REVIEW

Role of functional foods in periodontal health and disease

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ABSTRACT:

Probiotics is a live microbial feed supplement which beneficially affects the host animal by improving its intestinal microbial balance whereas Prebiotics are nondigestible substances (dietary fiber) that exert some biological effect on humans by selective stimulation of growth or bioactivity of beneficial microorganisms either present or therapeutically introduced to the intestine. This review focuses on the use of functional foods as preventive and therapeutic products for oral healthcare. Scientific understanding of functional foods and their potential for preventing and treating periodontal conditions is at its infancy, but moving ahead. Therefore, properly controlled, randomized, long term clinical trials are needed using the most promising strains and also testing various methods of application.

Key words: *Probiotics, Prebiotics, oral health care, functional foods, Periodontal conditions*

INTRODUCTION:

The age-old quote by Hippocrates, 'Let food be thy medicine and medicine be thy food', is certainly the tenet of today. First of all, Greco-Latin civilization considered dietary composition and nutrition style as an essential component of natural medicine. The market for functional foods that promote health beyond providing basic nutrition, is flourishing. The concept of beneficial-for-health microorganisms dates back to the ideas of Nobel Prize Laureate Ilya Metchnikov in the early years of the 20th century. Working as an Ukrainian bacteriologist, laid down the scientific foundation of probiotics.¹

The term "**functional food**" describes foodstuffs which, apart from their nutritive value, evidently improve health and well-being of consumers. Functional food can contain probiotics and prebiotics. Within the functional foods, is the small but rapidly expanding arena of probiotics.²

"**Probiosis**" can be defined as the positive effect

of consumption of fermented dairy products with cultures of lactic acid bacteria on the equilibrium of intestinal microflora. Recently, side effects of therapy with antibiotics and development of bacteria resistant to them have provoked increasing interest in probiosis. Probiotics and the phenomenon of probiosis were discovered by Metchnikoff (1908).²

PROBIOTICS:

The term probiotic is derived from the Greek, meaning "for life" is microorganisms proven to exert health-promoting influences in human and animals. "**Probiotics**" are defined as living organisms in foodstuffs which, when taken at certain levels in nutrition, provide equilibration of the intestinal flora, and hence have a positive effect on the health of the consumer.²

Parker defined probiotics as "organisms and substances which contribute to intestinal microbial balance".³

Fuller redefined probiotics as "A live microbial feed supplement which beneficially affects the host animal by improving its intestinal microbial balance".³

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International Life Science Institute Europe proposed a simple and widely accepted definition of probiotics as-“Viable microbial food supplements which beneficially influence the health.”⁴

Saito defined probiotics as “living microorganisms that when administered in adequate amounts confer health benefits upon the host.”¹

Probiotics are selected from the strains most beneficial for the host intestinal bacteria, that is bacteria from genera *Bifidobacterium*, *Lactobacillus* and yeast (figure I). A Probiotic may be made out of a single bacterial strain or it may be a consortium as well. The advantage of multiple strain preparations is that they are active against a wide range of conditions and in a wider range of animal species. Probiotics can be in powder form, liquid form, gel, paste, granules or available in the form of capsules, sachets, etc (figure II).

History :

The dietary use of living microorganisms has a long history. Mention of cultured dairy products in the bible and the sacred books of Hinduism. Sacred milks and cultured dairy products such as *kefir*, *koumiss*, *liben* and *dahi*, were often used therapeutically before the existence of microorganisms was recognized. In 1907, Elie Metchnikoff postulated that consumption of Bulgarian yoghurt promotes good health. In 1950, a probiotics product was used as a drug for the treatment of scour among pigs. Lilley and Stillwell (1965) introduced the term probiotics. Mann and Spoering in 1974 discovered that the fermented yoghurt reduced blood serum cholesterol. In 1984 Hull identified the first probiotic species, the *Lactobacillus acidophilus*. Later in 1991, Holcomb identified *Bifidobacterium bifidum*. WHO in 1994 described the probiotics as next most important in immune defense system following antibiotic resistance. The use of probiotics in antibiotic resistance is termed microbial interference therapy (replacement therapy or bacteriotherapy).

Classification⁴:

Probiotics may be yeast, bacteria or moulds, but most commonly bacterial species are predominate.

These are:

- Lactic acid producing bacteria (LAB): *Lactobacillus*, *bifidobacterium*, *streptococcus*.
- Non Lactic acid producing bacterial species : *Bacillus*, *propionibacterium*
- Non pathogenic yeasts: *Saccharomyces*
- Non spore forming and non flagellated rod or coccobacilli

Criteria for the selection of microorganisms⁴:

- Survival on passing through gastrointestinal tract at low pH and on contact with bile
- Adhesion to intestinal epithelial cells
- Stabilization of the intestinal microflora
- Non-pathogenicity
- Survival in foodstuffs and possibility for production of pharmacopeia preparations
- Fast multiplication, with either permanent or temporary colonization of the gastrointestinal tract
- Generic specificity of probiotics

Mechanism of action:

Probiotics can help prevent and treat disease through several mechanisms (figure III):

- Direct interaction: probiotics interact directly with the disease-causing microbes, making it harder for them to cause the disease.
- Competitive exclusion: Beneficial microbes directly compete with the disease-developing microbes for nutrition or enterocyte adhesion sites.
- Modulation of host immune response: Probiotics interact with and strengthen the immune system and help prevent disease.

Different species used as probiotics (table I):

Lactobacillus species- help in production of enzymes to digest and metabolize proteins and carbohydrates. They aid in synthesis of vit. B and vit. K and facilitates breakdown of bile salts. More than 100 species of *L. acidophilus*, *L. brevis*, *L. casei*, *L. rhamnosus*, *L. salivarius* has been identified. They are usually dispensed in gel, paste, powder and liquid forms.

Bifidobacterium species -are strictly anaerobic and predominate the large intestines. These species include metabolism of lactose, generate lactic ions

from lactic acid and synthesize vitamins. They relieve constipation, alleviate inflammatory bowel disease and prevent DNA damage.

Streptococcus thermophilus and *Lactobacillus bulgaricus*—these species help in metabolism of lactose, improve lactose intolerance and antimicrobial activity.

Probiotics and HIV⁴:

Lin Tao (2008) and his colleagues screened hundreds of bacteria taken from the saliva of volunteers. Results showed that some *Lactobacillus* strains had produced proteins capable of binding a sugar found on HIV envelope, called mannose. One strain secreted abundant mannose-binding protein particles into its surroundings, neutralizing HIV by binding to its sugar coating.

Probiotics in colon cancer prevention:

Ingestion of probiotics results in different spectrum of fermentation products, including the production of high concentrations of short chain fatty acids. Gut flora, especially after ingestion of resistant starch, includes the chemopreventive enzyme glutathione transferase in the colon. It results in excretion of byproducts of harmful bacteria such as ammonia, indols, phenols and sulphur components. Together, these factors lead to a reduced load of genotoxic agents in the gut and to an increased production of agents that deactivate toxic components (Reddy 1998, Pierre et al 1999).

Probiotics in calcium absorption:

Persons with lactose intolerance may probably develop osteoporosis due to decrease consumption of milk containing diet. So, if probiotics are fed to lactose intolerance patients, then milk lactose is hydrolyzed by probiotic strains and favor calcium absorption.

PROBIOTICS AND ORAL HEALTH (table II):

Ideal vehicles of probiotics installation are yoghurt, milk and cheese. Some of the hypothetical mechanism of probiotics action in the oral cavity is by:

- Direct interaction in dental plaque
- Involvement in binding of oral micro-organisms to proteins

- Action on plaque formation and on its complex ecosystem by competing and intervening with bacterial attachments

Nase et al showed marked reduction in caries risk with administration of probiotic milk from coded containers for 5 day/week for 7 months. In India, Sporolac, *Saccharomyces boulardii* and yoghurt (*L. bulgaricus* + *L. thermophilus*) are the most commonly used probiotics. *Lactobacilli* solution is an example of a probiotic, usually given to pediatric patients.

Probiotics and Periodontal health (table III):

Periodontitis is an infectious disease characterized by inflammatory changes in the tissues surrounding to teeth leading to periodontal attachment loss and alveolar bone destruction. As dental caries has declined, periodontitis has become the most common reason for tooth loss in adults.⁵

It is generally agreed that microorganisms residing in the periodontal pockets are responsible for periodontitis. Approximately 500 taxa inhabit periodontal pockets, which provide a moist, warm, nutritious and anaerobic environment for microbial colonization and multiplication. The abundance and diversity of periodontal pocket microorganisms depend upon several factors, including effectiveness of oral hygiene procedures, pocket depth, flow of gingival crevicular fluid, type of interacting microbes and viruses, transmission rate of microbes from other individuals and the antimicrobial efficacy of the host immune response.⁶

Treatment of periodontal diseases in recent years has moved towards an antibiotics /antimicrobial model of disease management. Probiotics might be a promising area of research in the treatment of periodontitis. For the periodontal treatment, a probiotic bacterium should be able to adhere to and successfully establish itself in the oral biofilm to exert health effects. The ability of probiotics to adhere to saliva-coated surfaces varies among species and it has been reported that *L. rhamnosus* and *Lactobacillus paracasei* strains possess strong binding activity (more than 20%) (Haukioja et al. 2006). Hillman J D et al 1985, concluded that presence of *S. Oralis* and *S. Uberis* provided a good indication of

periodontium. When these bacteria are absent from sites in the periodontal tissues, those sites are more prone to disease⁷. **Ishikawa et al. 2003**, reported that the daily intake of *L.salivarius* isolated from healthy humans led to a decreased number of black pigmented anaerobic rods. Another study conducted by **Koll-Klais et al. 2005**, they observed species-specific antimicrobial activity, with facultative heterofermentative lactobacilli being the strong inhibitors of *A.actinomycescomitans*, *P.gingivalis* and *P.intermedia*¹

Marcotte et al. 2005, have studied a novel means to utilize the beneficial properties of probiotics. They concluded that although lactobacilli as such are not common inhabitants of the gingival sulcus, they can be effectively used in delivering antibodies against *P.gingivalis*. **Mohammad S. et al. 2006**, have shown an inverse association between the intake of dairy products and prevalence of periodontitis.⁸ **Teughels et al. 2007**, reported that the subgingival application of a bacterial mixture including *Streptococcus sanguis*, *S.salivarius* and *Streptococcus mitis* after scaling and root planning significantly suppressed the recolonization of *Porphyromona gulae* (canine *P.gingivalis*) and *P.intermedia* in a beagle dog model. This guided approach may provide a valuable addition or alternative to the armamentarium of treatment options for periodontitis.⁹ **Recently Haukioja et al. 2008**, have shown that probiotic lactobacilli (*L.rhamnosus GG*, *Lactobacillus casei* Shirota, *L. casei* ATCC 11578) may affect the oral ecology by specifically preventing the adherence of other bacteria and by modifying the protein composition of the salivary pellicle. Similarly **Yoshihiro Shimazaki et al. 2008**, concluded that the routine intake of lactic acid foods may have a beneficial effect on periodontal disease.¹⁰

PREBIOTICS:

"Prebiotics" are defined as nondigestible substances (dietary fiber) that exert some biological effect on humans by selective stimulation of growth or bioactivity of beneficial microorganisms either present or therapeutically introduced to the intestine² (figure IV). The prebiotic concept was

introduced by Gibson and Roberfroid in 1995, several decades after the probiotic model.

Insulin with a low degree of polymerization oligofructosanes, and resistant starch comprise the prebiotics group. Oligofructoses can be found in wheat, onion, garlic, leek, asparagus, Jerusalem artichoke and banana. Mother's milk contains relatively high levels (3-6 g/L) of oligosaccharides. Fructooligosaccharides are selectively digested by bifidobacteria and stimulate growth of their colonies. Recently, Klahorst (2000) included polyols such as lactitol, mannitol, sorbitol and xylitol to the prebiotics group.

In order to be effective, a prebiotic must escape digestion in the upper gastrointestinal tract so that it can be released in the lower tract and used by beneficial microorganisms in the colon, mainly bifidobacteria and Lactobacilli. Prebiotic effects depend on solubility, distribution, and branching and length of the chains of the molecules (**Rossi M et al. 2005**)¹. Prebiotic fermentation results in the production of increased levels of hydrogen and carbon dioxide and bacterial cell-mass (**Cummings J H et al. 2001**).¹

SYNBIOTICS (EUBIOTICS):

Probiotics and prebiotics simultaneously present in a product are called either synbiotics or eubiotics. Such a combination aids survival of the administered probiotics and facilitates its inoculation into the colon. Additionally, the prebiotics induces growth and increases activity of positive endogenous intestinal flora.²

CONCLUSION:

Functional foods are emerging as a fascinating field in oral medicine. This concept prompts a new horizon on the relationship between diet and oral health. Today's new technological era would be the right time to change the way bacteria are treated. At present, effects of functional foods on periodontal health and maintenance are not clear. Functional foods have made their way into oral healthcare and are more likely to be our friend than our enemy. So, further studies are needed to find out the best probiotic / prebiotic and means of their administration.

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Figure I: Showing beneficial bacterias

Figure II: Commercially available probiotics

Figure III: Showing mechanism of action of probiotics

Figure IV: Showing commercially available prebiotics

Table 1: Microorganisms used as probiotics for Humans

Probiotics	Food product	Therapeutic Agent Registered
Lactobacillus acidophilus	Sour milk, Yoghurt, Buttermilk, fermented cheese	L.acidophilus, Lacidofil, Lakeid, Lakeid forte, Yoghurt
L. casei	Cheese, Yakult	
L.delbrueckii ssp.bulgaricus	Yoghurt	Trilac
L.plantarum	Cream, fermented bread	
Saccharomyces boulardii,		Enterol
L.reuteri		
Bifidobacterium adolescent		
B.bifidum	Selected dairy products	Trilac, Lactobif
B.breve,B.infantis, B.longum,B.lactis	Infants 's milk and probiotic Cheddar-like	Junior Bifidus Nestle
L.rhammosus	a	L.acidophilus, Lacidofil,

Table 2: Probiotic species and their health effect in the oral cavity

Probiotic species	Effect	Means of administration	References
L.reuteri ATCC 55730 L.reuteri ATCC PTA 5289	Reduction in salivary S.mutans level	Lozenge	Caglar et al. 2008
L.reuteri ATCC 55730	Reduction in salivary S.mutans level	Straw and tablet	Caglar et al. 2006
L.reuteri	Reduction of gingivitis and plaque	Probiotic formulation	Krasse et al.2006
L.rhamnosus GG, ATCC 53103	Reduction of the risk of the highest level of S.mutans	Cheese	Ahola et al. 2004
L.rhamnosus GG, ATCC 53103	Reduction of the risk of the highest level of S.mutans	Milk	Nase et al.2001
Bifidobacterium DN-173 010	Reduction in salivary S.mutans level	Yoghurt	Caglar et al. 2005
S.salivarius K12	Suppressed growth of black pigmented bacteria in saliva samples and also of bacteria implicated in halitosis	Mouthwash	Burton et al.2006
L.casei 37	Extended remission after treatment of chronic generalized periodontitis	Periodontal dressing	Volozhin et al.2004
L.rhamnosus GG	Reduction in growth of Candida and positive effect on hyposalivation	Cheese	Hatakka et al.2007
L.acidophilus LAFTI L10	Enhanced clearance of C.albica in mice	–	Elahi et al.2005

Table 3:Probiotic species investigated for treatment of periodontal diseases

Probiotic species	Effect	Means of administration	References
L.casei 37	Reduction of periopathogens and extension of remission period	Periodontal dressing	Volozhin et al.2004
Probiotic mix	Normalization of microflora and reduction of signs of gingivitis and periodontitis	Tablets 'AciLact' and 'Bifidumbacterin'	Grudianov et al.2002
L.acidophilus	Improved clinical parameters in periodontitis patients and shift in local microflora towards gram positive cocci and lactobacilli	Tablet 'Acilact'	Pozharitskaia et al.1994
L.reuteri	Reduction of gingivitis and plaque in patients with gingivitis	Study-tailored formula	Krasse et al.2006
S.sanguinis, S.salivarius	Delay in subgingival recolonization by periopathogens	Application of streptococci after root planing	Teughels et al.2007
L.salivarius WB21	Improvement in clinical signs of periodontal disease in smoker and nonsmoker patients	Tablet taken three times daily	Shimauchi et al.2008