REVIEW ARTICLE

Probiotics in Integrative Medicine: Bridging the Gap Between Traditional and Modern Approaches

Bhavani Sowndharya Balamurugan,[1] Mathan Muthu Chinnakannu Marimuthu,[1] Saravanan Anbalagan,[1] Vickram Agaram Sundaram,[1] Shivani Chopra[1]

1. Department of Biotechnology, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Chennai, Tamilnadu, India.

Citation:
Belamurugan BS, Chinnakannu Marimuthu MM, Anbalagan S, Agaram Sundaram V, Chopra S. Probiotics in integrative medicine: bridging the gap between traditional and modern approaches. Scr Med. 2025 May-Jun;56(3):537-46.

Corresponding author:
VICKRAM A S
E: vickramas.sse@saveetha.com

Abstract

As a transformational gateway between traditional and modern approaches within the field of integrative medicine, this review article investigates the incorporation of probiotics into healthcare procedures. The research traces the historical origins of probiotics in fermented foods and traditional medicines and explains how they evolved to be used in modern applications, demonstrating the dynamic continuity of knowledge. Mechanistic insights provide the scientific basis for the incorporation of probiotics into holistic healthcare methods by highlighting their considerable impacts on immunomodulation, metabolism and gut flora. The potential to combine traditional healing methods with evidence-based medicine is demonstrated via case studies and collaborative models including both contemporary practitioners and traditional healers. Probiotics' effectiveness in integrative healthcare is critically assessed in this paper, which highlights the benefits of both traditional and modern viewpoints. It emphasises the value of patient education and cultural awareness while addressing possibilities, problems and regulatory issues. Presented work supports continued investigation into the connections between probiotics, conventional medicine and traditional practices in order to further the development of patient-centred and culturally sensitive integrative healthcare approaches.

Key words: Probiotics; Gastrointestinal microbiome; Integrative medicine; Healthcare; Fermented foods.

Received: 18 September 2024
Revision received: 27 December 2024
Accepted: 30 December 2024

Introduction

People are becoming more aware that well-being is multifaceted, which is causing the healthcare sector to evolve. The review focuses on the use of probiotics in healthcare. This combines traditional and modern therapies into a single framework. Ancient medicinal traditions have existed for hundreds of years, but they are now employed alongside contemporary medicine, raising issues about how they might be combined to give better patient care.[1] Integrative medicine is a comprehensive approach that blends complementary and alternative medicine with standard techniques to manage a person's physical, mental and emotional health. This patient-centred approach strives to harmonise multiple treatments while emphasising the function of probiotics in delivering integrative medicine's goal of individualised and complete care.

Probiotics, found in fermented foods, bridge the gap between traditional and modern medicine. These microorganisms, which have long been associated with health advantages, can survive gastrointestinal transit and contribute to the gut microbiome while battling with pathogenic germs.[2] Fermented foods, which are high in bioactive chemicals produced during the fermentation process, have higher nutritional value and organoleptic features, such as cheese having a better flavour than milk. It increases the shelf life and reduces the cooking time of the finished product. For example, soybean derivatives and Ogi, a West African fermented maize dish, both illustrate fermentation. Substrate composition, management and process duration all have an impact on fermentation. The majority of fermented foods and beverages contain lactic acid bacteria.[3] *Enterococcus*, *Streptococcus*, *Leuconostoc*, *Lactobacillus* and *Pediococcus* are the five most important lactic acid bacteria genera. Other genera include *Saccharomyces* and *Penicillium* yeasts and moulds, respectively. Fermented foods, particularly milk products, have been linked to health benefits in studies; however, few dietary guidelines specifically advocate fermented foods. Probiotic effectiveness is determined by the strain's genetics, dosage, intended application and shelf life. Probiotics in food must have at least 10^6 CFU/g, with a recommended daily intake of 10^7-10^9 CFU/mg.[4] The health advantages are decided by strain specificity, as the human gastrointestinal tract contains trillions of bacteria responsible for food extraction, immunological defence and homeostasis.

The study aimed to explore the historical foundations of probiotic usage and show how they have developed into crucial elements of contemporary therapeutic approaches. Probiotics provide a scientific link between the evidence-based rigor of contemporary medical research and the experimentally verified methods of traditional medicine because of their complex mechanisms of action on the immune system, gut microbiota and metabolic pathways. The goal of the study was to present a strong case for the use of probiotics in holistic healthcare techniques by elucidating their tremendous impacts.[5] This introduction essentially lays the groundwork for an investigation of how probiotics, as agents of continuity and change, may transform the healthcare industry. Through an appreciation of the historical background, the tenets of integrative medicine and the function of probiotics in uniting the traditional and the modern, this study aimed to offer a thorough foundation for recognising the mutual benefit of various healthcare ideologies.

Evolution and prospects of fermented foods as functional foods

Probiotics are live microorganisms that help regulate the intestinal flora. Probiotics have been utilised for many thousands of years. Early people realised the advantages of fermented meals, which evolved into today's probiotic-rich goods. Fermentation is a metabolic process that transforms carbohydrates into acids and alcohols while lowering the pH to prevent spoiling. Fermentation has been around since about 6,000 BC;[6] however, its exact origin is unknown. It was utilised in ancient civilisations such as the Indus Valley, Egypt and Mesopotamia. Fermented milk products such as Laban Rayeb and Laban Khad have been around since 7,000 BC in the Fertile Crescent and Egypt, demonstrating their long-standing cultural significance. India, a country with a rich tradition, has generated around 350 types of fermented foods and beverages employing various substrates and cultures.[7] Throughout the country's north, most people eat traditional *lassi* and *dahi* (yogurt). *Lactococci* used to make mesophilic yogurt create diacetyl, which distinguishes it from other types of yogurts. Fermentables from Eastern India will be unique and diversified, with examples including Nagaland's axone-fermented soybean product and hentik-sun-dried fermented aroid plant with fish, both of which have been shown to have antibacterial, fibrinolytic and antioxidant properties.[8] Other fermented foods, such as sauerkraut, chicha and South American beer, are well-known for their health benefits worldwide. According to clinical evidence, consuming fermented foods reduces the risk of developing type 2 diabetes and cardiovascular disease. For example, fermented milk increases glucose metabolism and reduces muscle stiffness after exercise; therefore, the health benefit is direct. Figure 1 shows microbiome distribution across human organs and its impact on health and Figure 2 shows functions of probiotics on human health.

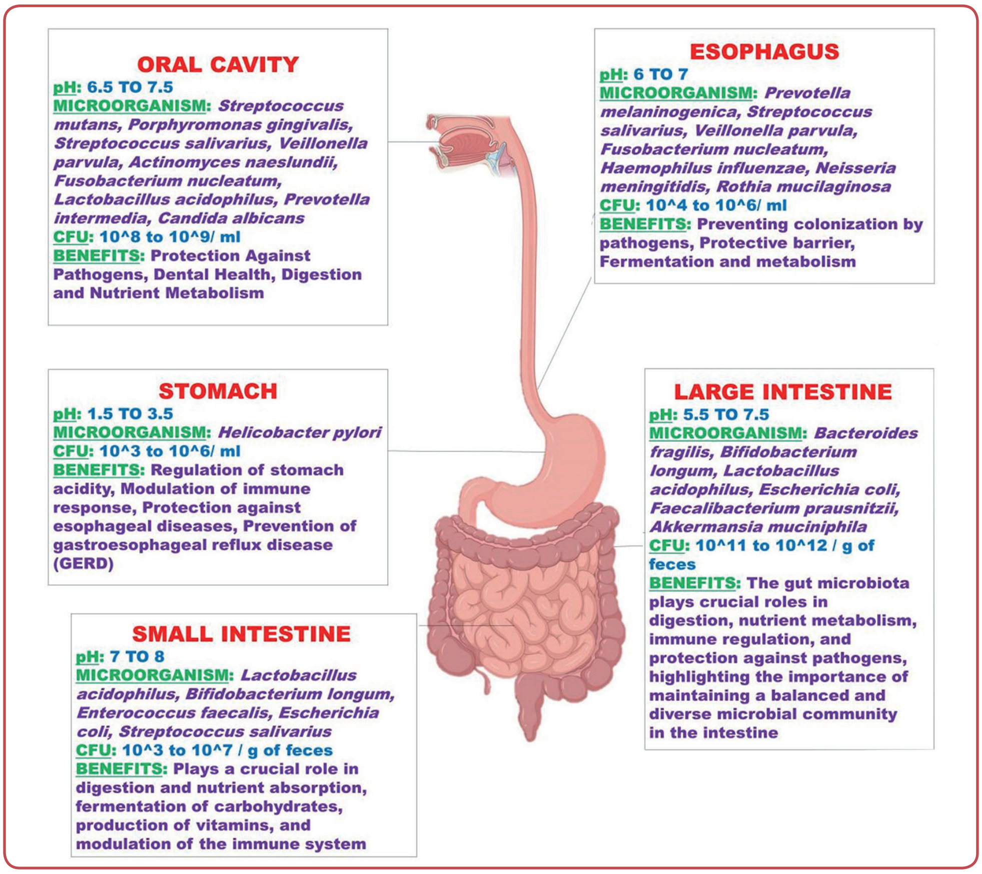

Figure 1: Microbiome distribution across human organs and its impact on health

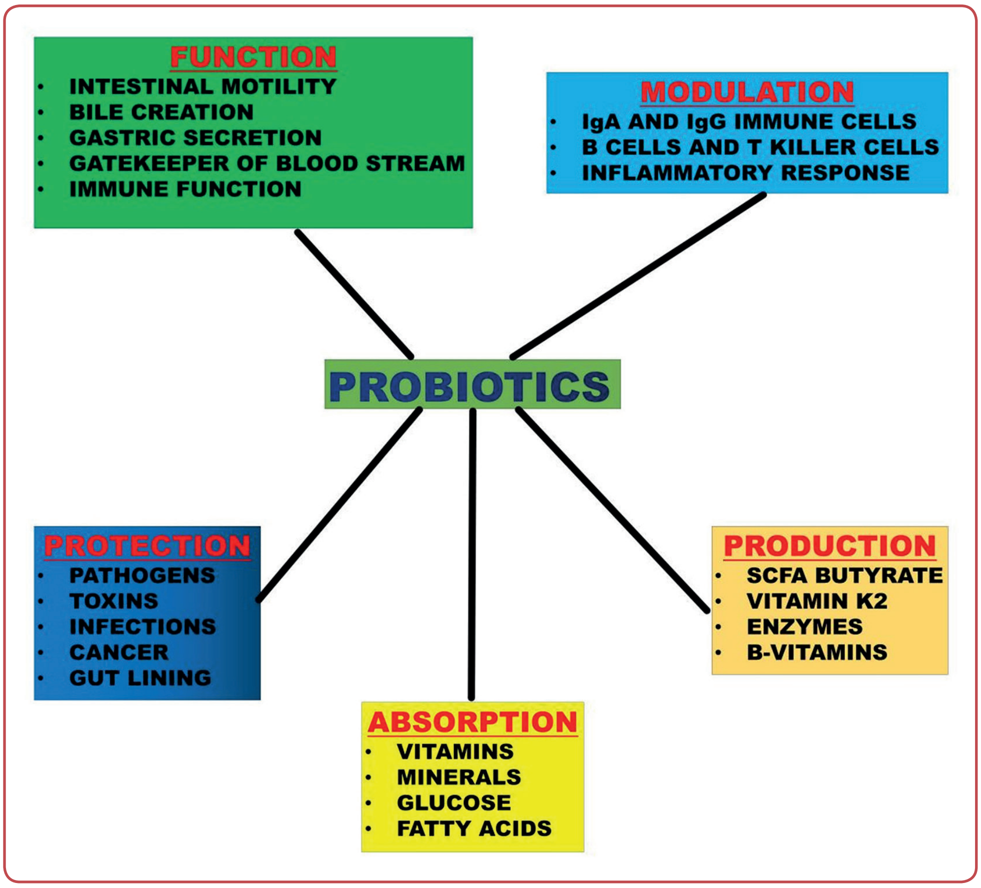

Figure 2: Functions of probiotics on human health

Traditional diets and microbiota

Traditional fermented foods, such as kimchi, kefir and tofu are linked to probiotic benefits. Metchnikoff found probiotics as early as the 1900s, citing *Lactobacillus bulgaricus* in fermented milk drank by Bulgarian peasants as a source of lifespan.[9] Many probiotics, such as lactic acid bacteria found in fruits and vegetables, may thrive in the stomach. A study of rural Japanese and Canadian people found that their diets high in fermented foods, fibre and fish increased gut bacterial diversity. The rural Japanese diets had more *Bifidobacterium* and *Lactobacilli*, but Canadians had more *Clostridia* species.[10] Sequencing investigations support these findings, linking traditional foods to lower levels of *Clostridium perfringens*. Nutrients influence microbial growth and glycans favour specific gut bacteria, influencing microbial abundance and growth rates. Rebuilding pre-industrial microbiomes is a challenging task. Research into ancient faeces (coprolites) demonstrates that traditional populations' microbiomes were as comparable to their predecessors' as their present descendants'. Spirochaetes were common in old communities but almost non-existent in industrialised ones.[11] Comparisons with great apes and traditional hunter-gatherer tribes reveal that ancestral microbiomes were more diverse and less affected by urbanisation. Industrialisation has reduced microbial diversity and altered CAZyme patterns.[12] Comparing the microbiota of Venezuelan Amerindians and Tanzanian Hadza hunter-gatherers to Western populations reveals that industrialised microbiotas are less diverse, especially in CAZymes that degrade complex plant fibres. This loss of variety is linked to decreased fibre consumption, the extinction of taxa such as *Prevotella* and an increase in mucus-degrading bacteria like *Akkermansia muciniphila*.[13, 14]

Varying effects of probiotics: application across populations

Probiotics are live bacteria that provide health advantages when provided in sufficient quantities, with effects differing depending on age, health and heredity.[15] For youngsters, some of the strains include *Bifidobacterium breve* and *Lactobacillus reuteri*, which assist in regulating gastrointestinal disorders, including diarrhoea.[16] Probiotics like *Lactobacillus rhamnosus* and *Bifidobacterium longum* improve gut health and immune function in the elderly by addressing reduced microbial diversity and increased susceptibility to infections.[17] For individuals with chronic conditions, strains such as *Lactobacillus plantarum* may reduce inflammation and improve metabolic outcomes. Proper probiotic use involves selecting the right strain, dosing (10^7-10^9 CFU/day), monitoring individual reactions and combining with prebiotics (synbiotics) for optimal gut health.[18] Probiotics have the potential to benefit a diverse population, but they must be used in an evidence-based, customised manner that supports overall healthcare goals in order to provide efficacy and safety. More relevant research details are explained in Table 1.

Table 1: Interventions of different probiotic strains to alleviate various health disorders

N	Probiotics	Intervention	Duration	Dosage	Disease/ problem associated	Outcome	References
1	*Lactobacillus salivarius* AP-32	Capsules containing these strains	6 months	8034.4 pg/mL	Type 1 diabetes mellitus	Elevated the levels of TGF-β1 in patients with T1DM	[19]
2	*Lactobacillus rhamnosus*	Obese patients	4 to 6 weeks	-	Obesity	Prevents obesity-related problems	[20]

3	*Lactobacillus plantarum PS128*	Supplements	127 months	3×10^{10} CFU – 30 kg	Autism spectrum disorder	Autism spectrum disorder Increased attention, communication skills	[21]
4	*Lactobacillus rhamnosus; Lactobacillus casei;*	Supplements	-	10^{8} to 112.5×10^{9} CFU	Auto immune disorders	Had significant effect on inflammatory markers	[22]
5	*Lactobacillus sporogenes;*	Sachet	6 months	1×10^{10} CFU	Pustular psoriasis	Ameliorating lesions	[23]
6	*Lactobacillus acidophilus;*	Capsules	12 weeks	5 billion CFU/ capsule	Acne	Decrease in lesion count	[24]
7	*Lactobacillus plantarum A7*	Probiotic soy milk	8 weeks	2×10^{7} CFU/mL	Type 2 diabetes kidney problems	Reduced glutathione concentration	[25]
8	*Lactobacillus acidophilus;*	Capsules	12 weeks	2×10^{9} CFU/g each	Diabetic haemo-dialysis patients	Improved glucose levels	[26]
9	*Lactobacillus salivarius,*	Capsules	12 weeks	3×10^{10} CFU	Type 2 diabetes mellitus	Improved glycaemic control and reduced HbA1c levels	[27]
10	*Lactobacillus casei*	Capsules	8 weeks	10^{8} CFU	Type 2 diabetes mellitus	Decreased fetuin levels	[28]
11	*Bifidobacterium sp, Lactobacilli sp*	Oral	5 days-12 weeks	5-40 billion CFU/day	Infantile gastroentities	Reduced the frequency of diarrhoea	[29]

TGF-β1: transforming growth factor beta 1; CFU: colony-forming unit; T1DM: type 1 diabetes mellitus; HbA1c: glycated haemoglobin;

Case studies in collaborative healthcare

Diet-induced variations in gut microbiota have been demonstrated in investigations including children from Burkina Faso and Italy.[30, 31] Children on plant-based diets (Burkina Faso) had more *Prevotella* and *Bacteroidetes*, but those on animal protein and saturated fat (Italy) had more *Bacteroides* and *Firmicutes*. *Prevotella* and *Xylanibacter* in Burkina Faso children's guts included fibre-digesting genes, highlighting the impact of nutrition on microbial composition.[32, 33] Similar studies have showed that a high-fat, high-carbohydrate diet causes obesity in germ-free mice. Obese patients have a *Firmicutes*-rich gut microbiota, which transforms to that of non-obese subjects after dietary adjustments or gastric bypass surgery. Such findings emphasise the significance of nutrition and lifestyle in determining gut microbiota and thus the trajectory of health and disease. Probiotics, which are well-known for their health advantages, enable the purposeful modification of gut microbial ecology.[34] However, the benefits of probiotics are frequently context-dependent, with sociocultural, regional and individual factors all influencing their effectiveness. This diversity complicates standardising their classification, safety and efficacy. Current rules frequently classify probiotics as dietary supplements rather than pharmaceuticals, with little established requirements for safety testing.[35] Advances in genetic engineering and DNA assembly have changed fermentation processes, allowing control over microbial communities *via* synthetic communication networks and metabolic pathways. However, artificial systems have the potential to reduce microbial biodiversity while degrading traditional practices—issues that necessitate the development of model systems that imitate natural evolution, including mechanisms such as selection and gene transfer.[36] Commercial probiotic therapies and their various applications in health, nutrition and disease management, emphasising their potential for gut microbiota regulation and therapeutic advantages is given in Table 2. Synbio-technologies such as CRISPR/Cas can draw microbial genes and pathways, combining indigenous biodiversity with innovation to provide fair benefit-sharing with respect to the resource, in line with Nagoya Treaty-like frameworks for conservation and resource use.[49] Ensuring that scientific innovation does not jeopardise tradition while progress continues is critical to the future of effective and sustainable advancements in the field of microbial biotechnology.

Table 2: Commercial probiotic interventions with different applications

N	Probiotic product	Brand	Probiotic strain	Dosage	Age	Intervention	Application	References
1	*Gold bifidum*	*Inner Mongolia Shuangqi Pharmaceutical* Co LTD, China	*Bifidobacterium lactobacillus*	0.5×10^7 CFU - live *Bifidobacterium longum;* live *Lactobacillus bulgaricus*	Adults	Capsules	Patients with dysentery affected by COVID-19	[37]
2	*Lepicol* probiotic and prebiotic formula	*Healthy Bowels Company Ltd,* Birmingham, UK	*Lactobacillus plantarum* (ATCC 14917)	10 g	Adults	Capsules	Non-alcoholic steatohepatitis treated with probiotics reduces liver fat	[38]
3	*Bifico*	*Sine Pharmaceutical Co, Ltd,* Shanghai, China	*B longum* NQ1501;	2.2×10^9 CFU; 0.53×10^9 CFU; 1.1×10^9 CFU	Adults	Capsules	Reduces intestinal imbalances in haemodialysis patients	[39]
4	*Hexbio*	*B-Crobes Marketing,* Malaysia	*Lactobacterium sp*	30×10^9 CFU	Adults	Sachet taken orally	Improved gut motility in Parkinson's disease	[40]
5	*Vita Biosa*	*Biosa Inc,* Hamilton, Ontario, Canada	*Bifidobacterium lactis; Bifidobacterium animalis;*	10^{10}-10^{11} CFU/g	Adults	Liquid	Potential to prevent diabetes	[41]
6	*FloraMax-B11*	*Vetanco,* Argentina	*Lactabacillus salivarius;*	100 mg/L	-	Powder	Increased gut morphology	[42]
7	*Suja* pressed probiotic waters	*Suja Organics,* California, USA	*Bacillus coagulans*	2 billion CFU	All age groups	Juice	Maintains vaginal health	[43] [44]
8	*Danone Pro Vivo*	Sweden, Finland	*Lactabacillus plantarum*	10 billion CFU	All age groups	Juice	Inhibits malate metabolism	[45] [46]
9	*Valio Gefius*	*Valio Ltd,* Finland	*Lactabacillus plantarum*	10^6 CFU/mL	All age groups	Juice	Prevents otitis media	[47]
10	*Rela*	*Biogaia,* Stockholm, Sweden	*Lactabacillus reuteri*	100 million CFU	All age groups	Juice	Improves gut health	[48]

CFU: colony-forming unit;

Global regulatory approaches and barriers to probiotic integration

The regulatory environment for probiotics varies by area, posing unique difficulties to their use in healthcare practices. In the United States, the FDA defines probiotics as dietary supplements or food additives, requiring minimum pre-market approval unless therapeutic claims are made, in which case they are classified as medicines.[50] However, this laxity results in inconsistencies in safety and efficacy requirements, as well as unregulated health claims. In contrast, the European Union takes a more stringent approach through the European Food Safety Authority (EFSA), which requires significant studies and paperwork to validate health claims for probiotics.[51] While this provides a better level of safety and efficacy, it also places major financial and time limits on manufacturers, restricting the flexibility of novel probiotic strains. These disparate regulatory methods impede global harmonisation, posing practical challenges for producers attempting to manage competing standards. Addressing these issues through uniform international rules could help probiotics gain widespread adoption while assuring both safety and creativity in their use.

Challenges and limitations

Integrating probiotics into integrative medicine highlights difficulties and potential at the junction of traditional and modern healthcare methods. To bridge the philosophical gulf between evidence-based, reductionist techniques in contemporary medicine and the holistic, culturally ingrained concepts of traditional healing, cultural sensitivity, collaborative communication and awareness of cultural dissonance in healthcare are required. More research is needed to better understand the efficacy, processes and cultural acceptance of probiotics. The research on indigenous probiotic knowledge and traditional fermentation techniques provides valuable insights into their medicinal application over generations. Ancient healing techniques and evidence-based medicine can be combined to provide culturally sensitive and equitable healthcare approaches. The most essential probiotic studies should focus on underrepresented communities and cultural impacts.

Conclusion

Probiotics can bridge the gap between traditional and modern medicine by bringing together historical knowledge, mechanisms of action, clinical data and cultural sensitivity. Patients must realise the benefits of probiotics, such as improved gut health, higher immunity and the management of metabolic problems, while also taking cultural aspects into consideration. Incorporating traditional medicine with the Western method can make healthcare more accessible, inexpensive and effective for symptom management. Probiotics must be tailored to the individual: strains and dosing must be carefully selected and patients must be referred to a doctor, particularly if they are taking other medications or have autoimmune or gastrointestinal disorders. Strains should be identified, CFU counts reported and health advantages discussed. Dosing must start low and increase as tolerance develops. To maximise safety and efficacy, use probiotics with strain-specific health effects and adjust dosage (10^7-10^9 CFU per day) based on individual tolerance. Yogurt and kefir are natural sources of probiotics. Professional assistance ensures that probiotics are used safely, effectively and personalised in healthcare.

Ethics

This study was a secondary analysis based on the currently existing data and did not directly involve with human participants or experimental animals. Therefore, the ethics approval was not required in this paper.

Acknowledgement

Authors are thankful to their parent institutions for the facilities.

Conflicts of interest

The authors declare that there is no conflict of interest.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Data access

The data that support the findings of this study are available from the corresponding author upon reasonable individual request.

Author ORCID numbers

Bhavani Sowndharya B (BSB):
0000-0001-9079-7778
Mathan Muthu C M (MMCM):
0000-0002-8427-3449
Saravanan A (SA):
0000-0002-5420-8662
Vickram A S (VAS):
0000-0003-4319-1575
Shivani Chopra (SC):
0000-0002-5890-389X

Author contributions

Conceptualisation: BSB, MMCM
Validation: SA, VAS, SC
Formal analysis:
Investigation: BSB, MMCM
Writing - original draft: BSB, MMCM
Writing - review and editing: BSB, MMCM, SA, VAS, SC
Supervision: SA, VAS, SC

References

1. Nugraha RV, Ridwansyah H, Ghozali M, Khairani AF, Atik N. Traditional herbal medicine candidates as complementary treatments for COVID-19: a review of their mechanisms, pros and cons. Evid Based Compl Alt Med. 2020;2020. doi: 10.1155/2020/2560645.
2. Leeuwendaal NK, Stanton C, O'Toole PW, Beresford TP. Fermented foods, health and the gut microbiome. Nutrients. 2022;14(7):1527. doi: 10.3390/nu14071527.
3. Urban J, Kareem KY, Atanasov AG, Matuszewski A, Bień D, Ciborowska P, et al. Postbiotics, a natural feed additive for growth performance, gut microbiota and quality of poultry products. Curr Res Biotechnol. 2024:100247. doi: 10.1016/j.crbiot.2024.100247.
4. Zheng X, Shi X, Wang B. A review on the general cheese processing technology, flavor biochemical pathways and the influence of yeasts in cheese. Front microbiol. 2021;12:703284. doi: 10.3389/fmicb.2021.703284.
5. Kumar H, Dhalaria R, Guleria S, Cimler R, Choudhary R, Dhanjal DS, et al. To exploring the role of probiotics, plant-based fermented products, and paraprobiotics as anti-inflammatory agents in promoting human health. J Agricult Food Res. 2023:100896. doi: 10.1016/j.jafr.2023.100896.
6. Harutyunyan M, Malfeito-Ferreira M. The rise of wine among ancient civilizations across the Mediterranean basin. Heritage. 2022;5(2):788-812. doi: 10.3390/heritage5020043.
7. Shan L, Park S, Barathikannan K, Chellia R, Kim D, Yang Z, Oh DH. Biopeptide-rich fermented hemp seeds: Boosting anti-inflammatory and immune responses through Lactiplantibacillus plantarum probiotic fermentation. Int J Macromol. 2024:138782. doi: 10.1016/j.ijbiomac.2024.138782.
8. Devi LS, Kumar V, Rani A, Tayalkar T, Mittal P, Anshu AK, et al. Fatty acid composition, antinutritional factors, and oligosaccharides concentration of Hawaijar (an ethnic fermented soyfood of India) as affected by genotype and Bacillus subtilis strain. Indones. Food Nutr Prog. 2020;17(2):45-50. doi: 10.22146/ifnp.58664.
9. Gebre TS, Emire SA, Aloo SO, Chelliah R, Vijayalakshmi S, Oh DH. Unveiling the potential of African fermented cereal-based beverages: Probiotics, functional drinks, health benefits and bioactive components. Food Res Int. 2024:114656. doi: 10.1016/j.foodres.2024.114656.
10. Yang Q, Liang Q, Balakrishnan B, Belobrajdic DP, Feng QJ, Zhang W. Role of dietary nutrients in the modulation of gut microbiota: a narrative review. Nutrients. 2020;12(2):381. doi: 10.3390/nu12020381
11. Thingholm LB, Bang C, Rühlemann MC, Starke A, Sicks F, Kaspari V, Jandowsky A, Frölich K, Ismer G, Bernhard A, Bombis C. Ecology impacts the decrease of Spirochaetes and Prevotella in the fecal gut microbiota of urban humans. BMC microbiology. 2021;21:1-20. doi: 10.1186/s12866-021-02337-5.
12. Vargas-Robles D, Morales N, Rodríguez I, Nieves T, Godoy-Vitorino F, Alcaraz LD, et al. Changes in the vaginal microbiota across a gradient of urbanization. Sci. Rep. 2020;10(1):12487. doi: 10.1038/s41598-020-69111-x.
13. Carter MM, Olm MR, Merrill BD, Dahan D, Tripathi S, Spencer SP, Feiqiao BY, Jain S, Neff N, Jha AR, Sonnenburg ED. Ultra-deep sequencing of Hadza hunter-gatherers recovers vanishing gut microbes. Cell. 2023.
14. Zhu D, Galbraith ED, Reyes-García V, Ciais P. Global hunter-gatherer population densities constrained by influence of seasonality on diet composition. Nature Ecol Evolut. 2021;5(11):1536-45. doi: 10.1038/s41559-021-01548-3.
15. Muthu CM, Vickram AS, Sowndharya BB, Saravanan A, Kamalesh R, Dinakarkumar Y. A comprehensive review on the utilization of probiotics in aquaculture towards sustainable shrimp farming. Fish Shellfish Immunol. 2024:109459. doi: 10.1016/j.fsi.2024.109459.
16. Bozzi Cionci N, Baffoni L, Gaggìa F, Di Gioia D. Therapeutic microbiology: the role of Bifidobacterium breve as food supplement for the prevention/treatment of

paediatric diseases. Nutrients. 2018;10(11):1723. doi: 10.3390/nu10111723.
17. Białecka-Dębek A, Granda D, Szmidt MK, Zielińska D. Gut microbiota, probiotic interventions, and cognitive function in the elderly: a review of current knowledge. Nutrients. 2021 Jul;13(8):2514. doi: 10.3390/nu13082514.
18. Fekete M, Lehoczki A, Major D, Fazekas-Pongor V, Csípő T, Tarantini S, et al. Exploring the influence of gut–brain axis modulation on cognitive health: a comprehensive review of prebiotics, probiotics, and symbiotics. Nutrients. 2024;16(6):789. doi: 10.3390/nu16060789.
19. Wang CH, Yen HR, Lu WL, Ho HH, Lin WY, Kuo YW, et al. Adjuvant probiotics of Lactobacillus salivarius subsp. salicinius AP-32, L. johnsonii MH-68, and Bifidobacterium animalis subsp. lactis CP-9 attenuate glycemic levels and inflammatory cytokines in patients with type 1 diabetes mellitus. Front. Endocrinol. 2022; 13:754401. doi: 10.3389/fendo.2022.754401.
20. Daniali M, Nikfar S, Abdollahi M. A brief overview on the use of probiotics to treat overweight and obese patients. Expert Rev. Endocrinol. Metab. 2020;15(1): 1-4. doi: 10.1080/17446651.2020.1719068.
21. Mensi MM, Rogantini C, Marchesi M, Borgatti R, Chiappedi M. Lactobacillus plantarum PS128 and other probiotics in children and adolescents with autism spectrum disorder: a real-world experience. Nutrients. 2021;13(6): 2036. doi: 10.3390/nu13062036.
22. Askari G, Ghavami A, Shahdadian F, Moravejolahkami AR. Effect of synbiotics and probiotics supplementation on autoimmune diseases: A systematic review and meta-analysis of clinical trials. Clin. Nutr. 2021;40(5):3221-34. doi: 10.1016/j.clnu.2021.02.015.
23. Vijayashankar M, Raghunath N. Pustular psoriasis responding to probiotics–A new insight. Our Dermatol Online. 2012; 3(4):326-9. doi: 10.7241/ourd.20124.71.
24. Jung GW, Tse JE, Guiha I, Rao J. Prospective, randomized, open-label trial comparing the safety, efficacy, and tolerability of an acne treatment regimen with and without a probiotic supplement and minocycline in subjects with mild to moderate acne. J Cutan Med Surg. 2013; 17(2):114-22. doi: 10.2310/7750.2012.12026.
25. AbdelQadir YH, Hamdallah A, Sibaey EA, Hussein AS, Abdelaziz M, AbdelAzim A, et al. Efficacy of probiotic supplementation in patients with diabetic nephropathy: a systematic review and meta-analysis. Clin Nutr ESPEN. 2020;40:57-67. doi: 10.1016/j.clnesp.2020.06.019.
26. Soleimani A, Mojarrad MZ, Bahmani F, Taghizadeh M, Ramezani M, Tajabadi-Ebrahimi M, et al. Probiotic supplementation in diabetic hemodialysis patients has beneficial metabolic effects. Kidney Int. 2017;91(2):435-42. doi: 10.1016/j.kint.2016.09.040.
27. Madempudi RS, Ahire JJ, Neelamraju J, Tripathi A, Nanal S. Efficacy of UB0316, a multi-strain probiotic formulation in patients with type 2 diabetes mellitus: A double blind, randomized, placebo controlled study. PLoS One. 2019 Nov 13;14(11):e0225168. doi: 10.1371/journal.pone.0225168.
28. Khalili L, Alipour B, Jafar-Abadi MA, Faraji I, Hassanalilou T, Abbasi MM, et al. The effects of Lactobacillus casei on glycemic response, serum sirtuin1 and fetuin-a levels in patients with type 2 diabetes mellitus: a randomized controlled trial. Iran. Biomed. J. 2019;23(1):68. doi: 10.29252/.23.1.68.
29. Khurshid M, Akash MS. Probiotic preparations for infantile gastroenteritis: the clinical and economic perspective. Future Microbiol. 2020;15(8):567-9. doi: 10.2217/fmb-2019-0111.
30. Dahl WJ, Mendoza DR, Lambert JM. Diet, nutrients and the microbiome. Prog Mol Biol Transl Sci. 2020;171:237-63. doi: 10.1016/bs.pmbts.2020.04.006.
31. Beam A, Clinger E, Hao L. Effect of diet and dietary components on the composition of the gut microbiota. Nutrients. 2021;13(8):2795. doi: 10.3390/nu13082795.
32. Moran-Ramos S, Lopez-Contreras BE, Villarruel-Vazquez R, Ocampo-Medina E, Macias-Kauffer L, Martinez-Medina JN, et al. Environmental and intrinsic factors shaping gut microbiota composition and diversity and its relation to metabolic health in children and early adolescents: A population-based study. Gut microbes. 2020;11(4):900-17. doi: 10.1080/19490976.2020.1712985.
33. Bezirtzoglou E, Stavropoulou E, Kantartzi K, Tsigalou C, Voidarou C, Mitropoulou G, et al. Maintaining digestive health in diabetes: the role of the gut microbiome and the challenge of functional foods. Microorganisms. 2021;9(3):516. doi: 10.3390/microorganisms9030516.
34. Gebre TS, Emire SA, Chelliah R, Aloo SO, Oh DH. Isolation, functional activity, and safety of probiotics from Ethiopian traditional cereal-based fermented beverage, "Borde". LWT. 2023;184:115076. doi: 10.1016/j.lwt.2023.115076.
35. Fusco V, Fanelli F, Chieffi D. Authenticity of probiotic foods and dietary supplements: a pivotal issue to address. Crit Rev Food Sci Nutr. 2022;62(25):6854-71. doi: 10.1080/10408398.2021.1907300.
36. Ramírez Rojas AA, Swidah R, Schindler D. Microbes of traditional fermentation processes as synthetic biology chassis to tackle future food challenges. Front Bioeng Biotechnol. 2022;10:982975. doi: 10.3389/fbioe.2022.982975.
37. Wang H, Wang Y, Lu C, Qiu L, Song X, Jia H, et al. The efficacy of probiotics in patients with severe COVID-19. Ann Palliat Med. 2021;10(12):123742380-12380. doi: 10.21037/apm-21-3373.
38. Wong VW, Wong GL, Chim AM, Chu WC, Yeung DK, Li KC, et al. Treatment of nonalcoholic steatohepatitis with probiotics. A proof-of-concept study. J Hepatol. 2013;12(2):256-62.
39. Liu S, Liu H, Chen L, Liang SS, Shi K, Meng W, et al. Effect of probiotics on the intestinal microbiota of hemodialysis patients: a randomized trial. Eur J Nutr. 2020;59:3755-66. doi: 10.1007/s00394-020-02207-2.
40. Ibrahim A, Ali RA, Manaf MR, Ahmad N, Tajurruddin FW, Qin WZ, et al. Multi-strain probiotics (Hexbio) containing MCP BCMC strains improved constipation and gut motility in Parkinson's disease: A randomised controlled trial. Plos One. 2020;15(12): e0244680. doi: 10.1371/journal.pone.0244680.
41. Aron NM. Functional beverages in health promotion, sport, and disease prevention: An overview. Sports and Energy Drink Nutrition. 2019:269-96. doi: 10.1016/B978-0-12-815851-7.00009-7.
42. Menconi A, Kallapura G, Latorre JD, Morgan MJ, Pumford NR, Hargis BM, et al. Identification and characterization of lactic acid bacteria in a commercial probiotic culture. Biosci Microbiota Food Health. 2014;33(1):25-30. doi: 10.12938/bmfh.33.25.
43. Gullo M, Zotta T. Probiotics in dairy products: microencapsulation and delivery. In Advances in Dairy Microbial Products. Sawston, England: Woodhead Publishing 2022. pp. 271-285.
44. Baroke S. Fresh opportunities for digestive health products: companies should align new development with evolving consumer needs. Nutraceuticals World. 2016;19(8):60-3.
45. Göransson M. Inhibiting malate metabolism in L. plantarum 299v by introducing lactic acid in ProViva apple drinks. Lund University 2016.

46. Trulsson V. Evaluating the behaviour of probiotic Bacillus coagulans XY1 in fruit juices and survival during heat treatment. Lund University 2020.
47. Chen TY, Hendrickx A, Stevenson DS, Bird P, Walls T. No evidence from a systematic review for the use of probiotics to prevent otitis media. Acta Paediatr. 2020;109(12):2515-24. doi: 10.1111/apa.15368.
48. Céspedes M, Cárdenas P, Staffolani M, Ciappini MC, Vinderola G. Performance in nondairy drinks of probiotic L. casei strains usually employed in dairy products. J Food Sci. 2013;78(5):M756-62. doi: 10.1111/1750-3841.12092.
49. Jeong SH, Lee HJ, Lee SJ. Recent advances in CRISPR-Cas technologies for synthetic biology. J Microbiol. 2023;61(1):13-36. doi: 10.1007/s12275-022-00005-5.
50. Garg V, Velumani D, Lin YC, Haye A. A comprehensive review of probiotic claim regulations: updates from the Asia-Pacific regions, the United States, and Europe. Pharma Nutrition. 2024:100423. doi: 10.1016/j.phanu.2024.100423.
51. Mukherjee A, Gómez-Sala B, O'Connor EM, Kenny JG, Cotter PD. Global regulatory frameworks for fermented foods: A review. Frontiers Nutr. 2022 May;9:902642. doi: 10.3389/fnut.2022.902642.