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Role of Gut Microbiome in Health and Immunity with Food-Based Approaches

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Abstract

Microbiome refers to the collective genomes of the microorganisms in a particular environment. Approximately 100 trillion micro-organisms (mostly bacteria, but also viruses, fungi, and protozoa) exist in the human gastrointestinal tract. Gut microbes are key to many aspects of human health including immune, metabolic and neurobehavioral traits. Each person has an entirely unique network of microbiota that is originally determined by one's DNA. A person is first exposed to microorganisms as an infant, during delivery in the birth canal and through the mother's breast milk. Exactly which microorganisms the infant is exposed to depends solely on the species found in the mother. Later on, environmental exposures and diet can change one's microbiome to be either beneficial to health or place one at greater risk for disease. Drugs, food ingredients, antibiotics, and pesticides could all have adverse effects on the gut microbiota.

Microbiota—the community of micro-organisms themselves. The composition of gut microbiota is commonly quantified using DNA based methods, such as next generation sequencing of 16S ribosomal RNA genes or whole genome shotgun sequencing which also allow inference of microbiota functions. Metabolic products of the microbiota are now measurable in stool and serum using metabolomics methods.

Importance of gut microbes in health and immunity

- Microbiota stimulate the immune system, break down potentially toxic food compounds, and synthesize certain vitamins and amino acids including the B vitamins and vitamin K. For example, the key enzymes needed to form vitamin B12 are only found in bacteria, not in plants and animals.
- Sugars like table sugar and lactose (milk sugar) are quickly absorbed in the upper part of the small intestine, but more complex carbohydrates like starches and fibers are not as easily digested and may travel lower to the large intestine. The microbiota helps to break down these compounds with their digestive enzymes.
- The microbiota of a healthy person will also provide protection from pathogenic organisms that enter the body such as through drinking or eating contaminated water or food.
- Large families of bacteria found in the human gut nclude *Prevotella*, *Ruminococcus*, *Bacteroides* and *Firmicutes*. In the colon, a low oxygen environment, you will find the anaerobic bacteria *Peptostreptococcus*, *Bifidobacterium*, *Lac tobacillus* and *Clostridium*. These microbes are believed to prevent the overgrowth of harmful bacteria by competing for nutrients and attachment sites to the mucus membranes of the gut, a major site of immune activity and production of antimicrobial proteins.

Gut microbes

Food based approaches for strengthening gut microbes

The three pillars of gut health include our ability to properly digest and absorb nutrients from food, the integrity of our gastrointestinal barrier and the composition of our microbiome

Probiotics

It can be most effective at both ends of the age spectrum because that's when your microbes aren't as robust as they normally are. Probiotics are the "good bugs" and can be found in fermented foods like sauerkraut, kimchi, miso and yogurt. Eating probiotics adds good bacteria to your gut. The most common are *Lactobacillus* and *Bifidobacterium*. In addition to helping balance your gut bacteria, probiotics can help if you have diarrhea, boost your immunity and keep your heart and skin healthy. Situations of stress to the body where probiotics may be helpful, such as reducing severity of diarrhea after exposure to pathogens, or replenishing normal bacteria in the intestine after a patient uses antibiotics.

The food-based approach commonly followed

Eat more: Probiotics, prebiotics, fiber, polyphenols and fermented foods

Eat less: Artificial sweeteners, red meat, processed foods and alcohol.

Dietary fiber

The consumption of whole grains, which contain soluble and insoluble dietary fiber, may enhance bacterial diversity and increase the abundance of important beneficial bacterial genera such as *Roseburia and Bifidobacterium*, both of which are important producers of short chain fatty acids. Diets deficient in dietary fiber degrade the protective mucus layer that lines our intestinal cells and tight junctions thus contributing to leaky gut by allowing pathogens into the blood stream. However, the consumption of resistant starch and wheat bran fibers can reverse this process by increasing mucus production in the intestinal epithelium of mice. Resistant starch, a type of insoluble dietary fiber, has the ability to positively influence our microbiome and undergo fermentation in our gut to yield beneficial metabolites. Consuming resistant starch may not only increase the population of *Bifidobacterium* in the gut, but it may also increase the levels of *Ruminococcus bromii* and *Eubacterium rectale*; two key species that play pivotal roles in the fermentation and degradation of dietary fiber.

If we are going to develop microbiota-directed foods aimed at providing benefits to human health, it's important to find ways to determine which food staples will be the best source of nutrients and how the microbiota will respond. Beans, Berries, Avocados, Leafy greens, Cruciferous vegetables, Apples, Flax seeds, Nuts, Sweet potatoes, Quinoa and Oats are rich source of dietary fibers

Polyphenols

Polyphenols, which are probably the most important secondary metabolites produced by plants, have attracted tremendous attention due to their health-promoting effects, including their antioxidant, anti-inflammatory, antibacterial, anti-adipogenic, and neuro-protective activities, as well as health properties. Dietary polyphenols can modulate the composition of intestinal microbes, and in turn, gut microbes catabolize polyphenols to release bioactive metabolites. They may directly modulate the gut microbiome, i.e., increasing beneficial microbial or decreasing harmful microbial species in the gut microbiota. Flavonoids from red wine in vitro feces fermentation Inhibit *Clostridium histolyticum* group. Mango peel In vitro model of the colon enhance Bifidobacterium and Lactobacillus. Ellagic acid and anthocyanins, Raspberry In vitro colonic fermentation Increase the abundance of *Escherichia coli*, butyric acid-producing bacteria, *Lactobacillus* and Akkermansia; Decrease Bacteroides and Ruminococcus. Proanthocyanidins, Sorghum bran In vitro model of the colon Increase *Bifidobacterium* spp. Procyanidins and anthocyanidins, Grape Broiler chicks Increase the populations of Enterococcus, Escherichia coli, Lactobacillus.

Fermented foods

Microbiomes of consumers of such fermented products were associated with *Bacteroides* spp., *Pseudomonas* spp., *Dorea* spp., *Lachnospiraceae*, *Prevotel l*Alistipesputredinis, *Oscillospira* spp., *Enterobacteriace ae*, *Fusobacterium* spp., *Actinomyces* spp., *Achromobacte r* spp. *Clostridium clostridioforme*, *Faecalibacterium prausnitzii*, *Bacteroides uniformis*, *Clostridiales*, and *Delftia* spp. They Improve lactose digestion for lactose maldigesters or modulating the immune system. The fermented food-rich diet results in an increase in alpha diversity of the gut microbiome that was not observed with the fibre diet**.** A fermented milk product with defined starters and adjuncts was able to significantly increase SCFA levels in vitro, especially butyrate; when administered to irritable bowel syndrome (IBS) sufferers, it led to a decrease in *Bilophila wadsworthia* (a so-called pathobiont, that is, a bacterium negatively associated with health) and an increase in two *Clostridiales* isolates (uncharacterized genera MGS203 and MGS126) known for butyrate production.

When the fermented juice was put through artificial digestion followed by colonic fermentation, significant increases in abundance were observed for *Lactobacillus*, *Akkermansia*, *E. coli*, and butyric acid-producing bacteria, while *Bacteroides* and *Ruminococcus* decreased. Daily consumption of avocado results in lower fecal bile acid concentrations, greater fecal fatty acid and short chain fatty acids (SCFAs), and greater relative abundances of bacteria capable of fiber fermentation. Further, it also provides evidence that this nutrient-dense food affects digestive physiology, as well as the composition and metabolic functions of the intestinal microbiota.

Foods to be consumed carefully

Alcohol

It is found to cause dysbiosis in the gastro intestinal tract that increase gram-negative bacteria, decrease short-chain fatty acid (SCFA) producing bacteria disrupting intestinal barrier integrity caused by endotoxin produced by gram-negative bacteria and increased permeability of the intestinal mucosa.

Processed foods

Fructose lysine is common in processed food, including ultra-pasteurized milk, pasta, chocolate, and cereals. *Collinsella intestinalis helps in breakdown processed food into harmless metabolites. Extravagant consumption of proceessed food will lead to decrease in this type of microorganisms*

Artificial sweetener

They may trigger glucose intolerance via changes in the gut microbiome, thereby increasing the risk of the issues they seek to solve diabetes, heart disease.

Artificial sweeteners can potentially turn healthy bacteria in the gut microbiome into harmful microbes and potentially cause serious health issues such as blood poisoning

saccharin, sucralose, and aspartame – found in soft drinks and processed foods – can cause beneficial bacteria in the intestines such as *E. coli* (*Escherichia coli*) and *E. faecalis* (*Enterococcus faecalis*) to become pathogenic, or disease causing.

Red meat

L-carnitine, a chemical compound widely present in red meat (and also some energy drinks), alters the composition of gut microbiota, leading to a potentially increased risk of heart disease so excessive consumption should be avoided to protect gut microbes for healthy life increasing immunity and strengthening gut microbes.

Conclusion

Nurturing a healthy gut microbiome is pivotal for overall health and immunity. Integrating food-based approaches that prioritize a diverse and nutrient-rich diet can be a cornerstone in promoting a balanced microbial community. The future holds exciting possibilities for harnessing the potential of the gut microbiome to optimize health outcomes and revolutionize healthcare practices. As we delve deeper into this complex ecosystem, unlocking the secrets of the gut microbiome may pave the way for innovative strategies to enhance well-being and resilience against a spectrum of health challenges.

References

Round J. L., and Mazmanian S. K. (2009). The gut microbiota shapes intestinal immune responses during health and disease. Nature Reviews Immunology, 9(5), 313-323.

Belkaid, Y. & Hand T. W. (2014). Role of the microbiota in immunity and inflammation. Cell, 157(1), 121-141.

Makki K., Deehan E. C., Walter J., and Backhed F. (2018). The impact of dietary fiber on gut microbiota in host health and disease. Cell Host & Microbe, 23(6), 705-715.

Gibson G. R., Hutkins R., Sanders M. E., Prescott S. L., Reimer R. A., Salminen S. J., Scott K., Stanton C., Swanson K. S., Cani P. D., Verbeke K., and Reid, G. (2017). Expert consensus document: The International Scientific Association for Probiotics and Prebiotics (ISAPP) consensus statement on the definition and scope of prebiotics. Nature Reviews Gastroenterology & Hepatology, 14(8), 491-502.

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