Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
CHAPTER

33

Significance of conventional Indian foods acting as immune boosters to overcome COVID-19

Madhavi Latha Kone\textsuperscript{a}, Dhanu Radha Samayamanthula\textsuperscript{b}

\textsuperscript{a}Department of Gynecology, Kalyan Hospital, Payakoropeta, Andhra Pradesh, India

\textsuperscript{b}Water Research Center, Kuwait Institute for Scientific Research, Shuwaikh, Kuwait

33.1 Introduction

The COVID-19 pandemic is enforcing every individual in this world to have a robust diet (Aman and Masood, 2020). The immune system remains the first line of defense against disease causing microorganisms and other noxious substances. It is a multifaceted system of cells and proteins that protect the body against infections. There are many factors influencing an individual being healthy or becoming sick based on their immunity. This entirely depends on an individual; the consumption of foods on regular basis in terms of quality and quantity. For a strong immune system, the body requires essential energy, nutrients with all vitamins, minerals, and herbs (Arshad et al., 2020). Moreover, it is important to understand that a strong immunity is not built overnight but is possible only by consuming healthy foods that have high nutritional values on a regular basis.

Immune system has different types of components. Type 1 is innate immunity. It acts as barrier from bacteria, viruses, and parasites. Chemical cells can rapidly raise the alert and begin to fight off the virus. The symptoms for COVID-19, such as sore throat, body aches, cold, cough, and fever are not caused by the virus itself, but triggered by our own body, as part of innate immune response. Type 2 is skin, airways, and mucus membrane that provides a barrier to infection. But once the virus gets past these defenses, it is necessary to induce the innate immunity (Alberts et al., 2002). Type 3 is known as adaptive immunity, which is composed of systemic cells and processes to
keep away pathogens by preventing their growth (Merlo and Mandik-Nayak, 2013); (John Wherry and Masopust, 2016). Usually this is given in the form of vaccine. Type 4 is herd immunity. This protects indirectly from infections especially, during either epidemic or pandemic through vaccination or previous infections (John and Samuel, 2000). Type 5 is nutritional immunity, which tries to limit the pathogens that causes infections by including minerals in the diet (Hood and Skaar, 2012).

Lysozyme (chemical cell), an enzyme, is a powerful tool for innate immunity. It has the most antibacterial and antiviral properties (Invitra, 2011). The bacterial growth is inhibited by peptidoglycan cell walls. It is very useful in molecular biology as it can perform cell lysis, an essential process in extraction of recombinant DNA (Eshdat and Sharon, 1977). Saliva is one of the sources of Lysozymes. It can be generated through saliva by consuming conventional Indian foods. Salivary glands help to protect from numerous microbes in the mouth by producing immunoglobulin A (IGA) antibodies. It binds to mucus layer that covers the epithelial lining of the oral cavity and acts as a barrier against potentially dangerous pathogens. Adequate salivation is a good sign of immune response.

Conventional Indian foods containing functional components like antioxidants, dietary fibers, and body healing chemicals are the primary sources for the immune system and can produce lysozyme. The processing techniques, such as soaking, sprouting, and fermentation further enhance functional properties of the Indian foods (Sarkara et al., 2015). Vitamins, minerals, and herbs are equally important for enhancing the immunity. Considering the past studies and importance of the diet to maintain good immunity, the present study has focused only on the traditional foods to raise awareness of every individual, which could develop immunity and resist any kind of contagious diseases.

### 33.2 Methodology

Few case studies of affected COVID-19 patients were collected and presented in the study. Conventional foods that can produce lysozyme, antioxidants, and vitamins, such as water and fat soluble, minerals, and herbs are the most important immune boosters that were considered for the study to maintain good health and help to prevent COVID-19 as well as other infectious diseases. Along with the abovementioned foods, few techniques such as soaking, sprouting, and fermentation were also discussed.

### 33.3 Results and discussion

It was evident from the case studies data (Table 33.1) that dietary habits played a major role to overcome COVID-19 in spite of their previous health history. Few studies reported that blood group O and B are less vulnerable compared to A and AB (Barnkob et al., 2020; Holand et al., 2020). But in the present case studies, many of the affected patients are O +ve and B +ve. So the virus may attack any individual depending on the environment or type of attacking strain in virus and also those who have less immunity. Irrespective of the age groups of the individuals; poor diet increases severity. Out of 16 case studies, only two cases lead to fatality. Hence it is necessary that enriching with all types of foods in the regular diet discussed as follows will definitely help every individual to prevent or overcome from COVID-19.

#### 33.3.1 Lysozyme foods

Viral infections like Cytomegalovirus and Epstein Barr virus were identified that the spread of virus is via saliva (De França et al., 2011). Even studies reported that saliva is one of the causes for transmission of COVID-19 (WHO, 2020; Xu et al., 2020). Since the saliva is one of the sources for transmission of viruses, intake of lysozyme foods would improve the immunity right from oral cavity and so the carrier of virus via saliva would be under control. Few vegetables and fruits have high concentrations of lysozyme (Chandan and Ereifej, 1981). Citrus fruits like lime and orange help to maintain saliva. Eating directly the lysozyme foods in the form of salads or by cooking on regular basis helps to sustain and be healthy. The reasonable way of improving the enzyme lysozyme naturally through saliva is by preferring Indian curd, which is equally important for healthy bacteria of the gut.

#### 33.3.2 Antioxidants

In general, corrosion of iron takes place by constant exposure to air or oxidation. Our body also functions in the same way. Oxidative stress and free radicals are linked to numerous diseases. The stress of modern lifestyle compels to experience the pollution from environment, emotional fatigue, and radiations released from smart phones and
TABLE 33.1  Case studies of affected COVID-19 patients with all details.

| Case Study | Gender | Type of Blood Group | Age | Regular dietary habits on daily basis | Previous health history | Type of Symptoms developed and Date | Date of Testing | Type of COVID testing | Severity | Type of Quarantine | Effect of COVID-19 | Diet during treatment along with medication | No. of days undergone for treatment | Date of retesting | Date of discharge/ Fatality/ Remarks | Recommended diet to regain immunity |
|------------|--------|---------------------|-----|--------------------------------------|-------------------------|----------------------------------|----------------|-----------------------|----------|---------------------|-----------------|------------------------------------------|-----------------------------|----------------|-------------------------------|----------------------------------|
| 1          | Male   | B+ve                | 27  | Low Vitamin C foods, fruits and nuts consumption is low, intake of green leaf vegetables is medium | _                       | Fever, sour throat, cold and severe cough from 30.06.2020 | 07.07.2020 | Initially Chest X-ray and followed by PCR | Severe | Hospitalized           | Accumulation of fluid into Lungs and Pneumonia | Lemon, fruits, dry fruits and nuts, diet includes one green leaf vegetable and rice | 18                          | 23.07.2020 | 24.07.2020 | Fruits—papaya, orange, lemon, guava Vegetables—green leaf, carrot, beetroot Curd and dry fruits |
| 2          | Male   | B+ve                | 52  | Millets, Fruits, Dry fruits, vegetables | Brain problem and Diabetics | Fever, cough from 02.07.2020 | 04.07.2020 | Antigen test | Mild | Home Quarantine | Severe weakness | Papaya, Fruit juices, rice and egg | 10                          | 18.07.2020 | Recovered | Vitamin C foods, egg, probiotic foods |
| 3          | Male   | O+ve                | 57  | Millets-Raagi, curd, green vegetables, rice | Diabetic | Severe cough from 12.07.2020 | 16.07.2020 | Chest CT | Severe | Hospitalized | Lung infection, High Lactate Dehydrogenase and Ferritin | Vitamin C foods, dry fruits, curd rice, Wheat chapatti, paneer | 8                          | PCR test on 23.07.2020 | Discharged on 25.07.2020 with weakness and high sugar levels | Fruits, vegetables and probiotic foods |
| 4          | Female | B+ve                | 49  | Lemon, Millets, Green leafy vegetables, fruits, carrot | _                         | Asymptomatic | 23.07.2020 | Antigen test | Very mild | Home Quarantine | _                | Vitamin C foods, dry fruits, papaya, guava, curd | _                          | Not tested | Recovered | Vitamin C, vitamin B complex foods, vitamin E and Zinc |
| 5          | Male   | B+ve                | 41  | Vitamin C foods, green vegetables and leafy vegetables | _                       | Fever from 01.08.2020 | 08.08.2020 | IgM-IgG rapid test | Very mild | Home Quarantine | _                | Vitamin C foods, fruits, dry fruits and nuts, | 14                          | Not tested | Slight weakness | Vitamin C, vitamin B complex foods, vitamin E and Zinc |
| 6          | Male   | B+ve                | 72  | Vitamin C foods, green vegetables and leafy vegetables | Diabetic and Thyroid | Fever from 04.08.2020 | 06.08.2020 | Antigen test | Severe | Hospitalized | Started with chest infection and affected to Heart, Kidney and Liver | Only medication in ICU | 10                          | _                          | Lead to Fatality | _                          | (continued) |
### TABLE 33.1 (Cont’d)

| Case Study | Gender | Type of Blood Group | Age | Regular dietary food habits on daily basis | Previous health history | Type of Symptoms developed and Date | Date of Testing | Type of COVID testing | Severity | Type of Quarantine | Effect of COVID-19 | Diet during treatment along with medication | No. of days undergone for treatment | Date of re testing | Date of discharge/Fatality/Remarks | Recommended diet to regain immunity |
|------------|--------|---------------------|-----|------------------------------------------|-------------------------|-----------------------------------|----------------|----------------------|----------|---------------------|------------------|---------------------------------------------|-------------------------------|-------------------|--------------------------|---------------------------------|
| 7          | Male   | B+ve                | 11  | Diet is rich with vitamin C, ginger, dry fruits and vegetables | _                       | Fever from 08.08.2020 | 09.08.2020 | IgM-IgG rapid test | Very mild | Home Quarantine | _                | Vitamin C foods, Fruits, dry fruits and nuts, | 10              | Not tested          | Completely recovered | Vitamin C, vitamin B complex foods, vitamin E and Zinc |
| 8          | Male   | B+ve                | 46  | Diet is not much rich with vitamin C, vitamin B and vegetables | _                       | Fever                | 14.07.2020 | PCR                | Severe   | Home Quarantine | Lungs            | Vitamin C, Vitamin B, Vitamin D supplements | 10              | PCR teston 28.07.2020 | Recovered       | Dry fruits, zinc intake, Fruits and green leafy vegetables |
| 9          | Male   | O+ve                | 50  | Very poor diet and no proper vitamin foods                      | Diabetics               | Fever, body pains | 06.09.2020 | PCR                | High risk | Hospitalized  | Brain attack | _                | 5                | ___                  | Lead to Fatality           | ___                  |
| 10         | Male   | B+ve                | 31  | Low vitamin C foods, less consumption of fruits and vegetables | Asthma                  | Asymptomatic        | 04.08.2020 | Antigen test | Mild    | Home Quarantine | ___              | Vitamin C, Green leafy vegetables, curd, carrot, banana, beetroot | 14              | 17.08.2020          | Recovered       | Dry fruits along with the regular diet preferred |
| 11         | Male   | O+ve                | 50  | Rich in vitamin C fruits, dry fruits, all vegetables            | Diabetic                | Fever, dry cough, diarrhea and headache from 28.08.2020 | 30.08.2020 | Antigen test | Severe  | Home Quarantine | Weakness         | Continued with vitamin C foods, dry fruits and green leafy vegetables | 15              | 11.09.2020          | Recovered       | Vitamin C foods, dry fruits and green leafy vegetables |
| 12         | Female | O+ve                | 45  | Vitamin C foods, carbohydrates, herbs, and spices              | Asthma                  | Fever, dry cough, and severe headache from 28.08.2020 | 30.08.2020 | Antigen test | Severe  | Home Quarantine and hospitalized after 10 days | Severe weakness and asthma | Vitamin C foods, curd, dry fruits | 20              | 19.09.2020          | Partially recovered and discharged with weakness on 20.09.2020 | Recommended diet with Fruits—papaya, orange, Lemon, gaava Vegetables—green leaf, carrot and beetroot curd and dry fruits |
### 5. Sustainable development goals and environmental justice

### 33. Results and discussion

| No. | Gender | Status | Age | Foods, vegetables, fruits, rice | Symptom | Date of Symptom | Confirmation | Treatment | Date of Recovery | Diet Recommendation |
|-----|--------|--------|-----|---------------------------------|---------|-----------------|-------------|-----------|------------------|---------------------|
| 13  | Male   | O+ve   | 21  | Vitamin C, vegetables, fruits, rice | Fever and headache from 02.09.2020 | 03.09.2020 | Antigen test | Mild | Home Quarantine | 11.09.2020 | Recommended all vitamin foods |
| 14  | Male   | O+ve   | 19  | Highly rich in vitamin foods, carbohydrates and Zinc | Fever and headache from 02.09.2020 | 03.09.2020 | Antigen test | Mild | Home Quarantine | 11.09.2020 | Recommended all vitamin foods |
| 15  | Male   | B+ve   | 75  | Fruits, vegetables, dry fruits, wheat and brown rice | Heart patient with diabetics, Fever and cough | 16.07.2020 | Antigen test | Mild | Hospitalized Severe weakness | Followed the same diet | Recommended with green leafy vegetables, egg, papaya, sesame and chia seeds |
| 16  | Female | O+ve   | 63  | Fruits, vegetables, dry fruits, wheat and brown rice | Diabetics, Fever, sour throat and cough | 16.07.2020 | Antigen test | Severe | | | |

PCR on 02.08.2020 Discharged with weakness on 04.08.2020 Recommended with green leafy vegetables, egg, papaya, sesame and chia seeds
laptops. All these outcomes lead to the generation of higher amount of free radicals in our body. Therefore, the antioxidants play a vital role in regularizing them by neutralizing and eliminating free radicals from bloodstream, tissues, and organs (Brambilla et al., 2008). If the free radicals are not quenched by antioxidants, it will cause damage to cells, proteins, DNA, and RNA. The adverse effects caused by free radicals were pathogenesis of diverse conditions, such as cancer, radiation damage, and accelerated aging (Lobo et al., 2010).

Fruits, vegetables, nuts, and spices are highly rich in antioxidants. Out of all fruits, the easily available Indian fruit: guava has maximum antioxidant activity whereas banana has the least activity. The most traditional Indian spices are rich in antioxidants; curcumin has antibacterial, antiviral, and antifungal activity (Narayanan et al, 2012; Zorofchian Moghadamtousi et al., 2014). Pulses like rajma have highest antioxidant property (Carbas et al., 2020). This is mostly used by every Indian with the combination of roti in breakfast or dinner. Selenium is one of the essential trace elements present in coriander and mustard seeds that helps to protect the body from free radical damage due to its potent antioxidant activity; most commonly used in Indian dishes. One of the studies states that eating foods containing antioxidants can reduce the duration of illness and severity of symptoms, when the viral infections were observed in the form of flue or cold (Peterhans, 1997). Antioxidants present in the body may also help to reduce the illness from COVID-19, its severity and duration of infection.

33.3.3 Vitamin C

The most popular supplement is vitamin C, which protects from organs infection due to its important role in immune health (Carr and Maggini, 2017). Deficiency of this vitamin is more prone to various types of infections. The vitamin C supports the function of various immune cells and increases their ability to protect against infections. It is also necessary for cellular death which helps to keep the immune system healthy by flushing out old cells and replacing with new ones, Vitamin C also acts as a powerful antioxidant. It is accessible in large quantities through natural sources like fresh fruits and vegetables. A serving of five different fruits and vegetables together provides the vitamin C required for an individual.

The only limitation of vitamin C content in foods is cooking and storing for a long times would reduce, which can be lowered by steaming and microwaving. When fruits are cut and exposed to air vitamin C is lost by oxidation.

33.3.4 Vitamin D

This fat-soluble vitamin helps in functioning of immune system particularly for lungs. Vitamin D enhances the pathogen fighting effects of monocytes and macrophages, white blood cells that are important in immune functioning and decreases inflammation, which helps to promote immune response. It is fortunate to have plenty of sunshine based on the seasons in India but today’s modern life style makes this generation deficient in vitamin D, which in turn effects immune function. In fact, low vitamin D levels are associated with increased risk of upper respiratory tract infections including influenza and allergic asthma. Review of few randomized controlled trials (RCT) confirmed that supplementing with vitamin D significantly decreases the risk of respiratory infections (Hansdottir and Monick, 2011). Few literature studies stated that vitamin D deficiency could be one of the reasons to be susceptible to COVID-19 and even increase its severity. The studies also reported that the number of patients in intensive care unit admission was reduced with supplements of vitamin D. The COVID-19 affected patients were treated with calcifediol known as 25-hydroxyvitamin D with promising results (Meltzer et al., 2020; Castillo et al., 2020). Many positive cases of COVID-19 have been diagnosed with acute lung infections. Therefore, balancing the vitamin D is relatively important for the innate immunity.

The best source of vitamin D is UV radiation from the Sun. UV radiation levels vary depending on location, season, time of day, and environment. Based on these factors, synthesizing vitamin D on exposed skin between 10 AM and 3PM would be beneficial. Fair skinned individuals may require 20 min exposure to direct sunlight 3 to 4 times a week for the skin to make adequate vitamin D. Darker skinned individuals require 30 to 40 min exposure 3 to 4 times a week. Half an hour of exposure synthesizes 50,000 IU of cholecalciferol. Obese people require higher levels of vitamin D (Wacker and Holick, 2013; Moan et al., 2014).

33.3.5 Vitamin A

If a person is deficient in vitamin A, both specific and non-specific protective mechanisms are impaired. Vitamin A is more significant for proper vision, growth development, protecting epithelium, and mucus integrity in the body. It is more often referred to as antiinflammation vitamin due to its vital role in enhancing immunity (Huang et al., 2018). In particular vitamin A deficiency diminishes antibody mediated responses. A study conducted by (Mawson,
2013) indicates that decreased vitamin D to vitamin A ratio is more susceptible to influenza virus infection. Higher levels of vitamin A lowers vitamin D levels and is more prone to respiratory tract infections. High levels of vitamin A over a period of time, particularly from animal sources lead to liver toxicity. Foods like liver from animal sources should be preferred in the required amounts.

33.3.6 Vitamin E
The immune function of vitamin E is nonspecific (Lee and Han, 2018). Indian traditional cooking involves mustard and sesame seed oils because of its high levels of vitamin E. Usually plants has more sources of vitamin E than animal foods. Heating oil is a common practice in cooking. The loss of vitamin while cooking entirely depends on the duration of heating, which can be minimized through different cooking methods.

33.3.7 Vitamin B6, B9 (folate), and B12
Vitamin B6 and B12 directly acts on the white blood cells (WBC) and CD4+ T cells. These cells are important in providing an adaptive immune response to a wide variety of pathogens. Folate restores T-cell proliferation and normal-cell cycle, decreases DNA-uracil content, and lowers CD4+/CD8+ ratio. Thus, deficiency of folate may affect the immune system by dropping the ability of CD8+ T cells to proliferate in response to activation. All the three vitamins of B are important for immunity and cellular functioning (Rail and Meydani, 2009); (Mikkelsen and Apostolopoulos, 2019). It formulates a protein interleukin-2 that helps the action of white blood cells. So deficiency of this vitamin affects the WBC.

33.3.8 Minerals: copper (Cu), iron (Fe), and zinc (Zn)
Inadequate minerals such as copper, iron, and zinc make humans more susceptible to illness by infections (Prohaska and Lukasewycz, 1990); Sherman, 1992; Prasad, 2008). The defective antibody production in human, impaired cellular function, and respiratory illness causes due to deficiency of copper. Deficiency of copper leads to neutropenia. The WBC reduces and more likely to get infections. Iron is important for the functioning of lymphocytes, a subtype of WBC (natural killer cells) which acts in cell-mediated, T cells and B cells for developing antibodies. Iron, copper, and zinc are required for optimal innate immune function (Ward et al., 2011); (Djoko et al., 2015). Copper and iron are important minerals for nutritional immunity and develop innate immune response to fight against microbial infections (Djoko et al, 2015). The uptake of copper is incorporated into ceruloplasmin, a primary ferroxidase enzyme that is responsible for the oxidation of ferrous to ferric so that iron can be bounded by transferrin and transported throughout the body. So copper plays a major role in iron homeostasis (Arredondo and Núñez, 2005); (Gavin-Smith, 2020). Zinc helps in maintaining a healthy appetite and assists in perception of taste. Loss of taste and smell were observed recently as one of the symptoms for COVID-19. So zinc would be under top priority of immunity.

Zinc is more readily absorbed from animal sources than plant products. Seeds, meat, eggs, and dairy products are the best sources. Fruits and vegetables are fair sources. Zinc deficiency is more prevalent in many and high in those who consumes large amount of cereals, potatoes, and legumes that would interfere with the absorption of Zinc because of phytic acid. This is rarely concern among us but it is a significant problem for developing countries for those who depend on cereals or legumes. So phytate content can be decreased by soaking, sprouting, and fermentation (Arnarson, 2018). The three techniques were discussed below.

33.3.8.1 Soaking
Soaking is one of the methods to decrease phytate content. To absorb the zinc into the body while consuming cereals and legumes, it is advisable to soak them in water overnight.

33.3.8.2 Sprouting
Green grams, chick peas, bengal grams, and legumes on sprouting possess high Vitamin C and acts as a powerful stimulant for WBC to fight against infections and builds immunity. It helps in reducing phytic acid on sprouting and balances the absorption of zinc. Sprouting even enriches vitamin A which has antioxidant properties and acts a good source for immune strength.

33.3.8.3 Fermentation
This helps to generate organic acids to break down the phytate. For instance, lactic acid is generated in making curd or sour dough. The most probiotic food consumed by Indians traditionally is curd rice. It is prepared by soaking cooked plain rice in milk, adding small amount of curd and leaving whole night to get fermented. Eating it next
day is a very common practice. This method is preferred in summer seasons particularly to protect us from various infections that can boost our immunity.

### 33.3.9 Herbs

Lastly the most common and regular spices, also known as herbs, that are used in Indian dishes are garlic and ginger since they are a part of immune system to fight against cold and flu. No Indian cuisine is complete without garlic and ginger. Garlic exerts immune potentiating effect by stimulating natural killer cell activity (Joe Leech, 2018). Ginger possesses antioxidant properties and reduces intestinal contractions (Mashhadi et al., 2013).

Obese, diabetic, and hypertension people are more prone to COVID-19. The above mentioned foods will have a positive impact on those people. In addition to all the above requirements; adequate hydration, personal hygiene practices by using proper personal protective equipment (PPE), good exercise, and sleep are equally important.

Out of many medicinal plants from India, neem is one of the most important medicinal plants with a number of therapeutic uses including antiviral activity (Badam et al., 1999). It is a rich source of antioxidants (Trivedi et al., 2019). In India it is used to treat viral diseases like small pox and chicken pox and also used in cooking to prevent from the viruses. Neem extracts absorb the viruses and helps to prevent them from transmission. This can be used as a disinfectant to kill the COVID-19 virus or the extract can be consumed to prevent from the viruses. One of the studies shows that sodium hypochlorite is used as a disinfectant but can have toxicological effects (Public Health England, 2015). This can be replaced by neem and curcumin extracts to maintain hygienic condition in the environment. Therefore, the immune booster types in Table 33.2 promote the immune system for every individual through balanced diet recommended per day (Dasgupta and Klein, 2014); (Sarkara et al., 2015); (Srilakshmi, 2018).

**TABLE 33.2** Immune booster recommendations and its available sources (Dasgupta and Klein, 2014); (Sarkara et al., 2015) and Srilakshmi, 2018).

| S.No | Name of the immune booster | Recommended quantity for men/ women per day | Available sources |
|------|-----------------------------|---------------------------------------------|------------------|
| 1.   | Lysozyme                    | 74 mg                                       | Vegetables—cauliflower, cabbage, broccoli, turnip and radish |
|      |                             |                                             | Citrus fruits—orange and papaya |
|      |                             |                                             | Egg white |
|      |                             |                                             | Fortified cheese with lysozyme enzyme |
| 2.   | Antioxidants                | 500–600 mg                                  | Fruits—guava, red grapes, pomegranate, and amla |
|      |                             |                                             | Vegetables—red cabbage, ladies finger, broad beans, raw mango, moringa leaves (drumstick), sour spinach (gongura), and mint leaves |
|      |                             |                                             | Seeds—chia, basil, coriander, and mustard |
|      |                             |                                             | Indian spices—cloves, cardamom, nutmeg, bay leaves, cumin seeds, fenugreek seeds and curcumin (turmeric) |
|      |                             |                                             | Nuts—walnuts |
|      |                             |                                             | Pulses—rajma |
| 3.   | Vitamin C                   | 90 mg                                       | Fruits—gooseberry, guava |
|      |                             |                                             | Citrus—lime, orange, tomato, and tomato juice |
|      |                             |                                             | Vegetables—moringa leaves, agathi (tamarind leaves), green and red peppers, and sour spinach (gongura) |
|      |                             |                                             | Sprouted green grams, chick peas, Bengal grams and legumes |
|      |                             |                                             | Chia seeds |
| 4.   | Vitamin D                   | 15 µg or 600 IU                             | Sunlight exposure for 20 min 3-4 times a week for fair skin and 30-40 min for dark skin. |
|      |                             |                                             | Egg yolk, butter, and Milk |
|      |                             |                                             | Salmon fish and mushrooms |
| 5.   | Vitamin A                   | 900/700 µg                                  | Fortified foods—dairy products, orange juice, soya milk, and cereals. |
|      |                             |                                             | Green leaf vegetables—moringa, amaranthus, spinach |

(continued)
### TABLE 33.2 (Cont’d)

| S.No | Name of the immune booster | Recommended quantity for men/ women per day | Available sources |
|------|-----------------------------|--------------------------------------------|------------------|
| 6.   | Vitamin E                   | 8–10 mg                                    | Vegetables—carrots and pumpkin, Egg, Moringa leaves, Legumes—rajma, chick peas, and soya beans, Vegetables—moringa leaves, sweet potatoes, and carrots, Nuts—pistachios, hazel, and peanuts, Fruits—banana and water melon, Seeds—sunflower seeds and sesame seeds |
| 7.   | Vitamin B6                  | 2.0 mg                                     | Cereals—wheat, maize, oats, barley, and millet, Legumes—rajma, chick peas and soya beans, Vegetables—moringa leaves, sweet potatoes, and carrots, Nuts—pistachios and peanuts, Fruits—banana and water melon, Seeds—sunflower seeds and sesame seeds |
| 8.   | Vitamin B9                  | 400 µg                                     | Green leafy vegetables and broccoli, Legumes and egg, Citrus fruits, Almonds and flax seeds |
| 9.   | Vitamin B12                 | 2.4 µg                                     | Cereals, barley grains, and banana, Egg and milk, Salmon and tuna fish, Moringa leaves, Yogurt and cheese |
| 10.  | Copper                      | 900 µg                                     | Nuts—almonds, cashew and walnuts, Moringa leaves, Sunflower and sesame seeds, Legumes and soya beans |
| 11.  | Iron                        | 19–20 mg/17–19 mg                          | Legumes—lentils, beans, and chick peas, Chia, pumpkin, and sunflower seeds, Nuts—cashew and almonds, Amaranthus and moringa leaves |
| 12.  | Zinc                        | 8/11 mg                                    | Nuts—soaked almonds and cashew, Meat and eggs, Moringa, green peas, and spinach, Pumpkin seeds and flax seeds, Dairy products |
| 13.  | Garlic                      | 600–1200 mg                                | ___ |
| 14.  | Ginger                      | 3–4 g                                      | ___ |
Starting the day with detox drinks improves the function of liver, gut, and kidneys to get rid of toxins and makes us feel refreshed and active. The perfect choice for the detox drink is a combination of apple, carrot, and beetroot (ABC) that can be preferred from one to three days. Proteinaceous breakfast would kickstart the day by increasing the basal metabolic rate. The last meal should be completed at least 2 to 3 hours prior to sleeping. Lastly, awareness of genetics play a significant role in the diet and to focus on foods that is local and seasonal, as adaptation of different foods while migration would influence the immune system.

Some of the studies predict that COVID-19 virus survives in alkaline environment, so it is more advisable to prefer the foods mentioned especially the citrus fruits and probiotics which are acidic. Hence, building self immunity through nutritious foods rich in lysozyme, antioxidants, vitamins, minerals and herbs help to overcome COVID-19 despite its pandemic spread.

33.4 Conclusion

References

Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., Walter, P., 2002. Molecular Biology of the Cell. Garland Science; 4th edition. https://www.ncbi.nlm.nih.gov/books/NBK21054.

Aman, F., Masood, S., 2020. How nutrition can help to fight against COVID-19 pandemic. Pak. J. Med. Sci 36 (COVID19-S4), S121–S123.

Arnarson, A., 2018. Phytic acid 101: Everything you need to know. Healthline. Nutrition. https://www.healthline.com/nutrition/phytic-acid.

Arredondo, M., Nuñez, M.T., 2005. Iron and copper metabolism. Mol. Asp. Med 26 (4-5), 313–327. https://doi.org/10.1016/j.mam.2005.07.010.

Arshad, M.S., Khan, U., Sadiq, A., Khalid, W., Hussain, M., Yasmeen, A., Asghar, Z., Rehana, H., 2020. Coronavirus disease (COVID-19) and immunity booster green foods: a mini review. Food Sci. Nutr. doi: 10.1002/fsn3.1719.

Badam, L., Joshi, S.P., Bedekar, S.S., 1999. In Vitro antiviral activity of neem (Azadirachta indica A.Juss) leaf extract against group B Coxsackieviruses. J. Commun. Dis 31 (2), 79–90.

Barnkob, M.B., Pottegård, A., Stovring, H., Haunstrup, T.M., Homburg, K., Larsen, R., Hansen, M.B., Tilsted, K., BittenAagaard, B.K.M., Barington, T., 2020. Reduced prevalence of SARS-CoV-2 infection in ABO blood group O. Blood Adv 4 (20), 4990–4993. https://doi.org/10.1182/bloodadvances.2020002657.

Brambilla, D., Mancuso, C., Scuderi, M.R., 2008. The roles of antioxidant supplement in immune system, neoplastic, and neurodegenerative disorders: a point of view for an assessment of the risk/benefit profile. Nutr. J. 7 (29) . https://doi.org/10.1186/1475-2891-7-29.

Carbas, B., Machado, N., Oppolzer, D., Ferreira, L., Queiroz, M., Brites, C., Rosa, E.A.S., Barros, A.I., 2020. Nutrients, antioxidants, phenolic composition, and antioxidant activity of common bean cultivars and their potential for food applications. Antioxidants 9 (186), 1–18.

Carr, A., Muggin, S., 2017. Vitamin C and immune function. Nutrients 9 (11), 1211. doi: 10.3390/nu9111211.

Castillo, M.E., Costa, L.M.E., Barrios, J.M.V., Díaz, J.F.A., Miranda, J., Bouillon, R., Gomez, J.M.Q., 2020. Effect of calcifediol treatment and best available therapy versus best available therapy on intensive care unit admission and mortality among patients hospitalized for COVID-19: A pilot randomized clinical study. J. Steroid Biochem. Mol. Biol 203, 105751. https://doi.org/10.1016/j.jsbmb.2020.105751.

Chandran, R.C., Ereifej, K.I., 1981. Determination of lysozyme in raw fruits and vegetables. J. Food Sci 46 (4), 1278–1279. doi:10.1111/j.1365-2621.1981.tb03042.x.

Dasgupta, A., Klein, K., 2014. Antioxidants in Food, Vitamins and Supplements. Prevention and Treatment of Disease, 1st Edition. Elsevier ebook ISBN: 9780124059177.

De França, T.R.T., De Albuquerque, T., Carvalho, A., Gomes, V.B., Gueiros, L.A., Porter, S.R., Leao, J.C., 2011. Salivary shedding of Epstein–Barr virus and cytomegalovirus in people infected or not by human immunodeficiency virus I. Clin. Oral Investig. 16 (2), 659–664. doi:10.1007/s00784-011-0545-8.

Djoko, K.Y., Ong, C.L.Y., Walker, M.J., McEwan, A.G., 2015. The role of copper and zinc toxicity in innate immune defense against bacterial pathogens. J. Biol. Chem 290 (31), 18954–18961. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4521016.

Djoko, K.Y., Ong, C.-I.Y., Walker, M.J., McEwan, A.G., 2015. The role of copper and zinc toxicity in innate immune defense against bacterial pathogens. J. Biol. Chem 290 (31), 18954–18961. doi:10.1074/jbc.R115.647099.

Eshdat, Y., Sharon, N., 1977. Lysozyme. Methods Enzymol. 46, 403–414. https://doi.org/10.1016/S0076-6879(77)46048-8.

Gavin-Smith, B., 2020. The Role of Nutrition in the Immune System. Global Public Health Nutrition Manager for Sight and Life.

Hansdottir, S., Monick, M.M., 2011. Vitamin D effects on lung immunity and respiratory diseases. Vitam. Horm., 217–237. doi: 10.1016/b978-0-12-386969-0.00009-5.

Holland, R.L., Fergusson, N.A., Mitra, A.R., Griesdale, D.E.G., Devine, D., Stukas, S., Cooper, J., Thiara, S., Foster, D., Chen, L.Y.C., Lee, A.Y.Y., Conway, E.M., Wellington, C.L., Sekhon, M.S., 2020. The association of ABO blood group with indices of disease severity and multitorgan dysfunction in COVID-19. Blood Adv 4 (20), 4981–4989. https://doi.org/10.1182/bloodadvances.2020002623.

Hood, M.I., Skaar, E.P., 2012. Nutritional immunity: transition metals at the pathogen–host interface. Nat. Rev. Microbiol 10 (8), 525–537. doi:10.1038/nrmicro2836.

Huang, Z., Liu, Y., Qi, G., Brand, D., Zheng, S., 2018. Role of vitamin A in the immune system. J. Clin. Med 7 (9), 258, 1–16 doi: 10.3390/jcm7090258.

Invitra, 2011. What is Lysozyme? n.d http://www.invitra.com/products-and-services/lysozyme.html.1/2/2011.

Joe Leech, M.S, 2018. 11 Proven Health Benefits of Garlic. Healthline.http.://www.healthline.com/nutrition/11-proven-health-benefits-of-garlic.

John Wherry, E., Masopust, D., 2016. Adaptive Immunity in Viral Pathogenesis, 3rd Edition. Elsvier, pp. 57–69. ISBN:9780128009642. doi: 10.1023/a:1007526500000.

John, T.J., Samuel, R., 2000. Herd immunity and herd effect: new insights and definition. Eur. J. Epidemiol 16 (7), 601–606.

Lee, G., Han, S., 2018. The role of vitamin E in immunity. Nutrients 10 (11), 1614, 1–18. doi: 10.3390/nu10111614.

5. Sustainable development goals and environmental justice
Lobo, V., Patil, A., Phatak, A., Chandra, N., 2010. Free radicals, antioxidants and functional foods: Impact on human health. Pharmacognosy Rev. 4 (8), 118 doi: 10.4103/0973-7847.70902.

Mashhadi, N.S., Ghiasvand, R., Askari, G., Hariri, M., Darvishi, L., Mofid, M.R., 2013. Anti-oxidative and anti-inflammatory effects of ginger in health and physical activity: review of current evidence. Int. J. Prev. Med 4 (1), S36–S42.

Mawson, R., 2013. Role of fat soluble vitamins A and D in the pathogenesis of influenza: A new perspective. ISRN Infectious Diseases, 1–26. http://dx.doi.org/10.5402/2013/246737.

Meltzer, D.O., Best, T.J., Zhang, H., Yokes, T., Arora, V., Solway, J., 2020. Association of vitamin D status and other clinical characteristics with COVID-19 test results. JAMA Netw. Open 3 (9), e2019722 doi:10.1001/jamanetworkopen.2020.19722.

Merlo, L.M.F., Mandik-Nayak, L., 2013. Adaptive immunity. Cancer Immunother., 25–40. doi:10.1016/b978-0-12-394296-8.00003-8.

Mikkelsen, K., Apostolopoulos, V., 2019. Vitamin B12, folic acid, and the immune system. Nutr. Immun, 103–114. doi:10.1007/978-3-030-16073-9_6.

Mohan, J., Grigalavicius, M., Dahlback, A., Baturaite, Z., Juzeniene, A., 2014. Ultraviolet-radiation and health: optimal time for sun exposure. Adv. Exp. Med. Biol 810, 423–428.

Narayan, A., Kehn-Hall, K., Senina, S., Lundberg, L., Van Duyne, R., Guendel, I., Kashanchi, F., 2012. Curcumin inhibits rift valley fever virus replication in human cells. J. Biol. Chem 287 (40), 33198–33214. doi:10.1074/jbc.m112.356535.

Peterhans, E., 1997. Oxidants and antioxidants in viral diseases: disease mechanisms and metabolic regulation. J. Nutr 127 (5), 962S–965S. doi: 10.1093/jn/127.5.962s.

Prasad, A., 2008. Zinc in human health: effect of zinc on immune cells. Mol. Med. 14 (5-6), 353–357. doi: 10.2119/2008-00033.prasad.

Prohaska, J.R., Lukasewycz, O.A., 1990. Effects of Copper Deficiency on the Immune System. In: Bendich, A., Phillips, M., Tengerdy, R.P. (Eds.), Antioxidant Nutrients and Immune Functions. Advances in Experimental Medicine and Biology. Springer, Boston, MA , 262.

Public Health England. 2015. Sodium Hypochlorite Toxicological Overview. 2014790.

Rail, L.C., Meydani, S.N., 2009. Vitamin B6 and immune competence. Nutr. Rev 51 (8), 217–225. doi: 10.1111/j.1753-4887.1993.tb03109.x.

Sarkara, P., Kumar DHa, L., Dhumala, C., Subrot Panigrahia, S., Choudhary, R., 2015. Traditional and Ayurvedic foods of Indian origin. J. Ethnic Foods 2, 97–109.

Sherman, A.R., 1992. Zinc, copper, and iron nutriture and immunity. J. Nutr 122 (suppl_3), 604–609. doi: 10.1093/jn/122.suppl_3.604.

Srilakshmi, B., 2018. Nutrition Science, 6th Edition. New Age International Publishers. ISBN 10: 9386418886 /ISBN 13: 9789386418883.

Trivedi, A., Fatima, N., Husain, I., Misra, A., 2019. An update of the therapeutic potential of neem and its active constituents: A panacea for all diseases. Era’s Journal. Med. Res 6 (1), 1–8.

Wacker, M., Holick, M.F., 2013. Sunlight and vitamin D. Dermato-Endocrinol. 5 (1), 51–108. doi: 10.4161/derm.24494.

Ward, R.J., Crichton, R.R., Taylor, D.L., 2011. Iron and the immune system. J. Neural Transm 118, 315–328. https://doi.org/10.1007/s00702-010-0479-3.

Xu, R., Cui, B., Duan, X., Zhang, P., Zhou, X., Yuan, Q., 2020. Saliva: potential diagnostic value and transmission of 2019-nCoV. Int. J. Oral Sci 12 (11), 1–6. https://doi.org/10.1038/s41368-020-0080-z.

Zoroofchian Moghadamtousi, S., Abdul Kadi, H., Hassanardarvish, P., Tajik, H., Abubakar, S., Zandi, K., 2014. A review on antibacterial, antiviral, and antifungal activity of curcumin. BioMed Res. Int., 1–12 doi: 10.1155/2014/186864.
