

Dairy and Dental Health

Volume 14, Issue 1 | March 2022



Summary Points

- Due to their protein, calcium and phosphorus content, the consumption of dairy products has long been associated with the development of a healthy dentition. In more recent years, the potential of dairy foods to impact the local environment within the mouth and to reduce tooth decay risk has also yielded promising results.
- Untreated dental caries is reported as the most prevalent of all diseases globally. Free sugars, such as dietary sucrose added to food or drinks is associated with increased risk. Although cow's milk contains about 4.8% lactose, when consumed as part of a healthy diet, milk sugar is generally regarded as non-cariogenic. Elite athletes appear to have a high prevalence of dental disease and it is possible that the use of plain milk for rehydration instead of commercial sports drinks, may help reduce the risk of dental disease.
- Epidemiology studies have associated the consumption of milk and dairy products, especially cheese, with a reduced risk of dental caries. The caries protective effect of cheese is thought to be mainly due to saliva stimulation and increased calcium concentration in the plaque biofilm. In addition, dairy proteins, such as casein, and casein-derived fractions, such as glycomacropeptide, can reduce adhesion and growth of oral bacteria.
- Researchers have proposed a matrix effect of dairy foods, whereby the health benefits are related to interactions between components within the overall food structure. The anticariogenic potential of milk-derived bioactives is also being explored for their role as functional ingredients for dental health.

Editorial

As the gateway to our digestive tract, the mouth is a unique organ and a critical player in the nutritional fate of food. The ability to taste food and the initiation of the digestive process begins in our mouth. Likewise, as oral health is intricately linked to several systems in the body, nutrition also plays a key role in influencing both the oral environment and dental health.

In this edition of DN Forum, we examine the role of dairy as a source of nutrients in dentition and we explore the influence of dairy intake on chronic dental diseases such as caries and erosion.

On page 4 of this publication, we feature our updated 'Nutrition & You' booklets for Teenagers and Adults. We hope you enjoy this edition and look forward to any feedback or comments you wish to share: nutrition@ndc.ie



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INTRODUCTION

Nutrition and oral health are intimately linked. Nutrition influences oral health directly by providing essential nutrients that are needed for the growth and development of dental structures; while a functioning masticatory system is required to liberate nutrients from food, for the maintenance of optimal nutritional status⁽¹⁾. Consumption of dairy products can impact oral health through tooth formation and jaw growth and also by having a direct local effect on the oral tissues. This direct effect is regarded as the most important⁽²⁾. Traditionally, consumption of milk and dairy products has been associated with the development of a healthy dentition as it provides a good source of proteins of high biological value, calcium, phosphorus and vitamins B2 and B12^(3,4). Undernutrition and nutrient deficiencies in vitamins A, C, D and calcium, in particular, can negatively impact the development of the dentition and supporting structures⁽¹⁾.

Oral diseases affect over 3.9 billion people across the world with untreated caries reported as the most prevalent of all diseases in the Global Burden of Disease study⁽⁵⁾. The results of poor oral health impact on pain, quality of life and nutritional status and create a high economic burden^(2,6,7). The high economic cost and dominant cycle of re-restoration within the surgical model of dentistry fails to address the underlying causes of disease^(5,8). Identifying food patterns of consumption and food ingredients, constituents or bioactives that can target dental diseases has provided research impetus for exploring the potential of dairy products⁽³⁾.

Several reviews discuss the role of milk and dairy products in dental caries prevention⁽⁹⁻¹¹⁾. Consumption of milk and dairy products, especially cheese, has been associated with a reduced risk of dental caries in epidemiological studies⁽¹²⁾. However, evidence for the potential caries protective effects (due to casein, calcium and phosphorus) derives largely from in vitro experiments⁽³⁾.

The primary dietary cause of dental caries is free sugar although all sugars that can be hydrolysed by oral bacteria are potentially cariogenic. The disaccharide lactose is the main carbohydrate in milk and is hydrolysed into glucose and galactose by intestinal lactase. Although cow's milk contains about 4.8g of lactose per 100g, when consumed as part of a healthy diet, milk sugars are generally regarded as non-cariogenic as milk also contains constituents which protect teeth^(1-3,8,10,11). Improper, or prolonged, nocturnal infant feeding practice with cow's milk based infant formula, may be a risk factor in the development of early childhood caries^(1,3).

As people eat food not nutrients, research has begun to examine the dietary pattern of whole food consumption rather than focus on the health effect of single nutrients⁽¹³⁾. Furthermore, researchers have proposed a matrix effect of dairy foods, especially cheese, where health benefits have been observed due to interactions between components within the overall food structure⁽¹⁴⁾. Similarly, the consumption of food or drink that contains caries protective factors may mitigate the caries risk from a food or drink that has high caries risk when consumed alone. Thus, understanding patterns of consumption and interactions between different foods, drinks and their constituents is important for assessing caries pathogenesis⁽³⁾. In this review we focus on dental caries, dental erosion and periodontal disease as these are the chronic dental diseases in which diet plays a significant role^(1,2).



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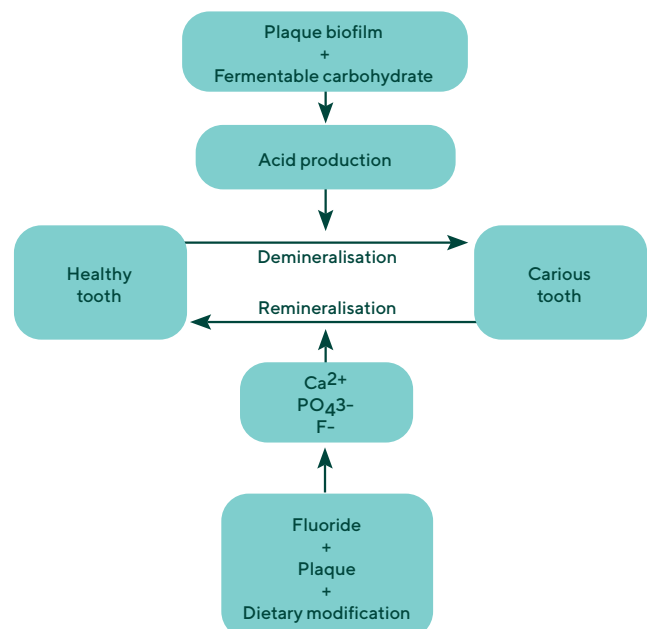
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PATHOPHYSIOLOGY OF DENTAL DISEASE

To appreciate the role of milk and dairy products on oral health it is important to understand the pathophysiology of dental disease mediated through the plaque biofilm⁽⁶⁾. Numerous authors have proposed pathophysiological models of the caries process^(6,15,16). However, a precise model for the interaction of food constituents at the molecular-biofilm level has yet to be fully elucidated. Dental caries arises due to the complex interaction between plaque biofilm, tooth susceptibility, saliva, dietary sugars and duration of contact with the biofilm⁽¹⁷⁾ (Figure 1). The 'ecological plaque hypothesis' proposes that the process develops due to changes in the oral environment following organic acid production from the fermentation of sugars⁽¹⁸⁾. Increasing the frequency of consumption of sugars prolongs the conditions which favour acidogenic and aciduric bacteria (*Streptococcus mutans* and *Lactobacilli*) and demineralisation of the tooth at the critical pH of approximately 5.5^(15,17). Determining how to reverse this microbiome dysbiosis is essential to developing approaches to improve oral health⁽¹⁹⁾. Many other factors can affect the processes of demineralization and remineralization including oral hygiene behaviours, composition and flow rate of saliva, morphological features of the teeth, fluoride exposures, and socioeconomic factors^(5,15,17,18).

Figure 1 Diagrammatic representation of the carious process with demineralisation and remineralisation - adapted from Selwitz *et al.*⁽¹⁷⁾ and Kidd⁽²⁰⁾.



Dental caries occurs due to the localised destruction of the tooth structure by demineralisation, caused by organic acids which are formed from the bacterial fermentation of dietary sugars^(15,17). The frequency and amount of free sugars are the main dietary factors contributing to dental caries^(1,17). While all free sugars can be utilised by the oral biofilm to generate organic acids, sucrose is unique as it can be converted by bacterial glycosyl transferases and fructosyltransferases into glucans and fructans, which can then facilitate attachment of bacteria, especially *S. mutans*⁽¹⁸⁾.

The bulk of the research supporting the caries protective properties for milk and dairy products is derived from animal studies and plaque pH studies. While epidemiological evidence is still equivocal, consumption of milk, cheese and possibly yoghurt has been associated with lower incidence of caries^(3,9,12). Cow's milk is considered to be non-cariogenic and may even be anticariogenic. A WHO review concluded that it "is possible" that milk consumption may decrease the risk of dental caries⁽¹¹⁾. Little research has been published on the role of yoghurt in oral health but it has been suggested that it is likely to have similar effects to milk. However, sugars are commonly added to many commercial yoghurts which may compromise any caries-protective effects⁽¹¹⁾. Indeed, the addition of added sugars, such as sucrose, to milk or yoghurt probably increases the risk of dental caries. The caries protective effect of cheese, especially hard cheeses, is thought to be mainly due to saliva stimulation and increasing the calcium concentration in the plaque biofilm^(1,9,21). However, proteins, such as casein, and casein-derived fractions, such as glycomacropeptide, can also reduce bacterial adhesion and inhibit growth^(9,22). While most clinical trials to date have reported positive associations with hard cheese consumption and caries reduction, a 2008 review by the European Food Safety Authority (EFSA) concluded that there was insufficient evidence to support a cause-and-effect relationship between the specific consumption of milk or cheese and dental health⁽²³⁾. However, a year later, evidence relating more precisely to nutrients which are found in dairy (calcium and phosphorus) was considered appropriate to authorise the health claim "contributes to the maintenance of normal bone and teeth"^(24,25).

Dental erosion is the progressive dissolution of tooth mineral by a chemical process in the absence of plaque⁽²⁶⁾. The prevalence of dental erosion, associated with dietary acids, appears to be increasing. Again, the aetiology is complex and multifactorial but a high dietary intake of acidic food and drink is an important extrinsic factor contributing to overall surface demineralisation of enamel and dentine. Unlike dental caries there is no critical pH for dental erosion as the concentration of calcium and phosphate ions in food or a drink determines the degree of saturation with respect to enamel and dentine⁽²⁷⁾. Thus, the buffering effects of high calcium and phosphate ion concentration in yogurt explains the non-erosive effect of a food with a low pH⁽²²⁾.

Periodontal diseases such as gingivitis and periodontitis are chronic inflammatory conditions initiated by the accumulation of plaque at the junction of the tooth and gingivae⁽¹⁶⁾. These conditions have an increased prevalence with age and combined with dental caries, are the main cause of tooth loss. Evidence is currently limited for the overall association between diet and periodontal disease. However, some nutrients derived from the diet perform as antioxidants and components of periodontal tissue structures that help to maintain normal body homeostasis, including periodontal functions⁽²⁸⁾. Depletion or lack of availability of nutrients can have marked effects on the periodontal tissues (such as those observed in scurvy, which is caused by severe vitamin C deficiency)⁽²⁹⁾. A balanced diet is therefore essential for maintaining periodontal health and a diet which is high in sugar and low in nutrients is a risk factor for periodontal disease^(1,30). Minor deficiencies in micronutrients (such as vitamin C, D, A, E, calcium and magnesium) can impact periodontal health, which appears to be a sensitive indicator of poor nutritional status^(30,31).

DAIRY CONSUMPTION AND NOVEL APPROACHES FOR ORAL HEALTH

Dairy consumption is promoted as part of the national healthy eating guidelines and although research suggests that it may play a

protective role against obesity, diabetes and cardiovascular disease, it appears that dairy consumption has declined in recent years^(32,33). Dairy products, are a widely consumed food group in the Irish population with 84% of teenagers (172g/d) and 98% of the adult population (244g/d) consumers of milk^(4,34). However, most Irish adults do not meet the recommendations of 3 servings per day.

The WHO guidelines on sugars intake recommend limiting free sugars to less than 10% and ideally, 5% of energy intake to protect oral health throughout life⁽³⁵⁾. This does not include sugars naturally present in liquid milk and milk products, whole fruits, vegetables and grains⁽³⁶⁾. In general, dentists should adopt the common risk factor approach and dietary advice for good general health is consistent with good oral health⁽³⁷⁾. Elite athletes appear to have a high prevalence of dental disease and it is possible that the use of milk for rehydration and nutrients, instead of commercial sports drinks, may help reduce the risk of dental disease⁽³⁸⁾. A multicentre research project exploring the relationship between the diet and oral health of Irish elite athletes is currently underway in Dublin Dental University Hospital.

It has been suggested that milk fluoridation may be beneficial to prevent caries in countries where water fluoridation is not sufficient⁽¹²⁾. While fluoride remains the mainstay of remineralisation and anticaries strategies there is commercial interest in developing dairy derived functional ingredients or bioactive fractions⁽³⁹⁾. Reviews of the potential anticariogenic properties of milk and dairy products emphasise the focus on selectively modifying the cariogenic biofilm or promoting the net remineralisation effects of dietary sugars^(9,10,22). Milk-derived peptides are now commercially produced and these peptides can be used as dietary supplementation in functional foods. Professional dental products are also available such as Tooth Mouse which uses 'Recaldent', a complex of casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) (Table 1)⁽²²⁾. Other milk-derived bioactives of interest include lactoferrin, lysozyme, lactoperoxidase, folate-binding protein, immunoglobulin proteins and growth factors^(10,36).

The potential effect of adding probiotic bacteria such as *Lactobacillus spp.* or *Bifidobacterium spp.* to milk, yogurt and cheese has been investigated in clinical trials with some promising results in reducing some caries risk factors such as *Streptococcus mutans* levels in plaque or saliva⁽⁴⁰⁾. However, most trials are short term, permanent colonisation has not been demonstrated and the current evidence is weak for a caries-reducing effect.

In conclusion, dairy products and milk provide an important source of key nutrients that are essential for healthy development and maintenance of the dentition. Multiple milk-derived fractions and products may have a therapeutic role in targeting and preventing the most common dental diseases but require further research.

Table 1 Constituents derived from cow's milk, cheese and yoghurt and potential effects on oral health⁽²²⁾

Constituent	Source/fraction	Potential effects
Casein	Main protein group	Antibacterial, inhibit adhesion, reduce glucan formation
Calcium, phosphorous	Milk, cheese, yoghurt	Remineralisation/pH buffering
Glycomacropeptide (GMP)	Hydrolysis of K-casein	Inhibition of bacterial adhesion
Casein phosphopeptide-amorphous calcium phosphate (CPP-ACP)	Enzymatic digestion and ultrafiltration of casein	Reduced demineralisation and enhanced remineralisation inhibit <i>S. mutans</i>
Lactoperoxidase, lysozyme	Whey protein peptides	Inhibit <i>S. mutans</i>
Lactoferrin	Iron-binding protein	Inhibit bacterial attachment
Proteose-peptones	Hydrolysis of β -casein	Inhibit demineralisation

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UPDATED NUTRITION & YOU BOOKLETS

Developed by the National Dairy Council and endorsed by the Irish Nutrition and Dietetic Institute, the Nutrition & You booklet series highlights the importance of a balanced diet across the life stages. The series is currently being updated, with the latest editions for 'Teenagers' and 'Adults' now available. Free copies are available to download from www.ndc.ie or order by contacting nutrition@ndc.ie

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To deliver real and unique value to Irish dairy farmers by protecting and promoting the image, quality, taste and nutritional credentials of Irish dairy produce to a wide variety of audiences in a clearly defined, focused and effective manner.

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