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The use of low or no calorie sweeteners – insights gathered

Position Statement (Updated: December 2018)

Introduction

Sweeteners are used as ingredients which are added to foods and drinks to produce a sweet taste. Sweeteners are generally classified into groupings based on whether or not they provide energy or calories. The calorie-providing sweeteners include free sugars (eg sucrose and fructose) and polyols (eg sorbitol and xylitol) which are also known as 'bulk sweeteners'; albeit polyols provide relatively less calories than free sugars. The other grouping, which is the focus of this position statement, are sweeteners which provide no or very few calories. They are also known as artificial sweeteners, low calorie sweeteners, sugar substitutes, high intensity sweeteners, intense sweeteners or low or no calorie sweeteners.

Low or no calorie sweeteners (LNCS) are food additives primarily used to reduce the calorie and sugar content of foods and drinks whilst at the same time maintaining a sweet taste. They are commonly used in soft drinks, chewing gum, confectionery, yogurts and desserts like sugar-free jellies (BNF, 2018) as well as medicines and hygiene products, such as toothpaste (Sylvetsky, 2018).

There are 11 LNCS currently approved for use in the UK. Each LNCS has unique properties and they vary in terms of their sweetening power, duration of sweetness, aftertaste and mouthfeel. As such, they are often used as blends to achieve the desired sweetness profile (Serra-Majem, 2018). They are included in the ingredient lists on product labels, either by referring to the appropriate E number or its name (EFSA, 2018).

What term to use?

It was felt by the consensus group (see 'Consensus group contributors' below) the use of the term 'low or no calorie sweeteners' was the most accurate and most clear description to use. The term artificial sweeteners had negative connotations amongst consumers, as something that was synthetic and processed and perhaps considered unhealthy. Other terms used for sweeteners, such as high intensity sweeteners, were considered too technical to use with the lay public and not necessarily clear in stating what they are.

LNCS and safety

The safety of LNCS is a topic that receives much publicity. Controversy remains amongst both consumers and healthcare professionals surrounding their use (PHE, October 2015), in part explained by the inconsistent and sometimes contradictory information that is presented in relation to their safety by popular media (BDA, 2016).

However, all LNCS currently licensed for use in the UK are highly regulated and rigorously tested for safety before being approved for use. Even after approval, they are re-tested regularly by the European Food Safety Authority (EFSA) to ensure that they remain safe (BNF, 2018) and are scheduled to be re-evaluated by 2020 (EFSA, 2018).

Food ingredient manufacturers have to provide evidence from safety studies showing that the LNCS in question:

- doesn't cause any adverse effects, including cancer
- doesn't affect reproduction
- doesn't cause allergic reactions
- isn't stored within the body, or metabolised into other potentially unsafe products.

As part of the safety evaluation process, each LNCS is given an Acceptable Daily Intake (ADI) level. This is set at one hundredth of the amount, per kilogram of body weight that can be safely consumed on a daily basis over a person's lifetime without incurring health risks. Consequently, it's extremely difficult for most people consuming typical diets to reach the ADI for any sweetener. The current average levels of intake of LNCS from common foods and drinks in the UK are considered safe (Diabetes UK, 2018; Martyn, 2018).

Recommendations:

- The use of LNCS remains safe with current intake levels within the ADIs. Any new safety issues arising from new research are regularly monitored.
- Public health messages around the safety of LNCS need to be given to consumers in a clear and consistent way and from reliable, trustworthy and evidence-based sources.
- Information for consumers explaining the ADIs for LNCS in the context of the food and drinks they buy and consume could be helpful, as well as reassurance that when sweeteners are used they must be labelled on products as a result of EU regulation - both by function (i.e. sweetener) and by name or E number.
- The safety of LNCS are currently regulated by EFSA. Continued regulation of the safety of LNCS, particularly of newer LNCS is important in the future, i.e. post-Brexit.

The use of LNCS in reformulation

While there is contradictory data relating to shifts in consumption patterns of LNCS over time (Sylvetsky, 2016; Martyn, 2018), and this may vary geographically, consumption of beverages containing LNCS, seems to be increasing (BNF, 2018). This may be influenced

by Government policies to reduce childhood obesity, such as the Childhood Obesity Plan, the Soft Drinks Industry Levy (DHSC, 2016) and the sugar reduction programme (PHE, 2017). These policies encourage the food and beverage industry to reformulate products to reduce free sugars. Using LNCS in place of sucrose (or other forms of sugars) is one of four mechanisms highlighted for action in shifting purchasing towards lower or no added sugar products (PHE, 2017). Whilst some businesses are concerned that a reduction in sugar levels would lead to an increase in the use and consumption of LNCS, others have indicated that their use is an important aspect of the reformulation work (PHE, 2018). In some foods and drinks, such as sugar-sweetened beverages, it is relatively straightforward to substitute sucrose with low or no calorie sweeteners, however with other foods, such as chocolate and baked goods, it is more difficult as sucrose plays an additional functional role, i.e. affecting the texture, structure, appearance and shelf-life of the food item, and there are some regulatory conditions for their use in products (PHE, 2018. EU 2008). Another reason businesses may decide against using LNCS in their products is because they're viewed as 'artificial' and may be less acceptable to consumers, who are increasing looking for 'natural' or 'clean' labels (Euromonitor, 2017).

The influence of reformulation on the presence of both caloric and non-caloric sweeteners in the food supply chain, is a rapidly evolving landscape. For example, even though the public is concerned about sugar intake, more 'natural' alternatives, such as honey, agave syrup, and coconut sugar are seen as being more acceptable and 'healthier' as they are derived from plant-based sources and carry a positive 'halo'. However, there is very limited evidence for any additional health benefits and these sugars still contribute to calorie intake and potentially weight gain (Euromonitor, 2017).

Recommendations:

- Businesses should continue to reduce free sugars in their products.
- Public health messages around the role of LNCS in reduction of free sugars, as part of reformulation activities, may be helpful in the wider context of reducing energy intake.
- As businesses may not always report change of formulation and/or alert consumers to the use of LNCS in their products, practical information for consumers about where to find this information (i.e. on food labels and company websites) may be helpful.
- Healthcare professionals should be aware of the different types of sweeteners (both caloric and non-caloric that are available, what their benefits are and how they are best used (eg some LNCS are better for baking) so they are able to give practical advice to people wanting to use LNCS to help reduce their free sugar and calorie intake.
- In order to understand trends, the Government should monitor changes in intakes of both caloric and non-caloric sweeteners.The EU instructs member states to maintain systems to monitor the consumption and use of food additives. The food industry should also monitor the use of free sugars and LNCS in products.

The role of LNCS in weight management

Products containing LNCS are often promoted as a lower or 'zero' calorie or 'light' option. Indeed many of the restrictions on conditions for use of sweeteners in the EU relate to use in reduced energy products, and marketing strategies that may suggest they could help with weight management (Pereira, 2013). However, the claim that LNCS contribute

to the maintenance or achievement of a normal body weight has not been authorised by the EFSA (EFSA, 2011) and so this claim cannot be made in information to consumers (e.g. on food labels or product websites).

The role of LNCS in weight management remains a controversial area. Study findings are inconsistent, with some trials (Peters, 2016) and systematic reviews (Wiebe, 2011; Rogers, 2016) indicating they could have a beneficial role in weight management, and others reporting modest weight loss (Miller, 2014; Mattes, 2009) but some observational studies suggesting they may paradoxically lead to weight gain (Azad, 2017). Results from the latter may be confounded by factors such as associations with other dietary behaviours / lifestyle factors and affected by reverse causation bias (Pereira, 2013; Lohner, 2017).

Various hypotheses and mechanisms to explain the findings of the observational studies have been proposed. Some studies have suggested that consuming LNCS in place of free sugars, could lead to a compensatory increase in calorie intake (Mattes, 2009; Yang, 2010; Garden, 2015). But, evidence from short-term intervention trials shows that the energy saved from swapping LNCS with sugar is not fully compensated and can help reduce overall calorie intake (Rogers, 2016). Other hypotheses have suggested that exposure to sweet tastes, even from LNCS, could lead to a general acceptance and preference of sweet foods and drinks (Pepino, 2011) and potentially hinder attempts to reduce intake of higher calorie foods. However, studies show no consistent relationship between the consumption of LNCS and an increased preference of sweet foods and drinks (Bellisle, 2015). There is also some suggestion that the sweetness of LNCS could activate the brain to expect calories and stimulate appetite (Pepino, 2011, Rogers, 2016). An increase in appetite with LNCS has also been reported in some animal studies (but not all) with stimulation of sweet taste receptors in the gut, which in turn could affect glucose metabolism (Pepino, 2011, Bryant, 2014). In contrast, other studies hypothesize that consuming LNCS could actually suppress appetite for sweetness and lead to a lower intake of sweet tasting foods or drinks and potentially facilitate weight loss (Piernas, 2013; Appleton, 2018; Bellisle, 2015).

Other position statements and health authorities have concluded that replacing free sugars with LNCS may help to reduce calorie intake and assist weight management (BDA, 2016; PHE, 2017) as long as substitution doesn't lead to later compensation with increased energy intake. This strategy may be especially useful for those who are accustomed to sugar-sweetened products (Gardner, 2012) or for adults who are habitually high consumers of sugar-sweetened drinks (Johnson, 2018). The BDA's policy statement on 'The Use of Artificial Sweeteners' concludes that LNCS may be recommended on a case-by-case basis as part of an individualised approach and should be considered by those wanting to manage their weight and/or diabetes (BDA, 2016). Diabetes UK's 'Evidence-based nutrition guidelines for the prevention and management of diabetes' (Diabetes UK, 2018) state LNCS 'may be recommended'.

When assessing whether the use of LNCS could be useful strategy for an individual, it may be helpful to consider if a large proportion of excess energy intake is coming from free sugars / sugar-sweetened beverages, and then introducing some LNCS-containing foods / drinks as part of a weight management programme (Johnson, 2018). Consideration should also be given to any potential energy compensation and total energy intake from all dietary sources (Rogers, 2016).

Much of the research into LNCS has been carried out in animal models and there is generally a lack of good human data showing consistent associations (Bellisle, 2015; BDA, 2016). More high quality research is needed to help to understand the underlying mechanisms and to explore the role of LNCS in the preference of sweet tastes, as well as on different aspects of weight management, from prevention of weight gain, to weight loss and weight maintenance (Bellisle, 2015; Lohner, 2017). The SWITCH study is one such study which aims to investigate the long term effects of LNCS use on behaviour, appetite regulation and food preferences, as well as their effect on weight and other health outcomes and findings are due to be reported in 2019 (Masic, 2017).

Recommendations:

- Substituting LNCS for free sugars (especially in sugar sweetened beverages) may be a useful, relatively simple, strategy (or a 'stepping stone') to help reduce calorie intake and assist with weight management.
- This strategy may be particularly helpful and practical for people who regularly consume sweet foods and drinks and prefer a sweet taste.
- The use of LNCS to aid weight loss should be in the context of an overall healthy diet and a wider weight management programme.
- Healthcare professionals should first assess an individual's free sugar and LNCS intake and then give individually tailored advice. If appropriate, they can offer practical ways to use LNCS as part of a healthy eating plan while monitoring for emergence of any compensatory behaviours.
- In the long term, healthcare professionals should continue to take an individualized personalised approach, whilst considering the whole diet.

The role of LNCS in diabetes management

Diabetes UK's recent 'Evidence-based guidelines for the prevention and management of diabetes' concluded that 'non-nutritive (artificial) sweeteners are safe and may be recommended' (Diabetes UK, 2018).

Since LNCS provide little or no carbohydrate and do not increase blood glucose levels after eating (Franz, 2010), they may be a useful substitute for free sugars in people with diabetes to help manage blood glucose. EFSA has also approved the claim that LNCS help to reduce post-prandial glucose levels if consumed instead of sugars (EFSA, 2011). However, the claim that LNCS (in place of sugar) could maintain normal blood glucose levels has not been authorized (EFSA, 2011). Further studies on long-term patient-relevant outcomes in diabetes are required (Lohner, 2017).

As weight management is key to managing and preventing Type 2 diabetes, using LNCS in place of free sugars may be a useful way to reduce calorie intake and maintain a healthy weight (BDA, 2016). See section on LNCS and weight management.

Recommendations:

- Replacing free sugars with LNCS can be a helpful strategy to aid glucose management.
- Healthcare professionals should give tailored, individualised advice about how LNCS can be used to aid glycaemic and, if relevant, weight management in people with diabetes.

- The effect of the Soft Drinks Industry Levy has led to reformulation of many brands and an increase in availability of drinks with reduced levels of free sugars; healthcare professionals need to be aware of these changes and communicate this to people with diabetes as it could reduce the effectiveness of some products as treatments for hypoglycaemia.

LNCS and the risk of Type 2 diabetes

Studies looking at the factors that may increase risk of developing a chronic condition such as Type 2 diabetes are typically observational studies. These show a similar inconsistent pattern to the findings reported in observational studies with regards to obesity, with some showing a positive association (Fagherazzi, 2017; Sakurai, 2014; Nettleton, 2009) and others no association (de Koning, 2011; Bhupathiraju, 2013) and some reviews have suggested a positive association between the consumption of LNCS sweetened beverages and the risk of developing Type 2 diabetes (Imamura, 2017; Greenwood, 2014; Azad, 2017)

In light of these observations, various hypotheses have been offered. For example, one suggestion is that the consumption of LNCS adversely affects glucose metabolism which could contribute to the development of Type 2 diabetes (Suez, 2014; Nettleton, 2016), another is an indirect link via mechanisms that lead to an increase in energy intake and weight (see 'The role of LNCS in weight management').

Another hypothesis is that certain LNCS could increase the risk of developing Type 2 diabetes by altering gut bacteria and subsequently affecting glucose metabolism, weight gain and glucose intolerance (Suez, 2014. Nettleton, 2016). However, this research has been mainly carried out in animal models or in human studies with very limited numbers of subjects.

Many randomised controlled trials (Anton, 2010; Barriocanal, 2008; Okuno, 1986; Grotz, 2017; Wiebe, 2011; Härtel, 1993) and reviews of trials (Nichols, 2018) have shown that LNCS do not adversely affect glucose homeostasis and insulin secretion.

A recent randomised control trial by Romo-Romo et al (2018) showed that LNCS (specifically sucralose) may have an effect on glucose metabolism. However, the authors concluded that 'further studies are needed...to explore the mechanisms for these metabolic alterations'.

With regards to the association of LNCS, in particular LNCS sweetened beverages, and the risk of developing Type 2 diabetes, the quality of evidence is limited, associations are not well established and no definitive conclusions can be drawn. Any positive associations that have been reported were more likely to be due to reverse causation (Azad, 2017) due to a likely higher consumption of LNCS drinks among overweight individuals (Pereira, 2013; Greenwood, 2014; Imamura, 2015) and findings are likely to be confounded by other factors such as adiposity (Romo-Romo, 2016). As with other reviews of observational studies; interpretation is limited because as well as reverse causality, studies have used different outcome measures, different types of LNCS and different lengths of follow-up times, which results in too much variability to robustly pool the results.

Similarly effects of LNCS on glucose metabolism are not clear and many of the trials are contradictory and not comparable because of the differences between them, such as different outcome measures, different types of LNCS, and different lengths of follow-up times (Azad, 2017).

Overall, there is not enough evidence to conclude that consuming LNCS on a regular basis leads to Type 2 diabetes and further higher quality trials are needed, evaluating specific LNCS, with an adequate sample size, a uniform study group, with sufficient exposure time, adjustment for potential confounding factors and previous consumption of LNCS (Romo-Romo, 2016). Also, as there is growing research on the gut microbiome, future research on the impact of LNCS on gut microbiota and metabolic health is needed (Nettleton, 2016).

As sugar-sweetened beverages intake is associated with a higher incidence of Type 2 diabetes (SACN, 2015) substituting them with LNCS sweetened beverages may be a useful strategy for those who are regular consumers, particularly if they are also at risk of developing Type 2 diabetes.

Recommendations:

- Currently, there is not enough evidence to say that LNCS consumption increases the risk of developing Type 2 diabetes.
- Further high quality human trials are needed, especially looking at the effect of frequent and long-term consumption of LNCS on glucose metabolism, appetite control and gut microbiota.

LNCS and cardiovascular disease

Some observational studies have reported an association between LNCS beverages and hypertension, risk of stroke, cardiovascular events (Azad, 2017. However, there is not enough data from RCTs to confirm these observations. Publication bias and confounding was also likely to exist, as consumers of LNCS sweetened beverages tended to be hypertensive (Pase, 2017; Azad, 2017).

Recommendations:

- There is not enough evidence to say that the consumption of LNCS leads to the development of hypertension, stroke or dementia.
- Future research is needed to investigate the mechanisms underlying the reported associations from some observational studies and whether any link is causal.

LNCS and children

The EFSA, after extensive review, has reported that LNCS are safe for children to consume up to the ADIs. However, in the EU, the use of LNCS, as well as all other additives, is prohibited in all foods specifically made for infants and young children up to the age of three years old, This age group has specific nutritional needs and increased energy requirements for optimal growth (BDA, 2017).

Water or milk are the best choices of drinks for children. On average, children in the UK consume three times the recommended amount of free sugar, a large proportion of which

comes from sugar-sweetened beverages (PHE, 2015). In addition, there is evidence that children and adolescents have an increased preference of sweet tastes when compared to adults (De Graaf, 1999; Appleton, 2018). Therefore, substituting sugar-sweetened beverages with LNCS sweetened beverages may be a helpful strategy in reducing sugar, energy intake and body weight in overweight children (Rogers, 2016; Bellisle, 2015; Miller, 2014). Evidence from RCTs in children and adolescents showed that those who consumed LNCS sweetened beverages gained less weight than those who drank sugar-sweetened beverages (SACN, 2015).

Although water and milk are preferred beverage choices, children with diabetes who consume a balanced diet and closely monitor their blood glucose may be able to prevent excessive glucose excursions by substituting LNCS sweetened beverages for sugar-sweetened beverages when needed (Johnson et al, 2018).

As children and teenagers are amongst the highest consumers of sugar-sweetened beverages (NDNS, 2018), substituting them with LNCS sweetened beverages may be a useful strategy for children who are regular consumers.

Further research is needed to inform dietary recommendations for children (Archibald et al, 2018; Reid, 2016) as there is a lack of evidence on the long-term health effects of the use of LNCS when used from early childhood (Serra-Majem, 2018).

Recommendations:

- LNCS are safe for children to consume up to the ADIs.
- LNCS (particularly substituting sugar-sweetened beverages with LNCS sweetened beverages) can be a useful strategy for children with diabetes to aid their glycaemic management.
- LNCS can be recommended to children as a weight management strategy (or a ‘stepping stone’) to reduce calorie intake and aid weight loss, particularly in those who have a high intake of sugary foods and drinks and/ or have a ‘sweet tooth’. When replacing sugars, LCNS can also help protect against tooth decay.
- Healthcare professionals should give individually tailored and practical advice when recommending LNCS as part of a healthy eating plan to children who regularly consume sugar-sweetened beverages. It is also important to consider overall diet quality and monitor for the emergence of any compensatory behaviours and to highlight that fizzy drinks may contain acids that can be harmful to teeth and that some of these drinks contain caffeine.

LNCS and diet quality

Evidence from observational studies have found that diets high in free sugars tend to have lower diet quality (Gibson, 2016). Some studies have reported higher diet quality in LNCS consumers than in non-consumers (Drewnowski, 2014; Gibson, 2016); whereas, others have found the use of LNCS sweetened beverages to be associated with a lower overall diet quality (An, 2016), an unhealthy lifestyle, reduced physical and mental health and unfavourable dietary habits with increased energy intake including free sugars, and reduced intake of some vitamins (Winther, 2017).

Recommendations:

- Healthcare professionals, such as dietitians, should assess overall diet quality and lifestyle in people who regularly consume sugar-sweetened beverages or LNCS sweetened beverages.
- LNCS can be used as a "stepping stone" to reduce intake of sugar in the diet as part of an overall healthy eating pattern.

Conclusion

LNCS are shown to be safe and they can be a used as part of a strategy for adults and children in the management of weight and diabetes. In particular, LNCS sweetened beverages may be helpful when they are used as a substitute by regular consumers of sugar-sweetened beverages and as long as substitution doesn't lead to later compensation with increased energy intake. This approach may be particularly helpful for people who are accustomed to a sweet taste and for whom water, at least initially, is an undesirable option (Johnson, 2018).

As there are some gaps in current knowledge, long-term studies are needed to examine the physiological effects of LNCS on metabolism and energy balance (Winther, 2017). New independent, larger, longer, good quality research is warranted to explore the long-term risks and benefits of different types of LNCS and their role in different food and drink products, as well as an understanding of the mechanisms (e.g. on appetite or food preferences).

As a result of reformulation, it will be important to monitor LNCS consumption and long-term use, in particular there is a need for studies that investigate the cumulative effect of routine LNCS consumption over long periods. It will also be important to ascertain the impact of increased LNCS use on overall diet quality.

Public health messages focusing on safety and appropriate use of LNCS in the context of a healthy diet should also be communicated, especially considering their increased use in beverages. Advice from healthcare professionals needs to be clear, unbiased and consistent, as well as practical (Harricharan, 2014).

Further information

Sugar, sweeteners and diabetes:

www.diabetes.org.uk/Guide-to-diabetes/Enjoy-food/Carbohydrates-and-diabetes/Sugar-sweeteners-and-diabetes

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