


REFORMULATION GUIDE

SPOTLIGHT ON SUGARS

For small to medium sized companies


report

leatherhead food research

a science group company

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21 November 2016

This document has been prepared by Leatherhead Food Research

fdf food & drink federation
passionate about food & drink

Foreword

Everyone working in food and drink will tell you that this is a dynamic, innovative and consumer-focused industry. Health is a major driver of innovation and has been for decades as the demand for great tasting, nutritious and affordable food and drink grows. Companies are capitalising on this trend by launching healthier variants with less salt or calories (with less sugars or fat) or with added nutrients. Many are also looking for opportunities to make changes to their standard products, in consultation with their loyal customer base.

At FDF, we know that producers of packaged food and drink can play a big role in helping their customers towards better overall diets. Government nutrition data shows that, on average, consumers are eating too much saturated fat, salt and free sugars and not enough fibre, fruit and vegetables, and some vitamins and minerals including iron and vitamin D.

In 2012, FDF developed guidance on salt reduction for SMEs in partnership with the British Retail Consortium and Leatherhead Food Research. Salt reduction is a success story for the British food and drink industry. Through voluntary reformulation we have helped lower salt intakes by 11% since 2005 and this work continues.

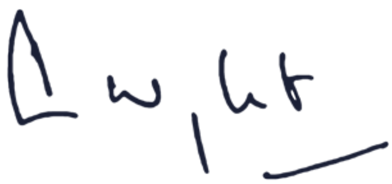
Today, sugars reduction is a major focus as consumers look increasingly closely at the sugars in their diets. This focus has been driven in part by a change to recommended sugars intakes by UK Government in 2015 following an evidence review by the Scientific Advisory Committee on Nutrition. FDF supports the view held by dietitians that people should take a whole-diet approach to healthier lifestyles, without undue focus on single nutrients. However, we recognise the industry's role in helping customers to reduce sugar intakes.

The current focus on sugars reduction presents both challenges and opportunities for our industry. As all producers of food and drink will know, sugars play a number of different roles in a recipe. These functions will vary from product to product and category to category, and must each be addressed when adapting a recipe. Sugars add colour and sweetness, enhance other flavours, provide bulk and texture, and improve shelf-life by reducing available water and inhibiting growth of bacteria. In some products, sugars are used to improve the palatability of fibre, wholemeal or bran, for instance.

FDF is helping small and medium-sized companies, which don't typically have significant in-house R&D expertise, in their reformulation journeys. We commissioned Leatherhead Food Research to produce guidance on sugar reduction in three categories: soft drinks, dairy desserts and baked goods.

This new guidance sets out regulatory considerations for sugars reduction, outlines available sugar replacers and factors affecting consumer acceptance of sugar replacers. The guide covers the different challenges and opportunities for sugars reduction in the three categories including available ingredients and labelling considerations.

A slow, stepped "health-by-stealth" approach is often required to ensure that consumers continue to enjoy the product and benefit from the changes made, often without realising the recipe is altering. Research shows that a gradual approach can have a large impact - the recent groundbreaking McKinsey report ranked reformulation of food products as the second most cost-effective intervention to reduce obesity worldwide. Recipe changes need to pass the consumer acceptance test to be successful, lasting and beneficial to consumer health.



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Director General at the
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1. Regulatory framework for the reduction of sugars

A regulatory review has to be the first stage of any reformulation work as it forms the basis for reformulating products.

The first point to recognise is that there are currently no regulatory requirements necessitating the reduction of sugars, and therefore any moves towards the reduction of sugars are being run very much along the lines used for salt reduction. The imposition in the UK of a levy on drinks sweetened with sugars is seen as a nudge towards reformulation rather than a requirement to reformulate.

Most of the work on the reduction of sugars and the government strategy on childhood obesity is being run by Public Health England.

What are the important regulatory considerations?

1.1 Ingredients

It is crucial that before any reformulation is carried out, regulatory restrictions are checked to identify ingredients permitted in different product categories. There may be restrictions on the use of specific ingredients and the labelling requirements for the country/countries in which the product is to be sold.

The main point to be considered here is the use of additives (which includes the use of sweeteners and substitute sugars), where there is strict regulation of what additive can be used in which product under EU Regulation 1333/2008. The EU has published guidance on what products fall under which category and this can be found on the EU Commission website.

For example, if you are reformulating cakes, biscuits and pastries (referred to in regulations as ‘fine bakery wares’), you need to be aware that decorations, coatings and fillings can fall under category 5.4 whilst fine bakery wares fall under category 7.2. Both of these have separate lists of permitted additives, so it may be possible to achieve the desired reduction of sugars by modifying the filling whilst leaving the pastry component alone.

1.2 Claims on packaging

This report will not cover the regulatory details for all claims relating to the reduction of sugars but the following definitions are useful to understand in the context of reformulation as in the EU Nutrition and Health Claims Regulations 1924/2006. These are the only claims that can be made on-pack with the following criteria to be met.

Being able to use one of these claims on-pack can be a driver for reformulation:

Low sugar

A claim that a food is low in sugars, and any claim likely to have the same meaning for the consumer, may only be made where the product contains no more than 5g of sugars per 100g for solids or 2.5g of sugars per 100ml for liquids.

Sugar free

A claim that a food is sugar free, and any claim likely to have the same meaning for the consumer, may only be made where the product contains no more than 0.5g of sugars per 100g or 100ml.

No added sugar

A claim stating that sugars have not been added to a food, and any claim likely to have the same meaning for the consumer, may only be made where the product does not contain any added mono- or disaccharides or any other food used for its sweetening properties. If sugars are naturally present in the food, the following indication should also appear on the label: ‘CONTAINS NATURALLY OCCURRING SUGARS’.

Energy reduced

A claim that a food is energy-reduced, and any claim likely to have the same meaning for the consumer, may only be made where the energy value is reduced by at least 30%, with an indication of the characteristic(s) which make(s) the food reduced in its total energy value.

The important point to note with all the above definitions is the repeated phrase “and any claim likely to have the same meaning for the consumer”. If you wish to make a statement on your packaging, if it can be interpreted as meaning the same as one of the above phrases, it has to meet the required conditions.

You also need to note that to use the “no added sugar” claim you cannot add “any other food used for its sweetening properties” (e.g. honey). There is a grey area here as to whether this includes sweeteners, but it seems to be accepted industry practice in the UK that it does not.

2. Challenges in understanding sugars and replacers

2.1 Sugars

Sugars are carbohydrates, which can be defined as either ‘extrinsic’ or ‘intrinsic’ depending on their source of origin. ‘Intrinsic’ sugars are naturally found within the cellular structure of food (mainly fruits and vegetables), whilst ‘free sugars’, which have replaced the term ‘non milk extrinsic’ sugars following the Government’s Scientific Advisory Committee on Nutrition report in July 2015, are sugars added to foods by manufacturers, cooks or consumers, plus sugars naturally found in honey, syrups and unsweetened fruit juice. The definition of free sugars excludes milk sugars naturally found in milk and sugars contained in cell walls, for example, in whole fruit.

Sugars can also be classified into the following categories based on their chemical structure: monosaccharides and disaccharides. The term ‘sugars’ on back-of-pack labels is often used as a short form of ‘total sugars’, which in turn refers to any mono or disaccharide, whether extrinsic/added sugars or intrinsic/naturally present. Chemical tests used for measuring sugars in products cannot differentiate between extrinsic and intrinsic sugars. The calorie content of carbohydrate sugars is 4kcal/g or 16kJ/g.

Monosaccharides

Monosaccharides are the simplest form with one unit of sugar; glucose, fructose and galactose are the most commonly found in food and beverages.

Disaccharides

Disaccharides are more complex carbohydrates, which are formed through the conjunction of two monosaccharides in a chemical reaction that also results in the loss of one water molecule. Common disaccharides found in food and beverages are sucrose (glucose and fructose), lactose (glucose and galactose) and maltose (two molecules of glucose). Disaccharides can break down to release monosaccharides which will affect the product characteristics and storage stability. For example, sucrose commonly used in soft drinks will break down under acid/heat to release glucose and fructose, which will affect the sweetness and colour of the drinks during storage.

2.2 Ingredients used for sweetness

Many ingredients are added to products for functional properties, including sweetness. Some common ingredients used to impart sweetness are: fruit juices, fruit purees, honey and fruit syrups. When these are used in products, it is important to note that they will contribute mono and disaccharides which will form a part of the total sugars. The use of such ingredients (foods with sweetening properties) need to be considered as part of any reformulation exercise to reduce sugars as these contribute to the levels of sugars in a product.

2.3 Sweeteners

These fall into two groups: bulk sweeteners (used in large quantities) and intense sweeteners (used in very small quantities) and can be used to replace sugars (in energy reduced foods or foods with no added sugars). It is important to note that the use of sweeteners has specific conditions of usage, which need to be adhered to (see Section 1 for more information).

For full compliance, the actual regulations should be consulted as additional labelling requirements/restrictions may be in place for using bulk and intense sweeteners. For example, their usage is prohibited in infant foods.

2.4 Bulk sweeteners

Polyols

Polyols are bulk sweeteners which can be used to replace sugars in foods. Polyols are derivatives of sugars of which some occur naturally e.g. sorbitol in fruits, but the industrial grades for production are made by hydrogenation of sugars. Therefore they are also often referred to as sugar alcohols. The list of permitted polyols for use in foods are given in Table 1. The calorific value of polyols is 10 kJ/g (2.4 kcal/g), with the exception of erythritol, which is 0 kJ/g (0 kcal/g). Therefore polyols can be used to achieve a significant reduction in calorie content when used at high levels to replace sugars. They are generally less sweet than sucrose and are often used in combination with high-intensity sweeteners, which have little or no calorific value. The sweetness profile of polyols is different to that of sucrose which needs to be considered when reformulating products to reduce sugars.

E-number	Name	Sweetness relative to Sucrose (100%)
E 966	Lactitol	30-40
E 953	Isomalt	45-65
E 420	Sorbitols	50-70
E 421	Mannitols	50-70
E 965	Maltitols	75
E 968	Erythritol	60-80
E 967	Xylitol	100

Table 1: Polyols used as bulk to replace sugars

It is important to note that a regulatory assessment is needed before polyols are used in products as they are not permitted for use in all categories of foods. Also the use of sucrose in combination with polyols is restricted. Furthermore, a laxative warning stating ‘excessive consumption may produce laxative effects’, is required when polyols are used at levels of more than 10% w//w. For this reason the use of polyols in products is often kept to below 10% in the formulation, so that there will be no negative impact on consumer acceptance.

Intense sweeteners

Intense sweeteners provide the sweetness without providing bulk in products and no contribution to calories which is partly due to the very low level of usage in products. The list of permitted intense sweeteners is given in Table 2. The use of intense sweeteners has regulatory restrictions which need to be considered when using them in products and in labelling of products. The product categories (where permitted) and the maximum dose allowed are specified in regulation.

Table 2: EU references to sweetness potency of low calorie sweeteners

	EFSA/SCF Opinion	**Commission Regulation (EU) 231/2012 laying down specifications for food additives[1]***
E 950 ACESULFAME K		Approximately 200 times as sweet as sucrose
E 951 ASPARTAME		Approximately 200 times as sweet as sucrose
E 952 CYCLAMIC ACID AND ITS Na AND Ca SALTS		Approximately 30-40 times as sweet as sucrose
E 954 SACCHARIN AND ITS Na. K AND Ca SALTS		Approximately between 300 and 500 times as sweet as sucrose
E 955 SUCRALOSE	A sweetness potency around 600-650 times that of sucrose[2]	
E 957 THAUMATIN		Approximately 2 000 to 3 000 times as sweet as sucrose
E 959 NEOHESPERIDINE DIHYDROCHALCONE		Approximately between 1 000 and 1 800 times as sweet as sucrose
E 960 STEVIOL GLYCOSIDES		Approximately between 200 and 300 times sweeter than sucrose
E 961 NEOTAME	Approximately 7000 to 13000 times greater than that of sucrose[3]	
E 969 ADVANTAME	Approximately 37 000 times sweeter than sucrose[4]	

*Where there are no references to sweetness potency included in Regulation 231/2012 on specifications, references to the sweetness potency in the EFSA/SCF opinions are provided.

Source: International Sweeteners Association

[1] Commission Regulation (EU) No 231/2012 of 9 March 2012 laying down specifications for food additives listed in Annexes II and III to Regulation (EC) No 1333/2008 of the European Parliament and of the Council

[2] Opinion of the Scientific Committee on Food on sucralose, September 2000

[3] EFSA Scientific Opinion on Neotame, September 2007

[4] EFSA Opinion on Advantame, July 2013

Some examples of additional labelling requirements when using sweeteners are given below:

i. A food containing a permitted sweetener or sweeteners, including , must be marked or labelled with the indication:

   "with sweetener/s".

ii. Where a food contains an added sugar or sugars and an authorised sweetener or sweeteners, it must be marked or labelled with the indication:

   "with sugar/s and sweetener/s".

The statements required by (i) and (ii) above must accompany the name of the food.

iii. A food that contains aspartame must be marked or labelled with the indication:

   “contains a source of phenylalanine”.

iv. A food that contains more than 10% added polyols must be marked or labelled with the indication:

   "excessive consumption may produce laxative effects".

For full compliance, the actual regulations should be consulted.

2.5 Other ingredients with bulking properties used to replace sugars

Ingredients with bulking properties such as soluble dietary fibres and dextrins (inulin, oligofructose, polydextrose) are commonly used to replace sugars in formulations and to achieve a reduction in calories. These ingredients provide bulk and can have an additional positive effect of improving the nutritional content by increasing the dietary fibre content of products whilst reducing sugars. Depending on the properties of the replacers, different levels of sugar reduction can be achieved before the product characteristics are altered beyond an acceptable level. Where polyols are permitted for use, the best solution for total replacement of added sucrose is through its replacement with a combination of polyols to replace the sweetness from the sugars and dietary fibres to replace bulk.

3. Consumer acceptance

3.1 What are the factors affecting consumer acceptance?

Taste

Taste is the key driver for consumers when purchasing products. Consumers are not willing to compromise on taste when it comes to reducing sugars in products. In the case of replacing sugars, the sweetness perception can be affected in two ways: overall sweetness perceived and length of the perception. Consumers can detect very low levels of reduction to the sugars in a product which is why reducing sugars is more difficult than salt reduction.

Clean label

Consumers remain interested in what is in their products and this can have profound effects on which reduction strategies to adopt. When asked about sugar alternatives for reformulation in a Leatherhead survey in 2015, UK consumers were most favourable to manufacturers using natural or less-refined ingredients, for example brown sugar or honey (these are generally perceived by consumers to have gone through less processing than white sugar). Substituting white sugar for brown sugar or honey, however, is unlikely to achieve a reduction in the product calories and may change the flavour, the textural properties and even the shelf life of the product.

Consumer perception of sweeteners

There are mixed views of sweeteners. While consumers are generally unware of the specific types of sweeteners used in products, there is consumer preference towards natural sweeteners (such as stevia) rather than artificial sweeteners (Leatherhead consumer survey 2015). Consumers are conscious of the bitter or metallic taste that some sweeteners can give a product and expect reduced sugar or reduced calorie products to have similar taste profiles to the original products containing sugar. The use of sweeteners requires product developers to blend different ingredients together to achieve an acceptable taste profile for consumers.

Other nutritive sweetening agents

E.g. fructose, honey and agave – these have a health halo with some consumers, but in reality they still contribute to the total sugars and the calorie content of the product.

Calorie reduction

It is important to understand the objective of reducing sugars in products, as this will have an impact on the types of ingredient that will be used in products and the product perception by consumers. Is the objective to simply lower sugars or is it to lower the overall calorie content of the product? In the majority of cases the objective is to lower the overall calorie content. Consumers are becoming savvier and are not only looking for products that are lower in sugars, but are looking for products which have the same amount or fewer calories. We have seen this trend manifest itself in the growing consumer wariness of products positioned as low fat; many consumers believe them to contain high levels of sugars to compensate for the reduction in fat.

It is important to consider reducing sugars in the context of calorie reduction. The energy content of recipes (given in kilocalories (kcal) and kilojoules (kJ)) can be calculated from values provided for each ingredient used or from a breakdown of the nutrients in the product. The calorie content should be calculated from nutrients present using the energy conversion factors given in table 3.

	kcal/g	kJ/g
Polyols (except erythritol)	2.4	10
Erythritol	0	0
Dietary fibre	2	8
Organic acids	3	13
Available carbohydrates including sugars	4	16
Protein	4	17
Fat	9	37

Table 3: Energy conversion factors for nutrients

Calculation of the total energy of a product as a paper exercise is important before starting reformulation of products, in order to determine the level of energy (calorie) reduction which needs to be achieved.

Sugars, as carbohydrates, contribute 4 kcals (16 kJ) per gram in a recipe. Where the aim is to reduce calorific value of a product, it may not be effective just to remove sugars from the recipe. Apart from affecting the functionality that sugars provide, recipe changes may actually increase the percentage of other calorie dense ingredients. As an example, the change in nutritional content from simply removing some of the sugars is shown in Table 4 for a product containing total sugars of 22g/100g. In this case, removing 8g of sugars (36% reduction) can actually be seen to increase the overall calorie content. As the proportions of the nutrients have changed, the ‘reduced sugar’ product has more fat and more calories per 100g after reformulation than the original product. This example demonstrates that to reduce calories significantly, sugars must be replaced with a lower calorie alternative rather than simply being removed from the recipe.

Typical values	Product before reducing sugars (g per 100g)	Product after reducing sugars (g per 100g)
Fat	23.0	25.3
Saturates	11.0	12.1
Monounsaturates	8.8	9.7
Polyunsaturates	2.7	3.0
Carbohydrate	63.0	59.3
Total sugars	22.0	14.0
Starch	41.0	45.0
Fibre	3.8	4.2
Protein	6.8	7.5
Salt	1.1	1.2
[Ash]	2.3	2.5
Energy	2063kJ	2105kJ
	494kcal	503kcal

Table 4: Effect of reducing sugars without replacement of a lower calorie ingredient in a product example with 22% sugars and 23% fat

4. Product categories

4.1 Soft drinks

Sugars in soft drinks

Soft drinks broadly fall into two categories: Ready-To-Drink (RTD) and concentrates. Almost any alcohol-free drink, which is to be served cold can be referred to as a soft drink, and in Table 5 examples are given of products, together with typical levels of sugars.

Category	Product examples	Typical levels of sugars (%)
Fruit juices	*Still 100% Juice*:	
	Grape juice	16.0
	Apple juice	9.7
	Orange juice	8.6
Smoothies	Non-dairy juice-based	11.6
Ready to Drink (RTD)	Still	9.8
	Carbonated drinks:	
	Lemonade/Cola	5.8 - 10.9
	Juice-based carbonated drinks	7.2
	No-added sugar fruit juice drinks, carbonated	<1.0
Concentrated soft drink	*Squashes and cordials:*	Undiluted
	Blackcurrant	54.2
	High juice drink (50% juice)	42.6
	High juice – no added sugar	4.6
	Fruit Juice drink – no added sugar	1.4
Other categories	Diet soft drinks	Trace
	Sports/Energy/Functional drinks	11.0 - 13.0

Table 5: Soft drinks classification

Source: McCance and Widdowson (2015). The Composition of Foods

The building blocks of soft drinks, excluding fruit juices (which are 100% juice), are the diverse ingredients used, but common to most are water, sugars, sweeteners, acidulants, flavours and colours, with some also containing stabilisers and preservatives. Each ingredient used plays a key role in the soft drink, and sugars or calorific sweetening ingredients are multi-functional in terms of functionality. Sugars are added not only to provide sweetness, but also to act as preservatives and contribute to product colour, texture or mouthfeel. Reformulation to reduce sugars is a complex process, which is governed not only by the potential nutritional and/or health benefits, but also by technical and legal requirements.

Reduced calorie soft drinks can be developed by reducing the total energy density (or calorie content), through the reduction of sugars. Products that are 'sugar free' and 'reduced sugar' are examples which demonstrate the options for reducing sugars in soft drinks.

The ingredients commonly used in the soft drink industry to provide sweetness are generally categorised as carbohydrate bulk sugars, ingredients used for sweetening purposes and intense sweeteners (covered later). The calorie-contributing bulk ingredients commonly used in soft drinks are shown in Table 6.

Ingredient category	**Ingredients commonly used in soft drinks**
Carbohydrate bulk sugars contributing calories	Sucrose Glucose/dextrose Fructose High fructose corn syrup Invert sugar Glucose syrup/dried glucose syrup Fructose syrup
Other ingredients used for sweetening purposes	Juices Purees Honey Fruit syrups

Table 6: Commonly used calorie-contributing bulk ingredients for sweetening soft drinks

Role of sugars and challenges in reducing sugars in soft drinks

Sugars play an integral role in the organoleptic quality and microbiological stability of soft drinks. The basic taste profile of all flavoured soft drinks is generated as a combination of the sweetening ingredient (normally sucrose or HFGS) and the acidulants. Figure 1 gives a summary of the functionality of sugars in soft drinks. Sugars are bulking agents, which give texture to the liquid, and without the sugars the soft drink will lack body and feel flat in the mouth. Additionally, sugars can act as preservatives and thus prolong the shelf-life of a product by inhibiting the growth of spoilage microorganisms, especially when used at higher Brix (soluble solids or soluble sugars) levels due to the resultant low water activity. However, the microbiological stability of soft drinks can be controlled through a range of other modes, including pH reduction (mainly through the use of acidulants), the use of preservatives and/or heat treatment, or non-thermal treatment such as High Pressure Processing (HPP). Ultimately, the strategies used to prolong the shelf-life of a soft drink are governed by the formulation, processing, packaging and storage conditions. For any sugars added, it is important that all of its functions are considered and not just sweetness.

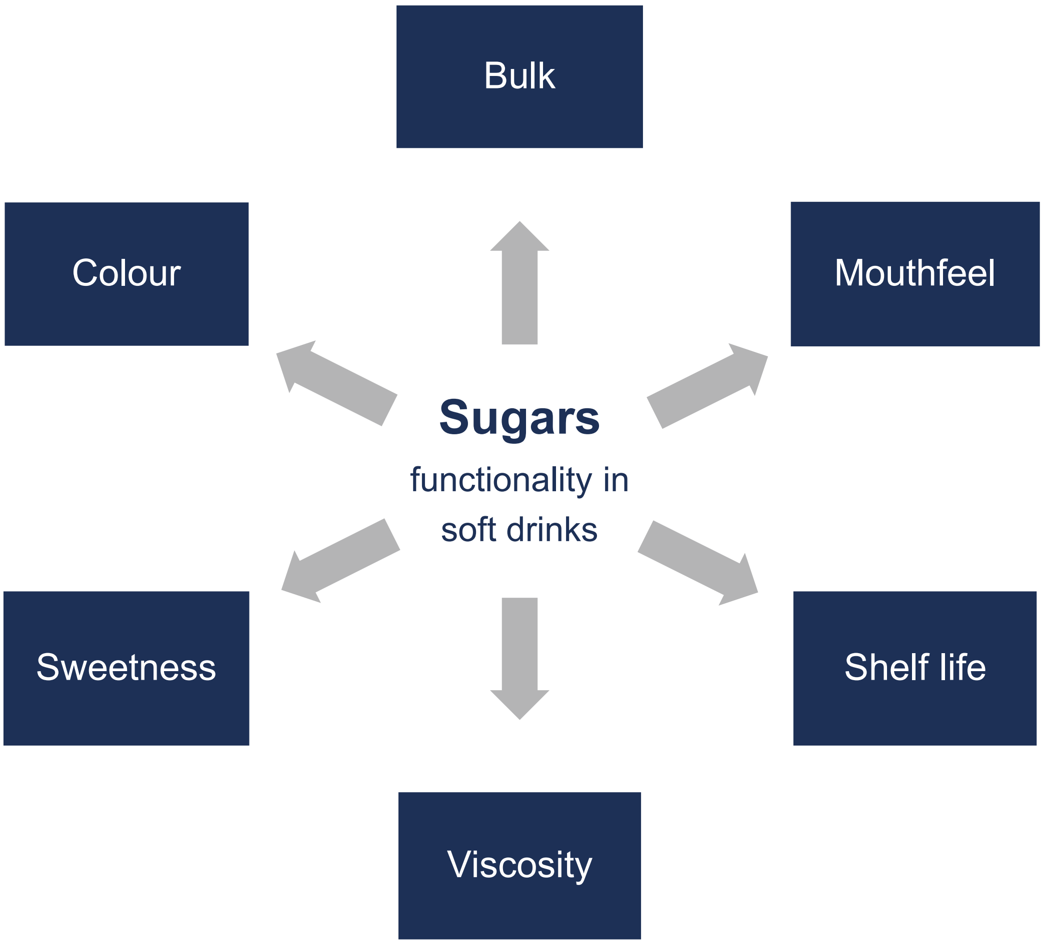

Figure 1: Functional properties of sugars in soft drinks

Guidance for reducing calories through reducing sugars

Sucrose (derived from either sugar cane or sugar beet) is the most common type of sugar used in soft drinks and it usually makes up 8 to 12 percent of a formulation by mass. It is the ‘gold standard’ sweetening ingredient to which all other sweeteners are compared. Sucrose is commercially available and is used, depending on the product format, as either a granulated solid or as a concentrated syrup (normally 67° Brix). Most of the calories in soft drinks come from sugars and therefore the only option for calorie reduction in soft drinks is to reduce the sugars. Two options are available for reformulation:

- Complete removal of sugars in the recipe to create ‘sugar free’ or ‘no added sugar’ products
- Partial removal of sugars to create ‘reduced sugar’ products

Considerations

The sugars’ reduction strategy used for soft drinks needs to be designed around the type of soft drink being reformulated. It is important to note that the reduction of sugars is not currently possible in 100% juices, as all the sugars are intrinsic to the product, the entirety of the total sugars being made up of ‘naturally occurring sugars’ found in the fruits and/or vegetables.

The permitted range of intense sweeteners (Table 2) can be used to completely replace sugars in soft drinks. However, although the sweetness can be replaced by the use of intense sweeteners, other important functionalities of sugars are not replaced. The use of intense sweeteners will give a calorie reduction because they are less energy dense than sugars (mostly non-nutritive) and are added at very low levels.

The considerations for reducing sugars in soft drinks require a focus on the formulation. As a first step, the contribution of each ingredient to the total sugars in the product has to be determined. Then it is important to identify the most effective approach and determine which ingredient(s) contributing to the sugars will be either reduced or totally replaced in the recipe. One option is to replace all bulk sugars with water, but this will have an impact on sweetness, flavour, mouthfeel, and microbiological stability. Along with a suitable intense sweetener or a sweetener blend, one or more ingredients will need to be added to replace the functional characteristics lost by removing the sugars. In a reformulated ‘reduced sugar’ or ‘no added sugar’ drink the texture-related issues such as a lack of body can be overcome by the addition of a thickener or another bulking agent. Where the microbiological stability has been reduced in a sugar-reduced recipe, preservatives may need to be added or additional processing applied to achieve the required shelf life.

When choosing a replacer(s) for sugars (low-calorie or non-calorie sweetener), it is also key to bear in mind that sweetening ingredients have different sweetness levels (see Table 2), taste profiles and aftertaste, which could impact on consumer acceptance. The key factors that will ultimately determine the choice of replacer(s) and dosage level(s) are the following:

- Soft drink formulation (or the type of soft drink)
- Regulatory framework in the country where the product will be sold
- Consumer acceptance (see section 3)
- Cost
- Processing conditions
- Stability and shelf-life of the replacer

Reducing and replacing sugars

Depending on the level of modification of the recipe and the reduction achieved, different claims can be made for soft drinks as follows:

- ‘Sugar free’ – this claim can be used where the ready-to-drink form contains less than 0.5g sugars per 100ml.
- ‘Reduced sugar’ – this claim can be used where a total reduction of 30% has been achieved compared to the original standard product.

It is important to note that polyols are not permitted to be used in soft drink formulations as a means of providing sweetness, but intense sweeteners can be used in ‘sugar free’ and calorie reduced formulations. The use and dosage levels of sweeteners permitted in different soft drink formulations depend on the regulations of the country where the soft drink is retailed. Table 7 shows a range of intense sweeteners and blends commonly used to replace sugars in soft drinks. Intense sweeteners can be either from naturally-sourced (e.g. stevia and thaumatin) or synthetic sources. The use of intense sweetener blends may produce a better quality of sweetness than the use of a single sweetener depending on the formulation. Owing to the very low levels of intense sweeteners required, ‘sugar free’ formulations with virtually no calories can be created, if significant levels of juice components are not used in the formulation. Other routes to reducing sugars include the use of a blend of sucrose with fructose or high fructose corn syrup (HFCS). Fructose has the same calorie content as other types of sugar gram for gram, but owing to the significantly higher sweetness, it can potentially reduce the level of sucrose in a recipe. The use of intense sweeteners is only allowed in certain categories and if the formulation can demonstrate that it is significantly energy reduced (30%) compared to a similar product on the market or is a product which contains no added sugars.

Drink type	**Intense sweeteners and blends**
‘Sugar free’ and ‘no added sugar’	Acesulfame K Aspartame Aspartame-Acesulfame salt Saccharin and its salts Saccharin Sucralose Intense sweetener blends: e.g. Aspartame/Acesulfame K
Reduced sugar	Sucrose/Fructose/HFCS Glucose/intense sweetener Sucrose/Intense sweetener

Table 7: Intense sweeteners and blends commonly used in reducing sugars in soft drinks

4.2 Dairy products

Dairy ingredients used in soft drinks include a wide variety of milk-derived ingredients that have been produced by mechanical separation (i.e. centrifugation, evaporation, drying, etc.), fermentation, enzymatic treatment, or acidification. Additionally, milk or milk ingredients are extensively used for the preparation of desserts, ice creams and cream liqueurs, amongst others. In this report, the most commercially important sweetened dairy products will be reviewed. These include:

- Yoghurts
- Milk-based beverages
- Dairy desserts
- Ice cream and frozen desserts

Sugars in dairy products

The total sugars present in dairy products are usually a combination of intrinsic and added sugars (often added to increase sweetness). The intrinsic sugars refer to the naturally occurring sugars already present in milk and, therefore, also present in most dairy products. Lactose, a disaccharide formed of glucose and galactose units, is the only intrinsic sugar present in milk. The level ranges from 4.2-5.0%. Lactose has very low solubility in water and, consequently, if not treated correctly, it can confer a “sandy” texture in concentrated milk or frozen dairy products. Lactose, like any sugar, greatly contributes to the physical properties of milk. Changes of lactose levels in milk will determine parameters such as osmotic pressure, freezing point and boiling point. These parameters will need to be taken into consideration when reformulating dairy products containing added sugars.

Since lactose is considerably less sweet than sucrose, the addition of other sugars or other sweeteners can be necessary in dairy products in order to increase the sweetness to the desired level. Additionally, the total sugars present in products such as yoghurts, trifles and cheesecakes containing fruit preparations can also be increased by the sugars present in the fruit layers. These will contain the naturally occurring sugars found in fruit (mostly fructose, sucrose and glucose) as well as the added sugars used to confer the right sweetness to the fruit layer. Finally, numerous types of flavourings containing sugars are used in frozen desserts and yoghurt. Examples of these flavourings are caramel and chocolate swirls, sweets, cookies, cake bits, enrobed nuts, etc.

The typical levels of sugars in selected dairy products are shown in Table 8.

Product type	Typical levels of sugars (g/100g)
Whole milk	4.6
Flavoured milk	8.9
Fruit low fat yoghurt	12.7
Vanilla ice cream	22.0
Chocolate dairy desserts	24.0
Luxury ice cream with chocolate	28.4

Table 8: Typical levels of sugars in selected dairy products

Source: McCance and Widdowson (2015). The Composition of Foods

The role of sugars and the challenges of removing sugars in dairy products

Whilst the main aim of adding sugars to dairy products might be the increase of the sweet taste and flavour, sugars also impart numerous other functional properties such as desirable organoleptic attributes, better shelf-life and chemical and physical properties. An overview of the functional properties of sugars in dairy products is given in Figure 2.

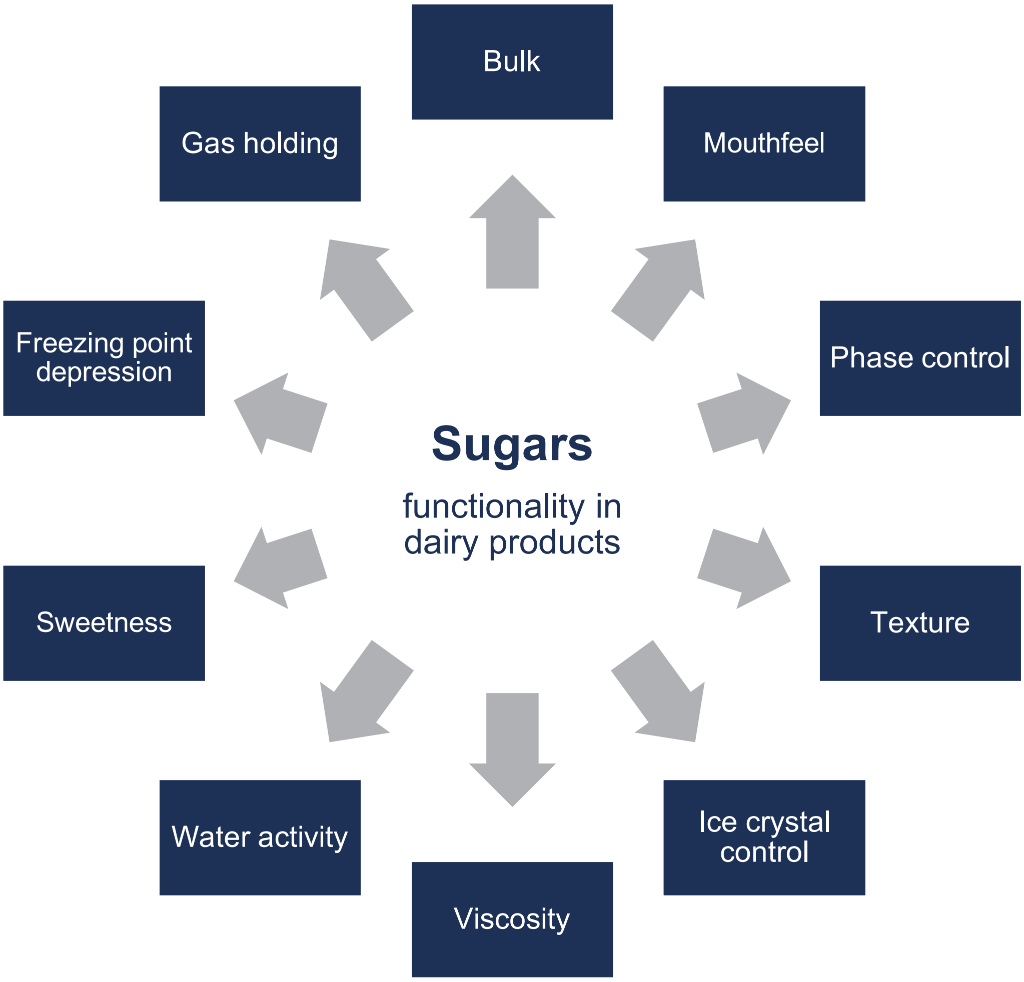

Figure 2: Functional properties of sugars in dairy products

The presence of sugars affect the freezing point of ice creams and frozen dairy products since the freezing point decreases as the concentration of sugars increases. A low freezing point is an important parameter in frozen products as it reduces the formation of large crystals of ice that might confer a gritty texture. Since dissolved sugars have the ability to bind water, diminishing the water available for crystallization, the addition of sugars therefore promotes the formation of small ice crystals that are not noticed in the mouth thus preserving the smooth soft texture of ice creams and frozen dairy desserts.

Sugars provide good dispersion of fats in ice creams. It also increases the stability to heat shock and preserves the texture when the products are subjected to freeze-thaw cycles (i.e. being in and out of the freezer). Additionally, sugars increase the viscosity or thickness of frozen desserts, yoghurts and flavoured milks, which helps to increase the smoothness perceived in the mouth. Sugars, despite not being fat substitutes, can be used in lower fat products to increase flavour, texture and to supply bulk for the missing fat.

Sugars also protect proteins from denaturation and have the ability to stabilize protein foams. These two attributes are very important in custard and mousse applications, respectively. The sugars present in a custard help to disperse the protein molecules within the mixture and increase the setting temperature of the custard, allowing the egg proteins to coagulate slowly and entrap the rest of the ingredients, forming a homogeneous gelled matrix.

The low temperatures of frozen desserts affect flavour perception since the taste buds become less sensitive. In this case, sugars act as a flavour enhancer, eliminating the need for additional flavouring.

In chocolate-flavoured milks, the addition of sugars serves to increase the product viscosity to impart a richer, thicker mouthfeel, and also to enhance the flavours of the cocoa and milk.

Sugars are also necessary as a precursor in the development of flavours through caramelisation in some desserts such as crème caramel or sweetened condensed milk, where the sugars are subjected to high temperatures promoting changes in colour (browning) and the creation of new flavours. Sugars are important in some dairy desserts such as crème brûlèe where a burnt sugar crust gives the typical flavour, appearance and texture of this dessert.

Sugars play an important role in the preservation of products such as condensed milk. The high levels of sugars present in this type of product increase the osmotic pressure of the media, where microorganisms are not able to grow and multiply, and the shelf-life of the product is amply extended.

The added sugars in fruit preparations found in some dairy desserts possess functional properties other than providing sweetness and bulk. Sugars are also essential in the gelling process of such preparations since it greatly influences the gelation ability of the gelling agent (pectin) normally used in such preparations. Sugars prevent the spoilage of these products by lowering their water activity to levels where microorganism growth is inhibited. In addition, it also helps retain colour of the fruit by attracting and holding water, preventing the fruit from absorbing water that would fade by dilution.

Guidance for reducing calories through reducing sugars

Yoghurts

The nutritional values of typical sweetened and plain fat-free, whole fat and Greek-style yoghurts are presented in Table 9. In a product like yoghurt, the reduction of sugars might lead to an increase in the percentage of protein and fat present in the product, which possess the same or higher energy densities than sugar. Consequently, in protein-rich products such as yoghurt and in fat-rich products such as dairy desserts, the reduction of sugars might not necessarily result in an energy reduction.

Product	**Carbohydrates (sugars) (g/100g)**	**Fat (g/100g)**	**Protein (g/100g)**	**Energy (kcal/100g portion)**
Plain Greek-style yoghurt	4.8 (4.5)	10.2	5.7	133
Plain whole fat yoghurt	7.8 (7.8)	3.0	5.7	79
Plain fat free yoghurt	8.2 (7.9)	0.2	5.4	54
Sweetened fruit flavoured fat free yoghurt	10.1 (9.4)	0.2	4.8	59
Sweetened fruit flavoured Greek-style yoghurt	11.2 (10.5)	8.4	4.8	137
Sweetened fruit flavoured whole fat yoghurt	17.7 (16.6)	3.0	4.0	109

Table 9: Typical nutritional values of sweetened and plain yoghurts

Source: McCance and Widdowson (2015). The Composition of Foods

Intense sweeteners and polyols can be used to replace sugars in energy reduced or 'no added sugar' yoghurt formulations. The stability of sweetening ingredients during processing or cold storage of yoghurt is a decisive factor for their incorporation into the manufacturing process.

Stirred and set yoghurts can be made using acesulfame K and sucralose since these are not degraded during the fermentation. Blends of acesulfame K with aspartame and/or sucralose offer optimal sweetness and flavour impact. Addition of small quantities of oligosaccharides (long chain sugars) such as inulin or oligofructose, polydextrose, or tagatose can round off the sweetness profile and usually provide improved mouthfeel in low-fat yoghurts. For layer-style yoghurt, addition of thickeners is recommended, in order to avoid mixing the fruit and yoghurt layers.

Aspartame can be used in sour milk products since it is stable at low pH (around 4) where hydrolysis occurs at a very slow rate. However, it might degrade during the fermentation process in set yoghurts as the fermentation temperature and neutral pH accelerate the degradation of this molecule. In order to overcome this problem, it is advisable to use cultures that quickly decrease the pH of the milk. In layered yoghurts, aspartame can be added to the acidic fruit component to completely avoid the loss of sweetener. In any case, aspartame should be used in short shelf-life products only owing to its stability.

Stevia can also be used in the production of yoghurt as it is not degraded during fermentation and is stable over a wide range of pH (2-10).

Isomaltulose, although completely absorbed during digestion, gives a low glycaemic index. Since it is not fermented by environmental microbes and lactobacilli, it can be used as a non-fermentable carbohydrate in the production of yoghurts. Sorbitol needs to be used in conjunction with sucrose since it reduces the growth rate of the starter culture when added before fermenting the milk.

Flavoured milk

In flavoured milks, intense sweeteners can be used in energy reduced and 'no added sugar' products. However polyols are not permitted when used in formulations for its sweetening purposes. In flavoured milk and cocoa beverages, acesulfame K, aspartame and sucralose have the advantage of being fully stable during high temperature treatment and subsequent storage at room temperature for several weeks. Depending on the desired sweetness level, these intense sweeteners should be used as the single sweeteners, or in blends with other stable sweeteners such as sucralose or cyclamate. Blends with aspartame should be used for products having limited shelf-life only, preferably in products intended for storage at low temperatures. Aspartame is not suitable for milk products with a neutral pH value.

Stevia can also be used in flavoured milks as it is able to resist high temperature treatments (up to 140℃ for 1 h) and subsequent storage at room temperature.

Ice cream and frozen desserts

As mentioned before, in ice cream, sugars are used not only as a sweet-tasting compound, but also as a functional ingredient. Therefore, this functionality must be replaced by adding bulking agents such as polydextrose or polyols. However, high intensity sweeteners such as acesulfame K, sucralose and neotame, which are not affected by pasteurisation and storage, can be used to increase and round the sweetness of ice cream containing polyols. Aspartame, albeit not being stable at neutral pH, can be used in ice creams, since the low temperatures prevent its decomposition.

Different combinations of bulking agents can be used to achieve the required freezing point depression. This, consequently, will influence the amount of intense sweeteners used, as the different bulking agents provide different levels of sweetness.

Polyols used in the production of reduced sugar frozen desserts include lactitol, maltitol, mannitol, sorbitol and xylitol. These have the ability to depress the freezing point of ice creams and frozen desserts and inhibit crystallisation of other sugars, resulting in frozen products with scooping properties comparable to those of the standard product. Xylitol, however, is not recommended as a sole sweetener because it depresses the freezing point of the product excessively making it too soft, and requiring the addition of thickening agents. Care also needs to be taken when reformulating low sugar frozen desserts with isomalt since this can crystallise due to its low solubility when used at levels higher than 15%.

Fructose offers another approach in reducing sugars in frozen desserts as it has an excellent taste and flavour enhancing qualities. Fructose has a sweetening power 1.7 times of that of sucrose and therefore, the sugars content can easily be almost halved by substituting sucrose with fructose in dairy frozen products. Being a digestible carbohydrate sugar with the same calories as sucrose, it decreases the freezing point further than sucrose.

4.3 Bakery products

Sugars in bakery products

The bakery products category is quite varied covering many different types of products including cakes, biscuits and pastries, which are referred to in regulations as ‘fine bakery wares’. The total level of sugars in bakery products can range from about 3% in white bread to 40% in fruit cake and 45% in iced biscuits. For this category of product it is important to look at not only the sugars contributed by the base product, but also to understand the levels of sugars contributed by additional components such as fillings, icing, chocolate coating etc., which can be significant (see section 1).

The common form of added (extrinsic) sugars in bakery products is sucrose, but a highly varied range of other sugars are used in bakery products. These include; invert sugar, fondant, brown sugar, molasses, fructose, starch hydrolysates, honey and malt syrup. The two main sources of commercial sucrose are from sugar beets and sugar cane. A common source of intrinsic sugars in bakery products is from the use of fruit-based ingredients. The first step of a reformulation exercise for an existing bakery product is the evaluation of the sugars contained within each component of the product (e.g. fillings, icing), followed by calculating the amount of sugars that each component ingredient contributes to the overall product. Table 10 gives some typical levels of sugars found in common product components used in bakery products.

Bakery component	**Typical levels of sugars (%)**
Fatty filling	40-50
Chocolate coating	50-60
Icing	70
Jam	70
Dried fruit (sultanas and raisins)	70

Table 10: Typical levels of sugars found in components used in sweet bakery products

Source: McCance and Widdowson (2015). The Composition of Foods

The role of sugars and the challenges of removing sugars in bakery products

Aside from sweetness, sugars also influence many product properties such as the volume, moistness, tenderness, colour, appearance, and energy content of baked products. Figure 3 outlines some important properties influenced by sugars in bakery products.

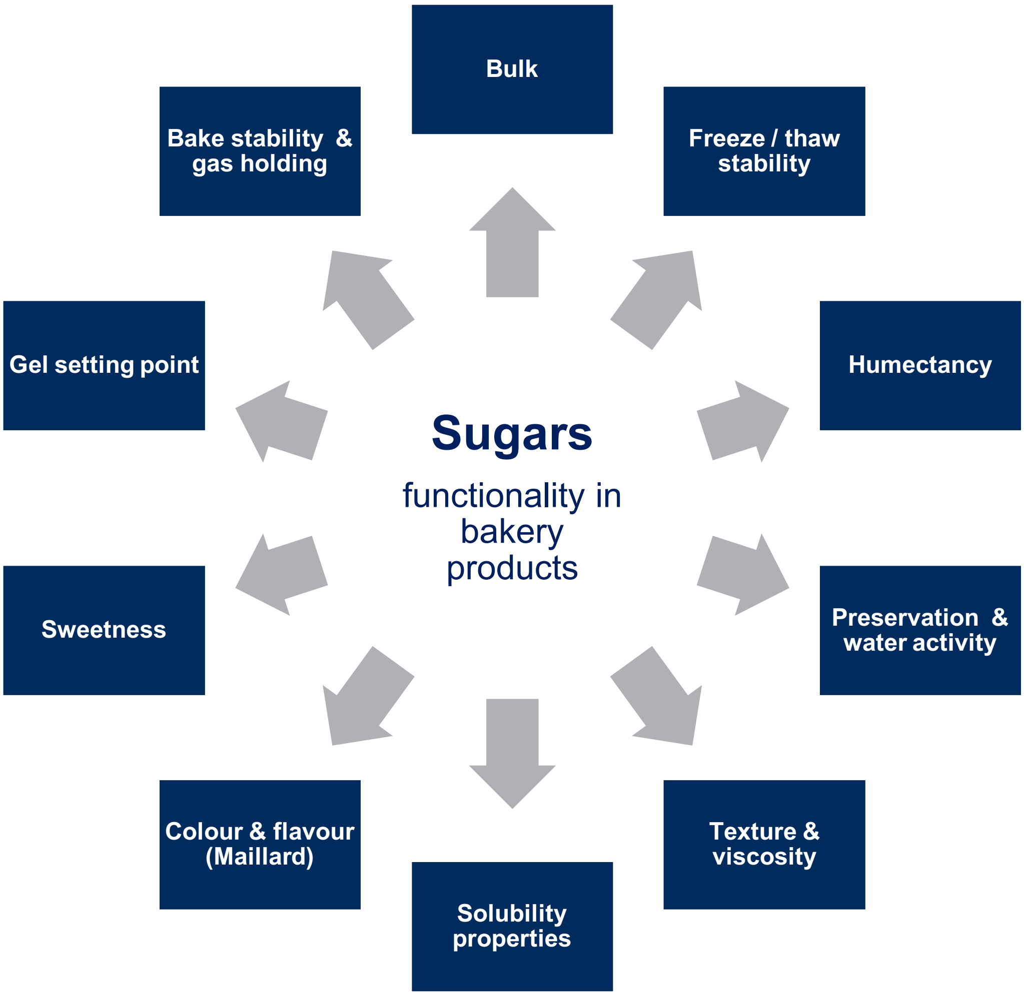

Figure 3: Functional properties of sugars in bakery products

Cakes

Most of the cellular structure of the cake is derived from egg protein. Air is the leavening agent that has been beaten into the eggs. Sugars function as a whipping agent to stabilise the beaten foam. Sugars also raise the temperature at which egg proteins set, thereby delaying coagulation long enough to permit entrapment of optimum air. This results in the cake having a tender texture and good volume. Sugars also help produce fine crumb texture and good volume during mixing and baking. During mixing, sugars tenderise cakes by absorbing liquid and preventing complete hydration of gluten strands. During baking, sugars tenderise shortened cakes by absorbing water and delaying gelatinisation. In addition, sugars give rise to a good taste, producing sweet flavours, a soft texture and brown surface colour in cakes.

Biscuits

In biscuits, sucrose, the commonly used sugar, introduces air into the batter during the creaming process. Approximately half the sucrose is thought to remain without dissolving at the end of the mixing stage. When the biscuit dough enters the oven, the temperature causes the shortening to melt and the dough to become more fluid. The undissolved sucrose dissolves as the temperature increases and the sugar solution increases in volume. This leads to a more fluid dough, allowing the cookies to spread during baking. Adding sucrose to biscuit recipes also helps to produce a good surface appearance, in some cases surface-cracking to enhance the sensory quality. Sucrose also contributes flavour, caramelising while the biscuits are baked.

Pastries

The levels of sugars in pastries, e.g. Danish pastries can be 20% or more. Pastry products are often composed of many components (pastry, icing, filling etc.), and therefore it is important to consider each component separately, considering the role that the sugars play in the structure and sensory properties of each component. In pastries, sugars are not only important for sweetness but the overall flavour, texture and stability. Any strategy for reducing sugars in these products will need to identify the amount of sugars contributed by each component as the first step and the consequences of reducing sugars in each component.

Fruit pies

In fruit pies, sugars can be present in the pastry case as well as the fruit filling and the total sugars can be more than 30%. The levels of sugars in the pastry component may be about 15% whereas the filling can be significantly higher. The sugars present in the pastry will provide sweetness and contribute to the structure. In the fruit filling, the levels of sugars will be made up of both added sugars and sugars present in the fruit/juice ingredients. The presence of sugars in the filling not only provides sweetness and flavour, but will aid gelling of the pectin in the fruit filling, and contribute microbiological stability.

Guidance for reducing calories through reducing sugars

Considerations

When reformulating to develop recipes with reduced sugar content, various problems may arise. For instance, the reduction of sugars in baked goods results in a loss of viscosity and body due to low solids, poor aeration, no browning, loss of shelf life and poor flavour release. Usually, a reduction of 15-20% can be reasonably achieved; however, a high level of reduction (more than 50%) is very challenging due to the multiple functions of sugars in baked products.

In bakery products such as cakes with a higher water content, shelf life issues such as staling and microbial spoilage can be major problem when sugars are removed and therefore these points need to be addressed before the reformulation work is carried out.

Reducing and replacing sugars in bakery products

When reducing the sugars in bakery products, it is important not only to address the reduction in sweetness, but importantly how to replace the bulk properties, as the main functions of sugars in baked goods are to provide bulk, volume, structure and tenderness. Consequently, in order to achieve an acceptable texture, addition of bulking agents such as polyols, polydextrose, gums, or modified starch will be necessary. Polyols are commonly used to replace sugars but it is important to note that when reformulating cakes, biscuits and pastries (and also the pastry component of fruit pies), polyols are only permitted to be used in energy-reduced and 'no added sugar' products.

The polyols used in these products include lactitol, erythritol, maltitol and xylitol. An important point to understand is that intense sweeteners e.g. sucralose, are not permitted in cakes, biscuits, pastries and pastry cases of fruit pies. Labelling is required when the polyol content exceeds 10% of the product. Foods containing more than 10 % added polyols must carry the warning 'excessive consumption may produce laxative effects'. It is vital to refer to the regulatory restrictions when reformulating bakery products.

It is worth noting that polyols do not contain a reducing end group, thus they possess remarkable heat stability and do not take part in Maillard browning reactions. As a consequence, baked goods formulated with polyols will develop less colour during the baking process than those formulated with sugars. Crystalline maltitol, which presents high sweetness and excellent humectancy properties, is said to be a perfect bulk sweetener for use as in bakery products including sponge cakes. Maltitol also gives normal viscosity to biscuit doughs, as well as good open structures and a very crispy texture. In the case of biscuits, replacing all the sucrose by maltitol in hard and shortbread biscuits has been suggested as a good route to producing sugar free biscuits. Maltitol is said to give a good open structure, together with a sandy and very crisp texture in the biscuits.

Lactitol, a polyol derived from lactose is stable at high temperatures and over a wide range of pHs, behaving like sucrose in food processing. Subsequently, lactitol can substitute sugars, weight for weight, although the reduced level of sweetness will need to be addressed. Baked products manufactured with lactitol are said to be similar in characteristics to their sucrose counterparts. The addition of humectants is recommended in products where moist texture is expected.

Most ‘no added sugar’ or reduced-sugar bakery items including cakes, biscuits and pastries can be formulated with xylitol. Xylitol, being the sweetest of the polyols and presenting a sweetness equal to that of sucrose, can be used as the sole sweetener in baked goods with minimal recipe adjustment. Xylitol also presents good humectant properties, which is desirable for obtaining moist sponges and muffins.

Sugar and calorie reduction can also be achieved by using erythritol, a non-caloric bulk sweetener, at concentrations between 7 and 10%. Biscuits, cookies and sponge cakes containing erythritol present a different melting behaviour and therefore may produce a more compact dough than those formulated with sucrose.

Polydextrose has also been found to be a useful ingredient to replace sucrose in bakery products, as it increases starch gelatinisation temperature and has similar solution viscosities to sucrose. It has therefore been suggested for use in sucrose-reduced cakes. Other soluble fibre ingredients such as inulin and oligofructose have been shown to improve taste and texture in baked goods and are often used not only as sugar replacers but also as fat replacers.

Interestingly, reducing sugars in baked goods can also be achieved by using the bulk sugar fructose. Crystalline fructose, has a sweetening power 80% greater than that of sucrose, and is therefore an effective ingredient for reducing sugars in baked products. It presents excellent humectant properties helping to retain moisture in cakes and granola bars. Fructose also exhibits flavour-enhancing properties and extends the shelf-life of products by lowering the water activity.

Reducing sugars in bakery products with more than one component

In the case of multi-component products e.g. iced or chocolate coated cakes, filled/glazed sweet pastries and fruit pies significant reduction in calorie content is possible through the adjustment of the individual components added to the base cake or pastry.

In fruit pies, the total sugars content is composed of sugars present in the pastry and sugars in the filling. The important point to remember when reformulating products containing more than one component such as fruit pies, is that each component has to be considered separately. It is important to be aware that the pastry component of fruit pies is considered as ‘fine bakery ware’, whereas the filling component is not part of this category. Therefore regulatory constraints for the pastry component will be the same as for other fine bakery products within the category (cakes/biscuits/pastries).

The following strategies can be used to reduce the sugars in fruit pies and pastries with a filling:

- Reduce sugars in pastry
- Reduce sugars in filling
- Change the ratio of pastry to filling

The ingredients which can be used in the pastry to replace sugars will be the same as suggested for cakes and biscuits. However, before reducing the sugars in the filling, it is important to consider regulatory constraints for the relevant filling type. In the case of fruit pies, the fruit content and added sugars in the filling can be adjusted to reduce sugars. By making adjustments to the ratio of pastry to filling, significant reductions in sugars may also be possible.

Some limited calculations made on typical home recipes of sponge cakes containing fillings such as jam and cream with toppings of icing or dusted with sugars, indicate that substitution of the sucrose in the fillings and toppings by polydextrose can give a calorie reduction (per 100 g) of approximately 10-20%, which can be raised to 25-30% if the 'cream' filling fat is also replaced by a hydrocolloid or carbohydrate, without adjustment of the base cake mix recipe.

Conclusion

This reformulation guide provides an overview and highlights the importance of the regulatory framework and the need to understand the functions of sugars in specific products, before undertaking any reformulation to reduce the sugar content of products. Various reformulation options are available, including changing the ratio of product components, depending on the product category and regulatory constraints. A key consumer consideration is to be aware of the energy content of any reformulated products; this should not increase as a result of reducing sugars. Specific examples have been highlighted for soft drinks, dairy and bakery product categories.

About Leatherhead Food Research

Leatherhead Food Research provides expertise and support to the global food and drink sector with practical solutions that cover all stages of a product's life cycle from consumer insight, ingredient innovation and sensory testing to food safety consultancy and global regulatory advice. Leatherhead operates a membership programme which represents a who's who of the global food and drinks industry. Supporting all members and clients, large or small, Leatherhead provides consultancy and advice, as well as training, market news, published reports and bespoke projects. Alongside the Member support and project work, our world-renowned experts deliver cutting-edge research in areas that drive long term commercial benefit for the food and drink industry.

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Science Group plc offers independent advisory and leading-edge product development services focused on science and technology initiatives. Its specialist companies, Sagentia, Oakland Innovation, OTM Consulting and Leatherhead Food Research, collaborate closely with their clients in key vertical markets to deliver clear returns on technology and R&D investments. Science Group plc is listed on the London AIM stock exchange and has more than 350 employees, comprised of scientists, nutritionists, engineers, mathematicians and market experts.

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About FDF

Representing a sector made up of over 6,500 companies - the vast majority of which are micro to medium-sized - FDF are helping companies to understand the regulatory and voluntary frameworks that they are operating in and what this means for them as businesses.

Within the health agenda we are helping our members, both large and small, to play their part - whether that's introducing them to reformulation considerations, helping them to understand the implications of labelling regulations or building awareness of Government's priorities.

This guide has been developed in conjunction with Leatherhead Food Research to assist companies without large R&D resources to begin the reformulation process by providing guidance, considerations and information which can help them on their journey to healthier products.

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