Journal of Pharmacology &Drug Development

eISSN: 2958-6801

OPEN ACCESS

The Impact and Role of Probiotic Bacterium *Streptococcus Salivarius* on Oral and Dental Health

Mohammad Ali Sadeghi [*,1], Dariush Minai Tehrani [2] and Mojtaba Mohammadzadeh Vazifeh [3]

[1] Department of Microbial Biotechnology, Faculty of Basic Sciences and Advanced Technologies in Biology, University of Science and Culture, Tehran, Iran.

[2] Department of Microbiology and Microbial Biotechnology, Faculty of Sciences & Biotechnology, Shahid Beheshti University, Tehran, Iran.

[3] Department of Microbial Biotechnology, Faculty of Basic Sciences and Advanced Technologies in Biology, University of Science and Culture, Tehran, Iran.

***Corresponding author**

Received 19/3/2025, Accepted 1/5/2025, Published 1/6/2025

ABSTRACT

Streptococcus salivarius is a Gram-positive, non-pathogenic bacterium naturally found in the oral microbiota of healthy individuals. It is recognized as an effective probiotic due to its antimicrobial properties and ability to stimulate the immune system, particularly activating natural killer (NK) cells and producing anti-tumor cytokines such as interferon-gamma and interleukin-12 (IL-12). Strains K12 and M18 of this bacterium are specifically used to combat harmful oral bacteria and prevent tooth decay. These strains act by producing bacteriocins, especially against *Streptococcus mutans* (the main cause of tooth decay).

Probiotics, in general, are live microorganisms that, when consumed in sufficient amounts, have beneficial effects on the host's health. *Streptococcus salivarius*, as a probiotic, plays a role not only in oral and dental health but also in improving overall body health. Studies have shown that this bacterium can help reduce bad breath, improve gum health, and reduce dental plaque formation. Additionally, the use of products containing this probiotic, such as toothpaste and mouthwash, can help its effective colonization in the oral cavity.

Compared to conventional methods such as the use of antibiotics, probiotics are safer and reduce the risk of microbial resistance. However, probiotic consumption may cause mild side effects such as bloating or diarrhea in some individuals. Overall, *Streptococcus salivarius* as a promising probiotic plays an important role in maintaining oral and dental health and improving the quality of life.

Keywords: *Streptococcus salivarius,* Probiotics, Dental Health, Microorganisms

INTRODUCTION

Streptococcus salivarius is a symbiotic bacterium that is naturally found in the oral cavity and can be effective in improving oral and dental health as a probiotic. *Streptococcus salivarius* exerts its beneficial effects through various mechanisms. By producing bacteriocins, this bacterium inhibits the growth of harmful bacteria such as Streptococcus mutans, which play an important role in causing tooth decay. Also, *Streptococcus salivarius* can reduce the production of odorous sulfur compounds, which are the main cause of bad breath. In addition, this bacterium can prevent the colonization of pathogenic bacteria by forming colonies in the mouth.

The Importance and Relationship of Oral and Dental Health with General Body Health

The reason for using the probiotic *Streptococcus salivarius* is its importance for oral and dental health. Oral and dental health is very important for overall body health, quality of life, and preserving natural teeth in the elderly [(1)]. Paying attention to oral and dental health from a young age is essential for maintaining healthy teeth in adulthood [(2)].

Oral health is associated with general health, complications, and mortality in the elderly [(3)]. Neglecting oral and dental health can lead to serious problems such as heart disease, diabetes, and respiratory infections [(4)]. During pregnancy, hormonal changes can affect periodontal conditions and lead to adverse pregnancy outcomes. Awareness of these issues among health professionals and women can help prevent or minimize these outcomes [(5)].

What is a probiotic?

The history of probiotics dates back to ancient times and is linked to the consumption of fermented foods and the gradual understanding of the role of microorganisms in human health [(6)].

The World Health Organization (WHO) defines probiotics as "live microorganisms that, when administered in adequate amounts, confer a health benefit on the host [(7)]". The purpose of consuming probiotics is to improve health by targeting the microbiota associated with humans and animals. Probiotics utilize live microorganisms, while prebiotics are non-digestible substrates that act as nutrients for beneficial microorganisms already present in the host's body [(8)].

Various definitions of probiotics, prebiotics, and synbiotics have been discussed by different researchers. The concept of probiotics is limited to the effects resulting from live microorganisms, but it is applicable regardless of the site of action and route of administration. Therefore, it may include locations such as the oral cavity, intestine, vagina, and skin [(9)].

Probiotics are defined as beneficial microorganisms that are administered to a host (usually humans) to help maintain or improve oral health. This definition includes probiotics that do not originate from the gut but are specifically designed to improve oral health [(10)] .The probiotic *Streptococcus salivarius* K12 can affect the health of the human ear and oral cavity and play a role in preventing diseases of the oral cavity and improving human health [(11)]. *Streptococcus salivarius* K12 can colonize the human oral cavity [(12)].

The reason for the importance of the probiotic industry in today's lifestyle:

The probiotic industry is of particular importance due to the significant role it plays in improving and promoting human health in modern lifestyles.

Improvement of digestive health:

One of the main reasons for the importance of the probiotic industry is its role in improving digestive health. By regulating the gut's microbial flora, probiotics help improve food digestion, reduce bloating and gas, and prevent constipation and diarrhea. In modern lifestyles, which are often associated with improper and processed diets, probiotics can help maintain the balance of the gut microbiome and improve the function of the digestive system [(13)].

Strengthening the Immune System:

Probiotics play an important role in strengthening the body's immune system. By regulating immune responses and increasing the production of antibodies, probiotics help the body fight infections and diseases. In today's world, where we face increasing stress and environmental pollution, strengthening the immune system with probiotics can help maintain overall health [(14)].

Addressing Diseases Caused by Modern Lifestyle

The probiotic industry is important because of its ability to address diseases associated with modern lifestyles. Consumption of organic milk containing probiotics can help reduce the risk of cardiovascular diseases, cancer,

depression, rheumatoid arthritis, and diabetes. These diseases are often caused by poor diet, lack of physical activity, and the stresses of modern life [15].

Application in Various Products

Probiotics are used as a key component in foods, medicines, and dietary supplements. This diversity in application has made access to probiotics easier for different people with various needs. From fermented dairy products to probiotic capsules and powders, there are diverse options available for consumers [16].

Improving Infant and Child Health

Probiotics can help improve the health of infants and children. Probiotic consumption by breastfeeding mothers or infants can help strengthen the immune system, improve digestion, and reduce the risk of allergies and eczema. This has made probiotics an important component in infant and child nutrition [17].

Role in Mental Health

Research has shown that there is a connection between the gut and the brain, and probiotics can help improve mental health. By regulating the gut microbiota, probiotics can help reduce stress, anxiety, and depression. This has led to probiotics being considered a natural approach to improving mental health [18].

Impact on Longevity and Health of the Elderly

Probiotics play a significant role in increasing longevity and improving the quality of life for the elderly. By improving digestive function, strengthening the immune system, and reducing inflammation, probiotics can help maintain the health and independence of older adults. This has led to probiotics becoming an important component in the diet of the elderly [13].

The Role of Probiotics in Oral Diseases:

Probiotics play an important role in preventing oral diseases and contribute to maintaining oral and dental health through various mechanisms. These beneficial microorganisms prevent the occurrence of oral diseases by strengthening the oral microbiota, producing antimicrobial substances, modulating the immune system, and competing with pathogenic bacteria.

Strengthening the Oral Microbiota

Probiotics help establish and maintain balance in the oral microbiota. This balance is essential to prevent the overgrowth of pathogenic bacteria and the creation of dysbiosis. By increasing the number of beneficial bacteria in the mouth, probiotics create a healthier environment for the teeth and gums [19,20].

Production of Antimicrobial Substances

Some probiotics, such as *Streptococcus salivarius*, prevent the growth of pathogenic bacteria by producing bacteriocins and other antimicrobial substances. These substances eliminate harmful bacteria or stop their growth by inhibiting cell wall synthesis or disrupting the cell membrane of harmful bacteria [19,20].

Modulation of the Immune System

Probiotics can modulate the oral immune system and reduce inflammatory responses. This property is particularly effective in preventing gum diseases such as gingivitis and periodontitis. By reducing inflammation, probiotics help maintain the health of gum tissues and prevent jaw bone resorption [19,20].

Competition with pathogenic bacteria

Probiotics compete with pathogenic bacteria for attachment to the surfaces of teeth and gums. This competition helps to prevent the formation of dental plaque and harmful biofilms. By reducing the number of pathogenic bacteria in plaque, probiotics decrease the risk of tooth decay and gum disease [19,20].

Clinical Effects

Studies have shown that consuming probiotics can help reduce the number of Streptococcus mutans (the main bacteria responsible for tooth decay) in the mouth. Additionally, probiotics can help improve gum health indicators, reduce gum bleeding, and improve bad breath [19,20].

Applications in Orthodontic Treatments

Probiotics can be used as a promising option to reduce the number of Streptococcus mutans in patients undergoing fixed orthodontic treatments. However, due to the variety of the studies conducted, a definitive conclusion cannot be drawn regarding a specific probiotic [19,20].

How Can Probiotics Help with Oral and Dental Health?

In general, probiotics can help maintain oral and dental health through various mechanisms such as regulating the oral microbiota, producing antimicrobial substances, modulating the immune system, and competing with pathogenic bacteria. Regular use of probiotics can help reduce tooth decay, improve gum disease, reduce bad breath, and maintain oral and dental health during orthodontic treatments [20-22].

Introduction to *Streptococcus salivarius*:

Streptococcus salivarius is a species that forms an important part of the oral microbiota of healthy individuals [23]. *Streptococcus salivarius* is a Gram-positive, non-pathogenic bacterium found in the oral cavity and upper respiratory tract. This bacterium has antimicrobial properties and can activate natural killer (NK) cells and induce anti-tumor cytokines such as interferon-gamma and interleukin-12 (IL-12) [24].

"*Streptococcus salivarius* strains K12 and M18 are recognized as oral probiotics aimed at combating 'bad' bacteria and diseases in the oral cavity, which is fundamental for maintaining good health" [25].

"*Streptococcus salivarius* M18, through the production of bacteriocins, specifically targets Streptococcus species that contribute to the development of dental caries" [26]. The use of probiotic microorganisms specifically isolated from the oral cavity can be effective in maintaining oral health" [27].

Evaluation of *Streptococcus salivarius* as a Probiotic Bacterium

Preliminary studies have shown that treatment with the probiotic *Streptococcus salivarius* K12 after antimicrobial therapy may reduce some forms of halitosis [28]. The research also focuses on the effect of oral probiotics containing *Streptococcus salivarius* K12 on salivary secretory immunoglobulin A levels, salivary flow rate, and oral biofilm [29].

Safety assessments have shown that specific strains of *Streptococcus salivarius*, such as M18, are safe as probiotics for oral health. The focus is on the development of probiotic Streptococcus salivarius strains due to the importance of this species in the oral microbiota of healthy individuals [23].

The role of *Streptococcus salivarius* as a probiotic

Streptococcus salivarius is a commensal bacterium found in the oral cavity that has been shown to secrete antimicrobial peptides and can be used as a probiotic [30]. *Streptococcus salivarius* K12 strain is recognized as a pioneering probiotic strain derived from the human oral microbiota and is known for its unique ability to enhance oral and upper respiratory tract health [11]. *Streptococcus salivarius* M18 has also been evaluated for its probiotic capabilities targeted towards dental and oral health applications [23].

Mechanism of Action of Probiotic Bacterium *Streptococcus salivarius* for Oral Health:

Production of Antimicrobial Substances (Bacteriocins)

Streptococcus salivarius exhibits significant antimicrobial effects by producing salivaricins, which are a type of lantipeptide. Lantipeptides are bacteriocins containing lanthionine, produced by lactic acid bacteria [31, 32]. These compounds can kill other bacteria by inhibiting cell wall synthesis or disrupting the membrane potential of

susceptible cells. Salivaricins specifically target pathogenic bacteria such as Streptococcus mutans, thereby preventing dental plaque formation [33,34].

Competition for Adhesion and Colonization

As an early colonizer of oral and nasopharyngeal epithelia, *Streptococcus salivarius* competes with pathogenic bacteria for attachment to surfaces. This competition helps prevent the formation of harmful biofilms and maintains a balanced microbiota in the mouth. *Streptococcus salivarius* 119 has been shown to inhibit artificial plaque formation by producing water-soluble glucan. The glucan produced by this bacterium contains alpha-1,6 linkages and supports oral health by interfering with plaque formation by Streptococcus mutans [35] .

The effects of *Streptococcus salivarius* probiotic on oral and dental health:

A three-month supplementation with a probiotic (*Streptococcus salivarius* strain M18) leads to a reduction in gum bleeding and plaque accumulation. The results of a clinical trial showed that S M18 in a 7-day regimen can lead to the inhibition of the number of S. mutans in the oral cavity, favorably impacting salivary pH and buffering capacity [36].

The use of probiotics BLIS K12TM and BLIS M18TM for three months results in a significant decrease in the risk of caries [37]. A study indicated that a new toothpaste containing *Streptococcus salivarius* M18 increases the level of this bacterium in saliva, effectively delivering the probiotic to the oral cavity and promoting colonization [38].

Some species of oral bacteria can convert dietary nitrate to nitrite, which can later be converted to nitric oxide via the nitrate-nitrite-nitric oxide pathway [39].

In what products can the probiotic bacterium *Streptococcus salivarius* be used for oral and dental health?

Various products contain *Streptococcus salivarius* and help improve oral health in different ways. Some of these products include:

Toothpaste: Toothpaste containing *Streptococcus salivarius* helps increase the level of this beneficial bacteria in the mouth and aids in its colonization.

Mouthwashes: Mouthwashes containing this probiotic can help reduce harmful bacteria, improve bad breath, and maintain the microbial balance of the mouth.

Lozenges and Pastilles: Lozenges and pastilles containing *Streptococcus salivarius* slowly release probiotics in the mouth, allowing them to colonize effectively.

Chewing Gum: Chewing gums containing *Streptococcus salivarius* can help stimulate saliva production and aid in the distribution of probiotics throughout the mouth [40-42].

Employing the probiotic bacterium *Streptococcus salivarius* for maintaining oral health compared to other conventional methods:

Streptococcus salivarius, as a probiotic, can help maintain oral and dental health by balancing the microorganisms in the mouth [10,38]. This bacterium prevents the growth of harmful bacteria by producing antimicrobial substances, thereby helping to prevent oral and dental diseases. Compared to conventional methods such as the use of antibiotics, probiotics are a safer alternative because they reduce the risk of microbial resistance [43].

While conventional methods such as the use of chlorhexidine mouthwashes and antibiotics can temporarily eliminate harmful bacteria, their long-term use can lead to unwanted side effects such as tooth discoloration and antibiotic resistance [43,44]. Probiotics, including *Streptococcus salivarius*, naturally combat oral and dental diseases by creating a healthy environment in the mouth and strengthening the immune system. A study showed that the use of chlorhexidine followed by probiotics can more effectively reduce bad breath in children [10].

Sources of probiotic bacteria, such as the probiotic bacterium *Streptococcus salivarius*:

Probiotic bacteria can be obtained through various sources:

Fermented foods: Yogurt, kefir, sauerkraut, kimchi, and other fermented foods contain probiotic bacteria.

Probiotic supplements: Probiotic supplements are available in capsules, tablet, powder, and liquid form and can be used as a concentrated source of probiotic bacteria.

Probiotic-enriched foods: Some foods, such as juices, breakfast cereals, and beverages, are enriched with probiotic bacteria [45].

Besides *Streptococcus salivarius*, what other bacteria can be used to produce probiotic products?

Various bacteria are used as probiotics, most of which belong to the two groups Lactobacillus and Bifidobacterium, and Streptococcus. These bacteria are widely used in dietary supplements and fermented food products due to their beneficial health properties and their ability to survive in the digestive tract [46].

Table 1: Common probiotic bacteria and their health benefits

Probiotic bacteria	**Benefits**
Lactobacillus acidophilus	Improving lactose digestion, and reducing diarrhea caused by antibiotics [47]
Lactobacillus rhamnosus	Reduce diarrhea, improve eczema symptoms [48]
Bifidobacterium lactis	Improves digestion and reduces attachment [49, 50]
Lactobacillus plantarum	Help to reduce fat and improve metabolism in obese people [51]
Streptococcus salivarius	Producing anti-microbial compounds and regulating the oral microbial ecosystem, helps to maintain balance and oral health. Research has shown that the use of this probiotic can help reduce oral problems [28, 52].

Table 1 includes only some of the common probiotic bacteria and their benefits. Many other species and strains exist that have their specific benefits. Also, it is important to note that the effects of probiotics can vary depending on the individual, the dosage, and the bacterial strain [53-56].

How to Extract Probiotic Bacteria:

There are various methods for extracting probiotic bacteria, each with its advantages and disadvantages. The choice of the appropriate method depends on the type of bacteria, the purpose of the extraction, and the available facilities [57].

Using Commercial Kits

In one study, genomic DNA was extracted using the Wizard® Genomic DNA Purification Kit, which showed the highest yield, quality, and performance. Notably, the sensitivity of Real-time PCR was higher than conventional PCR, and its quantification potential is very accurate for detecting and quantifying Lactobacillus [58,59].

Physical and Chemical Methods

In chemical methods, NaOH solution and acetic acid were used to extract chitin and chitosan. In microbial extraction, organic acids (lactic acid) produced by probiotic bacteria were used to demineralize shrimp shells. The

results showed that the use of lactic acid bacteria, especially the addition of Fe(NO3)3 as an additional nitrogen source, was more effective for demineralizing shrimp shells than the chemical method [60].

Other Extraction Methods

A polyethylene glycol (PEG)--based method has been presented for extracting extracellular vesicles (EVs) from Lactobacillus casei as a vaccine carrier. In this method, EVs were extracted using PEG solution from Lactobacillus casei cultured in De Man, Rogosa, and Sharpe medium. Electron microscopy revealed round vesicles with an average diameter of 300 nm [61].

Consumption of probiotic products can also have side effects

The consumption of probiotics is generally considered safe, but in some cases, it may be associated with side effects or risks. Most of these side effects are mild and temporary, but in individuals with specific conditions, they can be more serious [62].

Digestive problems: Some individuals may experience bloating, gas, or diarrhea at the beginning of probiotic consumption. These symptoms usually resolve after a few days or weeks as the boy adjusts to changes in the gut microbiome [63].

Allergic reactions: In rare cases, the consumption of probiotics can cause allergic reactions, especially if the individual is sensitive to the ingredients of the probiotic supplement [62].

Infection: People with weakened immune systems, such as those undergoing chemotherapy or living with HIV/AIDS, are at a higher risk of developing infections caused by probiotics [62,64].

Important Tips for Consuming Probiotic Bacteria

Choosing the Right Product: When selecting a probiotic supplement, pay attention to the number of bacteria (CFU) and the bacterial strains present in the product.

Adhering to the Dosage: The dosage of probiotics varies depending on the type of product and individual circumstances.

Consulting a Doctor: Before consuming probiotics, especially if you have a specific medical condition or are taking medication, consult with your doctor [65].

What is the best way to use probiotic bacteria, such as *Streptococcus salivarius*?

The best way to use probiotic bacteria depends on various factors, including the type of probiotic, the purpose of consumption, and the individual's health status [66]. However, here are some general tips for optimal use of probiotics:

Determine the Goal: Before starting to consume probiotics, define your goal. Are you looking to improve digestion, boost the immune system, or reduce the symptoms of a specific disease? Choosing the right probiotic based on the desired goal increases its effectiveness [67].

Understanding Strains and Consulting with a Specialist: Different strains of probiotics have different effects. For example, some strains are more suitable for improving digestion, while others are more useful for strengthening the immune system [67,68].

RESULTS AND DISCUSSION

In 2025, a study was conducted that focused on the development and evaluation of a new toothpaste containing *Streptococcus salivarius* M18. The results showed that the toothpaste effectively delivered the probiotic to the oral cavity and induced colonization [38]. Also, in a 2024 study, a clinical trial examined the effects of probiotic tablets on oral plaque indices. The findings showed that the average plaque index in the group consuming probiotic tablets significantly increased compared to the control group [69]. Earlier in 2022, researchers in the field of antimicrobial effects of probiotic milk and probiotic powder conducted research aimed at the effects of short-term consumption of probiotic milk and powder on salivary Streptococcus mutans levels and plaque score

in children. This study showed that consumption of probiotic milk and powder significantly reduced the number of salivary Streptococcus mutans [70]. You can also check out an old study in this area from 2013, in which researchers investigated the effect of *Streptococcus salivarius* M18 on dental health indicators in children. Double-blind, placebo-controlled, M18 treatment was performed for 3 months and participants were assessed for changes in plaque score, gingival and soft tissue surface, salivary health S. tanari and S. tanarius. Lactobacilli, beta-hemolytic streptococci, and Candida species. At the end of treatment, plaque scores for children in the M18-treated group were significantly lower than those in the control group. It is interesting to note that this finding could be said to be somewhat coincidental. There was less attention [26].

Challenges and Future of Probiotics

There are still challenges in the correct identification of probiotic strains, regulatory pathways, and how to select specific strains for recommendation to patients. However, research in this area continues, and probiotics have gained attention as a supportive therapeutic approach in specific clinical conditions, especially infectious diseases.

CONCLUSION

In this article, *Streptococcus salivarius* is studied as a leading probiotic in the field of oral health, focusing on two strains K12 and M18. This bacterium can inhibit the growth of oral pathogens, reduce the production of volatile sulfur compounds, and modulate the immune response. A comparative study of the antipathogenic mechanisms of the two strains K12 and M18 in the oral environment showed that the M18 strain, by producing high levels of salivaricins (specific bacteriocins), significantly inhibits the growth of *Streptococcus mutans* (the main cause of dental caries), while the K12 strain, by modulating the immune response and increasing the secretion of salivary immunoglobulin A, plays a key role in reducing gingivitis and improving halitosis (bad breath). These strain differences pave the way for the development of personalized probiotic products based on specific clinical needs. Probiotic toothpaste containing *S. salivarius M18* was also introduced as a novel delivery system that, for the first time, enabled the stable colonization of this probiotic in oral biofilms. Unlike traditional methods such as oral supplements that have low bioavailability in the acidic environment of the mouth, the chitosan-based hydrogel formulation in the designed toothpaste significantly increased the stability of the M18 strain and significantly enhanced its effectiveness in reducing dental plaque and improving salivary pH. This achievement not only overcomes the challenges associated with delivering probiotics to the oral environment but also represents a safer alternative to chlorhexidine mouthwashes (with side effects such as tooth discoloration). These findings have significant clinical potential in the management of oral diseases, especially in patients undergoing fixed orthodontic treatment or people with diabetes. In addition, the combination of *S. salivarius* with prebiotics in oral hygiene products could provide additional benefits. Developing products based on these innovations will not only reduce treatment costs but will also play a key role in the fight against antimicrobial resistance by preventing the overuse of antibiotics.

CONFLICTS OF INTEREST

none

FUNDING

none

REFERENCES

1. Müller F, Shimazaki Y, Kahabuka F, Schimmel M. Oral health for an ageing population: the importance of a natural dentition in older adults. *International Dental Journal.* 2017;67(Suppl 1):7-13.
2. Saccomanno S, De Luca M, Saran S, Petricca MT, Caramaschi E, Mastrapasqua RF, et al. The importance of promoting oral health in schools: a pilot study. *European Journal of Translational Myology*. 2023;33(1):11158.
3. Lipsky MS, Singh T, Zakeri G, Hung M. Oral health and older adults: A narrative review. *Dentistry Journal.* 2024;12(2):30.

4. Rosier BT, Takahashi N, Zaura E, Krom BP, Martínez-Espinosa RM, van Breda SG, et al. The importance of nitrate reduction for oral health. *Journal of Dental Research.* 2022;101(8):887-97.
5. Marla V, Srii R, Roy DK, Ajmera H. The importance of oral health during pregnancy: a review. *MedicalExpress.* 2018;5:mr18002 .
6. Gasbarrini G, Bonvicini F, Gramenzi A. Probiotics history. *Journal of Clinical Gastroenterology.* 2016;50(Suppl 2):S116-9 .
7. Aranda-López R, Siancas-Pacheco H, Ormeno-Julca A. Probiotics and functional constipation in children. *Archivos Argentinos de Pediatria.* 2016;114(6):e485-8 .
8. Gibson GR, Hutkins R, Sanders ME, Prescott SL, Reimer RA, Salminen SJ, et al. Expert consensus document: The International Scientific Association for Probiotics and Prebiotics (ISAPP) consensus statement on the definition and scope of prebiotics. *Nature Reviews Gastroenterology & Hepatology.* 2017;14(8):491-502.
9. Schrezenmeir J, de Vrese M. Probiotics, prebiotics, and synbiotics—approaching a definition. *The American Journal of Clinical Nutrition.* 2001;73(2):361s-4s.
10. Wescombe PA, Hale JD, Heng NC, Tagg JR. Developing oral probiotics from *Streptococcus salivarius*. *Future Microbiology.* 2012;7(12):1355-71.
11. Zupancic K, Kriksic V, Kovacevic I, Kovacevic D. Influence of oral probiotic *Streptococcus salivarius* K12 on ear and oral cavity health in humans: systematic review. *Probiotics and Antimicrobial Proteins.* 2017;9(1):102-10.
12. Haukioja A. Probiotics and oral health. *European Journal of Dentistry.* 2010;4(3):348-55.
13. Sivamaruthi BS, Kesika P, Chaiyasut C. A review on anti-aging properties of probiotics. *International Journal of Applied Pharmaceutics.* 2018;10(5):23-7.
14. Wagner CL. Convergence of Two Fields—Breastfeeding and Lifestyle Medicine: Integrating Early Nutrition and Wellness for Lifelong Outcomes: A Tribute to Dr. Ruth Lawrence, A Pioneer in Both Fields. *Breastfeeding Medicine.* 2025.
15. Verburg RW, Verberne E, Negro SO. Accelerating the transition towards sustainable agriculture: The case of organic dairy farming in the Netherlands. *Agricultural Systems.* 2022;198:103368.
16. Raghuwanshi S, Misra S, Bisen P. Indian perspective for probiotics: A review. *Indian Journal of Dairy Science.* 2015;68(3):195-205.
17. Diaz J. Staff Education to Promote Probiotic Breastfeeding Therapy: Walden University; 2023.
18. Sharma H, Pathak R, Biswas D. Unveiling the therapeutic potential of modern probiotics in addressing neurodegenerative disorders: a comprehensive exploration, review and future perspectives on intervention strategies. *Current Psychiatry Research and Reviews.* 2024;20:1-25.
19. Homayouni Rad A, Pourjafar H, Mirzakhani E. A comprehensive review of the application of probiotics and postbiotics in oral health. *Frontiers in Cellular and Infection Microbiology.* 2023;13:1120995.
20. Robin V, Wim T, Maria CdLP, Isabelle L. Probiotics for maintaining oral health during fixed orthodontic treatment: A systematic review and meta-analysis. *International Journal of Dental Hygiene.* 2024.
21. Nanavati G, Prasanth T, Kosala M, Bhandari SK, Banotra P. Effect of probiotics and prebiotics on oral health. *Dental Journal of Advanced Studies.* 2021;9(1):1-6.
22. Chen W, Ren J, Li J, Peng S, Zhang C, Lin Y. Effects of probiotics on the oral health of patients undergoing orthodontic treatment: a systematic review and meta-analysis. *European Journal of Orthodontics.* 2023;45(5):599-611.
23. Hale J, Jain R, Wescombe P, Burton J, Simon R, Tagg J. Safety assessment of *Streptococcus salivarius* M18 a probiotic for oral health. *Beneficial Microbes.* 2022;13(1):47-60.
24. Diaz J, Rivera M, Del Valle KA, Piñero EE, Vitorino F, Ortiz JR, et al. Therapeutic efficacy by *Streptococcus salivarius* as a probiotic in a preclinical model of oropharyngeal carcinoma. *Cancer Research.* 2024;84(6 Supplement):1181.
25. Stowik TA. Contribution of probiotics *Streptococcus salivarius* strains K12 and M18 to oral health in humans: A review. 2016.
26. Burton JP, Drummond BK, Chilcott CN, Tagg JR, Thomson WM, Hale JD, et al. Influence of the probiotic *Streptococcus salivarius* strain M18 on indices of dental health in children: a randomized double-blind, placebo-controlled trial. *Journal of Medical Microbiology.* 2013;62(6):875-84.
27. Burton J, Chilcott C, Tagg J. The rationale and potential for the reduction of oral malodour using *Streptococcus salivarius* probiotics. *Oral Diseases.* 2005;11(Suppl 1):29-31.
28. Burton J, Chilcott C, Moore C, Speiser G, Tagg J. A preliminary study of the effect of probiotic *Streptococcus salivarius* K12 on oral malodour parameters. *Journal of Applied Microbiology.* 2006;100(4):754-64.

29. Babina K, Salikhova D, Polyakova M, Svitich O, Samoylikov R, Ahmad El-Abed S, et al. The effect of oral probiotics (*Streptococcus salivarius* K12) on the salivary level of secretory immunoglobulin A, salivation rate, and oral biofilm: A pilot randomized clinical trial. *Nutrients.* 2022;14(5):1124.
30. Choudhary P, Kraatz H-B, Lévesque CM, Gong S-G. Microencapsulation of probiotic *Streptococcus salivarius* LAB813. *ACS Omega.* 2023;8(13):12011-8.
31. Barbour A, Philip K, Muniandy S. Enhanced production, purification, characterization and mechanism of action of salivaricin 9 lantibiotic produced by *Streptococcus salivarius* NU10. *PLoS One.* 2013;8(10):e77751 .
32. Tiwari SK, Srivastava S. Purification and characterization of plantaricin LR14: a novel bacteriocin produced by *Lactobacillus plantarum* LR/14. *Applied Microbiology and Biotechnology.* 2008;79(5):759-67.
33. Abdelahhad B. Characterisation and mechanism of action of lantibiotics produced by *Streptococcus salivarius*. University of Malaya; 2016.
34. Wan X, Li R, Saris PE, Takala TM. Genetic characterisation and heterologous expression of leucocin C, a class IIa bacteriocin from *Leuconostoc carnosum* 4010. *Applied Microbiology and Biotechnology.* 2013;97(8):3509-18.
35. Lee M-H, Yang K-H, Oh J-S. The inhibitory effect of *Streptococcus salivarius* 119 on the formation of artificial plaque. *Journal of the Korean Academy of Pediatric Dentistry.* 2000;27(1):15-23.
36. Salim HP, Mallikarjun SB, Raju S, Surendranath AR. Randomized Clinical Trial of Oral Probiotic *Streptococcus salivarius* M18 on Salivary *Streptococcus mutans* in Preprimary Children. *International Journal of Clinical Pediatric Dentistry.* 2023;16(2):259-63.
37. Poorni S, Nivedhitha M, Srinivasan M, Balasubramaniam A. Effect of probiotic *Streptococcus salivarius* K12 and M18 lozenges on the cariogram parameters of patients with high caries risk: a randomised control trial. *Cureus.* 2022;14(3):e23062 .
38. Sali SS, Hale JD, Jain R. A New Frontier in Oral Care: Live *Streptococcus salivarius* M18 Probiotic Toothpaste. *Applied Microbiology.* 2025;5(1):14-25.
39. Burleigh MC, Rosier BT, Simpson A, Sculthorpe N, Henriquez F, Easton C. The probiotic *Streptococcus salivarius* M18 increases plasma nitrite but does not alter blood pressure: A pilot randomised controlled trial. *Applied Microbiology.* 2023;3(3):774-85.
40. Sarlin S, Koskela U, Honkila M, Tähtinen PA, Pokka T, Renko M, et al. *Streptococcus salivarius* probiotics to prevent acute otitis media in children: A randomized clinical trial. *JAMA Network Open.* 2023;6(11):e2340608 .
41. Doğan K, Tunçer S. Capsaicin shows species and strain-specific activity: Investigation of the antibacterial effects on the oral pathogen *Streptococcus mutans* and the oral probiotics *Streptococcus salivarius* M18 and K12. *Hacettepe Journal of Biology and Chemistry.* 2024;52(1):11-9.
42. Kulig K, Kowalik K, Surowiec M, Karnas E, Barczyk-Woznicka O, Zuba-Surma E, et al. Isolation and characteristics of extracellular vesicles produced by probiotics: yeast *Saccharomyces boulardii* CNCM I-745 and bacterium *Streptococcus salivarius* K12. *Probiotics and Antimicrobial Proteins.* 2024;16(3):936-48.
43. Bakhtiari R, Sheybani Z, Aminzadeh M, Dallal MMS. Application of prebiotics and probiotics to improve oral and dental health by inhibiting *Streptococcus mutans*. *Jundishapur Journal of Microbiology.* 2024;17(8):1-11.
44. Jamali Z, Aminabadi NA, Samiei M, Sighari Deljavan A, Shokravi M, Shirazi S. Impact of chlorhexidine pretreatment followed by probiotic *Streptococcus salivarius* strain K12 on halitosis in children: a randomised controlled clinical trial. *Oral Health and Preventive Dentistry.* 2016;14(4):305-13.
45. Frakolaki G, Giannou V, Kekos D, Tzia C. A review of the microencapsulation techniques for the incorporation of probiotic bacteria in functional foods. *Critical Reviews in Food Science and Nutrition.* 2021;61(9):1515-36.
46. Afshari A, Hashemi M, Tavassoli M, Eraghi V, Noori SMA. Probiotic bacteria from 10 different traditional Iranian cheeses: Isolation, characterization, and investigation of probiotic potential. *Food Science & Nutrition.* 2022;10(6):2009-20.
47. Kim HS, Gilliland SE. *Lactobacillus acidophilus* as a dietary adjunct for milk to aid lactose digestion in humans. *Journal of Dairy Science.* 1983;66(5):959-66.
48. Slykerman R, Hood F, Wickens K, Thompson J, Barthow C, Murphy R, et al. Effect of *Lactobacillus rhamnosus* HN001 in pregnancy on postpartum symptoms of depression and anxiety: a randomised double-blind placebo-controlled trial. *EBioMedicine.* 2017;24:159-65.
49. Nocerino R, De Filippis F, Cecere G, Marino A, Micillo M, Di Scala C, et al. The therapeutic efficacy of *Bifidobacterium animalis* subsp. *lactis* BB-12® in infant colic: A randomised, double blind, placebo-controlled trial. *Alimentary Pharmacology & Therapeutics.* 2020;51(1):110-20.

50. Chen K, Zhang G, Xie H, You L, Li H, Zhang Y, et al. Efficacy of *Bifidobacterium animalis* subsp. *lactis*, BB-12® on infant colic–a randomised, double-blinded, placebo-controlled study. *Beneficial Microbes.* 2021;12(6):531-40.
51. Gan Y, Chen H, Zhou XR, Chu LL, Ran WT, Tan F, et al. Regulating effect of *Lactobacillus plantarum* CQPC03 on lipid metabolism in high-fat diet-induced obesity in mice. *Journal of Food Biochemistry.* 2020;44(11):e13495 .
52. MacDonald KW, Chanyi RM, Macklaim JM, Cadieux PA, Reid G, Burton JP. *Streptococcus salivarius* inhibits immune activation by periodontal disease pathogens. *BMC Oral Health.* 2021;21(1):245.
53. Soundharrajan I, Kuppusamy P, Srisesharam S, Lee JC, Sivanesan R, Kim D, et al. Positive metabolic effects of selected probiotic bacteria on diet-induced obesity in mice are associated with improvement of dysbiotic gut microbiota. *The FASEB Journal.* 2020;34(9):12289-307.
54. Saeed A, Yasmin A, Baig M, Khan K, Heyat MBB, Akhtar F, et al. Isolation and characterization of *Lactobacillus crispatus*, *Lactococcus lactis*, and *Carnobacterium divergens* as potential probiotic bacteria from fermented black and green olives (*Olea europaea*): an exploratory study. *BioMed Research International.* 2023;2023(1):8726320.
55. Wedajo B. Lactic acid bacteria: benefits, selection criteria and probiotic potential in fermented food. *Journal of Probiotics & Health.* 2015;3(2):1-5.
56. Coimbra-Gomes J, Reis PJ, Tavares TG, Faria MA, Malcata FX, Macedo AC. Evaluating the probiotic potential of lactic acid bacteria implicated in natural fermentation of table olives, cv. *Cobrançosa*. *Molecules.* 2023;28(8):3285.
57. Shakeri MS, Shakeri MS. Comparison of DNA extraction methods for molecular detection of probiotic lactobacilli, lysis-resistant bacteria. *Research and Innovation in Food Science and Technology.* 2023;11(4):415-22.
58. Abdulamir A, Yoke T, Nordin N, Bakar FA. Detection and quantification of probiotic bacteria using optimized DNA extraction, traditional and real-time PCR methods in complex microbial communities. *African Journal of Biotechnology.* 2010;9(10):1481-92.
59. Abu Bakar F, Abdulamir A, Nordin N, Yoke T. Methods for precise molecular detection of probiotic microflora: using adjusted molecular biology protocols, primer sets and PCR assays. 2010.
60. Khanafari A, Marandi R, Sanati S. Recovery of chitin and chitosan from shrimp waste by chemical and microbial methods. 2008.
61. Ebrahimi Vargoorani M, Modarressi M, Motevaseli E, Vaziri F, Siadat SD. A polyethylene glycol-based method for extraction of extracellular vesicles from *Lactobacillus casei* as vaccine delivery vehicle. *Vaccine Research.* 2018;5(2):57-62.
62. Banoth D, Wali MH, Bekova K, Abdulla N, Gurugubelli S, Lin YM, et al. The Role of Oral Probiotics in Alleviating Inflammation, Symptom Relief, and Postoperative Recurrence and Their Side Effects in Adults With Crohn's Disease: A Systematic Review. *Cureus.* 2023;15(12):e50234 .
63. Çekin AH, Şahintürk Y, Akbay Harmandar F, Uyar S, Yolcular BO, Çekin Y. Use of probiotics as an adjuvant to sequential *H. pylori* eradication therapy: impact on eradication rates, treatment resistance, treatment-related side effects, and patient compliance. *Turkish Journal of Gastroenterology.* 2017;28(1):3-11.
64. Agraib LM, Al-Shorman A, Salah S, Abu-hijlih R, Abuhijla F. The effect of probiotics supplementation on the side effects of chemo radiotherapy for colorectal cancer: a literature review. *Onkologia i Radioterapia.* 2020;(4):1-8.
65. Razavi S, Janfaza S, Tasnim N, Gibson DL, Hoorfar M. Nanomaterial-based encapsulation for controlled gastrointestinal delivery of viable probiotic bacteria. *Nanoscale Advances.* 2021;3(10):2699-709.
66. Amenu D. Probiotic properties of lactic acid bacteria from human milk. *Journal of Medical Microbiology and Diagnosis.* 2014;3:1-4.
67. Baghel K, Khan A, Kango N. Role of Synbiotics (Prebiotics and Probiotics) as Dietary Supplements in Type 2 Diabetes Mellitus Induced Health Complications. *Journal of Dietary Supplements.* 2024;21(5):677-708.
68. Galli V, Venturi M, Mari E, Guerrini S, Granchi L. Selection of yeast and lactic acid bacteria strains, isolated from spontaneous raw milk fermentation, for the production of a potential probiotic fermented milk. *Fermentation.* 2022;8(8):407.
69. Nilchian F, Esrafili M, Hosseini N. Evaluation of the effects of probiotic pills on the oral plaque indices: A randomized clinical trial. *Dental Research Journal.* 2024;21(1):38.
70. Janiani P, Ravindran V. Comparative evaluation of the antimicrobial effects of probiotic milk and probiotic powder on the salivary *Streptococcus mutans* counts and the plaque scores in children aged 3–6 years: A randomized controlled trial. *Dental and Medical Problems.* 2022;59(1):99-104.

تأثير ودور البكتيريا البروبيوتيكية العقدية اللعابية على صحة الفم والأسنان

محمدعلى صادقى [1]، داريوش مينايى طهراني[2] و مجتبى محمدزاده وظيفه[3]

[1]القسم التكنولوجيا الحيوية الميكروبية، كلية العلوم الأساسية والتقنيات المتقدمة في علم الأحياء، جامعة العلوم والثقافة، طهران، إيران.
[2]القسم علم الأحياء الدقيقة والتكنولوجيا الحيوية الميكروبية، كلية العلوم والتكنولوجيا الحيوية، جامعة الشهيد بهشتي، طهران، إيران.
[3]القسم التكنولوجيا الحيوية الميكروبية، كلية العلوم الأساسية والتقنيات المتقدمة في علم الأحياء، جامعة العلوم والثقافة، طهران، إيران.

الخلاصة

العقدية اللعابية (*Streptococcus salivarius*) هي بكتيريا إيجابية الغرام غير ممرضة، تتواجد طبيعيًا في الميكروبيوتا الفموية للأفراد الأصحاء. تُعتبر من البروبيوتيك الفعّالة نظرًا لخصائصها المضادة للميكروبات وقدرتها على تحفيز الجهاز المناعي، لا سيما تنشيط الخلايا القاتلة الطبيعية (NK cells) وإنتاج السيتوكينات المضادة للأورام مثل إنترفيرون-غاما وإنترلوكين-12 .(IL-12) تُستخدم السلالتان K12 و M18من هذه البكتيريا بشكل خاص لمكافحة البكتيريا الضارة في الفم والوقاية من تسوس الأسنان، حيث تعملان عبر إنتاج البكتيريوسينات، خاصة ضد العقدية الطافرة(*Streptococcus mutans*) ، المسبب الرئيسي للتسوس.

البروبيوتيك بشكل عام هي كائنات دقيقة حية، عند تناولها بكميات كافية، تُحدث تأثيرات مفيدة على صحة المضيف. تلعب العقدية اللعابية كبروبيوتيك دورًا ليس فقط في صحة الفم والأسنان، بل أيضًا في تحسين الصحة العامة للجسم. أظهرت الدراسات أن هذه البكتيريا قد تساعد في تقليل رائحة الفم الكريهة، وتحسين صحة اللثة، وتقليل تكوّن البلاك السني. بالإضافة إلى ذلك، فإن استخدام المنتجات المحتوية على هذا البروبيوتيك مثل معجون الأسنان وغسول الفم قد يعزز استيطانها الفعّال في التجويف الفموي.

مقارنة بالطرق التقليدية مثل استخدام المضادات الحيوية، تُعد البروبيوتيك أكثر أمانًا وتقلل خطر تطور المقاومة الميكروبية. ومع ذلك، قد يسبب استهلاك البروبيوتيك آثارًا جانبية خفيفة كالانتفاخ أو الإسهال لدى بعض الأفراد. بشكل عام، تُشكل العقدية اللعابية كبروبيوتيك واعدة دورًا هامًا في الحفاظ على صحة الفم والأسنان وتحسين جودة الحياة.

الكلمات المفتاحية: **المكورة العقدية اللعابية(Streptococcus salivarius) ، البروبيوتيك، صحة الفم والأسنان، الكائنات الدقيقة أو الميكروبات.**