An overview of the importance of probiotics in Health and Industry: A Mini Review

Running title: The importance of probiotics

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Abstract

Probiotics are living microorganisms that are mostly from the family of *Lactobacillus* and *Bifidobacterium* bacteria. These microorganisms are part of the natural intestinal microbiome. Many studies have shown that the consumption of a sufficient number of probiotics leads to the maintenance of the homeostasis of the intestinal microbiome through the strengthening of the immune and antioxidant systems, production of antimicrobial substances, various inhibitors as well as the competition with pathogenic agents. Although some of the mechanisms of probiotics have not been fully determined, its effect on the prevention and treatment of many diseases such as digestive problems, infections and even cancer has been proven. In addition to the direct effects of probiotics in the field of health, the use of these microorganisms in the field of industry also indirectly affects human health. Therefore, the purpose of this mini review article is to introduce probiotics and some of their roles in the fields of medicine and industry in improving human health.

Keywords: Probiotics, Microbiome, Health, Industry

Introduction

The first definition of probiotics was produced in 1965 by Lilly and Stillwell and was restricted to substances produced by bacteria that promote the growth of other bacteria. The current definition considers probiotics to be living microorganisms that must be ingested in a sufficient amount to have a positive effect on health that is not limited to the nutritional effects. Some inherent properties of probiotics include lack of toxicity and pathogenicity and the induction of health improvement in the host (1). The most important mechanisms of the effect of probiotics on the health of the human body are: 1: Strengthening the intestinal barrier by stimulating the production of occluding and claudin 1, which are essential proteins in the formation of tight junction (2).
2: Regulating the innate and adaptive immune response by producing anti-inflammatory cytokines and regulating the function of dendritic cells, macrophages and lymphocytes (3).
3: Reduction of intestinal pathogens by competing with these pathogenic microorganisms for binding to the receptors on intestinal epithelial cells and also the production of short-chain fatty acids, organic acids, hydrogen peroxide and bacteriocins (4,5).
4: Regulation of intestinal flora by increasing the number and diversity of specific bacterial strains. Intestinal flora (Microbiome) composition is dynamic and individualized depending on the influence of diet, exposition to ingested probiotic bacteria, environmental conditions of the intestine and other factors associated with the host that will include "transiently" some new strains in the ecosystem. Although gastrointestinal cells are continually exposed to microbial antigens and metabolites, we live in perfect symbiosis with these microorganisms. This arrangement is made possible through various elements. Several reports have validated the fact that manipulating the gut microbiota using probiotics as well as fecal material transplantation may affect host metabolism (6). Today, researchers are focusing on the beneficial effects of different species of probiotics, such as *Lactobacilli*, *Bifidobacteria*, and yeasts. A group of these probiotics is listed in figure 1(1,3). Therefore, in this mini-review, we focused on a number of applications of probiotics in the field of health and some industries.

Probiotics: disease prevention and control

Antibacterial effect of probiotics

Some studies showed the antibacterial and antioxidant effects of probiotics by strengthening the antioxidant system and the body's immune system. In two separate studies, after contaminating hands with *Staphylococcus aureus* and *Pseudomonas aeruginosa*, the total level of the body's antioxidant capacity, glutathione, and glutathione peroxidase activity were decreased. This difference was adjusted in both research groups after treatment with *Saccharomyces boulardii* and *Saccharomyces cerevisiae* respectively (7,8). Mahpishanian et al induced osteomyelitis in the thighs of rats after *Staphylococcus aureus* injection. In the radiographic and histopathological images, the spread of inflammation and infection was clearly evident. But after treating the rats with *Lactobacillus Plantarum* reduced the severity and spread of the disease and the level of interleukin 6 decreased to some extent (9).
Many probiotics are able to produce a lot of molecules that may be considered similar to, but differ from, antibiotics. Such molecules are commonly defined as anti-microbial peptides. In particular, *Lactobacilli* produce a broad spectrum of proteins and peptides called lantibiotics, with variable antimicrobial activity and low or absent phenomena of antibiotic resistance. The main lantibiotics are grouped under the name of bacteriocins, bioactive peptides with bactericidal activity on species belonging to the same species (Or similar) of their producer, generated by both gram positive and gram-negative bacteria during the primary growth phase. Bacteriocins are promptly released by bacteria after their production and it has been hypothesized that they mostly act in forming pores

in the phospholipid layer of the cytoplasmic membrane of the antagonized bacteria, and so lead the bacterium to death due to the subsequent unbalance of its internal environment (10). The effect of enterocin AS-48, nisin A&V and pediocin A on improving infections caused by *lactococcus garvieae* and *listeria monocytogenes* has been proven in the fishes and mice respectively (11,12). Currently, three categories of bacteriocins have been identified, each category including several subcategories. Figure 2 lists the classes of bacteriocins and the molecular characteristics of each class (4).

Probiotics and gastrointestinal diseases

The microbiome of the intestinal mucosa helps the metabolism and digestion of fats, proteins and carbohydrates. Metabolic advances have shown that there is a relationship between healthy and diseased mucosal microbiota with food sources. Today, various probiotic strains are used clinically to treat various complex and inflammatory gastrointestinal diseases (13).

Helicobacter pylori is one of the common pathogens causing chronic gastritis and peptic ulcer disease, which, if untreated, is prone to developing gastric adenocarcinoma and lymphoid tissue lymphoma. Certain types of probiotics can survive in the stomach and inhibit *Helicobacter pylori* by mechanisms such as inhibiting growth by secreting antibacterial substances, inhibiting areas enzyme activity, reducing the ability to adhere to the gastric epithelium, and regulating the host's immune responses. (14).

Irritable bowel syndrome (IBS) is the most common functional disorder of the digestive system. The treatment of this disease is much related to lifestyle modification, including stress reduction, diet regulation and exercise. But it seems that probiotics can be suggested as a therapeutic approach for IBS by stimulating the host's immune system, increasing intestinal permeability to nutrients and maintaining the composition of intestinal microbiota (14).

Another disease in which microbiome imbalance likely plays an important role is an inflammatory bowel disease (IBD) (Including Crohn's disease and ulcerative colitis). Because significant changes have been observed between the bacterial, fungal and viral population in the intestinal microbiota of these people and healthy people. In this disease as well, probiotics can be suitable candidates for treating IBD by reducing inflammation, improving the function of the mucous barrier and strengthening the immune system (15).

One of the common digestive diseases, especially in children, is acute gastroenteritis, which is often caused by an infection. The symptoms of this disease include nausea, vomiting, watery stools and abdominal pain. Studies have shown that by inhibiting the secretion of pro-inflammatory cytokines, *S. boulardii* leads to a significant reduction in the symptoms of the disease, especially diarrhea (16).

Chronic idiopathic constipation affecting colonic or anorectal function affects approximately 14% of the population worldwide. Drug side effects, gastrointestinal dysfunction related to the intestinal nervous system can be causes of constipation. Although lifestyle changes and eating habits, the use of bulking agents, stool softeners, stimulant laxatives, and the prescribing of stimulant drugs by doctors are among the treatments used, the treatment of constipation is currently still challenging. Several studies have shown that supplements containing strains of *Lactobacilli* and *Bifidobacteria* help relieve constipation by increasing bowel movements (16, 17). Table 1 lists the beneficial effects of strains of probiotics in the treatment of a number of gastrointestinal diseases (18)

Probiotics and skin Health

As the largest organ of the body, the skin plays an important role in human health by preventing the invasion of pathogens. Although many microbial species successfully colonize the skin, the skin microbiome consists of a variety of microorganisms that interact with each other to maintain skin health. Probiotics are very helpful in preventing chronic diseases by mediating their effects. They show positive effects in skin-related problems such as burns, scars, infections, and wounds. They increase the skin's innate immunity and help to regenerate healthy skin (19). Skin microbiota act as a defensive barrier and can regulate the skin's inflammatory response to minor epidermal injury by decreasing and promoting cytokine production to maintain healthy skin. Skin injuries cause disturbance in microbiota levels and increase the prevalence of bacteria that exert adverse effects on wounds. The process through which probiotics show positive effects includes directly killing the pathogen, increasing the epithelial barrier, competitive displacement of pathogenic bacteria, and induction of fibroblasts. (20).

Atopic dermatitis (AD) is a common inflammatory skin disease in the early stages of life that is associated with food allergies and asthma. The symptoms of this disease are a decrease in barrier function and a general decrease in trans-epidermal water loss (TEWL), which leads to dry and itchy skin. A relationship was observed between the microbiota and this disease, so that in infants with atopic dermatitis, clostridia showed a higher number than in healthy infants. In this study, the combined supplement of *Lactobacilli* led to a reduction in the severity of eczema in affected children (21).

Acne is one of the skin infections that *A. Vulgaris* and *P. acnes* are common pathogens in causing this disease. A number of studies showed that using a mixture of probiotics (*L. acidophilus*, *B. bifidum* and *L. delbrueckii*), inflammatory symptoms are significantly reduced. In addition, CBT SL-5(an antimicrobial compound produced by E. faecalis) reduced inflammation (22, 23). In Table 2, the effect of a group of probiotics on the healing allergic contact dermatitis (ACD), psoriasis and photoaging is also reported (22).

Probiotics and anti-cancer effect

Cancer is known as one of the main causes of human mortality in the world, and genetic and immune factors play an important role in its development. Considering that the imbalance in the intestinal microbiota causes pro-inflammatory immune responses and subsequently the development of various diseases, including cancer, the correct functioning of the microbiota can maintain the homeostasis of the body. Probiotics could be used as an adjuvant for various types of cancers based on their potential to modulate enteric flora and enhance innate and adaptive immunity. They prevent the initiation, progression, and metastasis of transplantable or chemically induced tumors (24,25). The interaction of probiotics and their metabolites (bacteriocins, peptides, and organic acids) with critical metabolic pathways such as cellular proliferation, inflammation, apoptosis, angiogenesis, and metastasis has been revealed by many researchers. Moreover, the probiotics inhibit carcinogenesis by inhibiting pathogens through competitive exclusion, increasing short-chain fatty acid production, binding carcinogens and mutagens, down-regulating NF-kappa B dependent gene products for cell proliferation (Cox-2, cyclin D1) and cell survivability (Bcl-3, Bcl-xl) and enhancing apoptosis (26). Probiotics have been demonstrated to inhibit hepatocellular carcinoma progression by reducing liver tumor size and down-regulating angiogenic factors. In breast cancer apart, from immunomodulation, the hypoxia-inducible factor pathway was also reported to be significantly suppressed by *Lactobacillus* culture supernatant (27). In a study, cell residues and supernatant of *Saccharomyces boulardii* were injected into breast tumors after induction of breast cancer in rats. After the treatment period, the resulting changes in hematological factors were moderated, BAX concentration was significantly increased and BCL-2 decreased compared to untreated cancerous rats. The researchers suggested that due to the decrease in the size of the tumors, apoptosis was probably induced in the cancer cells (28). The results of a number of clinical studies have shown the effectiveness of probiotics in reducing the progression of various types of cancer. These results are listed in Table 3 (25).

Application of probiotics in the industry

Probiotics and food industry

The public awareness of diet-related issues and ever-increasing evidence about the probiotic health benefits have increased consumer interest in probiotic foods. A large number of food items, including yogurt, powdered milk, frozen fermented dairy desserts, cheese and cheese products, ice creams, baby foods, cereals, and fruit juices, are among numerous probiotic foods (29). The most prominent barrier to using probiotics in the food industry is their sensitivity to heat treatments during processing, their vulnerability to stomach acid and digestive enzymes and delivery of sufficient live probiotics to the intestines. The most widely used technique to preserve probiotics used in various foods is to encapsulate them in biopolymer materials (30). The carrier particles in these systems can be designed in a number of ways to improve probiotic viability. First, they may be designed to form a physical barrier that protects the probiotics from any problematic components in the surrounding environment such as gastric acids, bile salts, or digestive enzymes. Second, the microparticles may be designed to trap specific components excreted by the probiotics that are beneficial to their survival. Third, they may be designed to contain additives that provide a favorable local climate for the probiotics such as antiacids to control the local pH. Finally, they may be designed to microencapsulate the probiotics with specific nutrients that help the probiotics to survive such as digestible carbohydrates, dietary fibers, proteins, lipids, or minerals (31).

In the food industry, various materials are used to encapsulate probiotics. Some of these materials are: 1. whey protein; It is a rich source of proteins that has the potential to create intermolecular cross-links with carbohydrate biopolymers to increase the stability of microcapsules. Adding lignin to whey protein not only helps to preserve the survival of probiotics, but also causes their slow release in the digestive system. 2. Soybean protein; Whey protein causes allergies in some people, so soy vegetable protein is another candidate for producing microcapsules. The characteristics of this protein are availability, usefulness, similarity with the extracellular matrix and low immunogenicity. 3. Alginates; alginates are natural polysaccharides containing mannuronic and guluronic acid residues. Due to having a negative charge in aqueous solutions, they are able to form complexes with positively charged gelatin polymers. 4. Gum Arabic; gum Arabic is a vegetable gum prepared from *Acacia branches*. Due to its good solubility in water, emulsifying properties and low viscosity, it is widely used in the food and pharmaceutical industry. 5. Chitosan; chitosan is a natural polysaccharide that together with xanthan creates an encapsulation system resistant to digestive enzymes and low pH (32).

Probiotics and cosmetic industry

The two phenomena of aging and exposure to ultraviolet radiation due to the increase in pH of the skin, decrease in the level of collagen and elastin in the skin, changes in immune and inflammatory responses, decrease in the level of antioxidants and the production of reactive oxygen species (ROS), as well as changes in the skin microbiome are the main factors in skin aging (33).

Dry skin is one of the important signs of skin aging, which is related to the surface evaporation of the skin due to the weakening of the epidermal barrier function and the destruction of the sebaceous membrane. A group of microorganisms such as *Streptococcus thermophilus* S244 and *Streptococcus salivarium* spp. has hydrating enzymes that use them in cosmetic formulas to reduce skin dryness (34). Nakai et al., 2019 showed that *Lactobacillus plantarum L-137* cell fluid activates the NFκB signaling pathway by producing the cytokine IFN. By increasing the expression of hyaluronate mRNA synthase in fibroblasts, through this cytokine, the production of hyaluronic

acid increases and skin moisture is maintained (35). In another study, the role *of Streptococcus thermophilus* in keeping the stratum corneum flexible by increasing the ceramide of the stratum cornea was reported (36).
The excessive increase of free radicals in skin cells that are exposed to UV light leads to lipid peroxidation and ultimately the production of lipofuscin, which indicates cell aging. Therefore, elimination of many ROS is necessary to prevent aging (37). Researches have shown that creams containing *Lactobacillus fermentum TKSN041* and heat-inactivated *Lactobacillus acidophilus* can prevent wrinkles by strengthening the skin's antioxidant system, producing anti-inflammatory cytokines (such as IL-10), regulating ROS levels, and inhibiting MMP (38,39). Lipopolysaccharides and lipoteichoic acid extracted from extracellular vesicles of bacteria increase skin elasticity and maintain cell shape by inhibiting MMP-1 and elastase activity (40, 41). In addition, the lactic acid present in lactobacilli inhibits the tyrosinase enzyme, reduces the formation of melanin in the cells, and removes the darkening of the skin (42). Today, the use of probiotics has increased in many cosmetics and skin care products due to their anti-aging, anti-wrinkle, antioxidant and hydrating properties. Table 4 lists the beneficial effects of a number of probiotics used in cosmetic products (42).
Probiotics and Agriculture industry
Modern agricultural practices have negatively affected the soil ecosystem due to factors such as intensive tillage, commercial fertilizers and chemical pesticides. Microorganisms break down organic and inorganic waste in the soil through the process of bioremediation. Fungi are the dominant species in the soil ecosystem and remove carbon sources and bioabsorbent heavy metals from contaminated soils. In addition (43). Heavy metals are non-degradable compounds that persist in numerous organic and inorganic forms. Some heavy metals such as Fe, Cu, and Zn are essential trace elements, but others such as cadmium, Lead and Mercury declared to be toxic even in traces Accumulation of heavy metals in human organs has an adverse impact on human health. (44). The use of heavy metals in various industries, especially agriculture can release them into the soil, air and water. When human ingested food or water contaminated with heavy metals, the acid medium of the stomach acidified them. Further, they oxidized to their numerous oxidation states. These radicals are able to bind to different molecules in biosystem such as proteins and enzymes forming stable and strong bonds (45). Probiotics was reported to adhere strongly to intestinal mucosa, has a strong antioxidative and immune regulatory capability, tolerate gastrointestinal fluid, and repress pathogen development (46). In a study, a group of rats were poisoned with aluminum. After treating rats with *Saccharomyces boulardi* and *Saccharomyces boulardi* enriched with selenium, the disorders caused by aluminum poisoning were reduced. So that's a total iron-binding capacity and the total antioxidant capacity returned to normal levels. In this research, the decrease in the concentration of malondialdehyde showed that probably the strengthening of the body's antioxidant system by the treated probiotic prevented the increase in oxidative stress in this group of rats (47). According to the conducted studies, the negative charge on the wall surface of probiotics can destroy positively charged heavy metals and remove them from the environment. Therefore, in a group of studies, the possibility of removing heavy metals from the body of living organisms has been evaluated. Kidneys are one of the most important organs related to the excretion of heavy metals. In the research conducted by Fatemi et al. Many anomalies were observed at the level of hematological factors, histopathology and parameters related to kidney function, including uric acid, creatinine and urea. Studies on antioxidant factors also showed disruption in the activity of catalase, glutathione, peroxidase and glutathione concentration, which indicated an increase in oxidative stress in the body and only through lead

poisoning. Following the treatment of rats poisoned with *Lactobacillus fermentum*, the improvement in the tissue structure of the kidneys and the measured factors was well evident. By observing a decrease in the content of lead in the blood and an increase in the feces of the group of mice treated with probiotics, these researchers suggested that the binding of lead to the wall of the probiotics may have helped to remove lead from the animals' bodies (48, 49).

Conclusion

Probiotics help regulate the intestinal microbiome by strengthening innate and adaptive immunity through the production of antioxidant and anti-inflammatory compounds as well as the competitive elimination of pathogens. An imbalance in the intestinal flora leads to a wide range of diseases, from digestive disorders to cancer. Therefore, a lot of research has been focused on the impact of probiotics on human health in medical fields and various industries, including food and pharmaceutical industries. The most important challenge in these fields was the lack of stability and sensitivity of these microorganisms to heat and pH. Currently, the most widely used method to protect probiotics is to encapsulate them in biopolymers such as whey protein, gum Arabic, soybean protein, alginates and chitosan in the form of microcapsules.

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Author Contributions

Mahnoosh Fatemi contributed to the conception of the manuscript; All authors performed the literature search and critically revised the work. Mahnoosh Fatemi edited the final draft.

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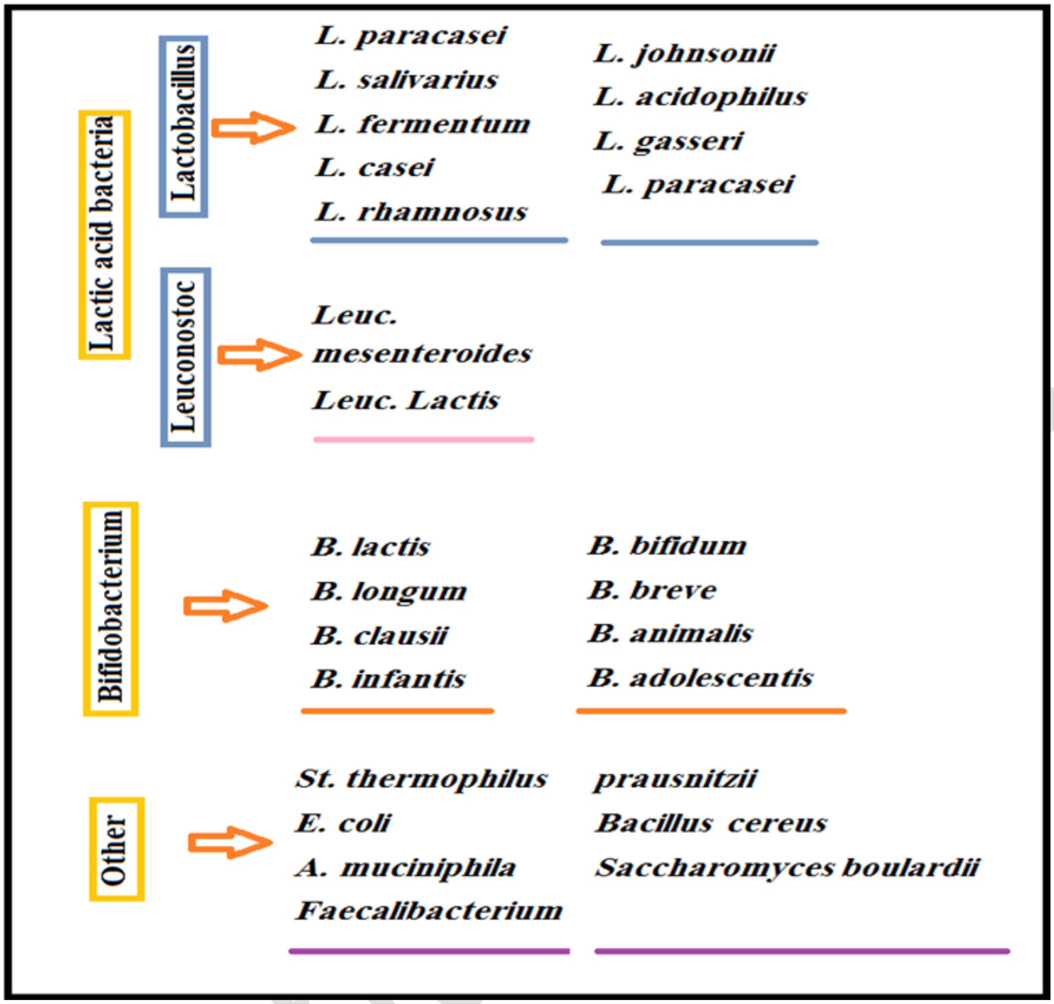

Figure 1. A number of species of probiotics

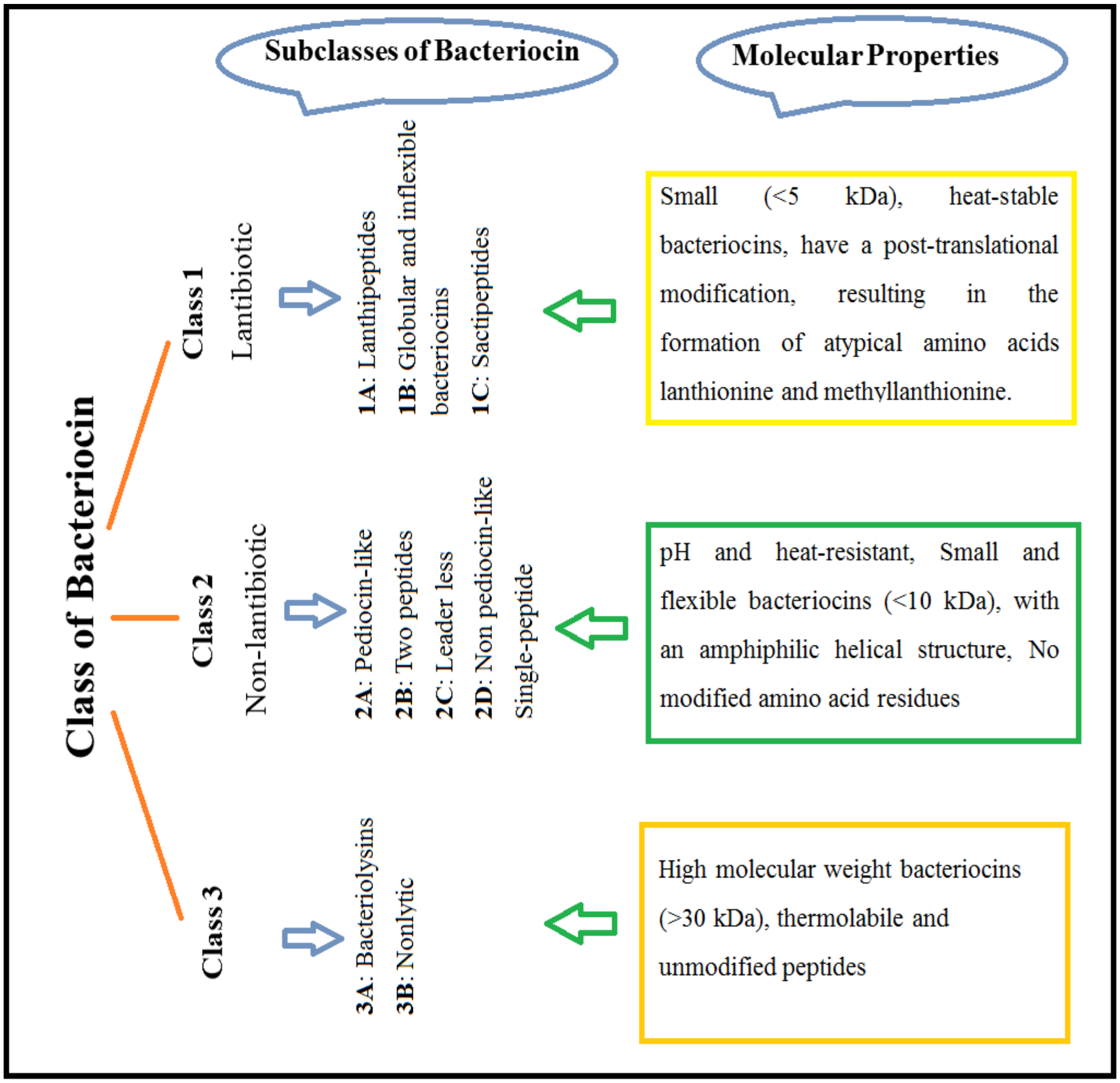

Figure 2. Classification of bacteriocins

Table 1. A variety of probiotics effective on a number of gastrointestinal diseases

Gastrointestinal diseases	Probiotics
Acute infectious diarrhea	*Lactobacillus rhamnosus GG, Saccharomyces boulardii*
Acute pancreatitis	*Bifidobacterium animalis subsp lactis, L.casei B. bifidum, B. Jongum, L. delbrueckii , Enterococcus faecalis, L.acidophilus, L. paracasei, Leuconostoc cremoris, Leuconostoc mesenteroides, Pediococcus pentosaceus, Streptococcus salivarius, Streptococcus thermophilus*
Antibiotic- associated diarrhea	*Bacillus coagulans, Bifidobacterium animalis subsp lactis, B.bifidum, B. longum, Clostridium butyricum, Enterococcus faecium, L. acidophilus, L.casei, L. delbrueckii, L. paracasei, Leuconostoc cremoris Saccharomyces boulardii, Saccharomyces florentinus, Streptococcus thermophilus*
C.difficile- associated diarrhea	*Bifidobacterium animalis subsp lactis, B. longum, Clostridium butyricum, L.acidophilus, L.casei, L. delbrueckii, L. paracasei, Saccharomyces boulardii, Streptococcus thermophilus*
C.difficile infection	*Bifidobacterium animalis subsp lactis, B.bifidum, B. longum Clostridium butyricum, Enterococcus faecium, L.acidophil L.casei, L. delbrueckii, L. paracasei, Saccharomyces boulardii 'Streptococcus thermophilus*
Chemotherapy- associated diarrhea	*Lactobacillus rhamnosus GG*
Colic	*Lactobacillus reuteri*
Crohen disease	*Bifidobacterium animalis subsp lactis, E. coli, B.bifidum, B. Jongum, L.johnsonii , L. acidophilus, L. delbrueckii, L. paracasei, Saccharomyces boulardii Streptococcus thermophilus*
Functional abdominal pain	*Bifidobacterium animalis subsp lactis, B. longum, L.acidophilus, L.casei, L. delbrueckii, L. paracasei, Streptococcus thermophilus*
Functional constipation	*Bifidobacterium animalis subsp lactis, B. longum, L.casei, L. delbrueckii, Streptococcus thermophilus*
Helicobacter pylori infection	*Bifidobacterium animalis subsp lactis, L.gasseri, L.acidophilus, L.casei, L. delbrueckii, L.johnsonii, Streptococcus thermophilus*
Hepatic encephalopathy	*B. longum, E. coli, L.acidophilus, L.casei, L. delbrueckii, L. [paracasei, Leuconostoc mesenteroides, Pediococcus pentosaceus, Streptococcus thermophilus*
Irritable bowel syndrome	*Bifidobacterium animalis subsp lactis, Enterococcus faecalis, B.bifidum, B. longum, E. coli, L.acidophilus, L. delbrueckii, L. iparacasei, L.lactis, Streptococcus thermophilus*
NAFLD/NASH	*Bifidobacterium animalis subsp lactis, B. longum, L.acidophilus, L.casei, Streptococcus thermophilus*
Necrotizing enterocolitis	*Bacillus cereus, Bacillus subtilis, Bifidobacterium adolescentis, Bifidobacterium animalis subsp lactis, B.bifidum, B. longum*

Table 2. Probiotics and their effect on skin diseases

Probiotics	Disease	Function
L. rhamnosus	*Atopic dermatitis (AD)*	Improvement of severity of eczema, reduction of risk of AD development in infants
L. reuteri	AD Infections (S. aureus)	Improvement of eczema. Blocks integrin, Reduces cell death due to S. aureus infection
L. delbrueckii Subspecies bulgaricus	Acne	Improvement of Acne symptoms (Acne Vulgaris)
L. sporogenes	Psoriasis	Improvement of symptoms, reduction of blood sugar levels and fever
E. coli Nissle 1917	ACD	Increase of TGF-, Foxp3, IFN-y and IL-10 expression
L. fermentum	Infections (Wounds)	Production of nitric oxide, increases productions of Interleukin 1 (IL-1) and Transforming Growth Factor B (TGF-B) cytokines
L. casei *L. salivarius*	ACD, Infections Methicilin Resistant S. aureus (MRSA)	Reduction of skin inflammation, inhibition of IFN-y, CD8+ T cells, increase in IL-10 production,
B.bifidum	AD Acne	Reduction of Ig-E, reduction of development of AD in infants, reduction of *Acne Vulgaris* symptoms
B. lactis	AD	Reduction of Ig-E, Reduction of development of AD in infants
B. breve strain yakult	Photoaging	Prevention of loss of elasticity, suppression of elastase, activation of IL-1
B. infantis	Psoriasis	Reduction of plasma TNF-y, increase of IL-6
S. epidermidis	Acne	Growth inhibition of *P.acnes* and Acne Vulgaris by competitive exclusion
E. faecalis	Acne	Reduction of inflammation areas, production of bacteriocins

Table 3. Clinical studies in the cancer prevention and the treatment using probiotics

Probiotic Strain	Subject	Time Treatment	Effect
Bifidobactrum breve yakult	42 patients during chemotherapy	6 weeks	Reduce the incidence of fever Reduce the need for intravenous antibiotics using compared to the control group
Bifidobactrum longum	60 patients with colorectal cancer undergoing colon resection	3 days	Increase the count of bacteria of the Bifidubactrum genus. Reduce the count of bacteria of Escherichia genus
L.plantarum CGMCC, L.acidophilus-11, Bifidobactrum	150 patients with colorectal cancer	6-10 days	Reduce the serum zonulin concentration, Reduce duration of postoperative pyrexia, Reduce duration of antibiotic therapy Inhibited the p38 (mitogen-activated protein kinase)
L.acidophilus, L.plantarum, B. lactis, S. boulardii	164 patients with colorectal cancer undergoing surgery	4 weeks	Reduce the risk of postoperative complications A positive correlation was observed between the expression of the SOCS3 gene and the expression of the TNF gene and IL-6.
Lactobacillus acidophilus L1	180 people with bladder cancer and 445 controls	10 weeks	Reduce the risk of bladder cancer correlated with habitual intake of lactic acid bacteria
L. rhamnosus LC 705, P.freudereichii subsp. shermanii	90 male students with high aflatoxin level in urine	5 weeks	61.5% reduce a liver cancer biomarker which leads to reduced urinary excretion of aflatoxin B1-N7guanine (AFB-N7- guanine)
Lactobacillus gasseri OLL2716 (LG21)	10 people with colorectal cancer and 20 controls	12 weeks	Increase the number of Lactobacillus genus Increase synthesis of isobutyric acid, Increase NK cell activity. Reduce the amount of *Clostridium perfringens.*
Lactobacillus casei shirota (LsC)	54 women with an HPV-positive intraepithelial lesion	6 months	60 % reduce in human papilloma virus (HPV) associated infection and cervical cancer precursors
Streptococcus thermophiles and L.delberuckii	Bulgaricus 45241 healthy people	12 years	Reduce the risk of colorectal cancer correlated with increased consumption of yogurt (Especially in men).

Table 4. A selection of cosmetic products containing probiotics

Probiotics and their products	Type of cosmetic product	Cosmetic Effects
Lactobacillus ferment extract	Lotion	Skin feels soft, moisturized, and revitalized. Restores skin barrier function and seal in moisture on the skin's surface
A lysate from *Bifidobactrum longum*	Toner	Maintain the balance between the skin's water and oil content. Improved skin stability. Revitalize and repair skin.
Alteromonas baumann ferment extract	Cream	Multidimensional repair of skin fragility and relieving skin discomfort.
Lactobacillus/soymilk ferment filtrate	Cream	Intensive moisture lock water and reduce skin moisture loss. Balance skin flora and improve skin health.
Vitreoscilla ferment	Mask	Repair skin barrier, and relieve redness and discomfort.
Lactobacillus/soymilk ferment filtrate, *Bifidobactrum longum* lysate	Lotion	Regulate skin flora, strengthen the micro-ecological barrier, and improve skin condition
Lactobacillus ferment extract	Gel	Balance the micro-ecological barrier to help reduce repeated breakouts.
Bifidobactrum/soybean ferment/ *Lactococcus* /milk ferment	Cream cleansing	Maintain skin elasticity and permeability.
Lactobacillus/ soy milk ferment filtrate	Cleaning serum	Help restore the dynamic balance of bacteria on the skin surface and create a stable skin microenvironment.
Lactococcus lactic fermentation lysate	Serum	Reduce skin redness, acne, and sunburn. Restore skin elasticity.
B. longum/L. ferment lysate, *Streptococcus thermophiles* ferment	Cleaning	Regulate skin pH.
Bifidobactrum longum lysate	Cream	Accelerate collagen regeneration and effectively improve skin fullness.
Lactobacillus	Mask	Enhance the outer strength of the skin.
Lactococcus ferment extract Yeast cytolytic extract	Lotion	Enhance wrinkles, unwind, and keep skin looking young.