DOI: 10.1515/cipms-2016-0002

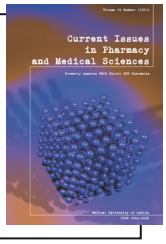
Curr. Issues Pharm. Med. Sci., Vol. 29, No. 1, Pages 8-10

DE GRUYTER OPEN

Current Issues in Pharmacy and Medical Sciences

Formerly ANNALES UNIVERSITATIS MARIAE CURIE-SKLODOWSKA, SECTIO DDD, PHARMACIA

journal homepage: http://www.curipms.umlub.pl/



Characteristics of oral probiotics – a review

Renata Chalas[1*], Magdalena Janczarek[1], Teresa Bachanek[1], Elzbieta Mazur[2], Maria Cieszko-Buk[1], Jolanta Szymanska[3]

[1] Chair and Department of Conservative Dentistry and Endodontics, Medical University of Lublin, Poland
[2] Chair and Department of Medical Microbiology, Medical University of Lublin, Poland
[3] Chair and Department of Paedodontics, Medical University of Lublin, Poland

ARTICLE INFO

Received 27 November 2015
Accepted 11 December 2015

Keywords:
probiotics,
oral cavity.

ABSTRACT

Probiotics are a group of microorganisms able to have a positive influence on a host organism when applied in adequate amounts. They are grouped either as: bacteria (mainly *Lactobacillus spp* and *Bifidobacterium*) or fungi (*Saccharomyces boulardii*). Recent studies have revealed many opportunities for their use in several fields of medicine, such as in: reducing the level of cholesterol in the body, cancer therapy, human immune system regulation, skin regeneration, pancreas necrosis, cirrhosis of liver treatment, regulation of post-antibiotic bowel function, constipation and digestive disorders in infants. Probiotics efficacy has also been demonstrated in oral cavity malfunctions. With the use of modern scientific methods, probiotics have the potential to become an important part of the daily diet and a natural drug supplementation in severe diseases.

Oral microbiota are implicated in a variety of systemic conditions. In recent years, an increasing interest in probiotics from an oral health perspective has been aroused among dental researchers. The term "probiotic" means in Greek "*pro bios*" which, in turn, means "for life", and the history of probiotics is like a history of mankind. Nowadays, the most accurate and contemporary definition is delivered by the Food and Agriculture Organization of the United Nations/World Health Organization and is accepted by the International Scientific Association for Probiotics and Prebiotics. Accordingly, probiotics are: "a group of microorganisms able to have a positive influence on the host organism when applied in adequate amounts" [17]. The medical term "probiotic" was first introduced in "Science" magazine, in 1965 [11]. From that time onwards, the global market of probiotic products has been growing, and, today, reaches approximately 20 billion [17].

The oral cavity is the first part of the gastrointestinal tract, hence, it is rational to believe that some probiotics can significantly influence the oral microbiota [2]. Currently, three major ways of action of probiotics have been revealed. The first one is a competition for nutrients and for ecological niche, so probiotics can have a direct effect on other microorganisms. The second mechanism is the production of bacteriocins. These substances (hydrogen peroxide or reuterin) inhibit the growth of other bacteria, and such action may result in the inactivation of toxins. The third mechanism is the stimulation of specific and nonspecific immune response by T-cell activation, to cytokine production. This mode of action is most likely important in the prevention and therapy of infectious diseases [4,17].

The aim of the study was to present information about safe probiotics as used in human oral health practices.

The following probiotics have been generally recognized as safe by the Food and Drug Administration in the United States: *Lactobacillus reuteri* DSM 17938; *Lactobacillus acidophilus*, *Lactobacillus lactis*, *Pediococcus acidilactici; Lactobacillus casei* subsp. *rhamnosus* GG; *Bifidobacterium longum* BB536; *Bifidobacterium lactis* Bb12 and *Streptococcus thermophilus* Th4; *Carnobacterium maltaromaticum* CB1; *S. cerevisiae* ML01 and *Saccharomyces cerevisiae* ECMo01 [4,18]. The most popular strains are represented by *Lactobacillus*, *Bifidobacterium* and *Streptococcus* genera.

LACTOBACILLUS SPECIES

Lactobacillus acidophilus can transform lactose into lactic acid. As a component of the intestinal microflora, this bacterium counteracts pathogen activity and also participates in the production of niacin, folic acid and vitamin B6. In general, *L. acidophilus* is applied to the food during the production of dairy products. It has also been observed in the animal (and also the human) alimentary tract, especially the oral cavity, as well as in the terminal part of the genital tract [12].

* **Corresponding author**
e-mail: renata.chalas@umlub.pl

Lactobacillus paracasei is a Gram-positive bacterium influencing other organisms via commensalism. Similarly to *L. acidophilus*, *L. paracasei* is present in dairy products and also in fermenting vegetables. As of 2016, 34 different types have been selected from their natural niche (oral cavity and long intestine), eight in particular have been found in humans. Among these, the two best-known strains IMPC2.1 and 8700:2 – present chemo prophylactic potential to the alimentary tract cells. In addition, *L. paracasei* 8700:2 has been found to counter *Helicobacter pylori* and *Salmonella enterica* infestation [3].

Lactobacillus plantarum was first isolated from saliva samples, and has been shown to present the ability to spread gelatin and also to produce lactic acid L and D isomers. Hydrogen peroxide is a final product of this reaction. This feature enables *L. plantarum* to compete for nutrients with other microorganisms, as hydrogen peroxide presents a broad spectrum of antimicrobial activity. What is more, *L. plantarum* demonstrates bacteriostatic action against pathogenic growth [8].

Two other strains of *Lactobacillus* bacteria are considered as probiotics *L. reuteri* and *L. rhamnosus*. *Lactobacillus rhamnosus*, primarily regarded as a *L. casei* subtype, is able to inhibit harmful microorganism proliferation in the large intestine. This strain demonstrates high resistance to bile acids and an affinity for the mucous cells of the small intestine. In addition, it may contribute towards the production of lactic acid. In pregnant women, it also plays a positive role in obesity treatment. In 2005, *Lactobacillus rhamnosus* was successfully applied against vancomycin-resistant enterococci in renal failure patients. [13]. It has also showed inhibitory effect on the carious biofilm model [10]. What is more, *Lactobacillus* has significantly inhibited the growth of streptococci, while glucosyltransferase expression was significantly reduced by *Lactobacillus rhamnosus*. However, integration of *L. rhamnosus* biofilm did not take place, but *L. acidophilus* and *L. casei* have been built into biofilms. The results of these studies have led to the conclusion that *L. rhamnosus* can inhibit the formation of biofilm formation by reducing the glucans production by *Streptococcus mutans* [10]. Indeed, numerous studies have revealed the reduction of S. *mutans* and the lack of growth of *Lactobacillus* in patients supplemented with probiotics. The influence of *Lactobacillus rhamnosus* GG, ATCC53103 (LGG) on *Streptococcus mutans* count was presented in an article by Ahola *et al*. Herein, the researchers provided adult volunteers aged 18-35 years with cheese containing probiotic. The results presented no statistical significance right after supplementation, however, post-treatment observation revealed a significant decrease in the counts of *S. mutans* (20%) and yeast (27%) [1].

L. reuteri naturally colonises the alimentary tract of most humans after dairy product consumption, and becomes the main organism in the formation of intestinal microflora. It is also transferred to the infants' organisms via their mothers' milk, although not everyone has an adequate amount of this, and additional supplementation may be required. During fermentation, *L. reuteri* produces reuterin, an antibiotic-like substance. Reuterin is potent against Gram positive and negative bacteria, fungi and protozoans, i.e. to: *Candida albicans*, *Fusarium samiaciens*, *Escherichia coli*, *Salmonella* Typhimurium, *Aspergillus flavus*, *Strepotococcus mutans*, *Prevotella intermedia*, *Helicobacter pylori*, etc. Like other probiotics, *L. reuteri* contributes to the production of lactic acid, and activates LPS monocytes [15].

BIFIDOBACTERIUM SPECIES

Bifidobacaterium species include four probiotic strains: *Bifidobacterium longum*, *Bifidobacterium bifidum*, *Bifidobacterium animalisandi* and *Bifidobacterium breve*.

Bifidobacterium longum is a Gram-positive bacterium that is a colonization pioneer of the infant alimentary tract. It is the most important component of a child's natural microflora – up to 90%, however, in adulthood, its amount dwindles to a level of 3% due to supplantation by *Eubacterium* and *Bacteroides*. In 2002, three previously distinct species: *B. longum*, *B. suis*, *B. infantis* were classified together as *B. longum*, since their DNA showed significant similarity, as gene 16s rRNA demonstrated 97% of resemblance. The presence of these bacteria has a beneficial effect on the increase of lactose tolerance, diarrhea prevention, food allergies and reduction of pathogen colonization. The persistence of these bacteria in the intestinal tract is associated with the presence of fimbriae – by which microbes are combined with glycoproteins and bacterial polysaccharides, and exhibit strong electrostatic properties which provide the possibility of adhesion of *B. longum* to the wall of the epithelium. This adhesion is strengthened by lipoteichoic acid, an element of the cell wall of *B. longum*. A certain part of particular *B. longum* strains also demonstrates antioxidant properties: the inhibition of linoleic acid in the form of peroxide. What is more, these microorganisms bind and inactivate bile acids, thereby reducing the level of cholesterol in the body. *B. longum* has been successfully applied in cancer therapy – this bacterium reveals the ability to locate and proliferate in hypoxic regions of solid tumors after intravenous administration. It is also effective in gene therapy, human immune system regulation, skin regeneration and pancreas necrosis treatment [12].

B. bifidum embeds in the mucosa of the large intestine and the vagina, and prevents colonization of *Salmonella*, *E. coli* and *Clostridium* species. Its activity is based on the production of lactic and acetic acids. Such compounds lower pH levels in the intestine and prevent the growth of pathogens. In addition, *B. bifidum* enables an increased absorption of iron, zinc, calcium and magnesium. These microorganisms may be applied in the treatment of cirrhosis of liver, the regulation of postantibiotic bowel function, constipation and digestive disorders in infants.

B. animalis is a Gram-positive anaerobic that inhibits the large intestine of most mammals, including humans. Previously, two species: *B. animalis* and *B. lactis* contemporarily identified as one, had been classified as separate. In 2005, Guyonnet *et al*. investigated the use of fermented milk containing *B. animalis* in patients with IBS (irritable bowel syndrome). In this work, the subjects confirmed the increase in life quality after therapy application [5,7].

B. breve is an immobile anaerobic bacterium. It demonstrates an ability to digest large number of pathogenic

bacteria, as well as plant fiber. There are numerous studies supporting the development of illnesses such as allergies, post-antibiotic diarrhea and IBS in the environment of reduced numbers of *B. breve*. The presence of *B. breve* in the intestine inhibits the development of *E. coli*, and in the vagina, it affects the growth of *Candida albicans*. The main function of these bacteria is to conduct the fermentation process of sugars and the production of lactic and acetic acid [17].

In accordance with the research performed by Lee do K. *et al*., *Bifidobacterium* strains may be used in dental caries prevention with no adverse effect consequences. Results obtained in the experiment revealed that *B. adolescentis* SPM1005 at 1.0 × 10 8 CFU reduced the growth of *Streptococcus mutans* when applied to adult patients [9].

STREPTOCOCCUS SPECIES

The third sub-group of probiotic bacteria incorporates *Saccharomyces boulardii*, as well as the *Streptococcus* species: *S. salivarius* and *S. thermophiles*. It should be noted that *S. thermophilus* has been recently classified as a sub-type of the former (*S. salivarius subsp. thermophilus*). It is the only one in the *viridans* group which is not naturally found within the human physiological bacterial microflora. On the basis of genome analysis, it has been ascertained that this microorganism has recently separated from other species during the process of regressive evolution. Fermentation is the main process conducted by S. *thermophilus*. This reaction leads to the production of lactate from lactose. The microorganism also presents an ability to metabolize glucose, fructose, galactose and sucrose. Furthermore, it is devoid of virulence factors, such as the ability of adhesion. Hence, in accordance with the GRAS scale, it is classified as safe. Bacteria from this group demonstrate the capacity to synthesize polysaccharides such as hyaluronic acid, and the ability to produce urease and bacteriocytogenic factors.

Streptococcus salivarius K12 has been shown to suppress all Gram-positive bacteria growth: *Atopobium parvulum* ATCC 33793, *Solobacterium moorei* CCUG 39336, *Eubacterium sulci* ATCC 35585 and also the *S. moorei* isolates, CH1#23, CH3#63, CH3A#109A, and CH8#20. All of the afore-mentioned strains are known to contribute to halitosis. In particular, *S. salivarius* K12 demonstrates an antimicrobial activity against these bacteria, and, in consequence, participates in natural malodour therapy [14].

S. boulardii is a tropical yeast strain isolated in 1923. It shows a beneficial effect on the functioning of the small and large intestine, however, in rare cases, the organism can cause thrush and local inflammation. In medicine, *S. boulardii* is used in the treatment of: post-antibiotic diarrhea, HIV/AIDS intestine malfunction, recurrent *Clostridium difficile* infection and Irritable Bowel Syndrome [6,16].

CONCLUSION

Potentially nonpathogenic probiotic organisms are represented by a great variety of species of bacteria and fungi capable of adhesion, colonization and induction of direct effects on animal organisms, particularly on the human body. With the use of modern methods such as micro-encapsulation, cell immobilization and constant fermentation, probiotics have the potential to become an important part of the daily diet and be natural drug supplementation in treating many diseases, particularly in aiding patients suffering from acquired immunodeficiency syndrome, being HIV positive, as well as enduring leukemia and post-transplant situations. In accordance with the recent data, longterm application of probiotics does not interfere with human health, however, longterm studies are needed to establish whether probiotic supplements are more beneficial then harmful to human health, particularly oral health. Future research should, thus, focus on understanding the mechanisms occurring between the natural bacterial flora and the lining of the gastrointestinal tract in healthy patients, with a focus on the oral cavity.

REFERENCES

1. Ahola A.J. et al.: Short-term consumption of probiotic-containing cheese and its effect on dental caries risk factors. *Arch. Oral Biol*., 47, 799, 2002.
2. Burton J.P. et al.: Persistence of the oral probiotic Streptococcus salivarius M18 is dose dependent and megaplasmid transfer can augment their bacteriocin production and adhesion characteristics. *PloSOne*.,8: e65991, 2013.
3. Chiang SS, Pan TM. Beneficial effects of Lactobacillus paracasei subsp. paracasei NTU 101 and its fermented products. *Appl. Microbiol. Biotechnol*., 93, 903, 2012.
4. de Vrese M, Schrezenmeir J. Probiotics, prebiotics, and synbiotics. *Adv. Biochem. Eng. Biotechnol*., 111, 1, 2008.
5. Guyonnet D. et al.: Effect of a fermented milk containing Bifidobacterium animalis DN173 010 on the health-related quality of life and symptoms in irritable bowel syndrome in adults in primary care: a multicentre, randomized, doubleblind, controlled trial. *Aliment. Pharmacol. Ther*., 26, 475, 2007.
6. Hasslöf P. et al.: Early intervention with probiotic Lactobacillus paracasei F19 has no longterm effect on caries experience. *Caries Res*., 47, 559, 2013.
7. Isselbacher K.J.: Irritable bowel syndrome: the possible benefits of probiotics. *Postgrad. Med*., 117, 7, 2005.
8. Kleerebezem M. et al.: Complete genome sequence of Lactobacillus plantarum WCFS1. *Proc. Natl. Acad. Sci. U S A*., 100, 1990, 2003.
9. Lee do K. et al.: Antimicrobial activity of Bifidobacterium spp. isolated from healthy adult Koreans against cariogenic microflora. *Arch. Oral Biol*., 56, 1047, 2011.
10. Lee SH, Kim YJ. A comparative study of the effect of probiotics on cariogenic biofilm model for preventing dental caries. *Arch. Microbiol*., 196, 601, 2014.
11. Lilly D.M., Stillwell R.H.: Probiotics: growth-promoting factors produced by microorganisms. *Science*, 147, 747, 1965.
12. Lin MY, Chang FJ. Antioxidative effect of intestinal bacteria Bifidobacterium longum ATCC 15708 and Lactobacillus acidophilus ATCC 4356. *Dig. Dis. Sci*., 45, 1617, 2000.
13. Manley K.J. et al.: Probiotic treatment of vancomycin-resistant enterococci: a randomised controlled trial. *Med. J. Aust*., 186, 454, 2007.
14. Masdea L. et al.: Antimicrobial activity of Streptococcus salivarius K12 on bacteria involved in oral malodour. *Arch. Oral Biol*., 57, 1041, 2012.
15. Oh P.L. et al.: Diversification of the gut symbiont Lactobacillus reuteri as a result of host-driven evolution. *ISME J*., 4, 377, 2010.
16. Rajkowska K., Kunicka-Styczyńska A.: Probiotic activity of Saccharomyces cerevisiae var. boulardii against human pathogens. *Food Technol. Biotechnol*., 50, 230, 2012.
17. Soccol C.R. et al.: The potential of probiotics: a review. *Food Technol. Biotechnol*., 48, 413, 2010.
18. Twetman S.: Treatment protocols: nonfluoride management of the caries disease process and available diagnostics. *Dent. Clin. North Am*., 54, 527, 2010.