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REVIEW ARTICLE

Exploring the Path to Probiotic Wellness

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Abstract: Probiotics—whose name comes from the Greek word meaning "for life"—are live bacteria that have been shown to have health advantages. An overview of the crucial function probiotics play in preserving the microbial balance in the human body, especially in the gastrointestinal system, is given in this review. Probiotics are important for digestion, immune system activation, and pathogen resistance since the gut contains about 500 distinct bacteria species. They support a number of metabolic processes, including as the digestion of carbohydrates, and the emergence of metabolic diseases such colon cancer and inflammatory bowel disease (IBD) has been linked to their dysbiosis. Prebiotics, postbiotics, and probiotics constitute a rapidly developing field of study with enormous promise for the creation of pharmaceuticals. The review highlights their diverse applications in treating gastrointestinal and non-gastrointestinal disorders, including diarrhea, inflammatory responses, and viral infections. Despite their promising benefits, probiotics carry risks, particularly in vulnerable populations, where they may lead to systemic infections. Understanding their mechanisms of action and potential adverse effects is crucial for their safe and effective utilization. Over the past two decades, probiotics have gained recognition as medical treatments, with the food industry spearheading their incorporation into various products. The World Health Organization acknowledges probiotics as a cost-effective and safe intervention against microbial illnesses, positioning them as a secondary immune system. As research in this field advances, probiotics hold significant promise for revolutionizing healthcare practices and offering novel therapeutic strategies for a wide spectrum of diseases.

Keywords: Probiotics; Health benefits; Gut microbiota; Immunity; Dysbiosis.

1. Introduction

The Greek phrase that gives rise to the term "probiotic" means "for life" [1].Probiotics are described by the WHO as "living micro-organisms" that, when consumed in moderation, provide some health benefits [2].The probiotics market is growing worldwide as a result of consumers' increased interest in probiotics due to their improved intestinal advantages, synbiotics, and prebiotic additions, among other reasons [3]. Probiotic use improves human health and immunity. Probiotic treatment has recently improved the management and prognosis of numerous metabolic illnesses, including diabetes, IBD, obesity, and others [4-5]. Probiotics are live beneficial bacteria that eat prebiotics; postbiotics are the healthful compounds that probiotics produce. Each plays a distinct role in the symbiotic relationship with the human host and significantly contributes to the overall homeostasis of the body [6]. Some of the most well-known genera of bacteria used as probiotics are Lactobacillus, Bifidobacterium, Enterococcus, and Streptococcus, in addition to the yeast Saccharomyces cerevisiae [7]. Each probiotic has unique strains that should be taken into account in order to learn more about how injection therapy affects humans [8].One in five Americans uses probiotics for digestive problems, and the majority of probiotics are used to treat gastrointestinal disorders [9].

Numerous microorganisms are found both within and outside of the human body, and they are all around us. The gastrointestinal tract contains 500 different kinds of microorganisms, many of which are highly beneficial for digestion, immune system stimulation, and host defense against bacteria and viruses [10,11].A large array of metabolic functions are provided to the host body by the 100 trillion bacteria found in the human gut [12]. For instance, because plants lack certain enzymes, gut microorganisms are crucial to the breakdown of carbohydrates [13].Furthermore, bacteria serve a variety of significant roles in the host, but new research indicates that the dysbiosis of microorganisms is a major contributing factor to the emergence of numerous metabolic illnesses, including IBD, ADD, colon cancer, ulcers, and others.[14]Probiotics are the essential remedy for preventing dysbiosis and preserving the equilibrium of homeostasis. Non-digestible dietary ingredients called probiotics improve the health of the host [15].These are recommended for patients with GIT illnesses in order to support both immunological and nutritional growth. Probiotics' anti-

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inflammatory effects in IBD have been shown in recent research to have therapeutic advantages, including the prevention of constipation, diarrhea, antibiotic-induced diarrhea (ADD), and immune system enhancement [16]. The present trend in in-depth study and development in this field suggests that probiotics, prebiotics, and metabolically generated postbiotics—all of which have immense potential for growth and use—may constitute the next generation of pharmaceuticals. This could fundamentally alter the way that we handle and treat illnesses. Examples of microorganisms used as probiotics are listed out in Table 1. This review focuses on probiotics, their current and potential future trends, and their health advantages for humans

Table 1. Examples of microorganisms used as probiotics

Species	**Name of the micro – organisms**
Lactobacillus	*L. paracasei* *L. reuteri* *L. salivarius* *L. bulgaricus* *L. acidophilus* *L. gasseri* *L. lactis* *L. coccus* *L. plantarum YYC-3* *L. casei 01* *L. rhamnosus GG*
Bifidobacterium	*B. bifidum* *B. breve* *B. infantis* *B. adolescentis* *B. longum* *B. animalis subsp. Lactis*
Streptococcus	*S. thermophilus* *S. salivarius subsp. Thermophilus*
Saccharomyces	*S. boulardii*

2. Probiotics used for specific conditions

Over the past 20 years, probiotic bacteria have become more well-known as a result of mounting scientific evidence supporting their beneficial effects on human health. Consequently, they have found use in a diverse range of products, with the food industry taking a leading role in their development and promotion[19]. Probiotics have been used as medical treatments for a variety of gastrointestinal and non-gastrointestinal conditions, including diarrhea, constipation, inflammatory responses, and more [20]. The idea behind utilizing probiotics to maintain health is that they compete with pathogens that survive in the digestive medium by preventing them from doing damaging things [21]. Probiotics are considered the secondary immune system by the World Health Organization [22] because they are inexpensive, safe, and effective against microbial illnesses.

In gastrointestinal and non-gastrointestinal disorders, probiotics have emerged as a promising medical therapy for diarrhea, constipation, irritable bowel syndrome, inflammatory bowel syndrome, asthma, atopic dermatitis, peptic ulcer, colon cancer, coronary heart disease, and urinary tract infections [23]. Probiotics are also utilized to treat female vulvovaginal candidiasis and Crohn's disease[24, 25]. Probiotics can help prevent and treat diverticulitis, lactose intolerance, Helicobacter pylori infection, microscopic colitis, and colon cancer [26]. After receiving probiotic therapy, some infants with colic have been observed to respond better [27]. One of the most prevalent bacteria in the human large intestine that produces vitamins B and K 95 is Escherichia coli [28].

Numerous probiotics are beneficial in treating acute viral gastroenteritis and antibiotic-associated diarrhea (e.g., Clostridium difficile toxin-induced diarrhea), according to recent reviews. Probiotics can reduce the risk of C. difficile infections in high-risk persons by 50%, per one study [29]. Probiotics were found to lower the incidence of streptococcal pharyngitis in another systematic review [30]. An further significant part of the health advantages is the biological elimination of chemical dietary pollutants by probiotics. Food contaminants are chemical pollutants produced by many industries and agricultural activities that can inadvertently or purposely find their way into our food supplies. These pollutants can have long-term detrimental consequences on human health. In this case, probiotics are a useful tactic to reduce toxicity and prevent dysbiosis brought on by outside contaminants. Various probiotics indicated in specific diseases are shown in Table 2. [31-34]

Table 2. Probiotics used for specific diseases condition

Probiotics	**Indicated in**
L. acidophilus	Intestinal Infection
B. infantis	
L. casei	Immune enhancement
L. acidophilus	
B. bifidum	
L. acidophilus	Diarrhea
S. thermhioplus	
B. longum	
L. rhamnosus GG	
B. bifidum	
B. longum	Cancer
L. casei Shirota	
L.acidophilus	
Bifidobaterium spp.	
L. rhamnosus GG	
L. rhamnosus GG	Hypercholesterolaemia
L. acidophilus	Lactose intolerance
B. angulatum	
B. breve	
B. longum	
B. Bifidum	
S. boulardii	Acute Liver Diseases
L.acidophilus	Inflammatory Bowel Diseases(IBD)
L. casei	Inflammation in Skin

3. Prebiotics

Prebiotics are indigestible food elements that selectively encourage the growth of probiotics or the action of certain probiotics that are linked to health benefits. Prebiotics, however, can also contribute to the increased viability and efficiency of ingested PRO bacteria. As per the latest definition, a prebiotic is defined as a component that has undergone selective fermentation, enabling particular alterations in the GI microbiota's composition and/or activity, hence improving the host's overall health and well-being. Prebiotics are now defined as "a substrate which is selectively fermented by the gut microflora and bestows health benefits to the host" by the International Scientific Association of Probiotics and Prebiotics. According to this revised definition, prebiotics can also include non-carbohydrate components, and their uses are not limited to the gastrointestinal tract [35]. "Non-digestible food ingredients that beneficially affect the host by selectively stimulating the growth and/or activity of oneor a limited number of bacteria in the colon for improving the host health" is how the relatively new word "prebiotics" is described [36]. A group of specialists from the International Scientific Association for Probiotics and Prebiotics (ISAPP) has examined the definition of prebiotic. The panel revised the definition to read as "a substrate that is selectively utilized by host microorganisms conferring a health benefit" in order to provide a broader viewpoint. According to this definition, prebiotics may now refer to compounds that are not carbohydrates, applications that are used in parts of the body other than the gastrointestinal tract, and a wide range of categories outside of food [37-42].

These are often short-chain carbohydrates that are not broken down but are instead utilized as growth substrates by probiotics in the upper gastrointestinal tract [43, 44]. Cocoa-derived flavanols are another class of chemicals that are not considered carbs but are suggested to be prebiotics. Experiments conducted both in vitro and in vivo have shown that flavanols can promote the growth of lactic acid bacteria [45]. Prebiotics are generally found in a number of plants, including wheat, chicory, onion, asparagus, garlic, Jerusalem artichokes, oats, and wheat. They stimulate the growth of bacteria in the gut, hence activating metabolic activity already

present in the colon. It has been shown that consuming fructooligosaccharides significantly increased the population of bifidobacteria in the feces [46]. Prebiotics typically consist of low levels of polymerization (2–20 units), with the monomers being glucose, galactose, fructose, and/or xylose. They are typically not hydrolyzed in the colon. Additionally, because they are not digested in the colon, they have calorie value and contribute energy through fermentation [47]. Prebiotics such as fructooligosaccharides (FOS), isomalto-oligosaccharides (IMO), and xylooligosaccharides (XOS) are the ones that are most frequently researched. Beneficial dietary fibers called FOS (neosugar and inulin) aid to improve fecal acidity, relieve constipation, and increase stool volume [48]. Widely found in a variety of plants, inulin is typically sold separately from chicory roots and is recognized to promote the growth of Bifidobacterium [49]. The enzyme β-fructosidase of Aspergillus niger catalyzes the transfructosylation of sucrose to produce neosugar, also referred to as meioligo. Bifidobacteria and other microorganisms including Lactobacillus acidophilus, Enterococcus faecalis, E. faecium, Bacteroides vulgatus, B. thetaiotaomicron, B. ovatus, and B. fragilis may readily digest both of these [50].

IMO are used by the Bacteroides and Bifidobacteria families and can be found in fermented foods including miso, soy sauce, and honey [51]. IMO stimulates the proliferation of Lactobacillus species and Bifidobacterium, which results in the modulation of immunological function and a localized Th-1-like immune response. The clinical trials have shown similar results [52]. Emerging prebiotics called XOS can be found in fruits, vegetables, milk, honey, bamboo shoots, and other natural foods [53, 54]. It has been documented that whereas Lactococcus lactis, Lactobacillus rhamnosus, and Lactobacillus plantarum effectively utilize oat β-glucooligosaccharides, Bifidobacterium adolescentis is able to use XOS [55] have shown that the presence of xylanolytic enzyme systems, such as xylosidase and a few arabinosidases, is responsible for the fermentation of arabino-XOS from wheat meal by bifidobacteria. Reports have indicated the presence of arabinosidases from Bifidobacterium breveK-110 and Bifidobacterium adolescentis DSM20083, as well as a β-D-xylosidase [56, 57]. According to a study on Bifidum, B. adolescentis, and B. infantis, only xylosidase and arabinosidase were produced by these species; α-glucuronidase, xylanase, and acetyl xylan esterase activity were not found [58]. Research on the fermentation of XOS from rice husks by a variety of probiotic bacteria revealed that when XOS was present, B. adolescentis CECT 5781 grew more rapidly than B. longum CECT 4503, B. breve CECT 4839, and B. infantis CECT 4551. Prebiotics' industrial development is essential to enhancing human health and food quality. Prebiotic-containing functional foods have been employed to create frozen yogurt, candies, biscuits, tabletop sweeteners, and more [59]. In Japan, food items classified as foods for specified health use (FOSHU) contain several prebiotics, including lactulose, XOS, IMO, FOS, lactosucrose, and oligosaccharides. Yogurts, cereals, fiber-rich biscuits, cakes, sauces, powdered drinks, pasta, cereal bars, newborn formula foods, breads, and a variety of fruit juices are a few more examples of prebiotic foods [60].

4. Future perspectives

Microorganisms known as probiotics are beneficial to health. They are always administered as dietary supplements rather than as medications [58]. Since most probiotics are made up of unicellular bacteria, it is simple to cultivate or develop them by giving them the right medium and environmental factors including the ideal pH, temperature, nutrients, and minerals. Large-scale production of probiotics is possible based on the needs of the cells that functional foods use. Without making a substantial expenditure, the circumstances necessary for their growth can be readily produced in a medium. Large tanks known as bioreactors are used in enterprises to produce their goods [59]. Probiotics can be made more effective if they multiply in the medium in which they are used. This can only happen when the ideal conditions are consistently provided for these cultures [37]. Probiotics have many health benefits, but they also have some drawbacks. For example, in cases of young children with weakened immune systems or severe illnesses, probiotics can enter the bloodstream through a process called bacteraemia leading to sepsis. In this condition, the body produces an extremely significant immune response, including heavy breathing,which, in most circumstances, is lethal. Further immune responses are only reactions with no more considerable generation of antibodies in response to bacterial activity because the immune system is already compromised or fighting the sickness [60].

5. Conclusion

Finally, probiotics present a range of potential opportunities for improving human health and treating a variety of illnesses. Their value in preventive and therapeutic interventions is highlighted by their key role in modifying the gut microbiota, maintaining immunological function, and reducing metabolic diseases. However, in order to reduce potential hazards such systemic infections, the careful use of probiotics is crucial, especially in individuals that are already vulnerable. Probiotics, like prebiotics and postbiotics, have enormous potential for new drug development and therapeutic approaches as this field of study develops. Acknowledged by the World Health Organization as a cost-effective and safe intervention against microbial illnesses, probiotics are increasingly recognized as a secondary immune system. In the future, achieving the full therapeutic potential of probiotics in enhancing human health and wellbeing will require comprehending their mechanisms of action and weighing the advantages against the disadvantages

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Currently pursuing my II year Bachelor's in Pharmacy at Sri Shanmugha College of Pharmacy, I am Selva Bharathi Saravanan, deeply captivated by the realms of cancer research and nanotechnology. while simultaneously being deeply intrigued by the integration of artificial intelligence into the pharmaceutical sector and also involving space medicine.

Senthil kumar C

Dr. C. Senthil Kumar currently working as Professor & Head in Department of Pharmaceutics at Sri Shanmugha College of Pharmacy, Sankari, Tamilnadu, India. I attained my Ph.D in Pharmaceutical Technology in the year January 2020 from Anna University, Chennai, Tamilnadu. I has completed M. Pharm in the year April 2008, Department of Pharmaceutics from Bharathidasan University, Tiruchirappalli, Tamilnadu and B. Pharm in the year February 2006 from The Tamilnadu Dr. M.G.R Medical University, Chennai, Tamilnadu. I has more than 16 years of experience in the field of Pharmacy profession in academic and research. In 16 years of experience, I was participated around 60 various Conferences, Workshops and Seminars. I also presented around 100 research and review papers at national & international level Conferences, Workshops and Seminars. I had published more than 17 research and review articles in several national and international peer reviewed journals with overall impact factor more than 12. I was published more than 7 Book Chapter as main author and co-authors in Elsevier publisher. I had given invited lecture as resource person in many Conferences and Faculty Development Programmes. Currently I am doing research in the area of nanotechnology in ocular drug delivery system & herbal nanoformulation in various routes of drug delivery systems with academic contributions.

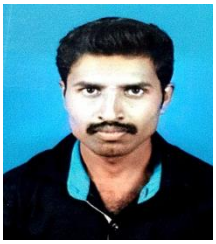
Gomathi S

Currently, I hold the position of Assistant Professor at Sri Shanmugha College of Pharmacy, located in Sankari, Tamil Nadu, India. I obtained my M. Pharm degree from Sri Ramakrishna Institute of Paramedical Sciences in 2021. With two years of academic experience, my passion lies in exploring case studies and uterine fibrosis.

Sathish Kumar K

Entering the dynamic domain of my second Bachelor's in Pharmacy at Sri Shanmugha College of Pharmacy, I proudly introduce myself as Sathish Kumar Kannan, a seeker of innovation and a passionate advocate for the transformative power of nanotechnology.

Elango S



At present, I'm engaged as a lab technician at Sri Shanmugha College of Pharmacy, where I play a pivotal role in scientific exploration. I earned my postgraduate degree (M.Sc. Microbiology) from Alagappa University in Karaikudi, where I honed my passion for life sciences and research.

Tharani D

Presently, I serve as an Assistant Professor at RDB College of Arts and Science. I completed my postgraduate degree (M.Sc. Microbiology) from Alagappa University in Karaikudi, where my fascination for life science research blossomed.