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Beneficial Effects Of Probiotics In Periodontal Health: A Review

The term *probiotic* is a relatively new word that means “for life”, currently used when referring to live bacteria associated with beneficial effects on humans and animals. In recent years, there has been a significant upsurge in research on the characterization and verification of the potential health benefits associated with the use of probiotics. In addition, the market for probiotics continues to expand exponentially as consumers rely on health claims made by manufacturers to make their choices. Probiotics are used to promote gastrointestinal health and immunity, and to prevent urogenital infections, allergies, cancer and other infectious conditions like periodontal disease. The complexity of the periodontal microbiota resembles that of the gastro-intestinal tract, where infectious diseases are treatable *via* probiotics. There is scientific evidence that specific strains of probiotic microorganisms confer health benefits on the periodontium and are safe for human use. This review appraises the available evidence for and against the health claims associated with probiotics and its use as preventive and therapeutic products for periodontal disease. However, considerable work is still needed to confirm these potential health benefits.

INTRODUCTION

The term *probiotic* means “for life” and is referred to the beneficial effects of live bacteria on humans and animals {1}. The term probiotics is often connected to the term functional foods. This term comprises the knowledge of the relationship between foods and health and the effect of food ingredients on physiological functions {2}. Pasteur and his associates noted as early as 1877 that the growth of anthrax bacilli in co-cultures with common bacilli (probably *Escherichia coli*) was suppressed. They commented that these facts perhaps justify the highest hopes for therapeutics {3}. The original observation of the positive role played by some selected bacteria was scientifically investigated by Eli Metchnikoff. He proposed, in 1907, that the lactic acid-producing strain *Lactobacillus bulgaricus* (contained in Bulgarian yoghurt) is able to displace pathological intestinal microbiota. He suggested that the dependence of the intestinal microbes on food makes it possible to adopt measures to modify the flora in our bodies and to replace the harmful microbes by useful microbes {4}. The term probiotics was introduced in 1965 by Lilly & Stillwell as substances produced by microorganisms which promote the growth of other microorganisms {5}. They showed that several species of protozoa during their logarithmic phases of growth produce substances that prolong the logarithmic phase in other species. Since then, several definitions of probiotics have been proposed. In 1974, Parker described a dietary supplement for animals and extended the definition of probiotics to organisms and substances which contribute to intestinal microbial balance {6}. In 1996, Schaafsma described probiotics as living microorganisms that, upon ingestion in certain numbers, exert health benefits beyond inherent basic nutrition {7}. In 1999, Naidu et al. defined probiotics as microbial dietary adjuvants that beneficially affect the host physiology by modulating mucosal and systemic immunity, as well as by improving nutritional and microbial balance in the intestinal tract {8}. The currently used consensus definition of probiotics was put forward by the World Health Organization and by the Food and Agriculture Organization of the United States. They defined, in 2001, probiotics as live microorganisms which when administered in adequate amounts confer a health benefit on the host {1}.

PROBIOTIC STRAINS AND METHODS OF DELIVERY:

Two main genera of Gram-positive bacteria, *Lactobacillus* and *Bifidobacterium*, are used extensively as probiotics {9}. However, other genera, such as *Escherichia*, *Enterococcus* and *Saccharomyces*, have also been marketed as probiotics {9, 10}, although concerns still remain regarding the safe use of these organisms for this purpose {11-13}. Current evidence indicates that probiotic effects are strain-specific; therefore, a beneficial effect attributed to one strain cannot be assumed to be provided by another strain, even when it belongs to the same species {14} (Table I).

According to recent Food and Agriculture Organization (FAO) and WHO guidelines {1, 15}, probiotic organisms used in food must be capable of surviving passage through the gut; i.e., they must have the ability to resist gastric juices and exposure to bile. Furthermore, they must be able to proliferate and colonize the digestive tract. In addition, they must be safe, effective, and maintain their effectiveness and potency for the duration of the shelf-life of the product.

Probiotics products are available in two main forms:

1. Refrigerated fermented food (*mainly dairy products- Yakult and Yoghurts and related products*).
2. Dried supplements (*Powder, Tablets and Capsules*)

Products may be formulated with one, two, or multiple cultures. Multiple cultures are more common in dried supplements, some containing 8 – 10 species {1, 15}. Yoghurt with added live probiotic strains is now available commercially, and a number of such products that have emerged as leaders in the European market are now also marketed internationally. In the USA, the National Yoghurt Association has introduced a ‘Live Active Culture Seal’ to identify refrigerated or frozen yoghurt products that contain at least 10⁸ or 10⁷ viable lactic acid bacteria/g at the time of manufacture.

BENEFICIAL AFFECTS OF PROBIOTICS STRAINS IN THE HUMAN HOST:

Although some of the effects of probiotics have been documented clearly, research is still ongoing in other areas, with important questions remaining unanswered. However, when considering the potential health benefits, it is crucial

to remember that different probiotic strains are associated with different health benefits (Figures 1 and 2).

PROBIOTICS AS A PREVENTIVE AND THERAPEUTIC PRODUCT IN PERIODONTAL DISEASE:

The effects of probiotic therapy have been studied extensively in a variety of systemic indications and medical disorders [16]. Presumably, oral administration of probiotics may also benefit oral health by preventing the growth of harmful microbiota or by modulating mucosal immunity in the oral cavity. Recently, small numbers of in vitro and in vivo studies have been performed on the role and effects of probiotics in the periodontal disease.

When compared with the criteria for probiotics in the gastrointestinal tract, “oral probiotics” may need some modification or addition. For instance, oral probiotic bacteria should adhere to and colonize on dental tissue, and should be a part of the biofilm. They should not ferment sugars, which subsequently lowers the pH and is detrimental to dental health. The key issues including definitive criteria for classification have not yet been resolved [17]. Studies revealed that probiotic Lactobacillus strains were useful in reducing gingival inflammation and the number of black-pigmented rods including Porphyromonas gingivalis in saliva and subgingival plaque [18-20]. However, little is known about the effects of probiotics on periodontal health and the microbiota of supra and subgingival plaque.

The current view on the etiology of plaque-related periodontal inflammation considers three factors that determine whether disease will develop in a subject: a susceptible host; the presence of pathogenic species; and the reduction or absence of so-called beneficial bacteria [21-23]. Given the risk of serious side-effects associated with altering the host response, (e.g., COX-2 inhibitors) treatment of periodontitis focuses on the reduction of the bacterial threat [24]. Conventional treatment involves mechanical subgingival debridement. This shifts the subgingival flora to a less pathogenic composition, characterized by high proportions of gram-positive aerobic species [25, 26]. Although reductions in the total subgingival microbiota of up to two-log values can easily be achieved, a recolonization, primarily by less pathogenic bacteria, towards baseline numbers occurs within 1–2 weeks [27-29]. The shift towards a less pathogenic microbiota is only temporary, with the re-establishment of a more aggressive microbiota within weeks to months [30-34]. The use of antibiotics or antiseptics, either locally or systemically, does not really improve the long-term effect of periodontal therapy [35]. Therefore, investigators start to focus on the third etiological factor for plaque-related periodontal inflammation, namely the reduction or absence of so-called beneficial bacteria. Restoring these reduced numbers of beneficial bacteria via probiotics might be of considerable interest in the treatment of plaque-related periodontal diseases. Probiotics might not only suppress the emergence of periopathogens or prevent the superinfection, they might also protect human through the promotion of a beneficial host response [36]. Russian anecdotal, reported on the use of probiotics in the treatment of periodontitis. The use of a Russian probiotic preparation called Acilact, a complex of five live lyophilized lactic acid bacteria, with or without Bifidumbacterin (probably Bifidobacterium) is claimed to improve both clinical and microbiological parameters in patients with gingivitis and mild periodontitis [37, 38].

In 1954, Kragen [39] studied the beneficial effect of lactic acid bacteria on inflammatory infections of the oral mucosa. In the late 1970s, research by Socransky's group, the first well-substantiated and large-scale research on the applicability of probiotics in periodontitis was initiated. They found that subgingival plaque samples of healthy patients contained organisms that could inhibit the growth of Actinobacillus actinomycetemcomitans [40] and other periodontopathogens [41-43]. The basis for their inhibition of A. actinomycetemcomitans lies in the production of hydrogen peroxide. In 1988, Hillman [44] conducted a study and stated that hydrogen peroxide production serves as the mechanism behind the interaction between S. sanguinis and A. actinomycetemcomitans. In the beginning of the 21st century, the appreciation of the beneficial oral microbiota and their use in the prevention and treatment of plaque related periodontal inflammation has undergone a revival. In 2003, Ishikawa et al., [18] investigated an L. salivarius strain regarding its potential to suppress periodontopathogens and improve periodontal health. The researchers observed in vitro that L. salivarius TI 2711 starts to kill P. gingivalis, Prevotella intermedia and Prevotella nigrescens after 6–12 h in co-culture.

In 2004, Volozhin et al., [45] reported that a periodontal dressing consisting of collagen and L. casei 37 exerted a beneficial effect on the subgingival microbiota of periodontal pockets. In 2005, Krasse et al., [19] evaluated the effect of another lactobacillus strain, L. reuteri, in the treatment of recurrent gingivitis. This led the authors to conclude that L. reuteri is efficacious in reducing gingivitis and plaque scores although the results are not statistically significant. In 2006, Kang et al., [46] isolated lactic acid bacteria from children's saliva. Two bacterial strains, CMS1 and CMS3, exhibited profound inhibitory effects on the formation of S. mutans biofilms and on the proliferation of S. mutans in vitro. Both strains were identified as Weissella cibaria by 16S rDNA sequencing. Weissella spp. is lactic acid bacteria and was formerly included among the lactobacilli. W. In contrast to the placebo rinse, there was a significant 20% reduction in plaque scores when the W. cibaria CMS1-containing rinse was used. These results indicate that the W. cibaria possesses the ability to inhibit biofilm formation, both in vitro and in vivo.

In 2007, Teughels et al., [47] examined presumed beneficial oral bacteria for their ability to interfere with the colonization of periodontopathogens. The bacterial strains were selected for their ability to induce, in vitro and in vivo, growth inhibition of pathogens, and to down-regulate fimbrial expression or biosurfactant production, for the absence of co-aggregation or because of their high prevalence in periodontal health. In a series of in vitro adhesion experiments, the effect of these bacterial strains on the colonization of hard surfaces and epithelial cells by A. actinomycetemcomitans, P. gingivalis, P. intermedia and Tannerella forsythia was elucidated. S. sanguinis KTH-4, S. salivarius TOVE and S. mitis BMS appeared to be the bacterial species that were most effective in inhibiting in vitro periodontopathogen colonization. This inhibition was partially caused by direct interbacterial interactions, environmental conditioning and interaction with epithelial cells. Further in 2007, Teughels et al., [48] tested the hypothesis that the subgingival application of these three selected beneficial bacterial spp. after mechanical debridement would enhance the microbial shift away from periodontopathogens, in an in vivo Beagle dog model. In 2008, Shimauchi H et al., [49] conducted a randomized

clinical study to evaluate the effect of probiotic intervention using lactobacilli on the periodontal condition. Results from the study indicate that probiotics could be useful in the improvement/maintenance of oral health in subjects at a high risk of periodontal disease.

Next to bacterial infections, the periodontal tissues are susceptible to fungal infections. Several *Candida* spp., most notably *C. albicans*, cause the most common oral and oropharyngeal fungal infections. Estimates range from 40% to 60% of healthy non-immunocompromised, nonhospitalized people harboring oral *Candida* spp. {50, 51}. Predisposing factors for oral candidiasis (candidosis) include multiple and broad-spectrum antibiotics, immunosuppressive drugs, anticholinergic agents, endocrine dysfunction, bone marrow depression, immunodeficiency disorders, malignancies, nutritional deficiencies, radiation treatment, dentures, xerostomia and extreme old age {51}. Fungal infections anywhere in the body are difficult to treat because these infectious agents are ubiquitous in nature and slow to respond to drug therapy. Useful drugs are fungistatic, not lethal and consequently rely heavily on innate immune defenses to rid the body of the infection. Therefore, some researchers are searching for alternative treatments to control oral candida carriage. The use of probiotics is one of these emerging treatment approaches. In 2005, Elahi et al., {52} investigated the clearance of *C. albicans* from the oral cavities of mice following the oral administration of *L. acidophilus* LAFTI L10 and *L. fermentum*. Finding suggested that colonization persisted up to day 8 in mice fed *L. fermentum*, although at significantly lower levels than found in the control group. In the control mice, *C. albicans* was detected up to 15 days after the challenge. The data from the study show that the probiotic bacteria used can help to protect against an oral candida infection in mice. In 2007, Hatakka et al., {53} performed a randomized, double-blind, placebo-controlled study on the effect of probiotics on the prevalence of oral candida. In the probiotic cheese, *Lactococcus lactis* and *Lactobacillus helveticus* were used as starter cultures, and 10^7 colony-forming units/g of each of the probiotic strains, *L. rhamnosus* GG, *L. rhamnosus* LC705 and *P. freudenreichii* ssp. *shermanii* JS were added. Control cheese contained only *L. lactis* as a starter culture, and no probiotic strains were added. After the intervention, the prevalence of high yeast counts in the probiotic group was reduced by 32%. In the control group, the prevalence of yeast had increased.

CONCLUSION

There is scientific evidence that specific strains of probiotic microorganisms confer benefits to the health of the host and are safe for human use. However, these cannot be extrapolated to other strains; as such effects are strain-specific. Use of probiotics has potential benefits for conditions such as periodontal disease. However, considerable work is required to affirm these benefits. A systematic approach based on the guidelines recommended by the Joint FAO/WHO Expert Consultation should be adopted by researchers. Much work is still needed before credibility can be given to health claims regarding the use of probiotic products in healthy individuals.

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Table I: Organisms commonly used as probiotics

LACTOBACILLUS SP.	BIFIDOBACTERIUM SP.	OTHERS
L. Acidophilus	B. Bifidum	Escherichia coli nissle
L. Casei	B. Breve	Saccharomyces boulardii
L. Crispatus	B. Infantis	Streptococcus thermophilus ¹
L. Delbrueckii subsp. Bulgaricus	B. Longum	Enterococcus faecium ²
L. Fermentum	B. Lactis	
L. Gasseri	B. Adolescentis	
L. Johnsonii		
L. Paracasei		
L. Plantarum		
L. Reuteri		
L. Rhamnosus		

¹There is still debate about the probiotic activity.

²Safety concerns remain because of potential pathogenicity and vancomycin resistance.

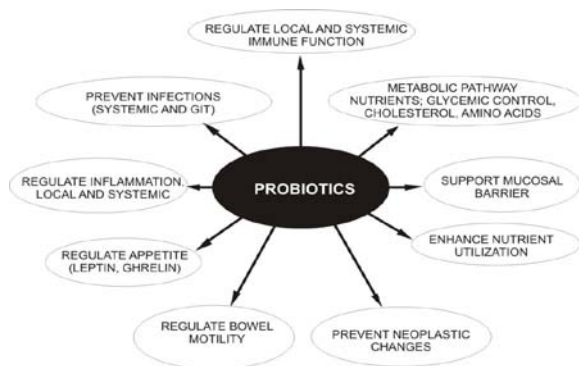


Figure 1: Beneficial effects of probiotics in humans

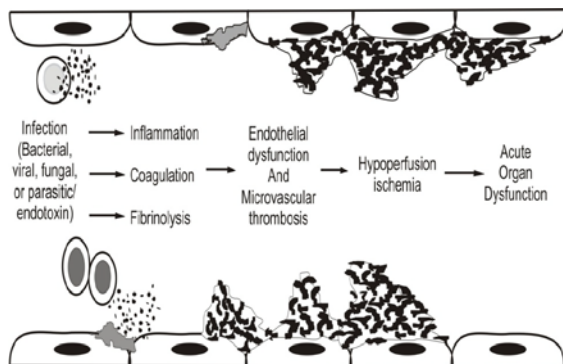


Figure 2: Mechanism of probiotics in humans