Exploring the Interplay of Prebiotic and Probiotics

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Abstract: ***The human gut is home to a diverse and complex community of microorganisms that play a crucial role in maintaining health. Over the past few decades, research has increasingly focused on the role of probiotics and prebiotics in modulating this gut microbiome to promote overall well - being.*** *Probiotics* ***have gained considerable attention for their ability to enhance digestive health, strengthen immune response, and even influence mental well - being. Meanwhile,*** *prebiotics* ***have emerged as key modulators of the gut environment. The relationship between probiotics and prebiotics is synergistic. Prebiotics serve as a fuel source for probiotics, fostering the growth and activity of these beneficial microorganisms. Together, they form the concept of*** *synbiotics****, which aims to optimize gut health by combining probiotics and prebiotics in a complementary manner. This review will explore the individual roles of probiotics and prebiotics, their mechanisms of action, and how their combined use can provide enhanced benefits for human health.***

Keywords: Prebiotics, Probiotics, Synbiotics, Gut - health

1. Introduction

Our gut microbiome changes with factors like age, environment, stress, lifestyle, food, and overall health, as well as drug exposure, ranging from in prenatal changes to post - partum changes. (Cresci *et al.*, 2015). Prebiotics assist in decreasing the growth of pathogenic enteric bacteria by enhancing the activity of some kinds of helpful bacteria or probiotic microorganisms. (Gibson *et al.*, 2005). Probiotics are live microorganisms that impart health benefits to the host when ingested in sufficient amounts, including common strains of lactic acid bacteria and *Bifidobacterium*. (Bermudez - Brito *et al.*, 2012). Probiotics and prebiotics combine to impart a synergistic effect on the host health (Noori *et al.*, 2017).

Prebiotics

Prebiotic foods have been utilized since the dawn of mankind. Geological record from dry cave deposits in the northern Chihuahuan Desert shows that desert plants high in inulin were widely used (Leach *et al.*, 2010). Foods including scallions, asparagus, chicory, Jerusalem artichokes, garlic, red onion, wheat, oats, soybeans, and other grains naturally contain prebiotics (Van Loo *et al.*, 1995). The two major classes of prebiotics with favourable effects on human health are fructo - oligosaccharides and galacto - oligosaccharides. Since fructo - oligosaccharides and galacto - oligosaccharides are found in small amounts in meals, scientists are striving to synthesise prebiotics on a large scale. (Davani *et al.*, 2019). The acceptability of dragon fruit oligosaccharide (DFO) for intake, as well as its efficacy on gut microbiota regulation and involvement in increasing the gut immune response in rats, were investigated. According to the findings, the DFO boosted intestinal *Bifidobacteria* and *Lactobacillus* while decreasing *Bacteroides* and *Clostridia*. The DFO also boosted immunological response by considerably increasing plasma immunoglobulin A and G levels. (Pansai *et al.*, 2020).

In the year 2015, the amount of Raffinose family oligosaccharides (RFOs) in Glycine max seed was investigated, and the prebiotic characteristic of this extract was then tested using an in vitro approach. In comparison to glucose supplementation, the activity of four *Lactobacillus* probiotic species was dramatically boosted in a basal nutrient broth supplemented with the extract as a carbon source. Following that, a defined mixed culture was investigated, and it was discovered that extracted sugars stimulated the increase of total *Lactobacillus*, while suppressing the growth of *Salmonella enterica serovar typhimurium* and *Escherichia coli (*Wongputtisin *et al.*, 2015). Cereal - glucan is a commonly found water - soluble, prebiotic, biologically active polysaccharide and dietary fibre that regulates human health. β - glucans derived from cereals have a number of distinct functional features, including increased solubility, viscosity, and the ability to be entirely fermented by gut microbes. (Mahtab Shoukat *et al.*, 2021). A substantial increase in *Bifidobacterium* spp. (Mikkelsen *et al.*, 2017; Velikonja *et al.*, 2019) and decrease in Bacteroides population (Fehlbaum *et al.*, 2018; Zhu *et al.*, 2020) was shown in some of the recent findings.

The exact mode of action of prebiotics is still not very clear. Mannan - oligosaccharides (MOS) are prebiotics consisting of complex carbohydrate molecules generated from the outermost cell wall of *Saccharomyces cerevisiae*, whose primary components, β - glucans (mannoproteins), have been shown to activate animal immune systems (Hady *et al.*, 2012; Broadway *et al.*, 2015). MOS is thought to work by agglutination, which occurs when mannose sensitive lectins on the bacterial cell surface of Gram - negative bacteria combine (Heinrichs *et al.*, 2003). MOS compete for attachment sites located in the digestive tract, preventing dangerous bacteria from colonising (Spring *et al.*, 2000).

Probiotics

Probiotics are defined as "live microorganisms that, when administered in adequate amounts, confer a health benefit on the host" (Hill *et al.*, 2014). A study in 2013 showed that, the probiotic strain, specifically *Lactobacillus rhamnosus* GG was able to grow and metabolize in cereal and pseudo - cereal substrates (Monika *et al.*, 2013). Although lactic acid bacteria have been found to be suitable for the fermentation of maize and amaranth, some *Lactobacillus* species, such as *Lactobacillus acidophilus*, do not grow well in grain products. (Pelikanova *et al.*, 2015). The products of lactic acid fermentation of cereals and its derivatives are safe, improve or change the nutritional content of cereals, and aid in the preservation of food. This method of processing is used to make refreshments, gruels, pancakes, and porridge from fermented rice, sorghum, corn, millet, non - cereal cassava, and wild legume seeds in Asia and Africa. (Franz *et al.*, 2014).

Enhancement of the epithelial barrier, enhanced attachment to the intestinal mucosa, competitive exemption of pathogenic microorganisms, development of anti - microbial compounds, modulation of the immune system, and concurrent inhibition of pathogen adhesion are all some of the major probiotic mechanisms of action. (Khare *et al.*, 2018). The processes by which probiotics improve the function of the intestinal barrier remain unknown. Several studies, however, have suggested that increasing the expression of genes that play a role in in tight junction signalling could be a way to strengthen the intestinal and gut barrier integrity. (Anderson *et al.*, 2010). Antibiotic (acidophiline, lactacin, bacitracin), anti - cancerogenic, and immunosuppressive activities may be found in some probiotic metabolic products. (Schellenberg *et al.*, 2006; Nova *et al.*, 2007).

Lactobacillus plantarum is a common lactic acid bacterium that can be found in a wide range of ecological environments, highlighting its adaptability and genomic flexibility. Another important feature of *L. plantarum* is its ability to create a wide range of potent bacteriocins, which are antimicrobial peptides that could be used as food preservatives or antibiotic complements (Seddik *et al.*, 2017). All of these traits combine to make Lb. plantarum a true model for academic research. *L. plantarum* DSM 20174 is also found to be an acid - and bile - tolerant isolate that has the ability to ferment FOS (Cebeci *et al.*, 2003). The increasing distribution of *Lactobacillus rhamnosus* in a variety of ecological niches which includes food, the gut, the buccal cavity, the vaginal cavity, and other tissue sites (Douillard *et al.*, 2013), has prompted numerous studies of the species' evolution (Ceapa *et al.*, 2016), niche adaptability (Kant *et al.*, 2014), and potential safety concerns related to its opportunistic pathogenicity (Rossi *et al.*, 2019). A study on the kinetic metabolic profiles of *L. rhamnosus* revealed that at low pH, consumption of glutamic acid and aspartic acid is low and high, respectively (Ebrahimi *et al.*, 2016).

Both live as well as heat - killed *L. rhamnosus* suspension cultures were found to trigger production of cytokines with proinflammatory (TNF - and IL - 6) and regulatory (IL - 10) functions, implying that strain *L. rhamnosus* ATCC 7469 may play a role in the regulation or stimulation of immune responses (Jorjão *et al.*, 2015). Findings from a study in 2020 suggested that encapsulated *L. rhamnosus* ATCC 7469 performed better than unencapsulated *L. rhamnosus* ATCC 7469 and has the potential to improve growth performance, flesh quality, and immunological response in rainbow trout (Hooshyar *et al.*, 2020). Apart from its role in health regulation, it has found application in second - degree burn wound healing as well, as demonstrated in Wistar rat (Barzegari *et al.*, 2018).

Prebiotic and Probiotic Relationship

Prebiotics include non - viable substrates that provide nourishment to the host's advantageous bacteria, such as the probiotic strains that have been administered as well as resident microorganisms (Gibson *et al.*, 2017). By comparing bioinformatics data on enzymes and genes involved in carbohydrates hydrolysis by *Lactobacillus* and *Bifidobacterium*, the genetic principles of prebiotic–probiotic connections were better defined (Petrova *et al.*, 2017).

Synbiotic bacteria, which combine prebiotics and probiotic bacteria, can deliver even greater benefits in comparison to probiotics and prebiotics administered alone. Together they aid in enhancing the health of the host (animal) by lowering load of pathogen through improved resistance to bacterial strain proliferation and increased immunity of host mucosa (Williams *et al.*, 2001; Choct *et al.*, 2009). Genome sequencing of probiotic *Lactobacillus* and *Bifidobacterium* revealed a complex carbohydrate metabolic gene repertoire specific to oligosaccharide catabolism (Jun *et al.*, 2015). The impact of probiotics and prebiotics on the gastrointestinal microbiota in both the maternal and neonatal health has been studied recently. (Angelica *et al.*, 2013). The two well - recognised modes of action of synbiotics are (i) action through the increased survivability of probiotic microorganisms and (ii) action through the use of the transmission of certain health effects (Manigandan *et al.*, 2012). Probiotics and prebiotics interact together in the intestine to influence metabolic activity, resulting in the preservation of intestinal biostructure, the establishment of commensal flora, and the suppression of pathogenic organisms in the gastrointestinal tract (De Vrese *et al.*, 2008).

According to findings in the literature, probiotic microbes gain greater tolerance to environmental factors such as pH, oxygenation, and temperature in the intestine of a specific organism when prebiotics are used. (Sekhon *et al.*, 2010).

2. Conclusion

In conclusion, probiotics and prebiotics each play pivotal roles in maintaining and enhancing gut health, with probiotics offering direct supplementation of beneficial microorganisms and prebiotics fostering the growth of these microbes through selective fermentation. The synergy between the two forms the foundation of synbiotics, which combine the strengths of both to optimize the balance and function of the gut microbiome. As research advances, the therapeutic potential of probiotics and prebiotics continues to expand, showing promise in a wide range of health applications, including digestive health, immune regulation, metabolic health, and even neurological function. Overall, the relationship between probiotics and prebiotics represents a crucial frontier in nutritional science, offering a promising pathway for improving human health through targeted modulation of the gut microbiome.

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