Probiotics and Prebiotics in Functional Foods: Advancing Nutritional Science

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Abstract

Probiotics and prebiotics are beneficial treatments for improving human health by either directly or indirectly affecting the colonizing microbiota. However, in a manner commensurate with the level of the evidence, the findings of this study have not been converted into dietary recommendations or endorsements of public health policy. More advancement has been made in the area of clinical guidance. Doctors are increasingly promoting probiotics as effective therapeutic remedies as they have acquired popularity as a means of managing digestive and immunological health. Human health depends on the gut bacteria in several important ways. Microbial symbiosis has been connected to several illnesses, and the number is constantly growing. Most recent studies have examined the links between disease and peculiar microbiome structure. Functional revisions by gut models (in vitro) are necessary to study the specific interfaces that follow among explicit bacteria (and bacterial groupings) and the smooth gut epithelial tissues/cells. Since its commencement at the beginning of the twentieth century, probiotic science has made great progress, especially in the last 20 years. Researchers have acquired clinical evidence demonstrating the health benefits and product quality of probiotics, developed a consensus definition, begun to understand many of the mechanisms of action, and identified characteristics essential to probiotic function. Clear, fact-based messaging is still required to educate people about the value of probiotics in a balanced diet and to educate medical professionals about their therapeutic use. However, many countries' regulatory structures have impeded development on this front. To find out which probiotics are best for specific health outcomes and which people are most likely to benefit from specific probiotic therapy, more research is needed.

Keywords: Probiotics, Microbiota, Bacterial, In-vitro, Prebiotic, Microbial, Microbiome

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Introduction

Live bacteria known as probiotics are sold with the claim that eating them may enhance or repair the gut flora, among other health benefits. Even though probiotics are generally regarded as safe to consume, they can occasionally cause unfavorable side effects and bacterial-host interactions (Sanders et al., 2018). Prebiotics serve as a food source for the microorganisms in your gut, but they must pass through digestion and reach your colon. To survive, the microbes their ferment and utilize the prebiotics. Because it produces numerous different byproducts that benefit you in various ways, this metabolism and fermentation process is good for the health of your gut (Roberfroid, 2000). Functional foods have a chance for the improvement in human health status, to reduce medical charges, and stimulate economic and social development schemes in countryside regions. The proverb "Let food be the medicine and medicine be the food," coined by Hippocrates over 2500 years ago, is becoming increasingly popular as food scientists and consumers become more conscious of the several health welfares of specific diets (El Sohaimy, 2012).

Functional foods are consumed as a regular part of daily diet and look similar to the traditional diet. In addition to fulfilling basic nutritional needs, like maintaining intestinal health, functional diet/foods have confirmed functional remunerations and can drop the danger of chronic diseases when compared to standard diets. "Functional food/food ingredients" is defined as food items that is produced or roasted as "scientific intelligence," regardless of whether the prepare understands how and why the meal is being created. Consequently, functional foods provide human body with the amount of carbohydrates, fats, vitamins, and protein and the other nutrients it needs to live a healthy life (FAO, 2007).

Overview of Prebiotics and Probiotics in Functional Foods

Numerous bacterial species inhabit the human gut, and these species have significant metabolic and immunological roles that have a very significant and vital impact on the host's nutritional and overall health. "Living micro-organisms which upon ingestion in definite amounts utilize health benefits elsewhere intrinsic basic diet/nutrition" is the generally known definition of probiotics (Guarner & Schaafsma., 1998) , 1998). According to Nissen et al. (2009), probiotics are alternatively defined as the live bacteria that are part of the natural biota and have

essential roles for the host's health and well-being while having little to no pathogenicity. Bifidobacteria, Lactobacillus reuteri, and Lactobacillus rhamnosus GG, certain basic strains of *Lactobacillus casei*, the Lactobacillus acidophilus group, *Escherichia coli* strain Nissle 1917, some enterococci, especially the probiotic yeast *Saccharomyces boulardii* and *Enterococcus faecium* SF68, are just a few of the numerous probiotic micro-organisms that are used in the probiotic items, particularly the fermented milk goods, or have been researched for possible medical uses. New probiotic genera and strains are seeming; some of them have significant health advantages, such as the *Lactobacillus plantarum* separates (PCS-20, PCS-22, PCS-25, and PCS-26) in Slovenian cheese, which have resilient immune-modulatory (Nissen et al., 2009) and antibacterial properties (Maragkoudakis et al., 2010).

Probiotics were first used to alter gut flora and impact human health. Numerous dietary matrices and preparations of solitary or mixed microbial cultures have demonstrated the benefits of probiotics for human health. Furthermore, it is now known that the strain of probiotics affects their ability to promote health (Nissen et al., 2009). A global skilled group of (ILSI) the International Life Sciences Institute has assessed the published and categorized sign of the efficacy of altered probiotics in four areas of (human) solicitation: chronic intestinal inflammatory, metabolism, functional diseases, contagions, and allergies (Maragkoudakis et al., 2010).

To support the existing body of knowledge on probiotic profits, the ILSI study provides specific examples illustrating advantages and shortcomings, as well as guidelines and recommendations on how to construct the next generation of probiotic studies. Although there are no clinical findings pertaining to the dosage or length of probiotic therapies, the benefits of probiotics on human wellbeing are good and so well-defined when it comes to treating the diarrhea (Minelli & Benini., 2008).

Since the special cause of probiotics on the host depends on probiotic straining, the type of infection (immunological, chronic and acute gastrointestinal infections, or inflammatory diseases), the various doses are used in length of management, the results of clinical findings have not been ultimate (Minelli & Benini., 2008). According to research, probiotics can help reduce the symptoms of AIDS, cancer, allergies, urinary tract and respiratory infections disorder (Kaur et al., 2009). Additionally, a number of studies indicate that probiotics may help reduce the risks of, obesity, and osteoporosis and may be type-2 diabetes syndrome, as well as symptoms related to aging, exhaustion, and autism (Douglas & Sanders, 2008).

Only when appropriate probiotic strain and selection of product for the purpose of commercial manufacturing doses standards are adhered to human food and medicine can the health benefits of probiotics be realized (Douglas & Sanders, 2008), ≥106 colony forming units (cfu) per milli-liter in small intestine and ≥108 cfu/g in the part of colon are frequently cited as the probiotic concentrations required to achieve a therapeutic impact. In terms of cfu, the dosage of a certain probiotic agent used to treat an acute sickness can be as low as 10 times or as high as 100 times. Higher dosages of probiotics administered for brief courses appear to be more helpful than smaller levels in treating acute infectious diarrhea.

The benefits of probiotics in immunological or chronic disorders (inflammatory, allergic and immune diseases) also depend on how the in gut immune system and the corresponding bacteria interact, as well as how long the medication is administered. Finding particular target groups of people who are more susceptible to the possible effects of probiotics may be crucial to assessing their effectiveness. According to Douglas and Sanders (2008) a prebiotic is described as "a fiber or component that conducts selective fermentation, which permits specific changes in the gastro-intestinal microflora's composition. This boosts the host health or well-being." Prebiotics also offer other, more specific indirect health effects, like reducing constipation or diarrhea, controlling the metabolism of gut flora, preventing cancer, affecting metabolism of lipid, encouraging adsorption of mineral, and having immune-modulatory properties. Despite their nutritional and nutraceutical value, prebiotics are a complex group of carbohydrates whose source, modes of fermentation, and dosages required for health benefits are not fully known (Douglas & Sanders, 2008). These days, only bifidogenic, indigestible oligo-saccharides meet all the requirements for prebiotic classification, especially insulin, its hydrolysis product oligo-fructose, and galacto-oligosaccharides (trans) (Douglas & Sanders, 2008)

There have been successful attempts in recent years to add fructo- and (mostly) galacto-oligosaccharides to infant formula in an effort to make it more like breast milk. According to Douglas and Sanders (2008), prebiotics and probiotics both have different functions in human diet that are mostly focused on modifying the populations and activities of the microbiota that live in the Gastro-intestinal tract. According to Douglas and Sanders (2008), regular use of prebiotics and probiotics provides several health welfares, such as improvement in digestion and elimination, reduced prevalence and interval of intestinal infections, increased immunological function, improved colonic reliability, and down-regulated allergic reaction.

Notably, human individuals and their intestinal microbiota have developed a mutually tolerant state together. A failure of this reciprocal interaction may be the cause of inflammatory bowel disease (IBD), according to growing data from human and animal research. However, there have been diversified outcomes from clinical trials looking into probiotics and prebiotics as therapies for IBD (Hedin et al., 2007). Less research has been concluded on the effects of prebiotics and probiotics on Crohn's disease bowl health, despite the fact that their advantages are well known. This could be due to changes in the range of prebiotic, probiotic, and (synbiotic) combination drugs confirmed, as well as variations in test field, such as in many patient groups (Hedin et al., 2007).

When administered in adequate amounts, probiotics—live microorganisms—value the host's health (FAO, 2001). A dietary prebiotic is defined by Gibson et al. (2010) as a selectively fermented material that modifies the activity and composition of the gastrointestinal-microbiota in a way that is advantageous in the host's health. In preterm, very low birth weight newborns, probiotics have been shown to improve blood lipid composition, reduce the incidence of infantile atopic dermatitis, alleviate symptoms of irritable bowel syndrome (IBS), inhibit antibiotic-associated diarrhea, minimize the duration of infectious diarrhea, regulate intestinal transit, and prevent morbidity and mortality associated with necrotizing enterocolitis (Alfaleh & Anabrees, 2011; Jacobs et al., 2013).

The advantages of the prebiotics include better calcium absorption through the consumption of prebiotic formulations; decreased incidence, duration, and symptoms of traveler's diarrhea; relief from IBS symptoms; prevention of certain allergies; decreased energy intake and insulin resistance markers and better body weight management; and increased satiety and decreased appetite) (Jacobs et al., 2013). By influencing the colonizing microbiota directly or indirectly, probiotics and prebiotics are helpful therapies for enhancing human health. The

results of this research have not, however, been translated into dietary guidelines or support for public health policies in a way that is consistent with the strength of the evidence. With regard to clinical advice, more progress has been made.

Mechanism of Action: How Probiotics and Prebiotics Work in Body

Probiotics primarily work by improving the intestinal mucosa, increasing attachment to the epithelial obstacle, concurrently impeding pathogen linkage, competitively eliminating pathogenic micro-organisms, producing the anti-microorganism substances, and modulating the immune-system. An essential defense system that shields the organism from its environment and preserves the reliability of its epithelium is the intestinal barrier. When the intestinal obstacle's defenses—secretory IgA, the mucous layer, anti-microbial peptides, and epithelial intersection adhesion complex are compromised, food and bacterial antigens can penetrate the sub-mucosa and source inflammatory responses that can lead to intestinal disorders (Ohland & MacNaughton, 2010).

Consuming the non-pathogenic bacteria can affect the function of the intestinal obstacle. The effect of probiotic bacteria in maintaining the barrier has been well studied. However, the precise mechanism in which the probiotics enhance gut barrier function is unknown. Numerous studies suggest that up regulating the expression of genes involved in tight junction indicating could be one strategy to improve the intestinal obstruction's integrity (Anderson et al., 2010). Probiotic bacteria may be able to adhere to epithelial cells and fend off infections. This mechanism has a major conclusion on host's health. Additionally, the adhesion of probiotic microorganisms to epithelial cells may trigger a cascade of signals that modify the immune system.

On the other hand, the discharge of some soluble components may activate immune cells directly or indirectly (via epithelial cells). This impact is crucial in the management of chronic inflammation of the alimentary canal or a portion of it, in addition to the prevention and action of infectious infections (Oelschlaeger, 2010).

Prebiotics use a range of surface bases to relate with the mucus and intestinal epithelial cells (IECs). By secreting mucin, glycoprotein a complex type mixture that makes up the mainstream of mucous, IECs prevent dangerous germs from sticking (Collado et al., 2005). Probiotics create organic acid and the antibiotic molecule bacitracin. The primary anti-microbial substances assumed to be in charge of probiotics' capability to prevent infections are organic acids, such as lactic and acetic acids. Gram-negative bacteria are effectively inhibited by these acids (Makras et al., 2006). The organic acid that is in detached form enters the bacterial cell and disintegrates in the cytoplasm.

Role of the gut Microbiota

Prebiotics use a range of surface determinants to interact with the mucus and intestinal epithelial cells (IECs). By secreting mucin, a complex glycoprotein mixture that makes up the mainstream of mucous, IECs prevent dangerous germs from sticking (Collado et al., 2005). Probiotics create organic acid and the antibiotic molecule bacitracin. The primary anti-microbial substances thought to be in charge of probiotics' capability to prevent infections from organic acids, such as lactic and acetic acids. Gram-negative bacteria are strongly inhibited by these acids (Makras et al., 2006). The organic acid's un-dissociated form enters the bacterial cell and disintegrates in the cytoplasm (Sekirov et al., 2010). According to Nicholson et al. (2012) and Wells et al. (2011), the gut microbiota affects the host through a range of host-microbiota interaction pathways and plays several important functions in human health. According to Flint et al. (2012), gut bacteria, for instance, facilitate the complex non-digestible carbohydrates fermentation and generate short-chain fatty acids (SCFAs), including butyrate, propionate, and acetate. Numerous an-aerobic bacteria that predominate in a well gut, including Faecalibacteria, are thought to improve intestinal barrier integrity and serve as a significant source of energy for colonocytes (Wang et al., 2012).

Additionally, a balanced immune system is greatly impacted by the "healthy gut microbiome." The intraluminal bacteria are somewhat immune-tolerant in the healthy gut. General analysis of the human gut microbiomes has revealed that "dys-biosis" of the gut microbiota is responsible for many mutual illnesses. Dys-biosis is defined as a concerned balance between "beneficial" bacteria type that have anti-inflammatory infectious possessions and pathobionts that have pro-inflammatory possessions. Additionally, certain illnesses are related with a reduced variety of the gut microbiota (Dave et al., 2012; Schippa & Conte, 2014).

It is yet unknown how much dysbiosis contributes to the development of most diseases or how it affects their management (Zhang et al., 2015). This matter is further complex by the point that in many studies focus on the bacterial conformation of in fecal material, which may differ expressively from the bacterial composition involved to the mucosa (mucosa-associated microbiota, or MAM), which may be more directly linked to the definite progress of the disease (Zoetendal et al., 2002). Additionally, in various parts of the gastrointestinal tract have different bacterial populations and compositions. It is a well-recognized that the two primary forms of inflammatory bowel disease (IBD), Crohn's disease (CD), ulcerative colitis (UC) are related with modifications in the microbiota (Kostic et al., 2014).

The commensal microbiota is a innately pre-disposed host causes an inappropriate mucosal immune response in both illnesses Compared to UC, changes in the gut microbiota appear to be more noticeable in CD Similarly, CD patients expression a less varied microbiota outline than healthy individuals (Kaser et al., 2010). Bacteroides and Firmicutes are typically found to be less abundant, while proteobacteria and fusobacteria are typically found to be more widespread (Kostic et al., 2014). One consistent finding is that adherent-invasive *Escherichia coli* (AIEC) were more dominant in CD patients, but 138 butyrate-producing *F. prausnitzii* was less prevalent (Kostic et al., 2014). Additionally, there have been reports of an increase in the mucindegrading bacteria *Ruminococcus gnavus* (Joossens et al., 2011). Endoscopic recurrent disease is more likely to occur in 140 CD patients with lower levels of *F. prausnitzii* and higher levels of pathobionts, including *E. coli*, after ileal/ileocecal resection (Sokol et al., 2008).

According to Fujimoto et al. (2013), CD patients by the smallest abundance of *F. prausnitzii* also frequently have a less auspicious disease trajectory, more inflammatory markers and worse disease ratings. According to Dubinsky & Braun (2015), the presence of *F. prausnitzii* may even serve as a biomarker for predicting the course of the disease in CD patients. Another illness where an aberrant microbiome composition is observed is celiac disease. Bacteroidetes are typically found in greater amounts in the duodenum of these patients (Cenit et al., 2015). Additionally, it has been reported that colon cancer formation and progression are linked to the gut microbiota (Garrett et al., 2015). Non-

gastrointestinal diseases and abnormal intestinal microbiota may be related, according to recent data. The link between changed microbiota composition and major metabolic illnesses with obesity and type 2 diabetes mellitus is becoming more well acknowledged (Khan et al., 2014; Dao et al., 2016).

For instance, a current study shows that a relatively high abundance of *Akkermansia muciniphila* is related with a good metabolic condition (Dao et al., 2016). Finally, connections between altered microbiome composition and neurologic or psychiatric conditions like depression, anxiety, and autism are explored.

Conclusion

Probiotics and prebiotics work collected to maintain a balanced gut microbiome, alleviating gastrointestinal symptoms, related diseases and improve gut health. These vital microorganisms with are present in prebiotic and probiotic support the immune system, precluding metabolic diseases like diabetes, obesity, and hyperlipidemia. Prebiotics can surge the absorption of essential minerals and vitamins. These essential microbes enhanced nutrient absorption. A healthy gut microbiome can reduce the risk of many diseases such as cardio-metabolic disorders, cancer, and neurodegenerative diseases. Plant-based matrices contain a wide range of phytochemicals with potential health benefits, including fibers, carotenoids, and phenolic compounds. Plant-based foods can serve as effective carriers for probiotic strains, ensuring their survival during processing, storage, and digestion. Probiotic products can be designed to support individual health needs, leveraging technologies like 3D printing and act as personalized nutrition. The use of new technologies and raw materials can diversify the functional food market, catering to consumers with dietary restrictions or preferences. Ensuring the safety, quality, and health benefits of functional foods remains a crucial aspect of product development

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