

Review

Microorganisms in Fermented Foods and Their Contribution to Oral Health: A Narrative Review

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Abstract

Fermented foods contain diverse microorganisms that may influence oral microbial ecology and contribute to oral health. This narrative review aimed to examine the current evidence regarding microorganisms present in fermented foods and their role in oral health promotion. Twenty relevant clinical, experimental, observational, and review studies published between 2016 and 2026 were identified through a structured literature search and critically synthesized according to major thematic areas, including oral microbiota modulation, dental caries prevention, periodontal health, probiotic delivery systems, and evidence from review articles. The findings appear to indicate that fermented food-derived microorganisms may reduce cariogenic and periodontal pathogens, modulate oral biofilms, improve gingival health, and promote microbial homeostasis. Yogurt, kefir, fermented dairy products, and kimchi-derived microorganisms were the most frequently investigated sources. Emerging evidence further suggests that the benefits of these microorganisms are linked to ecological regulation of the oral microbiome and host–microbe interactions rather than direct antimicrobial activity alone. Microorganisms associated with fermented foods may therefore represent promising functional dietary components for supporting oral health and complementing preventive oral healthcare strategies. Further well-designed clinical studies are needed to establish strain-specific recommendations and explore the potential of postbiotic applications in dentistry.

Keywords: fermented foods; fermented food-derived microorganisms; oral microbiome; oral health; dental caries; periodontal disease; biofilm; yogurt; kefir; postbiotics



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1. Introduction

The human oral cavity hosts a highly diverse and complex microbial ecosystem comprising more than 700 bacterial species, which interact with host tissues and environmental factors and contribute to the maintenance of oral homeostasis [1]. The balance of the oral microbiota plays a fundamental role in oral health, whereas microbial dysbiosis has been associated with the development of dental caries, gingivitis, periodontitis, peri-implant diseases, and halitosis [1]. Accordingly, probiotic approaches have been investigated for their potential to modulate the oral microbiota and improve selected caries-related and periodontal outcomes [2,3].

In recent years, increasing attention has been directed toward probiotic and dietary strategies capable of modulating the oral microbiome and supporting oral health through

non-pharmacological approaches [3,4]. Among these strategies, fermented foods have attracted substantial scientific interest due to their content of live microorganisms, bioactive metabolites, and probiotic strains that may exert beneficial effects on both systemic and oral health [5].

Fermented foods are produced through the metabolic activity of microorganisms, including lactic acid bacteria, bifidobacteria, yeasts, and other beneficial microbial species that transform food substrates into products with enhanced nutritional, functional, and microbiological characteristics [5,6]. Common fermented foods include yogurt, kefir, fermented milk products, cheese, kimchi, sauerkraut, kombucha, miso, and sourdough products. Some of these foods contain viable microorganisms at the time of consumption; however, fermented foods should not automatically be classified as probiotic foods unless their microorganisms are sufficiently characterized and shown to confer a demonstrated health benefit [5,6]. Fermented dairy products may additionally function as carriers of bioactive compounds that promote enamel remineralization and reduce demineralization, further supporting their potential role in oral health [7].

The Food and Agriculture Organization of the United Nations and the World Health Organization define probiotics as “live microorganisms which, when administered in adequate amounts, confer a health benefit on the host” [8]. Several probiotic strains belonging to the genera *Lactobacillus*, *Lactiacaseibacillus*, *Lactiplantibacillus*, *Bifidobacterium*, and *Streptococcus* have appeared to influence microbial ecology through competitive exclusion of pathogens, production of antimicrobial substances, modulation of biofilm formation, and regulation of host immune responses [2,3,9]. Accumulating evidence suggests that probiotic microorganisms, including strains delivered through fermented food products, may contribute to caries prevention by reducing cariogenic bacterial populations, particularly *Streptococcus mutans* (*S. mutans*); influencing plaque acidogenicity; and, in probiotic dairy-based formulations, supporting the balance between enamel demineralization and remineralization [4,7,10–12]. Experimental and clinical studies have reported reductions in salivary counts of cariogenic microorganisms following the consumption of fermented dairy products enriched with probiotic strains such as *Lactobacillus casei* Shirota, *Lactiacaseibacillus rhamnosus* SD11, and *Lactiacaseibacillus rhamnosus* GG [10,13,14].

Fermented foods and their associated microorganisms may also influence periodontal health beyond dental caries prevention. Several studies have suggested inhibitory activity of probiotic strains against major periodontal pathogens, including *Porphyromonas gingivalis* (*P. gingivalis*), while others have reported improvements in gingival inflammation, plaque accumulation, and periodontal parameters following probiotic interventions [15–18]. Epidemiological evidence also indicates that regular consumption of fermented dairy products may be associated with a lower prevalence of periodontal disease and reduced risk of tooth loss [16,19].

An additional mechanism through which fermented foods may support oral health involves the modulation of oral biofilm formation. Oral biofilms represent highly organized microbial communities that contribute to the initiation and progression of both caries and periodontal diseases [1]. Several in vitro investigations have shown that probiotic microorganisms and their metabolites can inhibit pathogen adhesion, interfere with biofilm maturation, and reduce biofilm biomass, thereby contributing to a healthier oral microbial environment [9,20,21].

Promising vehicles for probiotic delivery are fermented dairy products since they provide a protective food matrix that enhances microbial survival during storage and gastrointestinal transit while facilitating regular dietary consumption [13,14,22]. Products such as yogurt, kefir, probiotic curd, and fermented milk are considered func-

tional foods capable of supporting oral health through microbiome modulation and pathogen suppression [3,11,19].

Although numerous studies have investigated specific probiotic strains or fermented food products, the available evidence remains heterogeneous with respect to study design, microbial species, intervention characteristics, and oral health outcomes assessed [2–4]. In addition, the growing body of research in this field highlights the need for an updated narrative synthesis that integrates current evidence across different oral health domains. The present review therefore brings together findings on microorganisms derived from fermented foods, examining their potential role in oral microbiota modulation, dental caries prevention, periodontal health, probiotic delivery systems, and emerging postbiotic applications. Accordingly, the aim of this narrative review is to provide a critical overview of the current evidence regarding microorganisms present in fermented foods and their potential contribution to oral health, with particular emphasis on the underlying biological mechanisms, clinical relevance, and future research directions.

2. Materials and Methods

2.1. Search Strategy

A comprehensive literature search was conducted in May 2026 using PubMed, Scopus, and ScienceDirect to identify relevant studies published from January 2016 to May 2026. The search strategy was developed using combinations of keywords and Medical Subject Headings (MeSH) related to fermented foods, probiotic microorganisms, and oral health outcomes. Search terms included fermented foods, fermented beverages, yogurt, kefir, fermented milk, kimchi, probiotics, microbiota, microbiome, lactic acid bacteria, *Lactobacillus*, *Lactocaseibacillus*, *Bifidobacterium*, *Saccharomyces*, oral health, oral microbiome, oral microbiota, dental caries, periodontal disease, gingivitis, dental plaque, oral biofilm, halitosis, and peri-implant disease. Boolean operators (AND, OR) were used to combine search terms according to each database's search requirements. The search strategy was adapted to the indexing system of each database.

The PubMed search strategy was ((“Fermented Foods”[Mesh] OR “Cultured Milk Products”[Mesh] OR fermented food*[tiab] OR fermented beverage*[tiab] OR yogurt[tiab] OR yoghurt[tiab] OR kefir[tiab] OR “fermented milk”[tiab] OR cheese[tiab] OR kimchi[tiab] OR sauerkraut[tiab] OR miso[tiab] OR kombucha[tiab] OR sourdough[tiab]) AND (“Probiotics”[Mesh] OR “Lactobacillales”[Mesh] OR probiotic*[tiab] OR microorganism*[tiab] OR microbiota[tiab] OR microbiome[tiab] OR “lactic acid bacteria”[tiab] OR *Lactobacillus*[tiab] OR *Lactocaseibacillus*[tiab] OR *Lactiplantibacillus*[tiab] OR *Lactococcus*[tiab] OR *Leuconostoc*[tiab] OR *Pediococcus*[tiab] OR *Bifidobacterium*[tiab] OR *Saccharomyces*[tiab] OR “*Streptococcus thermophilus*”[tiab]) AND (“Oral Health”[Mesh] OR “Dental Caries”[Mesh] OR Periodontitis[Mesh] OR “Dental Plaque”[Mesh] OR Halitosis[Mesh] OR oral health[tiab] OR oral microbiota[tiab] OR oral microbiome[tiab] OR “dental caries”[tiab] OR caries[tiab] OR periodont*[tiab] OR gingivit*[tiab] OR plaque[tiab] OR halitosis[tiab] OR peri-implant*[tiab])) AND 2016/01/01:2026/05/31[dp].

The Scopus search strategy was (“fermented food*” OR “fermented beverage*” OR yogurt OR yoghurt OR kefir OR “fermented milk” OR cheese OR kimchi OR sauerkraut OR miso OR kombucha OR sourdough) AND (probiotic* OR microorganism* OR microbiota OR microbiome OR “lactic acid bacteria” OR lactobacill* OR lactocaseibacillus OR lactiplantibacillus OR lactococcus OR leuconostoc OR pediococcus OR bifidobacter* OR saccharomyces OR “streptococcus thermophilus”) AND (“oral health” OR “oral microbiota” OR “oral microbiome” OR caries OR “dental caries” OR periodont* OR gingivit* OR plaque OR halitosis OR peri-implant*).

The Science Direct search strategy was probiotics AND (“oral microbiome” OR “periodontal disease” OR “dental caries”) AND lactobacillus.

2.2. Eligibility Criteria

Studies were eligible for inclusion if they were published in English between January 2016 and December 2025 and investigated fermented foods, probiotic microorganisms, or probiotic-containing food products in relation to oral health. Clinical, observational, experimental, and in vitro studies, as well as relevant review articles, were considered eligible. Studies were excluded if they focused exclusively on gastrointestinal or systemic health without assessing oral health outcomes; investigated non-food probiotic formulations unrelated to oral health; were conference abstracts, editorials, letters, commentaries, or study protocols; represented duplicate publications; or did not provide sufficient methodological information or outcome data relevant to the objectives of the present review.

2.3. Study Selection, Data Extraction and Synthesis

Following the literature search, the retrieved records were screened by the authors based on their titles and abstracts according to the predefined eligibility criteria. Potentially relevant articles were subsequently evaluated through full-text review, and those considered most relevant to the objectives of the present narrative review were included to provide a comprehensive overview of the available evidence regarding microorganisms associated with fermented foods and their potential contribution to oral health. Relevant information was extracted from each included study using a standardized data extraction framework, including the authors and year of publication, study design, study population or experimental model, fermented food product and/or probiotic microorganism investigated, oral health outcome(s) assessed, and principal findings. No formal methodological quality assessment was undertaken because this was a narrative review intended to provide an integrative synthesis rather than evidence grading. The evidence was synthesized narratively and organized into thematic sections according to the major topics identified in the literature, including oral microbiota modulation, dental caries prevention, periodontal health, probiotic delivery systems, and emerging perspectives on postbiotic applications. Bacterial nomenclature follows updated taxonomy. Several species formerly classified within the genus *Lactobacillus* were reassigned to newly established genera (e.g., *Lactica-seibacillus*, *Lactiplantibacillus*, *Limosilactobacillus*). Original nomenclature is retained only when directly referring to the cited studies.

3. Results

3.1. Description and Characteristics of the Studies

The characteristics of the twenty studies included in this narrative review are summarized in Table 1. The selected publications, published between 2016 and 2026, reflect the growing scientific interest in the potential contribution of microorganisms derived from fermented foods to oral health. The available evidence encompasses a broad range of study designs, including randomized clinical trials, clinical intervention studies, prospective cohort and cross-sectional studies, experimental and in vitro investigations, as well as narrative, systematic, and literature reviews. This methodological diversity provides complementary evidence ranging from mechanistic insights to clinical observations. Most studies investigated fermented dairy products, particularly yogurt, fermented milk, kefir, probiotic curd, and other dairy-based probiotic formulations, as delivery vehicles for beneficial microorganisms. The probiotic genera most frequently examined were *Lactobacillus*, *Lactica-seibacillus*, *Bifidobacterium*, and *Streptococcus thermophilus* (*S. thermophilus*). Among the strains most commonly associated with favorable oral health outcomes were *Lacticas-*

eibacillus rhamnosus SD11 (*L. rhamnosus* SD11), *Lactocaseibacillus rhamnosus* GG (*L. rhamnosus* GG), *Lactobacillus casei* Shirota, *Lactocaseibacillus paracasei* Probio-01 (*L. paracasei* Probio-01), and *Lactobacillus brevis* CD2 (*L. brevis* CD2), although the magnitude and consistency of their reported effects varied across studies.

Given the heterogeneity of the included evidence, the methodological quality and strength of the findings should be interpreted in the context of the respective study designs. To facilitate interpretation, Table 1 presents the study characteristics together with an indicative classification of the level of evidence. Overall, the available literature suggests that microorganisms associated with fermented foods may contribute to oral health through multiple biological mechanisms, including modulation of the oral microbiota, inhibition of pathogenic microorganisms, regulation of biofilm formation, and support of periodontal and dental health. The evidence supporting these potential effects is discussed in the following sections according to the principal oral health outcomes investigated.

Table 1. Characteristics of the included studies.

Author (Year)	Study Design	Indicative Level of Evidence	Population/Sample	Fermented Food/Probiotics Strain	Intervention Duration	Dose	Oral Outcome	Main Findings
Gruner et al. (2016) [2]	Systematic Review	1	Published studies	Various probiotics	N/A	N/A	Oral diseases	Early evidence supporting beneficial effects of probiotics on oral health
Ben Taheur et al. (2016) [9]	Experimental Laboratory Study	5	In vitro cultures of selected oral pathogenic bacteria	Food-derived LAB (<i>Pediococcus pentosaceus</i> FB2, <i>Lactobacillus brevis</i> FF2, <i>Enterococcus faecium</i> FG1)	N/A (in vitro experimental assays)	N/A	Antibacterial activity, coaggregation, autoaggregation, and biofilm inhibition	Selected food-derived LAB exhibited strain-dependent antibacterial and antibiofilm activity against oral pathogens and showed probiotic characteristics supporting their potential use in oral health applications.
Lin et al. (2017) [10]	Non-randomized clinical intervention study	3	Children 7–11 years old	<i>Lactobacillus casei</i> Shirota	7 days	100 mL standard Yakult once daily.	Oral biofilm acidogenicity, <i>S. mutans</i> , <i>Lactobacillus</i> counts & caries risk.	Reduced oral biofilm acidogenicity without significant changes in salivary <i>S. mutans</i> counts or overall caries risk.
Rungsri et al. (2017) [13]	Randomized Clinical Trial	2	43 healthy adults	Fermented milk containing <i>L. rhamnosus</i> SD11	4 weeks	Once daily	Oral microbiota	Reduced mutans streptococci and total salivary bacterial counts
Lee & Kim (2019) [16]	Cross-sectional Study	4	9798 Korean adults (≥30 years)	Dairy foods (milk, yogurt)	Habitual intake (FFQ)	≥7 servings/week (200 mL for milk and 100 mL for yogurt)	Periodontal disease	Frequent dairy intake associated with lower prevalence of periodontal disease
Lim et al. (2020) [22]	Experimental Laboratory Study	5	Laboratory model	Kimchi-derived probiotic yogurt <i>Lactobacillus fermentum</i> KU200060 (<i>L. fermentum</i> KU200060)	24 h	1 × 10 ⁸ CFUs/well	Oral pathogens	Antimicrobial effects against oral pathogens
Ryu et al. (2020) [20]	Experimental Laboratory Study	5	In vitro oral biofilm model (<i>S. mutans</i> , <i>S. oralis</i> and <i>S. mitis</i>)	D-galactose treatment	24 h	D-galactose (0.002–200 mM)	Biofilm formation and bacterial adherence	Reduced <i>S. mutans</i> biofilm formation and adherence while promoting commensal streptococcal biofilms; inhibited glucosyltransferase gene expression.

Table 1. Cont.

Author (Year)	Study Design	Indicative Level of Evidence	Population/Sample	Fermented Food/Probiotics Strain	Intervention Duration	Dose	Oral Outcome	Main Findings
Shen et al. (2020) [7]	Experimental Laboratory Study	5	Enamel specimens prepared from extracted human third molars	Commercial probiotic yogurt supplemented with CPP-ACP Lactic acid bacteria (<i>Bifidobacterium lactis</i> CNCM I-2494, <i>S. thermophilus</i> , <i>Lactococcus lactis</i> and <i>Lactobacillus bulgaricus</i>)	14 days	0.2% and 0.5% (w/w) CPP-ACP	Enamel demineralization/remineralization	Addition of CPP-ACP to probiotic yogurt significantly reduced enamel demineralization, while 0.5% CPP-ACP promoted enamel remineralization under in vitro conditions.
Michaylova et al. (2021) [15]	Experimental Laboratory Study	5	<i>P. gingivalis</i> DSM 20,709 cultures	Dairy lactobacilli and <i>S. thermophilus</i> (<i>S. thermophilus</i> 187/4, followed by <i>L. delbrueckii</i> ssp. <i>bulgaricus</i> LBB.B1054, C3/2 and LBB.B120, <i>L. helveticus</i> LBB.H48/1 and <i>L. rhamnosus</i> I-1/13)	4–5 days (anaerobic condition)	10 ⁵ –10 ⁶ cfu/mL	Antimicrobial activity against <i>P. gingivalis</i>	Strain-dependent inhibition of <i>P. gingivalis</i> growth by dairy lactobacilli and <i>S. thermophilus</i> .
Reddy et al. (2021) [11]	Clinical Intervention Study	3	80 children (8–12 years old)	Kefir milk, probiotic curd, probiotic drink <i>Lactobacillus casei</i> subsp., <i>Pseudoplanarum</i> and <i>Saccharomyces cerevisiae</i>	Once daily for 1 month	100 mL	Salivary <i>S. mutans</i> counts	Kefir milk and probiotic curd produced the greatest reduction in salivary <i>S. mutans</i> counts after 1 month.
Nešković et al. (2022) [14]	Clinical Intervention Study	3	90 children (5–12 years old)	LGG-enriched yogurt (commercial or manually fortified with <i>L. rhamnosus</i> GG)	14 days	Daily intake of LGG yogurt	Plaque index and salivary pH	Significant reduction in plaque accumulation and increased salivary pH after 14 days of LGG yogurt consumption, suggesting a less cariogenic oral environment.
Ma et al. (2022) [19]	Prospective Cohort Study	2	1469 Japanese adults (40–79 years) with >10 teeth	Yogurt products (yogurt and lactic acid beverages)	5 years	Quartiles of daily yogurt product intake (0, 0.1–28.6, 28.7–79.9, ≥80 g/day),	Incident tooth loss and periodontal condition.	Higher yogurt product intake was associated with a lower risk of tooth loss, partly mediated by periodontal condition and accompanied by favorable oral microbiome composition.
Chandran et al. (2023) [23]	Randomized Clinical Trial	2	10 patients with moderate gingivitis aged 25–35 years	Probiotic yogurt (<i>Lactobacillus Acidophilus</i> and <i>Bifidobacterium Lactis</i>)	14 days	100 g/day	Gingival Index, salivary pH, salivary buffering capacity.	Significant improvement in gingival health; no significant changes in salivary pH or buffering capacity.
Butera et al. (2023) [24]	Systematic Review	1	Patients with periodontitis undergoing non-surgical periodontal therapy (NSPT)	Adjunctive domiciliary probiotics with NSPT	N/A	N/A	Clinical periodontal parameters (PPD, CAL, BOP, PI)	Weak evidence suggests that adjunctive probiotics may improve periodontal clinical parameters for up to 3 months; long-term benefits remain inconclusive due to study heterogeneity.

Table 1. Cont.

Author (Year)	Study Design	Indicative Level of Evidence	Population/Sample	Fermented Food/Probiotics Strain	Intervention Duration	Dose	Oral Outcome	Main Findings
Castro et al. (2024) [3]	Literature Review *	Not classified (NC)	Published studies	Various probiotics	N/A	N/A	Oral health	The reviewed literature reported potential applications of probiotics in the modulation of oral microbiota and selected oral-health outcomes; however, findings varied according to strain, formulation, and clinical indication.
Li et al. (2024) [17]	Clinical Intervention Study	3	32 Gingivitis patients (18–25 years of age)	Toothpaste containing inactivated <i>L. paracasei</i> Probio-01	3 months	Twice a day	Plaque-induced gingivitis and dental plaque microbiota.	Reduced gingival inflammation, plaque indices and modulation of dental plaque microbiota.
Campus et al. (2025) [12]	Clinical Intervention Study	3	26 healthy adults	<i>Lactobacillus brevis</i> CD2 (<i>L. brevis</i> CD2) lozenges	28 days	Three lozenges daily containing <i>Lactobacillus brevis</i> CD2 (200 mg lyophilised bacteria per lozenge).	Plaque acidogenicity, plaque microbiota and plaque index	Significant reduction in plaque acidogenicity and acidogenic potential of dental biofilm after 28 days of <i>L. brevis</i> CD2 administration.
Nguyen et al. (2025) [21]	Experimental Laboratory Study	5	Laboratory model	Kimchi derived <i>Pediococcus inopinatus</i> THK-30	24 h	100 µL, 1×10^6 CFU/mL	Oral pathogens	THK-30 showed a synergistic antibacterial effect against Gram-negative oral pathogens Potential applicability of LAB in teeth discoloration and halitosis
Sarvaiya et al. (2025) [18]	Narrative Review *	Not classified (NC)	Published studies	Probiotics	N/A	N/A	Periodontal disease	Concludes that probiotics may serve as an adjunctive therapy for periodontal disease.
Zulkapli et al. (2025) [4]	Systematic Review	1	34 randomized controlled trials (children and adults)	Various probiotic strains delivered through dairy products, lozenges, tablets, mouth rinses and other vehicles	N/A	N/A	<i>S. mutans</i> , <i>Lactobacillus</i> spp., plaque index, gingival status, salivary pH, buffering capacity, caries incidence	Probiotic interventions were associated with reductions in cariogenic bacterial levels in several studies, although findings varied across strains, vehicles, durations, and outcome measures.

Indicative level of evidence assigned by the authors based primarily on study design and its ability to support clinical inference within the context of this narrative review. The classification is intended solely to facilitate comparison among the primary studies included and does not represent a formal evidence grading system. Narrative and literature reviews were not assigned an evidence level because they represent secondary evidence syntheses whose methodological quality and level of evidence depend on the primary studies included. Level 1 = systematic reviews and meta-analyses; Level 2 = randomized clinical trials and prospective cohort studies; Level 3 = non-randomized clinical intervention studies and clinical observational studies; Level 4 = cross-sectional studies; Level 5 = experimental laboratory and in vitro studies. * Not classified (N/C): Narrative Reviews, Literature Reviews. N/A: Not Applicable.

3.2. Effects on Oral Microbiota and Biofilm Modulation

The modulation of the oral microbiota and the control of biofilm formation represent two of the most extensively investigated mechanisms through which microorganisms associated with fermented foods may contribute to oral health. Oral biofilms are complex microbial communities that develop on oral surfaces and play a central role in the initiation

and progression of dental caries, gingivitis, and periodontal diseases. The maintenance of a balanced oral microbiome is therefore essential for preserving oral health and preventing dysbiosis-associated oral conditions [1].

Several studies included in this review demonstrated that probiotic microorganisms derived from fermented foods can affect the composition and activity of oral microbial communities. Evidence synthesized in recent reviews suggests that probiotic microorganisms associated with fermented foods may reduce the cariogenic potential of oral biofilms primarily through ecological modulation of the oral microbiota rather than indiscriminate bacterial elimination [2,3]. Such strategies aim to promote beneficial microorganisms while suppressing the growth and activity of pathogenic species associated with oral diseases.

In addition to the probiotic microorganisms themselves, bioactive metabolites generated during the fermentation process may also contribute to the beneficial effects of fermented foods on oral health. Galactose is a monosaccharide generated through the hydrolysis of lactose during lactic acid fermentation and is therefore naturally present in fermented dairy products. Experimental results also suggest that metabolites generated during fermentation may contribute to oral biofilm modulation. Ryu et al. [20] demonstrated that D-galactose reduced *Streptococcus mutans* biofilm formation and bacterial adherence while promoting biofilm development by commensal oral streptococci, supporting the concept that fermentation-derived metabolites may contribute to oral microbial homeostasis through selective modulation of biofilm ecology. Similarly, Ben Taheur et al. [9] reported strain-dependent antibacterial and antibiofilm activity of selected food-derived lactic acid bacteria against tested oral pathogens, supporting their potential relevance to the control of pathogenic oral biofilms.

Consistent with these experimental observations, clinical studies have also provided evidence supporting the beneficial effects of fermented food-associated microorganisms on the oral microbiota. In a randomized clinical trial involving healthy adults, Rungsri et al. [13] found that daily consumption of fermented milk containing *L. rhamnosus* SD11 resulted in significant reductions in salivary *Streptococcus mutans* (*S. mutans*) and total bacterial counts. The observed reductions in salivary *S. mutans* and total bacterial counts support the potential role of fermented dairy products in modulating the oral microbial ecosystem toward a healthier balance.

The inhibitory effects of probiotic microorganisms against periodontal pathogens have also been documented. Michaylova et al. [15] investigated dairy-derived *Lactobacilli* and *S. thermophilus* strains and reported significant suppression of the growth of *Porphyromonas gingivalis* (*P. gingivalis*), one of the principal pathogens associated with periodontitis. The observed antagonistic activity was attributed to the production of antimicrobial metabolites and competitive interactions that limit pathogen survival and proliferation. More recent evidence further supports the role of probiotic-derived products in oral microbiome regulation. Li et al. [17] evaluated a toothpaste containing inactivated *L. paracasei* Probio-01 and demonstrated significant improvements in plaque-induced gingivitis accompanied by favorable alterations in dental plaque microbiota composition. These results expand the current understanding of probiotic-based interventions by demonstrating that biological activity may be retained even in non-viable microbial preparations, reinforcing the potential of postbiotic-related approaches in oral healthcare.

In conclusion, the available evidence suggests that microorganisms associated with fermented foods can contribute to oral health through multiple complementary mechanisms, including inhibition of pathogenic bacteria, suppression of biofilm formation, a reduction in cariogenic and periodontal microorganisms, and promotion of a more balanced oral microbiota. Accordingly, microorganisms associated with fermented foods may represent

valuable adjuncts to preventive oral healthcare by promoting microbial homeostasis and reducing the burden of biofilm-associated oral diseases (Figure 1).

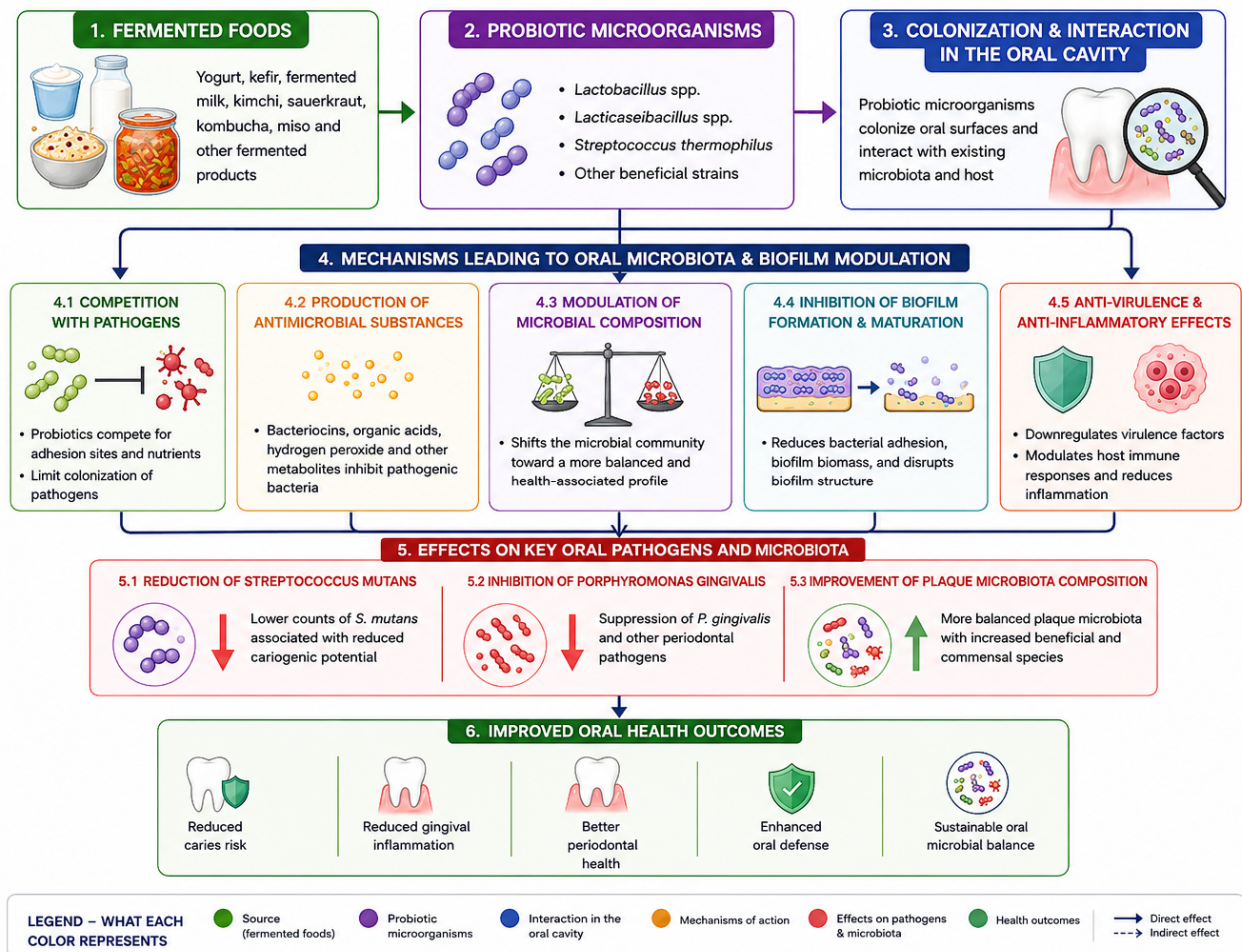


Figure 1. Proposed mechanisms of action of microorganisms in fermented foods on oral health. Fermented food-derived microorganisms may modulate the oral microbiota by suppressing pathogenic bacteria, inhibiting biofilm formation, and producing antimicrobial compounds, thereby supporting oral microbial homeostasis and periodontal and dental health. (Created in BioRender. Antoniadou, M. (2026) <https://BioRender.com/7kiedki>, accessed on 20 July 2026).

3.3. Effects on Dental Caries Prevention

Dental caries remains one of the most prevalent chronic diseases worldwide and is strongly linked to oral microbial dysbiosis, particularly related to the overgrowth of cariogenic bacteria such as *S. mutans*. Fermented foods, as natural delivery matrices for beneficial microorganisms, have attracted growing interest as preventive strategies for modulating the oral microbiome and supporting oral health, particularly in relation to the microbial basis of dental caries development. One of the primary mechanisms through which probiotic microorganisms may contribute to caries prevention is the suppression of cariogenic bacteria. Lin et al. [10] reported that short-term consumption of *Lactobacillus casei* Shirota improved oral biofilm acidogenicity by increasing minimum plaque pH, although no significant changes were observed in salivary *Streptococcus mutans* counts or overall caries risk. Additional clinical evidence supporting this mechanism was provided by Reddy et al. [11], who evaluated the effects of kefir milk, probiotic curd, and a probiotic drink in children aged 8–12 years. Daily consumption of these probiotic dairy products for one month resulted in significant reductions in salivary *S. mutans* counts, with kefir milk and probiotic curd showing the greatest reductions. These findings are particularly important

because *S. mutans* is considered a key etiological microorganism in the development of dental caries due to its ability to metabolize dietary sugars into organic acids and to thrive under acidic conditions. The observed reduction in salivary *S. mutans* counts suggests then that fermented dairy products may help reduce the cariogenic bacterial burden and thereby support caries prevention.

Probiotics may also influence the metabolic activity of dental plaque beyond direct effects on bacterial populations. Campus et al. [12] reported that daily administration of *Lactobacillus brevis* CD2 for 28 days significantly reduced plaque acidogenicity following sucrose exposure. This finding is clinically relevant because acid production within dental biofilms is the principal mechanism responsible for enamel demineralization. These observations emphasize that modulation of plaque metabolism may represent an important mechanism through which selected probiotic strains contribute to the maintenance of oral health.

The protection of dental hard tissues against mineral loss constitutes another significant mechanism. Shen et al. [7] demonstrated that yogurt supplemented with casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) significantly inhibited enamel subsurface demineralization. The study highlighted the potential of fermented dairy products to serve as functional delivery systems capable of enhancing enamel resistance to acid challenges although the protective effect was partly related to the remineralizing properties of CPP-ACP. The ability of fermented dairy products to act as carriers of remineralizing compounds broadens their potential contribution to oral health beyond microbial modulation, although the protective effect observed in this study cannot be attributed solely to the fermented dairy matrix.

Clinical intervention studies have also shown favorable effects on plaque accumulation and oral environmental conditions associated with caries development. Nešković et al. [14] evaluated daily consumption of *L. rhamnosus* GG-enriched yogurt for 14 days and reported significant reductions in dental plaque accumulation together with increased salivary pH. The elevation of salivary pH is particularly relevant because acidic oral environments promote enamel dissolution and the selective growth of aciduric cariogenic microorganisms. Together, these observations support the potential role of probiotic-containing fermented foods in creating a less cariogenic oral environment through combined ecological and physicochemical effects.

The findings of individual studies are further supported by higher levels of evidence. Zulkapli et al. [4], in a systematic review and risk-of-bias assessment including 34 randomized controlled trials, concluded that probiotic interventions generally reported reductions in cariogenic bacterial levels and were associated with improvements in several oral health outcomes related to caries prevention. Similarly, earlier evidence synthesized by Gruner et al. [2] suggested beneficial effects of probiotics on caries-related parameters, although the magnitude of the effect varied according to the probiotic strain, duration of intervention, and study design.

The available evidence suggests that microorganisms present in fermented foods may contribute to dental caries prevention through multiple complementary pathways. These include suppression of cariogenic microorganisms, particularly *S. mutans*; a reduction in plaque acidogenicity; improvement of salivary environmental conditions; inhibition of enamel demineralization; and promotion of ecological balance within the oral biofilm. Importantly, the collective findings suggest that fermented foods may represent functional dietary components capable of supporting preventive oral healthcare when used as part of a balanced diet. Nevertheless, variations in probiotic strains, intervention protocols, treatment duration, and outcome measures highlight the need for additional well-designed

randomized clinical trials to establish optimal probiotic formulations and evidence-based recommendations for caries prevention (Figure 2).

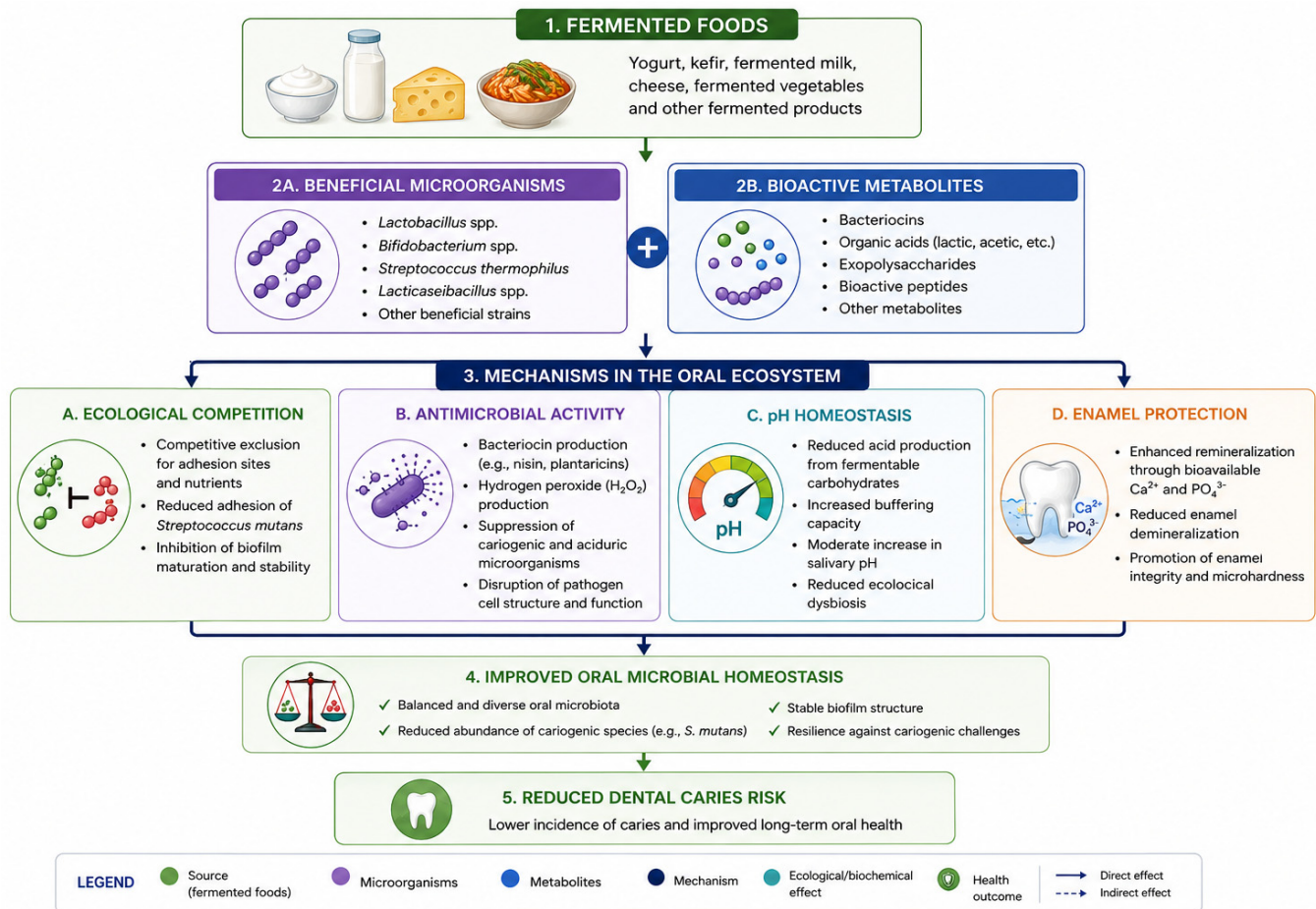


Figure 2. Proposed mechanisms of microorganisms in fermented foods for dental caries prevention. Fermented food-derived microorganisms may reduce *Streptococcus mutans*, modulate salivary pH, decrease plaque acidogenicity, and protect against enamel demineralization, thereby supporting oral microbial homeostasis and reducing caries risk. (Abbreviations: *Streptococcus mutans*: *S. mutans*). (Created in BioRender. Antoniadou, M. (2026) <https://BioRender.com/7kiedki>) (Accessed on 20 July 2026).

3.4. Effects on Periodontal Health and Gingivitis

Periodontal diseases, including gingivitis and periodontitis, are highly prevalent inflammatory conditions driven by interactions between dysbiotic oral biofilms and host immune responses, leading to progressive periodontal tissue destruction. Growing evidence indicates that microorganisms associated with fermented foods may support periodontal health through modulation of the oral microbiota and regulation of inflammatory pathways. Several studies included in this review suggest that probiotic microorganisms may exert beneficial effects on periodontal health by reducing pathogenic bacterial populations and improving clinical periodontal parameters. Clinical evidence was reported by Chandran et al. [23], who investigated the effects of probiotic yogurt consumption in patients with moderate gingivitis. Following 14 days of daily probiotic yogurt consumption, significant improvements in gingival health were observed, supporting the potential of fermented dairy products as delivery vehicles for microorganisms that may contribute to periodontal homeostasis. Collectively, the available evidence supports the potential role of probiotic-containing fermented foods as adjuncts to conventional oral hygiene measures through modulation of the oral microbiota and maintenance of periodontal health.

Epidemiological evidence appears to indicate a potential relationship between fermented food consumption and periodontal health outcomes. Lee and Kim [16] reported an inverse association between dairy food consumption and the prevalence of periodontal disease in a large cross-sectional study involving 9798 Korean adults. Individuals reporting higher consumption of dairy foods, particularly milk, exhibited a lower prevalence of periodontal disease than those with lower consumption levels. However, the association observed for yogurt consumption was no longer statistically significant after adjustment for potential confounding factors. The findings suggest a potential protective role of dairy foods in periodontal health, although causality cannot be inferred because of the observational study design.

Additional clinical evidence has demonstrated the beneficial effects of probiotic-based interventions on periodontal health. Li et al. [17] evaluated the use of a toothpaste containing inactivated *L. paracasei* Probio-01 in 32 patients with plaque-induced gingivitis over a three-month period. Participants using the probiotic toothpaste twice daily exhibited significant reductions in gingival inflammation and dental plaque accumulation, accompanied by favorable modulation of the dental plaque microbiota. The observed clinical and microbiological improvements support the potential value of probiotic-derived formulations as adjunctive strategies for the management of plaque-induced gingivitis. Moreover, longitudinal evidence was provided by Ma et al. [19], who investigated the association between yogurt product intake and tooth loss risk in a prospective cohort of 1469 Japanese adults followed for five years. Higher yogurt product intake was associated with a significantly lower risk of tooth loss, an association that was partly mediated by periodontal condition and accompanied by a more favorable salivary microbiota profile. These long-term observations highlight the potential contribution of yogurt products to the preservation of natural dentition through maintenance of periodontal health and oral microbial homeostasis.

In addition, the overall body of evidence was critically synthesized by Sarvaiya et al. [18], who concluded that probiotics represent promising adjunctive agents in periodontal therapy. The authors reported reductions in gingival inflammation, plaque accumulation, periodontal pocket parameters, and pathogenic bacterial counts following probiotic interventions. Similarly, Butera et al. [24] concluded that weak evidence supports the use of probiotics as adjuncts to non-surgical periodontal therapy for improving periodontal clinical parameters in the short term. Both reviews, however, emphasized the substantial heterogeneity among available studies regarding probiotic strains, dosage regimens, intervention duration, outcome measures, and the limited availability of robust long-term evidence.

The available evidence shows that microorganisms present in fermented foods may contribute to periodontal health through multiple complementary mechanisms, including suppression of periodontal pathogens, modulation of oral microbial communities, a reduction in plaque accumulation, and attenuation of inflammatory responses. Collectively, these biological mechanisms may contribute to clinically relevant improvements in gingival health, reduced risk of periodontal disease progression, and long-term preservation of natural dentition. Nevertheless, further well-designed randomized clinical trials are required to establish standardized probiotic protocols and clarify the long-term effectiveness of fermented food-based interventions in periodontal disease prevention and management. The principal mechanisms through which microorganisms associated with fermented foods may support periodontal health are summarized in Figure 3.

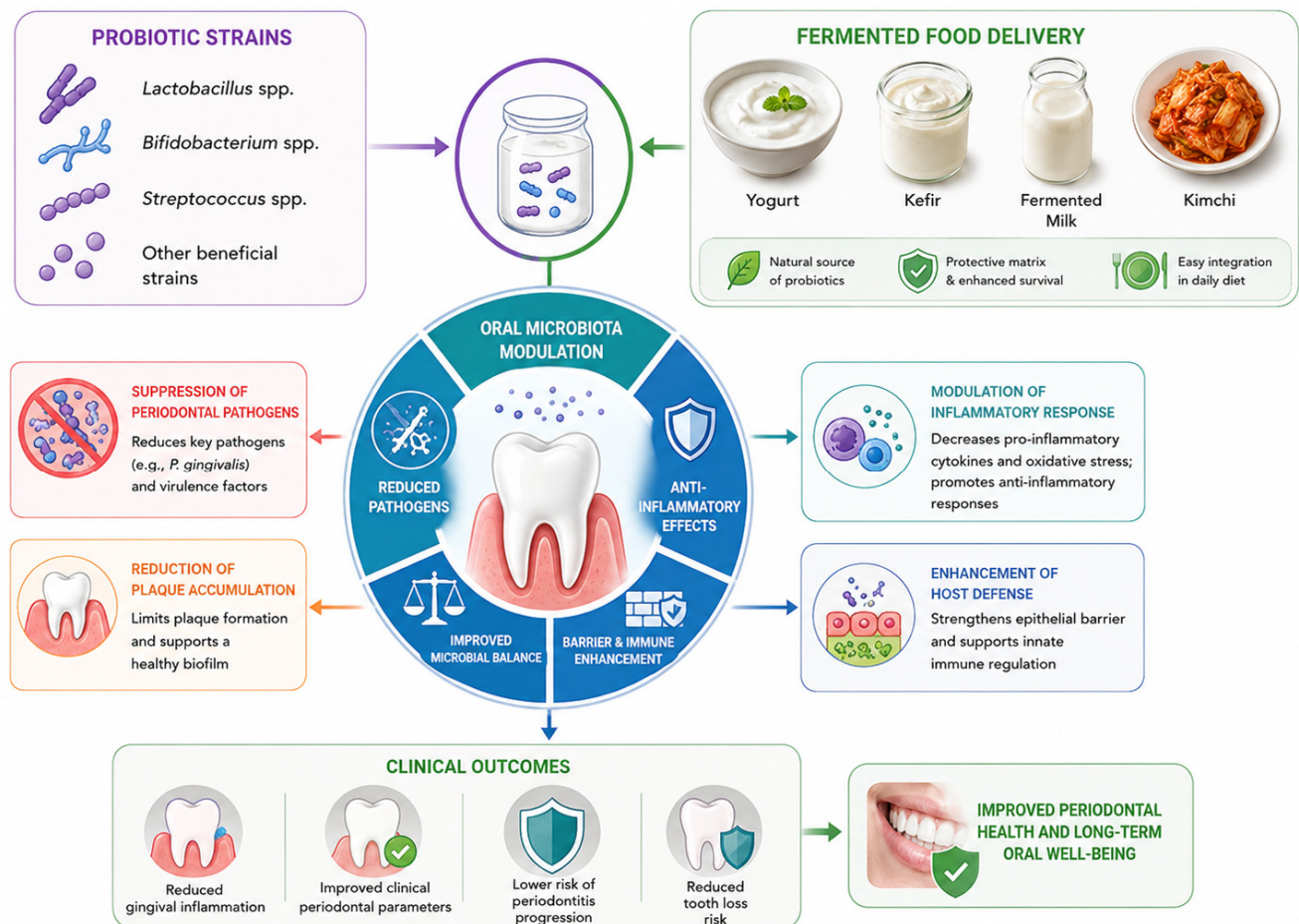


Figure 3. Proposed mechanisms by which microorganisms in fermented foods promote periodontal health. Fermented food-derived microorganisms may suppress *Porphyromonas gingivalis*, reduce plaque accumulation and gingival inflammation, and promote oral microbial homeostasis, thereby supporting periodontal health. (Abbreviations: *P. gingivalis*, *Porphyromonas gingivalis*). (Created in BioRender. Antoniadou, M. (2026) <https://BioRender.com/7kiedki> accessed on 20 July 2026).

3.5. Fermented Foods as Vehicles for Probiotic Delivery

Fermented dairy products represent the most extensively studied probiotic delivery systems. Their nutritional composition, buffering capacity, and favorable physicochemical properties contribute to the survival and activity of probiotic microorganisms, facilitating their interaction with the oral microbiota. Several studies included in this review demonstrated that yogurt and fermented milk products may effectively contribute in delivering probiotic strains capable of influencing oral microbial communities and improving oral health outcomes. One of the earliest clinical demonstrations of this concept was provided by Rungsri et al. [13], who investigated fermented milk containing *L. rhamnosus* SD11. The authors reported significant reductions in salivary mutans streptococci and total bacterial counts among healthy adults following regular consumption of the fermented milk product. These findings suggest that fermented milk can serve not only as a nutritional product but also as an effective vehicle for introducing beneficial microorganisms into the oral environment. Similarly, Reddy et al. [11] evaluated kefir milk, probiotic curd, and probiotic beverages in children and observed significant reductions in salivary *S. mutans* levels. Kefir is of particular interest because it contains a highly diverse microbial consortium composed of lactic acid bacteria, acetic acid bacteria, and yeasts that may act synergistically to influence oral microbial ecology. The results of this study support the potential of kefir-based products as functional foods capable of contributing to caries prevention through

probiotic delivery. It is important to distinguish between fermented foods and probiotics. Fermented foods constitute the food matrix or delivery vehicle, whereas probiotics are the live microorganisms that may be naturally present in or added to these products. Consequently, the potential oral health benefits discussed in this review are primarily related to the microorganisms associated with fermented foods, although the food matrix itself may also influence microbial survival and delivery.

Yogurt has also been extensively investigated as a probiotic carrier. Nešković et al. [14] reported that yogurt enriched with *L. rhamnosus* GG reduced plaque accumulation and increased salivary pH in children, while Chandran et al. [23] demonstrated improvements in gingival health and plaque control following probiotic yogurt consumption. These findings appear to indicate that yogurt provides an effective matrix for delivering probiotic microorganisms capable of influencing both cariogenic and periodontal parameters. Also, long-term observational evidence further supports the importance of fermented dairy products in oral health promotion. In a prospective cohort study involving 1469 adults, Ma et al. [19] found that higher yogurt consumption was associated with a lower risk of tooth loss. Although the mechanisms responsible for this association are likely multifactorial, the findings suggest that regular consumption of probiotic-containing dairy products may contribute to the long-term maintenance of oral and periodontal health.

Beyond dairy products, traditional fermented foods have also emerged as promising sources of novel probiotic strains. Lim et al. [22] isolated *L. fermentum* KU200060 from watery kimchi and successfully incorporated the strain into probiotic yogurt formulations. The study demonstrated antimicrobial activity against oral pathogens, highlighting the potential of kimchi-derived microorganisms as candidates for future oral health applications. These findings illustrate how traditional fermented foods can serve both as reservoirs of beneficial microorganisms and as sources for the development of innovative probiotic products.

3.6. Evidence from Reviews and Meta-Analyses

Evidence derived from reviews and meta-analyses provides an important opportunity to evaluate the consistency of findings across individual studies and to identify broader patterns regarding the contribution of fermented food-derived microorganisms to oral health. The available secondary evidence suggests a remarkable convergence of findings despite differences in study populations, probiotic strains, intervention protocols, and outcome measures.

The earliest comprehensive synthesis included in the present review was conducted by Gruner et al. [2], who performed a systematic review and meta-analysis evaluating the effects of probiotics on caries and periodontal diseases. Although the authors highlighted substantial heterogeneity among studies, the overall findings suggested beneficial effects of probiotic interventions on cariogenic bacterial levels, plaque accumulation, and periodontal parameters. Importantly, the review introduced the concept that probiotics may function primarily through ecological modulation of the oral microbiome rather than through direct eradication of oral microorganisms. This ecological perspective has subsequently become an important conceptual framework in probiotic oral health research.

Several years later, Castro et al. [3] reviewed the expanding body of evidence regarding probiotics in dentistry and reported consistent observations across multiple studies, including reductions in plaque accumulation, improvements in oral microbiota composition, and suppression of pathogenic microorganisms. Notably, the authors emphasized that the beneficial effects of probiotics were observed across different oral conditions rather than being restricted to a single disease entity. This observation suggests that microbial home-

ostasis may represent a common underlying mechanism linking probiotic interventions to multiple oral health outcomes.

The periodontal literature appears to indicate a similar pattern. Sarvaiya et al. [18] concluded that probiotics may serve as valuable adjuncts in periodontal therapy, particularly when combined with conventional mechanical plaque control. Across the studies reviewed, improvements were repeatedly observed in gingival inflammation, plaque indices, and periodontal parameters. Interestingly, clinical improvements were not always accompanied by proportional microbiological changes, suggesting that immunomodulatory effects may contribute alongside direct microbial modulation. This finding supports the growing recognition that probiotics influence not only the composition of oral biofilms but also host inflammatory responses and periodontal tissue homeostasis.

The strongest evidence regarding caries prevention was provided by Zulkapli et al. [4], whose systematic review included 34 randomized controlled trials. Despite considerable variation in probiotic strains and intervention protocols, the review consistently reported reductions in cariogenic bacterial counts, particularly *S. mutans*, together with improvements in several caries-related outcomes. Importantly, the authors identified a recurring pattern across studies: probiotic interventions rarely eliminated cariogenic microorganisms entirely but instead reduced their abundance and ecological dominance. This observation further supports the ecological plaque hypothesis, according to which disease prevention is achieved through restoration of microbial balance rather than complete microbial suppression.

When the findings of these reviews are considered collectively, several important correlations emerge. First, reductions in pathogenic microorganisms are consistently associated with improvements in clinical outcomes, including decreased plaque accumulation, lower gingival inflammation, reduced cariogenic activity, and improved periodontal status. Second, studies reporting favorable shifts in oral microbiota composition frequently are associated with parallel improvements in disease-related parameters, suggesting that microbial modulation represents a central biological mechanism underlying oral health benefits. Third, despite differences in probiotic strains, several reviews reported comparable trends across studies, suggesting that different microorganisms may promote similar clinical benefits through overlapping ecological and immunological mechanisms. Different probiotic microorganisms may contribute to an achievement of similar clinical benefits through overlapping ecological and immunological pathways. In particular, all reviews highlighted significant methodological limitations that currently restrict the development of definitive clinical recommendations. These limitations include small sample sizes, short intervention periods, variability in probiotic strains and dosages, inconsistent outcome measures, and insufficient long-term follow-up. Consequently, additional standardized randomized controlled trials are required to establish optimal strains, delivery systems, treatment durations, and evidence-based protocols for oral health applications despite the collective evidence strongly supporting the biological plausibility and potential clinical benefits of fermented food-derived microorganisms. Overall, the available review-level evidence suggests a unifying concept whereby microorganisms associated with fermented foods may promote oral health primarily through restoration of microbial homeostasis, suppression of dysbiosis, and modulation of host–microbe interactions. Rather than acting solely as conventional antimicrobial agents, these microorganisms appear to function as ecological regulators of the oral ecosystem, which may explain their beneficial effects across both cariogenic and periodontal conditions. The proposed interactions between microbial modulation, ecological homeostasis, host immune regulation, and oral health outcomes are summarized in the conceptual model presented in Figure 4.

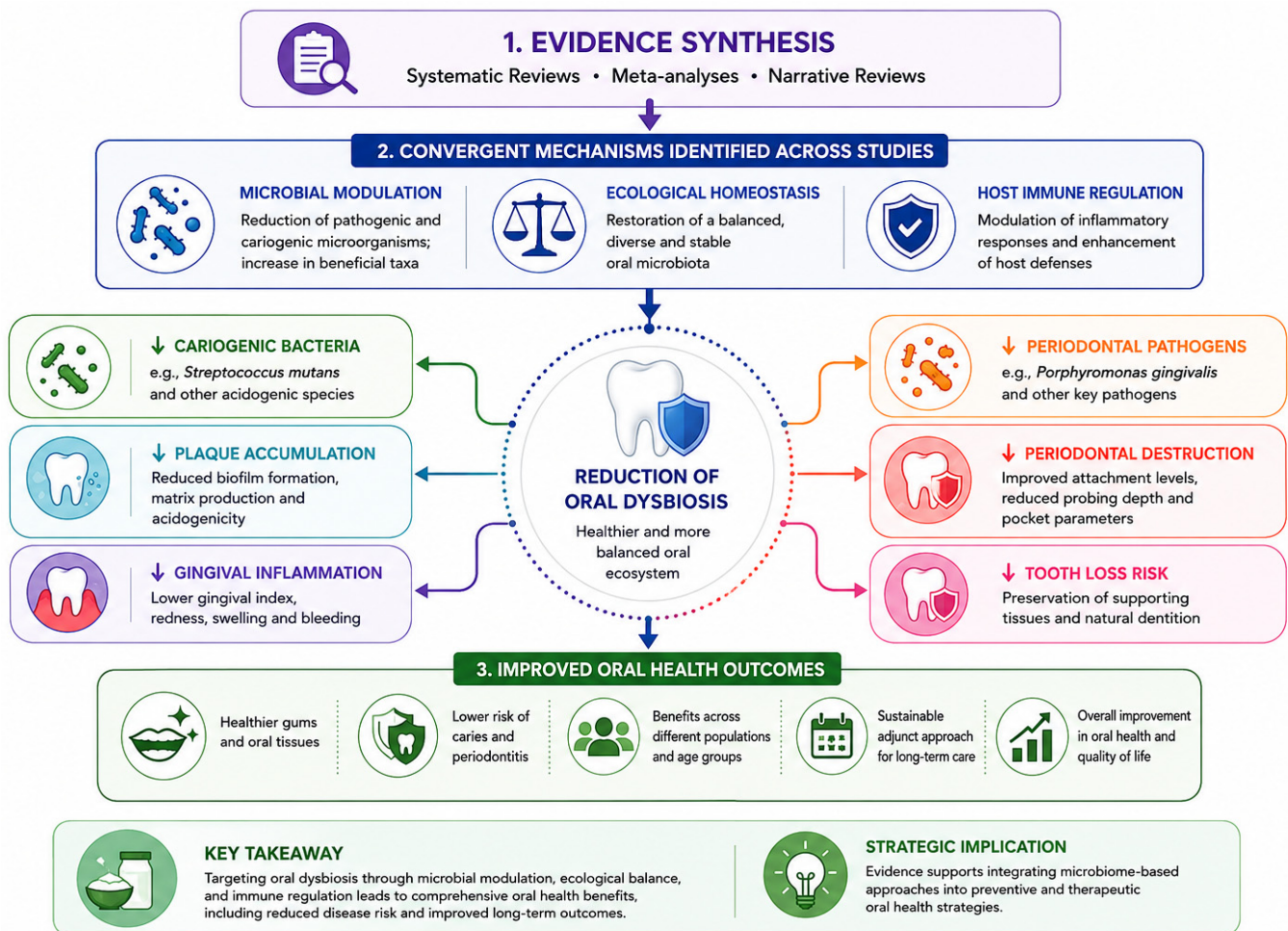


Figure 4. Integrated model of the proposed effects of fermented food-derived microorganisms on oral health. Fermented food-derived microorganisms may promote oral health through microbial modulation, ecological homeostasis, and host immune regulation, contributing to improved cariogenic, periodontal, and inflammatory outcomes. (Created in BioRender. Antoniadou, M. (2026) <https://BioRender.com/7kiedki>, accessed on 20 July 2026).

4. Discussion

The growing interest in fermented foods as functional dietary components has generated increasing attention toward their potential role in oral health promotion and disease prevention [5,25]. While probiotics have traditionally been investigated primarily within the context of gastrointestinal health, emerging evidence suggests that the oral cavity may represent one of the earliest and most biologically relevant sites of interaction between food-associated microorganisms and the human microbiome [25,26]. The studies included in the present review collectively appear to indicate that microorganisms derived from fermented foods influence oral health through interconnected ecological, microbiological, and immunological pathways rather than through simple antimicrobial activity alone [3,4].

A central finding emerging from the available evidence is the progressive shift from a pathogen-centered model toward an ecosystem-centered interpretation of oral health and disease [2,27]. Historically, probiotic interventions were evaluated according to their ability to suppress specific microorganisms, particularly *S. mutans* in caries and *P. gingivalis* in periodontal disease [2]. However, the collective findings reviewed here suggest that the clinical benefits of fermented food-derived microorganisms cannot be fully explained by reductions in individual pathogens alone [12,17]. Instead, improvements in oral health outcomes frequently occur alongside broader changes in microbial diversity, biofilm compo-

sition, ecological stability, and inflammatory regulation [3,18]. These observations support contemporary ecological theories of oral disease, according to which dysbiosis, rather than the presence of a single pathogen, constitutes the principal driver of disease initiation and progression [27,28].

The concept of microbial homeostasis may therefore represent the unifying mechanism underlying the beneficial effects observed across the studies included in this review. Reductions in cariogenic bacterial activity, improvements in plaque characteristics, enhanced salivary conditions, and favorable periodontal outcomes have been reported in clinical investigations involving fermented milk products, yogurt, kefir, and probiotic-derived formulations [11,13,14,17]. Importantly, complete eradication of oral pathogens was rarely achieved or even reported [2,4]. Probiotic interventions appeared to reduce the ecological dominance of disease-associated microorganisms while simultaneously promoting a more balanced microbial environment [3]. Such findings suggest that fermented food-derived microorganisms may function as ecological regulators rather than conventional antimicrobial agents, hence are highly consistent with the Ecological Plaque Hypothesis [2].

Another noteworthy observation concerns the remarkable overlap between the biological pathways implicated in dental caries prevention and those involved in periodontal health maintenance. Traditionally, caries and periodontitis have been investigated as distinct disease entities with separate etiological pathways. However, probiotic microorganisms influence both conditions through similar ecological mechanisms, including biofilm modulation, microbial competition, a reduction in pathogen virulence, and restoration of microbial balance as shown by the present review [1,15,18]. Probiotics may improve periodontal clinical parameters in the short term when used as adjuncts to non-surgical periodontal therapy, while the considerable heterogeneity among available studies and the lack of robust long-term evidence [24]. Other studies contribute to this trend [16,17,19,23]. This convergence suggests that fermented food-derived microorganisms may target the underlying process of oral dysbiosis itself rather than specific diseases. Such an interpretation may explain why improvements have been reported across diverse oral health outcomes, ranging from reductions in *S. mutans* counts and plaque acidogenicity to improvements in gingival inflammation and tooth retention [4,12,19].

The oral cavity occupies a unique position within this framework because it constitutes the first biological ecosystem exposed to microorganisms present in fermented foods [26]. Research on fermented foods has historically focused on gut microbiota modulation despite this obvious anatomical relationship, whereas oral microbial ecology has received considerably less attention [28]. Dietary patterns can rapidly influence oral microbial communities and biofilm composition, suggesting that oral microbiota modulation may represent a primary rather than secondary mechanism through which fermented foods exert health benefits [28,29]. This perspective positions fermented foods as potential modulators of oral ecosystem resilience and broadens their significance beyond nutrition.

The findings of the present review also highlight the growing importance of host-microbe interactions. Several studies reported clinical improvements that appeared greater than would be expected based solely on changes in microbial counts [17,23]. Similar observations have been documented in recent microbiome research, where probiotic microorganisms have been shown to influence cytokine expression, oxidative stress pathways, epithelial barrier integrity, and innate immune responses [18,27]. These observations suggest that the benefits of fermented food-derived microorganisms may arise not only from ecological modulation of the oral microbiota but also from regulation of host inflammatory pathways. Consequently, oral health improvement may result from a synergistic interaction between microbial and host-mediated mechanisms.

An emerging area relevant to microorganisms associated with fermented foods is the investigation of postbiotics, namely bioactive metabolites and non-viable microbial products derived from probiotic microorganisms. While the present review focuses on microorganisms present in fermented foods, recent evidence suggests that some of their beneficial effects may also be mediated through postbiotic compounds. The beneficial effects observed following the administration of inactivated *L. paracasei* reported by Li et al. [17] challenge the traditional assumption that microbial viability is essential for clinical efficacy. Similar conclusions have been proposed in recent reviews on postbiotic applications in oral healthcare [30]. Bioactive metabolites, extracellular vesicles, antimicrobial peptides, and cell-wall components may retain biological activity even in the absence of viable microorganisms, offering potential advantages in terms of safety, storage stability, formulation flexibility, and incorporation into oral healthcare products [30]. Recent experimental and clinical studies further suggest that postbiotics may inhibit oral biofilm formation, modulate microbial communities, and regulate host immune responses, supporting their potential as complementary strategies for promoting oral health [31,32]. Although these findings are promising, the current evidence remains limited, and further well-designed clinical studies are required to clarify the role of postbiotics derived from microorganisms associated with fermented foods in oral healthcare. The main biofilm-inhibiting components isolated from *L. rhamnosus* LR-32 were citric acid, silanol, and β -D-glucopyranose and were determined by in vitro chemical characterization and biofilm assays [31]. Downregulation of several key genes (*gtfB*, *gbpB*, and *ftf*) in *S. mutans* occurred due to the cyclic peptide (-L-Leu-L-Pro) isolated from the same species by in vitro gene expression analysis. Postbiotics also work towards regulation of the broader oral ecosystem. A postbiotic toothpaste containing inactivated *L. salivarius* LS97, *L. paracasei* LC86, and *L. acidophilus* LA85 in a clinical trial was shown to increase salivary microbial diversity, reduce *Klebsiella* and *Escherichia*, and elevate levels of IgA and short-chain fatty acids, supporting sustained immunomodulatory effects [32].

Oralbiotics, the probiotics in the oral cavity, compete with harmful bacteria for mucosal receptors and nutrients and lower the excessive inflammatory response by changing the natural environment of microorganisms [33,34]. Probiotics inhibit oral infections and thus decrease the prevalence of *S. mutans* and *Candida* strains in the oral cavity, the number of periopathogenic bacterial colonies, and improve oral mucosa and periodontium condition [35,36]. They are considered as effective therapy [37,38] and act by attaching to dental surfaces as part of the biofilm (or plaque) and compete with the growth of periodontal or cariogenic microbes.

The repeated identification of yogurt, kefir, fermented milk products, and kimchi-derived strains across the reviewed literature also suggests that fermented foods function as more than simple microbial reservoirs [11,19,22]. These food matrices may enhance microbial survival, facilitate prolonged oral exposure, and promote routine consumption patterns that are difficult to achieve through conventional probiotic supplements alone [5,39]. Consequently, fermented foods may represent one of the few oral health interventions capable of bridging nutrition, preventive dentistry, microbiome science, and public health. This characteristic is particularly relevant in an era increasingly focused on lifestyle-based disease prevention and precision nutrition strategies [29,39].

As previously discussed, disruption of microbial homeostasis within the oral cavity promotes the overgrowth of opportunistic pathogens, including *S. mutans*, *P. gingivalis*, and *Fusobacterium nucleatum*. The metabolic by-products and virulence factors produced by these microorganisms contribute to the development of dental caries, periodontitis, halitosis, and oral candidiasis [40]. Beyond their local effects, oral microbial imbalances may also influence systemic health through the oral-gut axis, which has been increasingly

associated with the initiation and progression of various systemic diseases [28]. In this context, fermented foods have emerged as promising dietary modulators of oral microbial ecology. Their beneficial effects are largely attributed to the presence of probiotics and bioactive metabolites, which may inhibit pathogenic microorganisms, regulate host immune responses, and promote the restoration of oral microbial homeostasis. Conventional management of oral diseases continues to rely primarily on mechanical plaque control measures, such as tooth brushing, interdental cleaning, and professional periodontal debridement, complemented by chemical agents including fluoride-containing products and antimicrobial mouth rinses such as chlorhexidine [41]. Nevertheless, growing evidence suggests that dietary approaches incorporating fermented foods may provide an adjunctive strategy for supporting oral health. It should be noted, however, that moderation in the consumption of certain fermented dairy products remains advisable, as excessive intake has been associated with an increased risk of dental erosion [42].

Despite the promising findings summarized in this review, the available evidence remains heterogeneous with respect to probiotic strains, fermented food matrices, intervention protocols, dosage regimens, treatment duration, and outcome measures. These methodological differences currently preclude firm clinical recommendations and highlight the need for larger, well-designed randomized clinical trials with standardized protocols and longer follow-up periods.

Limitations and Future Perspectives

This narrative review provides a comprehensive overview of the current evidence regarding the contribution of microorganisms associated with fermented foods to oral health by integrating findings from clinical, experimental, observational, and review studies. The approach described here, enables a comprehensive discussion of the underlying biological mechanisms, clinical relevance, translational applications, and emerging research trends that may not be fully captured by more restrictive review methodologies. However, several limitations should be acknowledged. As a narrative review, this work was not designed to provide a formal evidence grading or quantitative synthesis. Although a structured literature search was performed using multiple databases and predefined search concepts, study selection was guided by relevance to the objectives of this review rather than by exhaustive systematic screening. Consequently, publication bias and selection bias cannot be completely excluded. Furthermore, the available evidence is characterized by considerable heterogeneity with respect to study design, probiotic strains, fermented food matrices, intervention protocols, dosage regimens, treatment duration, study populations, and outcome measures, precluding direct quantitative comparisons and limiting the strength of clinical recommendations.

Nevertheless, the narrative approach facilitates the integration of mechanistic, clinical, and translational evidence while providing a broader perspective on the emerging role of microorganisms associated with fermented foods in oral health. It also enables the identification of important knowledge gaps and priorities for future research. Although current evidence supports the potential role of fermented food-derived microorganisms in oral health promotion, several important research gaps remain. Future research should prioritize well-designed randomized clinical trials with standardized intervention protocols, adequate sample sizes, and longer follow-up periods to evaluate strain-specific effects and clinically meaningful oral health outcomes. Greater attention should also be given to the influence of different fermented food matrices on microbial delivery and activity within the oral cavity and to the interactions between probiotic microorganisms and host immune responses. Beyond establishing clinical efficacy, future investigations should further elucidate the molecular mechanisms underlying probiotic and postbiotic activity,

including modulation of bacterial signaling pathways, quorum sensing, biofilm-regulatory gene expression (e.g., genes involved in bacterial adhesion and extracellular polysaccharide synthesis), microbial metabolite production, and host immune regulation. Particular attention should also be given to the identification and characterization of fermentation-derived bioactive metabolites, including organic acids, peptides, and other microbial products that may contribute to oral microbial homeostasis independently of viable probiotic cells. The integration of microbiome sequencing, metabolomics, transcriptomics, and systems biology approaches is expected to provide a more comprehensive understanding of the complex interactions between fermented food-derived microorganisms and the oral ecosystem. Finally, the development of strain-specific functional foods, targeted postbiotic formulations based on well-characterized microbial metabolites, and personalized microbiome-based nutritional strategies may represent promising directions for precision preventive dentistry and the translation of microbiome science into clinical practice.

5. Conclusions

Fermented food-derived microorganisms have considerable potential as modulators of oral microbial ecology and contributors to oral health promotion. The available evidence appears to indicate that their benefits extend beyond the suppression of individual pathogens and are more closely related to the restoration of microbial homeostasis, biofilm regulation, and host–microbe interactions. Fermented foods such as yogurt, kefir, and fermented milk products may therefore represent practical dietary tools for supporting preventive oral healthcare. Although current findings are promising, further well-designed clinical studies are needed to establish standardized recommendations and to explore the emerging potential of postbiotic and microbiome-centered approaches in dentistry.

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