

FACTS ABOUT SUGARS



1. INTRODUCTION

Sugars are found in nature. All green plants providing foodstuffs, including fruits and vegetables, grains, as well as milk and honey, contain naturally-occurring sugars.

Many types of sugars are found in the diet on a daily basis. These include, for example, glucose, fructose, sucrose, and lactose. When the term 'sugar' is used, people are referring to 'sucrose' (table sugar^a).

Over recent years, a debate has arisen over the amount of sugars people should eat and the potential effects sugars may have on health. This brochure explores the science around sugars and intends to put the evidence on sugars and health into context.



^aTable sugar is produced from sugar beet or sugar cane.

1.1 Biochemistry of sugars

Sugars are carbohydrates^b. As such, they provide the body with the energy that our organs and muscles need to function. Sugars are typically named in relation to their size and chemical structure (Figure 1).

Monosaccharides are single unit sugars with 'mono' meaning 'one' and 'saccharide' meaning sugar molecule. Monosaccharides commonly found in food are glucose, fructose and galactose.

Disaccharides consist of two monosaccharides joined together. Disaccharides commonly found in food are sucrose (glucose + fructose), lactose (glucose + galactose) and maltose (glucose + glucose).

Oligo - and polysaccharides contain more than two monosaccharides joined together. Starch is a well-known polysaccharide. Other examples include fructo-oligosaccharides and malto-oligosaccharides.

Oligo - and polysaccharides are sometimes called 'complex carbohydrates' in recognition of their size difference from mono- and disaccharides, which are classed as 'simple sugars' due to their small size. It is mono- and disaccharides which are the focus of this brochure.

Figure 1: Sugars Terminology

MONOSACCHARIDE	DISACCHARIDE
Contains a <i>single</i> saccharide molecule Examples: Glucose, fructose, galactose	Contains <i>two</i> saccharide molecules Examples: Sucrose (glucose + fructose) Lactose (glucose + galactose) Maltose (glucose + glucose)

Source: Cummings and Stephen (2007)² EUFIC (2012)¹

Carbohydrates, including sugars, provide 4 kilocalories of energy per gram which is similar to the calorie content of protein. In comparison, fats provide 9 kilocalories per gram and alcohol provides 7 kilocalories per gram^c.

^b Carbohydrates are one of the three macronutrients in our diet, in addition to fat and protein. The building blocks of all carbohydrates are sugars and they can be classified according to how many sugar units are combined in one molecule¹.

^c Regulation (EU) No 1169/2011.

1.2 Where are sugars found?

Sugars such as sucrose, glucose and fructose, are formed during the photosynthesis process (i.e. when plants use the energy of the sun to convert water and carbon dioxide into sugars)³. There are other natural forms of sugars, like lactose and galacto-oligosaccharide, which are found in human milk^{4,5}. See Table 1 below.

Table 1: Sources of sugars

SUGARS FORMS	EXAMPLES OF FOOD SOURCES
MONOSACCHARIDES	Can be found in commonly-eaten foods such as fruits, vegetables and honey, and are a component, as explained earlier, of disaccharides and other forms of sugars.
Glucose	Fresh, dried and cooked fruits, honey and most vegetables, glucose syrups, which are derived from wheat and maize starch.
Fructose	Honey, agave nectar, fruit juices, pure crystalline fructose and glucose-fructose syrups ^d which are derived from wheat and maize starch.
DISACCHARIDES	
Sucrose	Table sugar, which is derived from sugar beet or cane as these vegetables provide the most accessible stores of sucrose. Fruits and vegetables (e.g. peaches, pineapple and carrots).
Lactose	Milk and milk products e.g. buttermilk, curds, whey, malted milk, sweet or sour cream and yoghurt.
Maltose	This is formed mainly when starch is digested e.g. from barley and other grains such as wheat.

Source: Information extracted from: Cummings & Stephen (2007)²; Southgate et al. (1978)⁵; www.fructose.org⁶; Ferder et al. (2010)⁷.

^d Also known as isoglucose or, in the US, as high fructose corn syrup.

1.3 What terminology is used for sugars?

Several different terms are used to categorise sugars depending on their source and some of them overlap. Common ones are defined here:

- **TOTAL SUGARS** – This includes all sugars, whatever their food source (whether added or naturally present in foods), i.e. all monosaccharides and disaccharides. The amount of total sugars is provided in nutrition labelling in the EU².
- **FREE SUGARS** – Monosaccharides and disaccharides added to foods and beverages by the manufacturer, cook or consumer, and sugars naturally present in honey, syrups, fruit juices and fruit juice concentrates⁸.
- **ADDED SUGARS** – Sugars and syrups added to foods during home preparation or food processing, e.g. sugars mentioned in the ingredients list of a food product².
- **INTRINSIC SUGARS** – Sugars naturally found within the cellular structure of a food e.g. within whole fruits and vegetables².
- **EXTRINSIC SUGARS** – Sugars that are not found within the cellular structure of food, e.g. sugars naturally found in milk and fruit juice as well as added sugars².
- **NON-MILK EXTRINSIC SUGARS** – All extrinsic sugars (apart from milk sugar - lactose) added to foods in cooking or at the table, e.g. sugars added to drinks, breakfast cereals or during food processing².

This variety of terminology can lead to confusion and make it difficult for scientists and consumers to compare sugars intakes and recommendations across the world.



1.4 How are sugars digested and handled by the body?

The digestion of sugars is a well regulated process. Disaccharides and oligosaccharides are broken down into monosaccharides in the digestive system and these monosaccharides are then absorbed by the small intestine (gut) into the bloodstream where they are transported to places of use¹. All carbohydrates, no matter whether they started out as sugars or starch, eventually end up as glucose or fructose after digestion⁴.

Naturally-occurring v. added sugars

The human body does not differentiate between sugars naturally present in food and added sugars, as they have the same chemical and physical characteristics and are therefore digested in the same way^{9,e}.

1.5 Why do we need carbohydrates such as sugars?

Carbohydrates such as sugars provide the body with energy in the form of glucose, which is essential for the optimal functioning of the brain, muscles and nervous system under normal conditions. Glucose in food is absorbed very easily and performs a unique and vital role as a preferred source of energy for the brain². **About 130 grams of glucose is needed daily to fuel the brain¹⁰.**

1.6 Are sugars addictive?

Addiction, often referred to as dependency, is a medical term characterised by a compulsion to consume that is driven by cravings. In addiction, tolerance occurs over time so that increasing amounts of the substance are needed simply to achieve the same effect. If the substance is no longer consumed, withdrawal effects are experienced, making it difficult for a person to quit the substance.

Although media reports of studies in mice and rats have raised some concerns about whether sugars may be addictive, scientific studies in humans do not support the hypothesis that sugars are physiologically addictive. Recently, NeuroFAST, an EU-funded project to investigate the biology involved in eating behaviour, addiction and stress indicated that **the current evidence does not allow concluding that a single food substance can account for the fact that people overeat and develop obesity¹²**. In humans, there is no evidence that a specific food, food ingredient or food additive causes a behavioural condition like overeating¹¹.

In particular, findings from a review paper concluded that there was no evidence to support previous beliefs that sucrose was addictive or that it could contribute to overeating and obesity¹³.

^e Please see part 4 on sugars and health.

1.7 Consumption recommendations and intake trends

European guidelines advise that 45-60% of our daily energy intake should come from carbohydrates, including sugars¹⁰. In 2010, the European Food Safety Authority ('EFSA') concluded that "the available evidence is insufficient to set an upper limit for intake of (added) sugars based on their effects on body weight" and on non-communicable diseases like Type-2 diabetes, dental caries and cardiovascular risk factors¹⁰.

The World Health Organisation ('WHO') in 2015⁸ developed a set of recommendations calling for:

- A reduced intake of free sugars throughout the lifecourse (strong recommendation).
- In both adults and children reducing the intake of free sugars to less than 10% of total energy intake (strong recommendation).
- A further reduction of the intake of free sugars to below 5% of total energy intake. WHO classifies this recommendation as a conditional recommendation^f, and as such, clarifies that there is a need for substantial debate and involvement of stakeholders before this recommendation can be translated into action.

In terms of sugars trends, according to the statistics of the Food and Agriculture Organisation of the United Nations, sugar (sucrose) supply in the EU has remained stable over the last forty years^{14,g}.

Published data looking at sugars intake trends found that only 13 countries in the developed world estimated sugars intakes from national nutrition surveys, with definitions of dietary sugars being highly variable. Overall, it was found that dietary sugars intakes were either stable or decreasing, with increased sugars intakes being only seen in certain subpopulations¹⁵.



^f According to the WHO guideline, strong recommendations indicate that "the desirable effects of adherence to the recommendation outweigh the undesirable consequences". This means that "the recommendation can be adopted as policy in most situations". On the other hand, conditional recommendations are made when there is less certainty "about the balance between the benefits and harms or disadvantages of implementing a recommendation". This means that "policy-making will require substantial debate and involvement of various stakeholders" for translating them into action.

^g FAOSTAT, go to <http://faostat3.fao.org/home/E>, then "food balances", select "food supply- crops primary equivalent", then select as item "sugar, refined equivalent"

2. SUGARS PRODUCTION

2.1 How Is Sugar Produced?

History Of Sugar

It is thought that the Polynesians first found stalks of giant grass containing a 'sweet liquid' (cane sugar). In 510 BC the Emperor Darius of Persia referred to sugar cane as "*the reed which gives honey without the bees*"¹⁷.

In Western Europe, sugar was introduced as a result of the crusades in the 11th Century AD, with talk of this "new pleasant spice". Use of sugar was first recorded in England in 1099 while, in 1493, Christopher Columbus took sugar cane to the Caribbean Islands where it flourished in the favourable weather conditions and fertile soil¹⁸.

Later on, the Napoleonic Wars (1803-1815) caused a blockade of ocean trade routes, limiting access to imported sugar cane, thus leading to increased sugar prices due to lack of imports and driving interest in home-grown substitutes. It was at this time that scientists (e.g. Andreas Marggraf) discovered that sugar could be extracted from sugar beets to replace cane sugar¹⁹.

Farming Of Sugar Beet & Cane

Sugar is a valuable agricultural commodity. About 80 per cent of the world's sugar comes from sugar cane and about 20 per cent comes from sugar beet²⁰. **Most of the sugar marketed in the EU comes from EU sugar beets grown and harvested in the EU (at least 80 to 85 per cent).** Sugar beet resembles root-crops such as parsnip. Sugar cane (*Saccharum officinarum*) is similar to bamboo, having a shiny outer coating and sweet, woody inner fibre (Figure 3). Sugar cane grows in the tropical and subtropical regions, while sugar beet grows in colder more temperate regions. In 2013, the world's largest producers of cane sugar were Brazil, India, China, Thailand and Mexico^{21,h}. The EU is the world's largest sugar beet producer²¹ with France, Germany, Poland and the UK producing the most.



^hInternational Sugar Organization Sugar Yearbook 2014 edition.

Figure 3: Sugar cane and sugar beet



Source: <http://www.agricorner.com>

Sugar Production Process

Sugar beet are perishable and progressively lose sugar content from the moment they are harvested. Therefore, beet sugar factories are located close to sugar beet fields, mostly in rural areas. Sugar beets are washed, sliced into small pieces (known as cossettes) and mixed with hot water. Lime and carbon dioxide are applied to clean the juice. The brown liquid is filtered and boiled under a vacuum to produce thick syrup. This then begins to crystallize and the crystals are separated from the syrup using a centrifuge¹⁷.

The processing of sugar cane is very similar. Sugar cane tends to be extracted in sugar mills in the country where it is grown through the following processes:

1. Cutting, shredding and crushing between heavy rollers.
2. Hot water spray and lime to clarify the juice.
3. Filtering of the brown juice produced.
4. Boiling of juice under vacuum to form a thick syrup.
5. Separation of crystals (raw sugar) and syrup (molasses) in a centrifuge.
6. Brown raw sugar or crystals is then exported around the world for local refining.

2.2 How are starch based sugars produced?

History

References to starch use date back to 3500 BC in Egypt (in papyrus). The first records describing the starch extraction process in Europe date back to 200 BC (from wheat in Romania).

The limited access to imported sugar cane during the Napoleonic Wars resulted not only in the discovery of sucrose extraction from sugar beet but also the extraction of glucose from starch. The process, called hydrolysis, was invented by Gottlieb Kirchoff in St Petersburg in 1811. The interest in the sugar substitute however decreased after sugar cane imports resumed in 1814 and it was not until the 1850s that glucose syrups started to be produced on a commercial scale in Europe. At that time they were made exclusively from potato starch. From around 1866 the US started to extract glucose syrups from maize starch and today in Europe too, glucose syrups are extracted from maize and wheat starch.

The production of starch based sugars

Starch together with other co-products (mainly fibres and proteins) is extracted from cereal and tubers (in the EU, the main raw materials used to produce starch are maize, wheat and starch potatoes).

The starch molecule is a long chain of glucose units. Through hydrolysis these long chains can be broken up into smaller chains to produce, amongst other starch derivatives, glucose syrups and dextrose (pure glucose).



In a process called isomerisation, some of the glucose units in glucose syrups can be converted to fructose to produce glucose fructose syrups.

Under EU food legislation, the word fructose is part of the syrup name when the syrup contains more than 5% fructose, as follows: glucose-fructose syrup up to 50% fructose and fructose-glucose syrup above 50% fructose. In Europe the most commonly produced of these syrups has a fructose content of

42%. In the US the most commonly produced such syrup contains 55% fructose. It is known there as high fructose corn syrup.

The term isoglucose is used in EU legislation and applies to glucose-fructose syrups which fructose content exceeds 10%. This term appears in technical literature but cannot be used to replace the glucose-fructose syrup and fructose-glucose syrup designations in food labelling.

3. SUGARS IN FOOD AND DRINKS

3.1 What is the function of sugars in foods?

Sugars play an important role in different foodstuffs. As well as bringing sweetness, they also have important biological, sensory, physical and chemical properties²². For example, sugars help provide the taste, texture and colour of foods, extend their shelf-life, which preserves the safety and quality of the food. Sugars can in some cases be reduced/replaced, but no other single ingredient can replace all the functions of sugars.

- Taste - Sugars generate flavours by interacting with proteins when heating; a process known as the Maillard Reaction.
- Texture - Sugars contribute to the texture of foods, providing sensations of crispiness in biscuits, for example.
- Colour -Again through the actions of the Maillard Reaction, sugars interact with food proteins giving certain foods a 'golden colour' e.g. bread and pastries.
- Shelf-life - Sugars improve the shelf-life of foods by lowering the water activity. Sugars reduce the amount of available water that supports the growth of micro-organisms (bacteria, mould and yeast) so they cannot multiply and cause food spoilage. This preserves the safety and quality of the food.



3.2 How are consumers informed about the content of sugars in foods and drinks?

In the EU, Regulation (EU) No 1169/2011 on the provision of food information to consumers harmonizes the way in which sugars must be labelled. The nutrition declaration must indicate the amount of total sugars and in the ingredients list, the types of sugars added must be declared.

Sugars can be added in foods as such or through other ingredients. When sugars themselves are used as ingredient, the types of sugars added in the product are labelled in the list of ingredients. Sometimes, ingredients containing sugars (whether naturally-occurring or added), instead of actual sugars, are used in products. In this case, the list of ingredients will refer to the ingredient.

In all cases, the way to find the amount of total sugars contained in a food or drink is to look at the nutrition declaration on the label.

Examples of food labels compliant with the Food Information to Consumers (FIC) Regulation:

Figure 4: Pineapple coconut & banana smoothie²³

**PINEAPPLE,
COCONUT &
BANANA SMOOTHIE**

A blend of apple juice, banana, pineapple juice and coconut milk

Ingredients:
Apple juice (42%), Banana Puree (21%) [Banana Puree, Lemon Juice], Pineapple Juice (20%), Coconut Milk (17%)

Storage:
Keep refrigerated.
Once opened
Consume within 1 day. Do not exceed the Use By date.

250ml
For Use by: See lid

NUTRITION:	Typical values Per 100ml
Energy:	271KJ/65Kcal
Fat:	2.5g
Of which Saturates	2.3g
Carbohydrates:	9.6g
Of which Sugars	9.4g
Fibre:	0.6g
Protein:	0.6g
Salt:	Trace

Figure 5: Crisp coconut specialty with coconut filling and almond

INGREDIENTS: DESICCATED COCONUT 25.5%, VEGETABLE FATS (PALM, SHEA), SUGAR, ALMOND (8%), SKIMMED MILK POWDER, WHEY POWDER (MILK), WHEAT FLOUR, TAPIOCA STARCH, EMULSIFIER: LECITHINS (SOYA), FLAVOURINGS, RAISING AGENT (SODIUM BICARBONATE). SALT.

NUTRITIONAL INFORMATION		
Typical values		per 100g
Energy	(KJ / Kcal)	2606 / 628
Fat	(g)	48.6
of which Saturates	(g)	29.7
Carbohydrates	(g)	38.3
of which Sugars	(g)	33.3
Protein	(g)	7.2
Salt	(g)	0.305

4. SUGARS AND HEALTH

As with any nutrient, excessive consumption can have a negative health impact. Therefore, sugars should be eaten in moderation within balanced diets and alongside active lifestyles that promote a healthy body weight²⁵. It is the overall diet that needs to be considered, e.g. total calorie intake and, besides this, sufficient physical activity. Consumers are provided with a variety of food and drink products in order to be able to compose a balanced diet that will suit their dietary needs.

4.1 What about the role of sugars in overweight and obesity?

Overweight and obesity

The role of sugars in obesity and overweight and the development of non-communicable diseases, such as type 2 diabetes, is much debated. However, overweight and obesity risk relates more closely to energy balance (calories in exceeding calories out), than to the sugar content of the diet²⁵. The development of overweight and obesity is due to an energy intake greater than energy expenditure, which is why the whole diet is relevant and not any single food⁴⁰. Excessive consumption of calories from any source is the main cause of obesity, not the foods providing the calories.

In the CARMEN intervention²⁶, 398 obese adults ate either a typical high fat diet or two types of low fat diet, one high in sugar and the other high in starchy foods. After 6 months, there were no differences in weight change between the high sugar and starch diets. In two other clinical trials^{27,28}, low calorie diets were used to induce weight loss with the experimental diet being much higher in sugar than the control diet. In both of these studies, weight loss was similar whether participants had high or low sugar diets – the overall calorie content was the most important driver of weight loss.

Diet quality

Regarding diet quality, it is also claimed that diets high in sugars may be lower in vitamins and minerals (also called micronutrients). However, a review paper found no relationship between high levels of added sugars in the diet and low levels of vitamins and minerals in the body²⁹, a view supported by the European Food Safety Authority ('EFSA') in its report ¹⁰.

4.2 What about sugars and dental health?

The frequent consumption of fermentable carbohydratesⁱ, including sugars, has been linked to risk of tooth decay (caries), but simply advising individuals to reduce their sugars intake without taking into account overall oral hygiene and the frequency of sugars consumption is unlikely to benefit dental health.

Fermentable carbohydrates not only include sugars, starch, but are also found in fruits^{30,31} and whole grains³². All fermentable carbohydrates contribute to the development of tooth decay by creating a favourable environment for bacterial fermentation in the mouth.

There is a clear consensus that frequency of consumption, and not the amount, of all fermentable carbohydrates represent a caries risk in the absence of proper oral hygiene and of use of fluoride toothpaste^{10, 33, 34, 35}. For example a detailed review found that 19 of 31 studies reported significant links between sugar frequency and dental caries, with only 6 finding the 'amount' of sugar to be related to dental caries³⁶.

EFSA¹⁰ concluded that caries development is not just influenced by the amount of sugars eaten, but also the frequency of consumption, oral hygiene and exposure to fluoride.

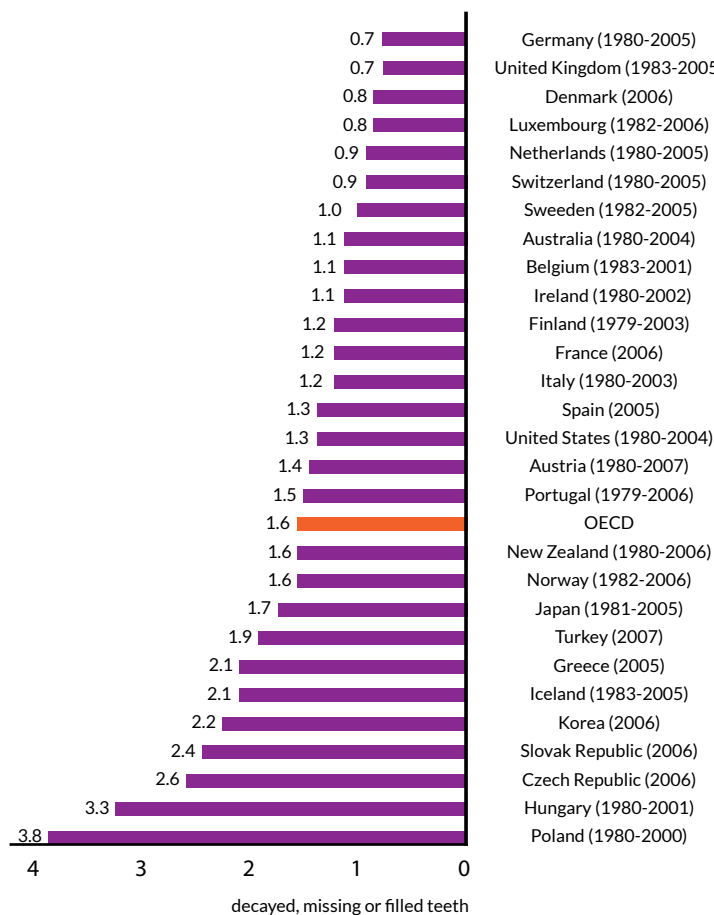
WHO and OECD data show that in Western countries, the trend of dental caries prevalence in children and adolescents has declined over the last 35-40 years while the average sucrose supply in these countries has remained constant^{37,38}. (see Figure 6)



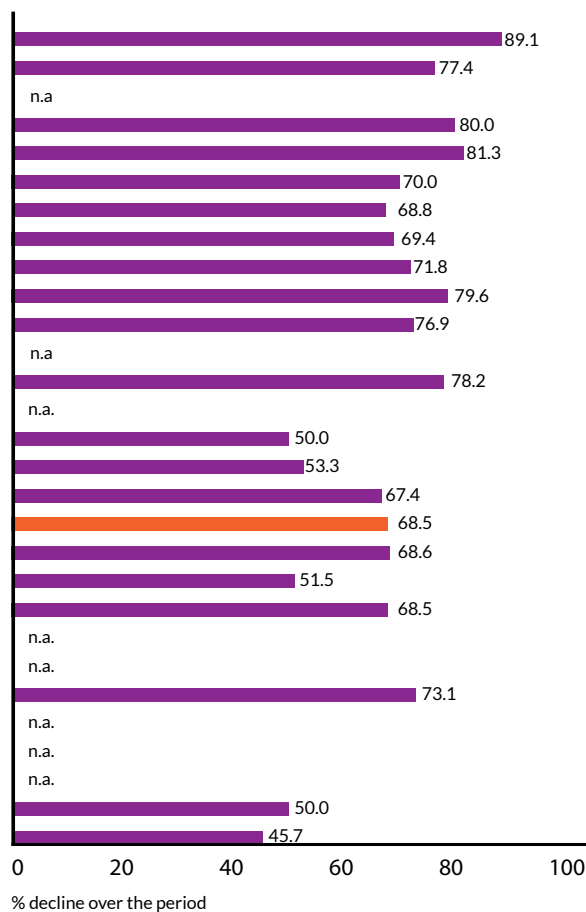
ⁱ Fermentable carbohydrates are carbohydrates or carbohydrate mixtures as consumed in foods or beverages that lower the plaque pH by bacterial fermentation in the mouth.^{10, 41}

Figure 6: Tooth decay in children in different countries

1.10.1 Average number of decayed, missing or filled teeth, 12-year-old children, 2006 (or latest year available)

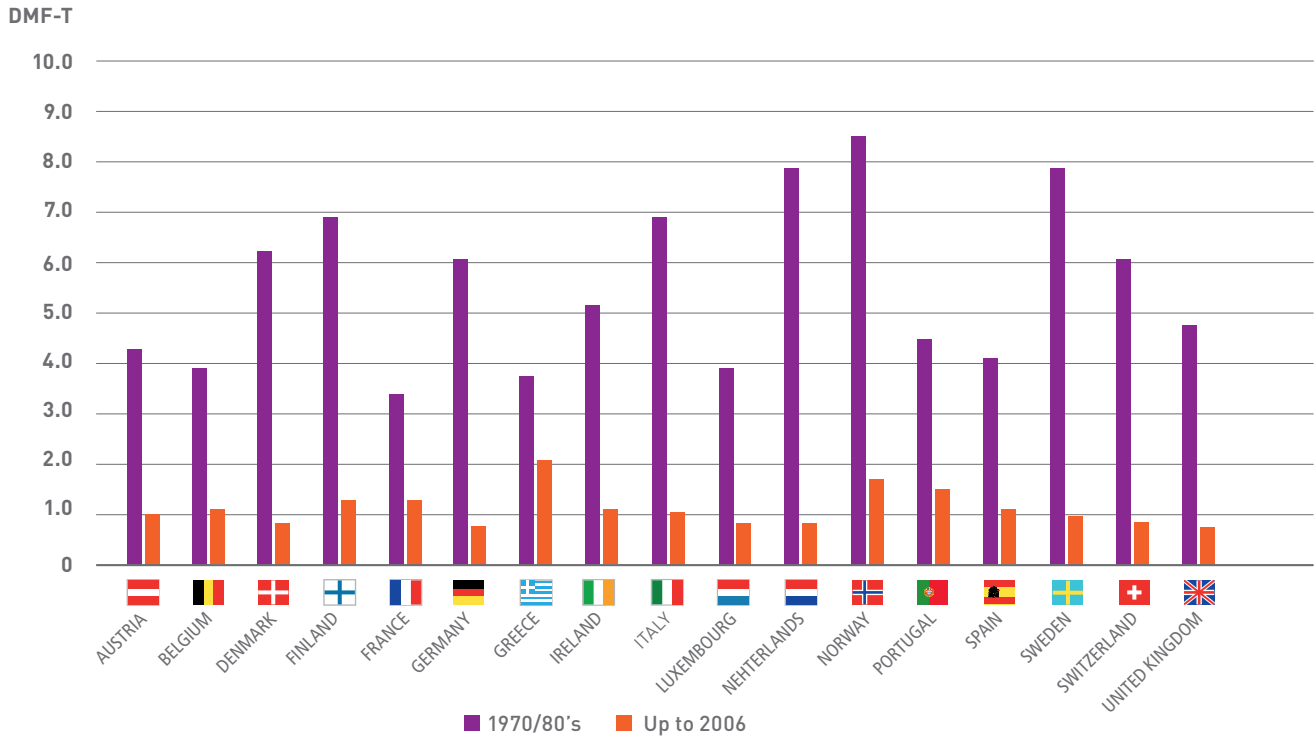


1.10.2 Decline in average number of decayed, missing or filled teeth, 12-year-old children, 1980-2006



Source: Health at a Glance 2009: OECD Indicators

Figure 7: Caries decline in 12-year-old children in Europe from 1970/80s to 2006



Source: WHO Europe Health for all Database & WHO Oral Health Country /Area Profile Programme & CECCO

Overall, the 'frequency' of fermentable carbohydrates exposure is a stronger risk factor for caries than fermentable carbohydrates' 'intakes'. Some simple lifestyle changes could help to reduce the risk of caries, including good oral hygiene using fluoride toothpaste³⁹ and reducing the frequency of exposure to fermentable carbohydrates.

5. CONCLUSIONS

1. Sugars provide a source of energy required by the body to function.
2. Sugars are found in nature. All green plants providing foodstuffs, including fruits and vegetables, grains, as well as milk and honey, contain naturally-occurring sugars.
3. Many types of sugars are found in the diet on a daily basis. These include, for example, glucose, fructose, sucrose, and lactose. When the term 'sugar' is used, people are referring to 'sucrose' (table sugar^j).
4. The human body does not differentiate between sugars naturally present in foods and added sugars.
5. In the EU, sugars must be labelled as total sugars according to Regulation (EU) No 1169/2011 on the provision of food information to consumers.
6. In addition to bringing sweetness, sugars have many functions in foods, such as helping provide taste, texture and colour, extend shelf-life, and ensure safety and quality. No other single ingredient can replace all the functions of sugars in every food and drink.
7. Scientific studies in humans do not support the hypothesis that sugars may be physiologically addictive.
8. Frequency of consumption of fermentable carbohydrates^k and lack of oral hygiene are the most important factors influencing the development of dental caries.
9. Sugars can be part of a healthy and balanced diet. Excessive consumption of calories from any source, combined with insufficient energy expenditure, is associated with an increased risk of overweight, obesity and non-communicable diseases.

^j Table sugar is produced from sugar beet or sugar cane.

^k Fermentable carbohydrates are carbohydrates or carbohydrate mixtures as consumed in foods or beverages that lower the plaque pH by bacterial fermentation in the mouth.

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