The Antimicrobial Role of Probiotics in the Oral Cavity in Humans and Dogs

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Abstract

Probiotics have been defined in 2001 by the World Health Organization (WHO) and Food and Agriculture Organization of the United Nations (FAO) as "live microorganisms, and as the main bacteria that administered in adequate amounts in humans and animals have beneficial effects on the health of the host".
Probiotics are single or mixed cultures of live and non-pathogenic microorganisms that are found in foods (especially acidic dairy yoghurt, kefir, buttermilk, cheese) or in nutritional supplements on the form of tablets, capsules or powder. These bacteria have to belong to the normal microbial flora of the host to withstand acidity, to survive the intestinal transit, to adhere to the intestinal mucosa, to produce antimicrobial substances and to maintain the health of the host. The most often strains that are used as probiotics are: *Lactobacillus*, *Bifidobacterium* and *Streptococcus*.
The objective of this study is to reveal the importance of probiotics on the health of oral cavity in humans and dogs.

Keywords: antimicrobial substances, host, live microorganisms, probiotics.

1. Introduction

The probiotic origin dates back to 1903 when *Metchinikoff* describes the beneficial effects of the use of *Lactobacillus spp*. from yogurt. The term "probiotic" was coined in 1965 by *Stillwell* and *Lilly*, then by *Parker* in 1974. Probiotics are defined as "microorganisms or substances which contribute to the microbial balance of the gut" [1].
In the countries belonging to the EEC (European Economic Community) in probiotic products group were included the yeasts, enzymes and other substances with probiotic role. In 1988 there were at least 20 different biological products, which were based on micro-organisms belonging to species of the genera *Streptococcus*, *Lactobacillus*, *Bacillus*, *Aspergillus*, *Saccharomyces*, *Enterococcus*, *Pediococcus*, enzymes (lactoperoxidase, glucanase, nonspecific enzymes) and extracts of the rumen [2].
The most used microorganisms as probiotics are *Lactobacillus*, *Streptococcus* and *Bifidobacterium* species (table 1), [4, 7]:
• from the genus *Lactobacillus*: *L. acidophilus*, *L. bulgaricus*, *L. casei*, *L. helveticus*, *L. lactis*, *L. salivarium*, *L. plantarum*;
• from the genus *Bifidobacterium*: *B. bifidum*, *B. breve*, *B. infantis*, *B. longum*, *B. lactis*, *B. adolescentis*
• from the genus *Streptococcus*: *S. termophylus*, *S. faecium*, *S. fecalis*; [2-4, 7].
Initially, probiotics have been used in the prevention and treatment of intestinal diseases (acute diarrhea, diarrhea associated with the administration of antibiotics, nosocomial infections), colitis, inflammatory bowel disease, in the prevention of constipation, irritable bowel syndrome, chronic hepatitis, *Helicobacter pylori* infection, bowel cancer and malabsorption syndromes. In this regard, the most effective

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bacterial species proved to be *Bifidobacterium bifidum*, *Lactobacillus casei*, *Lactobacillus rhamnosus GG* and *Streptoccocus thermophilus*. In the coming years, the use of probiotics has extended to prevent and to treat diseases of the oral cavity [5, 6].

Table 1. Examples of microorganisms that are considered to be probiotics [4, 7]

***Lactobacillus* spp.**	***Bifidobacterium* spp.**	**Others**
L. acidophilus	*B. bifidum*	*Saccharomyces boulardii*
L. casei	*B. breve*	*Lactococcus lactis subsp.cremoris*
L. crispatus	*B. infantis*	*Enterococcus faecium*
L.delbrueckii subsp.bulgaricus	*B. longum*	*S. salivarius subsp. thermophilus*
L. fermentum	*B. lactis*	*S. diaacetylactis*
L. gasseri	*B. adolescentis*	*S. intermedius*
L. johnsonii		
L. paracasei		
L. plantarum		
L. reuteri		
L. rhamnosus		

Note: i)There is still debate about the probiotic activity of *L. delbrueckii* subsp. *Bulgaricus* and *Streptococcus thermophilus*
ii) Safety concerns remain for *Enterococcus faecium* because of potential pathogenicity and vancomycin resistance

The formation of the oral cavity microbial biofilm is one of the main causes of pathological conditions created at this level. Once the biofilm becomes mature a dynamic link is established between the host and microorganisms. Probiotics have an important role in inhibiting the development of oral cavity microbial biofilm by reducing the inflammatory reactions [8] and by inhibiting the development of pathogenic bacteria in favor of the commensal microorganisms.

The beneficial effects of probiotics in oral cavity

In human medicine the researches regarding the beneficial effects of probiotics have included the treatment of bowel diseases in children, up to the prevention and control of urinary and oral cavity diseases in adults.

Thanks to the good results obtained in humans, an attempt was made to apply the methods of prevention and treatment in the form of supplements and diets to pets. Probiotic supplements, often administered to pets, contain species of *Lactobacillus*, *Bifidobacterium*, and *Streptococcus* [9].

To combat the pathogenic microorganisms of the oral cavity appeared more products containing probiotic bacteria appeared on the market which are residents of the dog's oral cavity. In dogs the most used oral probiotics were *Streptococcus oralis*, *Streptococcus uberus* and *Streptococcus rattus*.

Because the oral microflora is as complex as that of the gastrointestinal tract and vaginal, oral Biofilms are difficult to combat, the introduction of probiotics as alternative means to combat the [10]. In humans, the *Lactobacillus* species represent 1% of the commensal microflora of the oral cavity. For example from saliva were isolated: *Lactobacillus acidophilus*, *Lactobacillus casei*, *Lactobacillus fermentum*, *Lactobacillus plantarum*, *Lactobacillus rhamnosus* and *Lactobacillus salivarius* [11].

To assess the microbial composition of the oral cavity in order to determine the probiotic ability of some bacterial species of the genus *Lactobacillus*, there were made bacterial isolations from the saliva and crevicular fluid. *Hojo et al*. [12] frequently isolated *Lactobacillus salivarius* and *Lactobacillus fermentum* from the healthy oral cavity but also from patients with periodontitis. [12].

Sookkhee et al. [13] have isolated 3790 of strains of lactic acid bacteria from the oral cavity in humans and found that *Lactobacillus casei* subsp. *paracasei* and *L. rhamnosus* have powerful antagonist effect upon pathogenic bacteria in the oral cavity, including the species *Streptococcus mutans* and *Porphyromonas gingivalis* [13]. *Haukioja et al.* [14] have noticed recently that certain species of *Lactobacillus* and *Bifidobacterium*, isolated from dairy products, have the ability to adhere to the mucosa of oral cavity and teeth [14].

Wescombe et al. [15] have proposed, as an alternative therapy to antibiotic treatment of intestinal, oral cavity and respiratory diseases with probiotics containing *Streptococcus salivarius*. *Streptococcus salivarius* has beneficial effects in the prevention of dental caries [15]. The oral probiotics have many direct and indirect benefits.

Direct interactions

Probiotics have many positive influences in creating a better oral health. Probiotics have both direct and indirect interactions. The advantages of direct interactions are many. For example probiotics help in binding oral microorganisms to proteins and biofilm formation. Probiotics fight against plaque formation and on its complex ecosystem by compromising and intervening with bacterial attachments. Through its direct interactions, probiotics compete with oral microorganisms of substances available [7].

Bacterial attachment

Finally there was proved that there are certain bacterial species with probiotic role that have the ability to compete with periodontopathogenic species for the binding sites in the oral cavity. For example, *Streptococcus* species prevent the colonization of the soft and hard issues of pathogenic species.

Another advantage of the probiotics is their ability to produce biosurfactant substances which prevent oral adhesion. *Van Hoogmoed* [16], observed that the biosurfactant produced by S. mitis has inhibited the adhesion of pathogenic species *S. mutans*. Probiotics inhibit the adhesion of bacteria by altering the composition of the protein binding sites [16].

Haukioja et al. [14] have shown that certain probiotics have the ability to modify the protein composition of salivary pellicle by removing the gp 340 salivary agglutinin, necessary for *S. mutans* adhesion [14].

The synthesis of substances with antimicrobial role

Probiotic bacteria have the ability to synthesize antimicrobial substances: hydrogen peroxide, bacteriocins and inhibitory substances like bacteriocins [17, 18].

Short chain fatty acids (lactic acid) can cross the cell membrane of bacteria inhibiting bacterial proliferation. *Sookkhee et al*. [13] have isolated lactic bacteria in the oral cavity in humans and have noticed that they have antimicrobial activity towards *Streptococcus mutans* and *Porphyromonas gingivalis*. The antimicrobial activity was more intense at strongly acid pH [19].

Numerous studies have confirmed the antimicrobial effect of the probiotics through their ability to release hydrogen peroxide and to inhibit the growth of pathogenic bacteria. Hydrogen peroxide has a toxic effect on the micro-organisms that do not produce or produce small quantities of enzymes that splits the hydrogen peroxide [20].

Bacteriocins are substances such as proteins, but some of them may have a complex structure when they contain besides the protein component a glucidic or lipidic component with antimicrobial action, synthetized by some of the bacterial strains with probiotic role.

This prevents the attachment of bacteria of the same species or closely related species on the target cell receptors.

For example, *Balakrishnan et al.* [21] showed that *Streptococcus salivarius* produces two types of bacteriocins, salivaricin type A and type B salivaricin. This strain is used in the prevention of dental caries in humans produced by *Streptococcus mutans* and *Streptococcus sorbinus*. Salivaricin B has been used in the treatment of halitosis produced by *Prevotella spp*. and *Micromona micra* [21].

Metabolism of substrate

The probiotics have an important role in the metabolism of the substrate and in competing for the available substrate with pathogenic micro-organisms of the oral cavity. For example, *Porphyromonas intermedia* uses vitamin K as a nutritional source for with are also competing some *Lactobacillus* species [22].

Indirect effects are those that promote the removal of pathogenic bacteria and induce the restoring of normal ecological niche in the oral cavity; favor and regulate the specific and non-specific immune response and other non-immunological defense mechanisms; regulate the permeability of oral mucosa and fosters the formation of beneficial bacterial colonies from less pathogenic species in the oral microflora; have a beneficial effect on the prevention of the occurrence of diseases of oral cavity such as: dental caries, periodontal disease, halitosis and candidiasis [14, 23-27]. Besides antimicrobial activity, the probiotics have the ability to regulate the specific and nonspecific local immune response.

Bacteria and their metabolites (metabolites, cell wall components, DNA) are recognized by the host cells as epithelial cells and cells of the immune system. Probiotics can regulate the

expression of the receptor from the surface of neutrophils of healthy individuals and stimulate the activity of NK cells.

Della Riccia et al. [28] have studied the effect of immunomodulation "*in vivo*" *Lactobacillus brevis* probiotic on the periodontal disease. *Lactobacillus brevis* has induced a significant decrease in the activity of metalloproteinase, prostaglandin E2 (PGE2) level and interferon γ (IFN-γ) [28].

Conclusions

There are scientific data showing that probiotics offers many health benefits. However their beneficial role and their administration in the oral cavity diseases are still in infancy.

The use of probiotics, brings "new", in terms of connection between their use in food and their beneficial effects on the health status of oral cavity. The cumulative and competitive action of probiotics in the oral cavity, is not yet fully known.

To obtain satisfactory results it is necessary to know the way and form of administration of probiotics (particularly bacterial species which ferment sugars and decrease the pH of the oral cavity), and dosage variations in different preventive or therapeutic purposes in order to avoid the disease.

Probiotics should be used with care in immunocompromised patients.

Researchers have concluded that probiotics cannot colonize the oral cavity permanently, so it is recommended to take periodically probiotic cures.

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