Chapter 02

Bacteriocin-Producing Lactic Acid Bacteria: Probiotic Approach for the Treatment of Gut's Diseases

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ABSTRACT

Lactic acid bacteria (LAB) are the most common probiotics. It prevents many gastrointestinal (GI) tract diseases such as obesity, inflammatory bowel disease (IBD), dysbiosis, and chronic infection. They produce lactic acid that lowers the pH of the GI tract and inhibits the growth of different pathogenic bacteria. They also provide competition for food and produce different antimicrobial peptides known as bacteriocins, which can effectively kill or inhibit closely related bacterial strains as well as bacterial pathogens such as *E.coli,* and *Salmonella*. Bacteriocins are small cationic peptides that lead to bacterial cell death by forming pores and the release of cytosolic contents. Lactic acid bacteria as probiotics maintain homeostasis and have many beneficial effects on gastrointestinal tract health. They also play an important role in boosting the immune response of the host by stimulating the host immune cells of the intestine, which further activates the other cells by signal complex.

KEYWORDS
Probiotics, Bacteriocin, Lactic acid bacteria, Gut Disease

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INTRODUCTION

The gut microbiota plays a crucial role in developing the host's immune system, protecting against harmful microorganisms, and increasing the integrity of the gut. The important gut bacteria include Bacteroidetes, Firmicutes, Actinobacteria, and Proteobacteria (Zhang et al., 2015) Dysbiosis is a disease, that occurs when there is a disturbance in the normal balance of the gut microbial flora. This can be caused by various factors such as antibiotic use, an unbalanced diet, and infection. Various diseases such as inflammatory bowel disease (IBD), viral infections, and obesity are also linked to the imbalance of intestinal microbiota (Kim et al., 2019). These disturbances can lead to alteration in the gut microbiota, which in turn increases the risk of developing numerous serious diseases (Lange et al., 2016). Dysbiosis also leads to the emergence of diseases associated with immunological dysregulation, such as allergies, autoimmune disorders, and inflammatory conditions (D'Amelio and Sassi, 2018). Probiotics are the living bacteria that are used to treat the imbalance of intestinal microbiota, when consumed in sufficient quantities, they enhance the intestinal beneficial microbiota and give health benefits to humans (Binda et al., 2020).

Bacteriocin-producing probiotics colonize the gut and prevent the adherence of pathogens to intestinal epithelial cells by competing for food and producing inhibitory compounds (Figure 1) (Vieco-Saiz et al., 2019a). Bacteriocins have a distinct method of action compared to antibiotics since they eliminate target cells by creating pores and disrupting the cell membrane (Yang et al., 2014). In addition, bacteriocins possess a more simple biosynthetic process, and having a greater specific activity against microorganisms that are resistant to several drugs provides benefits for their use in medical treatments (Pérez-Ramos et al., 2021a). Bacteriocins are the proteins synthesized by ribosomes and are broken down by proteolytic enzymes. As a result, bacteria are unable to acquire resistance in the gut. Hence, the use of probiotics is an innovative strategy for treating various disorders such as enteric infections, and restoring a beneficial microbial community to promote health (Fong et al., 2020).

Gut Microbiota

The microorganisms that inhabit the digestive tract of humans including viruses, bacteria, and fungi are referred as Gut Microbiota. The gut microflora of mammals contains trillions of bacteria and around 500 different microbial strains

and some of the strains are used as probiotics. Microorganisms naturally reside on the skin, mouth cavity, vagina, and gastrointestinal system of humans by birth. Early infancy is a critical phase for the development of the microbiota, which is influenced by factors such as delivery method (vaginal versus cesarean section), gestational age, and usage of antibiotics throughout the perinatal period. Compared to cesarean section deliveries, vaginal births are linked to higher intestine colonization with *Bifidobacteria* but not *lactobacilli*. Conversely, greater colonization by hospital-associated microorganisms such as *Enterobacter*, *Klebsiella*, and *Clostridium* is linked to cesarean section births.

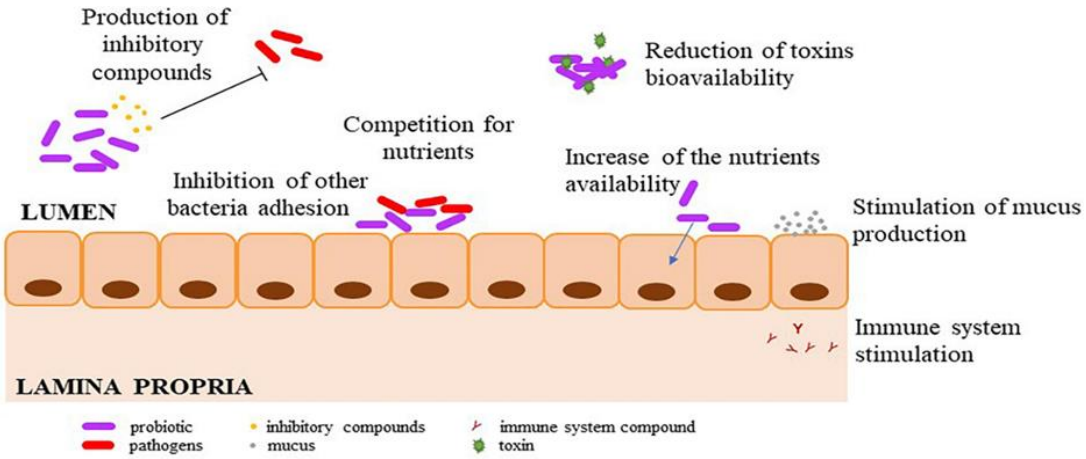

Fig. 1: Pathogen Inhibition mechanism by LAB, (Vieco-Saiz et al., 2019a)

Human microbiota changes during the course of life, from childhood to adulthood and old age. There appears to be a correlation between a lower microbial diversity during infancy and a higher chance of developing disease in later childhood. Reduced diversity of the gut microbiome is a common feature in several disorders that may be associated with dysbioses, necrotizing enterocolitis, chronic diarrhea, and IBD. Early exposure to specific bacteria and variations in the composition of the gut microbiome due to any factor have a lasting impact on an individual's health (Gareau et al., 2010a).

Probiotics

Probiotics are bacteria that have positive health effects on the host when consumed in a specific quantity. Their primary functions in the gut include modulating the immune system and maintaining the balance between beneficial and harmful microbes in the gut (Choi et al., 2010). The important probiotic includes many lactic acid-producing lactobacilli strains and several *Bifidobacteria*. Probiotics are typically regarded as safe for consumption, however, they may produce bacteria-host interactions and unpleasant side effects in rare situations (Gareau et al., 2010a).

Probiotic organisms have many beneficial impacts on intestinal epithelial cells. Certain strains can produce a mucus barrier by releasing mucus from goblet cells or by offering a physical barrier known as colonization resistance that prevents the entry of pathogens into the epithelial cell. They also help in maintaining the permeability of the intestine by more expression of the zona occludens (Gareau et al., 2010a).

Lactic Acid Bacteria

Lactic acid bacteria (LAB) are the important flora of the gut microbiota and have a crucial function in balancing the overall microbial population. Probiotic lactic acid bacteria (LAB) are a diverse collection of non-pathogenic, Gram-positive bacteria that do not produce spores and lack the enzyme catalase. They convert glucose into lactic acid, together with many growth-restricting compounds (Mokoena, 2017). They may be found in different foods such as fermented meats, seafood, drinks, and pickled vegetables, and in the oral and nasal cavities of humans. Significant genera in this context are *Lactococcus, Enterococcus, Streptococcus, Pediococcus, Aerococcus,* and *Lactobacillus*. Lactobacilli are the most abundant probiotics present in humans' gastrointestinal tracts. Sometimes, more than one probiotic is used to treat the disease and regain the host's normal microbiota. They produce different kinds of antimicrobial compounds which help in the prevention of disease (Table 1). Probiotic bacteria play a crucial role in immunoregulation by mediating the signal formation that activates other immune cells through intestinal immune system stimulation. Probiotics also lead to more IgA production which may stimulate interactions between dendritic cells and B and/or lymphocytic T cells (Anjana and Tiwari, 2022). In addition to LAB, *Bifidobacterium* is the predominant microorganism that colonizes the gut of the host and provides health advantages. (O'Callaghan and Van Sinderen, 2016).

LAB and *Bifidobacterium* are used as a cure for several gastrointestinal (GI) diseases. They limit harmful microbes, strengthen the GI barrier, and inhibit the production of proinflammatory cytokines (Xue et al., 2017). Apart from the lactic acid bacteria (LAB), other types of bacteria also prevail in the gut and have essential roles. For instance, the innocuous *E. Coli* Nissle, a probiotic often present in the gut, is mostly used to maintain a healthy balance of intestinal microbiota. It also stimulates the reestablishment of human β-defensin 2 synthesis, which can effectively protect the intestinal barrier against attachment of the pathogenic *E. coli* (Anjana and Tiwari, 2022).

Bacteriocin-producing LAB Bacteria

Lactobacilli bacteria that can produce bacteriocin, are used in treating several diseases of the GI tract. They prevent the colonization of the pathogenic bacteria in the human GI tract. When a bacteriocin-producing bacteria is administered orally, it does not alter the general structure of the gut, but it does cause some positive changes at a lower taxonomic level. However, some of these changes were reversed following the treatment (Umu et al., 2017). Probiotics, such as *Lacticaseibacillus casei*, and *Streptococcus thermophiles* may be taken orally and increase the expression of Ig-A and Ig-G in a way that depends on the dosage. When administered 8 days before infection with vancomycin-resistant *Enterococcus*, the use of nisin Z and pediocin AcH resulted in a decrease in pathogen colonization (Millette et al., 2008).

Table 1: Antimicrobial compounds produce by LAB

Molecule	Examples	Producer	Spectrum	References
Bacteriocins	Nisin	*Lc.lactis* subsp. l*actis*	Broad spectrum	(de Arauz et al., 2009)
	Pediocin PA-1	*Ped.acidilactic*	Broad Spectrum	(Rodríguez et al., 2002)
	Enterolysin AS48	*Ent.faecalis*	Gram-positive and many Enterobacteriaceae	(Karpiński and Szkaradkiewicz, 2013)
Bacteriocin-like		*Ped.acidikactic Kp10*	*L.monocytogenase*	(Wong et al., 2017)
inhibitory substances		*Leuc.mesenteroides 406*	*L.monocytogenase*	(Arakawa et al., 2016)
Antibiotic	Reutericyclin	*Lb.reuteri*	Gram-positive	(Rattanachaikunsopon and Phumkhachorn, 2010)
	Reuterin	Lb.reuteri DSM 20016	Gram-positive	(Stevens et al., 2011)
Organic acid	Lactic acid, acetic acid	LAB	Broad spectrum	(Vieco-Saiz et al., 2019a)

Bacteriocin, Abp118, which is produced by the *L. Salivarius* UCC118, has anti-listerial action in the gastrointestinal tract (Riboulet-Bisson et al., 2012). The *L. Plantarum* P-8 produces plantaricin, which leads to alterations in the fecal bacteria community in humans (Kwok et al., 2015). Thuricin CD, a bacteriocin, consists of two peptides, Trnα and Trnβ, and can kill several strains of *C. difficile* showing that it is possible to target difficult-to-treat bacteria without impacting the normal bacteria in the distal colon (Anjana and Tiwari, 2022b). Bacteriocin produced by lactic acid bacteria (LAB) has also shown great efficacy against foodborne pathogens such as *Listeria monocytogenes* found in the human gut (Harris et al., 1989; Millette et al., 2008).

Bacteriocins

Bacteriocins are small peptides, effective at low concentrations, and typically target closely related bacterial species, but there is evidence of some bacteriocins having a broader range of activity as well (Chi and Holo, 2018; Goyal et al., 2018). Bacteriocins modulate the levels of anti-inflammatory and pro-inflammatory cytokines via several signaling pathways and play a crucial role in maintaining the host's health via various actions (Sassone-Corsi et al., 2016). Bacteriocin-producing bacteria exhibit resistance to these antimicrobial peptides due to the presence of the immunity proteins on the cell membrane. There are three classes of bacteriocin, Class 1 referred to as lantibiotics, has a molecular weight of less than 5 kDa. They undergo posttranslational modifications, resulting in methyllanthionine formation. On the other hand, Class 2 is categorized as non-lantibiotics. They are heat stable and have a molecular weight of less than 10 kDa (Nishie et al., 2012). Class III comprises bacteriocins that are heat-stable, with a molecular weight of more than 30 kDa. Examples of Class III bacteriocins include enterolysin (Yang et al., 2014).

Bacteriocins have efficiency against several pathogens, making them beneficial in combating numerous human infectious disorders as shown in Table 2. Nisin has great efficacy in treating meningitis, and sepsis resulting from *Streptococcus pneumonia*. The cyclic bacteriocin griselimycin successfully eradicated tuberculosis (Anjana and Tiwari, 2022). Nisin inhibits cancer through ion channel formation on the cell membrane, resulting in the release of lactate dehydrogenase, and mitochondrial respiration disruption in cancer cells. Nisin, when used along with cancer medications, has been shown to have a synergistic effect in eliminating tumors (Preet et al., 2015).

Gut-Brain Axis and Microbial Community

The gut microbiota responds to the pattern of chemical messengers in the central nervous system (CNS) by secretion of different compounds (Anjana and Tiwari, 2022). The vagus nerve, which is tactile to deviated fibers, terminates in the nuclei within the brain stem. The brain stem nuclei may therefore affect a variety of bowel functions and transmit gestures to further CNS zones, including the cerebral cortex and midbrain (Wang and Wang, 2016)**.** Systemic blood flow can potentially facilitate an exchange between the central nervous system and the colon (Gibson and Mehler, 2019). The immunological and endocrine systems participate in duplex transmission halfway and sideways along the brain and microbiota axis (Borre et al., 2014). First, bacteria can replace, combine, and degrade neurotransmitters as well as transmodulators (Anjana and Tiwari, 2022). Additionally, cytokines and activator B cells in the host are produced by the gut microbiota, which operates as a harmful alternative to CNS (Alam et al., 2017). Therefore, through a variety of routes including antibody-mediated neuronal and endocrine systems, microbiota can affect the microbiota-gut-brain axis. Destruction, hypertension, and other coherent disorders may result from these neurological alterations in the brain. Changes in the gut microbiota have been linked to a number of neurological conditions. These include refractory epilepsy and neurodegenerative diseases (Nagpal et al., 2018).

Table 2: LAB involved in different bacterial disease treatment and immune modulation

Lactic acid bacteria	Bacteriocins	Target Pathogen	Animal Model	Reference
L. lactis	NisinZ	Immunomodulatory effect	Murine	(Millette et al., 2008)
L. lactis	NisinF	Respiration effect	Murine	(De Kwaadsteniet et al., 2009)
L. lactis	NisinZ	Enteric pathogen	Mouse	(Millette et al., 2008)
L. lactis	Nisin	Stress reduction	Mouse	(Jia et al., 2018a)
Lactobacillus salivarius	BacteriocinAbp118	Listeriosis	Murine	(Riboulet-Bisson et al., 2012)
L.salivarius NRRLB	BacteriocinOR-7	*Campylobacter jejuni*	Chicken	(Ilinskaya et al., 2017)
Pediococcus acidilactici	PediocinPA1	Listeriosis	Murine	(Dabour et al., 2009)
Enterococcus Mundtii RL35	EnterocinCRL35	Listeriosis	Murine	(Salvucci et al., 2012)

As of right now, no concrete data support the involvement of LAB in the gut-brain axis. On the other hand, some strains have the potential to modify the gut microbiota and hence indirectly impact the gut-brain axis. Some sequencing analyses revealed the correlation between the gut microbiota and the neurochemicals that influence communication between the gut and the brain (Jia et al., 2018a).

Immune Modulation

The immune system defends the gastrointestinal tract against invading microorganisms. The immune system primarily consists of mucosa-associated lymphoid tissue (MALT), and the epithelial layer. Interaction between dendritic cells and *Lactobacilli* in the human gastrointestinal tract activates the adaptive immune system, leading to the production of pro and anti-inflammatory cytokines. Probiotic strains' antigenic fragments have been exposed to M cells in Peyer's patches and intestinal epithelial cells, therefore modulating both the innate and adaptive immune system. Probiotic bacteria also play a crucial role in immunoregulation by mediating the signal formation that activates other immune cells through intestinal immune system stimulation. Probiotics lead to more IgA production which may stimulate interactions between dendritic cells and B and/or lymphocytic T cells (Gareau et al., 2010a)

The *Bifidobacterium breve* boosts the maturation and survival of the dendritic cells. The extended lifespan of dendritic cells (DC) is attributed to heightened amounts of antiapoptotic protein, ultimately enhancing the expression of CD86 and CD83 maturation markers. It plays a role in enhancing the immune response by increasing the ability of the antigen-presenting cells to stimulate the differentiation of the T-cells (Hoarau et al., 2006). Dendritic cells safeguard viable microbiota of the gut and transport germs to "mesenteric lymph nodes," leading to the generation of antibodies that protect against mucosal invasion (Macpherson et al., 2005; Macpherson and Uhr, 2004). The naïve T cells differentiated into several cell lineages, based on the interaction between dendritic cells (DCs) and certain pattern recognition factors. Cytophage-Bacteroides are necessary for the TH17 development in the lamina propria, contributing to maintaining the balance between regulatory T-cell populations and TH-17 cells (Delcenserie et al., 2008; Foligne et al., 2007). Nisin had an immunomodulatory impact, and prolonged treatment of nisin may potentially restore the equilibrium between B and T lymphocyte levels (Shin et al., 2016).

Role of Probiotics in the Treatment of Diseases

The gut microbiota dysbiosis leads to the development of multiple chronic illnesses, such as arthralgia, immune-mediated disorders, metabolic abnormalities, hepatic conditions, and different gastrointestinal ailments (Carding et al., 2015). The potential functions of probiotics in preventing diseases are shown in Figure 2**.** Bacteriocins produced by lactic acid bacteria and probiotics themselves could influence the composition of the host's microbiota, and immune system and contribute to the treatment of many diseases (Anjana and Tiwari, 2022)**.**

Colonic Infections

Bacteriocins-producing probiotics inhibit certain foodborne and clinical pathogens that cause serious illnesses. Bacteriocins function as pore formers, disrupting the potential of the cell and causing ATP to be expelled, ultimately resulting in the death of the cell. Therefore, the bacteriocins produced by LAB have the potential to be used as a substitute for conventional antibiotics in infection treatment (Li et al., 2022; Pérez-Ramos et al., 2021b; Sheoran and Tiwari, 2021). *Clostridium difficile* is the primary pathogenic bacteria responsible for colonic infection. The nisin exhibited a specific ability to deplete *C. difficile*. It is challenging to manipulate the fecal microbial ecology without impacting the existing gut microbiota (Papaconstantinou and Thomas, 2007). The GJ7 Kimchicin is manufactured by *L. Citreum* GJ7 suppressed the growth of *S. typhi* bacteria (Chang and Chang, 2011). The bacteriocin BM1829 is generated by the bacterium *L. Crustorum* MN047 suppressing the growth of *S. typhi* (Yan et al., 2021).

During the current era, viral infections have led to the occurrence of serious health issues. Several antiviral medicines have been developed and tried, and they have lately been shown to be effective in treating these infections. Nevertheless, these treatments exhibited toxicity and failed to achieve full symptom reduction. Bacteriocins have antiviral properties against many viruses by inhibiting the glycoprotein production during the last phase of virus replication (Anjana and Tiwari, 2022). Rotavirus, norovirus, and adenovirus are the primary causes of acute gastroenteritis in children under the age of 5. Rotavirus is a non-enveloped virus with double-stranded RNA that specifically targets and damages the epithelial cell lining in babies, leading to the development of diarrhea (Li et al., 2022).

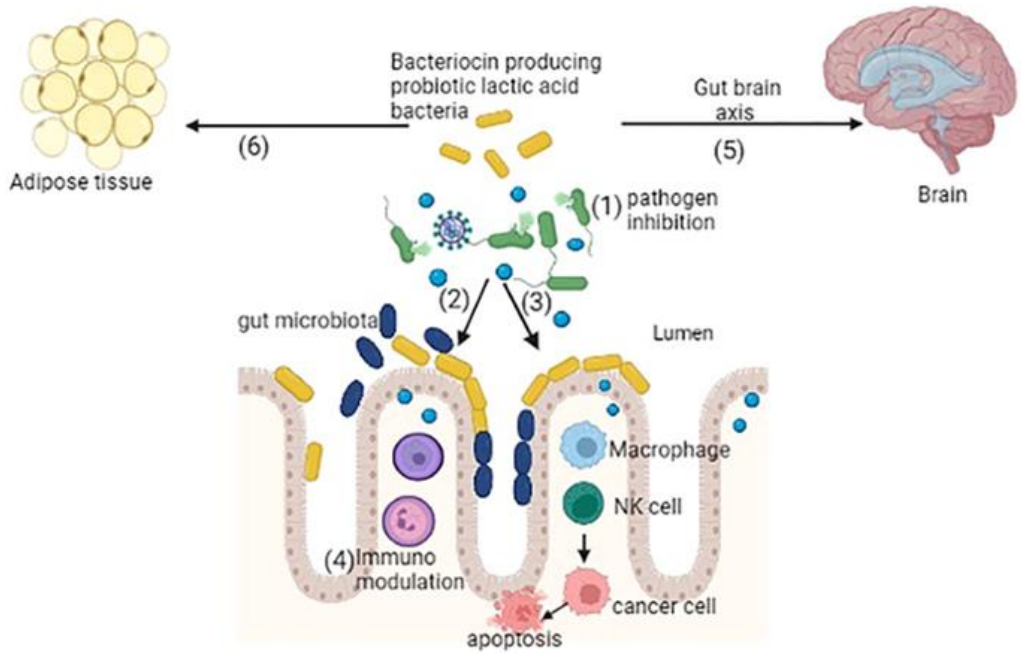

Fig. 1: Representing several potential functions of the Bacteriocin-producing probiotic lactic acid bacteria (1) Inhibition, (2) Colonization, (3) Immune cell activation, (4) Immune modulation, (5) Gut-Brain axis balancing, (6) Antiobesity Activity (Anjana and and Tiwari, 2022)

Bacteriocin prevents the several enzymatic activities that are essential to viral infection (Salman et al., 2020). The *Enterococcus faecium* CRL35 bacteria produces enterocin CRL35, which prevents the herpes simplex virus (Wachsman et al., 1999). Among enteric viruses, the norovirus possesses single-stranded RNA. After infection with the norovirus, the person has less Bacteroidetes and more proteobacteria. Influence on the gut microbiota composition is shown by the direct interaction between norovirus and proteobacteria isolated from feces samples. Furthermore, *L. casei* BL23 may prevent the virus's P-particles from attaching to epithelial cells (Salman et al., 2020).

Inflammatory Bowel Disease (IBD)

Inflammatory Bowel disease includes Crohn's disease (CD) and ulcerative colitis (UC). IBD is a chronic gastrointestinal disorder. It is currently unknown what causes inflammatory bowel disease. Depression, microbiological imbalance, and poor diet often make the problem worse. Still, a limited number of intestinal bacteria, like *Mycobacterium avium*, *C. concisus*, and *E. Coli*, are thought to be involved in the development of IBD (Toumi et al., 2021). The complicated origins of chronic inflammatory diseases, ulcerative colitis (UC), and Crohn's disease (CD) include hereditary genetics, environmental triggers, immune system changes, and aberrant gut microbiome response. A patient with dysbiosis has an imbalance of bacteria associated with certain diseases (Sidhu and van der Poorten, 2017). Although it is a potential treatment for IBD, fecal microbiota transplantation has limited effectiveness (Colman and Rubin, 2014).

Probiotics have been demonstrated to be effective and tolerable for people with IBD; nonetheless, it is unknown what bacteriocin's precise role and mechanism are. Inflammatory bowel disease (IBD) patients have a different microbiome than healthy individuals have (Shadnoush et al., 2015). Proteobacteria and Actinobacteria increased whereas Firmicutes, like *Faecalibacterium prausnitzi*, and Bacteroidetes decreased during IBD. To fight with infections, it is therefore essential to stabilise the gut flora. Probiotics that generate bacteriocins might be rather helpful as they encourage the development of a normal healthy microbiota (Gourbeyre et al., 2011). Probiotic supplementation, however, has been shown to be less successful in treating Crohn's disease than ulcerative colitis. Disturbance in gut microbiota leads to mucus layer changes, which increases the ability of bacteria to travel into the intestines, thereby triggering an immune response (Sicard et al., 2017). Bacteriocin directly kills or inhibits the pathogen, therefore preserving the structural integrity of the gut epithelium. It may also serve as a colonizing normal microbiota, helping *L. Reuteri*, a gut-dwelling bacterium species that generates reuterin, occupy niches in the intestine. Fungi and viruses are among the pathogenic microbes, inhibited by reuterin, and facilitate beneficial bacteria growth. Inflammatory bowel disease, probiotics, and the products of them, including short-chain fatty acids, significantly affect the immune system's reaction and the disturbance of the intestinal microbiological balance. The acidophilus strain isolated from breast milk reduced cholesterol, displayed competitive interactions with intestinal bacteria, and inhibited the growth of human colorectal adenocarcinoma cells (HT-29) (Toumi et al., 2021).

Colorectal Cancer

Colorectal cancer occurs when cells in the colon or rectum grow out of control. It is also known as "colon cancer." The colon is a big gut or bowel. The rectum is a canal that links the colon with the anus. The large intestine sections, the rectum, and the colon are the particular targets of colorectal cancer. The two main symptoms of this disease are a discernible drop in body weight and blood in the stool. The result depends on a number of factors, such as food, way of life, and the aging process itself (Center et al., 2009). *L. acidophilus* strengthens the immune response against colorectal

cancer. Among the substances released by probiotic bacteria include toxins, enzymes, and bacteriocins, all of which have been shown to combat cancer. The bacteria *Lactococcus lactis* synthesizes nisin A. In liver hepatocellular carcinoma (HepG2) lactis changes the structural integrity of the cell membrane and inhibits the growth of cancer cells. Nisin opens up the cell membrane and, via an innate process, starts apoptosis. Its ability to slow down the proliferation of melanoma cells also makes it an antimetastatic medication (Norouzi et al., 2018). Moreover, *P. acidolactici* K2a2-3 produces pediocin, which inhibits the development of human colon cancer cells (HT29) (Taherikalani and Ghafourian, 2021). Microcin causes caspase activation, phosphatidylserine release, DNA damage, and depolarization of the cell membrane (Baindara et al., 2018). Moreover, pediocin—produced by the bacterium *Pediococcus acidilactici* K2a2-3—was able to stop cancer cells. The dose of pediocin affect its ability to stop the proliferation of cancer cells. This suggests that colorectal cancer therapy may include bacteriocin, either directly or indirectly (Kaur and Kaur, 2015).

Obesity

It is one of the metabolic disorders closely associated with dysbiosis, an imbalance in the gut flora. Obesity is also influenced by a number of different variables including a poor lifestyle, hormonal imbalances, brain chemistry, and genetic and epigenetic modifications. The complex pathophysiology of obesity may help to explain why clinical obesity therapy is a significant public health policy concern. Although bariatric surgery has been shown to reduce body weight and treat comorbidities associated with obesity, it is a highly intrusive process. Adverse events are highly likely, and pediatric groups have safety concerns. Therefore, it would appear that the most effective way to treat obesity would involve a multimodal strategy that includes medication, behavior therapy, food modifications, and physical activity (Cerdó et al., 2019).

The gut microbiota is an important mediator between the host and the environment, controlling both fat deposition and energy homeostasis and probiotics help to control the flora of the stomach. Gut peptide signaling and neurological system modulation are two ways that gut bacteria affect calorie intake and satiety. The regulatory signaling peptide's balance may be upset if the gut flora changes. Thus, the re-establishing of the intestinal flora could be able to cure obesity. (Turnbaugh et al., 2008). Bacteriocin-producing probiotics reduce adipocyte size, increase the expression of genes linked to fatty acid oxidation, and reduce fatty acid absorption. *L. Plantarum* increases TNFα production and controls leptin hormone release. Probiotics control bacterial composition by generating bacteriocin, which affects obesity. Research is still needed to determine the best way to provide probiotics for the prevention or treatment of obesity, including the dosage, length of treatment, and long-term benefits of the various strains. (Million et al., 2013).

Adverse Effect

Probiotics are usually considered to be safe, however recent research has shown that they might not be the best choice for certain patient populations. For instance, probiotic-using children with short bowel syndrome and central venous catheters have sporadic reports of bacteremia, sepsis, and meningitis (Barton et al., 2001; Land et al., 2005). These people are more likely to experience the translocation of microorganisms, such as probiotic strains of live bacteria and fungi used in clinical settings. A probiotic mixture of six bacteria was administered intraduodenally to patients with severe pancreatitis who were receiving care in an intensive care unit (van Minnen et al., 2007). This human experiment did not lower the incidence of infectious complications of acute pancreatitis, despite preliminary animal research suggesting a possible benefit. Moreover, the population taking the probiotic formulation was found to have a markedly higher chance of poor outcomes. Necrotizing jejunitis was seen in the deceased patients. This discovery suggests that the splanchnic circulation may have already been weakened and that the proximal intestine may have been directly exposed to a large concentration of bacteria. Nonetheless, it is still unclear if using living organisms in high quantities puts some patient populations at an excessive risk of developing severe side effects, such as sepsis (Gareau et al., 2010b).

Conclusion

The bacteriocins are the small cationic peptides, produced by different lactic acid bacteria that has the ability to kill different pathogenic bacteria by pore formation. They had antimicrobial activity against many pathogenic bacteria of the human intestine including *Salmonella*, *Listeria*, *Clostridium*, and *Enterococcus*. They are also effective against diseases caused by viruses like noroviruses, rotavirus, etc. The gut is a very important human body part that helps in food digestion and stabilizing different functions. Most diseases of the gut are caused by an imbalance in the gut microbiota, i.e., IBD and obesity. Probiotics help in regaining the normal microbiota by providing food competition to pathogenic bacteria and the production of bacteriocin which has an antimicrobial affect on the pathogenic bacteria as well as they also boost the immunity of the host against pathogens.

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