Bhowmik et al., 2012](#_ENREF_8)).

Fluoride

Fluoride is also an important micronutrient for the human body; it mostly stores skeletal tissue and plays a vital role in bone and tooth health ([Dey and Giri, 2016](#_ENREF_15)). 1-3 mg of fluoride per day aids to prevent tooth decay. In the areas where fluoride concentration was 1 ppm in drinking water the fluoride intake in children was 0.05/mg, whereas in adults it was 0.7 mg/kg of body weight ([Moeinian et al., 2016](#_ENREF_34)). Dental caries is a common chronic disease of children, fluoride showed usefulness for prevention of caries and providing relief against this disease. During teeth development, regular exposure to fluoride protects against enamel fluorosis and tooth decay ([Dey and Giri, 2016](#_ENREF_15)). Food including tomatoes plays a major role in supplying the body's fluoride as it contains 2.3 μg of fluoride in 100g of fresh tomato that emulates for healthy bones and teeth.

**Vitamins**

Vitamins are organic, highly complex compounds present in different foodstuffs, vital for normal metabolism. The deficiency of these nutrients can cause serious health issues whereas; this deficiency can be recovered by supplementation of different vitamins. Vitamins play a key role in the normal growth and development of the human body. Thirteen vitamins come under the true vitamin category and are divided into two groups (i) water-soluble and (ii) fat-soluble. Vitamin A, E, D and K are fat-soluble vitamins, on the other hand, Vitamin B1, B2, B3, B5, B6, B9, B12, vitamin C and biotin are water-soluble vitamins. Some other components also have vitamin-like properties but they did not come under the true vitamin category. The direct source of vitamins includes plants and animals. For the proper continuance of human health, there is a need for a regular intake of vitamins.

***Tomato is a good source of vitamins***

Major nutritional components of tomato are shown in (Table 1) which shows that the tomato is a major source of vitamins including fat and water-soluble vitamins. Some vitamins are present in the form of antioxidants like vitamin C, E, carotenoids, flavonoids and other phenolics ([Hedges and Lister, 2005](#_ENREF_23)). These antioxidants combat reactive oxygen species (ROS), which are free radicals that can build up in our bodies as a result of a poor diet, pollution, or radiation or UV light exposure. These antioxidants have beneficial effects on the body yonder providing the nutrients required and preventing diseases. It is also assumed that these nutrients/vitamins prevent or slow down the occurrence of cardiovascular disease and cancer ([Maqbool et al., 2018](#_ENREF_32)).

Vitamin C (Ascorbic Acid)

It is present in two dietary forms dehydroascorbic acid and L-ascorbic acid. Due to its water-soluble nature, it is easily absorbed by the body but not stored ([Rigano et al., 2016](#_ENREF_43)). Previous studies reveals that salad tomatoes have 15-21 mg/100g of vitamin C in fresh tomatoes ([Abushita et al., 2000](#_ENREF_1)), On the other hand, industrial-grade tomatoes had an average of 19 mg/100 g ([Frusciante et al., 2007](#_ENREF_16)) stated the value of vitamin C in 100g of fresh tomato 8-16 mg.

Vitamin C has lots of health benefits, it supports the function of the epithelial barrier and promotes scavenging activity in the skin, it also protects against environmental stresses. Vitamin C plays a key role during apoptosis and clearance of accumulated neutrophils from the site of infection, by this means it decreases necrosis and possible tissue damage. Vitamin C required improving differential proliferation of T- and B-cells possibly due to gene-regulating effects ([Carr and Maggini, 2017](#_ENREF_10)). Vitamin C (Ascorbic Acid) has antioxidant potential depending on the redox status of the nearby environment. For the above-mentioned reasons, vitamin C has been studied to cure different diseases including cancer. Physiologically vitamin C is known as a free radical scavenger in the plasma, which protects and repairs the damage caused by ROS. It reduces potentially damaging ROS and produced stable free radicals ([Gallie, 2013](#_ENREF_17)). There are several examples of how this mechanism operates in cytoprotective functions under different physiological conditions, including inhibiting DNA mutation induced by oxidation, preventing lipid peroxidation and repairing amino acid residues oxidized by oxidation ([Carr and Maggini, 2017](#_ENREF_10)).

Vitamin C deficiency resulted in a weak immunity level and a person that has a low immunity level has more chances to become susceptible to different diseases and infections ([Carr and Maggini, 2017](#_ENREF_10)). This condition may result in scurvy if insufficient amounts of vitamin C are consumed; a disease characterized by dry skin, abrasions, fatigue, diminished wound healing, and depression ([Raiola et al., 2014](#_ENREF_41)). Vitamin C is actively available in tomatoes, so a daily consumption of a little amount of tomato product can improve the protection of cell and increase the protection from DNA damage that resulted from oxidative damage. This effect may produce by the combined action of vitamin C and lycopene([Riso et al., 2004](#_ENREF_44)). Jacob et al. ([Jacob et al., 2008](#_ENREF_26)) Taken over two weeks, The effects of tomato juice (500 mL) on cholesterol and CRP levels will be greater with vitamin C added. The effect was stronger when vitamin C was added in high quantities. This study established that there should be a Lycopene and vitamin C work synergistically in promoting tomato juice's anti-inflammatory properties.

***Vitamin E***

Tocopherols are lipid-soluble antioxidants that are not enzymatically produced, and that includes all four tocopherols found in vitamin E (α, β, δ, and γ). Vitamin E is found in the forms of α-tocopherol and α-tocopherol in human tissues and foods. While other forms of vitamin E are degraded and eliminated by the liver, α-tocopherol has the highest biological activity due to the hepatic α-tocopherol transfer protein (-TTP), which is thought to be the principal regulator of human VTE activity ([Belitz et al., 2004](#_ENREF_6)).

It prevents the production of reactive oxygen species by breaking the chain of chain-breaking antioxidants ([Rizvi et al., 2014](#_ENREF_45)). Recent studies suggested that regular intake of vitamin E Reduced the risk of heart diseases ([Raiola et al., 2015](#_ENREF_42)). The Institute of Medicine documented the Recommended Dietary Allowance of α-tocopherol is 15mg/day([Monsen, 2000](#_ENREF_36)). It has been observed that tomato consumption has advantageous properties related to tomato molecules' synergy properties, particularly lycopene and α-tocopherol, which inhabit the human promyelocytic leukaemia cells (HL-60 cell) differentiation, prostate carcinoma cell proliferation and low-density lipoprotein (LDL) oxidation ([Zanfini et al., 2010](#_ENREF_52)). Vitamin E works as an antioxidant that inhibits the formation of ROS resulting in oxidation([Rizvi et al., 2014](#_ENREF_45)). It serves as the primary line of defence against lipid peroxidation in cell and organelle membranes, where it has the highest protective effect ([Howard et al., 2011](#_ENREF_24)). Howard et al. ([Howard et al., 2011](#_ENREF_24)) Vitamin E has been shown to play a role in membrane repair by inhibiting membrane oxidation, a potential obstacle to membrane fusion. Another study confirms this ([Singh et al., 2007](#_ENREF_48)) Healthy people receiving γ-tocopherol enriched VTE experienced significant reductions in adenosine diphosphate-induced platelet aggregation. The antioxidant Vitamin E has also been shown to lower the risk of diabetes and prostate cancer ([Raiola et al., 2014](#_ENREF_41)). Moderate hypertensives who were administered tomato extract as part of their treatment plan had a strong association between systolic blood pressure and antioxidant levels([Paran et al., 2009](#_ENREF_38)).

Vitamin E is readily available in tomatoes. Tomatoes are rich in tocopherol, ranging from 0.17 to 1.44 mg/100 g FW ([Frusciante et al., 2007](#_ENREF_16)). Several studies have predicted the role of vitamin E in human health and disease control. Vitamin E promotes the repair of the plasma membrane and additionally, it helps maintain skeletal muscle homeostasis ([Howard et al., 2011](#_ENREF_24)). The vitamin may play a role in minimizing diabetes risk and improving cardiovascular health, according to other studies ([Raiola et al., 2014](#_ENREF_41)) and prostate cancer risks can be reduced ([Kirsh et al., 2006](#_ENREF_29)).

**β-Carotene**

           The β-carotenoids compose the group of chemicals in the human diet that are responsible for the coloration of foods, β-Carotene is an important pigment derived from the carotenoids ([Britton et al., 2008](#_ENREF_9)). As a powerful antioxidant, beta-carotene quenches excited triplet sensitizers so they cannot form singlet oxygen. Healthy skin is a healthy body. Carotene is one of the major carotenoid compounds in skin and when supplemented, it provides a boost to this tissue ([Grune et al., 2010](#_ENREF_20)).

β -Carotene is the most prevalent carotenoid in tomatoes, and it's what gives them their yellow and red hues. The mean level of β-Carotene in tomatoes ranged between 0.23-2.83 mg per 100g of fresh weight ([Baranska et al., 2006](#_ENREF_5)). A few studies suggest that processed tomatoes contain a higher concentration of beta-carotene (14.9 mg/100g DW) than fresh whole tomatoes (8.6 mg/100g DW) ([Kalogeropoulos et al., 2012](#_ENREF_28)). The primary precursor to vitamin A, β-carotene, contains two retinal groups. The intestine epithelium converts \*-carotene to retinol through an enzyme called 15,150-oxygenase ([Gong et al., 2017](#_ENREF_18)). Moreover, the pro-vitamin a activity, and other biological activities also are confirmed by some epidemiological studies, enhancement of the immune system, prevention of numerous cancers, and prevention of cardiovascular disease are among the numerous benefits of β-Carotene ([Szabo et al., 2018](#_ENREF_50)).

**Lycopene**

Lycopene is a member of the carotenoids group; which contained many pigments and is present in higher plants, fungi, bacteria and algae. The human and animal body is unable to produce lycopene that’s why they consume it with food ([Moise et al., 2014](#_ENREF_35)). When exposed to light, temperature, and chemical reactions lycopene isomerizes from all-trans to mono and poly-cis forms. There are more trans isomers of lycopene found in tomatoes than cis isomers, which are more commonly found in processed products([Przybylska, 2020](#_ENREF_40)) and which are more likely to be absorbed by humans ([Zepka et al., 2018](#_ENREF_53)).

Lycopene works as an antioxidant and protects the human body from different diseases. 50 years ago the first report on the beneficial effects of lycopene was published. At that time, scientists were studying the relation an association has been established between lycopene application Animals' resistance to infection and the development of abdominal cancer. Despite the fact that lycopene was discovered very early, there is still much to learn about its health effects ([Przybylska, 2020](#_ENREF_40)). Cancer is the second-leading cause of death in the United States; roughly 1.5 million new cases of cancer were reported in the United States in 2008. The regular intake of tomato and tomato products has been associated with a reduced incidence of different kinds of cancers, including most prostate, stomach and lung cancer ([Story et al., 2010](#_ENREF_49)). Cardiovascular disease (CVD) is also the leading cause of mortality in the United States and only in 2005, 652000 deaths have been reported in the USA ([Story et al., 2010](#_ENREF_49)). Lycopene is a powerful antioxidant that helps to lower the risk of cardiovascular disease and improves the biomarker for the disease ([Sesso et al., 2003](#_ENREF_46)). A study of 38445 women found that those who consumed more tomato-based products had a lower risk of cardiovascular disease and myocardial infarction. Despite the fact that studies on the ability of lycopene to alter cancer and CVD risk are the most common, lycopene consumption has also been studied for a variety of other disorders. UV-induced sunburn, gingivitis, osteoporosis, mental problems, and asthma are among these ailments ([Story et al., 2010](#_ENREF_49)).

Tomatoes are a rich source of lycopene in our daily diet (80%) ([Maiani et al., 2009](#_ENREF_31)). The percentage of lycopene in processed tomatoes is higher than in fresh ones, the reason behind that is water loss during processing ([Bacanli et al., 2017](#_ENREF_4)). The amount of lycopene varies in tomatoes concerning different factors which include variety, climate, ripeness and geographical site of cultivation ([Shi and Maguer, 2000](#_ENREF_47)). The concentration of lycopene in most fresh tomatoes is 54 mg/100g whereas dried tomatoes contained 46.5 mg in 100 g of tomatoes. Other products include varying amounts of lycopene, with ketchup containing 16.6 mg per 100 g, tomato liquids 5–7 mg per 100 g, and powder soups and sauces including 20.86 mg per 100 g and 23.88 mg per 100 g, respectively. (Hamułka & Wawrzyniak, 2004; Colle et al ., 2010).

**Tomato is a wonder fruit that boosts immunity against COVID-19**

The eruption of novel coronavirus disease induced by some respiratory syndrome coronavirus 2 (SARS-CoV-2), originated in china city of Wuhan in December 2019 and swiftly spread around the whole world. This virus brings the world public health emergency. WHO (World Health Organization) declared COVID-19 as a pandemic on 11th March 2020 ([Catanzaro et al., 2020](#_ENREF_11)). This virus transmits primarily through respiratory droplets. After infection, the median incubation period is 4-5 days approximately with no symptoms ([Guan et al., 2020](#_ENREF_21)), 97.5% of symptomatic patients observed the symptoms within 11.5 days ([Lauer et al., 2020](#_ENREF_30)). Typical symptoms of COVID-19 are fever, dry cough, sore throat and in severe case-patient face difficulty in breathing, muscle pain, headache, diarrhoea, nausea and coughing with blood ([Chan et al., 2020](#_ENREF_12)).

The intake of these vitamins and minerals has been found to improve immunity to viral infections. Following influenza vaccination, vitamin A and D supplementation improved the humoral immunity of paediatric patients ([Wintergerst et al., 2007](#_ENREF_51)). Different studies demonstrated that vitamin A and D had the ability to increase the immune system, especially in deficient populations, in the investigation of components that boost immunity, according to the report ([Jayawardena et al., 2020](#_ENREF_27)). Tomato is a rich source of vitamins and minerals that not improve the immune system but also protect the human body from different diseases, as ([Dagade et al., 2015](#_ENREF_14)) reported that potassium that is present in tomatoes can decrease the risk of hypertension well as avoid muscles weakness, abdominal pain, cardiac problems, distension and respiratory failure. So tomato has a huge potential to improve your immune system and help to overcome the deadly attack of COVID-19.

**Conclusion**

By increasing the world population, the risk of food shortage and nutrient deficiency is also increasing. In the past few decades’ plant breeders were mainly focused on the development of high yield crops by compromising the quality of crops, due to which nutrients start depleting the human food chain. This resulted in a weakened human immune system, and unable to fight against different cardiovascular, cancer, kidney, lungs and skin diseases. Under these circumstances, tomato emerges as a wonder crop that is rich in minerals and vitamins like (calcium, magnesium, potassium, vitamin C, E, A, lycopene and carotenoids). Tomato not only improves the nutrient status but also boosts the immune system that fights against many diseases. Tomato extract contains carotene, vitamin C and lycopene to work as an antioxidant that inactive free radicles and protect the human body from the dangerous effects of ROS. Now the dietitians recommended adding tomato to their daily diet because it is a rich source of nutrients.

Despite the lack of knowledge on nutritional elements in relation to the vulnerability and importance of viral infections such as COVID-19, the significance of nutrition in improving immunity has been demonstrated. The European Journal of Clinical Nutrition stated that the immune system is deprived of the components necessary for a successful immunological response when nutrition is inadequate. As a result, good nutrition is important in sustaining a healthy immune system that can reduce the risk of viral infections.. So, tomatoes can be an option to improve the immune system to combat deadly diseases like COVID-19, heart attack, cancer and blood pressure. This information suggested that the use of tomatoes in daily diet will boost the body's immune system to fight against diseases.

**Conflicts of interest/Competing interests**

Not applicable

**Funding:**

Not applicable

**Availability of data and material**

All the datasets generated for this study are included in the article.

**Code availability**

Not applicable

**Author Contributions:**

SA and YS conceived the idea and the review scheme. SA, MA and AR drafted the manuscript. All authors did significant contributions to improving the final version of the manuscript.

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Table 1 Nutritional Value of Red Fresh Tomato (Composition in 100 g) ([Collins et al., 2022](#_ENREF_13); [Menchú and Méndez, 2012](#_ENREF_33))

|  |  |  |
| --- | --- | --- |
| **Vitamins & Antioxidants** | **Minerals** | **Proximate** |
| Vitamin C (mg)  | 13.7-23 | Calcium (mg)  | 7-10 | Fiber (g)  | 1.2-1.83 |
| Choline (mg)  | 6.7 | Magnesium (mg)  | 0-11 | Sugar (g)  | 0.85-4.6 |
| Vitamin A (µg)  | 42 | Phosphorus (mg) | 24 | Protein (g)  | 0.78-0.88 |
| Vitamin E (mg)  | <1.8 | Potassium (mg) | 237 | Fat (g) | 0.2 |
| Flavonoids (mg)  | <8.2 | Sodium (mg)  | 5 | Carbohydrates (g) | 3.89 |
| A Carotene (µg)  | 449 | Fluoride (µg)  | 2.3 | Total Lipid (g)  | 0.20-0.3 |
| Β Carotene (mg)  | <1.1 | Iron (mg) | 0.27 | Water (g)  | 93.4-94.52 |
| Lycopene (mg)  | <14 | Zinc (mg) | 0.17 | Energy (Kcal)  | 18-34.67 |
| Vitamin K (µg)  | 123 | Manganese (mg) | 0.114 |  |  |
| Lutein + Zeaxznthine (µg)  | 123 | Copper (mg) | 0.059 |  |  |

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