# 6.
# Low/no calorie sweeteners and oral health

Low/no calorie sweeteners (LNCS) are non-cariogenic ingredients and therefore, contrary to sugars and other fermentable carbohydrates, LNCS do not contribute to the development of dental caries. Untreated dental caries is the single most common health condition globally, affecting more than 2 billion people worldwide.

This chapter aims to provide information about oral health, the effect of diet on dental caries and the role that LNCS and sugar-free chewing gum can play in good dental health.

## Introduction

Untreated oral diseases affect almost half of the world's population, making them the most widespread conditions among the more than 300 diseases and conditions that affect humanity *(WHO, 2022)*. In 2019, almost 3.5 billion people globally suffered from different forms of oral diseases including untreated caries of deciduous (primary) and permanent teeth, severe periodontal disease (gum disease), edentulism (total tooth loss) and cancer of the lip and oral cavity *(Global Burden of Disease, 2019)*.

Oral diseases can impact many different aspects of life, from overall health to personal relationships and self-confidence, to even enjoying food. In fact, oral health affects general health by causing considerable pain and by changing what people eat, their overall quality of life and well-being. According to the FDI World Dental Federation's definition of oral health, "Oral health is multi-faceted and includes the ability to speak, smile, smell, taste, touch, chew, swallow and convey a range of emotions through facial expressions with confidence and without pain, discomfort and disease of the craniofacial complex (head, face, and oral cavity)."

Oral diseases are also linked to other chronic non-communicable diseases (NCDs), sharing common causal pathways, and affecting each other in a bi-directional way *(Seitz et al, 2019)*. For example, research shows that periodontitis (gum disease) can result in patients changing their dietary habits to include less fruit and vegetables *(Tonetti et al, 2017)*. Tooth pain or tooth loss can lead people to opt for softer, easier-to-chew foods that can be higher in calories, fat and sugar. As a result, poor oral health can itself contribute to unhealthy dietary patterns that are associated with increased risk of chronic NCDs such as obesity and type 2 diabetes.

Our oral health impacts our general health and well-being!

# Facts about oral diseases


Oral diseases affect nearly **3,5 billion people worldwide**.


**Between 1990 and 2019**, estimated case numbers grew by more than 1 billion – a **50% increase**.

Oral diseases take many shapes and forms, with **the most common being dental caries** (also known as tooth decay) **and gum disease**.

**Risk factors for oral diseases** include poor oral hygiene, diets high in sugar, tobacco use and excess alcohol consumption.

**Sources:**
(1) World Health Organization (WHO). Global oral health status report: towards universal health coverage for oral health by 2030. Geneva: World Health Organization; 2022.
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(2) FDI World Dental Federation. Key facts about oral health. Available at: https://www.fdiworlddental.org/key-facts-about-oral-health (Accessed 9 March 2023)

## About dental caries

Dental caries, which is also known as tooth decay or cavities, is the most widespread chronic disease worldwide and constitutes a major global public health challenge affecting people of all ages across the lifespan *(WHO, 2022)*. Tooth decay forms over time, when bacteria in the mouth break down sugars and other fermentable carbohydrates, producing acids that damage the hard tissues of the tooth leading to the formation of cavities.

The negative health effects of dental caries are cumulative because the disease is the result of lifelong exposure to dietary risk factors. Being free of cavities in childhood does not mean being caries-free for life, and most dental caries is now occurring in adults *(Moynihan and Kelly, 2014)*. Importantly, dental caries is largely preventable and avoidable and can be treated in their early stages *(FDI, 2015a)*.

## Prevalence of dental carries

According to the Global Burden of Disease (GBD) Study (2019), untreated dental caries in permanent teeth is the most prevalent condition among all diseases, affecting more than 2 billion people worldwide – more than one third of the world's population. In deciduous (primary) teeth, untreated caries is the single most common chronic childhood disease, affecting 514 million children worldwide *(Bernabe et al, 2020)*. The estimated prevalence of dental caries of deciduous and permanent teeth worldwide is presented in Figures 1 and 2, respectively.

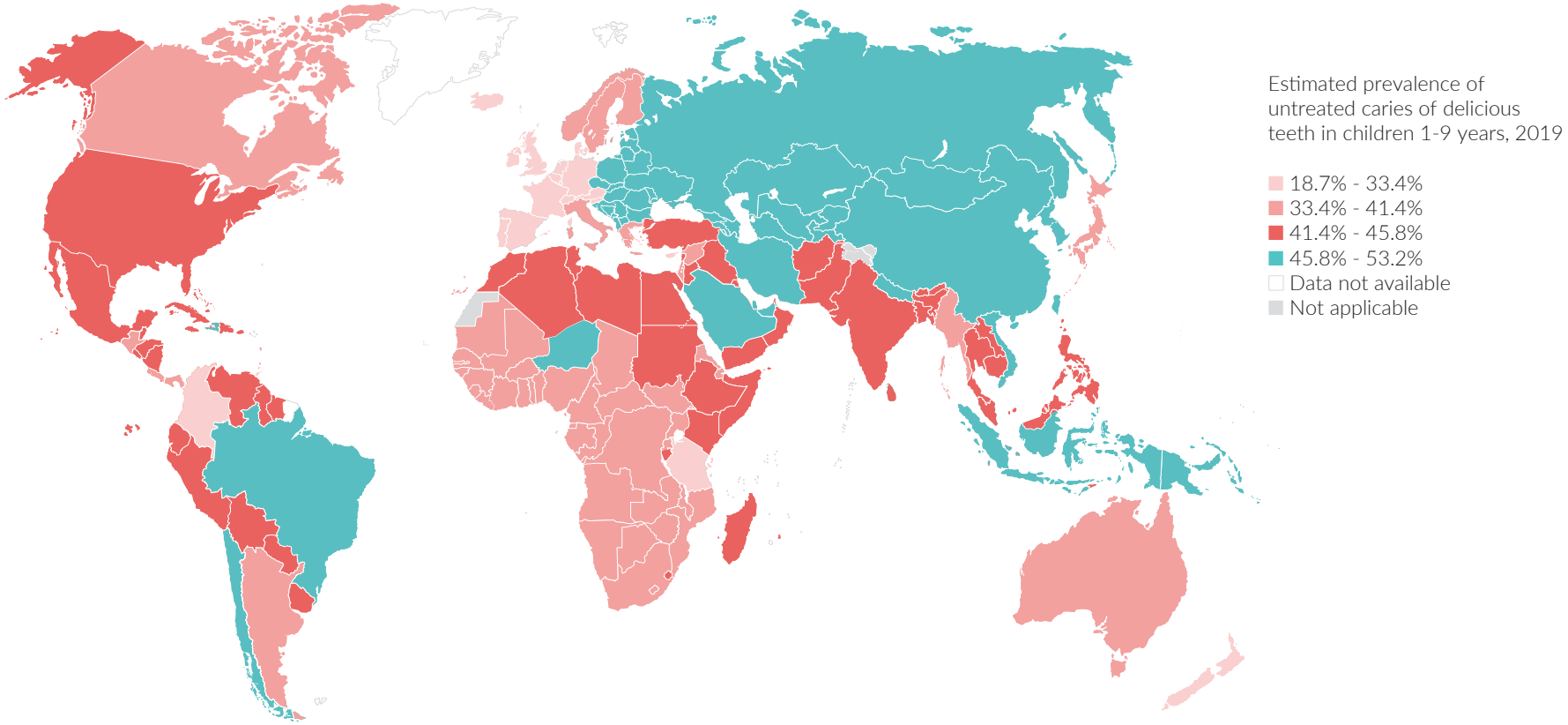



**Figure 1:** Estimated prevalence of dental caries of deciduous teeth in children 1-9 years globally
*Data source: Global Burden of Disease Collaborative Network. GBD 2019. Seattle: IHME; 2020. Map Production: WHO NCD/MND unit. Map Creation Date: 30 August 2022. Note. N = 194 countries; data are for children aged 1–9 years, both sexes, from GBD 2019*

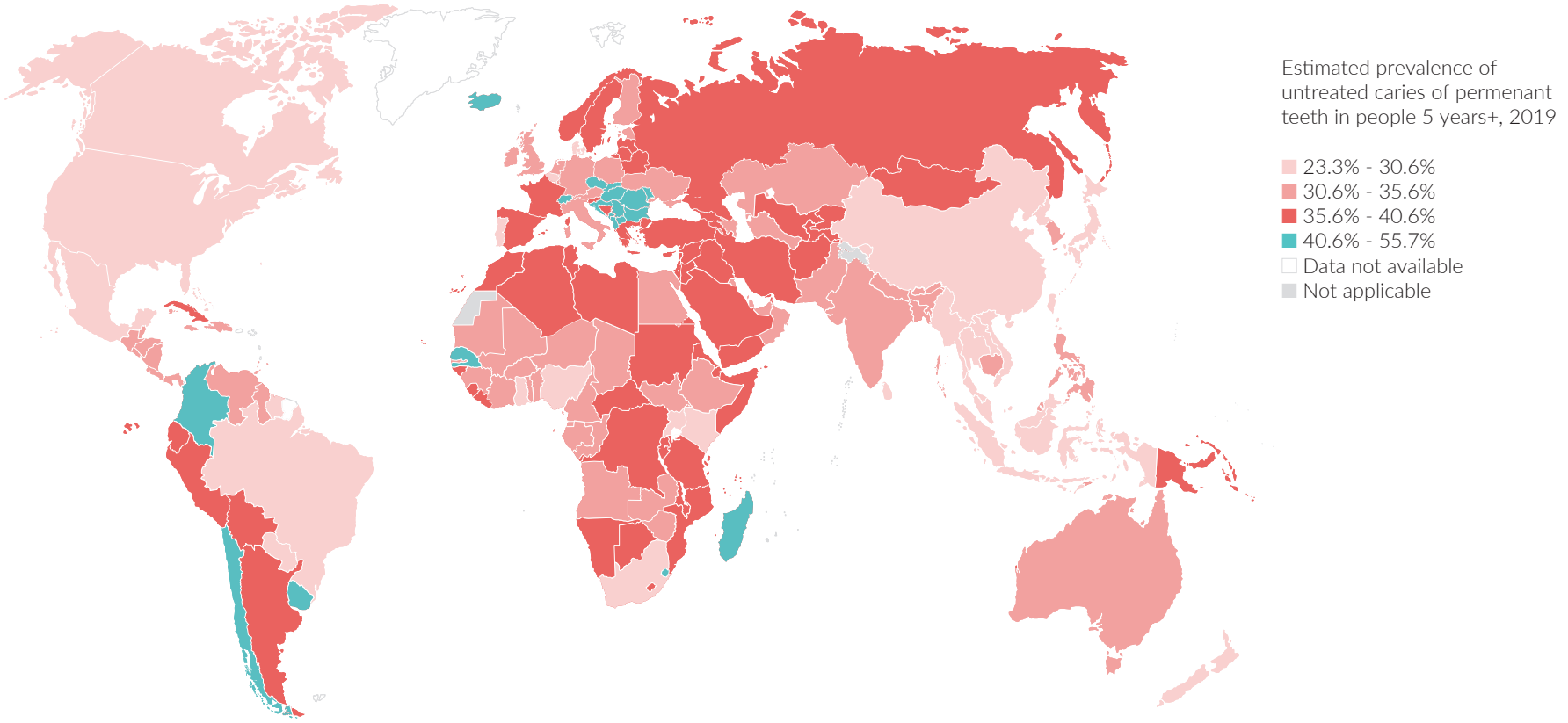



**Figure 2:** Estimated prevalence of dental caries of permanent teeth globally
*Data source: Global Burden of Disease Collaborative Network. GBD 2019. Seattle: IHME; 2020. Map Production: WHO NCD/MND unit. Map Creation Date: 30 August 2022. Note. N = 194 countries; data are age standardized, for ages greater than 5 years, both sexes, from GBD 2019*

## Diet and dental caries

Oral health and diet are connected. Nutrition affects the teeth during development and malnutrition may exacerbate periodontal and oral infectious diseases. However, the most significant effect of nutrition on teeth is the impact of diet in the mouth on the development of dental caries and enamel erosion.

Tooth decay is caused by acids produced when sugars and other fermentable carbohydrates present in our foods or drinks are broken down by oral bacteria of the dental plaque on the tooth surface. The acid produced leads to a loss of calcium and phosphate from the enamel, a process that is called demineralisation *(Gupta et al, 2013)*.

Following a healthy diet together with practicing good oral hygiene practices from an early age are key priorities for the prevention and early treatment of dental caries *(WHO, 2022)*. When it comes to a diet for optimal dental health, excess intake of sugars and other fermentable carbohydrates should be limited.

**Maintaining a good oral health is possible by practicing good oral hygiene including:**

Brushing our teeth for two minutes, twice a day, with a fluoride toothpaste

Visiting the dentist for regular check-ups and dental cleanings

Eating a well-balanced diet that is low in sugar and high in fruit and vegetables

Avoiding all forms of tobacco and limiting alcohol consumption

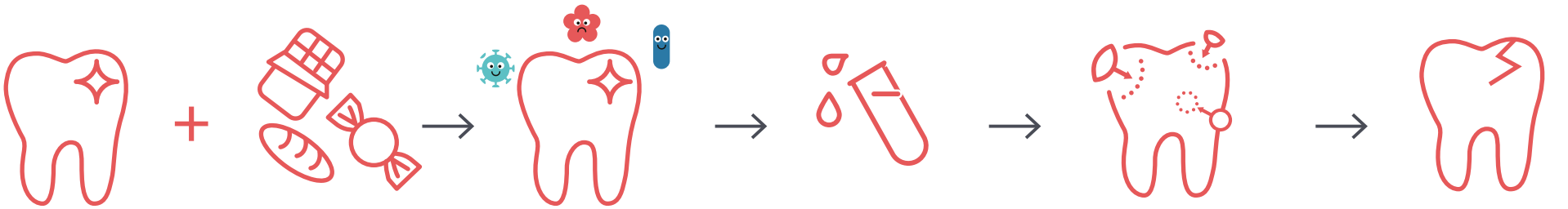
Chewing sugar-free gum after eating and drinking

**Sources:**
(1) FDI World Dental Federation. The Challenge of Oral Disease – A call for global action. The Oral Health Atlas. 2nd ed. Geneva. 2015a. Available at: https://www.fdiworlddental.org/oral-health-atlas (Accessed 9 March 2023)
(2) World Oral Health Day (WOHD) 2021-2023. WOHD is celebrated on 20th March every year and is an initiative of FDI World Dental Federation. Available at: https://www.worldoralhealthday.org/ (Accessed 9 March 2023)

## Sugar and dental caries

Frequent sugars' consumption is a significant dietary factor in the development of dental caries. A systematic review that was conducted aiming to inform the World Health Organization's (WHO) guideline on free sugars intake found that there is consistent evidence supporting a relationship between the amount of free sugars intake and the development of dental caries across age groups *(Moynihan and Kelly, 2014)*. The review process has also shown evidence of moderate quality to support that limiting intake of free sugars to <10% of daily energy intake minimises the risk of dental caries throughout the life course *(WHO, 2015)*.

Recently, in its Scientific Opinion on the Tolerable Upper intake level for dietary sugars, the European Food Safety Authority (EFSA) confirmed a positive linear dose-response relationship between total sugars intake and risk of dental caries in permanent and primary dentition *(EFSA, 2022)*. The mechanisms by which sugars increase the risk of dental caries are well established: they are metabolised by plaque microorganisms to organic acids which demineralise enamel and dentine, subsequently causing caries. Furthermore, caries risk has been found to be greater if sugars are consumed at high frequency and are in a form that is retained in the mouth for long periods *(Anderson et al, 2009)*.



## No cariogenic effect of low/no calorie sweeteners

Contrary to sugars, LNCS have no cariogenic effect, meaning that they do not cause dental caries, as they are not substrates for oral microorganisms. **All approved LNCS are sweet-tasting food ingredients with no, or practically no calories that cannot be fermented by oral bacteria, and therefore, they do not contribute to tooth decay** *(Roberts and Wright, 2012; van Loveren et al, 2012)*.

The first scientific evidence regarding the dental health benefits of LNCS dates to the 1970s *(Olson, 1977)*. Since then, a number of studies and reviews have examined and confirmed the non-cariogenic nature of LNCS *(Grenby et al, 1986; Mandel and Grotz, 2002; Matsukubo and Takazoe, 2006; EFSA, 2011; Giacaman et al, 2013; Gupta et al, 2013; Brambilla et al, 2014; Ferrazzano et al, 2015; Vandana et al, 2017; Cocco et al, 2019; Shinde et al, 2020; Zhu et al, 2021)*.

When evaluating a non-sugar sweetener in relation to dental caries, it is important to consider the potential for metabolism by oral microorganisms and dental plaque, the influence of consumption on cariogenic microorganisms, and the risk of microbial adaptation to the sweetener. Examining the impact of sugars and LNCS on dental health, a review concluded that LNCS such as aspartame, acesulfame-K, cyclamate, saccharin, sucralose and steviol glycosides, among others, are not metabolized to acids by oral microorganisms and they cannot cause dental caries *(Gupta et al, 2013)*.

In its policy statement published in 2008, the FDI World Dental Federation supported that when sugars are replaced with non-cariogenic sugar substitutes in products such as confectionary, chewing gum and drinks, the risk of dental caries is reduced *(FDI Policy Statement 2008)*.

**Scientific evidence into EU regulation**

Reviewing the available evidence, the European Food Safety Authority (EFSA) supports in the respective scientific opinions that "there is sufficient scientific information to support the claims that intense sweeteners, as all sugar replacers, maintain tooth mineralisation by decreasing tooth demineralisation if consumed instead of sugars" *(EFSA, 2011)*.

Based on this scientific opinion by EFSA, the European Commission authorised the health claim: "Frequent consumption of sugars contributes to tooth demineralisation. Consumption of foods/drinks containing low calorie sweeteners instead of sugar may help maintain tooth mineralisation by decreasing tooth demineralisation" *(Commission Regulation (EU) No 432/2012, 16 May 2012)*.

## How do low/no calorie sweeteners influence the cariogenic potential of oral microbiome?

**Dr Wendy Russell:** While there is an increasing understanding of the impact of diet on the gut microbiome, the oral microbiome is less well studied. It is known that oral bacteria generate acidic products from sucrose that lead to demineralization and that sugar substitutes can contribute to caries prevention *(Matsukubo et al, 2006)*, but the role of the oral microbiome has only recently been explored.

In a recent human study, it was shown that LNCS significantly impacted on the oral bacteria *(Suez et al, 2022)*. Changes were observed in the relative abundance of six Streptococcus species with sucralose and there was reduced relative abundance of Fusobacterium with saccharin and reduced abundance of Porphyromonas and Prevotella nanceiensis with aspartame. Apart from an impact of stevia on the metabolism-related KEGG pathway (which informs on biological high-level function), the impact of the changes in these microbial profiles on oral health is not known. However, changes in the Streptococcus abundance may be important as Streptococcus mutans, Streptococcus sanguinis and Streptococcus gordonii have been associated with the development of dental caries *(Takahashi and Nyvad, 2011)*. Recent work has also shown that acesulfame-K, aspartame, saccharin, and sucralose can suppress the growth and biofilm formation of both Streptococcus mutans and Streptococcus sanguinis *(Zhu et al, 2021)*. Although this work is early stage, it suggests potential of LNCS to beneficially impact oral health by modulating the cariogenic potential of oral microbiome.

## The role of sugar-free chewing gum in oral health

Chewing sugar-free gum, sweetened with non-fermentable LNCS, stimulates the production of saliva and has been shown to have important dental health benefits.

Reviewing the available evidence, EFSA concluded in its Scientific Opinions that a cause-and-effect relationship has been established between the consumption of sugar-free chewing gum and reduction of oral dryness, maintenance of tooth mineralisation, and neutralisation of plaque acids *(EFSA, 2009; EFSA, 2010a; EFSA, 2010b)*, all of which are beneficial to oral health by helping reduce the incidence of caries. Based on these Scientific Opinions by EFSA, the European Commission has authorised respective health claims.

A recent systematic review and meta-analysis of 12 studies also confirmed that chewing sugar-free gum may reduce the further development of dental caries *(Newton et al, 2020)*. Sugar-free chewing gums were found to significantly reduce caries increment giving a preventative fraction of 28%.

Finally, **the FDI World Dental Federation also supports the assertion that the regular use of chewing gum containing non-cariogenic sweeteners has a role to play in preventing dental caries because of its non-cariogenic nature and its salivary stimulatory effect** *(FDI Policy Statement, 2008)*.

The oral care benefits of chewing sugar-free gum are widely recognized, including by the European Union *(Commission Regulation (EU) No 432/2012, 16 May 2012)*, federal health departments and bodies in Canada *(Health Canada, 2014)*, and Australia *(Australia's National Oral Health Plan 2015-2024)*, the FDI World Dental Federation *(FDI, 2015b)* and more than 20 national oral or dental health associations around the world.

### How does sugar free chewing gum protect our teeth?

Chewing sugar-free gum stimulates the production of saliva – our mouth's defense system against tooth decay

Saliva neutralises plaque acids protecting enamel

Increasing saliva flow helps reduce dryness in our mouth

It also aids our teeth retain the minerals they need to maintain hardness and strength

Brushing our teeth twice a day and chewing sugar-free gum after meals and snack can help keep our teeth healthy

# Conclusion

By being not fermentable and thus non-cariogenic ingredients, LNCS are tooth friendly ingredients providing dental benefits when used instead of sugars in foods and beverages, sugar-free chewing gums, toothpaste and medications, provided that other constituents are also non-cariogenic and non-erosive (other ingredients in some low/no calorie sweetened food products such as starch and/or naturally occurring sugars may still cause caries) *(Gibson et al, 2014)*.

Overall, and from a public health perspective, reducing the amount and frequency of dietary exposure to sugars is an important adjunct in preventing caries and, in this context, LNCS can help people reduce overall sugar intake and still keep enjoying sweet taste in the context of a tooth-friendly diet without bearing a cariogenic effect.

## Low/no calorie sweeteners are tooth friendly ingredients

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