COVID-19 AND NUTRITION

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Summary. Currently Covid-19 pandemic is a leading challenge across the globe. It is mandatory to attain and maintain good nutritional status to fight against virus. Nutritional status of individual is affected by several factors such as age, sex, health status, life style and medications. Nutritional status of individuals has been used as resilience towards destabilization during this COVID-19 pandemic. Optimal nutrition and dietary nutrient intake impact the immune system, therefore the only sustainable way to survive in current context is to strengthen the immune system. There is no evidence found that supplement can cure the immune system except Vit C, which is one of the best way to improve immune system. A proper diet can ensure that the body is in proper state to defeat the virus. However along with the dietary management guidelines the food safety management and good food practices is compulsory. This article explores the importance of nutrition to boost immunity and gives some professional and authentic dietary guidelines about nutrition and food safety to withstand COVID-19.

The aim of the study – to analyze and systematize the literature data about the influence of nutrition on the manifestation of COVID-19 infection.

Materials and Methods. The study uses publications of the world scientific literature on COVID-19 infection, in particular the causes and mechanisms of its development, treatment, complications and its consequences as well as the influence of different nutrients and nutraceuticals on the course of COVID-19. This review highlights the nutritional interventions to increase the immune response in the body during viral infections, especially considering the novel coronavirus pandemic. Due to their beneficial effects on general healthcare and disease prophylaxis, nutraceuticals have been gaining more and more importance lately.

Results. During the COVID-19 pandemic, the nutritional status of individuals has been used as a measure of resilience toward destabilization. Optimal nutrition and dietary nutrient intake impact the immune system through gene expression, cell activation, and signaling molecules modification. In addition, various dietary ingredients are determinants of gut microbial composition and subsequently shape the immune responses in the body. Therefore the existing evidence suggests that the only sustainable way to survive in the current situation is to strengthen the immune system. An adequate intake of zinc, iron, and vitamins A, B12, B6, C, and E is essential for the maintenance of immune response and to prevent the destabilization of the gut microbial composition.

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COVID-19 and nutrition

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Function. In the current scenario, COVID-19 has imposed a new set of challenges for the individual to maintain a healthy diet. The state of self-isolation, lockdown, and social distancing are important measures to flattening the curve of the disease, although these measures have severe repercussions on an individual's life. The act of confining to one's home has significant impacts on one's health, including changes in eating patterns, sleeping habits, and physical activity. It would promote sedentary behaviors that affect mental and physical health and lead to an increased risk of obesity. Fear and anxiety may also cause changes in dietary habits leading to unhealthy dietary changes and less desire to eat or with lessened enjoyment during eating. Micronutrients are dietary components that may contribute substantially to a robust immune system. Essential micronutrients like vitamins A, D, E, C, B6, B12, and folate and trace elements such as iron, zinc, and selenium, available in a variety of fresh animal- and plant-based foods, aid the body's ability to fight infections.

**Conclusions.** COVID-19 became the most challenging pandemic influencing all countries worldwide. A proper and healthy diet can ensure a robust immune system that can resist any onslaught by the virus. A certain amount of particular nutrient saturates into cells and prevents any kind of nutritional deficiency. Individuals consuming well-balanced diets appear to be safer with better immune systems and lower incidence of chronic diseases and infections.

**Key words:** COVID-19; viral infection; nutrition; chronic disorders.

**INTRODUCTION**

COVID-19 pandemic is posing severe threats to international health and the economy.

- At the moment there is still no cure for the disease
- Alternative methods need to be found to control the spread of the virus [1].

COVID-19 is caused by specific Coronavirus (SARS-CoV 2). Coronaviruses primarily cause enzootic infections in animals but is capable of transferring to humans and causing infections eg.:  
  - Severe Acute Respiratory Syndrome (SARS) in 2002
  - Middle East Respiratory Syndrome (MERS) in 2012.
  - Both Zoonotic Diseases

The outbreaks of SARS, MERS and COVID-19 demonstrate how lethal Coronavirus can be when they cross the species barrier and infect humans [2]. Interestingly, the genome structure of COVID-19 is 82 % identical to that of the SARS-CoV genome [3]. Lessons learned from the SARS (2002) outbreak could be applied or tried to apply to COVID-19.

Symptoms of COVID-19 include:

- Fever, cough, respiratory symptoms, shortness of breath, breathing difficulties, fatigue and a sore throat.
- A minority group of people will present with more severe symptoms and will need to be hospitalised, most often with pneumonia, and in some instances, the illness can include ARDS, sepsis and septic shock [4].

**Nutrition**

1. Not a cure for COVID-19 but healthy patterns of eating optimize the function of the immune system, improve immunometabolism, and are a modifiable contributor to the development of chronic disease that is highly associated with COVID-19 deaths.

2. May have a positive impact on COVID-19 as it may be a way to support people at higher risk for the disease i.e. older people and people with pre-existing conditions (non-communicable diseases).

**The aim of the study** – to analyze and systematize the literature data about the influence of nutrition on the manifestation of COVID-19 infection.

**MATERIALS AND METHODS**

The study uses publications of the world scientific literature on COVID-19 infection, in particular the causes and mechanisms of its development, treatment, complications and its consequences as well as the influence of different nutrients and nutraceuticals on the course of COVID-19. This review highlights the nutritional interventions to increase the immune response in the body during viral infections, especially considering the novel coronavirus pandemic. Due to
their beneficial effects on general healthcare and disease prophylaxis, nutraceuticals have been gaining more and more importance lately.

RESULTS AND DISCUSSION

Symptoms and Risk Factors of COVID-19

Two to 14 days after exposure to the virus, the usual clinical signs are dry cough and shortness of breath. The Centers for Disease Control and Prevention (CDC) reported that the appearance of fever, chills, myalgia, headache, as well as the loss of smell and taste, could indicate an infection. The majority of humans have mild symptoms if any occur, and it has been reported that ca. 80% of infected people do not need hospitalization [4].

Nevertheless, in some individuals, the infection can cause severe problems. With aging, the immune response becomes weaker (immunosenescence), and the levels of inflammatory mediators in the blood increases (inflammageing). The high-risk group of COVID-19 that are clinically vulnerable includes primarily elderly individuals and those with inflammation-associated conditions such as overweight and obesity, chronic obstructive pulmonary disease, cardiovascular diseases, diabetes, kidney disease, etc. The majority of severe COVID-19 cases and mortalities were within the abovementioned group of individuals, although it is worrisome that younger and healthy individuals are showing up in this cohort [5, 6].

The virus rapidly multiplies and infects the surrounding cells throughout the respiratory system. At the time the virus gets to the lungs, an inflammatory process starts in the mucous membranes and damages the alveoli, which have difficulties in supplying oxygen, resulting in breathing difficulties. This can cause swelling in the lungs, which can result in the accumulation of fluids and dead cells and, finally, severe pneumonia. The infection can spread through mucous membranes of the body, such as the digestive system. In some cases, gastrointestinal symptoms like diarrhea, indigestion, and vomiting have been reported along with respiratory symptoms, and studies propose the possibility of fecal-oral transmission [7]. The typical symptoms of COVID-19 and their incidence percentage in 55,924 laboratory confirmed cases are illustrated in Figure 1 (according to the report of the WHO-China Joint Mission; 20 Feb., 2020).

SARS-CoV-2 has been isolated from the brain-stems of positive patients, which indicates that this virus has common pathways of transmission with other coronaviruses that can spread through synapse-connected routes from the lung and airways. The virus can cause problems in different parts of the body, such as the heart, liver, and kidneys, particularly in the later stage of the disease. Fatal cases of COVID-19 can be caused by multiple organ failure, especially in individuals with genetic immune factors [8, 9].

This review highlights the nutritional interventions to increase the immune response in the body during viral infections, especially considering the novel coronavirus pandemic. Due to their beneficial effects on general healthcare and disease prophylaxis, nutraceuticals have been gaining more and more importance lately [10].

World Health Organisation: Nutrition Advice during the COVID-19 outbreak. Good nutrition and hydration are important. A well-balanced diet keeps you healthy, strengthens the immune system, and reduces the risk of chronic disease and infectious disease. It is recommended that a diet with a variety of fresh food and unprocessed foods is followed daily, to provide the body with the necessary vitamins, minerals, dietary fibre, protein, and antioxidants [11].
Eat fresh and unprocessed foods every day
• Include fruits, vegetables, legumes, nuts and whole grains and foods from animal sources (e.g. meat, fish, etc)
• Daily portion recommendations:
  • 2 cups of fruit (4 servings)
  • 2.5 cups of vegetables (5 servings)
  • 180 g grains
  • 160 g meat and beans (red meat 1–2 times/week and poultry or fish 2–3 times/week)
  • Snack on raw vegetables and fruit, rather than foods that are high in sugar, fat or salt
• Avoid overcooking vegetables and fruit – to avoid the loss of important vitamins
• If using canned fruit or vegetables – choose wisely, avoid varieties with added salt and sugar
• Drink enough water every day
• Water is essential
• It transports nutrients and compounds in blood, regulates body temperature, gets rid of waste and lubricates and cushions joints
• Drink 8–10 cups of water daily
• Water is the best choice, other drinks can also be consumed such as lemon juice (diluted in water and unsweetened), tea and coffee. Avoid consuming too much caffeine, sweetened fruit juices, fizzy drinks and drinks high in sugar
  • Eat moderate amounts of fat and oil
  • Eat unsaturated fats rather than saturated fats
  • Choose meat that is low in fat
  • Avoid processed meats as it is high in salt and fat
• Avoid industrially produced trans fat – fast food, fried food, etc
• Eat less salt and sugar
• When cooking and preparing food, limit the amount of salt
  • Limit daily salt intake to less than 5g (1 teaspoon)
  • Avoid foods high in salt and sugar
  • Limit intake of soft drinks and sodas that are high in sugar
  • Choose fresh fruits instead of sweet snacks such as cookies, cake and chocolate

Immune Boosting Foods
A healthy immune system can defeat invading pathogens. Many products on store shelves claim to boost or support immunity. But the concept of boosting immunity actually makes little sense scientifically. In fact, boosting the number of cells in your body – immune cells or others – is not necessarily a good thing. For example, athletes who engage in “blood doping” – pumping blood into their systems to boost their number of blood cells and enhance their performance – run the risk of strokes.
• Attempting to boost the cells of your immune system is especially complicated because there are so many different kinds of cells in the immune system that respond to so many different microbes in so many ways. Which cells should you boost, and to what number? So far, scientists do not know the answer. What is known is that the body is continually generating immune cells. Certainly, it produces many more lymphocytes than it can possibly use. The extra cells remove themselves through a natural process of cell death called apoptosis – some before they see any action, some after the battle is won. No one knows how many cells or what the best mix of cells the immune system needs to function at its optimum level.

• There is some evidence that various micronutrient deficiencies – for example, deficiencies of zinc, selenium, iron, copper, folic acid, and vitamins A, B6, C, and E – alter immune responses in animals, as measured in the test tube.

Nutrition and immune defense
Micronutrients are dietary components that may contribute substantially to a robust immune system [12]. Essential micronutrients like vitamins A, D, E, C, B12, and folate and trace elements such as iron, zinc, and selenium, available in a variety of fresh animal- and plant-based foods, aid the body’s ability to fight infections [13, 14]. Health and survival are increasingly dependent on the functioning of the immune system. Mechanistically, a rapid innate immune response occurs through phagocytes when a pathogen assaults the living system, but an adaptive immune response more specifically identifies the invading pathogen. Basically, these immune responses are controlled and coordinated by T cells, which recognize the antigens and are classified as cytotoxic T cells. Cytotoxic T cells kill infected, damaged cells and the T helper cells Th1 and Th2. These cells are involved in antiviral and cellular immune responses as well as humoral and antiparasitic responses [15]. A strong immune system ensures host defense against pathogens and neoplastic cells, and balanced nutrition augments the immune system to provide optimal defense against infectious agents. Many scientists have explained the critical role of the immune system as well as the defense mechanisms involved in protecting the body from invading agents, particularly in the presence of appropriate nutrition. A lot of them reported their findings on the kinetics of the immune response to COVID-19, describing higher concentrations of follicular helper T cells, antibody-secreting cells, activated CD4+ and CD8+ T cells, and immunoglobulin M (IgM) and immunoglobulin G (IgG) antibodies, all of which were observed to bind to coronavirus SARS-CoV-2. The results thus validate the role of a strong immune defense in patients COVID-19.

An optimally functioning immune system is closely linked to an adequate supply of micronutrients to the body, while severe deficiencies of these micronutrients
lead to weakened immune responses and vulnerability to infections. Vitamins A, C, E, and B complex, along with folic acid, zinc, selenium, iron, and copper, all play important roles in boosting the immune system of the population [16, 17]. Several studies have confirmed that micronutrient deficiencies are associated with a weakened immune system that predisposes individuals to increased vulnerability to infections [18, 19]. It was demonstrated the critical role of essential vitamins and trace elements in boosting the immune system. They emphasized that micronutrients such as vitamins A, B6, B12, C, D, and E, (Figure 2) in addition to iron, selenium, and zinc (Table 1), [20-30] might work synergistically to help immune cells function appropriately.

Recent research also supports a role of certain minerals and vitamins as adjunct therapeutic agents to treat microbiological infections as well as immunological and nonimmunological chronic diseases [31–39].

More recently, it was reviewed the association between optimal nutrition and the immune system in providing better protection against viral infections. Scientists suggested that essential micronutrients and

Figure 2. Role of vitamins E, D, and C in innate and adaptive immunity. Abbreviations: COX, cyclooxygenase; Ig, immunoglobulin; IL, interleukin; MHC, macrophage histocompatibility complex; NK, natural killer; NO, nitric oxide; PEG, polyethylene glycol; TNF, tumor necrosis factor.

Table 1. Role of selected minerals in innate and adaptive immunity

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<tr>
<th>Mineral</th>
<th>Role in innate immunity</th>
<th>Role in adaptive immunity</th>
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| Folate    | • Supports innate immunity  
• Increases production of NK cells                                                              | • Improves cell-mediated immunity  
• Increases expression of antigen-presenting cells  
• Increases antibody-mediated immune response  
• Increases antibody production  
• Assists T-helper cell–mediated immune response |
| Iron      | • Regulates production of cytokines  
• Improves phagocytosis                                                                 | • Increases T-cell proliferation  
• Improves cytotoxic T-cell function |
| Zinc      | • Protects cells from oxidants  
• Helps maintain skin and mucosal cell membrane integrity                                     | • Promotes release of cytokines to mediate adaptive immunity  
• Assists T-helper 1 cells  
• Activates T cells |
| Copper    | • Aids neutrophil phagocytosis  
• Increases IL-2 production                                                                   | • Increases T-cell proliferation  
• Increases antibody production  
• Improves cellular immunity by activating cytokines and chemokines |
| Selenium  | • Helps selenium-dependent enzymes (sialoproteins) to resist oxidant production  
• Supports function of NK cells and leukocytes (macrophages, neutrophils, monocytes)        | • Increases antibody production  
• Promotes T-cell proliferation and differentiation |
the omega-3 fatty acids have the capacity to boost immunity against viral infections. Similarly, it was also described the complex relationship between trace elements and viral infections, highlighting the immunomodulatory properties and antiviral activities of certain micronutrients such as iron, zinc, selenium, and copper. Apart from functioning as antioxidants, these trace elements were shown to inhibit viral replication in host cells.

Older adults, compared with younger populations, are more susceptible to COVID-19-like viral infections and their associated serious outcomes. This increased susceptibility is attributable to aging-associated physiological changes, a weakened immune response, malnutrition, and multimorbidities [40]. Prolonged hospitalization to ensure the stabilization and recovery of COVID-19 patients increases the risk of malnutrition and severe loss of lean body mass and muscle function. Nutritional screening and treatment of malnutrition in older patients is therefore mandated as part of COVID-19 patient care [41]. A recent cross-sectional study from Wuhan, China, reported that 52.7% of the 182 older adult patients with COVID-19 were malnourished, with the mean Mini Nutritional Assessment score being below 17 [42]. Advanced age is associated with a high risk of nutritional frailty, characterized by sudden weight loss, loss of lean body mass, and loss of physiological nutritional reserves. Nutritional frailty compromises an individual’s ability to meet their nutritional needs and increases their susceptibility to disability [43]. The European Society for Clinical Nutrition and Metabolism [44] proposed several considerations for the nutritional care of older COVID-19 patients: nutritional screening; optimization of nutritional status by dietary counseling; supplementation with essential vitamins and minerals, oral nutritional supplements, and enteral and parenteral nutritional support when nutritional needs are not met; and regular physical activity in quarantine. Adverse clinical outcomes of viral infections have been linked to low intakes of micronutrients. Thus, providing the RDA of vitamins A, D, E, C, B12, and B6, and iron, zinc, selenium, and omega-3 PUFAs to malnourished older adults may help prevent or treat adverse clinical outcomes of COVID-19.

**CONCLUSIONS**

1. The role of optimal nutrition for managing the current COVID-19 pandemic cannot be underestimated. Nutrition has a demonstrable role in the prevention and treatment of moderate to severe respiratory and nonrespiratory infections.

2. Adequate nutrition is even more essential for marginalized communities and in low- and middle-income countries, where deficiencies in key vitamins and minerals expose individuals to greater morbidity and mortality.

3. Low- and middle-income countries should strategize to ensure the population at large has access to optimal nutrition to boost the immune system and should provide specific supplementation for treatment of COVID-19 patients, especially those with severe disease.

4. Older adults represent a high-risk population and may be prioritized to receive care in nursing facilities and to receive specialized nutritional support to improve physical and mental outcomes of the COVID-19 pandemic.

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