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Probiotics Role in Reduction of the Dental Caries

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Introduction

Dental caries and periodontal disease are major public health problems that bother all countries in the world. Dental caries is an infectious, communicable disease that acid-forming bacteria of dental plaque can destroy tooth structure in the presence of fermentable carbohydrates such as sucrose, fructose, and glucose. The mineral content of teeth is sensitive to increases in acidity from the production of lactic acid. S0, the infection results in Loss of tooth minerals from the outer surface of the tooth and can progress through the dentin to the pulp, finally compromising the tooth vitality. Industrialized nations have controlled the problem with fluoride enriched water and personal hygiene products since early in the 1960s, but cariogenicity remains a crisis that economical burdens the health care system. Dental disease remains a" silent epidemic ‘in the world that threatens children and adults. The oral streptococci especially (mutans Streptococci) are related with the development of caries in humans and animals For the past 150 years, the predominant mode of caries management has been the surgical approach, predating our current understanding and reliable with the original concept that dental caries was a gangrenous process resulting in extraction of carious teeth Later, just the demineralized portions of the tooth were removed and replaced with an inert restorative material. This mechanical solution tor a biological problem prevailed.

Oral health has a direct impact on an individual’s wellbeing and quality of life. Oral diseases can limit the individual’s capacity of eating, speaking and smiling thereby greatly damaging personal and social life. Latest research, both in vitro and in vivo, has unveiled significant role of probiotic strains in prevention of a vast gamut of oral health problems ranging from caries to halitosis and periodontal diseases. Studies have shown the direct role of probiotics in inhibiting oral pathogens as well as changing the oral microenvironment which acts as a deterrent for further colonization by the pathogens. Indigenous probiotic pre- parations have also been shown to significantly prevent or reduce oral diseases when administered continuously for a few weeks. Most of the studies included in this review indicate towards daily consumption of probiotics to produce the intended effects, such as inhibiting pathogens, growth of indigenous species and maintaining the pH balance. It was also revealed that the action of probiotics is not universal instead specific oral diseases require specific probiotic interventions/combinations to impart the intended effects. Therefore, probiotics can be adopted as a novel approach to prevent the demineralization of enamel, improve periodontal health, eliminate halitosis and reduce the prevalence of C. albicans in adults. Moreover, the selection of the best-suited probiotic Journal of Functional Foods 70 (2020) 103985 for oral health is an issue that certainly calls for further study. Research to unravel the mechanisms of possible probiotic action and long-term clinical trials are further needed before including them into daily oral- health regimen.

Probiotics

The term probiotic was derived from theGreek word, meaning "for life". The WorldHealth Organization along with an expert panelcommissioned by the Food and AgricultureOrganization of the United Nations defined probiotics as "Live microorganisms which when administered in adequate amounts-confer a health benefit on the host"17. Experimental studies using naturally occurring and genetically engineered probiotic strains including Lactobacillus rhamnosus, L. casei, L. reuteri, L. plantarum, L. brevis, Bifidobacterium spp. have aimed to evaluate the effect of probiotics on caries incidencereduction, mutans Streptococci andLactobacilli count change, plaque pH control and root caries lesions reversal18-40. However, the most widely researched probiotic bacteria belong to the Lactobacilli and Bifidobacteria genera, but some strains of Streptococci have also been investigated4]

Mechanism of action

Not all lactic acid bacteria or Bifidobacteriaare probiotic and possess the ability to confer health benefits on the host. Certain bacteria have potential beneficial effects on health depending on their ability to regulate host immune response either directly (local) or indirectly (systemic)42. Moreover, probiotic bacteria do not colonize the host permanently and permanent-colonization is not at all necessary fir probiotic action to occur. Studies in faeces,plaque and saliva reveal that ingested probiotic bacteria can be recovered only until a period of one week after termination of intake43,44. The widely understood mechanisms of action of probiotics include co-aggregation and growth inhibition, organicacid, bacteriocin and hydrogen peroxide production, competitive exclusion through antagonistic activities on adhesion and nutrition and immunomodulation . The different probiotic strains of Lactobcailli were tested and identified that salivary pellicle protein modification and inhibition of adherence of cariogenic bacteria were the two mechanisms predominantly by which the Lactobacillus rhamnosus L. casei, L. reuteri, L. plantarum, L. brevis strains acted. These strains bind with the salivary agglutinin gp340, a protein responsible for adherence of S. Mutans, thereby purging it from the saliva. I ne L.salvarus supernatant strain can destroy certain cariogenic bacteria by release of hydrogen peroxide. S.Mutansis one among them as the lack hydrogen peroxide scavenging systems . I he down regulation of the vicKX operon responsible for the expression of virulence associated genes

was demonstrated In S. Mutans,when the bacteria was exposed to L. casel. L. Reuteri supernatants47, Thus, Lacobacillus sp. can inhibit dental caries by restraining growth and virulence properties of S. Mutans. Streptococcus salivarius are good probiotic candidates that have anti-mutans streptococcus

(MS) action. S. Salivarius JH subtype probiotic produces anti-MS bacteriocin, salivaricin E and has hydrolytic activity that destroys exopolymerase substance of MS.

Table 1 Studies involving probiotic supplementation in caries risk factors and incidence in humans (chronological order)

Number of participants	Age	Probiotic and amount	Treatment duration	Probiotic effect	Reference
594	1–6 years	*Lactobacillus rhamnosus* GG ATCC (LGG) 53103 $5–10 \times 10^9$ CFU/mL	7 months	Reduction in the caries incidence.	[14]
74	18–35 years	*Lactobacillus rhamnosus* GG ATCC 53103 1.9×10^7 CFU/g *Lactobacillus rhamnosus* LC 705 1.2×10^7 CFU/g	3 weeks	Tendency of *Streptococcus mutans* reduction in the oral cavity, but without statistical difference.	[10]
261	2–3 years	*Lactobacillus rhamnosus* SP1 10^7 CFU/mL	10 months	Reduction of caries prevalence (54.4% in the probiotic group and 65.8% in the placebo group) and incidence (9.7% new cases in the probiotic group and 24.3% in the placebo group).	[13]
35	–	1.88×10^9 live cells/day: *L. sporogens* 16%, *L. bifidum* 12%, *L. bulgaricus* 12%, *L. termophilus* 18%, *L. acidophilus* 20%, *L. casei* 10%, *L. rhamnosus* 12%	45 days	Increase *Lactobacilli* count but not reduce *Streptococcus mutans* count.	[25]
21	21–24 years	*Bifidobacterium* DN-173 010 7×10^7 CFU/g	2 weeks	Reduction of *Streptococcus mutans* oral count.	[44]
120	21–24 years	*Lactobacillus reuteri* ATCC 55730 10^8 CFU	3 weeks	Reduction of *Streptococcus mutans* oral count.	[38]
80	21 - 24 years	*Lactobacillus reuteri* DSM 17938 and ATCC PTA 5289 1.1×10^8 CFU of each strain	3 weeks	Reduction of *Streptococcus mutans* oral count.	[31]
20	Mean age 20 years	*Lactobacillus reuteri* DSM 17938 and ATCC PTA 5289 1×10^8 CFU of each strain	10 days	Reduction of *Streptococcus mutans* oral count.	[32]
24	Mean age 20 years	*Bifidobacterium lactis* Bb-12 1×10^7 CFU/g–53 g/day	10 days	Reduction of *Streptococcus mutans* count.	[30]
248	1–5 years	*Lactobacillus rhamnosus* LB21 10^7 CFU/ml–150 ml per day	21 months	Reduction in the caries incidence.	[23]
20	21–35 years	*Streptococcus oralis* strain KJ3sm, *Streptococcus uberis* strain KJ2sm and *Streptococcus rattus* strain JH145, in two doses, 10^5 or 10^6 CFU of each probiotic per day	4 weeks	Reduction of *Streptococcus mutans* count.	[49]
78	20–26 years	*Lactobacillus paracasei* GMNL-33	2 weeks	Reduction of *Streptococcus mutans* count.	[11]
100	58–84 years	*Lactobacillus rhamnosus* LB21 10^7 CFU/mL	15 months	RCI reversal and improvement of caries lesions.	[24]
40	12–14 years	*Bifidobacterium lactis* Bb-12 ATCC27536 and *Lactobacillus acidophilus* La-5 1×10^9 CFU/g of each strain	10 days	Reduction of *Streptococcus mutans* count, but not in *Lactobacillus* levels in saliva.	[52]
13	Mean age 25.3 years	*Lactobacillus rhamnosus* GG and *Lactobacillus reuteri*	2 weeks	No effect.	[27]
30	Mean age 26 years	*Lactobacillus reuteri* DSM 17938 and ATCC PTA 5289 1×10^8 CFU of each strain	2 weeks	No effect.	[28]
62	Mean age 23 years	*Lactobacillus reuteri* DSM 17938 and ATCC PTA 5289 1×10^8 CFU of each strain	6 weeks	No effect.	[29]
106	1–2 months	*Bifidobacterium animalis* subsp. *lactis* BB-12 (BB-12) 10^{10} CFU/day	14.9 ± 6.7 months	*Lactobacillus* oral count. No effect.	[46]

Number of participants	Age	Probiotic and amount	Treatment duration	Probiotic effect	Reference
40	12–15 years	*Lactobacillus rhamnosus* hct 70 2.34×10^9 CFU/day	3 weeks	Reduction of *Streptococcus mutans* count in saliva.	[22]
25	6–10 years	*Lactobacillus rhamnosus* GG ATCC 53103	14 days	Reduction of *Streptococcus mutans* count in saliva.	[21]
19	4–12 years	*Lactobacillus reuteri* strains DSM 17938 and ATCC PTA 5289 1×10^8 CFU/day	25 days	No effect.	[39]
191	6–8 years	*Lactobacillus brevis* CD2 2×10^9 colonies	6 weeks	Reduction of *Streptococcus mutans* oral count, plate acidogenicity and bleeding.	[43]
26	–	*Bifidobacterium animalis* subsp. *lactis*DN-173010	2 weeks	No effect.	[47]
20	–	*Lactobacillus paracasei* DSMZ16671	2 days	Reduction of *Streptococcus mutans* oral count.	[35]
40	18–25 years	*Lactobacillus paracasei* SD1 $7.5 \pm 0.20 \times 10^8$ CFU/g	4 weeks	Reduction of *Streptococcus mutans* and increase in	[34]
179	4 months	*Lactobacillus paracasei* F19 (LF19) 1×10^8 CFU/day	9 months	No effect.	[36]
100	5–10 years	*Streptococcus salivarius* strain M18 3.66×10^9 CFU/day	3 months	Increase in *Streptococcus salivarius* count, reduction of *Streptococcus mutans* count and in the plaque score.	[50]
60	6–12 years	*Lactobacilli reuteri* (2×10^8 CFU/day) or *S. uberis* KJ2, *S. oralis* KJ3, and *S. rattus* JH145 ($\geq 1 \times 10^8$ CFU/day)	28–30 days	Reduction of *Streptococcus mutans* and *Lactobacillus* in saliva.	[57]
106	1–2 months	*Bifidobacterium animalis* subsp. *lactis* BB-12 (BB-12) 10^{10} CFU/day	14.9 ± 6.7 months	No effect.	[45]
64	Mean age 24.8 ± 2.3 years	*Lactobacillus salivarius* strains WB21 (6.7×10^8 CFU/day) and TI 2711 (2.8×10^8 CFU/day)	2 weeks	Reduction of *Streptococcus mutans* and increase of *Lactobacillus* in saliva.	[41]
113	Last month of pregnancy and first year of life	*Lactobacillus reuteri* 10^8 CFU/day (mothers and children)	13 months	Reduction of caries incidence.	[37]
31	6–8 years	*Lactobacillus casei* Shirota	10 days	Reduction of *Streptococcus mutans* oral count.	[26]
36	12–17 years	*Lactobacillus reuteri* (DSM 17938 and ATCC PTA 5289) 1×10^8 CFU of each strain/day	3 months	Tendency of less demineralization on early enamel lesions, but without significant difference.	[40]
60	–	*Lactobacillus paracasei* SD1 $7.5 \pm 0.20 \times 10^8$ CFU/g	6 months	Reduction of *Streptococcus mutans* and increase in neutrophil peptide 1–3 oral count.	[33]
50	6–12 years	*Bifidobacterium lactis* Bb-12 and *Lactobacillus acidophilus* La-5 (1×10^8 CFU of each) or *Lactobacillus casei* strain Shirota (6.5×10^8)	7 days	Reduction of *Streptococcus mutans* oral count.	[54]
60	6–12 years	*Bifidobacterium lactis* Bb-12 and *Lactobacillus acidophilus La-5* 1×10^8 CFU of each probiotic	7 days	Reduction of *Streptococcus mutans* oral count.	[53]
49	6–12 years	*Bifidobacterium lactis* 1×10^8 CFU/g	2 weeks	No effect.	[48]
40	4–6 years	*Streptococcus uberis* KJ2, *S. oralis KJ3*, and *S. rattus* JH145	2 weeks	Reduction of *Streptococcus mutans* oral count.	[51]
33	12–15 years		3 weeks		[56]

Number of participants	Age	Probiotic and amount	Treatment duration	Probiotic effect	Reference
		Lactobacillus acidophilus, *Bifidobacterium longum*, *Bifidobacterium bifidum*, and *Bifidobacterium lactis*		Reduction of *Streptococcus mutans* oral count.	
138	2–3 years	*Streptococcus uberis* KJ2, *S. oralis* KJ3, and *S. rattus* JH145 1×10^8	1 year	Reduction of the risk of developing caries.	[18]
11	23–44 years	*Lactobacillus salivarius* CECT 5713 10^9 inactivated cells per day	1 week	Reduction of *Streptococcus mutans* oral count.	[42]
50	19–27 years	*Lactobacillus acidophilus* ATCC 4356 and *Bifidobacterium bifidum* ATCC 29521 1.5×10^8 CFU/g	3 weeks	Reduction of *Streptococcus mutans* oral count.	[55]

Table 1 Studies involving probiotic supplementation in caries risk factors and incidence in humans

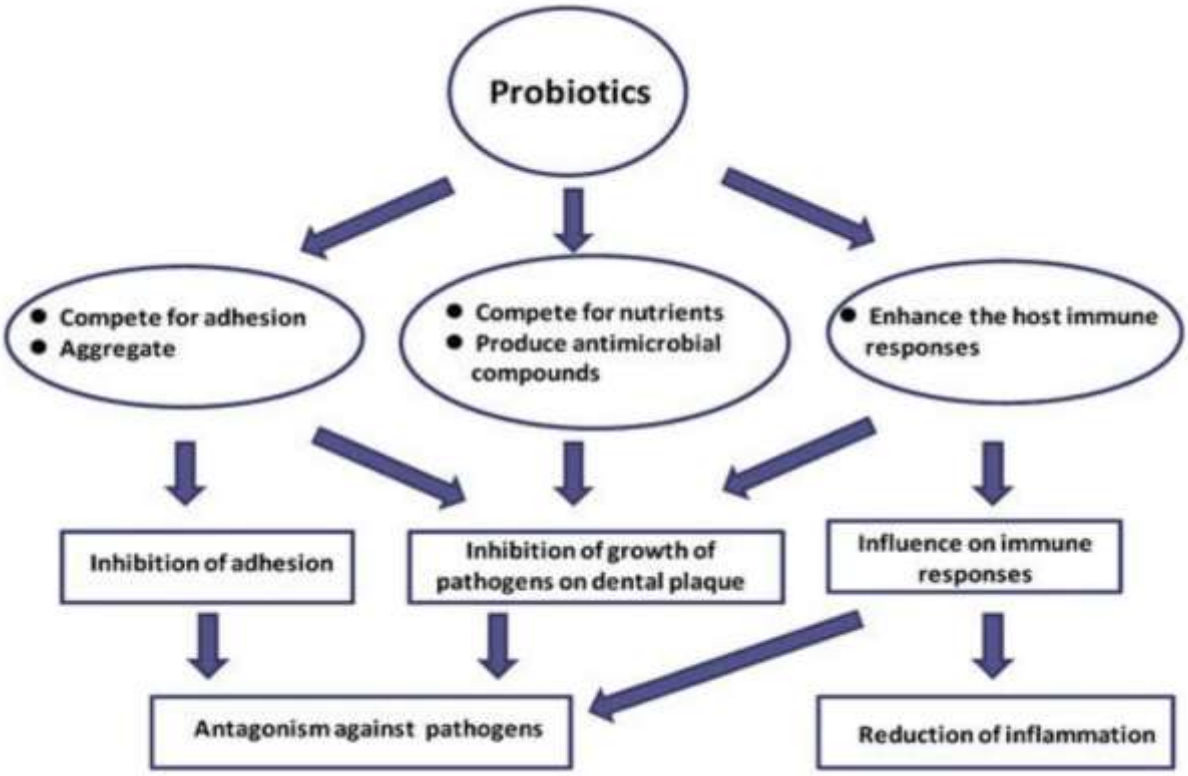
Benefits of Dental Probiotics

One of the most amazing things about oral probiotics is that they have multiple applications beyond simply treating oral malodor. Conditions such as dental caries, gingivitis, periodontitis, pharyngitis, tonsillitis, and oral candidiasis are all inhibited by exposure to the K12 and M18 strains of S. salivarius.[4] These additional benefits hold much promise in dentistry, as many patients have difficulty with home care and these probiotics are easy to use.

In the battle against dental caries, the M18 strain has a molecular mechanism that reduces plaque formation and increases oral pH. Specifically, this bacteria releases salivaricin M, a substance that limits the growth of the caries-causing bacterial species, such as Streptococcus mutans and Streptococcus sobrinus.[7]

In patients with gingivitis, M18 lozenges have been found to significantly reduce supragingival plaque, gingival inflammation, sulcular bleeding, and pocket depth.[8] Both strains K12 and M18 have been found to be effective in reducing levels of P. gingivalis, A. actinomycetemcomitans, and F. nucleatum-induced IL-6 and IL-8, which are typically indicators of periodontal disease.[4]

The multiple applications of dental probiotics could provide substantial benefits to patients who have ongoing issues with oral hygiene due to their ability level. Imagine in the future that a nursing home patient could receive a dental probiotic, along with his or her normal medications, as part of a regimen to positively affect the person's oral health. It's amazing to think how a little lozenge provided on a regular basis could help so many people so easily.



The advantage of using oral probiotics

Over-the-counter dental products used for fighting bad breath focus on masking the odor or attempting to kill bacterial culprits in the oral cavity. Some of these products specifically target VSCs. The problem with this is that bacteria repopulate quickly, so the relief from bad breath is usually short-lived.[4] Another aspect to consider is that when a bacterial population is reduced, something always replaces it, whether good or bad. This is where dental probiotics step in to combat bad breath in an entirely different way.

Dental probiotics focus on promoting the growth of good bacteria in the oral cavity and curtailing the growth of pathogenic bacteria. There are normally more than 700 different bacterial species found in the human mouth.[5] With dental probiotics, daily exposure helps to colonize the oral cavity with bacteria that do not produce VSCs. Research has shown that 85% of people who took oral probiotics for one week experienced a significant reduction in volatile sulfur compounds.[4] Even more impressive is the fact that the majority of study participants maintained a reduced level of VSCs for two weeks following exposure to oral probiotics. With this treatment modality, there is finally potential for a more long-term solution to bad breath.

How dental probiotics differ from conventional probiotics

Dental probiotics are completely different from the probiotics needed for digestion. Specifically, the Streptococcus salivarius strains K12 and M18 have been found to be especially beneficial when it comes to the health of the oral cavity.[3] In the study mentioned earlier, K12 is the strain that is effective in combating bad breath.[4]

Gut probiotics typically come in capsule form so they can reach the stomach and quickly begin to do their job. Oral probiotics, on the other hand, are typically in the form of a lozenge that is chewed or sucked on after normal oral care. Using a lozenge provides longer exposure time than other methods so that more bacteria are able to colonize the oral cavity.

Future for probiotics in caries prevention

Bacterial interference using probiotics to bed the stability and diversity of oral biofilm is gaining utmost momentum in dentistry42. Even though the use of probiotic strains for caries prevention has showed promising results, there are very few clear clinical outcomes In Probiotics in Dental Caries Prevention this favour. Convincing scientific evidence is still not available. A regular daily usage through products like toothpaste, mouth rinses Is a possible potential way or administration of probiotics into daily life.

However, this may be a great challenge in terms of patient compliance and costs. Dietary supplements with probiotic bacteria are an effective and a more economical alternative for an average consumer than. tablets and capsules.

Summary and Conclusions

The interest in oral probiotics has been growing during the last decades. Most of the studies have been conducted with probiotic strains originally suggested for gut health; however, it is important to realize that each of the suggested health benefits should be studied for each bacterial strain individually. Thus, a probiotic bacterium in the mouth is not necessarily an oral probiotic.

Furthermore, it is quite possible that the same species are not optimal for all oral health purposes, e.g., different properties might be desired in respect to dental and gingival health.

At least some of the probiotic bacteria used in various probiotic products may colonize the oral cavity during the time they are in use; thus, the effects of probiotic bacteria in the oral cavity are important

to understand. Probiotic bacteria seem to affect both oral microbiota and immune responses. On the other hand, the extent to which bacteria in food or in food ingredients can influence relatively stable oral microbiota is difficult to predict. Thus, both research to unravel the mechanisms of possible probiotic action and long-term clinical trials are needed if probiotics are to provide a new scientifically proven means of preventing or treating oral diseases.

Several health-promoting effects of probiotic bacteria are well documented, and there is no reason to restrict the use of probiotic products because their effects on oral health are not yet well understood; however, their recommendation for dental health purposes is not yet justified.

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