Benefits and safety of low calorie sweeteners

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Although low calorie sweeteners are sometimes seen as modern ingredients, they have been used for more than a century. In Europe and around the world, low calorie sweeteners, like other food additives, undergo a rigorous assessment process. The European Food Safety Authority sets acceptable daily intake levels and reviews new evidence on any safety issues that arise. These safeguards can reassure the public that approved low calorie sweeteners are safe.

1. What are low calorie sweeteners?

Low calorie sweeteners are ingredients that are many times sweeter than sugar (sucrose). Examples include acesulfame-K, aspartame, saccharin, stevia and sucralose which are between 150 and 600 times sweeter than sucrose, and neotame which is between 7,000 and 13,000 times sweeter (Table 1). The sweetness intensity of low calorie sweeteners depends on their inherent sweetening power and the concentration at which they are used. The calorie content varies from zero to 4 kilocalories per gram, but all deliver very few calories in practice because they are added to products in only tiny amounts. Low calorie sweeteners are typically found in soft drinks, desserts, dairy products, confectionery, chewing gums and hot chocolate drinks. Most are also available as table top sweeteners, which are used in tea and coffee or on other foods, such as fruit and breakfast cereals.

Table 1: Examples of low calorie sweeteners

Name	Sweeteing power compared to sucrose	Date discovered	Use
Acesulfame-K (E950)	150-200 times sweeter	1966	198
Aspartame (E951)	150-200 times sweeter	1965	198
Cyclamate (E952)	30-50 times sweeter	1937	195
Neotame (E961)	7,000-13,000 times sweeter	1990	201
Saccharin (E954)	300-400 times sweeter	1879	188
Steviol glycosides (E960)*	200-300 times sweeter	1901	201
Sucralose (E955)	400-600 times sweeter	1976	200

*Steviol glycosides are the natural sweet components found in the leaves of the stevia plant.

Low calorie sweeteners have been available for more than a century. Saccharin was discovered in 1879 by Constantin Fahlberg, a chemist working at Johns Hopkins University in the United States, and was used extensively during sugar shortages, e.g. during World War I. Although in some countries after 1945 soft drinks were sweetened with combinations of sucrose and saccharin, diet and light beverages did not become popular until the early 1980s when aspartame was introduced. Over the past three decades, sales of low calorie soft drinks in Europe have risen more than 15 fold.1 Indeed, in some countries, the low

calorie versions of well-known brands have become best sellers.

Low calorie sweeteners are used in a broad variety of foods and drinks for a number of reasons, including consumers' interest in controlling their weight and efforts by manufacturers to offer a choice of calorie levels in their products. The improved palatability of low calorie sweeteners is another reason. Whereas early sweeteners had some taste challenges, particularly when used as a unique sweetener in a product, the introduction of newer low calorie sweeteners improved taste profiles. Blends of sweeteners are also used because they often have a higher level of sweetness than would be expected from the amount of the individual sweeteners that are present: the whole is greater than the sum of the parts.

In addition to low calorie sweeteners, polyols are used in confectionery, chewing gum and desserts. Polyols, such as maltitol, isomalt, sorbitol, mannitol and xylitol provide about 2.4 kilocalories per gram (8.4 kJ/g) as opposed to the 4 kilocalories per gram (16.8 kJ/g) found in dietary sugars and carbohydrates. The exception is erythritol, a zero calorie bulk sweetener approved in Europe in 2006.2 The role of polyols in products is not just to replace sweetness but to take over many of the functional properties provided by sugars, including mouth feel, colour, structure, and moisture retention properties.

2. Role in the diet

Humans are predisposed from birth to recognise and prefer the sweet taste.3 This, and the innate dislike of bitterness, are thought to be physiological adaptations that helped early humans to distinguish between potentially harmful and potentially nutritious plant foods. Breast milk gains its sweet taste largely from the 7.2% lactose (milk sugar) that it contains. To put this in context, apple juice and orange juice contain nearly 10% sugars. Studies show that a strong preference for sweetness persists throughout childhood but declines during late adolescence to adult levels.4 People of all ages have sweetened their food with honey and fruits for many centuries.

With the advent of the widespread availability of affordable and above all excellent quality food in the twentieth century, problems associated with a shortage of calories in the diet virtually disappeared from developed countries. At the same time, many aspects of people's lives became much less labour intensive, resulting in a significant proportion of the population consuming more calories than they were burning. This is the fundamental reason for the increase in the incidence of overweight and obesity, which have their own health consequences and which remain a challenge today. In this context, and given people's innate desire for sweet taste, foods and drinks with low calorie sweeteners can make a useful contribution in the diet.

Weight management

Successful weight reduction depends on creating an energy deficit within a healthy, balanced diet by combining lower energy intake and higher energy expenditure. Successful long-term dieting also benefits from the inclusion of palatable foods and drinks, and for many people sweetened products will be an important part of this. Thus, products in which some or all of the calories are reduced by the use of low calorie sweeteners can offer weight-conscious consumers a practical solution, depending on the calorie

reduction achieved in the final product.

A growing body of scientific evidence suggests that low calorie foods and drinks contribute to people's weight management efforts.5-10 A recent study found that substitution of added sugar by sweeteners in carbonated soft drinks has beneficial effects on body mass index (BMI).6 Furthermore, a review (which investigated 16 randomised controlled studies) found that choosing foods and drinks that contain aspartame in place of their regular sugars resulted in reductions in both energy intake and body weight (the estimated rate of weight loss for a 75kg adult was 0.2 kg/week).7,8 The importance of randomised controlled trials has recently been highlighted.11In addition, low calorie sweeteners can encourage dietary compliance by providing more choice and variety.

Although scientific evidence suggests that low calorie foods and drinks contribute to people's weight management efforts, it is important to note that low calorie sweeteners alone are not a solution for obesity as they do not suppress appetite.8 Therefore, it is important that low calorie foods and drinks form part of a balanced diet and healthy lifestyle which includes regular physical activity. This approach is supported in the literature.8,9

Diabetes

According to the World Health Organization (WHO), over 346 million people worldwide have diabetes; type 2 diabetes being the more common.12Dietary advice for people with diabetes is in line with healthy eating recommendations for the general public. Re-establishing a healthy body weight in diabetics is, however, all the more important as it helps to offset their higher risk of conditions such as high blood pressure and cardiovascular disease.

Studies have found that the use of low calorie sweeteners can help people with type 2 diabetes to control their body weight.13,14 Products such as soft drinks, yogurts, desserts and confectionery with low calorie sweeteners play their role in providing different calorie ranges within food categories, as such offering people a wider dietary choice. Organisations such as the American Diabetes Association and Diabetes UK point out that products sweetened with low calorie sweeteners can help manage sweet cravings without jeopardising blood glucose levels. This is linked with the advice to check overall product composition for any remaining glycaemic ingredients, but also to be aware of the actual calories consumed.

There is broad consensus in the medical communities that low calorie sweeteners can improve food choice. They offer people with diabetes the pleasure of sweet tasting foods and drinks and do not affect their blood glucose control. 14-17

Dental health

Dental caries are caused by a lack of oral hygiene in which carbohydrates present in the mouth are fermented by naturally occurring bacteria, resulting in the production of acid. Some of this acid can be neutralised by saliva, but, in the absence of good dental hygiene, the remaining acid will cause demineralisation of the teeth and result in caries. Low calorie sweeteners, however, cannot be metabolised

by oral bacteria to form acids. Therefore, they do not contribute to tooth decay.18 If you have a full meal, other components of the food can still contribute to tooth decay, so oral hygiene remains important.

As well as supporting dental health, low calorie sweeteners can be used to improve the palatability of toothpastes, mouthwashes and fluoride supplements, thereby encouraging greater use. Indeed, the European Food Safety Authority (EFSA) has approved the claim that chewing gum with low calorie sweeteners helps maintain tooth mineralisation and neutralise acids.19

3. Safety

Acceptable Daily Intake (ADI), regulation and approval

All of the low calorie sweeteners used in European food production have been subjected to rigorous safety testing. The authorisation and use of low calorie sweeteners, like all other food additives, is harmonised at European Union (EU) level and governed by advice from EFSA. Ingredient manufacturers can only apply to EFSA for the assessment of a low calorie sweetener after extensive safety tests have been completed. The application must provide technical details about the product and comprehensive data obtained from safety studies. During the safety assessment performed by EFSA, an Acceptable Daily Intake (ADI) is established for each low calorie sweetener. The ADI is a guide to the amount of a low calorie sweetener that can be safely consumed on a daily basis throughout a person's life-time. It is calculated as a fraction (normally one hundredth) of the amount that has been shown to be safe in animal models. Studies confirm that the amount of low calorie sweeteners actually consumed is below the ADI.20

Once a food additive has been approved by the European Commission it is given an E number (E stands for Europe). The E number is therefore an indication that an additive has been approved and is safe for human consumption. This helps transcend language boundaries in a market as diverse as the European Union. All approved low calorie sweeteners have their own E numbers within the range E900-999.

Claims of adverse health effects

Over the past few decades, there have been sporadic claims that low calorie sweeteners are associated with a range of adverse health effects. Unsubstantiated anecdotal reports are occasionally covered in the media and online, leaving some consumers unsure as to whether low calorie sweeteners are safe. The responsibility for examining new evidence concerning the safety relating to food ingredients falls under EFSA's remit and opinions on sweeteners are reviewed when necessary. EFSA's advice to the European Commission remains the same: the use of approved low calorie sweeteners in foods and drinks, consumed within the acceptable daily intake level, poses no threat to human health.

One allegation about low calorie sweeteners relates to possible links with cancer in humans. These concerns, however, are not supported by well-controlled studies. For example, a team of Italian researchers evaluated intakes of low calorie sweeteners in patients with various types of cancers.21Data were collected over a 13-year period on almost 9,000 cases and were compared with data from controls. After accounting for other factors, such as smoking, the risk of developing cancer was not associated with

consumption of low calorie sweeteners. Furthermore, when low calorie sweetener use was categorised by type of sweeteners (i.e. saccharin, aspartame, etc.), there were no significant associations with any cancer site.

The most frequently used low calorie sweeteners are saccharin and aspartame. Saccharin safety was questioned after animal studies conducted in the early 1970s appeared to show that it increased the incidence of bladder cancer. Subsequent laboratory studies demonstrated that this effect was specific to male rats and not relevant for humans. Consequently, epidemiological studies did not show any significant associations between saccharin consumption and bladder cancer, even in people with high intakes. Research conducted over the past 25 years does not support the hypothesis that saccharin causes cancer in humans.2

Aspartame has also been questioned, particularly in Europe, following animal studies performed in Italy which claimed a possible link between aspartame and lymphoid cancer in rats. EFSA conducted detailed reviews of the data and concluded that the research had significant flaws and that the studies did not provide evidence that aspartame causes cancer. EFSA's opinion on aspartame’s safety for human consumption, therefore, remained unchanged and EFSA reconfirmed that the ADI of 40mg/kg body weight was appropriate.23 This conclusion was supported by other reviews.24,25Furthermore, in May 2010, EFSA worked with a group of national experts from EU countries to review all published papers on aspartame since 2002. The group concluded that no new evidence had been identified that required EFSA to review the previous opinion that aspartame is safe for use in food and drink products at intakes below the ADI.26

Aspartame, however, should be avoided by individuals with a rare genetic disease known as phenylketonuria (PKU), which affects about 1 person in 10,000. Aspartame contains two amino acids, one of which is phenylalanine. Phenylalanine is an essential amino acid, which means that we need to obtain it from our diet in order to remain healthy. Sufferers of PKU cannot metabolise phenylalanine fully and have to follow a special diet to grow and develop normally. Phenylalanine is present in most proteins, and aspartame represents a minor source. Nevertheless, products that are sweetened with aspartame are labelled as a source of phenylalanine. For people who do not suffer from PKU, phenylalanine is a normal and essential part of the diet.

4. Consumer attitudes

According to a 2009 online survey carried out in five European countries by Harris Interactive on behalf of Tate & Lyle, consumers are looking for healthy foods but don’t want to compromise on taste.27 The research was conducted among 18–65 year olds living in France, Germany, Italy, Spain and the UK. More than half wanted healthy products which could help them to manage their weight, although only 20% said that they would compromise on taste to get a healthier product. In this context, good-tasting products with low calorie sweeteners can play a useful role in helping people to reduce their calorie intake.

A Eurobarometer survey on risk issues, commissioned in 2010 by EFSA, asked the opinions of more than 26,600 consumers aged over 15 years living in 27 Member States.28 When asked to identify any specific concerns that they had, a wide range of topics arose, with no one issue dominating. Only 9% of consumers

suggested that food additives posed a risk (compared with 19% mentioning the presence of chemical products, pesticides and toxic substances, the most popular answer given). Similarly, a study commissioned by the UK Food Standards Agency in 2012 asked 2,141 people what food issues, if any, they were concerned about.29 Twenty eight per cent mentioned additives; however, when asked to expand further on their specific concerns no one mentioned low calorie sweeteners.

All low calorie sweeteners, like all other food additives approved in the EU, are rigorously assessed by EFSA. These assessments painstakingly scrutinise the evidence from all scientific studies, and are updated when relevant new studies are published. In this way, the safety of approved low calorie sweeteners is guaranteed by independent authorities, and in the case of aspartame, is based on more than 200 studies. Therefore, low calorie sweeteners are a valuable and safe tool for providing consumers with the opportunity to choose foods and beverages with different calorie levels.

5. The future

New sweeteners continue to be developed. An emerging low calorie sweetener is advantame, which is made from a combination of aspartame and vanillin, a component of vanilla. Advantame has been approved for use as a food additive (according to good manufacturing practices) in Australia and New Zealand.30 Its use as a food additive is also being considered by the US Food and Drug Administration31 and the European Food Safety Authority.32

In conclusion, it is clear that people can be confident that, because of the thorough regulatory framework for their assessment and approval, low calorie sweeteners are a safe component of our diet. Foods and drinks with low calorie sweeteners are likely to continue to be a growing part of the European diet, helping to provide choice for people who wish to consume fewer calories and maintain a healthy weight.

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Addendum January 2014:

The latest assessment of aspartame by EFSA was published on 10thDecember 2013. It forms part of its re-evaluation of all food additives which were authorised in the EU prior to 20 January 2009.

EFSA concluded that aspartame and its breakdown products in the body (phenylalanine, aspartic acid and methanol) are safe for human consumption at current intake levels and that the current Acceptable Daily Intake (ADI) of 40 milligrams per kilogram of body weight per day is suitable for the general population. However, in patients suffering from the medical condition phenylketonuria (PKU), the above ADI is not applicable, as they require strict adherence to a diet low in phenylalanine. With respect to pregnancy, EFSA noted that there was no risk to the developing foetus from exposure to phenylalanine derived from aspartame at the current ADI (with the exception of women suffering from PKU). EFSA also makes clear that the breakdown products of aspartame are also naturally present in other foods, for example methanol is found in fruit and vegetables. The contribution of breakdown products of aspartame to the overall diet is low.

For further information please see:

European Food Safety Authority. (2013). Scientific Opinion on the re-evaluation of aspartame (E 951) as a food additive. EFSA Journal 11(12):3496

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