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Research Article

Gut Microbiota, Nutraceuticals, and Human Physiology: Scientific Evidence, Consumer Protection Laws, and Regulatory Perspectives: A Narrative Review

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Abstract

The human intestinal microbiota is a diverse community of microorganisms that has established itself as being crucial for human health and the course of various diseases. Growing evidence indicates that microorganisms in the human gut contribute to host physiological processes, including digestion, metabolism and immune responses as well as neurophysiological processes. Meanwhile, nutraceuticals are of great interest due to their demonstrated ability to influence and promote health through interaction with the intestinal microbiota.

Nutraceuticals such as prebiotics, probiotics, synbiotics and postbiotics, as well as functional foods, have become a burgeoning product sector in the recent decade, and increased attention on product quality, security, potency and marketing claims has been attracted, as well as regulatory control and consumer protection laws. This narrative review seeks to discuss interactions between gut microbiota, nutraceuticals and human physiology, and evaluate scientific evidence and application of nutraceuticals along with their consumer protection legislation and regulatory structure in different countries.

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1. INTRODUCTION

There are trillions of microorganisms in the human gastrointestinal tract, known as the gut microbiota. This is an umbrella term referring to a number of micro-organisms, including bacteria, archaea, viruses and fungi, living in a symbiotic relationship with their host. It has been due to modern molecular biology techniques and next generation sequencing technology that we now have a new appreciation of the complex and integral role of the gut microbiota in human physiology.

In recent years the use of nutraceuticals has increased rapidly due to their proposed beneficial effects on human health and in the prevention of disease. Nutraceuticals can be broadly defined as food-based products which have medicinal or health benefits outside the scope of the normally anticipated nutrition. Probiotics, prebiotics, dietary fibres, omega-3 fatty acids, polyphenols, vitamins, minerals and herbal supplements fall into this category, among others.²

There has been growing interest in the relationship between gut microbiota and nutraceuticals. Nutraceuticals can have positive effects on the overall microbial composition, structure and metabolism. On the other hand, microbes can influence the host physiology as well as the metabolism and bioavailability of nutraceutical compounds. These interactions have impacts on metabolism, immune status, cardiovascular function, psychological well-being and chronic disease prevention.

Despite the rise of nutraceutical use, regulation in most countries varies considerably. The problem of misleading claims on health benefits, lack of robust evidence for efficacy, adulteration and consumer safety is causing regulatory authorities to become more cautious about how nutraceuticals are presented. This review article aims to explore the scientific, physiological and legal aspects of gut microbiota-targeted nutraceuticals.⁶

Gut Microbiota and Human Physiology

Gut microbes

~100 trillion in number, the major phyla present in the gut are Firmicutes and Bacteroidetes. They have a variety of physiological functions crucial for human well being.³

Digestive Functions

Gut microbes ferment and break down the indigestible complex carbohydrates that cannot be fermented by human enzymes, producing short chain fatty acids such as acetate, propionate, and butyrate, all of which are energy substrates for the colonocytes.⁴

Metabolic Regulation

It influences food energy extraction, glucose and lipid metabolism, as well as body weight. It is known that microbiota

Immune System Modulation

70% of immune cells of the human body are in the gut; gut microbes modulate the immune system by stimulating the intestinal epithelium and immune cells within. They can mediate the development of immune tolerance, whereas dysbiosis could mediate autoimmune diseases and inflammation.⁸

Gut-Brain Axis

The gut microbiota has a two-way cross talk between the brain (Gut-Brain Axis) through neuronal, hormonal and immune systems. This interaction has an influence on the cognitive, behavior and mood responses. Increasing evidence indicates the association between gut dysbiosis with anxiety, depression and other neurodegenerative diseases.⁶

Cardiovascular and Endocrine Regulation

Produced microbial metabolites affect blood pressure regulation, as well as the control of lipid profile, endothelial function and hormone production.¹²

Nutraceuticals and Their Classification

Nutritional products also include a whole range of products, which have elements of nutrition and some which are in the realm of the medicine.²⁵

Probiotics

Probiotics are live microbiota that provide health benefits when present in sufficient quantities. They include species such as Lactobacillus, Bifidobacterium, Saccharomyces and Streptococcus. They do this through improved balance of microbes in the gut and improved immune response.¹

Prebiotics

Prebiotics are non-digestible food components that beneficially affect the host by selectively stimulating the growth and activity of one or a limited number of bacteria in the colon. Examples are inulin, fructooligosaccharides and galactooligosaccharides.²

Synbiotics

Synbiotics consist of both probiotics and prebiotics used together. They are intended to be synergistic and provide for enhanced survival and colonization of bacteria within the gastrointestinal tract.¹⁶

Postbiotics

They are known as postbiotics are defined as preparation of inanimate microorganisms and/or their components that confer a health benefit on the host. They contain inactivated microbial cells (cell fractions) and/or their components that provide health benefits. Postbiotics-comprise bioactive compounds produced by the microorganisms during fermentation such as;-- Enzymes,Peptides,Cell wall fragments,Metabolites.¹⁰

Functional Foods

Functional foods deliver health improvements not achievable with traditional nutrients. Such foods include yogurt, and fermented foods. Other functional foods include fortified cereal and bioactive-enriched foods.²⁵

Influence of Nutraceuticals on Gut Microbiota

Nutraceuticals have been observed to modulate the gut microbiota composition and metabolic activity in several ways. Probiotic supplementation has shown an enhancement in beneficial bacterial communities as well as potential inhibiting effects on pathogenic bacteria via competition exclusion and production of inhibitory compounds. Prebiotics provide readily available substrates that benefit the beneficial gut bacteria, contributing to a more diverse community and higher SCFA production.

Polyphenols found in many food sources including berries, tea, cocoa, grapes etc. Readily interact with the gut bacteria. These polyphenols are transformed into more biologically available forms via the gut bacteria which can be beneficial for their anti-oxidant and anti-inflammatory potential.

Dietary fibres lead to enhanced populations of beneficial bacteria and a more robust intestinal barrier. Furthermore omega-3 fatty acids have shown to alter the gut bacteria as well as inflammation.

The net effect of nutraceutical supplementation is enhanced digestive function and improved immune function as well as potentially reducing the risk of chronic disease.

Scientific Evidence Supporting Gut Microbiota-Targeted Nutraceuticals

Scientific evidence increasingly suggests nutraceuticals that influence the gut microbiota could have therapeutic effects.⁸

Gastrointestinal disorders

Probiotics have been shown to be beneficial in antibiotic-associated diarrhea, irritable bowel syndrome, inflammatory bowel disease, and in specific cases of infections affecting the gut. Several studies report better control of symptoms and reestablishment of normal microbiota composition.⁸

Metabolic diseases

The results of some research suggest that certain probiotic and prebiotic interventions could enhance insulin sensitivity, glycemic control and lipid profiles. The potential role of nutraceuticals in treating obesity and type 2 diabetes can therefore be envisioned.¹²

Immune health

The mucosally-mediated immune response can be enhanced by nutraceuticals, along with their influence on inflammatory pathways. It is known that certain probiotics could decrease the prevalence of respiratory tract infections and improve the immune response.²³

Mental health

The term psychobiotics, the class of probiotics targeting mental health, has been defined, and promising results were observed. Some studies demonstrate an improvement in both anxiety and depressive states through modulating the gut-brain axis.⁶

Cardiovascular health

The effects on cardiovascular outcome observed for dietary fibers, probiotics and plant-derived bioactive compounds, are mainly related to reduction of serum cholesterol level, inflammation and oxidative stress.

Despite promising research findings that are consistently being generated, some variability in clinical trial design, probiotic strain selection, administration protocol and evaluated outcomes indicates that controlled clinical trials with rigorous standardization are required.¹²

Safety Concerns and Challenges

In spite of its beneficial safety profile, nutraceuticals can be hazardous.¹⁷

Product Quality

Manufacturing may lead to varying product quality and potency. It is possible some products contain lower concentration of active compounds than what is described on their label.¹⁸

Contamination

Some nutraceutical products contain traces of microbes, heavy metals, pesticides or adulterants that can be deleterious.¹⁸

Misleading Health Claims

Claims on disease prevention and treatment made by various products in this category often overestimate actual benefits and may lead people to choose nutraceuticals over well-tested therapeutic regimens.²⁰

Vulnerable populations

Certain probiotics may be dangerous to immunocompromised, elderly and critically ill patients. This has to be seriously considered when making recommendations.²³

Growing Popularity Creates Need for Regulations:

India

Nutraceuticals in India are regulated by Food Safety and Standards Authority of India (FSSAI). The Food Safety and Standards Act lays down regulations regarding composition of the food, quality standards, label and packaging, labeling and health claims permitted.¹⁸

A manufacturer is also accountable to see to it that the ingredients, labelling information and advertisement does not misrepresent fact or is not misleading. Misleading

advertisements are governed by consumer protection act and legal action can be taken if it is so.

United States

Nutraceuticals are mainly categorized under Dietary Supplement in the USA under Dietary Supplement Health and Education Act (DSHEA) regulations. Manufacturers are considered to be responsible for product safety even before product introduction to the market. The product safety will be checked by the Food and Drug Administration (FDA) once launched in the market if it includes harmful ingredients or misleading claims.¹⁹

European Union

In the European Union there are stringent regulations with respect to health claims. Health claim approvals require validation and assessment of all relevant scientific evidence for claims by the European Food Safety Authority (EFSA).²⁰

International Challenges

Diverse definition, classification of product in different regions and variation in quality checks makes global marketing difficult for many manufacturers. So far, harmonization of these diverse global regulations for nutraceuticals, as for other food supplements is a challenge.²⁰

Digital Marketing and Consumer Protection

Social media and digital marketing have changed nutraceutical advertising dramatically. Most advertisements online are likely to mention possible benefits while omitting limitations and possible risks. Personalities other than medical doctors could also recommend a product without any strong scientific basis to do so. Health authorities are more and more aware of misleading advertisements and claims on digital platforms.²⁰

Future Directions

Additional studies need to be developed that apply the concept of personalized nutrition or precision medicine in response to an individual's microbiome profile. Technology to profile the human microbiome may contribute to developing personalised nutraceutical approaches.²⁴

AI and machine learning may be useful in detecting microbial signatures of risk for certain diseases or responses to therapy. The next generation of probiotics and microbe-based therapeutics represents a potential avenue of research.²⁴ Stronger quality control, increased post-market surveillance and international consensus development for regulation should also be considered. Further collaboration of scientists, clinicians, industrial partners and policymakers will enable responsible innovation in the nutraceutical industry.²⁰

CONCLUSION

The gut microbiota is one of the key factors regulating overall human health and can affect different systems such as the digestive system, metabolism, immune system and neuro-

behavioural activity. The usage of nutraceuticals, such as probiotics, prebiotics, synbiotics and functional food, represents promising applications to influence the gut microbiota and the human physiology. The efficiency of nutraceuticals, which support health across various physiological systems, is already well supported by scientific literature but higher quality and further research is necessary to clearly indicate guidelines and clinical use.

The market of nutraceuticals, in constant expansion, will require increasing attention on quality, scientifically based formulation, and public health protection, the consumer need must be met through adequate legal framework and regulation to guarantee against health fraud. Further research and development will bring together advances from microbiology, physiology and regulatory sciences for future applications in healthcare.⁵

Author Contributions

All authors conceived of the article, reviewed the literature, wrote the manuscript, and approved the final draft. The manuscript has been reviewed and approved by all authors.

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Conflict of Interest

The authors indicate no conflicts of interest in the writing of this article.

Ethical Approval

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REFERENCES

1. Hill C, Guarner F, Reid G, Gibson GR, Merenstein DJ, Pot B, et al. Expert consensus document: The International Scientific Association for Probiotics and Prebiotics consensus statement on the scope and appropriate use of the term probiotic. *Nat Rev Gastroenterol Hepatol.* 2014;11(8):506-514.
2. Gibson GR, Hutkins R, Sanders ME, Prescott SL, Reimer RA, Salminen SJ, et al. Expert consensus document: The International Scientific Association for Probiotics and Prebiotics consensus statement on the definition and scope of prebiotics. *Nat Rev Gastroenterol Hepatol.* 2017;14(8):491-502.
3. Thursby E, Juge N. Introduction to the human gut microbiota. *Biochem J.* 2017;474(11):1823-1836.

4. Valdes AM, Walter J, Segal E, Spector TD. Role of the gut microbiota in nutrition and health. *BMJ*. 2018;361:k2179.
5. Kho ZY, Lal SK. The human gut microbiome: A potential controller of wellness and disease. *Front Microbiol*. 2018;9:1835.
6. Cryan JF, O'Riordan KJ, Cowan CSM, Sandhu KV, Bastiaanssen TFS, Boehme M, et al. The microbiota-gut-brain axis. *Physiol Rev*. 2019;99(4):1877-2013.
7. Rinninella E, Raoul P, Cintoni M, Franceschi F, Miggiano GAD, Gasbarrini A, et al. What is the healthy gut microbiota composition? A changing ecosystem across age, environment, diet, and diseases. *Microorganisms*. 2019;7(1):14.
8. Sanders ME, Merenstein DJ, Reid G, Gibson GR, Rastall RA. Probiotics and prebiotics in intestinal health and disease. *Gastroenterology*. 2019;156(1):46-59.
9. Marco ML, Sanders ME, Gänzle M, Arrieta MC, Cotter PD, De Vuyst L, et al. The International Scientific Association for Probiotics and Prebiotics statement on fermented foods. *Nat Rev Gastroenterol Hepatol*. 2021;18(3):196-208.
10. Aguilar-Toalá JE, Arioli S, Behare P, Belzer C, Berni Canani R, Chatel JM, et al. Postbiotics: An evolving term within the functional foods field. *Trends Food Sci Technol*. 2021;108:389-397.
11. Cani PD. Human gut microbiome: Hopes, threats and promises. *Gut*. 2018;67(9):1716-1725.
12. Fan Y, Pedersen O. Gut microbiota in human metabolic health and disease. *Nat Rev Microbiol*. 2021;19(1):55-71.
13. Lynch SV, Pedersen O. The human intestinal microbiome in health and disease. *N Engl J Med*. 2016;375(24):2369-2379.
14. Shreiner AB, Kao JY, Young VB. The gut microbiome in health and disease. *Curr Opin Gastroenterol*. 2015;31(1):69-75.
15. Singh RK, Chang HW, Yan D, Lee KM, Ucmak D, Wong K, et al. Influence of diet on the gut microbiome and implications for human health. *J Transl Med*. 2017;15:73.
16. Swanson KS, Gibson GR, Hutkins R, Reimer RA, Reid G, Verbeke K, et al. The International Scientific Association for Probiotics and Prebiotics definition of synbiotics. *Nat Rev Gastroenterol Hepatol*. 2020;17(11):687-701.
17. Markowiak P, Śliżewska K. Effects of probiotics, prebiotics, and synbiotics on human health. *Nutrients*. 2017;9(9):1021.
18. Food Safety and Standards Authority of India. *Food Safety and Standards (Health Supplements, Nutraceuticals, Food for Special Dietary Use, Food for Special Medical Purpose, Functional Food and Novel Food) Regulations, 2022*. New Delhi: FSSAI; 2022.
19. U.S. Food and Drug Administration. *Dietary Supplement Health and Education Act of 1994 (DSHEA)*. Silver Spring (MD): FDA; 1994.
20. European Food Safety Authority. Scientific and technical guidance for the preparation and presentation of applications for authorization of health claims. *EFSA J*. 2021;19(1):6554.
21. Pandey KR, Naik SR, Vakil BV. Probiotics, prebiotics and synbiotics: A review. *J Food Sci Technol*. 2015;52(12):7577-7587.
22. Sivamaruthi BS, Kesika P, Chaiyasut C. A review on role of microbiome in obesity and anti-obesity properties of probiotic supplements. *Biomed Pharmacother*. 2019;114:108822.
23. Hemarajata P, Versalovic J. Effects of probiotics on gut microbiota: Mechanisms of intestinal immunomodulation and neuromodulation. *Ther Adv Gastroenterol*. 2013;6(1):39-51.
24. O'Toole PW, Marchesi JR, Hill C. Next-generation probiotics: The spectrum from probiotics to live biotherapeutics. *Nat Microbiol*. 2017;2:17057.
25. Cencic A, Chingwaru W. The role of functional foods, nutraceuticals, and food supplements in intestinal health. *Nutrients*. 2010;2(6):611-625.

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