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Review Article

Gut microbiota and human health: The role of nutrition in shaping a flourishing microbiome

Juhi Aggarwal[1], Luna Sinha[1], Urvashi Midha[1]*

[1]Dept. of Biochemistry, Santosh Medical College, SDTU Ghaziabad, India.

Abstract

The human gut microbiota is essential for preserving health because it affects immunological responses, brain function, metabolic activities, and pathogen defence. Recent developments in the study of the microbiome have brought attention to the dynamic interplay between microbial makeup and food, indicating that nutrition plays a significant role in regulating gut health. Examining how particular nutrients—such as dietary fibre, polyphenols, prebiotics, and fermented foods—promote microbial diversity and stability, this review delves into the complex interaction between dietary patterns and the gut microbiome. On the other hand, westernized diets that are low in fibre and heavy in saturated fats and refined sugars are linked to inflammation, dysbiosis, and an increased risk of non-communicable diseases like diabetes, obesity, cardiovascular disease, and certain types of cancer.

We summarize results from preclinical and clinical research to show how dietary changes might change the composition of the microbiome to be more advantageous. The review also takes into account the impact of tailored nutrition, dietary requirements particular to each stage of life, and new approaches like microbiome-directed foods and synbiotics. The gut-brain axis and the possibility of diets that target the microbiota in the management of mental health and neurodegenerative diseases are given particular attention.

This study emphasizes the significance of integrative dietary approaches in fostering long-term health by stressing the reciprocal and adjustable nature of the diet-microbiome connection. Gaining insight into how diet affects gut microbiota opens up exciting possibilities for tailored nutrition plans and preventative healthcare that aims to preserve and restore microbial equilibrium.

Keywords: Gut microbiota, Human health, Nutrition, Microbiome diversity, Dietary fibre, Fermented foods

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1. Introduction

The human gut possesses millions of microbes that define a complex microbial community. The gut microbiota has been characterized as a vital organ forming its multidirectional connecting axis with other organs. This gut microbiota axis is responsible for host-microbe interactions and works by communicating with the neural, endocrinal, humoral, immunological, and metabolic pathways. The human gut microorganisms (mostly non-pathogenic) have symbiotic host relationships and are usually associated with the host's immunity to defend against pathogenic invasion. The dysbiosis of the gut microbiota is therefore linked to various human diseases, such as anxiety, depression, hypertension, cardiovascular diseases, obesity, diabetes, inflammatory bowel disease, and cancer. The mechanism leading to the disease development has a crucial correlation with gut microbiota, metabolic products, and host immune response in humans. The understanding of mechanisms over gut microbiota exerts its positive or harmful impacts remains largely undefined. However, many recent clinical studies conducted worldwide are demonstrating the relation of specific microbial species and eubiosis in health and disease.[1]

*Corresponding author: Urvashi Midha
Email: urvashimidha28@gmail.com

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2. Discussion

2.1. Role of gut microbiota in digestion and nutrient absorption

The gut microbiota plays a crucial role in both digestion and nutrient absorption. It helps break down complex carbohydrates and fibre's that humans can't digest on their own, producing short-chain fatty acids (SCFAs) which are a primary energy source for colonocytes. Additionally, gut microbes aid in synthesizing certain vitamins (B1, B9, B12, K) and can even influence mineral absorption and metabolism.

1. Digestion of complex molecules: Gut bacteria possess enzymes that can break down dietary fibre's, such as cellulose, inulin, and resistant starch, which humans lack the necessary enzymes for. This fermentation process generates SCFAs, which are beneficial for gut health and energy metabolism.
2. Vitamin synthesis: Many gut bacteria synthesize essential vitamins, including B1, B9, B12, and K, which are crucial for various bodily functions.
3. Mineral absorption: Influences mineral metabolism by directly affecting mineral absorption and by producing enzymes that release minerals from food.
4. Regulation of digestion: Gut bacteria can modulate bile acid deconjugation, which can impact the digestion of lipids and absorption of fat-soluble vitamins.
5. Metabolic interplay: SCFAs, produced by gut bacteria, can be used as an energy source, influence glucose and energy homeostasis, and even have anti-cancer effects in the colon.
6. Immune system: The gut microbiota interacts with the immune system, helping to train it to distinguish between beneficial and harmful microbes.
7. Nervous system: Gut microbes can influence the nervous system through the gut-brain axis, affecting neurotransmitter production and overall brain function.
8. Endocrine system: Gut microbes and their metabolites interact with endocrine cells in the gut lining, potentially influencing various metabolic processes.[2]

3. Role of gut microbiota in Immune System Development and Function:

It plays a crucial role in the development and function of the immune system. It actively influences the immune system by shaping the maturation of immune cells, particularly in the gut, and by modulating immune responses. The gut microbiota also helps to maintain intestinal homeostasis, preventing overgrowth of pathogens and contributing to overall health.

1. Immune Cell Maturation:
2. Stimulating Immune Responses:
3. Maintaining Intestinal Homeostasis:
4. Preventing Pathogen Colonization:
5. Producing Metabolites:
6. Cross-talk with Immune Cells:

The gut microbiota is not just a collection of microbes in the gut; it is a crucial partner in shaping the development and function of the immune system, maintaining intestinal health, and influencing a wide range of diseases[3]

3.1. Diet and gut microbiome

Our diet's food components give our bodies the nutrition they need, but they also serve as substrates for the gut microbiome—the mutualistic microbial flora that lives in our gastrointestinal tract. A wide variety of metabolites are produced by the metabolism of undigested dietary components. Therefore, the structure, makeup, and function of the gut microbiome—which interacts with the mucosal immune system and gut epithelium to maintain intestinal homeostasis in a healthy state—are shaped by the food we eat. Numerous illnesses, including inflammatory bowel disease (IBD), are linked to changes in the gut microbiota. Few studies have examined gut physiology, despite the current boom in research on the impact of nutrition on the compositional shifts in the gut microbiota.

Nutrition plays a crucial role in shaping the composition and function of the gut microbiome, impacting overall health. A balanced diet, rich in diverse foods, supports a healthy microbiome, while unbalanced diets can lead to dysbiosis and related health issues. Understanding the impact of dietary choices on the gut microbiome is essential for promoting gut health and preventing diseases.[4]

3.2. Dietary fiber

A diet rich in dietary fibre, found in fruits, vegetables, and whole grains, is crucial for a thriving gut microbiome. Fiber serves as a food source for beneficial bacteria, promoting their growth and diversity.[5]

3.3. Probiotics and prebiotics

Probiotics (live microorganisms that provide health benefits) and prebiotics (non-digestible carbohydrates that act as food for beneficial bacteria) can be incorporated into the diet to support a healthy microbiome.

3.4. Dietary fats

Specific types of dietary fats, such as omega-3 polyunsaturated fatty acids (PUFAs), can positively influence gut microbiome composition and function.[6]

3.5. Dietary protein

A diet with a balance of plant and animal proteins can influence the gut microbiome. A diet rich in animal proteins, especially red meat and dairy, may increase the abundance of certain bacteria, like Bacteroides, that produce TMAO, a compound linked to cardiovascular disease.

4. Dietary Shifts and Dysbiosis

Dietary changes, such as a shift to a Western diet high in processed foods, fats, and sugars, can lead to dysbiosis (imbalance of the gut microbiome) and related health issues like leaky gut and chronic inflammation.[7]

5. Metabolites and Host-Microbe Interactions

The gut microbiome produces metabolites from ingested food, which can impact host health. These metabolites can influence the interaction between the gut microbiome, the gut epithelium, and the mucosal immune system.

5.1. Diet patterns influence gut microbiome

Dietary patterns significantly shape the gut microbiome by influencing the types and abundance of bacteria present. Specifically, diets rich in plant-based foods like fruits, vegetables, and grains, and prebiotics like those found in onions, garlic, and leeks, are associated with increased gut microbiome diversity and beneficial microbial populations. Conversely, diets high in processed foods, red meat, and refined grains are linked to reduced diversity and potentially dysbiosis, which can negatively impact health.

The type and quantity of food consumed directly impact the gut microbiome. Different bacteria thrive on different substrates, and dietary choices determine which species can colonize and persist in the gut. Diets rich in plant-based foods, particularly fibre, promote a diverse and healthy gut microbiome. Fiber serves as a food source for beneficial bacteria like Bifidobacterium and Lactobacillus, which produce beneficial metabolites like short-chain fatty acids (SCFAs) that nourish the gut lining and improve overall health. A study in 2013 surveyed that there is a beneficial role of probiotics—especially lactic acid bacteria—in managing metabolic diseases like hyperlipidaemia, diabetes, and obesity. It highlights how probiotics can reduce cholesterol levels, improve insulin sensitivity, and alter gut microbiota to prevent fat accumulation. The findings support using probiotics as a complementary or alternative approach to conventional therapies, though further research is needed to fully understand their mechanisms and efficacy.[8]

Consuming large amounts of processed foods, high in refined carbohydrates, sugar, and unhealthy fats, can disrupt the gut microbiome's balance. This can lead to a reduction in beneficial bacteria and an increase in harmful species, potentially contributing to conditions like obesity, metabolic disorders, and inflammation.

The type of food consumed also influences the metabolism of gut bacteria. For example, a high-protein diet can lead to the production of trimethylamine N-oxide (TMAO), which has been linked to an increased risk of cardiovascular disease.

Understanding the impact of diet on the gut microbiome allows for targeted dietary interventions to promote gut health. For example, incorporating more plant-based foods, fermented foods (like yogurt), and prebiotics can help to restore balance and diversity in the gut microbiome.

6. Nutrition and Shaping a Flourishing Microbiome

Although it is one of the most importa*n*t variables that might affect gut microbiota and human health, patient reactions to dietary changes vary greatly. Recent data that suggests the baseline intestinal microbiota as a predictor of weight loss effectiveness in individuals on a calorie restriction diet reinforces the need for a customized nutritional intervention. Although the characteristics of the microbiome linked to weight loss currently differ throughout studies and need further investigation, this association may have a significant influence on therapeutic practice.

In addition to family genes, environment, and medication use, diet plays a large role in determining what kinds of microbiota live in the colon. All of these factors create a unique microbiome from person to person. A high-fibre diet in particular affects the type and amount of microbiota in the intestines. Dietary fibre can only be broken down and fermented by enzymes from microbiota living in the colon. Short chain fatty acids (SCFA) are released as a result of fermentation. This lowers the pH of the colon, which in turn determines the type of microbiota present that would survive in this acidic environment. The lower pH limits the growth of some harmful bacteria like Clostridium difficile. Growing research on SCFA explores their wide-ranging effects on health, including stimulating immune cell activity and maintaining normal blood levels of glucose and cholesterol.[9]

6.1. Future directions

Western-type diet, low in dietary fibre's, lacks consequently microbiota-accessible carbohydrates (MACs), known to have an important impact on the host's physiology. Tomioka et al. have shown that two different MACs, l -arabinose, and sucrose can act cooperatively on specific bacteria, such as Bacteroides, in order to suppress diet-induced obesity, modulate host's metabolic functions and short-chain fatty acid production. Moreover, their observations suggest that each MAC can have a specific action on gut microbes, potentially allowing the use of these carbohydrates as precise modulators of gut microbiota.[10]

Another important therapeutic approach for gut microbiota modulation is fecal microbiota transplantation (FMT), and recent studies show that the combination of two strategies, diet, and FMT, could lead to interesting results. Kedia et al. observed that in patients with mild-moderate ulcerative colitis, FMT combined with an anti-inflammatory diet was superior to the optimized standard medical therapy in inducing clinical and deep remission at 8 weeks. Moreover, the prosecution of the anti-inflammatory diet was more effective than the optimized standard medical therapy in maintaining deep remission until 48 weeks. The combination of faecal microbiota transplantation with low-fermentable fibre supplementation has been employed also in patients affected by metabolic syndrome and severe obesity, improving insulin sensitivity.[11]

7. Conclusion

In summary, nutrition and diet is a key driver of gut microbiome health, influencing its composition, function, and interaction with the host's immune system. By adopting a balanced diet rich in diverse foods, including fibre, probiotics, and prebiotics, individuals can support a healthy gut microbiome and promote overall well-being.

The gut microbiota has emerged as a key regulator of host physiology, influencing metabolic homeostasis, immune function, neuroendocrine signalling, and barrier integrity. Among the various environmental factors shaping microbial composition and function, nutrition exerts a predominant and modifiable influence. Diets enriched in microbiota-accessible carbohydrates, polyphenols, omega-3 fatty acids, and fermented substrates promote taxonomic diversity and the proliferation of beneficial commensals, particularly short-chain fatty acid (SCFA)-producing taxa such as *Faecalibacterium prausnitzii* and *Bifidobacterium* species. In contrast, high-fat, high-sugar Western diets are associated with reduced microbial diversity, an overrepresentation of pro-inflammatory pathobionts, and dysregulated host-microbe interactions, contributing to the pathogenesis of metabolic syndrome, inflammatory bowel disease, and other non-communicable disorders.

This review underscores the mechanistic pathways through which diet-microbiota interactions influence host health, including modulation of immune responses, gut-brain communication, and epigenetic regulation. It further highlights emerging nutritional strategies—such as precision prebiotics, synbiotics, and microbiota-directed foods—as therapeutic avenues for restoring eubiosis and mitigating disease risk.

Advancing our understanding of the diet–microbiome–host axis requires interdisciplinary approaches combining metagenomics, metabolomics, and controlled human intervention studies. Moving forward, personalized nutrition grounded in microbiome science holds significant promise for optimizing health outcomes and developing next-generation dietary interventions tailored to individual microbial and metabolic profiles. Conversely, alternative nutritional approaches have arisen aimed at treating or preventing diseases; however, their impact on the gut microbiota and metabolome must be considered, since they may induce dysbiosis or adversely affect patients if not properly selected.

8. Source of Funding

None.

9. Conflict of Interest

None.

References

1. Hou K, Wu ZX, Chen XY. Microbiota in health and diseases. *Sig Transduct Target Ther*. 2022;7:135 .
2. Valdes A M, Walter J, Segal E, Spector T D. Role of the gut microbiota in nutrition and health *BMJ* 2018;361:k2179.
3. Li Z, Xiong W, Liang Z. Critical role of the gut microbiota in immune responses and cancer immunotherapy. *J Hematol Oncol*. 2024;17(1):33.
4. Zhang P. Influence of Foods and Nutrition on the Gut Microbiome and Implications for Intestinal Health. *Int J Mol Sci*. 2022;23(17):9588.
5. Ayokunle OlubodeAdemosun, Olufunke Florence Ajeigbe, Mary Tosin Ademosun, Omodesola Oluwafisayo Ogunruku, Ganiyu Oboh,Improving gut microbiome through diet rich in dietary fibre and polyphenols: The case for orange peels, *Hum Nutr Metab*. 2005;39:,200295.
6. Czaja J, Sokal-Dembowska S, Filip A. Effects of Selected Food Additives on the Gut Microbiome and Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD). *Medicina*. 2025;61:192.
7. Giuseppe A, Rufián Henares José Ángel, Lauria Fabio, Personalized nutrition and gut microbiota: current and future directions Frontiers in Nutrition 2024;11:2296-861.
8. Aggarwal J, Swami G, Kumar M. Probiotics and their Effects on Metabolic Diseases: An Update. *J Clin Diagn Res*. 2013;7(1):173-7.
9. den Besten G, Van Eunen K, Groen AK, Venema K, Reijngoud DJ, Barbara M Bakker BM. The role of short-chain fatty acids in the interplay between diet, gut microbiota, and host energy metabolism. *J Lipid Res*. 2013;54(9):2325–40.
10. Tomioka S, Seki N, Sugiura Y, Akiyama M, Uchiyama J, Yamaguchi G. Cooperative action of gut-microbiota-accessible carbohydrates improves host metabolic function. *Cell Rep*. 2022;40(3):111087.
11. Kedia S, Virmani S, Bajaj A, Markandey M, Singh N, Madan D, Ahuja V. Coconut water induces clinical remission in mild to moderate ulcerative colitis: Double-blind placebo-controlled trial. Clinical Gastroenterology and Hepatology: *Official Clin Pract J Am Gastroenterol Assoc*, 2024;22(6):1295-306.

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