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Review Article

Foods Influence the Gut Microbiota: Boost Immunity Against Covid-19

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Abstract

The current investigation has been conducted on foods that improve gut microbiota health and boost immunity, which is an aid to protection against COVID-19. Plant-based food, including fruits, vegetables, cereals, beans, and legumes, plays a vital role in the improvement and development of the gut microbiota system because it contains those components that are good for gut microbiota health. Prebiotic and probiotic foods promote microbiota in the gut, its natural sources are yogurt, kimchi, sauerkraut, kefir, kombucha and tempeh products are fermented food good for the gut microbes. COVID-19 has spread rapidly in the world and attacks people who have a weak immune system. So, this review found that eating selective foodshelps to boost immunity against COVID-19.

Keywords: COVID-19; Gut Microbiota; Immunity; Plant-based Food; Probiotic; Prebiotic

Introduction

Covid-19

The spectrum of viruses in humans causes severe respiratory syndrome (SARS) and the common cold and the coronavirus are included in them. Significant threats to public health are emerging infectious diseases like SARS. World Health Organization has been confirmed that the unique coronavirus has spread to multiple countries rapidly. COVID-19 is an attack on low immunity people, which is usually caused by a virus. People with low immunity and people with under and overages are the primary victims of COVID-19. When the human body's immune system does not respond properly, then it becomes a site for COVID-19 infections or diseases like that cancer, heart disease and diabetes [1].

The virus responsible for COVID-19 regarding its morphology and chemical formation is identical to other man surrogate coronaviruses, about which more statistics is accessible concerning to their environmental sustainability as well as effective measures of coagulation [2].

In many countries of the world, COVID-19 cases have been discovered [3]. Encompassing, temperature, dry cough, dyspnea, myalgia, fatigue, ideal or lessening of leucocytes counts plus pneumonia proved by radiography are the clinical evidence exhibited by the sufferer's COVID-19 [4].

Gut microbes

The human body's largest population of microorganisms including fungi, bacteria, and archaeans that live in digestive tract and are collectively known as the microbiome or gut microbiota or human microbiota. An intricate ecosystem of about 300-500 gastrointestinal microbiota subsists in man, consisting of approximately 2 million genes (the microbiome). The gut microbes has important roles in the training of host immunity, digesting food, regulating other gut functions [5].

The gastrointestinal pathway of the man shelters a complicated and vigorous population of microbes. At the same time, in the course of homeostasis and ailment, the significant impacts are deployed by the gut's microbiota. In the infancy period, the constitution of the gut microbiota of humans is influenced by various factors. Throughout the lifetime, the formation of a gut microbiota diet is contemplated as one of the primary necessities. For governing the immune, metabolic homeostasis and shielding from pathogens, the gut microbiota plays a vital role. The pathogenesis of different inflammatory ailments and infections are concerned with the change in composition of gut microbiota, the elucidation of these scrutiny, reckons on more accurate perception of inter-individual disparities, heterogeneity of communities of bacteria inside out the G.I. tract, superfluity in the functions and the necessity of differentiation cause from the outcomes in condition of dysbiosis [6].

By a variety of physiological characteristics like making the gut probity strong or aligning the epithelium harvesting energy of intestine, various benefits to the host are proffered by the microbiota [7,8], safeguarding from pathogens [9] as well as managing the immunity of its host [10].

The human gastrointestinal tract is one of the most significant boundaries (250-400 m^2) between the human body's antigens, host and environmental factors. The human G.I. tract allows 60 tons of food to pass through it, in a regular life span, having many microorganisms from the environment that are harmful to the whole gut [11]. 'Gut microbiota is the sum of all colonies of bacteria, archaea, and eukaryote in the G.I. tract, and has grown up with host over a thousand years to make a complicated and mutual relation [12,13]. More than 1014 microorganisms are living in G.I. tract, this indicates that bacterial cells are ten times more than number of human cells and more than hundred times the genomic microbiome than human genome [14]. Though, current information suggested that the ratio of human and bacterial cell is near to 1:1 [12,15].

The human digestive system portion shelters a perplex and influential the number of microorganisms, the gut microbiota, which apply a marked consequence on the host during homeostasis and disease. During infancy, multiple factors involve to the establishment of the human gut microbiota. Microbiota across the lifetime shaped by one of the main drivers which is diet. To maintain immune, metabolic homeostasis and protect against pathogens intestinal bacteria play a big role [16].

Foods that aid in boosting gut bacteria

Plant-based food

Plants base foods such as broccoli, blueberries, bananas and Jerusalem artichokes are beneficial to human health as they help develop a more diverse gut microbial system [17,18].

The dietary composition has a long-lasting and acute impact on the gut microbiota ecosystem [19]. Vegetarian/vegan vs. omnivorous diets is various long term dietary patterns that have significant effects on gut microbiota composition. The various gut microbiota collection is shown to give various food nutrients metabolites called postbiotics. Plant-based food is more linked with phytoestrogens or isothiocyanates for instance. In different ways, these and other postbiotics take part in the metabolism of the host [20].

Previous studies revealed that consumption of food nutrients with low bioactivity is necessary. In large food particle, the plant cell wall is unbroken and the food which does not undergo any thermal treatment have low nutrient bioavailability, more nutrients passed to lower G.I. tract and improve nutrient transport to gut microbiota. Function and development of gut microbiota are activated by this support [21]. Entire plant base food have defensive effects, supporting the development of beneficial fiber-damaging bacteria in the colon. [22].

Some plant-based foods are rich in dietary fiber include constituents of non-digestible carbohydrates, a form of resistant polysaccharides that reach the large intestine where gut microbiota is an aid to ferment this food and provide energy or create postbiotics. Moreover, Gut microbiota is enhanced by a source of digestible and non-digestible CHO. Glucose, sucrose and fructose are digestible sugars that function in the gut to reduce the *Bacteroides* and Clostridia. In plants, starch-like non-digestible sugars are enhanced lactic acid bacteria, *Ruminococcus, E. rectale,* and *Roseburia*, and decrease *Clostridium* and *Enterococcus* species [23].

Another study reported that persons feasting on diet based on just vegetables and the other eating omnivorously have variations in the composition of their microbiota. It is exposed by study that in comparison to omnivores, divergent microbiota are nurtured by the vegetarian or vegan diet with only a border line variation amid of vegan and vegetarian [24]. The factors that affect the configuration of microbiota might be because of straight ingestion of different bacteria by food, variation in substrates being devoured, divergence in the time of conveyance across the gastrointestinal tract, pH, secretions of host effected by the dietary orders, as well as control of its host's own self plus his/her microbiota gene expressions [25].

Eat fermented foods

Yogurt, kimchi, sauerkraut, kefir, kombucha and tempeh products assembled by the microorganisms and the enzymatic transformation of chief and trivial constituents of foods are normally elucidated as fermented foods and beverages. Now a definite testimony is present that the fermented products (for example, pickles, yoghurt, bread, wines, kefir, beers, mead) manufactured or conserved due to the microbial activity, have the strong influence on the balance of microbiota present in gut and brain functions in addition to their generally known impacts on the healthiness of digestive system (dysbiosis) plus overall health of human. The microorganisms that yield alcohol and lactic acid namely lactic acid bacteria and Saccharomyces yeasts, are required for the production of fermented foods. In reconciliation of the permeability and impediment functions of intestine, intake of dynamic probiots, peculiarly that are present in fermented foods bring good amelioration. Every facet of our health is managed and sighted by our gut. Our mood, behavior, energy, weight, food cravings, hormone balance, immunity, and overall wellness are the factors that are associated with the way we digest our food as well as food sensitivities [26].

Fermented foods have become the real time subject but for better purposes. Digestion is improved, immunity gets boosted, and healthy weight is accomplished by the aid of these beneficial bacteria especially from our gut. The importance of these powerful bacteria for human health is still investigated, though the former results are encouraging, your gut will look after you well when you will look after your gut well. The one method to spur the health of your gut is by the intake of foods crowded by the good bacteria i.e. probiotics (moreover additional intake of fiber rich and the foods that have high number of probiotics is also important). Higher number of probiotics is present in fermented yoghurt and kimchi. During the process of fermentation flourishing of good bacteria occurs [27].

The lactose is broken down by the bacteria in the process of dairy product's fermentation, to make fermented dairy products like cottage cheese, kefir and yogurt (make sure that the product you have selected have the active cultures) favorable for the lactose intolerant persons. To maintain the gut health, make an effort to add one serving of minimum one or more than one of the foods that are fermented. In order to spare the benefiting microorganisms from high temperature, while using in cooking, either use them as topping or add them in your meal at the end of cooking [28].

Prebiotic food

Prebiotics is food for gut microbes. There are many sources from where we can get prebiotics these include chicory root, Jerusalem artichokes, raw dandelion greens, onions, bananas, leeks, garlic, spinach, asparagus, beans, oats, whole wheat and soybeans [29,30].

Prebiotics are food components and they provide many health benefits and also used by the host microbes. In high fiber foods many prebiotics are found and these cannot be broken down by using human digestive enzymes and they go towards large intestine and are fermented with the help of gut bacteria. Natural occurring prebiotic fiber can be obtained from vegetables, fruits, whole grains and legumes like peas and beans. Prebiotics are also classified on the basis of ingredients in some packaged foods which include inulin and oligosaccharides as most people don't like and eat some fiber [31].

Prebiotic fibers are non-digestible carbohydrates that also promote the growth of beneficial bacteria in the gut. Using prebiotics also better for obesity and associated co-morbidities as they improve and normalize the dysbiosis of gut microbiota. Doses of the gut microbiota, body composition and obesity related risk factors in healthy as well as genetically obese rats have been tested for a prebiotic diets. Prebiotic fibres, which are often associated with a slimmer appearance, improved *Firmicutes* as well as reduced *Bacteroidets*. There has also been increased numbers of *Lactobacillus* and *Bifidobacteria*. We present here an exhaustive study analyzing the findings with the intestinal microbiota microscope [32].

Prebiotics show resistance to gastric acidity [33,34]. Prebiotics are primarily characterized by their focused stimulation of bowel development and/or behavior regarding well-being and health [34]. The most famous prebiotics include inulin, fructooligosaccharides, lactulose and galactooligo saccharides [35]. Prebiotics are being used for the health purpose for the host in form of fermented prebiotics and also used for the enhancement of strains like *Bifidobacterium* and *Lactobacillus*, as they can produce lactate and acetate [36]. The gut microbiota shows that prebiotics are useful as they shown competition between bacteria and are cooperative in nature. In cross-feeding phenomenon various microorganisms cooperate and utilize complex carbohydrates efficiently [37]. When these carbohydrates are fermented with the help of microbes in the gut as a result metabolites are produced in the gut [38]. In the complex carbohydrates resistant starch and plant cell-wall polysaccharides are also included and they contribute in human diet, with a daily amount of 20-60g reaching the colon, and they act as fermentation substrates for the gut microbiota [39]. SCFAs, particularly acetate, butyrate, and propionate, are made in the gut as a consequence of digestion. They provide a numerous health benefits to the host, like serving to activate cellular processes that maintain integrity of tissues, contribute to the immune response and have anti - inflammatory activity [40]. They are a source of energy for colon tissues. In addition, various organic acids, such as lactates, formats, as well as succinates, developed through dietary fiber fermentation prevent pathogenic bacteria and lower intestine pH from developing [41]. The prevalence of specific bacteria developing such metabolites is thus important in terms of their prebiotic characteristics.

Probiotic foods

The human gut is a diverse ecosystem of microbiota, host cells, and nutrient availability, and bacteria avoids many chronic diseases by immunomodulation in animals and humans. The gut microbiota have an impact on human nutrition, metabolism, physiology and immunity [42]. Some other research reports shows that probiotics promote healthy gut microbiome, and it prevent gut inflammation and other intestinal problems [43].

When treating diseases in humans, modifying gut microbiota by probiotic organisms is very common. Research has increasingly inspired probiotic organisms to research the development of probiotic products and the regulation of intestinal microbiota. Since the beginning of the 20th century, there has been a broad review on eating functional products with a particular mix of bacteria, with yogurt at the heart of preserving good health through growth of the gastrointestinal tract and protection of various chronic diseases [44].

Recent research works of the human intestinal flora show that an alteration of microbial populations can increase a tendency to do something to different genetic diseases in humans. Dietary fibers are converted into primary metabolites by gut microbes that act as secondary metabolites compounds affecting regulatory functions in the host. Probiotics can restore the composition of the intestinal microbes. It produce beneficial functions to gut microbial populations. The results showed the probiotics consumption can be reduce the gut inflammation and systemic genetic disease [43].

This finding indicated that such bacteria can be beneficial to human health if ingested. Until then, probiotics, especially as dietary supplements as well as functional food ingredients, were consumed and marketed. Probiosis processes include gut bacterial population regulation, pathogens destruction, immunomodulatory, stimulation of its development of epithelial cells, and separation and enhancement of intestinal barrier. Probiotics can control intestinal bacteria community by producing β-defensin as well as IgA production from the host, and inhibit the growth of harmful bacteria. Probiotics can reinforce the gastrointestinal tract by keeping tight interconnections and creating mucine. Bacterial-mediated immune function may occur via cytokine production by signaling including NFŢB as well as MAPKs, which would also impact immune cell differentiation and proliferation (such as T cells). Good motility can be modified via pain recipient expression as well as neurotransmission secretion regulation [45].

Eat foods rich in polyphenols

Red wine, dark, cocoa chocolate, broccoli grape skins, almonds, green tea, onions, blueberries, and potato are important sources of polyphenol [46]. In the potato skin anthocyanins and chlorogenic acid are present in the form of phenolic acids [47].

Phenolic antioxidants were measured electrochemically through cyclic voltammetries with a glassy carbon electrode, using dark chocolate cocoa powder, and milk chocolate extracts [48]. Red-fleshed plum and peach are of the genotypes distinguished by their total content of phenolic as well as anthocyanin. Rich phenolic genotypes were selected with high activity antioxidants, stable color characteristics and strong antimicrobial activity [49].

Polyphenols [50], are increasing the abundance of *Lactobacilluain* and *Bifidobacterium*, offering antibacterial and anti-inflammatory properties and cardiac defense. Popular foods rich in polyphenols involve fruits, cocoa nuts, vegetables, tea, and wine. For instance, tea polyphenol extracts enhance *Bifido-bacterium* as well as *Lactobacillus-Enterococcus spp*., resulting in higher SCFA development on intestinal microbiota [51].

Dietary polyphenols are natural compounds present in food products such as fruit, vegetables, rice, tea, cocoa powder, coffee, dark chocolate, and wine. These substances constitute a large set of diverse compounds, but have structural units closely related to all phenolics (phenol rings or hydroxylated aromatic rings) [52,53]. The phenolic substances are found into classes, based on the number of phenol rings, they contain and the structural components connecting such rings. Phenolic acids, tannins, flavonoids, stilbenes as well as diffuloylmethane [52,53] are the major food polyphenols. Phenolic acids are made up of the phenol ring and a carboxylic function and divided into gallic and protocatechuic acid derivatives, p-coumaric, caffeic and ferulic acid derivatives. Stilbenes are double bond hydrocarbon substituted by a phenyl group of the two double bonded carbon atoms [53]. These occur on low levels in plants and are the most prevalent resveratrol as well as its isomer trans-resveratrol, frequently placed in grapes and wine. More than 10,000 compounds contain flavonoids, which are almost ubiquitous in plants (more than 9,000 species) [52,53].

Gut microbes enhance immunity against covid-19 and pathogen

The human intestinal microbiota is made up of 10^{14} resident bacteria, archas, viruses and fungi [15]. Among healthy individuals, four phylactinobacteria, firmicutes, proteobacteria and bacteroidets dominate intestinal bacteria in the first place [54]. The colon has exceptionally high bacteria densities in the *Rikenellaceae*, *Bacteroidaceae*, *Prevotellaceae*, *Ruminococcaceae* and *Lachnospiraceae* families [55]. The microbiota of the gut plays a significant role in health through its trophic, defensive, and metabolic behavior. The hosts interactions with the microbiota are complex, multiple and two-way. Innal and adaptive immune system production and function should be substantially controlled by gut microbiota [56].

Unlike gut microbiota, there is also evidence that various microorganisms are found in the lung [57]. *Bacteroidetes* as well as firmicutes predominate in the intestines, while firmicutes, bacteroidetes, and proteobacteria predominate in the lung [58]. Interestingly, a vital interaction between gut bacteria and the lungs, known as the "good-lung axis" was shown to impact pulmonary health [59]. In other words, microbial metabolites can influence the lung via the blood, and when an infection occurs in the lung, they can also affect the gut microbiota [60].

This poses an interesting ability that novel SARS-Cov2 could also affect the gut microbiota. In addition, a number of studies have shown a variation in the formulation of gut microbiota as a result of respiratory infections [61]. One of Covid-19's severe clinical outcomes is progression to ARDS, as well as pneumonia especially among the elderly, immune-committed patients [62]. A variety of laboratory and clinical studies have shown that intestinal microbiota plays a significant role in sepsis and ARDS pathogens is [63]. Loss of diversity in intestinal bacteria can give rise to dysbiosis and can be associated with numerous diseases (Mosca., *et al*. 2016). Elderly people actually have less diverse intestinal microbiota and beneficial microorganisms, including *bifidobacterium* [64]. Because many elderly and immune-comitted patients move towards severe adverse clinical effects, it is also tempting to conclude that there is a potential cross-discussion of the outcomes of the clinical presentation of the Covid-19 between the lungs and the intestinal microbiota.

Covid-19 is a global pandemic faced by SARS-CoV-2 that affects our interpretation of infectious diseases. While SARS-Cov-2 mainly causes lung infection by binding ACE2 receiver in the alveolar epithelium cells, SARS-CoV-2 RNA in the fecal matter of patients has been documented recently. Importantly, ACE2 receptors are also expressed in the intestinal epithelium, especially the enterocytes of the intestinal tract. Affecting lung diseases, the function of gut microbiota has been well expressed. It is also documented that infection with respiratory viruses causes disruptions of the gut microbiota. Diet, genetic and environmental factors play a major role in forming gut microbiota that can affect immunity. In old age, good microbiota diversity decreases and Covid-19 was mostly fatal to elderly patients, indicating again the role of gut microbiota in the infection. Strengthening the microbiota profile of the gut through nutritional interventions and immune enhancement would be one of the preventative ways in which the impact on the elderly and immunological-compromised persons can be minimized. Further research can be conducted to detect the impact of the co-supplementation of specific functional foods like prebiotics/probiotics with existing treatments [65].

Conclusion

The COVID-19 mostly attacks peoples that have a weak immune system. To aid, or enhance immunity, some foods like plant-based, probiotic and prebiotic, fermented and rich phenolic play a major role by promoting gut microbiota in the human body. Broccoli, blueberries, bananas, Jerusalem artichokes onions, leeks, garlic, spinach, asparagus, beans, oats and whole wheat are vital components of gut microbiota health. So, concluded that by eating these foods humans can get protection from COVID-19. More research is required on foods that help against COVID-19.

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