SCIENTIFIC BACKGROUND

Toothfriendly beverages

Formulating drinks without cariogenic or erosive potential

Cover image: David M. Pacey

Cheers to your teeth

Kati Weiss reports on a discussion with Dr. Albert Bär on the challanges of formulating a toothfriendly beverage.

Formulating a toothfriendly beverage means creating a product that does not contain unacceptable amounts of (a) carbohydrates that can be fermented by the dental plaque (Imfeld, 1983) and (b) food acids that directly attack the tooth surface (Lussi, 2006).

There is no precise quantitative limit for what constitutes an acceptable level of fermentable carbohydrates. However, in-vivo plaque-pH telemetry has shown that even low levels of fermentable sugars can lead to a drop of the plaque pH below the threshold value of 5.7 after consumption of a serving of a drink by sipping it over a longer period of time (cumulative effect). It follows from this that only “toothfriendly” sweeteners may be used to bring the sweetness of a beverage to the desired level and that fruit extracts may be used in it only very sparingly, if at all. Also dairy ingredients could not be used if they bring too much lactose in the final product.

It also is not possible to define an acceptable level of acid because the neutralization of this acid by saliva, which flows at a higher rate after consumption of an acidic drink, has a significant impact on the salivary pH in the oral cavity.

Only preliminary in-vivo pH-telemetry tests of prototype recipees can, therefore, guide the beverage formulators on the way to a toothfriendly product.

Sweetener systems

All intense sweeteners that are authorized for use in beverages are fit for formulating toothfriendly products. Although not all of them have been tested specifically, it is clear that they will not have an impact on plaque pH at the required low levels of use.

For the bulk sweeteners which may be needed for a good so called „mouthfeel“ of the beverage, the choice is much more limited. Among the polyols, which are key ingredients of toothfriendly confectionery, only erythritol qualifies for use in beverages because of its good intestinal tolerance.

Toothfriendly beverages

A respective amendment of EU Regulations which so far preclude the use of polyols in beverages is in preparation and will provide for the use of erythritol in beverages (≤1.6%).

Among the sugars, isomaltulose and D-tagatose qualify because they are not fermentable to a significant extent. In future, pure D-psicose (D-allulose) may attract particular interest by beverage manufacturers because this novel sugar not only is toothfriendly but also has a very low energy value.

Given the limited choices of toothfriendly sugars and polyols that may be used in beverages and - even more importantly - considering cost, it is likely that a toothfriendly beverage will be sweetened predominantly with intense sweeteners, except perhaps for flavored mineral waters which need a touch of sweetness that could be provided easily by erythritol, isomaltulose and/or D-tagatose. The use of one or both of these sugars would have the additional benefit of an improved mouthfeel which otherwise would have to be generated by the addition of non-fermentable, i.e. toothfriendly, oligo- or polysaccharides such as resistant dextrin (e.g. Nutriose FB), polydextrose or gum acacia.

A product of an isomaltulose containing instant tea for babies is produced and sold by HiPP. The resulting, only slightly sweet beverage has successfully passed the standard intra-oral pH-telemetry tests for lack of cariogenic and erosive potential. It therefore carries the "Toothfriendly" mark. The product has been designed for being purchased by health-conscious mothers.

Acid systems

The erosive potential of a beverage is influenced by the concentration and the buffering capacity of the applied food acids.

Citric acid and malic acid, which are used most often in beverages, have a high buffering capacity between the pH of the beverage (≤4.5) and the pH above which there is no erosive potential anymore (≥5.7). The neutralizing effect of saliva may, therefore, not suffice to bring the pH of the oral cavity quickly enough back into an acceptable range.

For the formulation of a toothfriendly beverage, acids with no or low buffering capacity in the critical range are required. Carbonic acid, phosphoric acid, sodium hydrogensulfate and lactic acid correspond to this criterion. Yet, erosion of dental enamel and dentin is a complex process which is modulated by many factors (Lussi, 2006; Shellis et al., 2010, 2013). Therefore, even if these acids are applied, the pH of the beverage should not be too low. In fact, the higher it is, the more likely the product will be successful in the intra-oral pH telemetry test for erosive potential. This, however, may put the microbiological stability of the product at risk, except if aseptic packaging can be guaranteed.

Flavour systems

Except for fruit extracts, which often contain unacceptably high levels of fermentable carbohydrates, any flavor may be used for formulating a toothfriendly beverage, unless it contained a rapidly fermentable carrier.

In practice, however, the range of flavors that reasonably may be considered for formulating a toothfriendly beverage is limited because most main-stream flavors (e.g. cola, fruits) require the presence of food acids. Strong citrus flavors, which are expected by the consumers to be associated with a high acidity and a correspondingly high sweetness, can probably not be used. Ideal would be flavors that require little or no acid such as green tea, herbal extracts, mint or flower flavors (rose, hibiscus, orange etc.).

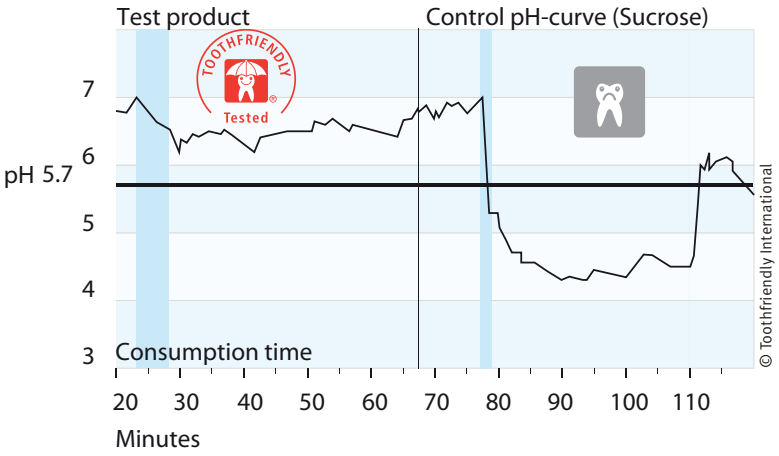

Figure 1. Volunteer is drinking a Toothfriendly beverage (for circa 8 minutes, see blue bar at left of figure). Before, during, and for 30 minutes after consumption, the pH of the dental plaque is measured by means of an indwelling electrode.

Measuring the cariogenic and erosive potential of drinks

The dental safety of beverages, in terms of their cariogenic and erosive potential, is best evaluated by means of a standardized pH telemetry test. In this test, the cariogenic potential is determined in vivo by means of a plaque-covered, indwelling electrode. The erosive potential is measured by means of a plaque-free electrode (Imfeld, 1983). Beverages which do not lower the pH of dental plaque below 5.7 (due to acid formed by the fermentation of sugars and other carbohydrates) are considered to lack a significant cariogenic potential. Beverages which upon normal consumption do not expose the teeth to more than 40 µmol H^+ x min are considered to not have a significant erosive potential.

If both criteria are met, the product may carry the "Toothfriendly" certification mark which serves as a signpost for the health-conscious consumer (www.toothfriendly.org)

Toothfriendly beverages

For beverages positioned for children, banana, coconut and chocolate flavors may be considered, if necessary in combination with a slightly acidic fruit note (e.g., banana/strawberry).

Flavoured mineral water

Carbonated mineral water may be a particularly suitable starting basis for creating a flavored toothfriendly beverage which offers more taste than plain mineral water, yet does not dominate the taste buds by high levels of sweetness and acidity. Particularly health conscious consumers who drink two liters liquid per day in countless small sips, may look forward to such products which are light not only in calories but also in taste. Such consumers may be particularly receptive for the toothfriendly claim and for more sophisticated flavors, particularly if they are linked to a perception of health (e.g. green tea, Aloe vera, ginseng).

Addition of calcium salts

The erosive potential of acidic beverages may be reduced by the addition of calcium (Hara & Zero, 2008).

In 2000, a black currant flavored soft drink was launched in the UK and promoted to consumers as being „toothkind". The product contained low residual amounts of sugars (from the black currant extract), food acids and a calcium salt which was added for counteracting the erosive effect of those acids. The UK Advertising Standards Authority (ASA) ruled that this claim was misleading and should be removed. The company disagreed and the case had to be decided by the High Court which decided in favor of ASA (BBC, 2001).

More recently mixed opinions were expressed by the European Food Safety Authority (EFSA) on two similar health claim applications. In the first case, EFSA concluded that a beverage with a low sugar content (‹1%), a pH ›3.7 and a calcium: acid ratio of ›0.3 mol/mol „may help reduce tooth demineralisation" in comparison to a standard beverage with sugar (8-12%), a pH of 2.6-3.6 and a calcium: acid ratio of ‹0.1 mol/mol (EFSA, 2010). This conclusion is not surprising but it does not mean that such a beverage would be Toothfriendly, i.e. safe for the teeth.
In the second, subsequent case, EFSA criticised that the potential of added calcium for reducing erosion was not properly examined. Accordingly, the Authority issued a negative opinion (EFSA, 2011).

It follows that, it is not yet established that the erosive potential of a beverage which contains more acid than accepted for the Toothfriendly certification can be overcome by the addition of calcium.

Outlook

The wake-up call to the beverage industry for producing healthier products has been launched. First attempts to improve existing products by adding functional ingredients are made. However, as much as in the confectionery industry, ingredient related health claims will only be credible if the product is not based on ingredients with a questionable health related track-record.

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Dental erosion

Food acids, if consumed frequently and in high amounts can have a direct demineralizing effect on the tooth surface which may develop to dental erosion, i.e. the visible disappearance of the surface layer of the tooth enamel. In addition, the frequent consumption of acidic foods favors the growth of acid-tolerant microorganisms in the dental plaque and thereby increases its cariogenic activity (Svanberg, 1980).

Furthermore, excessive consumption of food acids may not only expose teeth to a risk. It may also have other adverse health effects, for example on the body's calcium balance and the incidence of heartburn.

The German Federal Institute of Risk Assessment warned about the risk for dental health of high levels of citric acid and other food acids in confectionery and beverages (BfR, 2004/2005). The UK Committee on Toxicity issued a similar statement which reminded food operators of the general food safety clause and ended with the recommendation that food manufacturers should be required to provide evidence of the safety of acid sweets to the Competent Regulatory Authorities (COT, 2004).