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Low-calorie Sweeteners: Role and benefits

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Introduction

Low-calorie sweeteners are among the most extensively studied of all food additives, yet there can be confusion amongst consumers and health professionals about the role of sweeteners in the diet, what health benefits they offer, and whether or not they are safe. A liking for sweetness and a dislike for bitterness are innate human traits, i.e. present from birth.[1] While sugar and honey have been used traditionally as sweeteners, a desire to offer lower calorie alternatives led to the development of a range of intense sweeteners. Several decades later, these are used widely in foods and beverages aimed typically at healthy eaters, people with diabetes, and those concerned about weight management or dental health. Yet, with such a considerable body of evidence about these ingredients, how can health professionals evaluate the science on low-calorie sweeteners and provide useful advice for patients? This article reviews previously published literature in order to explore the role, benefits and safety of low-calorie sweeteners.

The human preference for sweetness

'Sweet' is one of the five taste sensations that play a role in evaluating the nutrient content of food and preventing the ingestion of toxic substances – the others being salt, bitter, sour and umami. Recognising sweetness in foods helps the body to identify energy-yielding nutrients. Compounds in food stimulate the sweet sensation by interacting with taste receptors in the mouth and throat. Through a transduction mechanism (converting one kind of signal to another) the sweet chemical message is then changed to a nerve signal for the perception of sweet taste.

Within hours of birth, the liking for sweet tastes is unequivocal and newborns will demonstrate preference for a sugar solution when compared with water.[2] This is no surprise as breast milk is relatively sweet. Young infants even respond to dilute sweet tastes and are able to differentiate varying degrees of sweetness.[3] The desire for sweet taste is long-lasting. Observational studies have reported that preference for sweetness remains heightened throughout childhood[4] and early adolescence[5] after which it declines to adult levels.[6]

What are low-calorie sweeteners?

Low-calorie, intense, or artificial sweeteners are distinct terms used to describe compounds that taste sweet but provide few or no calories. Often, this is because certain types of low-calorie sweeteners are so many times sweeter than sucrose that they can be used in tiny amounts, thus minimising their calorie contribution in food and beverage products.[7] Indeed, the capacity for calorie reduction is the major advantage of low-calorie sweeteners.

Low-calorie sweeteners are used in a variety of food and beverage products including soft drinks, chewing gum, confectionery, frozen desserts, yoghurts, dessert mixes and puddings. They are also widely used in healthcare products for improving the palatability of medicines.

The newest low-calorie sweetener, gaining European approval in November 2011, is steviol glycosides, a purified extract derived from the leaves of the Stevia plant (*Stevia Rebaudiana Bertoni*). Native to Central and South America, Stevia belongs to the Chrysanthemum family and, in the unprocessed form, has been used for centuries as a traditional sweetener by indigenous South

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American natives. It is now cultivated extensively across Asia and South America.

See **Table One** for characteristics of low-calorie sweeteners commonly used in Europe.

Low-calorie sweeteners and health

Weight management

It is well established that successful weight loss depends upon creating an energy deficit within a healthy, balanced diet, with regular physical activity having an important role in this. It is also widely known that the sensory appeal of food and drink is aided by sweetness. Thus, replacing all or some of the sugar in products (providing 3.75 kcal per gram) with a low-calorie sweetener (providing 0 kcal per gram in many cases) is likely to benefit weight management by lowering calorie intake. However, there is a contrary view that sweetness in the absence of energy may create ambiguous signals that confuse the body's regulatory mechanisms, leading to a loss of control over appetite.[8-9] Despite this theoretical concern, a growing body of scientific evidence suggests that low-calorie sweeteners are an effective way to aid weight management.[10–17]

In 2007, Bellisle and Drewnowski examined the hypothesis that low-calorie sweeteners and related products may cause weight gain. While their review found the opposite – that low-calorie sweeteners tend to support weight loss – it did caution that sweeteners should not be viewed as a magic bullet as they are not appetite suppressants. This emphasises that successful use of low-calorie sweeteners depends upon their integration into a whole lifestyle approach, which enables energy reduction by replacing higher calorie foods and drinks with lower calorie alternatives.[11]

Rolls and colleagues also examined the effects of low-calorie sweeteners and low-calorie products on hunger, appetite and food intake.[18] The review published in 1991, in the American Journal of Clinical Nutrition, stated that if low-calorie sweeteners are 'part of a weight control programme, they could aid calorie control by providing palatable foods with reduced energy. It needs to be stressed that there is no data suggesting that consumption of foods and drinks with intense sweeteners promotes food intake and weight gain in dieters.'[18]

Even modest weight loss has been found to reduce significantly the risk of obesity-related chronic conditions, such as Type 2 diabetes and cardiovascular disease. The type of sweetener used

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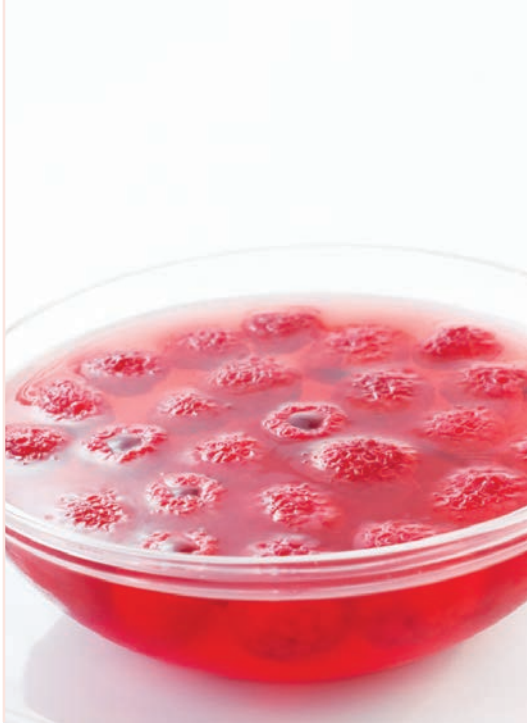
Table One: Characteristics of Low-calorie Sweeteners Commonly Used in Europe

	Acesulfame Potassium (Ace-K) E950	Aspartame E951	Saccharin E945	Sucralose E955	Steviol Glycosides (Stevia) E960
Accepted Daily Intake (for adults and children)	0-15mg/kg	0-40mg/kg	0-5mg/kg	0-15mg/kg	0-4mg/kg
Year discovered	1967	1969	1879	1976	Structure of glycosides first published in 1955
Caloric value	Calorie free	4kcal/g but used in tiny amounts	Calorie free	Calorie free	Calorie free
Uses	Mainly used as a tabletop sweetener in foods, drinks and oral care products	Used in over 6000 food and drink products due to its good sensory properties	Used as a tabletop sweetener in drinks, desserts, confectionary and in pharmaceutical products	Used in baked goods, desserts, ice cream and dairy products, breakfast cereals and confectionary	Used to sweeten foods and drink products
Approval milestones and recent safety evaluations in Europe	Approved by the SCF in 1984 The EU's Scientific Commission on Food (SCF) re-evaluated and reaffirmed ace-K safety in 2000	First approved in the UK in 1983 following the review of its safety by the UK's Committee on Toxicity, Consumer Products and Environment EFSA re-evaluated and reaffirmed aspartame safety in 2002, 2006, 2009, 2010, 2011	Approved by the SCF in 1984 The SCF re-evaluated and reaffirmed saccharin safety in 1995	Approved by the SCF in 2000	EFSA evaluated the safety of steviol glycosides in 2010 The European Commission authorised the use of Stevia in food and drinks in 2011



Stevia plant

may help support this. A review by De la Hunty, *et al* (2006), found that swapping sugar-containing foods for products which contain aspartame resulted in significant reductions in both energy intakes and body weight.[19] In addition, low-calorie sweeteners enabled a more versatile approach to weight management and encouraged dietary compliance by improving the palatability of foods without increasing calories.

Diabetes

In the next two decades, World Health Organisation experts predict that there will be in excess of 334 million people globally living with diabetes. There is broad consensus in the medical and scientific communities that not only are low-calorie sweeteners safe for people with diabetes, but are useful within diabetic diets. Low-calorie sweeteners do not cause a rise in blood sugars but nevertheless deliver sweetness, making them ideal for improving palatability and helping to manage blood glucose levels.

An important aspect of the management of Type 2 diabetes is encouraging patients to achieve and maintain a healthy weight, since this improves health outcomes. Studies have found that the use of low-calorie sweeteners can help people with Type 2 diabetes to control their body weight.[20] Thus, low-calorie sweeteners offer people with diabetes the pleasure of sweet tasting foods and drinks without negative side effects.

Low-calorie sweeteners provide people with diabetes with a broader choice of foods and drinks. Drinks, mueslis, dairy and fruit products prepared with low-calorie sweeteners are suitable for people with diabetes.[21] With a more varied diet, it is easier to comply with dietary guidance and, thus, achieve blood glucose control. Also, since low-calorie sweeteners are neither carbohydrates nor fats, they do not need to be restricted.

Dental health

As sugar is a fermentable carbohydrate, when sugar-sweetened foods and drinks are consumed, bacteria naturally present in the mouth convert the sugar to acid. If the bacteria and plaque are not controlled by good oral hygiene and fluoride, permanent damage to tooth enamel can occur, resulting in decay. Unlike sucrose and glucose, low-calorie sweeteners are not metabolised by oral bacteria to form acids. Therefore, they do not contribute towards tooth decay.[22] As well as supporting dental health by offering a healthy alternative to sugary foods and drinks, low-calorie sweeteners can be used to improve the palatability of toothpastes, mmouthwashes and fluoride supplements thus encouraging greater use. They are also used in children's medicines.

Low-calorie sweeteners and cancer

There have been concerns that low-calorie sweeteners may be associated with cancer, however, this has been consistently rejected by expert panel reviews of the evidence. Researchers from the Institute of Pharmacological Research Mario Negri, Italy, evaluated intakes of low-calorie sweeteners in patients with various types of cancers.[23] Data was collected over a 13-year period on over 11,000 cases and healthy controls after taking into account confounding factors, such as smoking. The results showed that 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.), none of the results suggested a significant association with any cancer site. A subsequent report found no association between low-calorie sweeteners and gastric, pancreatic or endometrial cancers.[24]

Safety and regulation

Regulation and approval

As in the case of all food additives, all low-calorie sweeteners used in European food production have been subjected to rigorous safety testing.[25-27] The authorisation and use of low-calorie sweeteners, is harmonised at EU level and governed by advice from the European Food Safety Authority (EFSA). Ingredient manufacturers can only apply to EFSA for approval of a low-calorie sweetener once extensive safety tests have been completed and the manufacturer is convinced of the product's safety and usefulness. The application must provide technical details about the product, and comprehensive data obtained from safety studies.

Acceptable Daily Intake (ADI)

In the approval process, an Acceptable Daily Intake (ADI) is set for each low-calorie sweetener. The ADI is a guideline quantity that represents the amount of a low-calorie sweetener that can be safely consumed on a daily basis throughout a person's life-time. The safety data is then examined in detail by EFSA whose members can, at any time, request further information from the manufacturer. As EFSA may request additional studies, completing and analysing the safety studies on additives can take up to 15 years.

Adverse health effect claims

Over the past few decades, some individuals and campaigning groups have claimed that low-calorie sweeteners are associated with a range of adverse health effects such as cancer, neurological symptoms and appetite stimulation. EFSA and other international agencies have examined such reports from time to time but have concluded on each occasion that the claims about low-calorie sweeteners are without substance. It would appear that many of the proposed adverse effects have arisen due to misunderstandings, data dredging, case studies or selective use of information, rather than a balanced view of the evidence.

One example was a study in Denmark which found associations between self-reported use of low-calorie beverages during pregnancy and an increased risk of medically-induced pre-term delivery.[28] However, this study was observational, not a controlled trial, and did not adequately

control for variables which influence pre-term delivery, such as smoking, socio-economic group and body mass index. The study was subsequently dismissed by EFSA which noted that: 'There is no evidence available to support a causal relationship between the consumption of low-calorie sweetened soft drinks and preterm delivery.'

Nonetheless, unsubstantiated reports continue to appear online and in the media, leaving some consumers unsure about the safety of low-calorie sweeteners. Health professionals have an important role in advising patients about the evidence supporting the use of low-calorie sweeteners within a healthy diet. It is worth noting that regulatory agencies, such as EFSA, continue to advise the European Commission that low-calorie sweeteners pose no threat to human health when consumed within ADIs.

Safety of saccharin

Saccharin safety was once questioned after animal studies conducted in the early 1970s showed that it increased the incidence of bladder cancer.[29] Subsequent laboratory studies demonstrated that this effect was specific to male rats and was not replicated in human studies. It was confirmed that no significant association existed between saccharin consumption and bladder cancer, even in people with high intakes. Thus, research conducted over the past 25 years clearly demonstrates that saccharin does not cause cancer in humans.[24, 30]

Safety of aspartame

The low-calorie sweetener, aspartame, was also the subject of cancer claims, particularly in Europe, following the publication of findings by scientists from the European Ramazzini Foundation (ERF) indicating a link between aspartame and lymphoid cancer in rats.[31] However, there was no consistent dose-dependent relationship, nor adequate survival analysis, and the findings have not been replicated by other research groups. In response to the claim, EFSA conducted a detailed review of the ERF studies and concluded that there were significant flaws in the research, leading to a view that the studies did not provide evidence that aspartame causes cancer.

A 2007 review undertaken by Gallus, *et al.*[32] concluded that there was no indication that aspartame increased cancer risk and, thus, no reason to revise the previously established ADI of 40mg/kg body weight/day. This view has been supported by several other papers. In a US study, sponsored by the National Cancer Institute and involving around 450 people aged from 50 to 69 years, no statistically significant link was found between aspartame consumption and leukaemia, lymphomas or brain tumours.[33] Furthermore, an expert panel review on this topic has considered over 500 studies, articles and reports conducted over the last 25 years, including unpublished research submitted to government regulatory bodies.[34] The authors concluded that suggestions of adverse effects had 'no credible scientific basis'.

As recently as May 2010, EFSA worked with a group of experts from 10 EU countries to review all published papers on aspartame since 2002. The aim was to address any remaining questions raised about the safety of aspartame for use in food. 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.[35]

In May 2011, EFSA was asked by the European Commission to bring forward the full re-evaluation of the safety of aspartame to 2012. Previously planned for completion by 2020, the review of this sweetener is part of the systematic re-evaluation of all food additives authorised in the EU prior to 20 January 2009.

Conclusion

Low-calorie sweeteners have a positive role to play in supporting dietary change for overweight people and those with diabetes. Reviews suggest that swapping sugar-containing foods for products which contain low-calorie sweeteners can help lower energy intakes and help to manage body weight. In addition, low-calorie sweeteners reduce the risk of dental caries.

Despite the clear benefits offered by low-calorie sweeteners, consumers often need reassurance that the ingredients are safe. Health professionals have an important role to play in this process by offering balanced, evidence-based advice on low-calorie sweeteners, particularly the evidence on their benefits, and how the regulatory framework in Europe continues to act as an important safeguard.

Low-calorie sweeteners have a positive role to play in supporting dietary change for overweight people and those with diabetes.

Useful sources of information on low-calorie sweeteners:

- Food Standards Agency: www.food.gov.uk
- European Food Safety Authority: www.efsa.europa.eu
- British Nutrition Foundation: www.nutrition.org.uk

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