Universidad Europea

GRADUATION PROJECT

Degree in Dentistry

THE IMPACT OF DIET ON ORAL MICROBIOME COMPOSITION

Madrid, academic year 2024/2025

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ABSTRACT

Introduction: The oral microbiota plays a crucial role in maintaining both oral and systemic health. Recent research highlights that dietary patterns significantly influence the balance between beneficial and pathogenic microorganisms in the oral cavity. **Objectives**: The primary objective of this review was to explore the mechanisms through which different types of diets affect the composition and function of the oral microbiome. Secondary objectives included identifying key dietary components that influence microbial balance and examining how these can be modulated to promote oral and systemic health. **Materials and Methods:** A systemized review of scientific literature was conducted, focusing on studies involving adult individuals who followed various dietary patterns, including omnivorous, vegetarian, vegan, Mediterranean, and Western diets. The studies were analyzed to determine how elements such as fiber, sugar, antioxidants, and fats affect microbial diversity and composition. **Results**: Plant-based and Mediterranean diets were associated with higher microbial diversity, increased levels of beneficial bacteria (e.g., *Rothia* spp., *Lachnospiraceae* spp.), and better periodontal outcomes. In contrast, omnivorous and Western diets, especially those high in sugar and processed foods, were linked to microbial dysbiosis, greater abundance of pathogenic species (e.g., *S. mutans*, *Prevotella* spp.), and elevated periodontal inflammation. **Conclusion**: Diet is a significant modulator of the oral microbiome. Promoting diets rich in fiber and antioxidants may enhance microbial equilibrium, reduce inflammation, and support periodontal health through non-invasive and natural means.

KEYWORDS
Odontology, oral microbiota, dietary habits, microbial diversity, periodontal health

RESUMEN

Introducción: La composición del microbiota oral desempeña un papel crucial en el mantenimiento de la salud oral y sistémica. Investigaciones recientes han demostrado que los patrones dietéticos pueden modular significativamente el equilibrio entre microorganismos beneficiosos y perjudiciales**. Objetivos:** El objetivo principal de este estudio fue comprender los mecanismos por los cuales los diferentes tipos de dieta influyen en la composición y función del microbioma oral. Los objetivos secundarios incluyeron identificar qué componentes dietéticos tienen mayor impacto y cómo pueden ser modulados para favorecer una mejor salud oral y sistémica. **Materiales y métodos:** Se realizó una revisión bibliográfica de estudios centrados en adultos que seguían dietas omnívoras, vegetarianas, veganas, mediterráneas y occidentales. Se evaluaron elementos dietéticos como fibra, azúcar, antioxidantes y grasas para observar su influencia en la diversidad microbiana. **Resultados:** Las dietas vegetales y mediterráneas se asociaron con mayor diversidad microbiana, niveles más altos de bacterias beneficiosas (*Rothia* spp., *Lachnospiraceae* spp.) y mejores parámetros periodontales. En cambio, las dietas occidentales y omnívoras, especialmente aquellas ricas en azúcares y alimentos procesados se relacionaron con disbiosis, mayor presencia de especies patógenas (*S. mutans*, *Prevotella* spp.) y aumento de inflamación periodontal. **Conclusión:** La dieta influye significativamente en la composición y estabilidad del microbioma oral. Promover dietas ricas en fibra y antioxidantes puede mejorar el equilibrio microbiano, reducir la inflamación y favorecer la salud periodontal mediante medios naturales y no invasivos.

PALABRAS CLAVE

Odontología, microbiota oral, hábitos alimentarios, diversidad microbiana, salud periodontal

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1. INTRODUCTION

1.1. The oral microbiome:

The oral microbiota refers to the diverse community of bacteria, fungi, and viruses that inhabit the oral cavity. Its composition is primarily shaped by factors such as saliva composition, diet, oral hygiene, masticatory forces, and various environmental and genetic influences (1). This microbiota forms a dynamic and adaptable ecosystem, crucial in maintaining oral and overall health (2). At birth, the oral cavity is sterile, but over time, microbial colonization begins, influenced by environmental exposure and host-related factors (Figure 1).

The mouth contains several distinct ecological "niches," each with unique compositions and functions that contribute to the overall microbiome (3). Alterations in one niche can impact the balance of the oral microbiome (3). Maintaining stability within this environment is difficult due to constant exposure to external substances, such as food, tobacco, and sugary products (1). According to the type of microorganisms present in the saliva, subgingival and supragingival plaque, the composition of the oral environment may vary (2).

Saliva is essential for regulating the microbiota, as its flow continuously influences microbial presence and composition (2). In contrast, the teeth have a different mechanism; once the bacteria have adhered to the tooth surface, they are not naturally removed, as teeth lack desquamative ability (2). Without proper oral hygiene, microorganisms can accumulate, leading to plaque formation and subsequent changes in the microbiome and, subsequently, to caries or other periodontal diseases (3).

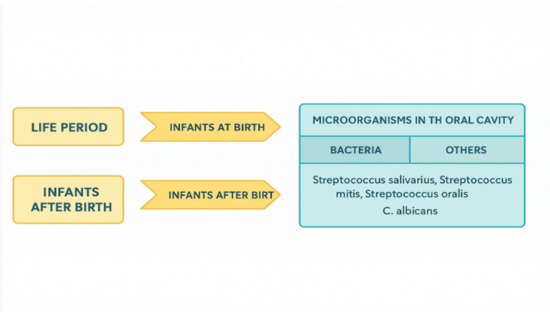


Figure 1: Change in the oral microbiome over time from birth to adulthood.

Data extracted from (2).

A wide variety of microorganisms inhabit the oral cavity. Species like *Actinobacteria spp.*, *Chlamydia spp.*, *Fusobacterium spp.*, *Spirochetes* spp. are present in the mouth (2). Fungi represent only 0,004% of the total oral microbial population. The most observed fungi include *Candida albicans* (involved in caries and the development of periodontal disease) and *Aspergillus* spp. (2). These fungi are constantly present in the oral cavity but do not cause harm if they remain in a healthy balance, thanks to regulatory mechanisms. When this balance is disturbed by factors such as poor hygiene or reduced salivary function; oral diseases, infections, periodontitis, or even cancer may develop (2).

The state where all the microorganisms are in balance is known as homeostasis (4). For the entire body, it is a concept in which the body relies on its regulatory mechanisms to maintain balance within the biological system, helping to preserve stability and ensure the organism functions effectively (5). It is the state where the internal conditions of the body strive to remain stable even when challenged by external factors like medications od sugary products (4). Just as the body relies on homeostasis to maintain internal stability, the oral cavity depends on a healthy balance of microorganisms to prevent any type of oral conditions (Figure 2).

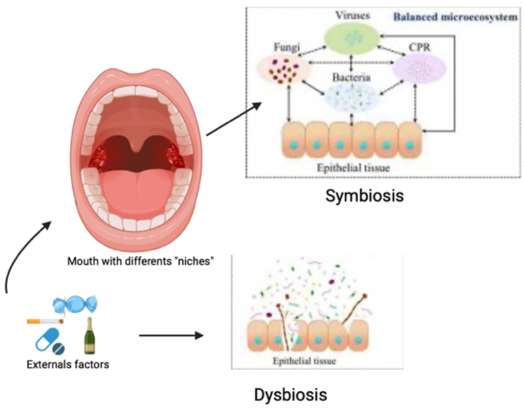


Figure 2. Composition of the microbiota in dysbiosis due to external factors.

Data extracted from (2).

1.2.Oral health:

Oral health refers to the condition in which all components of the mouth coexist in balance, and where no microorganisms cause disease. It is a crucial parameter for an individual’s systemic health, encompassing the good condition of the teeth, tongue, gums, bone and other tissue (6).

The primary cause of oral disease is the dysbiosis between the niches present in the mouth and the microorganisms that inhabit them (6). This dysbiosis refers to a harmful disruption in the balance and composition of the microbiome, which varies depending on the health status of the individual. This imbalance can lead to several diseases, with periodontal disease being a notable example (6) (Figure 3). Periodontal disease affects the periodontium, the supportive apparatus surrounding the tooth, which is composed of the gingiva, alveolar bone, cementum and periodontal ligament (7). The development of this pathology can be due to the accumulation of bacterial plaque in the subgingival and supragingival area (2), which can be initiated by a lack of oral hygiene, genetic conditions or the hosts' habits, such as tobacco use, stress, or even systemic diseases. Poor oral hygiene is considered the main risk factor (8). This variability is particularly significant in our generation due to its prevalence and the impact it has on the general health of the population (8).

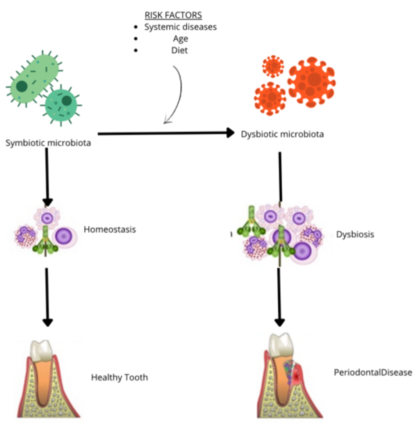


Figure 3 : impact of dysbiosis on the periodontal ligament. Data extracted from : (9).

When the dysbiosis surpasses the protective capacity of the periodontium particularly due to a lack of hygiene or an excessive plaque build-up, the host immune reaction will commence, resulting in inflammation (8). This means that the bacteria have progressed enough to reach deeper layers and begin destroying the periodontal ligament, a condition known as periodontitis (9).

Gingivitis, like periodontitis, is characterized by an accumulation of microorganisms at the surface of the tooth that causes inflammation of the periodontium but without associated tissue destruction (9). If untreated, it may lead to inflammation and tissue destruction, but this does not occur in every case (10).

Another common condition that affects the population is dental caries. The primary cause of its development is the excessive intake of carbohydrate-rich products (11). The common bacteria for the development of caries are *Streptococcus mutans* or *Lactobacillus* spp. (12) that have the capacity to metabolize sugar, and transform it into acid, causing a diminution of the pH of the mouth (13). This chain reaction will cause later a demineralization of the surface of the tooth, creating cavitation. *Streptococcus* spp. can colonize this cavity to go deeper and cause a caries which may develop more if not treated in time. It could reach a deeper layer of the tooth, the pulp, and cause intense pain, infection or abscess which may require a root canal therapy or tooth extraction (13). If the infection spreads beyond the tooth to the surrounding tissues, it can lead to a life-threatening condition called cellulitis or even sepsis, a systemic infection (14).

So, periodontal disease and caries are both polymicrobial infections that arise from a perturbation of the oral biofilm that can come from dietary variations or changes of the oral hygiene (15).

1.3.Diet and microbiome:

The mouth is the first place where digestion begins. All food begins digestion in the mouth and continues to the gut. Depending on the host's diet, the composition and state of the oral microbiome can change (16). Since birth, we have all been exposed to different types of diets. This process begins in infancy; the breastfed child is exposed to different nutrients and microorganisms compared to formula-fed baby (3). Today, many types of diets exist, such as carnivores, omnivores, vegetarian diet, and more, each with different food choices and varying amounts of proteins, carbohydrates, and lipids, all of which contribute to a distinct oral environment composition. The diet is therefore a pivotal variable in oral health since it shapes the oral microbiome, which plays a crucial role in the prevention and development of periodontal disease and caries (2).

A diet rich in fruits and vegetables involves a high level of fiber in the oral cavity. This fiber is useful for regulating the pH, protecting gingival tissue against bacterial infections, and providing a probiotic effect (11). Food including yogurt and other dairy products are rich in probiotics as well; they support the growth of beneficial microorganisms like the *Lactobacillus* spp. or

Bifidobacterium spp. . They help in the production of lactic acid, aiding in the degradation of harmful substances (17), and help regulate acid levels, thereby reducing the probability of developing caries (11). This lactic acid, mainly produced by *S. mutans* during sugar fermentation, plays a key role in lowering the pH of the mouth, creating a more acidic environment (14). This shift can inhibit bacteria that prefer neutral or alkaline conditions, disrupting the balance of the oral microbiota (14).

A balanced diet is key; no food group should be consumed excessively or completely excluded. Some studies show that excessive sugar consumption, combined with poor dental hygiene or genetic predispositions, can increase the risk of dental caries (7). Conversely, a deficiency in calcium-rich foods, such as vegetables and dairy products, can negatively impact the oral microbiota (18). Calcium is vital not only for the general health but also for oral health. It plays a crucial role in the mineralization of teeth, a process that strengthens enamel and dentin increasing the resistance to acids and bacteria that cause decay (18). When exposed to acidic foods, enamel can lose minerals, causing demineralization; however, calcium, especially when combined with phosphate and fluoride, helps to remineralize the enamel and restore its strength (19).

One of the most important bacteria in the mouth, *Porphyromonas gingivalis*, has been linked to both oral and systemic disease including gut inflammation and inflammatory bowel disease (IBD) (20). The oral cavity has a direct connection with the gut, after passing through the mouth, food ends up in the bowel via the saliva. It can be translocated to the stomach and disrupt its microbial balance along with other microorganisms like *Pseudomonas spp.* (21). The microorganisms have a highly dynamic pathway, they start their course in the mouth and end in the feces (Figure 4).

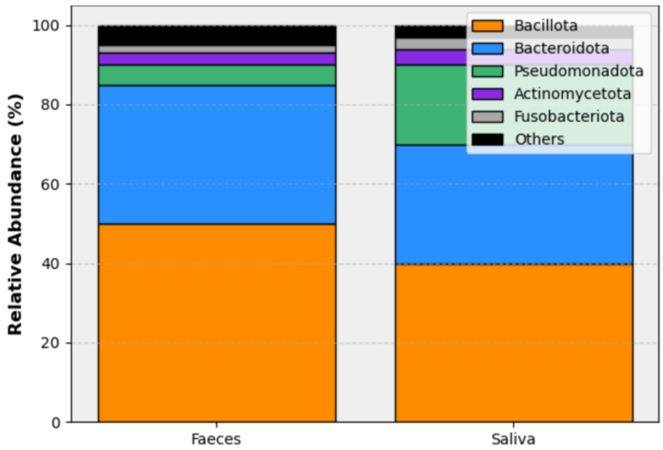


Figure 4: distribution of the microorganisms in the oral cavity and in the gut. Data extracted from : (21)

The gut and the oral cavity connection is possible thanks to the oral-gut axis. Dysbiosis in the gut can influence the oral environment by promoting the growth of pathogens in the mouth (21). This phenomenon is possible due to the bacteria present in the gums, which can be transported via the bloodstream, promoting chronic gum inflammation or contributing to the development of systemic diseases (22).

A diet with a high-fat or lower fiber has demonstrated an alteration in the composition of the oral microbiota, increasing the risk of periodontitis and caries (22). A diet low in fiber reduces the production of prebiotics, which have a positive effect on the bacteria in the gut. This leads to a decrease in the production of short-chain fatty acids, such as butyrate, which play an important role in reducing inflammation and supporting gut health (22). Butyrate also has systemic effects, including reducing inflammation in the mouth and potentially helping to prevent or manage periodontitis and other inflammatory oral conditions (23). Conversely, a high-fat diet increases the production of cytokines, which are involved in the inflammatory process and immune responses. When cytokine levels rise, it can contribute to systemic inflammation that affects both the gut and the oral cavity, resulting in periodontitis (22).

The oral microbiota is a complex and dynamic ecosystem influenced by various factors, with diet being one of the most significant determinants of its composition and function (1). Over time, changes in human dietary patterns—such as the transition from natural, fiber-rich diets to processed, high-sugar foods—have led to shifts in microbial diversity, affecting oral health and disease susceptibility (2). Understanding how different diets modulate the oral microbiome is crucial in identifying strategies to maintain microbial balance and prevent oral dysbiosis (1).

Research has shown that diet influences the oral microbiota by affecting bacterial diversity, metabolic activity, and interactions within the microbial community (8). The Western diet, characterized by high consumption of refined sugars and processed foods, fosters the growth of acidogenic bacteria such as *S. mutans*, a key contributor to dental caries (24). This dietary pattern also promotes inflammation, leading to an increased risk of periodontal disease (19). In contrast, the Mediterranean diet, rich in fiber, polyphenols, and healthy fats, has shown a more diverse oral microbiome, with an increased presence of beneficial bacteria that help maintain oral homeostasis (16). The anti-inflammatory properties of this diet contribute to lower levels of periodontal disease and improved oral health outcomes (16).

Similarly, Plant-based diets, including vegetarian and vegan, help balance the oral microbiota by increasing beneficial bacteria like *Neisseria subflava* and *Haemophilus parainfluenzae*, which reduce inflammation (25). Vegetarians eat dairy and eggs, while vegans avoid all animal products, including ethical concerns, avoiding animal products in food, clothing, and more (26). Plant-based diets focus on whole plant foods but don't always include the ethical aspect of veganism.

However, vegan diets, in particular, may increase the risk of dental erosion due to frequent consumption of acidic foods (19). On the other hand, low-carbohydrate diets, such as the ketogenic diet, restrict sugar intake, potentially reducing the prevalence of cariogenic bacteria. But the long-term effects of carbohydrate restriction on microbial diversity and overall oral health remain uncertain (19).

The impact of diet on the oral microbiome is mediated through several mechanisms. Nutrient availability plays a crucial role in determining which bacterial species thrive, while pH regulation, influenced by acidic or alkaline food consumption, affects microbial survival and growth (1). Additionally, immune modulation through diet—such as the anti-inflammatory effects of polyphenols—helps maintaining microbial balance, reducing the presence of pathogenic bacteria (2). Moreover, bacterial competition is influenced by dietary components, with fiber-rich diets promoting beneficial bacterial growth and inhibiting harmful species.

Despite these findings, gaps remain in understanding the precise mechanisms by which diet shapes the oral microbiota over time. While evidence suggests that dietary interventions can help maintain microbial balance and prevent oral diseases, further research are needed to establish clear guidelines on optimal nutrition for oral health. Investigating the long-term effects of different dietary patterns on microbial composition will provide valuable insights into how nutrition can be leveraged to support a healthy oral microbiome.

This research, based on defined criteria, provides insight into how diet influences the oral microbiome. This leads us to ask more deeply: In adult patients, how does a specific type of diets influence the composition and function of the oral microbiome?

1.4. Justification:

The oral microbiome plays a fundamental role in maintaining health, yet various factors, particularly diet, can disrupt its equilibrium, leading to microbial dysbiosis and disease. The justification for this work lies in the growing importance of understanding the oral microbiome within the field of dental and general health. The oral microbiota plays a fundamental role in the development of conditions such as caries and periodontal disease. In a context where dietary patterns vary greatly, from vegan and vegetarian diets to Western-style eating habits, it becomes essential to examine how these choices influence microbial balance in the oral cavity. This study is also justified by the increasing need to promote non-invasive strategies for disease prevention, in line with modern approaches in preventive medicine and dentistry.

2. OBJECTIVE

Primary objective:

To understand the mechanisms in which the aliments modulate the composition of the oral microbiome composition and its impact on the function of it.

Secondary objective:

To analyze which dietary factors have a greater impact in shaping the oral microbiome and determine how these can be controlled to optimize oral and systemic health.

Hypothesis:

H0: dietary habits do not have an impact on the composition of the oral microbiome

H1: dietary habits have an impact on the composition of the oral microbiome

3. MATERIAL AND METHODS

This study is a systemized review conducted searching through following databases : Medline, PubMed, dentistry, and oral science resources, ranging from 2011 to 2025. The search strategy consisted of headings, subheadings, texts words and word variations for diet, oral microbiota, periodontal disease combined with vegetarian or vegetarian diet, vegan, omnivore or carnivore diet.

Following the PICO approach, we can ask : In adults over 17 years old following different dietary patterns (Population), how does adherence to a vegetarian, vegan, omnivorous, or plant-based diet (Intervention) compared to the daily diet of the patient (Comparison) influence the composition and diversity of the oral microbiota (Outcome) ?

Inclusion and exclusion criteria were used and described in the following table.

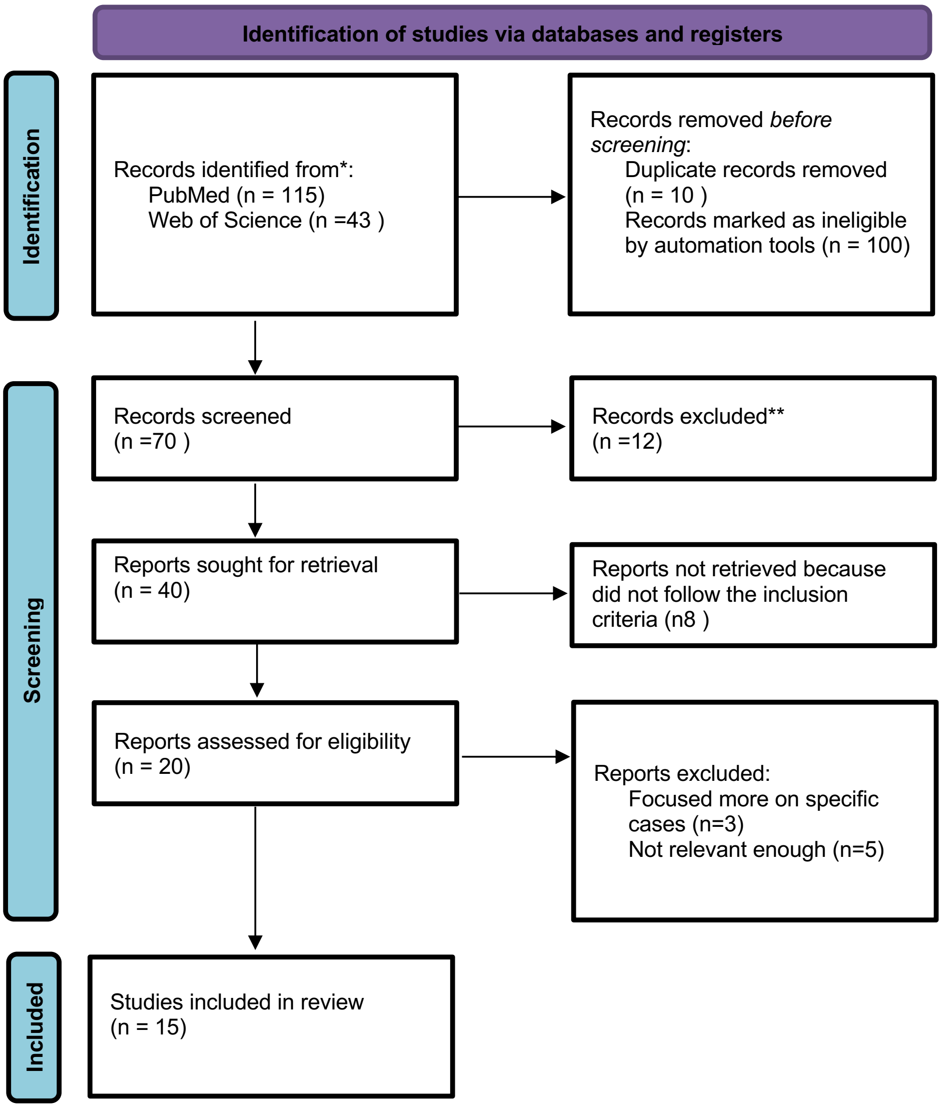
Table 1: Inclusion and exclusion criteria

Inclusion criteria	**Exclusion criteria**
Studies made on Human living-being	Animal studies, non-human microbiome studies
Article in the topic of nutrition: oral microbiota, gut microbiota, homeostasis, oral disease	Articles not relevant for my topics
Studies with different types of diet experienced in human living organism: carnivore, omnivore, vegan, vegetarians, plant-based diet, high-sugar consumption	Studies made on children (younger than 17 years old)
Articles with a timeframe of 2011 - 2025	Articles older than 2011
Reliable database	

The key words used in the databases were: ((“diet” or “vegan” or “omnivore”) AND (“oral microbiome” or “oral microbiota” or “oral health”)). Also, ((“homeostasis” OR “dysbiosis”) AND “periodontal disease” OR “ oral health”)); ((“based-plant diet” OR “juice-based diet”) AND (“gut microbiota" or "oral microbiome or "salivary microbiome") AND ("diet impact" or "microorganisms")).

We were interested in observational or intervention studies comparing a vegetarian diet with a nonvegetarian diet in terms of dental health outcomes.

Figure 5 : study selection table :



4.RESULTS

References	Type of study	Diet	Sample size	Control/intervention	Outcome
Chowdurhy M, Rajaram 2022(27)	Cross-sectional study	Vegetarian and non-vegetarian diet	240 participants : 120 vegetarian and 120 non-vegetarians	Both groups were matched for age and gender, allowing for an effective comparison of periodontal health parameters between vegetarian and nonvegetarians under similar demographic conditions	Probing pocket depth : Group 1 : 2.23 ± 0.21 mm Group 2 : 4.01 ± 0.11 mm Gingival recession : Group 1: 0.34 ± 0.34 mm Group 2: 0.28 ± 0.22 mm Clinical attachment loss : Not provided for both groups Decayed tooth : Group 1 : 0.51 ± 0.12 Group 2 : 0.67 ± 0.14
Hansen TH, Kern T, 2018 (28)	Observational cross-sectional study	Vegan diet and omnivorous diet	160 participants: 78 vegans and 82 omnivores	The searchers collected the saliva and used the omnivore as a baseline to assess how the absence of animal-derived foods in the vegan diet impact the microbiome composition	Differential abundance : 22OTUs differed between vegans and omnivores. Core microbiome : 23 genera were shared by over 95% of individuals in both groups. Notable differences : Higher in vegans : *Neisseria* spp. and *Haemophilus* spp. Higher in Omnivores : *Prevotella* spp. and *Streptococcus* spp.
Atarbashi-Moghadam F, Moallemi-Pour S, 2020 (29)	Cross-sectional study	Raw vegan diet and omnivorous diet	118 participants; 59 raw vegans and 59 omnivores (control)	The omnivores were macheted with the raw vegans participants in terms of sex and ages. They were randomly selected from companions in the case group or from another patient attending dental clinic	Salivary pH : lower in raw vegans (6.52 ± 0.31) vs. omnivore (6.78 ± 0.27) Probing depth : lower in raw vegans (1.9mm) vs. controls (2.1mm) Bleeding on probing (BOP) : significantly lower in raw vegans (P=0.017)
Nasidze I, Li J, Schroeder Res, 2011 (30)	Cross-sectional observational study	Population with higher consumption of meat and plants compared to more agricultural societies	Population from the Batwa Pygmies and 20 individuals from Kinshasa and 13 from Sierra Leone	Batwa Pygmies population diet was compared to two control groups by analyzing the saliva microbiome from these agricultural groups with different lifestyle and dietary factors	Microbial diversity : The saliva microbiome of the Batwa was found to be significantly more diverse, with 127 different genera compared to 54 in the DRC group and 71 in the SL group.

References	Type of study	Diet	Sample size	Control/intervention	Outcome
Sardaro MLS, Grote V, Baik J, 2025 (31)	Randomized controlled trial	Exclusive juice diet compared to juice plus food diet and plant-based whole-food diet	14 participants	Three-phase design, the control aspect involved the initial elimination diet, which consisted of organic fresh fruits, vegetables, gluten-free and limited processed foods. After the suppression they were randomized to one of three intervention diets for three days.	Cheek Microbiome : No significant changes in microbial diversity due to the elimination diet Saliva microbiome : significant differences in microbial composition ($p<0.005$, $p=0.0025$) Bacterial changes : Firmicutes : decreased in both cheek ($p=0.01$) and saliva ($p=0.004$ greater reduction) Proteobacteria : increased in both cheek ($p=0.05$) and saliva ($p=0.005$, greater increase).
Anderson AC, Rothballer M, 2020 (32)	Longitudinal study	Compare different type of diets following specific phases	151 samples from participant across all five dietary phases	The control of this study is the comparison of the composition of the oral microbiota with the previous one and with the initial phase. Phase 1: regular diet Phase 2: increase sucrose intake : Phase 3: increase diary intake Phase 4: increase dietary fiber intake Phase 5: return to regular diet	Streptococcus Abundance : Increased significantly in phase II ($P<0.01$ compared to phase I) Decreased significantly in phase III and IV ($P<0.00001$ compared to Phase II) with the introduction of dairy and dietary fibers. Alpha-Diversity: Increased in Phase IIII and Phase IV compared to phase II, indicating greater microbial diversity.
Staufenbiel I, Weinspach K, 2013 (33)	Prospective controlled clinical trial	Compared vegetarians (composed of lacto-ovo-vegetarians and vegans) and non-vegetarian diet	A total of 200 participants : 100 vegetarian and 100 non-vegetarians	Comparison between the two groups of diet that were matched for known periodontal risk factors such as age, gender and smoking habits to ensure that any differences In periodontal conditions could be attributed to the diet type rather than other confounding factors	Probing poking depth (PPD) : Higer in non-vegetarians (3.14 ± 0.81 mm) vs. vegetarians (2.91 ± 0.81 mm, $P = 0.037$). Bleeding on probing (BOP) : higher in non-vegetarians (19.43 ± 17.40%) vs. vegetarians (12.18 ± 13.12%, $P = 0.001$). Periodontal screening index (PSI) : better (lower) in vegetarians ($P=0.012$), indicating healthier periodontal status

References	Type of study	Diet	Sample size	Control/intervention	Outcome
Li H, Zou Y, Ding G. 2016 (34)	Meta-analysis	Acidic food and impact on the dental erosion	total sample size of 8,877 participants across nine studies.	This analysis employed strict inclusion and exclusion criteria to ensure that only relevant studies were considered.	Soft drinks : 2.4x higher risk of dental erosion (OR= 2.41, CI: 2.03-2.85) Vitamin C : slightly increased risk ? (OR = 1.16, CI: 1.10–1.22). Milk : no signifiant association (OR = 0.67, CI : 0.11–4.01).
Fackelmann G, Manghi P, 2025 (35)	Multidirectional observational cohort study	Omnivore diet compared to vegetarian and vegan diet	The sample consisted of 21,561 individuals from five independent, multinational cohorts, categorized into three dietary patterns: omnivore, vegetarian, and vegan. Specifically, the participants included 19,817 omnivores, 1,088 vegetarians, and 656 vegans.	The omnivorous group serve as a baseline for comparison against the vegetarian and vegan diet. It helps highlight the specific microbial and health-related changes that arise from adopting a vegetarian and vegan dietary pattern within the study population	Gut microbial richness (SGBs) : Vegans : 201-266 species Vegetarians : 201-269 species Omnivores : 217-299 species (highest diversity) Omnivore microbial signatures : *Ruminococcus torques*, *Bilophila wadsworthia, Alistipes putredinis* : linked to red meat consumption and negative cardiometabolic health effects. Vegan microbial signatures : *Lachnospiraceae spp., Butyricicoccus sp*. : associated with fiber degradation and SCFA production, beneficial for health.
Sidhu SRK, Kok CW, 2023 (25)	Randomized controlled trials	Plant-based diet compared to vegan, ovo-lacto vegetarian diet	A total of 583 participants across the 12 studies	Some studies compared plant-based diets (vegan or ovo-lacto vegetarian) to omnivorous diets. In certain cases, the control group consisted of participants following a conventional diet while the intervention group followed either a low-fat vegan diet or a Mediterranean diet, among other comparisons	This beneficial bacterium was significantly increased in plant-based and vegan diets. Some studies reported increases by 30% to 50% compared to baseline measurements in those switching diets.
De Filippis F, Vannini L , 2014(36)	Observational cross-sectional study	Omnivore diet, ovo-lacto-vegetarian diet and vegan diet	161 healthy sample	Sample were distributed in three groups according to their type of diets : omnivores, vegan and ovo-lacto-vegetarian. They followed this diet for at least one year	Key compounds linked to dietary choices : Omnivores : urea, formate, uridine Vegetarians/vegans : hexanoid acid, proline Diet classification accuracy : The study could correctly classify dietary habits 64-70% of the time using metabolome data. Salivary composition : while diet influenced salivary metabolites, the bacterial composition of saliva was similar across different dietary habits.

References	Type of study	Diet	Sample size	Control/intervention	Outcome
Zapała B, Stefura T, 2022, (24)	Comparative observational study	Western diet (high caloric intake, high saturated fats, processed food)	167 individuals (59 patients with Parkinson disease and 108 healthy controls	Participants in the control group were without neurodegenerative disorders, ensuring they do not have conditions that could confound the results regarding oral microbiota and dietary habits. The healthy controls were matched for age with the patients having Parkinson's Disease. the control participants were also excluded if they had a medical history of neurological, immunological, or gastrointestinal diseases	Microbial Richness: Healthy controls had significantly higher species richness compared to patients with periodontal disease (PD). PD Microbial Composition : Increased abundance of *Prevotella spp., Streptococcus spp. , Lactobacillus spp.* in PD patients. Food-Bacteria Correlations: *Veillonella rogosae* positively correlated with high leaf vegetable consumption. *Prevotella histicola* negatively correlated with low red meat consumption.
J. P. Woelber, K. Bremer, 2016 (37)	Randomized controlled pilot study	Oral health optimized diet (Low Carbohydrate Intake, Rich in Omega-3 Fatty Acids, High in Vitamins and Antioxidants, High Fiber Content)	10 participants in the experimental group and 5 participants in the control group	The control group consisted of participants who were encouraged to continue their dietary habits without making any changes. They did not receive any specific dietary interventions; instead, they maintained their usual diets, which primarily included a higher carbohydrate intake	Gingival Index (GI): Experimental Group: Decreased from 1.10 ± 0.51 to 0.54 ± 0.30. Control Group: Remained stable, with values ranging from 1.01 to 1.30. Bleeding on Probing (BOP): Experimental Group: Decreased from 53.57% to 24.17%. Control Group: Values ranged from 46.46% to 64.06%, with no significant reduction. Periodontal Inflamed Surface Area (PISA): Experimental Group: Decreased from 638 mm² to 284 mm². Control Group: Remained between 662.24 mm² and 963.24 mm².

References	Type of study	Diet	Sample size	Control/intervention	Outcome
Gabriel Innocenti, Maria Elena Martino, 2022 (38)	cross-sectional study	Omnivorous diet	40 dental calculus samples collected from participants	Collected samples from 40 individuals with no current signs of gingival inflammation, bleeding, or caries. All participants were evaluated during scheduled periodontal maintenance to ensure uniformity in dental calculus formation.	Dental Calculus Microbiome : Dominated by 10 phyla and 39 genera, with significant variability among individuals. Dominant Phylum: *Firmicutes spp.* (found in 75% of samples), followed by *Actinobacteria*, *Bacteroidetes*, and *Proteobacteria*. Major Genera: *Streptococcus spp.*, *Rothia* spp. *Tannerella spp.*, *Lautropia spp.* ,*Fusobacterium spp*. Dietary Link: Specific genera were associated with distinct dietary components, indicating a correlation between dietary habits and microbiome profiles.
Kirstin Vach, Ali Al-Ahmad, 2023 (39)	experimental clinical study	Compare different type of diets following specific phases	11 participants	The control phase of the study is Phase I, referred to as the "Introductory Phase." During this phase, the participants maintained their normal dietary habits without any changes, which provided a baseline for comparison with the subsequent phases.	Phase 1: Baseline measurements were taken, with typical bacteria like *Streptococcus spp.* , *Actinomyces* spp. , and *Neisseria* spp. present. Phase 2 (Sucrose Consumption) : Increased levels of *Streptococcus* spp., linked to higher sugar intake. Phase 3 (Plain Yogurt) Increased levels of *Lactobacillus* spp., indicating a positive response to dairy. Phase 4 (Vegetable Puree) : Increased populations of health-associated bacteria. Phase 5 (Return to Pre-Study Diets): Microbiota composition shifted back.
Anderson AC, Rothballer M, 2018 (40)	Longitudinal study	High Sucrose consumption	11 participants	The control of the study is represented by (Phase I), during which the participants maintained their regular diet without any additional sucrose consumption. This allowed for a comparison to be made against the second phase (Phase II), where participants consumed an additional 10 g of sucrose daily in the form of rock candy for three months.	Beta-Diversity & Species Richness: Significant differences were observed in beta-diversity, with a marked decrease in species richness in the dental biofilm after the sucrose consumption phase. Impact of Sucrose: The additional sucrose led to shifts in the supragingival microbiota, indicating that frequent carbohydrate exposure can alter the microbial community in dental plaque. Comparison to Control Phase: There was a significant decrease in species richness during the sucrose phase compared to the control phase.

References	Type of study	Diet	Sample size	Control/intervention	Outcome
Johansson I, Esberg A, 2018 (41)	observational study that employs a cohort design	Bovine milk intake	a total of 31,725 participants across two cohorts: Primary cohort: 154 adolescents aged 17 years were recruited Replication cohort: 31,571 adults aged 30–64 years	The adolescents (n = 154) who participated were considered a control group based on specific inclusion criteria such as being healthy, not having taken antibiotics in the previous six months. This cohort provided additional data on dental caries and lifestyle variables, functioning as a control for verifying the findings seen in the adolescent cohort regarding milk intake and oral microbiota	Adolescents (n = 154): Lowest tertile: Mean D1FS score = 6.2 Middle tertile: Mean D1FS score = 5.3 Highest tertile: Mean D1FS score = 4.5 Conclusion: No significant difference in caries prevalence across milk consumption groups (p = 0.460). Adults (n = 31,571): Lowest quintile: Mean DMFS score = 62.9 Middle quintile: Mean DMFS score = 62.5 Highest quintile: Mean DMFS score = 63.8 Conclusion: No significant difference in caries prevalence across milk intake quintiles (p = 0.986). Overall Finding: Despite higher milk consumption being linked to lower *S. mutans* in both adolescents and adults, dental caries prevalence did not differ significantly based on milk intake.

Table 1: diet, sample size, control and outcome of impact of the diet on the oral microbiome

The reviewed studies revealed that plant-based, vegan, and Mediterranean diets are associated with a higher microbial diversity and an increased presence of beneficial bacteria such as *Rothia spp.* and *Lachnospiraceae spp.*, which contribute to reduced inflammation and better periodontal outcomes. These diets were linked to shallower probing depths and less bleeding on probing. In contrast, omnivorous and high-sugar diets favored the growth of pathogenic species like *S. mutans* and *Prevotella spp.*, leading to dysbiosis and greater periodontal damage. Overall, diet strongly influences the balance of the oral microbiota and plays a key role in periodontal health.

Figure 5: repartition of the microorganisms presents in the oral microbiota according to the type of diets

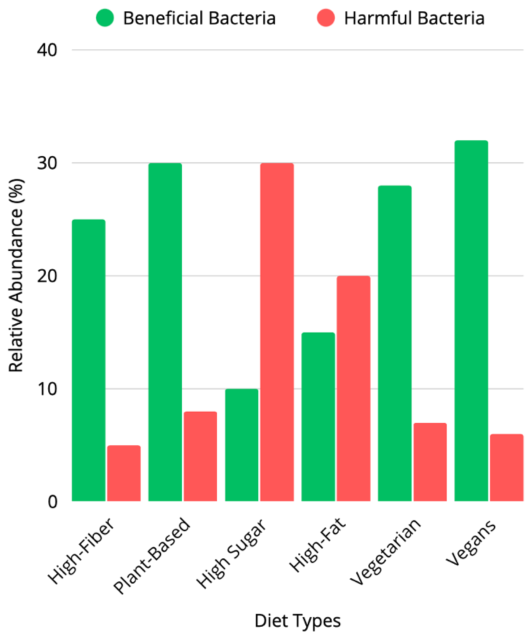


Figure 6: Abundance in percentage of the beneficial and harmful bacteria in the oral cavity according to the type of diets

4. DISCUSION

In the present study, changes in the composition of the oral microbiome were evaluated by analyzing multiple studies involving adults adhering to different dietary patterns. The findings reveal a strong link between dietary habits and the oral microbiota, indicating that food choices can shape microbial diversity, influence inflammation, and impact the overall balance of the oral ecosystem. The studies included in this analysis demonstrate that specific eating patterns can significantly affect the composition of oral bacteria, either encouraging the growth of beneficial microorganisms or fostering harmful ones (Figure 5).

Despite the numerous findings established in recent decades, several limitations were identified in the reviewed studies. A major issue is the variability across trials. Differences in study designs, dietary interventions, and analytical techniques make it difficult to draw definitive conclusions. Furthermore, the absence of standardized control groups across studies complicates direct comparisons and may introduce variability that impacts the overall outcomes. These factors should be taken into consideration when interpreting the findings.

This study aimed to compare modern dietary patterns based on their distinct nutrient profiles and potential effects on the oral microbiome. Several review articles published in the past decade highlight significant differences in microbial compositions among individuals following vegan, vegetarian, omnivorous, plant-based or high-sugar diets.

One of the most extensively studied dietary patterns is veganism, which excludes all animal-derived products. Observational studies suggest that individuals following a vegan lifestyle tend to have a more diverse and stable oral microbiota profile (35). For example, *Lachnospiraceae* spp. and *Butyricicoccus* spp. are linked to anti-inflammatory properties and fiber metabolism (35). These bacteria contribute to the production of short-chain fatty acids (SCFAs), which help maintain mucosal integrity and modulate immune response (28). Additionally, vegans often exhibit a lower presence of *S. mutans* and other bacteria associated with caries, partly due to the reduced consumption of fermentable sugars and animal fats (35). The high fiber content in this diet promotes a symbiotic microbial environment and offers protection against oral dysbiosis and inflammation.

In contrast, the omnivorous diet, which includes both plant and animal-based foods, has been linked to a different oral microbial profile. Studies indicate that omnivores tend to have higher levels of *Streptococcus spp.*, *Prevotella* spp. and *Ruminococcus torques,* all of which are considered pathogenic bacteria (Figure 5) and associated with inflammation in the oral environment (42). These bacteria grow in a low-pH environment, often created by frequent consumption of meat and carbohydrates, common components of the omnivorous diet (43). The elevated presence of pro-inflammatory bacterial species in omnivorous may increase the susceptibility to gingivitis and periodontitis. Moreover, individuals generally exhibit reduced microbial diversity compared to the vegans diet, conducting into an overall oral dysbiosis (42).

A predominantly plant-based diet, especially one rich in whole grains, vegetables, legumes and fruits, has shown a more balanced and diverse oral microbiome. The abundance of fiber and polyphenols in plant foods supports the growth of beneficial bacteria species while inhibiting the proliferation of pathogenic species (43). Polyphenols are known to suppress the proliferation of harmful microorganisms and promote the colonization by beneficial species. Individuals adhering to plant-based diets tend to have a higher level of beneficial bacteria *Lachnospiraceae spp., Butyticiococcus spp, Rothia spp.,* all of which contribute to mucosal homeostasis and modulation of inflammation (25). *Rothia spp*., are linked to a more stable and less pathogenic microbial profile (Figure 5) and associated with a lower risk of periodontal disease (Figure 6). Additionally, these diets exclude saturated fats, sugars, and processed meats, which helps create a more stable oral environment. This stability limits the growth of acidogenic bacteria (Figure 6), such as *S. mutans* or *Prevotella Intermedia* (37).

On the other hand, high-sugar diet, those rich in sucrose and fermentable carbohydrates, have attracted great interest in recent years. They have demonstrated an effect on the composition and stability of the oral microbiota. Frequent sugar intake lowers the pH of the oral cavity and promotes the growth of acid-loving bacteria such as *S. mutans*, *Lactobacillus spp.*, and *Scardovia wiggsiae*, which are involved in the development of dental caries and in the early stages of periodontal disease (39). These microorganisms metabolize sugars into acids, leading to a decrease in the pH of the oral cavity, causing the demineralization of the tooth enamel and causing an oral dysbiosis (40). In a study conducted by Kirstin Vach - (39), an increase in sucrose consumption caused a rapid shift toward a more pathogenic microbiota, characterized by a diminution of the oral microbial diversity (Figure 6) making the cavity more susceptible to disease.

High sugar diets also encourage the growth of inflammatory microorganisms like *S. mutans* and *Prevotella* spp., which are implicated in gingivitis and other periodontal diseases (39). However, research has shown that reducing sugar intake or introducing protective foods, such as dairy products or fiber-rich vegetables can help restore microbial balance, reduce acidity, and support the growth of beneficial bacteria like *Rothia spp.* and *Haemophilus spp.* (Figure 5) (32).

In addition to these types of diets, the most common diet in our society is the Western diet, characterized by high intake of saturated fats, refined sugars, meat and low consumption of fiber, have been correlated with a high tendency of oral dysbiosis (24). It promotes the proliferation of pathogenic bacteria like *Streptococcus* spp., *Lactobacillus* spp. and *prevotella* spp., which are engaged in acid production and inflammation. The chronic exposure of those carbohydrates and the low consumption of fiber, favor the reduction of the pH of the oral cavity and then contribute to enamel erosion and plaque formation (34). In contrast, the Mediterranean diet, rich in whole grains, fruits, vegetables and oils supports a more diverse and balanced oral microbiota (16). Anti-inflammatory compounds such as polyphenols and antioxidants in this diet inhibit the growth of harmful bacteria and promote the colonization of beneficial species like *Prevotella* spp. or *Subflava spp.* (16).

Beyond its influence on the oral microbiome, diet plays a crucial role in shaping periodontal health by regulating inflammation and maintaining microbial balance at the tooth and gum level. Plant-based diets, particularly vegans and vegetarian, demonstrate a protective effect on the periodontal tissue. In the study conducted by Ingmar Staufenbiel (33) vegetarians showed a significant better periodontal health than the non-vegetarians, including reduced probing depth and sign of inflammation. Among vegetarians, there was a notable decrease of the bleeding on probing and fewer tooth mobility, indicating healthier periodontal conditions (33). Conversely, non-vegetarians demonstrated a higher rate of periodontal damage, with sign of more severe inflammation and a poorer overall periodontal condition. This can be attributed to the anti-inflammatory potential of fiber that support beneficial microbial taxa such as Lachnospiraceae and *Rothia* spp., that are known for promoting immune homeostasis (33). Conversely, the omnivorous diet, especially those high in red meat and saturated fats have been associated with a higher abundance of pro-inflammatory bacteria such as *Prevotella spp*. and *Streptococcus spp*., which contribute to plaque accumulation and gingival inflammation (37). As previously mentioned, high sugar intake reduces oral microbial diversity and promotes the growth of acidogenic species such as *S. mutans*. This shift disrupts oral pH and triggers host inflammatory responses (44). These findings support the idea that diet not only alters the oral microbiome but also directly influences periodontal health through mechanisms like microbial composition, inflammation and immune regulation.

Focusing on the anti-inflammatory mechanism, SCFAs play an essential role in modulating inflammation and protecting periodontal health. Diets that promote the formation of those fatty acids are mainly created by diet such as high-fiber diet, plant-based diet or Mediterranean diet (32). Anti-inflammatory molecules, particularly polyphenolic compounds found in plant-based foods, have received considerable attention for their oral health benefits. These compounds exert their effects through various mechanisms, primarily by modulating inflammatory pathways and suppressing the growth of pathogenic bacteria (32). Polyphenols act as powerful antioxidants, neutralizing reactive oxygen species, thereby reducing the inflammation in the oral cavity. They achieve this by downregulating pro-inflammatory cytokines and enzymes such as cyclooxygenase and lipoxygenase which are involved in inflammatory responses (44). They also inhibit the synthesis of glucans, a key structural element of dental biofilms, leading to a decrease in the adhesion and colonization of cariogenic bacteria such as *S.mutans*. This disruption of bacterial growth not only diminishes the risk of dental caries but also supports a more balanced oral microbiota, which is pivotal for maintaining periodontal health (32). Through these multiple mechanisms, anti-inflammatory molecules contribute to the reduction on inflammation and prevention of oral diseases.

5. CONCLUSION

In this review, we have summarized recent studies on the oral microbiota and the endogenous and exogenous factors influencing its composition.

This study confirmed that different types of diets have a strong influence on the composition and function of the oral microbiome. Diets rich in fiber, antioxidants and plant-based foods, such as vegetarian, vegan, and Mediterranean diets were associated with higher microbial diversity, lower inflammation, and increased presence of beneficial species. In contrast, omnivorous and Western diets, higher in sugars, animal fats and processed foods, were linked to dysbiosis and a higher abundance of pro-inflammatory and acidogenic bacteria. These findings highlight that dietary habits shape the oral microbiota through mechanisms including pH regulation, nutrient availability, immune modulation, and bacterial composition.

Among the dietary components analyzed, sugar, fiber, and antioxidants showed the greatest impact on microbial balance. Frequent sugar intake led to lower microbial diversity and favored the growth of cariogenic and pathogenic bacteria, increasing the risk of caries and periodontal disease. On the other hand, fiber-rich and antioxidant-rich foods helped maintain a more stable and protective microbiome. These elements can be easily modulated in daily life through dietary changes to improve oral and systemic health.

6. SUSTAINABILITY

The relationship between diet and the oral microbiome brings together environmental, social, and economic dimensions of sustainability, aligning closely with Sustainable Development Goal: Good Health and Well-being. Environmentally, promoting diets rich in plant-based foods contributes to reducing greenhouse gas emissions, conserving water, and lowering the ecological footprint of food production. These sustainable dietary patterns, such as the Mediterranean or vegetarian diet, also help preserve biodiversity and soil health.

Socially, improving access to nutritional education empowers individuals and communities to make informed choices that benefit both oral and overall health, particularly in populations where dental care may be limited. This fosters better health equity and supports preventive healthcare models.

Economically, encouraging sustainable diets can reduce the long-term costs associated with treating oral diseases by shifting the focus toward prevention through healthier lifestyles. Public policies that integrate sustainable nutrition into healthcare and education systems can reduce pressure on national health budgets and improve quality of life. By understanding how food choices shape the oral microbiome and applying this knowledge through sustainable practices, we create a healthier, more equitable, and more resilient society.

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