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Review Article

FERMENTED DAIRY PRODUCTS AND ORTHODONTICS

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Abstract: *The oral environment constitutes a critical component of the human microbiome. The intake of probiotic products can exert beneficial effects on the oral microbiota, thereby reducing the risk of diseases. Nutrition is the most essential component not only for survival but also for maintaining a healthy lifestyle. This review aims to explore the impacts of probiotic products on oral flora and specifically address the role and significance of probiotics in the context of orthodontic treatment processes. For this purpose, two impartial reviewers examined the search results from four electronic databases (Web of Science, Google Scholar, Scopus, and Dergipark), and then selected articles that might be pertinent for full-text analysis. Data extraction and methodological flaws were addressed in articles that satisfied the inclusion criteria, and the quality of the studies was rated using the Cochrane Instrument for Risk of Bias Assessment. Fermented dairy products are acquired as a result of the fermentation of milk with the activity of beneficial and suitable microorganisms. In addition to fermentation bacteria, fermented milk products contain bacterial bioactive compounds and metabolites produced throughout fermentation. With this content, fermented dairy products are a unique composition due to the inclusion of ingredients that serve the ultimate product properties on the other side of nutrition. This review focuses on the available scientific data on the consumption of fermented milk products and their orthodontic utilities. Orthodontic patients avoid many types of food because their teeth are sensitive to chewing. Thus, these individuals consume significantly less protein and other essential nutrients, calcium, and some vitamins. This article provides an overview of the relationship between fermented milk products and orthodontic treatment. The role of fermented milk products in the nutrition of orthodontic patients is discussed to achieve a healthy mouth and general health.*

Keywords: *Nutrition, fermented dairy products, orthodontics*

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1. Introduction

Nutrition has been adopted as the most basic component of a healthy lifestyle. To support healthy nutrition in societies, it is practiced to constantly explain healthy nutrition through health services [1]. In today's world, what we expect from food is not only to meet the energy required for our basic physical needs but also to contribute to human health. For this reason, food manufacturers are no longer looking for varieties that are both high-yielding and reducing exposure to disease and environmental impacts, not just to feed the ever-growing world population. Food suppliers are turning to products that will both meet the current consumer demand for healthy food products and provide health benefits. Because there are many expectations such as supporting the immune system, preventing chronic diseases, and providing enough energy without causing obesity [1, 2]. Considering all the necessary elements in nutrition, it is formed by determining the age, nutritional habits, likes and dislikes of individuals, etc.

[3, 4]. Milk is a good source of vital nutrients such as protein, enzymes, fat, lactose, vitamins, minerals, immunoglobulins, and hormones. Dairy products are an effective functional food not only to meet the nutritional needs of consumers but also to prevent many diseases such as osteoporosis, dental diseases, obesity, poor gastrointestinal health, cardiovascular diseases, and hypertension [4]. Studies on the effect of milk on oral health have shown that each component in the composition has many benefits. For example, it is known that glycomacropeptides in the composition of milk can prevent dental caries and gingivitis, and show antiviral and antibacterial effects. On the other hand, conjugated linoleic acid and lactoferrin protect oral health by modulating the immune system [5]. Fermented milk products have many properties such as anti-microbial, anti-mutagenic, anti-carcinogenic, and anti-hypertension and It is known that it has benefits on tooth mineralization metabolism. It is known that fermented milk products are the major carriers of probiotic microorganisms, and some clinical studies show the impacts of probiotic strains on dental health [3, 6-8]. However, there is a need for component-effect-based studies on this.

The success of orthodontic treatment hinges significantly on the patient's engagement and cooperation throughout the therapeutic process. Throughout this period, the challenges patients face while eating with orthodontic appliances become a matter of significant concern. A thorough understanding by orthodontists of how orthodontic devices affect their patients' dietary habits and nutritional regimens will enable the provision of more effective nutritional strategies and guidance [4, 5]. This comprehension is crucial in ensuring that orthodontic interventions are not only mechanically successful but also supportive of maintaining overall patient health and well-being during treatment.

Orthodontic problems in individuals can occur as soon as they are born with the wrong habits they have acquired. There is a bilateral relationship between nutrition and orthodontics. Treatment where orthodontic treatment affects food intake and nutritional quality affects the speed of orthodontic treatment [3]. At the same time, it is accepted that individuals who receive orthodontic treatment are in the high-risk group for dental caries and periodontal diseases, and for this reason, the foods that individuals take with diet are important [9]. On the other hand, orthodontic devices have been used for a long time to treat malocclusions and weak jaw relations, but their influences on patient food intake showed that total fat, copper, manganese, and lipid levels from food were significantly reduced [10]. Nutritional follow-up of patients is very important considering the effects of nutrients on periodontal status and the effects of orthodontic treatment on nutrition [6]. Because diet determines oral flora, periodontal condition, and healing. Orthodontic treatment is related to many factors, from the growth and development of the craniofacial complex to the movement of teeth through periodontal tissues [6]. Today, the increasing importance of oral aesthetics; directs individuals to orthodontic treatment in order to improve their dental appearance. With the development of fixed orthodontic treatment applications, the demand for orthodontic treatment has increased. Bands, brackets, and wires used in orthodontic treatment create areas suitable for the retention of nutrients. Thus, it becomes difficult to maintain oral hygiene and an ecological area is created for microorganisms that cause tooth decay. There are many studies in the literature reporting an increased incidence of caries during fixed orthodontic treatment [8]. *Streptococcus mutans* and lactobacilli are the leading microorganisms that cause dental caries [11]. Fermented dairy products can play a significant role in the diet, both to strengthen the anatomy in orthodontic treatments and to prevent caries that may occur during treatment. Another positive aspect of fermented dairy products in the diet of orthodontic patients is that they are a unique food choice for braces wearers because most fermented milk products are soft and require little chewing [12]. This study aims to evaluate the future of orthodontic treatment by considering the role of fermented milk products in reducing the bacteria that cause dental caries.

2. Materials and Methods

Two impartial reviewers examined the search results from four electronic databases (Web of Science, Google Scholar, Scopus, and Dergipark), and then selected articles that might be pertinent for full-text analysis. Data extraction and methodological flaws were addressed in articles that satisfied the inclusion criteria, and the quality of the studies was rated using the Cochrane Instrument for Risk of Bias Assessment.

3. Results and Discussion

3.1. Fermented Milk Products

Fermented milk products have shown a significant increase in consumption in the last years and market tendency suggests that this will increase even more. As fermented dairy products contribute to healthy living and increase life expectancy, there is an increasing consumer interest owing to the health benefits these products offer [13]. Fermentation processes often increase the bioavailability and nutritional relevance of many foods. The fermentation effect of lactic acid bacteria leads to the conversion of antinutritional agents such as galactose and lactose in milk, increasing bioavailability [14]. The conversion of lactose to lactic acid is the major phenomenon in fermentation. The enzymes of lactic acid bacteria change milk carbohydrates into oligosaccharides, some of which have prebiotic features [15]. The formation of other compounds produced by lactic acid bacteria depends on the composition of the raw milk used, the microbial strains, and the status of the fermentation process. The most known types of lactic acid bacteria utilized for milk fermentation are *Bifidobacteria* or *Streptococcus thermophilus*, which is usually associated with *Lactobacilli* [15, 16].

3.2. Probiotics and Orthodontics

The term probiotic is derived from the words “pro” and “biota” and means “vital, vital”. While defining the concept of probiotics, Elie Metchnikoff (17), who won the Nobel Prize in 1908, pointed out that harmless live bacteria in the human body could have beneficial effects on the host, and then in 1998, Guarner and Schaafsman defined probiotics as “live microorganisms that provide significant health gains beyond supporting a healthy life”. According to the definitions of the World Health Organization and the Food and Agriculture Organization, probiotics are live microorganisms that provide health benefits to the host when taken in sufficient amounts [18, 19]. The bacteria most frequently used as probiotics are *lactobacilli* and *bifidobacteria*, as seen in Table 1. *Lactobacilli*, one of the lactic acid bacteria, are bacteria found in large quantities, especially in fermented animal foods. Adhesion of probiotics with pathogenic bacteria in the oral microbiota It creates a promising alternative in terms of oral and dental health as they compete for the surface and inhibit them with their metabolites. The usability of probiotic cultures in oral health studies has gained importance in recent years. Today, products such as chewing gum, toothpaste, lozenges, tablets, and mouthwash containing oral probiotics produced in some countries such as America and Canada are offered to people in the markets. In a study by Jose et al.(2013), in which they compared the effects of systemic probiotic paste consumption and topical probiotic toothpaste application on Streptococcus mutans levels in the plaques of orthodontic patients, they reported that probiotic toothpaste was more effective than systemic consumption [20]. Several studies have indicated the effectiveness of various *Lactobacillus* species in orthodontic treatment. These include *Lactobacillus reuteri* strain [21], *Lactobacillus paracasei* strain [22], as well as *Lactobacillus salivarius*, *Lactobacillus plantarum*, and *Lactobacillus rhamnosus* [23]. Additionally, research suggests that *Lactobacillus brevis* may offer benefits due to its anti-inflammatory properties [24, 25, 26]. *Streptococcus salivarius* M18 strain has been predominantly assessed for its anti-caries activity [27]. *Bifidobacterium* is another species that has shown promise in positively impacting

periodontal disease [25]. In a separate study, the *Streptococcus salivarius* K12 strain was evaluated for its potential to influence oral malodor parameters [26]. In theory, multi-strain probiotic products may offer synergistic and symbiotic benefits due to interactions among their different strains. However, there is limited evidence suggesting that probiotic strains could also inhibit each other. For instance, while the production of hydrogen peroxide and bacteriocins may effectively inhibit endogenous strains such as Streptococcus mutans, they might also inadvertently suppress other probiotic strains within the same formulation, potentially reducing the product's overall efficacy [28]. For probiotics to exert their intended effects, bacteria must adhere to and colonize the inner surface of the mouth [28]. Effective probiotic activity cannot be expected if there is biofilm present on the oral surface or if the oral pH is not conducive to bacterial survival [22]. In such scenarios, it may be necessary to either increase the concentration of the probiotic or extend the duration of administration to observe potential clinical improvements in the patient [29]. Notably, changes in bacterial composition were observed only after six weeks of administering an oral probiotic preparation [30].

Table 1. Widely used probiotics in the dairy industry [16,19]

Genus	Probiotic strain	Some products containing probiotics
Lactobacillus	*L. plantarum, L. acidophilus, L. paracasei, L. rhamnosus, L. casei, L. gasseri, L. crispatus, L. bulgaricus, L. reuteri*	yogurt, kefir, buttermilk, cheese,
Lactococcus	*L. rhamnosus, L. lactis, L. plantarum, L. reuteri, L. curvatus, L. casei, L. acidophilus*	yogurt, cultured butter, buttermilk, cheese, sour cream
Bifidobacterium	*B. breve, B. longum, B. Bifidum, B. catenulatum, B. animalis, B.infantis*	yogurt, kefir, fermented milk drinks, fermented dairy products for infants and children, probiotic supplements
Streptococcus	*S. thermophilus, S. salivarius, S. sanguis, S. oralis, S. mitis*	yogurt, cheese, fermented milk drinks, probiotic supplements, oral health products such as probiotic lozenges or chewing gums
Propionibacterium	*P. freudenreichii, P. jensenii*	Swiss cheese, Emmental cheese, Gruyère cheese
Bacillus	*B. subtilis, B. coagulans, B. laterosporus, B.cereus*	traditional dairy products such as yogurt, cheese, or fermented milk drinks
Pediococcus	*P. pentosaceus, P. acidilactici*	cheese, fermented milk drinks, yoğurt, buttermilk, probiotic supplements
Saccharomyces	*S. boulardii, S. pastorianus, S. cerevisiae*	kefir, fermented dairy drinks, probiotic supplements, cheese
Akkermansia	*A. muciniphila*	it is not currently a common component of dairy products on the market.
Escherichia	*E. coli Nissle 1917*	supplement form, pharmaceutical preparations
Enterococcus	*E. faecium, E.munditii, E.durans, E. hirae*	cheese, fermented dairy products, probiotic supplements,
Leuconostoc	*L. mesenteroides*	cheese, fermented milk drinks, buttermilk, sour cream, probiotic supplements

Probiotic microorganisms should be able to produce antimicrobial compounds, stimulate the immune response, not transfer the antibacterial resistance feature to pathogenic microorganisms, and should not be pathogenic. It was reported that the first anaerobic bacteria isolated from the oral cavity was the *Bifidobacteria* group [31]. The effects of probiotic bacteria occur through three mechanisms; reducing the number of pathogenic bacteria, improving the immune system, and altering the metabolism (enzymatic activity) [32]. Probiotics also exert individual and strain-specific effects. Probiotics are transient microorganisms on the host, but they must be continuously colonized in order to have efficacy. This does not pose a disadvantage since they do not need to be colonized. The use of probiotics in oral health focuses on maintaining a balanced oral microbiome, which may help prevent conditions such as dental caries (tooth decay), gingivitis (gum inflammation), and periodontal disease (gum disease).

Some probiotic strains commonly associated with oral health include *Lactobacillus* species: Certain strains of *Lactobacillus*, such as *Lactobacillus reuteri* and *Lactobacillus acidophilus*, have been studied for their potential benefits in promoting oral health by reducing levels of harmful bacteria in the mouth and supporting a healthy balance of the oral microbiome [6, 11].*Streptococcus salivarius*: This bacterium is a natural inhabitant of the oral cavity and is known to produce bacteriocins, which are proteins that can inhibit the growth of other bacteria, including pathogenic strains. Some strains of *Streptococcus salivarius* have been investigated for their potential to promote oral health [9, 12].*Bifidobacterium* species: Certain strains of *Bifidobacterium* have also been studied for their potential benefits in oral health, although research in this area is still relatively limited compared to other probiotic strains [11, 12]. While these probiotic strains may have potential benefits for oral health, including supporting orthodontic treatment by reducing the risk of oral health problems, more research is needed to fully understand their effectiveness and optimal use in this context. In a study on saliva and plaque, probiotics have been shown to recover one week after discontinuation of treatments [7].

3.3. Prebiotics and Orthodontics

Prebiotics are food components consisting of indigestible short-chain carbohydrates that selectively induce the activity and growth of probiotics [33, 34]. They are hydrolyzed by probiotics in the large intestine and transformed into beneficial molecules instead of being digested in the upper portion of the digestive tract [35]. What is expected from prebiotics is that they pass through the upper parts of the digestive system and have the ability to increase the growth of beneficial bacteria in the large intestine. Another role of prebiotics is to increase the absorption and synthesis of B vitamins [36]. As a result, in order to prebiotics to be utilized by the bacteria in the large intestine, they must be able to resist acid hydrolysis in the stomach, transit into the large intestine undamaged, or be absorbed in the small intestine [37]. Galactooligosaccharides, fructooligosaccharides, and inulin are some naturally occuring prebiotics in foods. Lactosucrose, lactulose, isomaltooligasaccharide, glucooligosaccharides, xylooligosaccharides are generally synthesized prebiotics. Fermented dairy products comprise probiotics, which become accepted as synbiotics as prebiotics are added they support enhancing calcium absorption [38]. Many studies have demonstrated a relationship between bone density and various clinical problems in dentistry. Chugh et al. (2013) reviewed that information on bone density in an area of the oral cavity may be helpful in assessing orthodontic tooth movement as well as in planning to improve the success rate of treatment [39]. Children fed milk and orange juice containing inulin and oligofructose for a year had increased bone calcium homeostasis; their bone mineral density increased by 45% and their bone mineral content increased by 15%, according to previous studies [40, 41].

4. Conclusions

The impact of orthodontic appliances on patients' nutritional functions has been well-documented within the scientific literature. Developing a comprehensive understanding of the challenges faced

during alimentation with these appliances will enable the creation of more effective patient education materials. Consequently, this could lead to an increase in patient compliance, and thereby, the overall success of the treatment can be targeted for improvement. Quantitative and qualitative research methods could be employed to systematically measure these difficulties and to examine the effects on the dietary quality of patients with orthodontic appliances. Armed with this data, tailored dietary recommendations could be developed to minimize the adverse effects of orthodontic appliances on daily dietary habits, integrating these recommendations into the treatment process to optimize therapeutic outcomes.

Food choice restriction was encountered by individuals wearing various types of orthodontic appliances. The causes of these dietary limitations were most commonly attributed to three factors: The impact of the appliance on the teeth, such as the physical/functional challenges associated with wearing an appliance which necessitates substituting hard or crunchy foods (for example, carrots, hard chocolate) with softer alternatives (such as pasta, yogurt); the dietary restrictions recommended by orthodontists aimed at reducing decalcification risks (for instance, avoiding sweets, fizzy drinks) and avoiding breakages (for example, not chewing gum, toffees) as well as the apprehension concerning potential damage to the appliance. The wearers of orthodontic appliances often impose dietary restrictions upon themselves to mitigate the embarrassment or inconvenience caused by food particles becoming lodged in their appliances, such as meats or green vegetables.

There is a bilateral relationship between nutrition and orthodontic treatment; the delivery of orthodontic treatment affects food intake, and the quality of nutrition affects the speed of orthodontic treatment. A proper diet strengthens orthodontic treatment by providing all the elements necessary to keep oral tissues healthy and help bone remodel. On the other hand, ensuring the maximum comfort of the patient while applying orthodontic treatment affects the diet at a minimum level. Fermented dairy products are important food groups in orthodontic treatment with their content and consistency.

In conclusion, this review highlights the potential orthodontic benefits associated with the consumption of fermented dairy products. Fermented dairy products, such as yogurt and cheese, are not only rich in essential nutrients but also contain beneficial microorganisms, bacterial bioactive compounds, and metabolites produced during fermentation. These components contribute to the unique composition of fermented dairy products and offer potential health benefits beyond basic nutrition.

Orthodontic patients, who often experience sensitivity and dietary restrictions, may benefit from incorporating fermented dairy products into their diet. These products provide essential nutrients such as protein, calcium, and vitamins while offering probiotic properties that support oral health. Furthermore, fermented dairy products are often soft and require minimal chewing, making them suitable choices for individuals undergoing orthodontic treatment.

Probiotic microorganisms found in fermented dairy products, including lactobacilli and bifidobacteria, have been studied for their potential to reduce the risk of dental caries, gingivitis, and periodontal disease. Additionally, prebiotics found in some fermented dairy products, such as inulin and oligofructose, may support bone health and calcium absorption, which is particularly relevant for orthodontic patients.

Overall, the consumption of fermented dairy products represents a promising avenue for supporting oral health and general well-being during orthodontic treatment. Further research and clinical studies are warranted to explore the specific mechanisms and optimal strategies for integrating these products into orthodontic care effectively. By emphasizing the role of nutrition, including fermented dairy products, in orthodontic treatment, this review contributes to a comprehensive understanding of holistic approaches to oral health management.

In conclusion, probiotic dairy products emerge as a promising option for enhancing oral health. Future research should expand to include the effects of other dairy products, such as ice cream and various types of cheese, on oral health beyond dental caries and periodontal disease. Additionally,

detailed surveys will be necessary to evaluate changes in the profile of research conducted post-pandemic, the relationship between the flow of publications and the countries most affected, and the impact of the use of probiotics in dentistry.

Conflicts of interest

All authors have none to declare.

Ethical statements

The authors declare that this document does not require ethics committee approval or any special permission. This review does not cause any harm to the environment and does not involve the use of animal or human subjects.

Authors' contributions

AA-Aİ and S-KA made a substantial contribution to the literature search and article write-up. Both authors read and approved the final document.

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