



CoronaVirus: Introduction and Food Technological Approach to Defend during Pandemic Outbreak

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ABSTRACT

Corona virus, a deadly virus discovered several decades before, World Health Organization identified this virus as a virus that can cause acute respiratory disorders and they declared it as pandemic, which can cause serious issue or threat to the public at global level. The novel virus can infect various organs in the respiratory system viz. throat, nose, lungs and windpipe. The diseases can be transmitted easily through social relationship i.e. person to person contact, and also through infected person, while sneezing or coughing or touching face or nose. The virus is pandemic; therefore prevention is very much mandatory to stop further spreading of disease. This review highlights the various strategies adopted for prevention of corona virus, which includes maintaining personnel hygiene, washing hands with soap multiple times a day, wearing face mask, maintaining social distancing, cleaning surfaces with disinfectant, taking treatment's and also adopting food technological approach like strengthening the immunity by consuming immune boosting foods, so that the disease can be controlled to certain extent.

Key Words: Corona, Disease, Transmittance, Washing, Immune boosting foods

INTRODUCTION

Corona Virus, a kind of human virus, which was first discovered in 1960.¹ There are variety of species, which can cause severe respiratory disorders, to name a few in the year 2003 a virus i.e. SARS-CoV had been identified, in 2004 HCoV NL63, in 2005 HKU1, in 2012 MERS-CoV, in 2019 and 2020 SARS-CoV-2 (2019-nCoV/COVID-19) were identified. World Health Organization (WHO) identified this as a new virus that can cause acute respiratory disorders and they declared it as Pandemic, which can cause serious issue or threat to the public at global level. The novel virus can infect various organs in the respiratory system viz. throat, nose, lungs and windpipe. The diseases can be transmitted easily through social relationship i.e. person to person contact, and also through infected person, while sneezing or coughing or touching face or nose. Based on immunity level, the patient may suffer from mild to serious infections. The symptoms of COVID-19 include fever, cough, throat infection, pain and fatigue. In advanced stage, this virus can cause chest pain, bluish face or lips, pneumonia and ultimate death. This virus can also infect both birds and mammals and bring similar infections as like in human. In chicks, the virus can cause respiratory problems, while in cow and pigs, it can cause di-

arrhea. The coronavirus name is derived from Latin word corona, which means crown, when we view this virus under electron microscope, we can find them as the big bulb projection surface,² which can create a crown like image. The red colored club shaped viral spike peplomers can be identified under microscope as shown in Figure 1.

Morphology

The diameter of the corona virus is approximately 120 nm.³ This virus comprises of two layered lipid, which supports membrane, spike structural proteins and envelope together with them.⁴ A small spike like protein, which is known as hemagglutinin esterase, which is seen in betacoronavirus sub groups.⁵ Nucleocapsid was seen within the viral envelope, which came from several copies of nucleocapsid protein, which are tied and attached to the single stranded RNA genome in an beads on a string type identification.^{3,6} This virus will be protected by membrane proteins, lipid two layer envelope and nucleocapsid, particularly when it exist outside the host cell.⁷ The virus genome size may vary from 27 to 34 kilobases,⁸ it was further observed that corona virus genome size is very largest compared to other RNA viruses and the genome has 3' polyadenylated tail and a 5' methylated cap.³

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Life Stages of Corona Virus

First Stage

The viral spike gets fixed to the host cell receptor. Once it is get attached, host cell protease cleaves activate the receptor attached spike protein. The endocytosis process permit the corona virus to enter into the host cell by means of cleavage and activation steps, and it is totally depend on the availability of the host cell protease. Sometimes straightaway fusion of viral envelope with host membrane may occur,⁹ once the virus get entered into the host cell, the virus particle will be uncoated and the viral genome make an entry into the cell cytoplasm.¹⁰ The RNA gets attached to the host cell's ribosome for translation by means of coronaviral RNA genome's 3' polyadenylated tail, and 5' methylated cap.¹⁰ Long polyprotein is formed by host ribosome

translation process by means of preliminary stage overlapping open reading frame of the virus genome. This polyprotein possess its own proteases, which can cleave them into several non-structural proteins.³

Second Stage

The non-structural proteins coalesce to create a multi-protein replicase-transcriptase complex (RTC). The RNA-dependent RNA polymerase (RdRp) is the major replicase-transcriptase protein. It helps in involving in transcription and replication of RNA from RNA Strand. The complex non-structural protein helps in transcription and replication process. The proof reading function was provided by exoribonuclease non-structural protein, they also provide extra fidelity to replication, in which the RNA-dependent RNA polymerase lacks. The complex main function is viral genome replication. The synthesis of negative-sense genomic RNA from the positive-sense genomic RNA was mediated by RdRp, followed by positive-sense genomic RNA replication from the negative-sense genomic RNA.³ The other main function of complex is viral genome transcribition.

The synthesis of negative-sense sub genomic RNA molecules from the positive-sense genomic RNA is directly mediated by RdRp, followed by negative-sense sub genomic RNA molecules transcription to positive sense mRNAs.³

Third Stage

At this stage, progeny virus genome will be the replicated positive-sense genomic RNA. After initial overlapping reading frame, mRNAs were the gene transcripts of the last third of the virus genome. Host ribosome will translate this mRNAs into structural proteins and more accessory

proteins.³ Inside the endoplasmic reticulum, the RNA translation occurs, the structural proteins of virus (S, E & M) will move along the secretory pathway into the Golgi intermediate compartment. The M proteins will route protein-protein interactions, essential for assembling virus and it's binding

with nucleocapsid.¹¹ By exocytosis process, the progeny viruses were released from host cell through secretory vesicles.¹¹

Symptoms of Corona Virus

The most noticeable symptoms of corona virus will be dry cough and severe fever. The other symptoms include production of respiratory sputum (phlegm), fatigue, breath shortness, sore throat, headache, muscle joint pain.¹²⁻¹⁵ According to World Health Organization (WHO), which states that in a current scenario i.e. in a group comprising of six members, out of them every one member was becoming ill with some breathing difficulty? The list of corona virus symptoms was projected by U.S. Centers for Disease Control (CDC), which includes pressure, chest pain, bluish face or lips, breathing difficulties etc.¹⁶ They advised if such symptoms were noticed immediately, one need to approach the medical practitioners. At severe condition, pneumonia, sepsis, respiratory distress syndrome may occur. The total incubation period of virus is around 5-14 days.¹²

Disease Transmission

There is still no evidence that regarding about the transmission of virus. According to reports of WHO¹² and CDC,¹⁶ which states that the disease can be transmitted through close contact of a person or when the infected person cough or sneezes, the respiratory droplets are the source of viral transmittance to the human being. The researcher from Singapore found that coughing without mask covering or any kind of protection can spread droplets till 4.5 meters.^{17,18} This coronavirus is not an airborne microbes,¹² but cardiopulmonary resuscitation and intubation can lead to respiratory secretions and which may result in airborne spread.¹² The spreading may occur by means of touching the contaminated surfaces, or by touching through nose or eyes or mouth.¹² Fecal transmittance of virus is very less.^{12,16} The European Centre for Disease Prevention and Control (ECDC) states that, the disease can be transmitted through one infected person, who will be the spreader for another 2-3 persons.¹⁹ At surface, the virus can stay for starting from hours to days.^{16,19} It was observed that the virus can be detectable upto a period of 3 days in the stainless steel and plastic items, cardboard on one day and upto 4 hours on copper.²⁰ Humidity and temperature will decide the survivability.²¹

Diagnosis of Corona Virus

Based on symptoms, the virus infection can be confirmed by CT imaging and also through reverse transcription polymerase chain reaction (rRT-PCR) of infected secretions.²² WHO publication states that there were several RNA based testing procedures for identifying SARS-CoV-2¹².

The testing is based on real-time reverse transcription polymerase chain reaction (rRT-PCR).¹⁶ For carrying out this

test, blood samples can be collected and it's a rapid method, which give results output within few hours.²³ The imaging test is based on tomography computations and radiographs obtained from patients.²⁴ This test has limitation, which includes the infection will overlap with other infections like adenovirus; therefore it has limited specificity in screening COVID-19.²⁴ The China researcher proved that by their comparative studies, chest CT results

with PCR assay and further advised that imaging, which is less specific for viral infection, but its rapid, and more sensitive, recommending its usage as a screen tool for identifying corona virus in epidemic areas.²² A new approach known as Artificial intelligence-based convolutional neural networks had been identified to find out virus imaging features with CT and radiographs.²⁵

Prevention of Corona Virus

The virus is pandemic; therefore prevention is very much mandatory to stop further spreading of disease. The various strategies employed for prevention of corona virus is given below:

Maintaining Personnel Hygiene

Cleanliness is godliness as prescribed by our forefathers. Therefore in order to eradicate the spread of corona virus, everyone has to maintain personnel hygiene. It can be maintained by washing hands thoroughly (multiple times/day), avoiding physical touching like touching nose or eyes or ear or mouth, and tissue to be used during sneezing or coughing. It is advised that the infected person should wear surgical mask to prevent spreading of virus through droplets, while sneezing or coughing, particularly when they were mingling with public.^{12, 16} The transmission can be prevented by physical distancing.²⁶ Globally, many governments had advised to ban travelling to corona virus affected countries, the virus is spreading within communities. The transmission can be further prevented by contact tracing.²⁷

Washing of Hands

Hand washing is an important process to prevent the spread of disease. CDC advise that hands should be washed thoroughly with soap and water for minimum 20 sec, when one goes to toilet or found when hands were dirty, before taking food also one need to wash hands, and also at the time of coughing or sneezing. According to CDC, if soap is not used for washing one can use alternatively hand sanitizer containing 60% alcohol by volume.¹⁶ WHO and CDC prescribe people to avoid eye touching, mouth or nose with unwashed hands.^{12, 16}

Cleaning of Surfaces

The surface cleaning is mandatory, as it seems that the surfaces contain several microorganisms. The surfaces can be

decontaminated with several solutions like ethanol (62-71%), isopropanol (50-100%), sodium hypochlorite (0.1%), hydrogen peroxide (0.5%), povidone-iodine (0.2-7.5%). CDC further recommends that if COVID case is confirmed to any person, immediate precautionary steps one has to follow by disinfecting the persons used items like tablets, keyboards, remote control, ATM machines, touch screens quickly.¹² Office area, daycare and toilets should be disinfected to prevent disease transmittance.

Using Face Masks and Respiratory Hygiene

WHO recommends that people should protect their mouth as well as nose with elbow shaped face masks while coughing or sneezing.¹² The infected persons should wear surgical mask.²⁸ It was observed that this mask can further prevent droplets dispersement while speaking, coughing and sneezing.²⁹ WHO prescribes that the healthy person also can wear mask, when he care any infected persons. On the other side when one wear mask, the face touching can be prevented.²⁸ Many countries started using the mask at higher levels. China started using the medical mask (disposable type) after the mass spread.³⁰ Almost all the countries suggested using face mask to their citizens, especially during travelling or particularly while gathering in crowded places.

Social Distancing

It is otherwise known as physical distancing. It is mainly needed to prevent the disease spread through individuals. The social distancing can be implemented or maintained by closing all schools, theatres, malls, offices, stadiums for definite period of time to avoid the disease spread. The best way to control such diseases is to stay at home, avoiding travel and crowded mass areas, maintaining physical distancing one from others.¹⁶ Many governments advised that the social distance to be maintained, where the areas were severely infected by this outbreak issues. Germany has banned social gathering of even more than 2 people. The diseased persons like cardiac, hypertension, respiratory disease and diabetic people will have more prone to this corona illness and they were strictly advised to stay themselves in their home during this community outbreak timing.¹⁶

Self-isolation

Home kind of self-isolation is recommended for the persons, who have been infected with COVID-19. The detailed instructions were issued by several health agencies for proper self-isolation.¹² Several governments were prescribed self-quarantine for most populations, those who dwell in affected areas.¹² The government advised self-quarantine for a period of 14 days, those who already infected with COVID-19, because of travelling to severely infected countries or those who got infected through diseased persons through physical relations.¹²

Containment and Mitigation

The disease outbreak strategies lie in either containment or mitigation. The containment is implemented in early outbreak stages, tracing and isolation of infected person separately to further prevent its spread to other population, when couldn't able to control the infection then adopt mitigation, and appropriate control measures need to be taken to slow the spread and in order to mitigate its effect on society and health care system. Integrated steps of control measures can be adopted at the same time to minimize the disease spread.¹²

Corona Virus Disease Management

So far, there was no medicine available for controlling disease spread by this cruel virus COVID-19, medical inventions were still in progress. During this pathetic situation, consuming counter cold medications,¹² drinking plenty of fluids and relaxing may alleviate symptoms.¹⁶ Based on severity of disease, oxygen therapy, intravenous fluids and breathing support, the person may require. WHO has recommended that traditional and home based remedies can relieve the symptoms caused due to SARS-CoV-19.

Increasing Health Care Facilities

The ECDC and the WHO 'European regional office issued guidelines for hospitals and private health services for shifting resource at many levels, which includes focusing lab services towards COVID-19 testing, isolating COVID-19 positive patients and enhancing intensive care facilities by training various personnel's and also enhancing the number of several available beds and ventilators.³¹

Food Technological Approach to defend one-self during Pandemic Outbreak

The corona viral disease is pandemic and severely spreading at global level. Still there were no vaccines or medications available to cure such pandemic outbreak, if it is invented it may take prolonged time to make it commercially available to the public. In the meantime, several deaths were occurring at global level due to corona virus. Prevention is always better than cure, therefore one has to cultivate habit of having foods which were rich in increasing the white blood cells, and thereby one can enhance the immunity to the greater extent.

The various immune boosting foods, which include watermelon, low fat yogurt, wheat germ, spinach, sweet potato, tea, garlic, ginger and pomegranate juice (Figure 2 a-j).

Watermelon

The watermelon fruit quenches the thirst of consumers especially during summer season. The fruit contains glutathione, a powerful antioxidant which can enhance the immunity to the greater extent. The benefit is achieved, if one can consume

red flush portion attached near to rind, which contains more amount of glutathione. It's a good source of vitamin C which can heal the wounds at a faster rate.

Wheat Germ

The wheat germ contains packed nutrients like zinc, B vitamins and antioxidants, besides that it also contains good portion of protein, fibre and good fat. The presence of such nutrients may enhance immunity and fight disease and infections. The antioxidants scavenge the formation of free radicals and further fight against infections.

Defatted wheat germ globulin (DWGG) was hydrolyzed utilizing different enzymes like papain, trypsin, alcalase, neutrase, pepsin in order to enhance the immunomodulatory protein effects. The immunomodulatory effect, hydrophobicity, extent of hydrolysis (EH), distribution of molecular weight and secondary structure was analyzed.³² It was observed that Alcalase hydrolysate (AH) had exhibited significant immunomodulatory effect as recorded by lymphocyte multiplication, phagocytosis of impartial red and emission of pro-inflammatory cytokines. The molecular weight distribution of AH ran somewhere in the range of 300 and 1450 Da and it was

made out of α -helix and β -turns. The hydrophobic value was found to be highest, the EH and hydrophobicity give off an impression of being identified with immunomodulatory exercises. Therefore, It was presumed that the hydrolysate developed by the alcalase treatment over DWGG might be utilized as an immune booster by the various food companies.

Low Fat Yogurt

It's a probiotic product prepared by using beneficial microbes. It will minimize the increased coldness and reduce gut inflammation. It will kill pathogenic microbes in gut, thereby boosting the immune system. Body microbial infections were controlled by consuming such yogurt. It can also reduce high blood pressure.

A large number of experiments have demonstrated that par-enteral administration of different well-defined LAB in mice could exert immune-stimulatory effects, and enhance host resistance against experimental infections.³³⁻³⁵ Effects seem mainly due to the activation of the macrophages and non-specific immunity by cell wall components of the LAB.^{36,37} These experiments permit the screening for active strains, and can suggest potential applications for animal or human health.

Perdigon *et al.*³⁸ showed that mice previously fed with *L. casei* or *Streptococcus salivarius ssp. thermophilus* were protected against *S. typhimurium* infection, in contrast to mice pretreated with *L. acidophilus* or *L. delbrueckii ssp. bulgaricus*. It has subsequently been shown that the protection

by *L. casei* was related to increased levels of sIgA. *L. casei* administered two days after an infection with *S. typhimurium* resulted in increased levels of sIgA in intestinal fluid, in combination with lower numbers of salmonella in the organs and higher percentages of recovery in the mice.

Spinach

The spinach contains folate, which can aid in formation of new cell as well as it repairs DNA.

It enhances the formation of white blood cell, which can further boost immunity. In addition to folate, it also contains antioxidants and beta carotene, which can help immune system in fighting infection and diseases.

Tea

Consuming tea can enhance immune system, whether it may be either white or green or black tea, which can provide ample amount of antioxidants like flavonoids and polyphenols. These antioxidative agents shield the cell from its harm caused because of antioxidative pressure, subsequently increasing the immune system to the more noteworthy degree. The advantages can be accomplished more by devouring green tea. The immunocompromised condition is considered as a deformity in the safe framework. This condition will in general increment the danger of oral candidiasis, because of the powerlessness of the resistant framework to kill the attachment of *Candida albicans* and prompts fundamental candidiasis with a death pace of 60%. Green tea (*Camellia sinensis*) contains potential cell reinforcement and has immunomodulatory impact, which can likewise go about as anticancer, antifungal, and antiviral operator.

The investigation was led by Rahayu *et al.*³⁹ to design natural based medication, which goes about as an immunomodulator and antifungal operator or an agent to treat contagious contamination in immunocompromised patients. Thirty-five immunocompromised Wistar rodents prompted with *C. albicans*, which were isolated into 7 groups (n=5): Control group (C+); fed for 4 days with green tea extract 1.25% (GT 4), epigallocatechin gallate (EGCG) 1% (EGCG 4), EGC 1% (EGC 4); and fed for 7 days with green tea extract 1.25% (GT 7), EGCG 1% (EGCG 7), and EGC 1% (EGC 7). Tongue tissue was gathered and broke down with immunohistochemistry recoloring utilizing monoclonal immunizer; interleukin (IL)- 17A, IL-8, and human beta-defensin 2 (HBD)- 2. The statement of IL-17A, IL-8, and HBD-2 was fundamentally expanded (p=0.000) after feeding green tea in 7 days, though in 7 days, the outflow of IL-8, IL-17A, and HBD-2 after EGCG and EGC feeding didn't give a critical outcome. Inside the constraints of this investigation, green tea extract has the capacity as an immunomodulatory operator in an immunocompromised patient tainted by *C. albicans* through articulation increase of IL-8, IL-17A, and HBD-2 contrasted with EGCG and EGC.

Sweet Potato

The sweet potato contains immune boosting constituent like beta carotene that is further converted into vitamin A, which can eradicate damage of free radicals. In addition to beta carotene, they were loaded with vitamin C, calcium, phosphorus and fibre.

Kim *et al.*⁴⁰ investigated the immunomodulatory effects of extracts obtained from purple sweet potato by feeding immune deficient mice with induced LP-BM5 murine leukemia virus (MuLV) for a period of three months. It was observed that the feeding had significantly enhanced the various antioxidant enzyme levels viz. glutathione peroxidase and superoxide dismutase. It was further noticed that the feeding of purple sweet potato extracts were remarkable prohibited lymphadenopathy and splenomegaly induced by LP-BM5 MuLV, suppressed the B- and T- cell growth among the infected mice. Therefore the extracts obtained from purple sweet potato can nullify immune dysfunction to the greater extent.

Broccoli

Broccoli, which is the food that can enhance or boost body immunity. It contains vitamins like A & C, and glutathione. Gut plays a predominant role in immune system functioning in a healthy manner. The glutathione presence can reduce gut inflammations and destroy formation of free radicals by recycling of various antioxidants. One has to take utmost care, while processing foods. There are currently several techniques, which are available to preserve the nutrients during processing, to name a few non-thermal techniques, hurdle processing techniques etc., which can retain the nutrients to the greater extent, so that the functional effect can be achieved. The broccoli additionally possesses components like isothiocyanates and sulforaphane (SFN). The SFN showed potent anticancer and anti-inflammatory properties. Bessler and Djaldetti⁴¹ led an examination to check whether SFN can influence the safe transfer between human fringe blood mononuclear cells (PBMCs) and HT-29 and RKO human colon malignant growth cells lines. Non-or mitogen-activated PBMCs were hatched with different centralizations of SFN, and the emission of TNF α , IL-1 β , IL-6, IFN γ , IL-2, IL-10 and IL-1ra was resolved. Likewise, the impact of SFN on the creation of these cytokines by PBMCs co-refined with colon carcinoma cells was inspected. They found that SFN applied a fixation subordinate inhibitory impact on the provocative cytokine creation by the invulnerable cells. The effect of SFN on the collaboration among resistant and colon disease cells underscores its ability for malignancy avoidance and advancement.

Garlic

The garlic has the ability to fight various microbes like bacteria, viral and fungi because of its antimicrobial activity.

Garlic in raw form can help to fight against several skin infections.

It can also lower cholesterol and also further improve immunity by enhancing immune fighting mechanisms. It augments the virus fighting T-cells in blood. It promotes heart health by reducing the homocysteine levels. It can be consumed in either raw form or in capsule form to prevent against cold, coughs and chest infections. It is important for homeostasis maintenance in the immune system. Several research studies⁴²⁻⁴⁶ clearly depict that garlic acts as an immunomodulatory agent in animal model, which are shown in Table 1.

Pomegranate

The inclusion of pomegranate in diet can help body fight against various viruses and bacteria. The antioxidant rich fruit can fight inflammations in body. Antioxidant capacity of this fruit is three times higher than green tea. It is the highly recommended immune boosting foods.

Hosseini *et al.*⁴⁷ reported that feeding of pomegranate extracts for obese with a time period of one month had significantly reduced the biomarkers of lipid peroxidation and inflammations, thereby pronouncing anti-inflammatory activity. The feeding of peel extracts of pomegranate for period of two months has drastically reduced the blood pressure among diabetic patient, exhibiting antioxidant and hypoglycemic properties.⁴⁸ Pomegranate derived products showed good potency for curing viral based infections among mice experimental in vivo model. The peel extract had been utilized in mice to cure jejunum injury and inflammations caused by infections of *Eimeria papillata*⁴⁹ and similarly, it also reduced the disease caused by *Citrobacter rodentium* infection in mice model.⁵⁰

Ginger

It's the traditional age old medicine for curing several diseases. It can stop nausea and vomiting. It also contains antioxidants. It can be consumed along with tea with incorporated honey, which can ease throat congestion, improve immunity to the greater extent and it also restore the immune system for proper functioning. The ginger extract can be mixed with honey and given to kids during throat congestion, which can defend body against various diseases.

The ginger rhizomes can be utilized as a food or flavor supplements. Several anti-inflammatory and antioxidant components were reported in ginger.^{51, 52} Rheumatoid arthritis and certain inflammations can be minimized by use of ginger in its powder form.⁵³ The mitigating impacts of ginger and its parts have additionally been exhibited in patients with type 2 diabetes,⁵⁴ osteoarthritis,⁵⁵ rheumatoid joint inflammation,^{53, 56} intense respiratory pain condition⁵⁷ and essential dysmenorrhea.⁵⁸ The mitigating exercises of ginger concentrate or its sharp constituents, for example, gingerol and

shogaol have been likewise exhibited in test creature models, for example, models of aviation route irritation,⁵⁹ ulcerative colitis,⁶⁰ neuro-aggravation⁶¹ and gastric ulcers.⁶² It was portrayed that ginger-rewarded EAE mice displayed gentle indications of EAE, a deferral in infection beginning and low penetration of the provocative cell into the CNS. Also, treatment with ginger concentrate tweaks the outflow of IL-27 and IL-33 mRNA in EAE mice model.⁶³

CONCLUSION

The disease outbreak can be controlled by adopting the precautionary measures suggested by WHO, which includes maintain personnel hygiene, keeping social distancing, wearing protective mask, undergoing hospitalization in advanced stage and also defending oneself by enhancing immunity by consuming foods, which can boost immunity.

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REFERENCES

1. Kahn JS, McIntosh K. History and recent advances in coronavirus discovery. *Pediatr Infect Dis J* 2005; 24: S223-S6.
2. Goldsmith CS, Tatti KM, Ksiazek TG, Rollin PE, Comer JA, Lee WW, et al. Ultrastructural characterization of SARS coronavirus. *Emerg Infect Dis* 2004; 10: 320-6.
3. Fehr AR, Perlman S. *Coronaviruses: an overview of their replication and pathogenesis; Section 2 genomic organization*. In: Maier HJ, Bickerton E, Britton P, editors. *Methods in Molecular Biology*: Springer; 2015a. p. 1-23.
4. Lai MM, Cavanagh D. *The molecular biology of coronaviruses*. *Adv Virus Res* 1997; 48: 1-100.
5. De-Groot RJ, Baker SC, Baric R. Family Coronaviridae. In: King AM, Lefkowitz E, Adams MJ, Carstens EB, editors. *International Committee on Taxonomy of Viruses, International Union of Microbiological Societies, Virology Division. Ninth Report of the International Committee on Taxonomy of Viruses*. Oxford: Elsevier; 2011. p. 806-28.
6. Chang CK, Hou MH, Chang CF, Hsiao CD, Huang TH. The SARS coronavirus nucleocapsid protein--forms and functions. *Antivir Res* 2014; 103: 39-50.

7. Neuman B, Kiss G, Kunding A, Bhella D, Baksh M, Connelly S, et al. A structural analysis of M protein in coronavirus assembly and morphology. *J Struct Biol* 2011; 174:11-22.
8. Sexton N, Smith E, Blanc H, Vignuzzi M, Peersen O, Denison M. Homology-based identification of a mutation in the coronavirus RNA-dependent RNA polymerase that confers resistance to multiple mutagens. *J Virol* 2016; 90:7415-28.
9. Simmons G, Zmora P, Gierer S, Heurich A, Pöhlmann S. Proteolytic activation of the SARS-coronavirus spike protein: cutting enzymes at the cutting edge of antiviral research. *Antivir Res* 2013; 100: 605-4.
10. Fehr AR, Perlman S. *Coronaviruses: an overview of their replication and pathogenesis; Section 4.1 attachment and entry*. In: Maier HJ, Bickerton E, Britton P, editors. *Methods in Molecular Biology*: Springer; 2015b. p. 1-23.
11. Fehr AR, Perlman S. *Coronaviruses: an overview of their replication and pathogenesis*. In: Maier HJ, Bickerton E, Britton P, editors. *Methods in Molecular Biology*: Springer; 2015c. p. 1-23.
12. WHO. "Report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19)". World Health Organization [cited 2020 Mar 8].
13. Hopkins, Claire. "Loss of sense of smell as marker of COVID-19 infection". *Ear, nose and throat surgery body of United Kingdom* [cited 2020 Mar 28].
14. Fung SY, Yuen KS, Ye ZW, Chan CP, Jin DY. A tug-of-war between severe acute respiratory syndrome coronavirus 2 and host antiviral defence: lessons from other pathogenic viruses. *Emerg Microbes Infect* 2020; 9: 558-70.
15. Wu D, Wu T, Liu Q, Yang Z. The SARS-CoV-2 outbreak: what we know. *Int J Infect Dis* 2020; 94: 44-8.
16. CDC. "Coronavirus disease 2019 (COVID-19)—symptoms". *Centers for Disease Control and Prevention*. <https://www.cdc.gov/coronavirus/2019-ncov/index.html> [cited 2020 Mar 21].
17. Loh N, Tan Y, Taculod J, Gorospe B, Teope A, Somani J, et al. The impact of high-flow nasal cannula (HFNC) on coughing distance: implications on its use during the novel coronavirus disease outbreak. *Can J Anesth* 2020; 67: 893-4.
18. Bourouiba L. Turbulent gas clouds and respiratory pathogen Emissions. *JAMA* 2020; doi: 10.1001/jama.2020.4756
19. ECDC. "Q & A on COVID-19". *European Centre for Disease Prevention and Control* [cited 2020 Mar 23].
20. NIH. New coronavirus stable for hours on surfaces". National Institutes of Health (NIH) [cited 2020 Mar 24].
21. Moriyama M, Hugentobler W, Iwasaki A. Seasonality of respiratory viral infections. *Annu Rev Virol* 2020; 7: 83-1.
22. Ai T, Yang Z, Hou H, Zhan C, Chen C, Lv W, et al. Correlation of Chest CT and RT-PCR Testing for Coronavirus Disease 2019 (COVID-19) in China: a Report of 1014 Cases. *Radiology* 2020; 296:E32-E40.
23. Brueck H. There's only one way to know if you have the coronavirus, and it involves machines full of spit and mucus. *Business Insider Australia*. <<https://www.businessinsider.com.au/how-to-know-if-you-have-the-coronavirus-per-test-2020-1>> [cited 2021 Apr 17].
24. Li Y, Xia L. Coronavirus disease 2019 (COVID-19): Role of chest CT in diagnosis and management. *Am J Roentgenol* 2020; 214: 1280-86.
25. Heaven, Douglas W. "A neural network can help spot Covid-19 in chest x-rays". *MIT Technology Review* [cited 2020 March 27].
26. Spinney and Laura. Coronavirus and the geopolitics of disease. <https://www.lauraspinney.com/coronavirus-and-the-geopolitics-of-disease/> [cited 2020 Jan 28].
27. HPSC. Covid 19 information. Health Protection Surveillance Centre, Ireland; 2020.
28. NHC. Coronavirus information. New Hanover County Health Department, <https://health.nhc.gov/your-environment/public-health/coronavirus/> [cited 2020 Apr 29].
29. CHP. Centre for Health Protection, Department of Health, Government of Hongkong, 2020.
30. Sukhman D. Coronavirus: can we stay safe as lockdown eases? <https://news.yahoo.com/coronavirus-stay-safe-lockdown-eases-072105811.html>. [cited 2020 May 26].
31. Li L, Quin L, Xu Z, Yin Y, Wang X, Kong B, et al. Artificial intelligence distinguishes COVID-19 from community acquired pneumonia on chest CT. *Radiology* 200905; 2020. doi: 10.1148/radiol.2020200905
32. Wu W, Zhang M, Sun C, Brennan M, Li H, Wang G, et al. Enzymatic preparation of immunomodulatory hydrolysates from defatted wheat germ (*Triticum Vulgare*) globulin. *Int J Food Sci Technol* 2016; 51: 2556-66.
33. Adachi S. Lactic acid bacteria and the control of tumours. In: Wood BJW, editors. *The lactic acid bacteria in health and disease*. London: Elsevier Applied Science; 1992. p. 233-61.
34. Tomioka H, Saito H. Lactic acid bacteria in the support of immune compromised hosts. In: Wood, editor. *The lactic acid bacteria in health and disease*. Elsevier; 1992. p. 263-96.
35. Perdigon G, Alavarez S. Probiotics and the immune state. In: Fuller R, editor. *Probiotics, the scientific basis*. London: Chapman & Hall; 1992. p. 145-80.
36. Yokokura T, Nomoto K, Shimizu T, Nomoto K. Enhancement of hematopoietic response of mice by subcutaneous administration of *Lactobacillus casei*. *Infect Immun* 1986; 52:156-60.
37. Ohashi T, Minamishima Y, Yokokura T, Mutai M. Induction of resistance in mice against murine cytomegalovirus by cellular components of *Lactobacillus casei*. *Biotherapy* 1989; 1: 89-5.
38. Perdigon G, Alvarez S, Medici M, de Ruiz Holgado A. Influence of the use of *Lactobacillus casei* as an oral adjuvant on the levels of secretory immunoglobulin during an infection with *Salmonella typhimurium*. *Food Agr Immunol* 1993; 5: 27-7.
39. Rahayu R, Prasetyo R, Purwanto D, Kresnadi U, Iskandar R, Rubianto M. The immunomodulatory effect of green tea (*Camellia sinensis*) leaves extract on immunocompromised Wistar rats infected by *Candida albicans*. *Vet World* 2018; 11:765-70.
40. Kim OK, Nam DE, Yoon HG, Baek SJ, Jun W, Lee J. Immunomodulatory and antioxidant effects of purple sweet potato extract in LP-BM5 murine leukemia virus-induced murine acquired immune deficiency syndrome. *J Med Food* 2015; 18:882-9.
41. Bessler H, Djaldetti M. Broccoli and human health: immunomodulatory effect of sulforaphane in a model of colon cancer. *Int J Food Sci Nutr* 2018; 69: 946-3.
42. Liu C, Su H, Lii C, Sheen L. Effect of supplementation with garlic oil on activity of Th1 and Th2 lymphocytes from rats. *Planta Med* 2009; 75:205-10.
43. Keiss HP, Dirsch VM, Hartung T, Haffner T, Trueman L, Auger J, et al. Garlic (*Allium sativum* L.) modulates cytokine expression in lipopolysaccharide-activated human blood thereby inhibiting NF-kappaB activity. *J Nutr* 2003; 133: 2171-75.
44. Feng Y, Zhu X, Wang Q, Jiang Y, Shang H, Cui L, et al. Allicin enhances host pro-inflammatory immune responses and protects against acute murine malaria infection. *Malar J* 2012; 11: 268.
45. Hanieh H, Narabara K, Piao M, Gerile C, Abe A, Kondo Y. Modulatory effects of two levels of dietary Alliums on immune response and certain immunological variables, following immunization, in White Leghorn chickens. *Anim Sci J = Nihon chikusan Gakkaiho* 2010; 81: 673-80.

46. Washiya Y, Nishikawa T, Fujino T. Enhancement of intestinal IgA production by ajoene in mice. *Biosci Biotechnol Biochem* 2013; 77: 2298-01.
47. Hosseini B, Saedisomeolia A, Wood LG, Yaseri M, Tavasoli S. Effects of pomegranate extract supplementation on inflammation in overweight and obese individuals: a randomized controlled clinical trial. *Complement Ther Clin Pract* 2016; 22: 44-5.
48. Grabez M, Skrbic R, Stojiljkovic MP, Rudic-Grujic V, Paunovic M, Arsić A, et al. Beneficial effects of pomegranate peel extract on plasma lipid profile, fatty acids levels and blood pressure in patients with diabetes mellitus type-2: a randomized, double-blind, placebo-controlled study. *J Funct Foods* 2020; 64:103692.
49. Amer O, Dkhil M, Hikil W, Al-Quraishy S. Antioxidant and anti-inflammatory activities of pomegranate (*punica granatum*) on eimeria papillata-induced infection in mice. *BioMed Res Int* 2015; 2015:1-7.
50. George NS, Cheung L, Luthria DL, Santin M, Dawson HD, Bhagwat AA, et al. Pomegranate peel extract alters the microbiome in mice and dysbiosis caused by *Citrobacter rodentium* infection. *Food Sci Nutr* 2019; 7: 2565-76.
51. Ahui M, Champy P, Ramadan A, Pham-Van L, Araujo L, Brou-André K, et al. Ginger prevents Th2-mediated immune responses in a mouse model of airway inflammation. *Int Immunopharmacol* 2008; 8:1626-32.
52. Haniadka R, Saldanha E, Sunita V, Palatty PL, Fayad R, Baliga MS. A review of the gastroprotective effects of ginger (*Zingiber officinale* Roscoe). *Food Funct* 2013; 4: 845-5.
53. Al-Nahain A, Jahan R, Rahmatullah M. *Zingiber officinale*: a potential plant against Rheumatoid Arthritis. *Arthritis* 2014; 2014:1-8.
54. Priya-Rani M, Padmakumari K, Sankarikutty B, Lijo-Cherian O, Nisha V, Raghu K. Inhibitory potential of ginger extracts against enzymes linked to type 2 diabetes, inflammation and induced oxidative stress. *Int J Food Sci Nutr* 2010; 62:106-10.
55. Drozdov V, Kim V, Tkachenko E, Varvanina G. Influence of a specific ginger combination on gastropathy conditions in patients with osteoarthritis of the knee or hip. *J Altern Complement Med* 2012; 18: 583-88.
56. Ramadan G, El-Menshawey O. Protective effects of ginger-turmeric rhizomes mixture on joint inflammation, atherogenesis, kidney dysfunction and other complications in a rat model of human rheumatoid arthritis. *Int J Rheum Dis* 2013, 16: 219-29.
57. Vahdat Shariatpanahi Z, Mokhtari M, Taleban F, Alavi F, Salehi Surmaghi M, Mehrabi Y, et al. Effect of enteral feeding with ginger extract in acute respiratory distress syndrome. *J Crit Care* 2013; 28: 217.e1-217.e6.
58. Rahnema P, Montazeri A, Huseini H, Kianbakht S, Naseri M. Effect of *Zingiber officinale* R. rhizomes (ginger) on pain relief in primary dysmenorrhea: a placebo randomized trial. *BMC Complement Altern Med* 2012; 12: 92.
59. Kuo P, Hsu Y, Huang M, Tsai MJ, Ko YC. Ginger suppresses Phthalate Ester-induced airway remodeling. *J Agric Food Chem* 2011, 59: 3429-38.
60. Ajayi B, Adedara I, Farombi E. Pharmacological activity of 6-gingerol in dextran sulphate sodium-induced ulcerative colitis in BALB/c mice. *Phytother Res* 2015; 29:566-72.
61. Ha SK, Moon E, Ju MS, Kim DH, Ryu JH, Oh MS, et al. 6-Shogaol, a ginger product, modulates neuroinflammation: A new approach to neuroprotection. *Neuropharmacology* 2012; 63: 211-23.
62. Wang Z, Hasegawa J, Wang X, Matsuda A, Tokuda T, Miura N, et al. Protective effects of ginger against aspirin-induced gastric ulcers in rats. *Yonago Acta Med* 2011; 54:11.
63. Jafarzadeh A, Mohammadi-Kordkhayli M, Ahangar-Parvin R, Azizi V, Khoramdel-Azad H, Shamsizadeh A, et al. Ginger extracts influence the expression of IL-27 and IL-33 in the central nervous system in experimental autoimmune encephalomyelitis and ameliorates the clinical symptoms of disease. *J neuroimmunol* 2014; 276: 80-8.

Table 1: Garlic Immunomodulatory Properties

Experimental Model	Research Findings	References
Male Wistar rats	Garlic oil enhances and shifts toward Th1-type response at low doses (10 mg/kg). It promotes an anti-inflammatory environment at high doses i.e. 200 mg/kg by shifting Th1-Th2 balance toward the Th2 type.	Liu <i>et al.</i> ⁴²
Human(in vitro cell lines)	Garlic compounds viz. garlic powder extracts modulate inflammatory cytokines, leading to overall reduction of NF-κB activity	Keiss <i>et al.</i> ⁴³
Mice	Allicin reduced parasitemia and prolonged survival due to improved host immune responses. Enhancement of proinflammatory mediators IFN-γ, TNF-α, and IL-12p70. No changes in anti-inflammatory cytokines IL-4 and IL-10.	Feng <i>et al.</i> ⁴⁴
Chicks	<i>Allium sativum</i> (G) and <i>Allium cepa</i> (O) (low doses: 10g/kg (GL and OL) or high doses 30g/kg (GH and OH) enhanced anti-NDV, anti-SRBC, and anti-BA antibody productions in chicks. Only GL- and GH had a comitogenic effect on splenocytes and thymocytes. Reduction in CD4 ⁺ and increase in CD4 ⁺ :CD8 ⁺ lymphocyte ratios were observed with GH or OH in chicks.	Hanieh <i>et al.</i> ⁴⁵
Mouse	Intestinal IgA level was increased by ajoene; thus, ajoene may have influenced B-cell stimulation or interleukin secretion.	Washiya <i>et al.</i> ⁴⁶

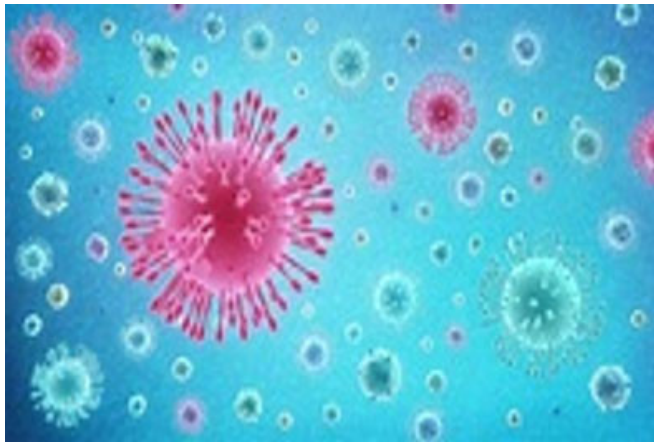


Figure 1: Corona virus.

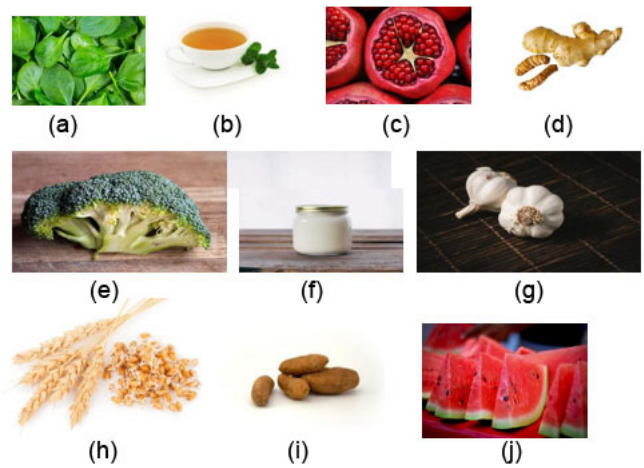


Figure 2: Top Ten immune boosting foods (a-spinach;b-green tea;c-pomegranate;d-ginger; e-broccoli; f-yogurt; g-garlic; h-wheat germ; i-sweet potato; j-watermelon).