Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Faculty of Natural Resources and Agricultural Sciences

How is sugar replaced by other ingredients in products labelled with "no added sugar" and how does this affect the energy, fat, carbohydrate, sugar and protein content?

Vilka ingredienser har ersatt sockret i produkter märkta med ”utan tillsatt socker” och hur har det påverkat produktens innehåll av energi, fett, kolhydrater, sockerarter och protein?

Stina Bladin

Department of Molecular Sciences
Master Thesis • 30 hec • Second cycle A2E
Agriculture Programme - Food sciences
Molecular Sciences, 2018:6
Uppsala, 2018

How is sugar replaced by other ingredients in products labelled with ”no added sugar” and how does this affect the energy, fat, carbohydrate, sugar and protein content?

Vilka ingredienser har ersatt sockret i produkter märkta med ”utan tillsatt socker” och hur har det påverkat produktens innehåll av energi, fett, kolhydrater, sockerarter och protein?

Stina Bladin

Supervisor: Roger Andersson, Swedish University of Agricultural Sciences, Department of Molecular Sciences

Assistant Supervisor: Minna Hellman, Stockholm Consumer Cooperative Society (Konsumentföreningen Stockholm)

Examiner: Lena Dimberg, Swedish University of Agricultural Sciences, Department of Molecular Sciences

Credits: 30 hec
Level: Second cycle, A2E
Course title: Independent Project/degree Project in Food Science – Master thesis
Course code: EX0425
Program/education: Agricultural Programme – Food Science

Place of publication: Uppsala
Year of publication: 2018
Title of series: Molecular Sciences
Part number: 2018:6
Online publication: http://stud.epsilon.slu.se

Keywords: sugars, added sugar, free sugar, food labelling, sweeteners, energy, obesity

Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Faculty of Natural Resources and Agricultural Sciences
Department of Molecular Sciences

Abstract

Labels such as “no added sugar” is commonly used by food manufacturers and consumers may think that these products are healthier than similar products that contain “added sugar”. To recreate the sweet taste, the mouthfeel and texture in products with “no added sugar”, some other kind of ingredients need to be added. This can contribute to changes in the nutritional composition in the product. The aim of this study was to determine whether a replacement of sugar by other ingredients in the products; quark, muesli and protein bars change the energy, fat, carbohydrate, sugar and protein content. The aim was also to identify the used sweeteners in the selected products labelled with “no added sugars” and investigate the definition of the term “added sugar”. The study showed that the most commonly used sweeteners in products on the market labelled with “no added sugar” were; asesulfame k, aspartame, barley malt syrup, maltodextrin, oligofructose, fruits (dried, juice, concentrate and puree) and maltitol. Quark with “added sugar” contained more energy, fat, carbohydrates and sugars compared to quark with “no added sugar”. Protein bars with “added sugar” contained more energy, carbohydrates and sugars compared to protein bars with “no added sugar”. Protein bars with “no added sugar” contained more protein. Muesli with “added sugar” contained more sugars compared to muesli with “no added sugar”. Muesli with “no added sugar” contained more energy, fat and protein. The study also shows that the definition of “added sugar” differs between agencies and it can be hard for consumers to understand which kind of sweeteners that can replace sugar in products labelled with “no added sugar”.

Keywords: sugars, added sugar, free sugar, food labelling, sweeteners, energy, obesity

Sammanfattning

Livsmedelsprodukter märkta med bland annat ”utan tillsatt socker” syns ofta i mataffärerna. Konsumenter kan tro att dessa produkter är ett hälsosammare alternativ jämfört med liknande produkter som innehåller socker. För att bevara sötman, munkänslan och texturen i produkter märkta med ”utan tillsatt socker” behövs någon annan ingrediens tillsättas, vilket kan leda till att näringsinnehållet i produkten ändras. Syftet med studien var att undersöka hur innehållet av energi, fett, kolhydrater, sockerarter och protein påverkas av ingredienser som ersätter sockret i produkterna; kvarg, müsli och proteinbars märkta med ”utan tillsatt socker”. Syftet var också att undersöka vad produkten har sötats med istället för socker i de utvalda produkterna märkta med ”utan tillsatt socker” samt att undersöka definitionen av ”tillsatt socker”. Studien visade på att de vanligaste ingredienserna istället för socker i produkterna på marknaden märkta med ”utan tillsatt socker” var; asesulfam k, aspartam, maltsirap, oligofruktos, frukt (torkad, juice, koncentrat och puré) och maltitol. Kvarg med ”tillsatt socker” innehöll mer energi, fett, kolhydrater och sockerarter jämfört med kvarg märkt med ”utan tillsatt socker”. Protein bars med ”tillsatt socker” innehöll mer energi, kolhydrater och sockerarter jämfört med protein bars märkt med ”utan tillsatt socker”. Protein bars märkt med ”utan tillsatt socker” innehöll mer protein. Müsli med ”tillsatt socker” innehöll mer sockerarter jämfört med müsli märkt med ”utan tillsatt socker”. Müsli märkt med ”utan tillsatt socker” innehöll mer energi, fett och protein. Studien visade också på att ”tillsatt socker” varierar i definition mellan olika myndigheter. Komplexiteten gör det svårt för konsumenter att veta vilka ingredienser som kan ersätta sockret i produkter märkta med ”utan tillsatt socker”.

Nyckelord: socker, tillsatt socker, sötningsmedel, energi, övervikt, livsmedelsmärkning

Table of contents

List of tables

List of figures

Abbreviations

* DP: The Degree of Polymerization
* EFSA: European Food Safety Authority
* FDA: Food & Drug Administration
* FOS: Fructooligosaccharide
* GI: Glycemic Index
* HFCS: High Fructose Corn Syrup
* IMO: Isomaltooligosaccharide
* JECFA: Joint FAO/WHO Expert Committee on Food Additives
* NFA: National Food Agency, Sweden
* NNR: Nordic Nutrition Recommendation
* NNS: Non-nutritive Sweeteners
* NS: Nutritive Sweeteners
* WHO: World Health Organization

1 Introduction

The consumption of food with high energy density such as sugar and fat is associated with an increased risk of obesity, cardiovascular disease, type 2-diabetes and different types of cancers (Cornelsen & Carreido, 2015).

The World Health Organization (WHO) recommends adults and children that the intake of free sugar should be less than 10% of their total energy intake. Free sugars refer to monosaccharides, such as fructose and glucose and disaccharides, such as sucrose (table sugar) and sugar naturally occurring in for example, syrups, honey, fruit juice and fruit juice concentrate. A reduction of free sugar, an intake below 5% of their total energy intake, would even provide further health benefits. The guidelines do not refer to the naturally occurring sugar found in for example fresh fruit, fresh vegetables and milk (World Health Organization, 2015). Sugar is high in energy density and low in vitamins and minerals. A diet with much sugar can contribute to nutrient deficiencies and energy that may be hard to get rid of, which thereafter can lead to overweight and obesity. A study done by the National Food Agency, Sweden (2017c) showed that four out of ten persons in Sweden eat more free sugars than what is recommended.

Sugar is added as an ingredient in foods under several different names such as, sucrose, glucose, maltose, fructose, honey, invert sugar and High Fructose Corn Syrup (HFCS) etcetera. These ingredients are frequently used by food manufacturers although a reduction of the sugar intake is to recommend. So why is it like that? Sugar is used for different reasons, one of them is that sugar has a sweet taste and therefore it is often used for flavouring food. Sugar, mainly sucrose, is added to jam due to its preservative effect. Sucrose is also used as a bulking agent and it has an important role when it comes to texture and structure in baked products as well as to lowering the freezing point in ice-creams (National Food Agency, 2017c; Keen, 1989).

Different strategies are needed to reduce obesity and the associated diseases. Alternative sweet ingredients such as fructans, isomaltooligosaccharides, malt extracts or fruits are used as a replacement for sugar to reduce the added sugar

content in some food products with the purpose of making the product healthier, tastier or cheaper (Berryman, 2012). But, it is not always easy to replace sugar in food products with other ingredients. A reduced energy content is most easily achieved in food where sugar is the main source of energy, for example in soft drink sweetened with sugar. In soft drinks, sugar is usually replaced with more water and a high intense sweetener such as aspartame and asesulfame k, which will lead to an energy density near zero. It is more difficult to reduce the energy content by removing sugar from more complex food such as cakes or muesli, where sugar is one of many other energy-providing components. Sugar is often replaced with another type of carbohydrate, usually starch. Sugar can also be replaced with a higher proportion of fat. The energy density will then be the same, or in some cases even higher (Berryman, 2012; Sadler & Stowell, 2012).

The labelling "no added sugar" can be misleading for consumers who may expect the product to be healthier (Gorton *et al.*, 2010; Mhurchu & Gorton, 2007) and that the amount of reduced sugar corresponds to the amount of reduced energy. But in fact, the product that contains "added sugar" may contain a lower amount of energy and not increase the blood glucose level faster than the product with "no added sugar" (Patterson *et al.*, 2012; Jenkins *et al.*, 1981). A high energy intake and a high blood glucose level are both associated with negative health implications and there is no evidence that energy from another food source is less harmful then energy from added sugar (Erickson & Slavin, 2015; McKeown *et al.*, 2004).

The label on the front of the food package has been shown to be important for consumer's choice. Consumers prefer simplified nutrition information on front of the food packages instead of the more complicated nutrition label on the back. The reasons for that are that they do not have time to understand the more complicated nutrition label on the back of the food and that they have lack of education to compare products and interpret the nutrient table (Grunert & Wills, 2007).

To avoid misleading for consumers it is important that labelling's regarding a reduced sugar content are found on food products that have better nutritional composition compared to the similar product without the labelling (Nguyen *et al.*, 2016; Wills *et al.*, 2012; Wansink & Chandon, 2006).

To recreate the sweet taste, the texture and the mouthfeel in products with reduced sugar content, some other kind of ingredients need to be added. This can contribute to changes in the nutritional composition in the product. The aim of this study was to investigate the changes in nutritional composition in products on the market labelled with "no added sugar".

2 Background

2.1 Carbohydrates and sugar

Carbohydrates are a broad range of starches, sugars and dietary fibre, which include mono- and disaccharides, oligosaccharides and polysaccharides. They are found naturally in foods such as vegetables, fruits, dairy products and grain foods. These foods bring important nutrients to the body such as antioxidants, vitamins, minerals and dietary fibre. The amounts of natural carbohydrates in food vary, included sugars added to the food due to the sweet taste properties. Sugar is the collective name for mono-and disaccharides (National Food Agency, 2015).

Monosaccharides, also known as simple sugars, are the basic units of carbohydrates. Glucose, galactose and fructose are examples of monosaccharides. Disaccharides, oligosaccharides and polysaccharides are built up by monosaccharides. Disaccharides are formed from two monosaccharides and examples of disaccharides are lactose (milk sugar), which is built up by glucose and galactose, maltose, which is formed from two glucose units and sucrose, also known as table sugar, which is built up by glucose and fructose (National Food Agency, 2017c).

Oligosaccharides and polysaccharides are complex carbohydrates mainly built up by the monosaccharaides fructose, glucose and galactose. Oligosaccharides contain three to ten monosaccharaides. An example is raffinose, which is found in broccoli, beans and other legumes. Polysaccharides are built up by several monosaccharaides. Starch, glycogen and cellulose are some examples. Not all oligosaccharides and polysaccharides are digestible. For example, cellulose cannot be broken down in human and is moving through the intestine preventing constipation. Starch is found as energy store in plants and is the most common digestible carbohydrate in human diets. The oligosaccharide raffinose is nondigestible and acts as a prebiotic to the gut microbes (Packer, 2017).

The carbohydrates that are digestible are broken down in the small intestine to sugar units, often glucose. They are called glycemic carbohydrates and are used in

metabolism to provide energy to the cells (National Food Agency, 2017c). As mentioned, the carbohydrates differ in structure and how they act after intake. This contribute to that they are found under different headings in the nutrient list of foods and beverages. Mono- and disaccharides are found under "carbohydrates, of which sugars", while poly- and oligosaccharides that cannot be broken down are found under "fibres". The residual poly- and oligosaccharides that can be broken down are found under "carbohydrates" (National Food Agency, 2017b).

Carbohydrates can be divided in carbohydrates rich in sugar and carbohydrates rich in starch. Carbohydrates rich in starch consist of polysaccharides and are found in foods such as potato, cereal flour, rice, pasta, flakes and grouts. Carbohydrates rich in sugar can be divided into two groups: Naturally sweet products and products with added sugar. Fruits, berries, juices and dairy products belong to the naturally sweet products while candy, ice cream and soft drinks belong to the products with added sugar. According to the EU regulation 1924/2006, added sugar includes free mono- and disaccharides or some other ingredient used because of its sweetening properties. One of the most commonly used added sugars is sucrose (table sugar) (National Food Agency, 2015; EU, 2006). Added sugar can appear on the ingredient list under different names and according to the National Food Agency, Sweden (2017b) the product contain added sugar if the ingredient list include some of the following names; dextrose, fructose, invert sugar, rice syrup, malt syrup, barley malt syrup, sucrose, molasses, fruit juice concentrate, honey, High Fructose Corn Syrup (HFCS), malt extract, glucose, etcetera.

2.1.1 Glycemic carbohydrates

Glycemic carbohydrates are carbohydrates that are broken down in the small intestine and cause an increase in the blood sugar level. How fast and how much it increases depends on how much and which kind of carbohydrate it is. It also depends on how fast the carbohydrates are taken up in the body which depends on the matrix of the food, how it is cooked and other components in the meal. Bread for example has bigger surface than pasta, which contributes to that the bread increase the blood sugar level faster than pasta. Another example is starch encompassed by fat that do not increase the blood sugar level as fast as free starch (National Food Agency, 2015).

Glycemic index (GI) is a relative measure of the glycemic carbohydrate fractions in foods and are based on how fast or slow foods are broken down to glucose in the body and cause an increase in blood glucose level. The blood glucose level is measured in two hours after an intake of 50 grams of carbohydrates and the concentration is plotted against time in a graph. The area under the blood glucose level from the tested carbohydrate is divided with the area from a reference food

where glucose or white bread often are used. The value is multiplied with 100 and a GI value for the food is established (Wolever, 2007).

Food with high glycemic index has a value >70, food with intermediate GI has a value of 55-70 and foods with low and very low GI have a value of 40-55 and 0-40, respectively. Food with high glycemic index are food such as candy, soda, juice, cakes and white bread. The carbohydrates in these foods are broken down to glucose more quickly and increase the blood glucose level faster than carbohydrates in foods with low glycemic index (Foster-Powell *et al.*, 2002). Some foods have higher glycemic index then sucrose, which have GI=64. That results in higher increases in blood glucose level compared to sucrose (Jenkins *et al.*, 1981). It has been shown in observation studies that a diet with high glycemic index is linked to a higher prevalence of fatty liver, insulin resistance, metabolic syndrome and metabolic risk factors such as increased level of HDL-C and triglycerides (McKeown *et al.*, 2004; Liu *et al.*, 2001). This could further result in metabolic and hormonal changes and alter the appetite regulation in obese humans (Ludwig *et al.*, 1999).

Foods with low glycemic index are foods with high amounts of whole grain, fibres and small amount of sugar. These foods are more related to health benefits. For example, it can decrease the glycemic- and insulin responses, reduce the risk of type II diabetes (Foster-Powell *et al.*, 2002; Hu *et al.*, 2001) and prevent risk for excess weight gain (Roberts, 2000).

2.2 Energy

Carbohydrates, fat, protein and alcohol are macronutrients that provide energy (calories) to the diet. Energy is required in body functions and without macronutrients we would not be able to live. How much energy a meal contains depend on the amount of energy the ingredients in the food provides. Carbohydrates and protein contain 4 kcal per gram, fat 9 kcal per gram, fibre 2 kcal per gram and alcohol 7 kcal per gram (National Food Agency, 2017a).

The Nordic Council of Ministers recommends that 45-60% of the total energy intake should come from carbohydrates and not more than 10% of the total energy intake should come from added sugars, 10-20% should come from protein and 25-40% from fat. The total energy intake that is needed varies from person to person and it depends on weight, gender, age, height and activity level. People who have a higher energy intake than they burn in physical activity or normal daily activities are more prone to gain overweight (Nordic Council of Ministers, 2014).

2.3 Sugar related health effects

Consumption of sugar has been shown to be associated with overweight and other kinds of negative health effects. Bray *et al.* (2004) found that increased consumption of High Fructose Corn Syrup (HFCS) in beverages was related to obesity. Consumption of sugar in beverages have also been found to be linked to metabolic syndrome (Mirmiran *et al.*, 2015), cardiometabolic risks (Duffey *et al.*, 2010) and insulin resistance (Samuel, 2011). When the body becomes resistant to insulin, the blood glucose level increases, and this can lead to various diseases such as type II diabetes, obesity and cardiovascular disease (Grundy, 1999). Sugar also has negative impact over oral health. Sucrose and other fermentable carbohydrates give substrate for oral bacteria. Strong relations between sugar intake and dental caries have been shown (Touger-Decker & van Loveren, 2003).

Consumption of sugar can also have an effect on the brain, which can affect the appetite in different ways. One study showed that consumption of fructose in beverages decreased activity in the satiety center of the brain as well as increased the hunger compared with glucose-sweetened beverages (Page *et al.*, 2013). Teff *et al.* (2004) and Bray *et.al*. (2004) also showed that fructose did not decrease the hunger hormone ghrelin as much as glucose did. A diet high in fructose could indirectly contribute to increased energy intake as well as obesity (Bray *et al.*, 2004; Teff *et al.*, 2004).

It has been reported that sugar has negative health effects, but there are also available studies which report that sugar not differ from other carbohydrates. For example, Anderson (1995) concluded that there is no reason to support studies that conclude that sugar is the main factor that stimulate appetite and increase energy intake. He means that there is no evidence that sugar differ from other carbohydrates in affecting energy intake. This is confirmed by a long-time study showing that to maintaining control of the weight it is less important if the carbohydrates are sugars or starch and according to the study there is no reason to avoid solid food high in sugar if you want to lose weight. However, it seems important for the weight control if the source of sugar is solid or liquid (Saris *et al.*, 2000). Other studies have also confirmed that consumption of sugar not is the main reasons to obesity, and that it is the total energy intake that we should be worried about (Stanhope, 2016; Erickson & Slavin, 2015; Hill & Prentice, 1995). In a study by Hill and Prentice (1995) it was found that people with moderate intake of sugar not are more overweight than people with less sugar intake (Hill & Prentice, 1995). Further, they found that consumption of fat is associated with obesity, while high intake of sugar is negatively associated with obesity. The study concluded that there are no reasons to associate sugar intake with obesity but reasons to associate fat intake with obesity (Hill & Prentice, 1995).

However, a negative energy balance is necessary to obtain weight loss and it does not matter where the energy comes from; weather it is from protein, fat, carbohydrate or alcohol (Sadler & Stowell, 2012) and since the obesity is rapidly growing (World Health Organization, 2015), different strategies are needed to change the negative direction. Nutrition knowledge is important when it comes to controlling diet. Consumers seem to have limited knowledge of nutrition, which can lead to misunderstanding of nutrient content in foods and beverages (Dickson-Spillmann *et al.*, 2011). Patterson *et al.* (2012) found that consumers were confused around energy and sugar content. Consumers believed that a reduction of sugar in food products corresponds to the same amount of reduction in energy content (Patterson *et al.*, 2012).

How sugar is named as ingredient on the ingredient list has also been shown to influence consumer's health perceptions of foods and beverages. A consumer study found that participants associated cereals containing "fruit sugar" healthier compared to cereals containing "sugar", although the nutrient value were the same in both cereals (Sutterlin & Siegrist, 2015).

2.4 Definitions of "added sugar" and "no added sugar"

The main reason why sugar is added in foods or beverages is for its preservative effect and the sweet taste it contributes to. Due to the health associations, it has been more common with "no added sugar" products. To recreate the sweet taste in products with no added sugar, some other kind of sweeteners needs to be added. If a product should have the label "no added sugar", there are guidelines that the food manufactures need to achieve (Nordic Sugar, 2012).

Regulations and definitions regarding "added sugar" have been proposed by policy markers worldwide, with no general accepted definition (Table 1). The EU regulation (EU) no. 1924/2006 requires the following statement for product labelled with "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'"(EU, 2006).

The Food and Drug Administration, (FDA) define "added sugar" as; mono- and disaccharides that are added to the food during packaging or production including sugars from honey, syrups and fruit or vegetable juice concentrates, etcetera. The definitions exclude 100 percent fruit juice that is sold to consumers (frozen 100 percent vegetable or fruit juice concentrate) and sugars found in vegetable

and fruit juices, jams, jellies, fruit spreads and preserves (U.S. Food and Drug Administration, 2017a).

For the EU regulation (EG) no. 1924/2006 there is a guideline regarding fruits and berries. The guideline says: “Fruits and berries have properties which may have beneficial effects when added to food products. Desirable effects are fruit flavours, a specific consistency, a desirable mouth experience when consuming the product, but also to increase the content of dietary fibre. An assessment needs to be done in order to evaluate whether addition of fruits and berries are made with reason to give rise to a sweet taste. If the purpose of adding fruit and berries to a food product exclusively is made to add a sweet taste to the food, the statement "no added sugar" is not allowed.” (National Food Agency, 2013).

This guideline enables food companies to use for example fruit juice concentrate for other purposes than just sweetening and because of that it should be possible to use the label “no added sugar” even if the product contains for example fruit juice concentrate. It is the food companies that are using the label "no added sugar" responsibility to show that the label is used properly, as required by law. They need to be able to explain for their control authority the purpose of the added fruit juice concentrate and an assessment must be made in each case (National Food Agency, 2013).

A common point between the different definitions seen in Table 1 is whether fruit juice and fruit juice concentrate should or not should be included in the definition of “added sugar”. FDA classifies fruit juice concentrate added to food or beverage as added sugar while fruit juice concentrate that can be sold to consumers is classified as “no added sugar” (U.S. Food and Drug Administration, 2017a).

The EU regulation (EU) no. 1924/2006 does not specify individual ingredients at all but that just define “added sugars” as added mono- or disaccharides or another kind of ingredients added for its sweetening purpose. This definition is similar to The Nordic Council of Ministers definition about added sugar where they use the sentence “other isolated sugar preparations” in their definition (Nordic Council of Ministers, 2014; EU, 2006).

In addition to different definitions and rules regarding the term “added sugar” The World Health Organization (WHO) use the term “free sugar”. Free sugar and added sugar are similar but in WHOs definition for free sugar they also include sugars naturally found in fruit juices and fruit juice concentrate (World Health Organization, 2015).

Table 1. *Definitions of "added sugar" and distinctions from various agencies.*

Agencies	Definitions
European Parliament (EP) European regulation (EG) no. 1924/2006 (EU, 2006)	"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'"
National Food Agency, Sweden (2017b) on its website	*Added sugar does not occur naturally in raw materials but is added as an ingredient to food products. If you find some of these ingredients in the nutrient list; "dextrose, fructose, honey, invert sugar, maltose syrup, rice syrup, sucrose, molasses, fruit juice concentrate, High Fructose Corn Syrup (HFCS), glucose, lactose, maltose, malt extract, beet sugar, agave syrup etcetera", the product contains added sugar.*[1]
Food and Drug Administration (FDA), U.S (2017a) on its website	"Added sugars includes sugars that are either added during the processing of foods, or are packaged as such, and include sugars (free, mono- and disaccharides), sugars from syrups and honey, and sugars from concentrated fruit or vegetable juices that are in excess of what would be expected from the same volume of 100 percent fruit or vegetable juice of the same type. The definition excludes fruit or vegetable juice concentrated from 100 percent fruit juice that is sold to consumers (e.g. frozen 100 percent fruit juice concentrate) as well as some sugars found in fruit and vegetable juices, jellies, jams, preserves, and fruit spreads"
The Nordic Council of Ministers. Nordic Nutrition Recommendations (NNR) 2012 (2014)	"Sucrose, glucose, fructose, starch hydrolysates (high fructose corn syrup and glucose syrup). And other isolated sugar preparations used as such or added during food preparation and manufacturing."
World Health Organization (WHO) Free Sugar Guidelines (2015)	"Free sugars include monosaccharides and disaccharides added to food and beverages by the manufacturer, cook or consumers, and sugars naturally present in honey, syrups, fruit juices and fruit juice concentrates!"

[1])Translated from Swedish to English.

(National Food Agency, 2017b; U.S. Food and Drug Administration, 2017a;

World Health Organization, 2015; Nordic Council of Ministers, 2014; EU, 2006).

Sweeteners

Sweeteners added to foods and beverages are divided into two groups; nutrient sweeteners (NS), which provide nourishment and energy, and non-nutrient sweeteners (NNS), which is energy-free (non-nutritive). Sugar and sugar alcohols contain few minerals and vitamins and since those ad carbohydrates and energy to the food those belong to the NS group (Table 2 and Table 3). Aspartame, acesulfame K and sucralose are some of the sweeteners that belong to the NNS group (Table 4). The energy content of these sweeteners is the main difference between the groups and that is important when it comes to comparing the sugar and energy content of food and beverage (National Food Agency, 2017d).

Some of the sweeteners that are used in foods are classified as food additives, while some are not. Those who are classified as food additives have an E-number. Additives are normally not consumed as a food themselves and are added to the food for a technical purposes, for example they increase shelf life, give colour and affect the consistency and the taste (National Food Agency, 2017d).

2.4.1 Nutrient sweeteners

Sugar alcohols

Sugar alcohols are carbohydrates called polyols and are classified as food additives. These carbohydrates have chemical characteristics of both alcohols and sugars and are obtained from a sugar when the keto or aldo groups are reduced to a hydroxyl group. Polyols are commercially produced from starch and sugars but can also be found naturally in small amounts in different vegetables and fruits (Flambeau *et al.*, 2012).

Sugar alcohols are slowly or incompletely absorbed into the blood from the small intestine, which causes water to remain in the intestine. As a result of not being complete absorbed they contain only around 2.4 kcal per gram compared to sucrose, which is fully absorbed and contain 4 kcal per gram. The incomplete absorption contributes to lower change in blood glucose level compared to other carbohydrates. Sugar alcohols have sweet taste and are often used together with artificial sweeteners in food as reduced-energy sweeteners instead of sugar. They also provide texture and bulk in the food, prevent browning during heating and help retain moisture (Flambeau *et al.*, 2012).

Sugar alcohols do not cause cavities or tooth decay since they are not metabolised by plaque bacteria and do not decrease the pH in mouth. This is one reason why sugar alcohols often are used in chewing gum and toothpaste. Since sugar

alcohols are not fully absorbed they are fermented by bacteria in the large intestine. This can cause bloating, diarrhea and abdominal gas. If the content of sugar alcohol is more than 10% of the food, the product needs to have the label "Excessive consumption can have laxative effects" (Bieleski, 1982). Examples of sugar alcohols are maltitol and xylitol.

Maltitol (E965) is one sugar alcohol produced from the naturally occurring sugar maltose. It has similar structure to maltose (a disaccharide formed by two glucose units) but compared to maltose it is not found in the nature. It has around 60-70% of the sweetness of sucrose (Table 3). Maltitol has been used in food as a sweetener for about 20 years in Europe. Is typically found in chewing gum, hard candy, chewy candy, dairy desserts and chocolate (Kearsley & Deis, 2012).

Xylitol (E967) is another sugar alcohol produced from the monosaccharide xylose, also known as birch sugar. Xylitol can be found naturally in low concentrations in the fibres of vegetables and fruits. It is almost as sweet as sucrose (Table 3) and is usually found as an additive in the same foods as maltitol such as hard candy, chewing gum, chewy candy, dairy desserts and chocolate (Zacharis, 2012).

Fructans

The class of carbohydrates called fructans (a polymer of fructose) are found in the leaves, roots, seeds and stems in different plants (National Food Agency, 2013).

There are various naturally occurring chain lengths of the fructan polysaccharides, which have been named after the lengths of the fractions. The most common fractions are inulin and fructooligosaccharides (FOS). The chain consist of the monosaccharide fructose that usually ends up with a single terminal glucose. Inulin is naturally occurring in chicory root or artichoke and the degree of polymerization (DP) for inulin range between three and 60. FOS is produced by degradation of inulin and have a DP range up to 20.

Fructans are fermented by bacteria in the large intestine since they are not fully absorbed in the small intestine due to the linkages between the monomers (Environ International Corporation, 2012). Due to that, fructans such as inulin and FOS are classified as fibres and provides around 2 kcal per gram compared to sucrose that provide around 4 kcal per gram (Roberfroid, 1999). Because of the reduced energy content, its slightly sweet taste and its function as a bulking agent, fructans are used as replacement for fat and sugar in foods and beverages (Environ International Corporation, 2012). In the ingredient list fructans are commonly named as; inulin, oligofructose, fructooligosaccharides and chicory root fibre (National Food Agency, 2013).

Isomaltooligosaccharide

Isomaltooligosaccharide (IMO), also known as fibre syrup, is a branched oligosaccharide that is produced from starch being treated with enzymes. IMO consist of two to four degrees of polymerization made up by a mixture of glucose oligomers such as isomaltotriose, isomaltose, isomaltotrose, panose and isomaltoshexose. Like fructans, IMO is fermented by the bacteria in the large intestine since it is not fully absorbed in the small intestinal tract. This contributes to a content of 1.6 kcal per gram (BioNeutra Inc, 2005). IMO is mildly sweet and used in food and beverages as a low energy, prebiotic sweetener. It is often found in nutrition bars marked with "no added sugar", "low-carb" or "high in fibre" (BioNeutra Inc, 2005).

Maltodextrin

Maltodextrin is a nutritive non-sweet polysaccharide that consists of glucose units. It presents as a concentrated solution or a white powder from hydrolysis of starch from corn, potato or wheat. Maltodextrin is used as filler and to enhance flavour and texture. Maltodextrin contains around 4 kcal per gram, which is the same as sucrose. Since the glycemic index for maltodextrin is quite high, it increases the blood glucose level faster than sucrose (Auerbach & Dedman, 2012).

Barley malt extract

Barley malt syrup (malt extract) is produced from malt. Malt is a germinated product from barley used for baking and to make beer. Malt syrup or malt extracts are products obtained by extracting malt by mixing it with hot water. The solution is filtrated and ends up with a brown, viscous and sweet liquid containing amylolytic enzymes and other plant constituents such as maltose, dextrin and a small amount of glucose. Malt syrup contains around 3-3.5 kcal per gram and it is typically used for its sweet taste in home cooking and baking (U.S. Food and Drug Administration, 2017b).

Fruits

There are two kinds of fruit juices on the market. Fruit juice and fruit juice from concentrate. Fruit juice is an unfermented but fermentable liquid produced from fresh, ripened or chilled fresh fruit. Juices from lemon fruits are made from the pulp (endocarp), which differ from limejuice that can be produced from the whole fruit. Fruit juice from concentrate is concentrated fruit juice with addition of water where the soluble solids in the finishing product need to meet the lowest allowed brix value (sugar content) for reconstituted fruit juice. Concentrated fruit juice is the product obtained from fruit juice where a portion of water is removed. In these cases, food manufactures are allowed to restore aromas, cells and pulps from the

same fruit that have been removed from physicals methods under processing (National Food Agency, 2012).

Fruit puree is also an unfermented but fermentable product obtained from edible parts of whole or peeled fruit that have been physical processed with methods such as mashing, passage or grinding. Fruit juices, concentrate and puree are used in many different ways, for example in the ice cream and dairy industry, in the baking and confectionary industry and in the beverage and tea industry (National Food Agency, 2012).

2.4.2 Non-nutritive sweeteners

Non-nutritive high intensive sweeteners are thoroughly researched ingredients and approved by European and international authorities: World Health Organization Expert Committee on Food Additives (JECFA) and European Food Safety Authority (EFSA). In the European Union (EU) there are 11 non-nutritive high intensive sweeteners that are approved and safe to use in foods and beverages (Table 4). A high intensive sweetener means that the sweetness is over a hundred times higher than sucrose. The high intensity sweeteners can be divided into two groups. One group is natural high intensity sweeteners; those substances are extracted from a variety of plants. Extracts from the plant *Stevia rebaudiana* is one example. The other group is the chemically, artificial-synthesized sweeteners. Substances belong to this group are for example: aspartame, acesulfame K and sucralose (International Sweeteners Association, 2016).

Steviol glycosides

Steviol glycoside (E690) is a high intensive sweetener naturally found in the leaves on the plant, *Stevia rebuadiana* Bertoni. The plant is commonly known as Stevia. Steviol glycosides are between 200 and 400 times sweeter than sucrose and just as sucralose it is added in products in a small amount. It is typically used in certain flavoured beverages, energy reduced soups and confectionary (Lindley, 2012).

Aspartame

Aspartame (E951) is one artificial high intense sweetener built up by two amino acids; aspartic acid and phenylalanine, which are naturally occurring building blocks in many proteins presents in a normal diet. Aspartame is broken down in to aspartic acid, phenylalanine and methanol. Methanol exists naturally in a small amount in fruit and fruit juices. Aspartame is about 180-200 times sweeter then sucrose. It is usually referred to a non-nutrient sweetener due to its high sweetness and the small amount that is added in products. Aspartame is usually used in soft

drinks and juices. Aspartame is sensitive to heat and acid solutions; it is broken down and losing its sweetness and due to that it is not used in baked products (O'Donnell, 2012).

Acesulfame potassium (Ace-K)

Acesulfame potassium (E950), also known as Ace-K and Acesulfame K, is a high intensive sweetener and about 130-200 times sweeter than sucrose. As oppose to aspartame it is heat stable, which means that the taste stays sweet in high temperatures during baking which makes this substance suitable as a sugar replacement in baked products, such as cakes. Acesulfame K is often used in beverages, baked products, candies and frozen desserts, and it is often found together with other sweeteners such as aspartame (Klug & von Rymon Lipinski, 2012).

Sucralose

Sucralose (E955) is an artificial form of sucrose. It is a high intensive sweetener and since the beginning of year 2000 it has gained popularity. The substance is between 400 and 800 times sweeter than sucrose which means that it is added in a very small amount as an ingredient. It can sustain high heat which makes it a useful alternative to sugar in baked products. Sucralose is used in a variety of foods and it is typically found in beverages, baked products, chewing gum, frozen dairy desserts and gelatins (Molinary & Quinlan, 2012).

Table 2. *Nutrient sweeteners, commonly used name and the relative sweetness compared to sucrose.*

Sugars	**Name**	**Relative sweetness**
Lactose	Milk sugar	0.4
Maltose	Malt sugar	0.5
Trehalos		0.5
Glucose syrup		0.4-0.6
Glucose	Dextrose	0.6-0.7
Isoglucose	High Fructose Corn Syrup (HFCS)	0.8-1.0
Tagatose		0.9
Sucrose	Sugar, table sugar	1.0
Invert sugar		1.0
Fructose	Fruit sugar	1.0–1.3

(Shallenberger, 1993)

Table 3. *Nutrient sweeteners, their E-number and relative sweetness compared to sucrose.*

Sugar alcohols	**E-number**	**Relative sweetness**
Laktitol	E 966	0.4
Isomalt	E 953	0.5-0.6
Sorbitol, Sorbitol syrup	E 420	0.6
Mannitol	E 421	0.6–0.7
Erytritol	E 968	0.7
Maltitol, Maltitol syrup	E 965	0.8
Xylitol	E 967	0.9–1.0

(Sadler & Stowell, 2012)

Table 4. *High intensive non-nutritive sweeteners approved and safe to use in food and drinks in European Union (EU), their E-number and relative sweetness compared to sucrose.*

High intensive sweeteners	**E-number**	**Relative sweetenss**
Cyclamate	E 952	30–50
Acesulfame K	E 950	130–200
Aspartame	E 951	180–200
Steviol glycosides	E 960	200–400
Saccharin	E 954	300-500
Neohesperidin DC	E 959	300–2000
Aspartame-Acesulfame salt	E 962	350-400
Sucralose	E 955	400-800
Thaumatin	E 957	2000-3000
Neotame	E 961	7000–13000
Advantame	E 969	7000–47000

(International Sweeteners Association, 2016; de Cock, 2012).

2.4.3 Sweeteners as replacement of sugar

There are many studies and debates about using non-nutritive high intensive sweeteners (NNS) as replacement for sugar and whether NNS are beneficial to human health or not. Studies have investigated the role of energy intake, body weight, hunger and satiety after consumption of NNS (Tordoff & Friedman, 1989; Peters *et al.,* 2014; Peters *et al.,* 2016; Anton *et al,* 2010).

Some studies have shown that NNS increase the appetite and contribute to higher energy intake. For example, one study concluded that consumption of saccharin increased food intake of rats (Tordoff & Friedman, 1989), which have been confirmed by another study shown that consumption of aspartame was associated with increased appetite and decreased feelings of fullness, compared to consumption of glucose (Blundell & Hill, 1986).

However, some studies have shown the opposite, that non-nutritive sweeteners decrease energy intake. For example, two new randomized behavioural intervention studies by Peters *et al.* (2014 & 2016) that lasted 12 and 40 weeks and aimed to investigate weight loss and weight maintenance showed higher weight loss and maintenance in a group with obese participants that were required to drink non-nutrient sweetened beverages every day compared to control group required to drink the same amounts of water. The hunger feelings were decreased and fewer sweets were consumed in the non-nutrient sweetened drinking group compared to the water group. The authors suggested that the participants in the water group compared to the sweetened drinking group may have sought sweetness and consumed other kinds of sweet food that resulted in less weight loss and higher energy intake (Peters *et al.*, 2016; Peters *et al.*, 2014).

In an 18-month intervention study, Ruyter *et al.* (2012) also concluded that children reduced their weight when consuming non-nutritive sweetened beverages instead of their daily sugar-sweetened beverages. These conclusions are confirmed by meta-analyse (Miller & Perez, 2014; De La Hunty *et al.*, 2006) and a systematic review (Bellisle, 2015) concluded that the usage of non-nutrient sweeteners facilitated weight loss by decreasing the appetite for sweet drinks and food as well as decreasing the daily energy intake.

Other studies have concluded that there is no difference between consumption of non-nutritive sweeteners or sugar regarding energy intake. For example in 2011, EFSA's NDA Panel investigated the health effects linked to intense sweeteners. The panel concluded that there is no evidence that replacement of high intensity sweeteners instead of sugar contributes to maintain or achieve normal body weight or maintain normal blood sugar level. However, the same study showed on the other hand that high intensity sweetener lowered the blood glucose level as well as

it preserved the dental surface (Efsa Panel on Dietetic Products & Allergies, 2011).

Another study investigated the satiety, food intake and postprandial glucose and insulin levels when consuming preloads containing sucrose, steviol glycosides and aspartame before consumption of lunch and dinner (Anton *et al.*, 2010). An intake of steviol glycosides and aspartame preloads did not cause the participants to eat more for either dinner or lunch compared to when they consumed sucrose preloads. They were also reported the same levels of satiety when consuming aspartame, steviol glycosides and sucrose preloads (Anton *et al.*, 2010). This is confirmed by a study from 2015 made by Antenucci and Hayes including 401 participants. This study showed that usage of non-nutritive sweeteners compared to sugar does not lead to increased sweet cravings or sweet taste buds.

2.5 Aim and objective of the study

There are constantly debates in media what we should or not should be eating. Food labelling such as “light”, “diet”, “reduced” or “no added sugar” is commonly used on food products and it is possible to buy a large variety of these. There are many reasons why sugar should not be over consumed; these are often connected to the high energy density that the sugar contributes to. Consumers may think that products labelled with “no added sugar” are healthier than similar products with “added sugar”. But in fact, to recreate the sweet taste, the mouthfeel and the texture in these products, some other kind of ingredients need to be added. Depending on which kind of ingredients that has replaced sugar, the similar product that contains “added sugar” may contain a lower amount of energy than products with “no added sugar”.

The aim of this study was to determine whether a replacement of sugar by other ingredients in the products on the market; quark, muesli, and protein bars change the energy, fat, carbohydrate, sugar and protein content. The work was also aimed towards identifying the most common sweeteners in the selected products labelled with "no added sugar” and investigating the definition of the term “added sugar”.

3 Methods

This study was performed using data collection and a literature survey where the following questions were used to reach the final conclusion.

- What are used as replacement of sugar in the products; quark, muesli and protein bars?
- How does a replacement of sugar change the energy, fat, carbohydrate, sugar and protein content in the products; quark, muesli and protein bars?

3.1 Literature research

Articles and information regarding sugar and the role of sugar both in food and in the body have been retrieved from internet using scientific databases such as *PubMed, Google scholar* and *Web of science*. The aim of the literature review was to give an introduction and present the topic to the reader. Other relevant information about the topic has been collected from websites: National Food Agency, Sweden (NFA) and United States Food and Drug Administration (FDA).

3.2 Inventory and collection of data

The study was limited to investigation of three products; namely quark, muesli and protein bars. These products were chosen because they are commonly seen on the market under the category “no added sugar”. These products are usually considered as healthy options in media and are therefore interesting to investigate. The inventories of the products were collected from the stores; Ica, Hemköp, Willys and Coop. The website gymgrossisten.se and apotea.se were used to collect information about protein bars and mathem.se was used for muesli. Quark and yoghurt/quark were investigated in the same category. In the muesli category, only muesli and not granola was investigated. The same brand was found on more than one product in each category of products but with different flavours. If the nutri-

tional composition was the same, only one product was included. The three categories of products were further divided into two categories; “added sugar” and “no added sugar”. For the protein bars the label “low on sugar” and “only 0.9 gram sugar” were also included in the category “no added sugar”. In this study, a total of 113 products were included; 33 quark and yoghurt/quark products (16 products with “no added sugar” and 17 products with “added sugar”), 53 muesli products (18 products with “no added sugar” and 35 products with “added sugar”) and 27 protein bars products (14 products with “no added sugar” and 13 products with “added sugar”). For quark, 12 different brands were included, 3 brands had products with both “no added sugar” and “added sugar”. For muesli, 15 different brands were included, 4 brands had products with both “no added sugar” and “added sugar”. For protein bars, 16 different brands were included, 2 brands had products with both “no added sugar” and “added sugar”.

Data of the nutritional labelling for each product was collected and compiled in Microsoft Office Excel 2007. The nutritional values collected were measured in the amount of energy, fat, carbohydrates, sugar and protein in each product. Any other sweeteners in category “no added sugar” were also noted. The data present in Appendix 1 were used for the calculations.

3.3 Statistical analysis

All statistical analyses were performed using Minitab 16. Standard deviations and mean value were calculated and analysed using a One-Way Analysis of Variance (ANOVA) procedure. The level of significance of $p<0.05$ was calculated to evaluate differences in energy, fat, carbohydrate, sugar and protein content between the two categories “added sugar” and “no added sugar” in all food products.

4 Results and Discussion

The result of each food product; quark, muesli and protein bars concerning added sweeteners and significant differences between the categories “no added sugar” and “added sugar” in energy, fat, carbohydrate, sugar and protein content is presented in Tables 5-8.

4.1 Sweeteners

The sweeteners occurring in the selected products labelled with “no added sugar” are presented in Table 5.

Table 5. *Sweeteners seen in the ingredient list on products in the category “no added sugar” and the numbers of products where it was found in each product; quark, muesli and protein bars.*

Sweeteners	**Quark**	**Muesli**	**Protein bars**
Acesulfame K	8		3
Aspartame	14		
Barley malt extract		3	
Dried fruits		12	
Fruit juice	1	2	2
Fruit juice concentrate	1	3	
Fruit juice puree	2	2	2
Inulin/oligofructose/ “chicory root fibre”		7	2
Isomaltooligosaccharide			3
Maltitol	2		10
Maltodextrin		3	
Sucralose	1		5
Steviol glycosides			4
Xylitol			2

In quark it is most common to replace sugar with a non-nutritive high intensive sweetener and acesulfame K and aspartame are the most commonly used. These two are often added together. Fruit juice, juice concentrate and fruit puree were observed in quark only in four products.

For muesli it is most common to replace the sugar with nutrient sweeteners and these are often used together. Non-nutritive sweeteners were not observed in any product. The most commonly observed sweeteners in muesli were barley malt syrup, maltodextrin, oligofructose or fruits in different forms (dried, juice, concentrate or puree).

In protein bars it varied. Sugar is replaced both with nutrient sweeteners and non-nutrient sweeteners. Sugar alcohols are often used where maltitol were seen in 10 products which makes it to the most commonly used sweetener. The sugar alcohols are sometimes used together with a high intensive sweetener where sucralose, steviol glycosides and acesulfame K were observed. Fruit juice and fruit puree were observed together in only two products.

Based on the results seen in Table 5, the conclusion is that many of the products labelled with “no added sugar” still contain ingredients that contribute to energy. For example, the products can contain fruit juice, fruit puree or juice concentrate and malt extract. All of these ingredients contain carbohydrates that breaks down and absorbs as simple sugars in the body.

4.2 Quark

Differences between the categories “added sugar” and “no added sugar” in energy, fat, carbohydrate, sugar and protein content for quark product are shown in Table 6.

Table 6. *The mean values and the standard deviations for energy, fat, carbohydrates, sugar and protein content per 100 gram, in the two categories “added sugar” and “no added sugar” for quark products.*

	No added sugar (n=16)	Added sugar (n=17)	P-value
Energy (kcal)	59.0±7.8	102.2±36.5	***
Fat (g)	0.57±0.4	2.97±2.9	**
Carbohydrate (g)	3.9±0.9	10.6±3.4	***
Sugars (g)[1]	3.48±0.8	10.2±3.3	***
Protein (g)	8.2±2.1	7.4±1.4	ns

**=p<0.01, ***=p<0.001

[1] Total amount of added and naturally occurring mono- and disaccharides.

The results show that quark products with “added sugar” contained more energy, fat, carbohydrates and sugars compared to quark with “no added sugar”. No significant differences were shown in protein content between the groups. According to Table 5, the sugar in quark is usually replaced with non-nutrient high intensive sweeteners that do not provide energy to the product. This could be confirmed by the results in Table 6 showing that quark with “no added sugar” contains less energy than quark with “added sugar”.

Quark with “added sugar” contains more fat than quark with “no added sugar”. These findings differ from the results of Nguyen *et al.* (2016), who show that products high on sugar contain a lower amount of fat. It seems like the food manufacturers have focused on that the product with “no added sugar” should be a healthier product, since the products with “no added sugar” contain less energy, fat, carbohydrates and sugars.

4.3 Muesli

Differences between the categories “added sugar” and “no added sugar” in energy, fat, carbohydrate, sugar and protein content are shown in Table 7.

Table 7. *The mean values and the standard deviations for energy, fat, carbohydrates, sugar and protein content per 100 gram, in the two categories “added sugar” and “no added sugar” for muesli.*

	No added sugar (n=18)	Added sugar (n=35)	P-value
Energy (kcal)	405.2±55.3	362.9±51.2	***
Fat (g)	13.6±11.1	7.7±4.6	**
Carbohydrate (g)	53.4±11.8	59.9±10.6	ns
Sugar (g)[1]	7.4±5.7	11.7±6.6	*
Protein (g)	12.4±2.3	9.9±2.3	***

ns= not significant, *=p<0.05, **=p<0.01, ***=p<0.001
[1] Total amount of added and naturally occurring mono- and disaccharides.

The results show that muesli with “added sugar” contained more sugar compared to muesli with “no added sugar” but no differences were shown between the categories in carbohydrate content. Further it shows that muesli with “no added sugar” contained both more energy, fat and protein compared to muesli with “added sugar”.

These results may be explained by that fact that muesli is a complex food with many energy-providing ingredients, and this makes it more difficult to replace sugar and decrease the energy content. In muesli, it is common to replace sugar with other kinds of carbohydrates (Sadler & Stowell, 2012) and, as shown in Table 5, dried fruit, fruit juice, juice concentrate or fruit puree is common additives in muesli in the category “no added sugar”. These sweeteners belong to the group nutrient sweeteners, which means that they provide energy to the food as confirmed by the results in Table 7.

The findings that muesli with “no added sugar” contains more fat compared to muesli with “added sugar” are similar with findings from Sadler & Stowells (2012) shown that it is common to add more fat in products with “no added sugar”. These findings are also similar with other research which shows that products high on sugar contain a lower amount of fat (Nguyen *et al.*, 2016). Nuts are usually used as ingredients in muesli and nuts contain a lot of fat and protein. Fat has higher energy content per gram compared to carbohydrates. Together with the fact that nutrient sweeteners often replace sugar in muesli, this could be one reason why muesli with “no added sugar” contains more energy, fat and protein compared to muesli with “added sugar”.

Earlier studies have shown that consumers think that cereals product containing “fruit sugar” are healthier compared to cereals product containing sugar (Sutterlin

& Siegrist, 2015). And, due to the results in Table 5 and 7, muesli labelled with "no added sugar" could be a misleading product for consumers who look for a better alternative.

4.4 Protein bars

Differences between the categories "added sugar" and "no added sugar" in energy, fat, carbohydrate, sugar and protein content are shown in Table 8.

Table 8. *The mean values and the standard deviations for energy, fat, carbohydrates, sugar and protein per 100 gram in the two categories "added sugar" and "no added sugar" for protein bars.*

	No added sugar (n=14)	Added sugar (n=13)	P-value
Energy (kcal)	352±23.3	400.3±40.4	***
Fat (g)	12.9±3.4	15.1±5.6	ns
Carbohydrate (g)	27.1±12.1	39.3±8.3	**
Sugar (g)[1]	6.3±8.8	25.9±10.5	***
Protein (g)	34.6±10.1	26.1±4.9	*

ns= not significant, **=p<0.01, ***=p<0.001
[1] Total amount of added and naturally occurring mono- and disaccharides.

Protein bars with "added sugar" contained more energy, carbohydrates and sugars compared to protein bars with "no added sugar". Protein bars with "no added sugar" contained more protein compared to protein bars with "added sugar". No significant differences were shown in the fat content between the groups. According to Table 5, protein bars with "no added sugar" contains both nutrient sweeteners and non-nutrient sweeteners. However, the results seen in Table 8 shows that the energy content was lower in the products with "no added sugar". Food manufacturers seem to have focused on that the product with "no added sugar" should be a healthier alternative compared to the product with "added sugar".

4.5 Energy content

Differences between the categories “added sugar” and “no added sugar” in energy content are shown for quark, muesli and protein bars in Figure 1.

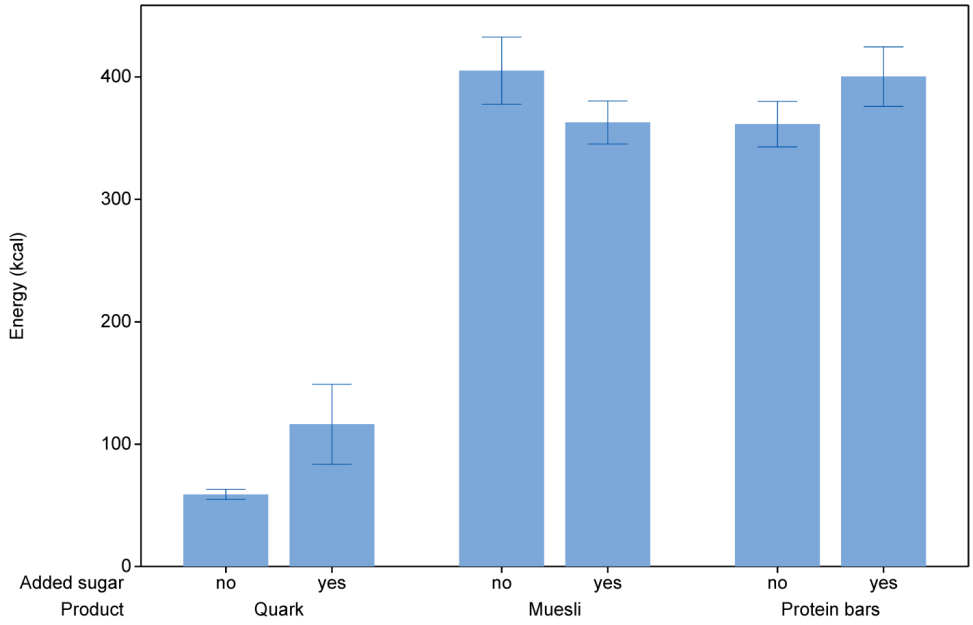

Figure 1. Energy content in products with “added sugar” and with “no added sugar”. The mean value and the standard deviations are shown in each category for quark, muesli and protein bars.

For quark and protein bars the food manufactures have managed to reduce the energy content by replace sugar with another sweetener. These products could therefore seem to be a healthier choice compared to the regular products. These findings agree with Gorton *et al.* (2010) and Mhurchu and Gorton (2007) who found that consumers believed that products labelled with "no added sugar" are healthier than products without that label. They also agree with Patterson *et al.* (2012) who found that consumers believed that reduced sugar content contributes to a reduced energy content. On the other hand the results for muesli seen in Figure 1, disagree with Patterson *et al.* (2012). Muesli with “no added sugar” contain more energy than muesli with “added sugar”. Hence, in the case of muesli, reduced sugar can be a misleading term for consumers.

5 Final Discussions

This section, covers discussions on how the results relate to the literatures and to the recommendations made by health organisations along with comments from food manufacturers.

Definitions and recommendations

The World Health Organisation (WHO) and the Nordic Council of Ministers recommend the same intake of free and added sugar. The dietary recommendations are based on much scientific work and compilations of available studies concerning the area. There are many studies focusing in how foods affect health and these studies need to be confirmed by several studies before the recommendations are established. This is the reason why the recommendations cannot be changed in first hand.

The definitions of "added sugar" are varying between agencies. This makes it difficult for consumers to interpret the sugar content in food and beverages. It could also make it difficult to follow the nutrition recommendations of the total intake of "added sugar", or as WHO define it, "free sugar".

According to WHO and NNR the intake of free sugar or added sugar should be less than 10% of the total energy intake. WHO and NNR and include different ingredients in their definition of added and free sugar. WHO include fruit juice and fruit juice concentrate in the definition while NNR does not mention fruit juice or fruit concentrate as individual ingredients at all. The reasons for this can be due to that they have different starting conditions. WHO has recommendations that should fit for the whole world while NNR only include the Nordic countries. Different ingredients may be of interest in different parts of the world due to economical circumstances. Juice concentrate may be a problem in some poor countries, but for the Nordic countries there are other things that seem to be the problem, for example cakes and buns containing much sucrose.

From a consumer's perspective, it can be difficult to know if a product labelled with "no added sugar" contribute to the intake of the recommended 10% of added sugar or not. For example, this situation makes it possible for consumers to buy a product labelled with "no added sugar" and believe that the product does not contribute to an increased intake of added sugar, but the product could still contain juice concentrate, and according to WHO's definition, the product contains "added sugar" and would thus contribute to an increased intake of added sugar.

The definitions of "added sugar" differ in more places. National Food Agency, Sweden mention on their website that if the product contain some of these ingredients; "dextrose, fructose, honey, invert sugar, maltose syrup, rice syrup, sucrose, molasses, fruit juice concentrate, High Fructose Corn Syrup (HFCS), glucose, lactose, maltose, malt extract, beet sugar, agave syrup etcetera", the product contains "added sugar" (National Food Agency, 2017b).

In this study, it was found that many of the products labelled with "no added sugar" contained dried fruits, fruit juice, fruit juice concentrate and fruit puree. So how is this possible? It is the formulation of the EU regulation that makes this possible. According to EU regulation (EG) no. 1924/2006, products can contain these ingredients, and still be labelled with "no added sugar" if the purpose of the added ingredient is not to sweeten the product. A food manufacturer can therefore use dried fruits, fruit juice, fruit juice concentrate or fruit puree and still use the label "no added sugar" if they could explain why it has been added, the sweetening comes as a side effect.

An example of a product that has been identified in this study is a protein bar that had the label "no added sugar" and still had a high content of fruit juice and fruit puree. The total amount of added and naturally occurring mono- and disaccharides in this product was 28 gram per 100 gram. This value of sugars can be compared to a chocolate from Marabou, "Marabou Premium 70%" which has the same sugar content per 100 gram. It could also be compared to the chocolate balls from "Delicato" which contain 30 gram of sugar per 100 gram. Due to the guideline regarding fruits and berries (National Food Agency, 2013), the food manufacturers may intend to convey a specific mouth feel or a specific consistency in the product, which it certainly does, however, the high amount of fruit juice, fruit puree etcetera will contribute to the sweetness and an increased content of sugar.

Malt extract, or barley malt syrup, is an ingredient in addition to fruit juice concentrate that the National Food Agency define as "added sugar" on their website (National Food Agency, 2017b) and due to this study's results this was also a common ingredient in products labelled with "no added sugar". This is one more example that shows how it makes it hard for consumers to know if these products contain added sugar and if it should be included in the recommended 10% of added sugar or not.

Comments from food manufactures

This study involved contact with food manufactures to get some understanding of why they have chosen to use fruit (juice, concentrate and puree) as ingredients in products labelled with “no added sugar”. One company that have food products containing a large amount of these ingredients and is still labelled with “no added sugar” explained that the added ingredients contribute to a characteristic berry flavour to the product, while the ingredients in some products contribute to texture. The food companies explained that they follow the regulations regarding the labelling and that the ingredients are okay to use if the purpose is not to sweeten the product.

One food company mentions that the purpose of the added fruit juice is to prevent berries in the product to dry or harden. The same food company explained that they had decided to remove fruit juice, fruit concentrates and fruit puree in breakfast products labelled with "no added sugar" and that the recipes will be renewed in 2018. The new recipes were not ready but are most likely to contain dried and freeze dried berries and fruits instead. The reason why the food company has chosen to renew the recipes was to make it more clearly for consumers to choose right. They also explained that it is important for them to be responsive for their consumer’s desires for healthy products.

Regarding malt extract or barley malt syrup as ingredients, two food companies answered that the ingredient was added as a filler and to give the product a juicy flavour. It was also used to give the flakes in the cereals more colours. The food company claimed that the low amount of the ingredient does not contribute to a sweeter taste in the whole product.

It is well known that human beings should not consume “added sugar” in large amounts. Sugar should be consumed in caution due to the high energy density and the low amounts of vitamins and minerals. Food manufactures have therefore reduced the amount of “added sugar” in food products. In some cases the manufacturers label their products with ”no added sugar”. This may affect customers will to buy and therefor may be seen as a possibility of sale for the manufacturer.

People are choosing these products for different reasons, and most likely they are concerned about carbohydrates and energy, perhaps because they have diabetes or just want to avoid the carbohydrates.

For people who want to reduce their energy intake, instead of focusing on “added sugar”, more focus should be on the macronutrients, which are the sources for the total energy content.

Findings from this study showed that labels such as "no added sugar" can be misled to consumers even if they are used according to regulations. These results show that the regulation perspective and the recommendations regarding “added sugar” are not synced with the perspective from consumers.

Findings from this study can be used to teach consumers how to interpret the labels and to inform about the apparent complexity in regulations that arise due to the difference in definitions. To support consumers to a better choice, the message to the manufactures may be that products with “no added sugar” may need to have better total nutritional composition including fat, protein and carbohydrates compared to the regular product. The products should also have a reduced content of energy and total sugar, including the naturally occurring sugar and not just a reduced content of the “added sugar”.

6 Conclusions

“No added sugar” does not necessarily mean that the product is low in energy, fat, carbohydrate, sugar and protein content. Products labelled with “no added sugar” contain non-nutritive as well as nutritive sweeteners and other ingredients that contribute to energy in different amounts. These products do not need to be the best alternatives for people with obesity that need to reduce their total energy intake.

Products that contain “added sugar” may have better nutritional composition compared to similar products labelled with “no added sugar”. It is important for consumers to learn how to read the nutrient list to see the whole nutrient composition and not be misled by the food labels.

The definitions of “added sugar” differ between agencies. That makes the term complex and it can be hard to understand which kinds of sweeteners that can replace sugar in products labelled with “no added sugar”.

7 Future work

There is a lack of studies that compare the energy content of foods and beverages labelled with “no added sugar” with those without the label. This study only compare some examples of products, therefore, further studies may be of interest if this method was applied on more products to increase the reliability of the results.

These types of studies are important to be able to reach the consumers expectations. Different labels such as “no added sugar”, “low on fat”, “light” and “reduced” etcetera, indicates a healthier product in consumers perspective. More research regarding the topic is needed to prevent possible false expectations that consumers have for that type of labelling.

Acknowledgements

I would like to thank my assistant supervisor Minna Hellman, responsible for food and health at Stockholm Consumer Cooperative Society (Konsumentföreningen Stockholm), for letting me write this thesis for her organization. I have enjoyed working with you and I am really grateful that you made it possible to me to carry out this project.

I would also like to thank my supervisor Roger Andersson, professor at the Department of Molecular Sciences, SLU. You have been very helpful, instructive and enthusiastic during my thesis.

References

Anderson, G.H. (1995). Sugars, sweetness, and food intake. *Am J Clin Nutr,* 62(1 Suppl), pp. 195S-201S; discussion 201S-202S.

Antenucci, R.G. & Hayes, J.E. (2015). Nonnutritive sweeteners are not supernormal stimuli. *Int J Obes (Lond),* 39(2), pp. 254-9.

Anton, S.D., Martin, C.K., Han, H., Coulon, S., Cefalu, W.T., Geiselman, P. & Williamson, D.A. (2010). Effects of stevia, aspartame, and sucrose on food intake, satiety, and postprandial glucose and insulin levels. *Appetite,* 55(1), pp. 37-43.

Auerbach, M. & Dedman, A.-k. (2012). Bulking agents – multi-functional ingredients. In: *Sweeteners and Sugar Alternatives in Food Technology.* eds, O'Donell, Kay & Malcolm, Kearsley. Wiley-Blackwell, pp. 433-470. Available from: http://dx.doi.org/10.1002/9781118373941.ch20.

Bellisle, F. (2015). Intense sweeteners, appetite for the sweet taste, and relationship to weight management. *Current Obesity Reports,* 4(1), pp. 106-110.

Berryman, P. (2012). Mindre socker ger inte alltid färre kalorier. *Perspektiv tidskrift om socker och näring nr 1 juni 2012,* pp. 5-7.

Bieleski, R.L. (1982). Sugar alcohols. In: Loewus, F.A. & Tanner, W. (eds) *Plant Carbohydrates I: Intracellular Carbohydrates*. Berlin, Heidelberg: Springer Berlin Heidelberg, pp. 158-192. Available from: https://doi.org/10.1007/978-3-642-68275-9_5.

BioNeutra Inc (2005). *GRAS exemption claim for Isomalto-oligosaccharide or IMO*: Food and Drug Administration. Available from: https://www.fda.gov/downloads/Food/IngredientsPackagingLabeling/GRAS/NoticeInventory/ucm268863.pdf [2017-11-23].

Blundell, J.E. & Hill, A.J. (1986). Paradoxical effects of an intense sweetener (aspartame) on appetite. *Lancet,* 1(8489), pp. 1092-3.

Bray, G.A., Nielsen, S.J. & Popkin, B.M. (2004). Consumption of high-fructose corn syrup in beverages may play a role in the epidemic of obesity. *Am J Clin Nutr,* 79(4), pp. 537-43.

Cornelsen, L. & Carreido, A. (2015). Health-related taxes on foods and beverages. *Food Research Collaboration Policy Brief,* 20.

de Cock, P. (2012). Erythritol. In: *Sweeteners and Sugar Alternatives in Food Technology.* eds, O'Donell, Kay & Malcolm, Kearsley. Wiley-Blackwell, pp. 213-241. Available from: http://dx.doi.org/10.1002/9781118373941.ch10.

De La Hunty, A., Gibson, S. & Ashwell, M. (2006). A review of the effectiveness of aspartame in helping with weight control. *Nutr Bull,* 31(2), pp. 115-128.

de Ruyter, J.C., Olthof, M.R., Seidell, J.C. & Katan, M.B. (2012). A trial of sugar-free or sugar-sweetened beverages and body weight in children. *New England Journal of Medicine,* 367(15), pp. 1397-1406.

Dickson-Spillmann, M., Siegrist, M. & Keller, C. (2011). Development and validation of a short, consumer-oriented nutrition knowledge questionnaire. *Appetite,* 56(3), pp. 617-20.

Duffey, K.J., Gordon-Larsen, P., Steffen, L.M., Jacobs, D.R., Jr. & Popkin, B.M. (2010). Drinking caloric beverages increases the risk of adverse cardiometabolic outcomes in the "Coronary Artery Risk Development in Young Adults" (CARDIA) Study. *Am J Clin Nutr,* 92(4), pp. 954-9.

Efsa Panel on Dietetic Products, N. & Allergies (2011). Scientific Opinion on the substantiation of health claims related to intense sweeteners and contribution to the maintenance or achievement of a normal body weight (ID 1136, 1444, 4299), reduction of post-prandial glycaemic responses (ID 4298), maintenance of normal blood glucose concentrations (ID 1221, 4298), and maintenance of tooth mineralisation by decreasing tooth demineralisation (ID 1134, 1167, 1283) pursuant to Article 13(1) of Regulation (EC) No 1924/2006. *EFSA Journal,* 9(6), pp. n/a-n/a.

Environ International Corporation (2012). *GENERALLY RECOGNIZED AS SAFE (GRAS) NOTIFICATION FOR FRUTAFIT**: Food and Drug Administration. Available from: https://www.fda.gov/downloads/food/ingredientspackaginglabeling/gras/noticeinventory/ucm261559.pdf [2017-11-23].

Erickson, J. & Slavin, J. (2015). Are restrictive guidelines for added sugars science based? *Nutr J,* 14, p. 124.

REGULATION (EC) No 1924/2006 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 December 2006 on nutrition and health claims made on foods (2006). (OJ L 404, 30.12.2006, p.9).

Flambeau, M., Respondek, F.e.e. & Wagner, A. (2012). Maltitol syrups. In: *Sweeteners and Sugar Alternatives in Food Technology,* eds, O'Donell, Kay & Malcolm, Kearsley. Wiley-Blackwell, pp. 309-330. Available from: http://dx.doi.org/10.1002/9781118373941.ch14.

Foster-Powell, K., Holt, S.H. & Brand-Miller, J.C. (2002). International table of glycemic index and glycemic load values: 2002. *Am J Clin Nutr,* 76(1), pp. 5-56.

Gorton, D., Mhurchu, C.N., Bramley, D. & Dixon, R. (2010). Interpretation of two nutrition content claims: a New Zealand survey. *Aust N Z J Public Health,* 34(1), pp. 57-62.

Grundy, S.M. (1999). Hypertriglyceridemia, insulin resistance, and the metabolic syndrome. *The American Journal of Cardiology,* 83(9, Supplement 2), pp. 25-29.

Grunert, K.G. & Wills, J.M. (2007). A review of European research on consumer response to nutrition information on food labels. *Journal of Public Health,* 15(5), pp. 385-399.

Hill, J.O. & Prentice, A.M. (1995). Sugar and body weight regulation. *The American Journal of Clinical Nutrition,* 62(1), pp. 264S-273S.

Hu, F.B., van Dam, R.M. & Liu, S. (2001). Diet and risk of Type II diabetes: the role of types of fat and carbohydrate. *Diabetologia,* 44(7), pp. 805-17.

International Sweeteners Association (2017). *Low calorie sweeteners regulation & safety*. Available at: http://www.sweeteners.org/category/11/sweeteners/56/low-calorie-sweeteners-regulation-and-safety [2017-11-01].

Jenkins, D.J., Wolever, T.M., Taylor, R.H., Barker, H., Fielden, H., Baldwin, J.M., Bowling, A.C., Newman, H.C., Jenkins, A.L. & Goff, D.V. (1981). Glycemic index of foods: a physiological basis for carbohydrate exchange. *Am J Clin Nutr,* 34(3), pp. 362-6.

Kearsley, M.W. & Deis, R.C. (2012). Maltitol powder. In: *Sweeteners and Sugar Alternatives in Food Technology,* eds. Wiley-Blackwell, pp. 295-308. Available from: http://dx.doi.org/10.1002/9781118373941.ch13.

Keen, H. (1989). *Dietary Sugars and Human Disease: Report of the Panel on Dietary Sugars, Committee on Medical Aspects of Food Policy*: H.M. Stationery Office. Available from: https://books.google.se/books?id=y90pAQAAIAAJ.

Klug, C. & von Rymon Lipinski, G.-W. (2012). Acesulfame K. In: *Sweeteners and Sugar Alternatives in Food Technology,* eds, O'Donell, Kay & Malcolm, Kearsley. Wiley-Blackwell, pp. 91-115. Available from: http://dx.doi.org/10.1002/9781118373941.ch5.

Lindley, M.G. (2012). Natural High-Potency Sweeteners. In: *Sweeteners and Sugar Alternatives in Food Technology,* eds, O'Donell, Kay & Malcolm, Kearsley. Wiley-Blackwell, pp. 185-212. Available from: http://dx.doi.org/10.1002/9781118373941.ch9.

Liu, S., Manson, J.E., Stampfer, M.J., Holmes, M.D., Hu, F.B., Hankinson, S.E. & Willett, W.C. (2001). Dietary glycemic load assessed by food-frequency questionnaire in relation to plasma high-density-lipoprotein cholesterol and fasting plasma triacylglycerols in postmenopausal women. *Am J Clin Nutr,* 73(3), pp. 560-6.

Ludwig, D.S., Majzoub, J.A., Al-Zahrani, A., Dallal, G.E., Blanco, I. & Roberts, S.B. (1999). High glycemic index foods, overeating, and obesity. *Pediatrics,* 103(3), pp. e26-e26.

McKeown, N.M., Meigs, J.B., Liu, S., Saltzman, E., Wilson, P.W. & Jacques, P.F. (2004). Carbohydrate nutrition, insulin resistance, and the prevalence of the metabolic syndrome in the Framingham Offspring Cohort. *Diabetes care,* 27(2), pp. 538-546.

Mhurchu, C.N. & Gorton, D. (2007). Nutrition labels and claims in New Zealand and Australia: a review of use and understanding. *Aust N Z J Public Health,* 31(2), pp. 105-12.

Miller, P.E. & Perez, V. (2014). Low-calorie sweeteners and body weight and composition: a meta-analysis of randomized controlled trials and prospective cohort studies. *The American Journal of Clinical Nutrition,* 100(3), pp. 765-777.

Mirmiran, P., Yuzbashian, E., Asghari, G., Hosseinpour-Niazi, S. & Azizi, F. (2015). Consumption of sugar sweetened beverage is associated with incidence of metabolic syndrome in Tehranian children and adolescents. *Nutr Metab (Lond),* 12, p. 25.

Molinary, S.V. & Quinlan, M.E. (2012). Sucralose. In: *Sweeteners and Sugar Alternatives in Food Technology,* eds. Wiley-Blackwell, pp. 167-183. Available from: http://dx.doi.org/10.1002/9781118373941.ch8.

National Food Agency. Föreskrifter om ändring i Livsmedelsverkets föreskrifter (LIVSFS 2003:18) om fruktjuice och fruktnektar (2012). Sweden.

National Food Agency, S. (2013-07-10). *Vägledning till kontrollmyndigheter m.fl. Näringspåståenden och hälsopåståenden om livsmedel. Förordning (EG) nr 1924/2006* Available at: https://www.livsmedelsverket.se/globalassets/produktion-handel-kontroll/vagledningar-kontrollhandbocker/vagledning_narings-_och_halsopastaenden.pdf [2017-11-16].

National Food Agency, S. (2015-3-1). *Vad är nyttiga och onyttiga kolhydrater?* Available at: https://www.livsmedelsverket.se/globalassets/livsmedel-innehall/naringsamnen/kolhydrater/vad-ar-nyttiga-och-onyttiga-kolhydrater.pdf [2017-11-16].

National Food Agency, S. (2017-06-22). *Energi, kalorier*. Available at: https://www.livsmedelsverket.se/livsmedel-och-innehall/naringsamne/energi-kalorier [2017-11-16].

National Food Agency, S. (2017-11-07). *Naturligt och tillsatt socker – hur ser du skillnad?* Available at: https://www.livsmedelsverket.se/livsmedel-och-innehall/text-pa-forpackning-markning/naturligt-och-tillsatt-socker-hur-ser-du-skillnad [2017-11-13].

National Food Agency, S. (2017-05-30). *Socker*. Available at: https://www.livsmedelsverket.se/livsmedel-och-innehall/naringsamne/kolhydrater/socker [2017-11-13].

National Food Agency, S. (2017-09-28). *Sötningsmedel*. Available at: https://www.livsmedelsverket.se/livsmedel-och-innehall/tillsatser-e-nummer/sotningsmedel [2017-11-13].

Nguyen, P.K., Lin, S. & Heidenreich, P. (2016). A systematic comparison of sugar content in low-fat vs regular versions of food. *Nutrition & Diabetes,* 6(1), p. e193.

Nordic Council of Ministers (2014). *Nordic Nutrition Recommendations 2012 - Integrating nutrition and physical activity*. Available at: http://norden.diva-portal.org/smash/get/diva2:704251/FULLTEXT01.pdf [2017-11-13].

Nordic Sugar *Perspektiv tidskrift om socker och näring nr 1 juni 2012*. Available at: http://perspektiv.nu/files/Filer/PDF/perspektiv1201_svensk.pdf [2017-11-16].

O'Donnell, K. (2012). Aspartame, Neotame and Advantame. In: *Sweeteners and Sugar Alternatives in Food Technology,* eds, O'Donell, Kay & Malcolm, Kearsley. Wiley-Blackwell, pp. 117-136. Available from: http://dx.doi.org/10.1002/9781118373941.ch6.

Packer, N.H. (2017). *Essentials of glycobiology, third edition*. (Oligosaccharides and Polysaccharides: Cold Spring Harbor Laboratory.

Page, K.A., Chan, O., Arora, J., Belfort-DeAguiar, R., Dzuira, J., Roehmholdt, B., Cline, G.W., Naik, S., Sinha, R., Constable, R.T. & Sherwin, R.S. (2013). Effects of fructose vs glucose on regional cerebral blood flow in brain regions involved with appetite and reward pathways. *JAMA : the Journal of the American Medical Association,* 309(1), pp. 63-70.

Patterson, N.J., Sadler, M.J. & Cooper, J.M. (2012). Consumer understanding of sugars claims on food and drink products. *Nutr Bull,* 37(2), pp. 121-130.

Peters, J.C., Beck, J., Cardel, M., Wyatt, H.R., Foster, G.D., Pan, Z., Wojtanowski, A.C., Vander Veur, S.S., Herring, S.J., Brill, C. & Hill, J.O. (2016). The effects of water and non-nutritive sweetened beverages on weight loss and weight maintenance: A randomized clinical trial. *Obesity (Silver Spring),* 24(2), pp. 297-304.

Peters, J.C., Wyatt, H.R., Foster, G.D., Pan, Z., Wojtanowski, A.C., Vander Veur, S.S., Herring, S.J., Brill, C. & Hill, J.O. (2014). The effects of water and non-nutritive sweetened beverages on weight loss during a 12-week weight loss treatment program. *Obesity (Silver Spring),* 22(6), pp. 1415-21.

Roberfroid, M.B. (1999). Caloric value of inulin and oligofructose. *J Nutr,* 129(7 Suppl), pp. 1436s-7s.

Roberts, S.B. (2000). High-glycemic index foods, hunger, and obesity: is there a connection? *Nutr Rev,* 58(6), pp. 163-9.

Sadler, M. & Stowell, J.D. (2012). Calorie Control and Weight Management. In: *Sweeteners and Sugar Alternatives in Food Technology,* eds, O'Donell, Kay & Malcolm, Kearsley. Wiley-Blackwell, pp. 77-89. Available from: http://dx.doi.org/10.1002/9781118373941.ch4.

Samuel, V.T. (2011). Fructose induced lipogenesis: from sugar to fat to insulin resistance. *Trends in Endocrinology & Metabolism,* 22(2), pp. 60-65.

Saris, W.H., Astrup, A., Prentice, A.M., Zunft, H.J., Formiguera, X., Verboeket-van de Venne, W.P., Raben, A., Poppitt, S.D., Seppelt, B., Johnston, S., Vasilaras, T.H. & Keogh, G.F. (2000). Randomized controlled trial of changes in dietary carbohydrate/fat ratio and simple vs complex carbohydrates on body weight and blood lipids: the CARMEN study. The Carbohydrate Ratio Management in European National diets. *Int J Obes Relat Metab Disord,* 24(10), pp. 1310-8.

Shallenberger, R.S. (1993). *Taste Chemistry*. 1st. ed. London ; New York: Blackie Academic & Professional. Available from: Table of contents only http://www.loc.gov/catdir/enhancements/fy0820/92011271-t.html.

Stanhope, K.L. (2016). Sugar consumption, metabolic disease and obesity: The state of the controversy. *Crit Rev Clin Lab Sci,* 53(1), pp. 52-67.

Sutterlin, B. & Siegrist, M. (2015). Simply adding the word "fruit" makes sugar healthier: The misleading effect of symbolic information on the perceived healthiness of food. *Appetite,* 95, pp. 252-61.

Teff, K.L., Elliott, S.S., Tschop, M., Kieffer, T.J., Rader, D., Heiman, M., Townsend, R.R., Keim, N.L., D'Alessio, D. & Havel, P.J. (2004). Dietary fructose reduces circulating insulin and leptin, attenuates postprandial suppression of ghrelin, and increases triglycerides in women. *J Clin Endocrinol Metab,* 89(6), pp. 2963-72.

Tordoff, M.G. & Friedman, M.I. (1989). Drinking saccharin increases food intake and preference--I. Comparison with other drinks. *Appetite,* 12(1), pp. 1-10.

Touger-Decker, R. & van Loveren, C. (2003). Sugars and dental caries. *The American Journal of Clinical Nutrition,* 78(4), pp. 881S-892S.

U.S. Food and Drug Administration (2017-11-11). *Changes to the Nutrition Facts Label*. Available at: https://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/LabelingNutrition/ucm385663.htm [2017-11-16].

U.S. Food and Drug Administration (2015-03-20). *CPG Sec. 515.200 Malt Extract; Malt Syrup; Malted Cereal Syrup; Liquid Malt; Dried Malt*. Available at: https://www.fda.gov/iceci/compliancemanuals/compliancepolicyguidancemanual/ucm074436.htm [2017-12-01].

Wansink, B. & Chandon, P. (2006). Can "low-fat" nutrition labels lead to obesity? *Journal of Marketing Research,* 43(4), pp. 605-617.

Wills, J.M., Storcksdieck genannt Bonsmann, S., Kolka, M. & Grunert, K.G. (2012). European consumers and health claims: attitudes, understanding and purchasing behaviour. *Proceedings of the Nutrition Society,* 71(2), pp. 229-236.

Wolever, T.M.S. (2007). Effect of blood sampling schedule and method of calculating the area under the curve on validity and precision of glycaemic index values. *British Journal of Nutrition,* 91(2), pp. 295-300.

World Health Organization (2015). *Guideline: sugars intake for adults and children*: World Health Organization.

Zacharis, C. (2012). Xylitol. In: *Sweeteners and Sugar Alternatives in Food Technology,* eds, O'Donell, Kay & Malcolm, Kearsley. Wiley-Blackwell, pp. 347-382. Available from: http://dx.doi.org/10.1002/9781118373941.ch16.

Appendix 1

Table 1. Collected data of the nutritional compositions of quark and quark/youghurt products categorised "no added sugar" and "added sugar" and the added sweeteners in the category "no added sugar".

Quark & Quark/Yoghurt (n=33)	Added sugar	Energy		Fat	Carbohydrates	Sugars	Protein	Sweetener
		kJ	kcal	g/100g	g/100g	g/100g	g/100g	
A1	no	250	60	0.2	3.5	3.1	11	acesulfame K, aspartame
B1	no	300	70	0.8	3	2.8	8	maltitol, aspartame, acesulfame K
C1	no	250	60	0.2	3.4	3.1	11	acesulfame K, aspartame
D1	no	200	50	1	2.1	2.1	6.4	acesulfame K, aspartame
E1	no	280	70	0.8	4.6	4	9.5	fruit preparation (water, apple (4,2%), lemon concentrate, sucralose
F1	no	190	54	0.1	5.1	4.5	5.7	aspartame
G1	no	200	50	0.2	5.6	5.3	5.7	aspartame
H1	no	230	50	0.8	3.8	3.1	6.6	lemon juice, aspartame
I1	no	300	70	0.8	3	2.8	8	maltitol, aspartame, acesulfame K
J1	no	220	50	0.7	4.1	3.5	6.3	acesulfame K, aspartame, pinapple puree
K1	no	250	60	1.7	4.6	4.1	5.2	aspartame, acesulfame K
L1	no	270	70	0.2	3.4	3.1	11	
M1	no	240	60	0.2	4	3.6	10	aspartame
N1	no	220	50	0.8	3.7	3.4	6.7	passion fruit puree, aspartame, acesulfame K
O1	no	260	60	0.2	3.4	3.1	10	aspartame
P1	no	250	60	0.2	4.7	4	9.4	aspartame
Q1	yes	360	90	0.2	13.6	13.1	6.5	
R1	yes	550	130	5	13	13	8.2	
S1	yes	600	150	7.5	13	12	7.4	
T1	yes	330	80	1.4	9.1	8.7	6.9	
U1	yes	320	70	1.5	8.1	7.7	7	
V1	yes	261	62	0.2	5.4	5.2	9.5	
W1	yes	276	66	0.7	5.2	5.0	9.5	
X1	yes	340	80	0.2	8.7	8.3	9.5	
Y1	yes	320	70	0.2	7.8	7.4	9.8	
Z1	yes	340	80	1.8	8.9	8.4	6.6	
A2	yes	650	160	7.8	15	14	6.8	
B2	yes	650	150	7.9	15	15	6.9	
C2	yes	650	160	7	16	16	7.2	
D2	yes	440	140	2.9	13.1	12.4	6.4	
E2	yes	371	88	2.4	10.4	9.9	5.3	
F2	yes	330	80	1.8	8.5	8.3	6.6	
G2	yes	80	320	1.9	8.7	8.1	5.2	

Table 2. Collected data of the nutritional compositions of muesli products categorised "no added sugar" and "added sugar" and the added sweeteners in the category "no added sugar".

Muesli (n=18)	Added sugar	Energy		Fat	Carbohydrates	Sugars	Protein	Sweetener
		kJ	kcal	g/100g	g/100g	g/100g	g/100g	
H2	no	1580	376	7.5	58	3.6	12	blueberry puree, blackcurrant juice concentrate, fiber from chicory root
I2	no	1557	370	5.5	61	6.2	12	fiber from chicory root, dried apple and strawberry pieces
J2	no	1619	385	9.7	57	7.9	11	fiber from chicory root, raisin, dried strawberry pieces
K2	no	1757	419	13	56	7.1	12	fiber from chicory root, apple concentrate ,dried blackberrys and dates
L2	no	1753	418	14	54	7.8	12	fiber from chicory root, acai puree, blackcurrant juice concentrate, apple juice concentrate, dried cranberry containing tranberry
M2	no	1500	360	5	62	7.1	11	raisins, berry crisp containing blueberries, raspberries, lingonberries, cranberries, maltodextrin
N2	no	1450	350	3.5	61	1.9	11	barley malt extract, fruit and berry crisp containing peach, raspberry, maltodextrin
O2	no	1630	390	13	52	15	12	freeze dried berries
P2	no	1800	430	19	49	10	12	dates
Q2	no	1750	420	15	56	21	11	dried berries and fruits
R2	no	1700	410	13	50	6	18	dried apple pieces
S2	no	1650	400	12	54	6.5	14	cranberry pieces (cranberrie- and pineapple juice), freeze dried
T2	no	1450	350	4	63	0.9	11	oligofructose
U2	no	1560	370	8.1	60.5	1.3	11.1	maltodextrin
V2	no	1500	360	4.9	66	7.5	9.6	barley malt extract, oligofructose, raisinr, dried apple pieces
W2	no	2150	510	33	36	5	18	
X2	no	1700	410	16	50	18	14	dried berries, pinapple juice, barley malt extract
Y2	no	2361	565	48	15	0.4	12	

Table 2. Cont.

Muesli (n=35)	Added sugar	Energy		Fat	Carbohydrates	Sugars	Protein
		kJ	kcal	g/100g	g/100g	g/100g	g/100g
Z2	yes	1730	410	15	52	18	13
A3	yes	1650	390	9	66	25	7
B3	yes	800	190	7.3	23	1.7	5.7
C3	yes	1400	330	2.7	62	16	8.3
D3	yes	1510	360	5.1	66	25	8.4
E3	yes	1580	380	6.1	65	11	11
F3	yes	1680	400	9.6	68	18	7.5
G3	yes	1630	390	8	65	11	9.8
H3	yes	1550	370	5	63	4.2	12
I3	yes	800	190	6.6	25	6.7	5
J3	yes	1550	370	6.7	62	6.3	10
K3	yes	1810	433	16	57	16	11
L3	yes	1467	351	7	58	10	12
M3	yes	1399	334	6	56	9	11
N3	yes	1540	370	6.2	64	18	9.6
O3	yes	1600	380	7	65	21	8.8
P3	yes	1450	350	3.6	64	16	9.3
Q3	yes	1650	394	10	60	17	11
R3	yes	1600	380	10	60	23	9
S3	yes	1500	360	6.3	61	12	8.6
T3	yes	1500	350	4.7	62	6.9	11
U3	yes	1550	370	6.9	59	1.3	12
V3	yes	1500	360	5	66	19	8
W3	yes	1450	350	3.5	66	4	10
X3	yes	1500	360	4.5	63	5	11
Y3	yes	1515	360	7.6	58.6	6	9.5
Z3	yes	1998	480	28.5	33.6	4.8	17.9
A4	yes	1550	370	5	69	18	8
B4	yes	1500	360	4.9	66	7.5	9.6
C4	yes	1634	388	9.3	62.8	8.1	9.4
D4	yes	1550	370	6.7	61	8.6	11
E4	yes	1500	360	7	57	8	11
F4	yes	1500	360	6.2	60	8.1	11
G4	yes	1540	370	9	55	9.7	11
H4	yes	1500	360	6.5	60	8.1	11

Table 3. Collected data of the nutritional compositions of protein bars products categorised "no added sugar" and "added sugar" and the added sweeteners in the category "no added sugar".

Protein bars (n=27)	Added sugar	Energy		Fat	Carbohydrates	Sugars	Protein	Sweetener
		kJ	kcal	g/100g	g/100g	g/100g	g/100g	
I4	no	1602	384	18	37	3.3	31	maltitol
J4	no	1591	380	16	38	3.1	33	maltitol
K4	no	1340	320	8.5	24	1.8	40	maltitol
L4	no	1513	362	14	27	2.8	38	maltitol, isomaltooligosaccharides, sucralose, acesulfame K
M4	no	1402	335	11	22	1.8	40	maltitol, xylitol, sucralose
N4	no	1516	360	9.6	28	2.2	50	maltito, steviol glycosides
O4	no	1489	356	12	29	3.1	38	maltitol, sucralose, acesulfame K
P4	no	1514	359	9.7	28	2.4	50	maltitol, steviol glycosides
Q4	no	1533	369	18	26.3	4.3	25.4	maltitol, acesulfame K
R4	no	1291	311	9.4	4.1	3.1	33.1	isomaltooligosaccharide, oligofructose, steviol glycosides, sucralose
S4	no	1363	328	12	4.3	3	32.7	isomaltooligosaccharide, oligofructose, steviol glycosides, sucralose
T4	no	1500	360	14	23	3.3	39	maltitol, xylitol
U4	no	1756	419	11	41	28	21	fruit juice and fruit puree concentrate from mango, apple, pear
V4	no	1751	418	18	47	26	13	fruit juice and fruit puree concentrate from blackberry, apple, pear
W4	yes	1600	380	15	44	17	30	
X4	yes	1684	402	13	43	35	25	
Y4	yes	1850	440	19	41	36	29	
Z4	yes	1678	398	11	48	34	26	
A5	yes	1650	390	12	40	30	33	
B5	yes	1599	383	15	41	36	20	
C5	yes	1789	427	19	37	29	25	
D5	yes	1650	390	9.7	43	29	32	
E5	yes	1629	400	14	45	31	22	
F5	yes	1708	404	15	44	30	20	
G5	yes	2081	500	30.8	23.5	13.5	25.8	
H5	yes	1386	333	11.2	19.7	4.9	32.3	
I5	yes	1429	357	11	41	11	19	

Data is collected from shops (Coop, Hemköp, ICA and Willys) and the internet (mathem.se, gymgrossisten.se and apotea.se).

Appendix 2: Popular scientific summary

The consumption of food with high energy density such as sugar and fat is associated with an increased risk of obesity, cardiovascular disease, type 2-diabetes and different types of cancers. The World Health Organization (WHO) and the Nordic Council of Ministers recommends adults and children that the intake of “added sugar”, or as WHO define it; “free sugar”, should be less than 10% of their total energy intake. A study done by the National Food Agency, Sweden showed that four out of ten persons in Sweden eat more “free sugars” than what is recommended. “Added sugar” do not occur naturally in food products and are added in food under different names such as; sucrose, glucose, maltose, fructose, honey, invert sugar and High Fructose Corn Syrup (HFCS) etcetera. These ingredients are frequently used by food manufacturers for different reasons, one of them is for flavouring food.

Different strategies are needed to reduce obesity and the associated diseases. Alternative sweet ingredients are used as a replacement for sugar to reduce the “added sugar” content in food products with the purpose of making the product healthier, tastier or cheaper. To recreate the sweet taste, the texture and the mouthfeel in products with reduced sugar content, other ingredients need to be added. But, it is not always easy to replace sugar in food products with other ingredients. A reduced energy content is most easily achieved in food where sugar is the main source of energy. It is more difficult to reduce the energy content by removing sugar from more complex food, such as cakes or muesli. In these foods, sugar is often replaced with another type of carbohydrate, usually starch. Sugar can also be replaced with a higher proportion of fat. The energy density will then be the same, or in some cases even higher.

Consumers may expect the product to be a healthier alternative because they expect that the amount of reduced sugar corresponds to the amount of reduced energy. To avoid misleading for consumers it is important that labelling regarding a reduced sugar content are found on food products that have better nutritional composition compared to the similar product without the labelling.

The purpose of this thesis was to determine whether a replacement of sugar by other sweet ingredients in the products; quark, muesli, and protein bars change the energy, fat, carbohydrate, sugar and protein content. The work was also aimed towards identifying the most common sweeteners used in the selected products labelled with "no added sugars". The aim was also to investigating the definition of the term “added sugar”. This study was performed using data collection from products present on the market and a literature survey.

This study showed that the term “added sugar” is varying in definition between the agencies. That contributes to that the term is complex and difficult for consumers to understand which kind of sweeteners that can replace sugar in products labelled with “no added sugar”.

The study also showed that products labelled with “no added sugar” contain nutritive as well as non-nutritive sweeteners and other ingredients that contribute to energy in different amounts. The most commonly used sweeteners in quark, muesli and protein bars labelled with “no added sugar” were; asesulfame k, aspartame, barley malt syrup, maltodextrin, oligofructose, fruits (dried, juice, concentrate or puree) and maltitol. In this study, it was shown that quark with “added sugar” contained more energy, fat, carbohydrates and sugars compared to quark labelled with “no added sugar”. Protein bars with “added sugar” contained more energy, carbohydrates and sugars compared to protein bars labelled with “no added sugar”. Protein bars with “no added sugar” contained more protein. Muesli with “added sugar” contained more sugars compared to muesli labelled with “no added sugar”. Muesli with “no added sugar” contained more energy, fat and protein.

It is important for consumers to learn how to read the nutrient list to see the whole nutrient composition and not be misled by the food labels.