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The Use of Probiotics in Dentistry: A Review of Current Evidence

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ABSTRACT

Probiotics, mostly known for their positive effects on gut health, are also increasingly showing beneficial effects in the context of oral health. This review paper discusses the role of probiotics in the prevention and treatment of oral diseases such as dental caries, periodontal disease and halitosis. It emphasizes that the microbial balance in the oral cavity – know as eubiosis – is crucial for the health of teeth and gums. Dysbiosis, the disruption of this balance, promotes the growth of pathogenic bacteria leading to disease. Probiotics work by directly competing with carious bacteria, producing antimicrobial substances and influencing the immune system. Studies have been presented showing the effectiveness of strains such as *Lactobacillus rhamnosus, L. reuteri, Weissella cibaria* and *Streptococcus salivarius* in reducing pathogenic bacteria and oral disease symptoms. Regular consumption of fermented diary products can help maintain a healthy oral microbiota. In conclusion, probiotics can provide important support in prevention and treatment of oral diseases, but their effectiveness depends on the type of strain, form of administration and regularity of use.

Introduction. The human oral cavity hosts a diverse and complex microbiome that plays crucial role in maintaining oral and overall health. Disruptions in oral balance can lead to various oral diseases, including dental caries, periodontal disease and halitosis. Traditional methods of managing oral health, such as mechanical plaque removal and the use of antiseptics or antibiotics, may not always be sufficient and can sometimes cause undesirable side effects, including the development of resistance. In recent years, growing attention has been given to probiotics – live microorganisms that, when administered in adequate amounts, confer health benefits to the host (official Food and Agriculture Organization/World Health Organization

definition of probiotics). Originally studied for their positive effects on gut health, probiotics are now being explored for their potential to modulate the oral microbiome, inhibit the growth of pathogenic bacteria and support oral tissue health. This paper aims to provide a comprehensive overview of current scientific findings regarding the use of probiotics in the prevention and treatment of oral diseases, as well as discuss their mechanisms of action, effectiveness and possible limitations.

Aim of the work. The aim of this work is to review and summarize the current knowledge on the use of probiotics in the prevention and treatment of oral diseases. This paper focuses on understanding the mechanisms by which probiotics influence the oral microbiome, highlighting their potential benefits in maintaining oral health, preventing conditions such as dental caries, periodontal disease and halitosis, as well as evaluating the effectiveness of specific probiotic strains used in dental applications.

Methods and Materials. This review was conducted using literature from PubMed and Google Scholar, covering publications mostly from past 30 years (1994-2024). Keywords used included *probiotics, oral health* and *microbiota*. Only English-language, peer-reviewed articles relevant to the role of probiotics in oral health were included. Studies without full-text access or unrelated to oral applications were excluded. The selection prioritized human studies and clinical relevance with noted limitations such as small sample size in some sources.

Literature review results. Recent studies suggest that probiotics may play a beneficial role in maintaining oral health. Strains from *Lactobacillus, Bifidobacterium* and *Streptococcus* genera have shown potential in reducing harmful bacteria, modulating the immune response and promoting microbial balance in the oral cavity.

Probiotics have been testes in various forms – such as lozenges, chewing gums and dairy products – with promising outcomes in managing conditions like gingivitis, periodontitis and dental caries. However, inconsistent methodologies, strain variations and short trial durations make it difficult to draw firm conclusions.

Despite these limitations, the literature points to probiotics as promising adjunct in oral healthcare. Further research is needed to identify optimal strains, dosages and treatment protocols.

Keywords: probiotics, microbiota, oral health, gingivitis, periodontitis, halitosis

Subsections

- The Origins and Evolving Role of Probiotics in Human Health
- Probiotics and Oral Microbiota
- Mechanisms of Action
- Dental Caries and Probiotics
- Periodontal Diseases and Probiotics
- Halitosis and Probiotics

The Origins and Evolving Role of Probiotics in Human Health

Today the use of probiotics is quite common – we reach for them during antibiotic treatment, we may take them as an everyday dietary supplement when facing stomach or gut issues. In addition to probiotic dietary supplements, we may ingest natural probiotics daily – fermented food, such as pickles, kefir, yogurt or many types of cheese and many more are all reliable source of human-friendly bacteria [1]. The fact is that many times a year we are exposed to situations that can disrupt our microbiota. In such situations we go to the drug store to buy something that can restore our natural bacterial environment – probiotic. There are many options to choose from – sometimes it is hard to pick one from variety of products on pharmacist's shelf. Despite the long history of probiotic use, their specific application in oral health remains underexplored. This review examines their potential mechanisms and effects in maintaining oral microbial homeostasis.

It may come as a surprise that the history of probiotics takes us back as far as to the ancient China. Back then people used human feces in infection treatment or food poisoning. Fecal material has been used in ancient medicine for more than five hundred years, but probiotics as we know them today, that contribute to obtain specific strains of bacteria by human organism, have been described only for half a century. This treatment was first proposed in the early 19th century after observations showed a decline in bifidobacterial populations in children with diarrhea, suggesting that oral supplementation with bifidobacteria could restore this microbial subgroup and promote health [2]. First, probiotics were defined as substances produced by bacteria that contribute to the growth of other, desired strains of bacteria (1965) [3]. Today, we define probiotics as living microorganism that can have positive effect on human's organism if they are ingested by them in sufficient amount ("Live microorganisms which when administered in adequate amounts confer a health benefit on the host." – official Food and Agriculture Organization/World Health Organization definition) [4]. This positive effect is not

limited only by better nutrition, but also probiotics may improve resident microbiota, intestinal epithelium cells and immune system [3].

Lactobacillus or *Saccharomyces* was genre of bacteria that first probiotics contained. They were used to prevent infectious diarrhea or post antibiotic diarrhea due to *Clostridium difficile* induced colitis [5].

Today the majority of probiotic bacteria are the genera of *Lactobacillus, Bifidobacterium, Propionibacterium and Streptococcus*. Some modern studies show that probiotics may be useful in treating cardiovascular diseases, urogenital infections, oropharyngeal infections and even cancers [6]. Can they affect oral health?

Probiotics and Oral Microbiota

When it comes to human microbiome, there are four main areas, where symbiotic bacteria are located in body – intestines, skin, vagina and oral cavity. In conclusion, oral cavity is one of the largest regions of probiotic bacterial aggregation [7]. Bacteria is found on teeth, tongue, palate, in tonsils and gingival sulcus [8]. The oral microbiota consists of many types of bacteria, but *Actinobacteria, Proteobacteria, Fusobacteria, Bacteroidetes,* and *Firmicutes* predominate (they account for up to 80-95% of the total oral microbiome) – according to the whole metagenome sequencing methods. [9] Using different methods, *Prevotella, Streptococcus, Fusobacterium, Leptotrichia, Veillonella, Rothia, Corynebacterium, Capnocytophaga, Selenomonas, Treponema, Haemophilus,* and TM7 Genes 1 and 5 are most prevalent species [10].

According to World Health Organization, almost half of world's population suffers from oral diseases. The most common oral diseases is teeth decay, which affects about 2,4 billion people with permanent teeth and 532 million children with primary teeth [11]. Caries is multi-factor disease – rich in carbohydrates, cariogenic diet, lack of oral hygiene, high count of cariogenic bacteria (*Streptococcus* ssp, *Lactobacillus* ssp), and time, in which all of above can simultaneously affect teeth, contributes to caries development. What is more, slow saliva flow (which can be indicated by many commonly used drugs among people) and lack of fluoride exposure (which becomes more common, due to people's fear of its toxicity) also accelerates caries occurrence [12]. Oral cavity has its own microbiota. During cariostasis, when there is a balance between demineralization and remineralization in oral cavity's environment, oral microbiota can exist and prevent cariogenic bacteria from thriving in its niche. When the oral microbiota is disrupted and the balance is shifted in favor of carious bacteria, oral disease such as tooth decay may develop. This situation is called dysbiosis [12]. One of cariogenic bacteria that contributes to caries is *Streptococcus mutans*. This bacterium is one of the most cariogenic

microbiotas and is known for its biofilm-forming abilities [13]. If bacterial imbalance is one of the most key factors for causing teeth decay, then bacteriotherapy should be an effective way to prevent oral disease [14]. As stated previously, if sufficient number of probiotics as ingested, then they can be advantageous for human's health [4, 15]. Many in vitro and in vivo studies have shown that probiotics may prevent or even cure periodontal diseases and tooth decay [16, 17].

Mechanisms of Action

Probiotics may work within direct and indirect mechanisms.

First direct mechanism is that probiotic bacteria compete with cariogenic bacteria during plaque formation. This contributes to slowing down the plaque formation and making it less cariogenic. Next mechanism is competing with other bacteria, also cariogenic, for substrates needed for bacterial growth and survival in oral environment. Probiotic bacteria produce antimicrobial substances that can inhibit other oral bacteria, such as bacteriocins, organic acids, fatty acids and hydrogen peroxide [18]. Last, they can disrupt biofilm formation by their involvement in binding of microorganisms to proteins [12, 19].

When it comes to indirect mechanisms, probiotic bacteria may affect local immunity and non-immunologic defense mechanisms or regulate systemic immune function – probiotics may promote nonspecific immunity and modulate humoral and cellular immune response. Also, it can regulate mucosal permeability. They can modify oral environment by modulating its pH or oxidation-reduction potential. In addition, probiotic bacteria may influence oral bacterial colonization and promote less pathogenic species growth, despite cariogenic genre [6, 12].

All this is possible during homeostasis, but when homeostasis is disturbed, dysbiosis occurs, and such a phenomenon leads to disease of a particular microbiome system. Dysbiosis of the oral microbiome can occur as a result of poor dietary habits, improper oral care, the development of disease or taking certain medications. This in turn can lead to tooth decay, gingivitis, periodontitis, tooth loss and even cancer [12].

Dental Caries and Probiotics

Some studies have found that saliva samples of people with caries have an increased percentage of *Porphyromonas* and *Prevotella* ssp bacteria compared to healthy people. It was proven, that as the severity of the disease increases, bacterial diversity decreases [20]. A poor, carbohydrate-rich diet and poor hygiene promote the growth of pathogenic bacteria. The metabolism of a dysbiotic microbiota leads to an acidic environment in the mouth, which contributes to further disease development [21]. Moreover, this new environment, unfamiliar to probiotic bacteria,

prevents them from surviving, but on the other hand, the dysbiotic microbiome can prosper and continue to grow. Cariogenic bacteria, such Streptococcus mutans, is insensitive to the acidic environment and can grow in such conditions, unlike probiotic bacteria. Beside *S. mutans, Actinomyces spp., Bifidobacterium, Scardovia,* and *Lactobacillus* species are also acid-resistant [12]. Research indicates that a diverse array of bacterial strains contributes to tooth decay. A study by Chhour et al. (2005) reported the presence of seventy-five species or phylotypes across ten caries lesions, with up to thirty-one species identified in individual samples. *Lactobacilli* species constitute approximately 50% of the detected bacteria, while *Prevotellae* account for around 15%. Other highly prevalent species include *Fusobacterium nucleatum, Pseudoramibacter alactolyticus, Dialister* spp., *Selenomonas* spp., *Eubacterium* spp., *Olsenella* spp., *Bifidobacterium* spp., members of the *Lachnospiraceae* family, and *Propionibacterium* sp [22].

The primary goal of dental treatment is to preserve tooth structure and prevent further decay. Since dental caries is initially a reversible, multifactorial disease, dentists now focus less on immediate intervention and more on long-term management. Given the excessive cost and time required for treatment, prevention – through personal hygiene and dietary changes – is a more practical approach [23]. One potential approach to preventing caries development is the consumption of probiotics, so that bacterial imbalance would not occur. For gaining possible advantages of such action, the probiotic must adhere to dental surfaces in order to integrate to dental biofilm, from where it can compete with cariogenic species and inhibit their growth [6]. It is necessary that probiotic bacteria's metabolism of food-grade sugars should lead to minimal acid production. One key benefit of incorporating probiotics into dairy products is their ability to neutralize acidic conditions. For instance, research has shown that cheese can help prevent enamel demineralization while also promoting its remineralization [24, 25].

Haukioja et al. assessed the survival and adherence of dairy probiotics (*Lactobacillus* and *Bifidobacterium*) in saliva and on oral surfaces. While all strains survived well in saliva, *Lactobacillus* showed superior adherence compared to *Bifidobacterium* [26]. Daily consumption of yogurt with Lactobacillus *rhamnosus* allowed its presence in saliva for up to three weeks post-consumption [27], but some researchers claim that it lasted temporarily [28]. These findings suggest that probiotics in consumer products may colonize the oral cavity, but sustained intake may be necessary for lasting effects [6].

In different studies, it was reported that only two strains of bacteria (out of twenty-three that were tested) used in dairy products had a potential to adhere to biofilm on tooth surface and prevent development of *Streptococcus sobrinus*, one of cariogenic bacterium. These two strains

were *Streptococcus thermophilus* and *Lactobacillus lactis* ssp [29]. Many more studies have been conducted over the years, assessing the potential of bacteria for caries prevention. In these studies it was concluded that *Weissella cibaria* had capacity to inhibit biofilm formation by *S. mutans* and prevent its proliferation, *L. rhamnosus* and *L. casei* inhibited growth of *S. mutans* and *S. sobrinus, S. thermophilus* and *L. bulgaricus,* that can be found in yogurt, were bactericidal for *S. mutans* [30, 31, 32]. Consistent diary consumption, especially yogurt, milk or cheese, which are rich in probiotic bacteria, may contribute to decreasing number of cariogenic bacteria in saliva and prevent caries development. Intake of yogurt that contains *Lactobacillus reuteri* may reduce *S. mutans* population in oral cavity up to 80% after 2 weeks period of time [6, 33]. What is more, children consuming milk with probiotic bacteria such as *L. rhamnosus* had less *S. mutans* count in their saliva and fewer caries compared to children that did not consume such supplemented milk.

In conclusion, probiotics may prevent dental caries, both in adults and children (ECC early childhood caries) [34].

Periodontal Diseases and Probiotics

There are two types of periodontal disease: gingivitis and periodontitis. Gingivitis is reversible condition that is limited to inflammation of gingiva only, manifesting by its bleeding and swelling. Periodontitis is much more extended condition that leads to irreversible tissue loss – it affects all teeth supportive structures. As we know, periodontal disease is caused by pathogenic bacteria. Insufficient hygiene and resulting plaque build-up lead to microbiome imbalance, where pathogenic bacteria dominate over probiotic bacteria. Main pathogenic bacteria for periodontal disease are *P. gingivalis, Treponema denticola, Tannerella forsythia* and *Aggregatibacter actinomycetemcomitans* [30]. Apart from bacterial factor, patient's immunity, chronic diseases, medications are also essential modifying factors for periodontal disease development.

There are many studies that prove probiotic bacteria presence is beneficial for periodontium health. Some bacteria species can inhibit growth of pathogenic ones. First example of such probiotic bacteria is *Lactobacillus gasseri* and *Lactobacillus fermentum*. This microbiota has greater prevalence among people with healthy periodontium, in contrary to people with chronic periodontal disease, among whose said probiotic bacteria is less widespread. It was proven by many studies that *L. gasseri* and *L. fermentum* may inhibit the growth of periodontopathogens, including *P. gingivalis, Prevotella intermedia* and *A. actinomycetemcomitans* [36, 37].

L. reuteri, apart from being evaluated to have positive impact in caries prevention, also have beneficial effect against gingivitis. In this evaluation it was used as an ingredient of chewing gum. Patients with gingivitis, who chewed gum with *L. reuteri* experienced positive effect – their plaque index have been lowered [38]. This positive impact in gingivitis fighting of *L. reuteri* is explained in three possible mechanisms – first, *L. reuteri* secrete bacteriocins such as reuteris and reutericyclin, both known to inhibit pathogen's growth. Second, this bacterium inhibits intestinal mucosa's proinflammatory cytokines secretion, providing anti-inflammatory effects. Last, *L. reuteri* has adherent properties for tissues [6].

Other studied bacterium is also one from *Lactobacilli* genre – *Lactobacillus brevis*. Patients with chronic periodontits used lozenges with *L. brevis*, leading to lowering their plaque index, gingival index and bleeding on probing index. Same as *L. reuteri, L. brevis* provided anti-inflammatory effects, reducing presence of prostablandin E2 (PGE2) and metalloproteinases (MMPs) in patient's saliva. Additionally, it was also suggested that *L. brevis* reduced quantity of plaque [39].

Regular consumption of diary products containing *Lactobacillus* bacteria contributed to reducing periodontitis parameters such as clinical attachment loss and probing depth.

Halitosis and Probiotics

Halitosis is a condition resulting from bacterial activity, which degrades salivary and food proteins into sulphur compounds causing bad breath – *Fusobacterium nucleatum* is an example of bacterium that produce volatile sulphur compounds. This is another situation, where dysbiotic environment contributes to development of oral cavity disease. Apart from microbiota, consumed food, metabolic disorders, respiratory tract infections, but also medications or habits as smoking are other important modifying factors for halitosis [6]. Another study found that specific bacterial species, such as *Atopobium parvulum, Eubacterium sulci,* and *Solobacterium moorei,* are dominant on the dorsal surface of the tongue in individuals with halitosis [41].

Studies showed that some strains of *Weissella cibaria* produce hydrogen peroxide that makes it impossible for *F. nucleatum* to proliferate. That contributes to inhibiting volatile sulphur compounds production by *F. nucleatum*. Reduction of *F. nucleatum* and products of its metabolism (such as hydrogen sulphide and methanethiol) reduces halitosis. *W. cibaria* can be delivered to oral cavity by gargling with a solution containing this bacterium [40].

Streptococcus salivarius is one of the cariogenic bacteria, but also, according to some studies, can be considered a commensal probiotic of the oral cavity [41]. It was found among people without diagnosed halitosis. It is known to produce bacteriocins that can inhibit growth of bacteria producing volatile sulphur compounds. *S. salivarius* can be delivered to oral cavity in a form of gum or lozenges [42].

Conclusions

Probiotics play a crucial role in maintaining oral health by influencing the balance of the oral microbiota. Numerous studies have demonstrated their potential in preventing and managing various oral conditions, including dental caries, periodontal disease, and halitosis. By competing with pathogenic bacteria, producing antimicrobial substances, and modulating the immune response, probiotics help maintain a healthy microbial environment in the oral cavity. Their beneficial effects on dental caries are particularly promising, as probiotic strains such as *Lactobacillus rhamnosus, Weissella cibaria,* and *Streptococcus thermophilus* have been shown to inhibit cariogenic bacteria like *Streptococcus mutans*. Regular consumption of probiotic-rich dairy products, such as yogurt and cheese, may help reduce the risk of tooth decay by neutralizing acids and supporting enamel remineralization.

Probiotics also show potential in managing periodontal diseases by inhibiting periodontopathogens and reducing inflammation. Strains like *Lactobacillus reuteri* and *Lactobacillus brevis* have demonstrated their ability to lower plaque and gingival inflammation, offering a promising adjunct to traditional periodontal treatments.

Additionally, probiotic intervention may provide a natural approach to combating halitosis by targeting volatile sulfur compound-producing bacteria such as *Fusobacterium nucleatum*. Strains like *Weissella cibaria* and *Streptococcus salivarius* have shown effectiveness in reducing bad breath through their antimicrobial properties.

While existing research supports the role of probiotics in oral health, further clinical studies are needed to establish optimal strains, dosages, and delivery methods. Incorporating probiotics into daily oral hygiene routines, alongside traditional preventive measures, could offer a holistic approach to improving oral health and reducing the prevalence of common oral diseases.

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