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## Affirmation

I hereby declare that the master's thesis submitted was in all parts exclusively fabricated on my own, and that other sources or aids than those explicitly referred to have not been utilised. All passages quoted from publications or paraphrased from these sources are properly cited and attributed.

The thesis was not previously submitted in same or similar form to another examination committee and was not published elsewhere.

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Signature

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## List of Abbreviations

**AGES = Österreichische Agentur für Gesundheit und Ernährungssicherheit (Austrian Agency for Health and Food Safety Ltd.)**

**AHA = The American Heart Association**

**BLS = Bundeslebensmittelschlüssel (The German Nutrient Database)**

**BLV = Bundesamt für Lebensmittelsicherheit und Veterinärwesen (Federal Food Safety and Veterinary Office)**

**CVD = Cardiovascular Disease**

**DGE = Deutsche Gesellschaft für Ernährung (German Nutrition Society)**

**DRI = Dietary Reference Intake**

**EFSA = European Food Safety Authority**

**ESPGHAN = European Society for Paediatric Gastroenterology, Hepatology and Nutrition**

**FDA = Food and Drug Administration**

**FODMAP = Fermentable oligo-, di- and monosaccharides and polyols**

**GLUT = Glucose transporter**

**M = Mean**

**MAX = Maximum amount**

**MDN = Median**

**MIN = Minimum amount**

**MUFA = Monounsaturated Fats**

**N = Number of products analysed**

**NUT.S = Nutritional Software**

**NAFLD = Non-alcoholic Fatty Liver Disease**

**NCD = Non-communicable disease**

**NMES = Non-milk extrinsic sugars**

**ÖGE = Österreichische Gesellschaft für Ernährung (The Austrian Nutrition Society)**

**ÖNWT = Österreichische Nährwerttabelle (Austrian Nutrition Database)**

**PUFA = Polyunsaturated Fats**

**T2D = Type 2 Diabetes**

**SD = Standard deviation**

**SGLT = Sodium-glucose transport protein**

**SCFA = Short-chain fatty acid**

**USDA = United States Department of Agriculture**

**WHO = World Health Organisation**

# 1 Introduction

Dairy products are an important food group for many people, and most countries worldwide consider them in their nutritional recommendations. Dairy products have made an important contribution to human health for more than 8000 years (Rozenberg S. et al. 2016). One of the most popular milk products is yoghurt, which dates to around 6000 BC. It is fermented milk which contains viable bacterial strains such as Lactobacillus bulgaricus and Streptococcus thermophilus, having potential health benefits (Fisberg M. and Machado R. 2015). Dairy products contain various important nutrients such as calcium, phosphorus, protein and potassium, and contribute with approximately 52-65 % to the dietary reference intake (DRI) of calcium in developed countries (Rozenberg S. et al. 2016).

Calcium is important for bone health and this mineral also supports the bioavailability of vitamin D in the body (Wang Y. and Li S. 2008). According to the nutritional recommendations from the Austrian Nutritional Society (ÖGE), every person should eat three portions of low-fat dairy products daily, which include milk, yoghurt and cheese (Österreichische Gesellschaft für Ernährung). Recommendations differ slightly from country to country, but most of the Nutrition Societies recommend to consume dairy products daily. Especially for children and adolescents is it crucial to get enough calcium to ensure a good bone quality, before it reaches its peak bone mass where bone mass and density will be declining. This is based on sex, lifestyle factors, maturational timing and skeletal site and bone compartment (Gordon CM. et al. 2017).

Nowadays there are plenty of different dairy products on the market, however, not only the traditional ones mentioned above. It is easy to buy yoghurts, milk shakes, desserts etc. of different colours and flavours. Unfortunately, many of these products contain a high amount of added sugar and other artificial ingredients such as colourants, sweeteners or flavours. Children often prefer a sweeter taste than adults, and the feeling of pleasantness when tasting something sweet is innate (Mennella JA. et al. 2016). A sweet taste could possibly affect children leading to a more frequent purchase and a higher sugar consumption. Dairy products which have many health benefits become a potential contributor to child obesity and diabetes, due to the high amount of sugar added to dairy products which could easily exceed the acceptable daily sugar intake. According to studies on this topic, the consumption of dairy products is inversely related to obesity, but a further distinction between products of high and low sugar concentration is still needed (Lu L. et al. 2016).

This paper will evaluate the amount of added sugar in dairy products on the Austrian market. It will try to estimate how much added sugar the products contain by using and comparing different sugar calculation models. This estimation is important for consumers in order to realise how much sugar is added to products, which appear to be healthy, and to be aware and maybe look actively for products free of added sugar. This might also put pressure on companies and producers to adjust and alter their recipes regarding sugar content, as it is easier to see where the potential for sugar reduction lies.

# 2 Literature Survey

## 2.1 Sugar and Health Aspects

Inadequate diets are often associated with obesity, dental caries and other non-communicable diseases (NCDs). There is a direct link between a high sugar intake and caries. An indirect link is found between sugar and diseases associated with obesity. NCDs caused 38 million deaths of a total 56 million deaths in 2012, 40 % of deaths being premature. Physical inactivity and poor diet are common causes of NCDs. Free sugars are often a cause of a positive energy balance due to a higher energy density in food, and dental caries is an increasing problem (WHO 2015).

Despite enough fluoride intake, the prevalence of caries remains high in industrialised countries. It affects all age groups and is the most prevalent NCD worldwide and causes pain and anxiety. According to animal studies, the amount and frequency of sugar intake is an important risk factor for caries. Few studies with humans have measured the amount and frequency of free sugar intake from all sources. It is, however, difficult to evaluate because the amount and frequency are correlated and an increase in one variable causes an increase in the other. The WHO conclusion is that both factors are important (Moynihan 2016).

A systematic review by Moynihan and Kelly found that 7 out of 8 cohort studies reported higher dental caries when there was a high intake of sugar. However, all studies were conducted in children, but the aetiology of dental caries is the same in adults and children. Out of 20 populations studies, 18 showed a positive dose-response between dental caries and sugar intake. Five of the cohort studies compared sugar consumption and dental development when sugar intake was below 10 % or above 10 % of the daily energy intake. All studies proved higher caries when sugar intake was > 10 %. The quality of evidence was classified as “moderate” by the GRADE process. Thus, there is evidence to suggest that dental caries and a high sugar intake are linked (Moynihan and Kelly 2014).

Meta-analyses that investigated RCTs on obesity found evidence that a change in the amount of dietary sugar intake from current levels affects body weight. In children, cohort studies proved a link between the risk of becoming overweight and the intake of sugar sweetened beverages. The data concerning adults was found to be moderate, whereas for children the evidence for a decrease in sugar intake causing a decrease in body weight was moderate, and an increase in sugar intake causing an increase in body weight was low (WHO 2015).

A meta-analysis by Te Morenga et al. 2012 identified five studies for the analysis of the effect of reducing sugar intake on body fatness in adults. There was a significant association established between the reduction of dietary sugar and the reduction of body weight. Ten other studies examined the effect of increasing sugar intake on body fatness. Here, an adverse effect was shown. At the end of the intervention period, a greater weight was associated with an increased intake of dietary sugar when comparing the control group with the intervention group. The higher sugar intake in the studies was often achieved by consuming sugar-sweetened soft drinks. Twenty one cohort studies were available for children, and the link between sugar intake and a higher risk of being overweight was established here too (Te Morenga et al. 2012).

The guideline by the German Nutrition Society (DGE) has classified the different evidence found for the relation between carbohydrate intake and various diseases. They concluded that the evidence for a link between saccharose intake and T2D (type 2 Diabetes) is probable, but more studies of good consistency are needed. They also concluded that there might be a link between regular consumption of sugar-sweetened beverages and T2D (DGE 2011). A meta-analysis by Schwingshackl et al. 2017 identified ten studies examining the relation between sugar-sweetened beverages and T2D. A significant positive association between sugar-sweetened beverages and T2D was identified. Three servings of sugar-sweetened beverages were associated with a threefold increased risk of T2D. There was some evidence of heterogeneity between subgroups. However, by inspecting the funnel plot visually, there may be some smaller scale studies that showed null or an inverse association missing (Schwingshackl et al. 2017).

## 2.2 Importance of Sugar Reduction

Since a high amount of sugar poses a threat to general health, it is important to reduce the amount of sugar added to foods and drinks. It is crucial to reduce health care costs and loss of working days due to NCDs. Europeans consume too much added sugar, salt and saturated fats. To ensure a reduction it is important to let the consumers adjust to new products and make the healthier choice the easy one. Information about the product should be clearly labelled and people should have the possibility to educate themselves on the topic (Ministry of Health, Welfare and Sport 2016).

In order to achieve this, all EU countries need to cooperate, and different preferences and cultures must be taken into consideration. National governments need to address these issues and cooperate with the WHO, EFSA and NGOs in order to succeed, as products can easily cross boarders in the EU (Ministry of Health, Welfare and Sport 2016).

Most countries also have their own sugar reduction program. In Austria, the Federal Ministry of Labour, Social Affairs, Health and Consumer Protection together with the food industry aim to reduce sugar and salt in processed food. The main food groups in debate are soft drinks, breakfast cereals and dairy products. Target values are being defined as well as steps aiming to reduce intake of sugar and salt. For sugar there will be a progressive decline in sweet taste taking the technological possibilities and the acceptance of consumers into consideration (Bundesministerium für Gesundheit 2019).

Likewise, in Switzerland, food producers and the Federal Council aim to reduce added sugar, and yoghurt and breakfast cereals are currently the main focus. In 2015, ten Swiss companies and the Federal Council Alain Berset signed an agreement to validate their current recipes and, when possible, reduce the amount of sugar in yoghurts and mueslis in the upcoming years. A 3.5 % reduction of added sugar in yoghurts, and a 13 % reduction in mueslis has been achieved, but a further reduction is aimed. In 2017 another four companies signed the agreement to reduce the sugar content of their products (Bundesamt für Lebensmittelsicherheit und Veterinärwesen BLV 2019).

In Germany the Federal Ministry of Food and Agriculture has developed a strategy to reduce the amount of sugar, salt, and fats in convenience food and improve the nutrition profile of products. Special consideration is given to those placed for children. An improvement of knowledge and education about nutrition is a strategy. Importance is given to the innovation of new products. The plan should be put into action until 2025 aiming to reduce the amount of added sugar by 20 % in mueslis and 10 – 15 % in yoghurt and soft drinks for children. A prohibition on sugar and artificial sweeteners in teas for babies is also planned, as well as a prohibition on added sugar and other sweeteners like honey, syrup and juice in products for children (Bundesministerium für Ernährung und Landwirtschaft 2019).

## 2.3 Definition of Sugar

There are different ways to define free and added sugars. According to the WHO, free sugars are defined as: *"free sugars include monosaccharides and disaccharides added to foods and beverages by the manufacturer, cook or consumer, and sugars naturally present in honey, syrups, fruit juices and fruit juice concentrates" (WHO 2015).*

The United States Food and Drug Administration (FDS) defines added sugars as: *"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." (FDA 2018).*

The European Food and Safety Authority (EFSA) decided to define added sugar as: *"sucrose, fructose, glucose, starch hydrolysates (glucose syrup, high fructose syrup) and other isolated sugar preparations used as such or added during food preparation and manufacturing. Sugar alcohols (polyols) such as sorbitol, xylitol, mannitol, and lactitol, are usually not included in the term "sugars"" (EFSA 2010).*

The Federal Ministry of Food and Agriculture in Switzerland uses the same definition for added sugar as EFSA and the European High-Level Group on Nutrition and Physical Activity. In addition, sugars present in fruit juices, fruit juice concentrates, honey and syrup are considered added sugar (Schweizer Bundesamt für Lebensmittelsicherheit und Veterinärwesen BLV 2018)

These definitions are quite similar, but the EFSA definition also explicitly mentions sugar alcohols which are not counted as added sugar, and the main difference between the EFSA definition and WHO definition is that the WHO also includes sugars from honey and fruit juices as added sugars. However, all three agree that added sugar include monosaccharides and disaccharides. The definitions are also used in this thesis in the models aiming to calculate added sugars in dairy products. A summary of included sugars for each authority is presented in table 1.

| Added/free sugar | EFSA 2010 Added sugar | WHO 2015 Free sugar | FDA 2018 Added sugar | Switzerland BLV 2018 Added sugar | Notes |
|---|---|---|---|---|---|
| **Mono- and disaccharides** | ✓ | ✓ | ✓ | ✓ | |
| **Fruit juice** | × | ✓ | × | ✓ | |
| **Fruit juice concentrate** | × | ✓ | ✓ | ✓ | FDA: only concentrates with more sugar than the same amount of pure juice |
| **Honey** | ✓ | ✓ | ✓ | ✓ | |
| **Syrup** | ✓ | ✓ | ✓ | ✓ | |
| **Sugar alcohols** | × | n.s. | n.s. | n.s. | N.s: Not specified |
| **Other (i.e. jams, jellies, isolated sugar preparations etc.)** | ✓ | × | ✓ | ✓ | Switzerland: Specified in table 4.<br><br>EFSA & FDA: See definition |

**TABLE 1 ADDED SUGAR ACCORDING TO DIFFERENT AUTHORITIES.**

## 2.4 Sugar Intake

### 2.4.1 Recommendation

The WHO has divided its recommendation into “strong recommendation” and “conditional recommendation”. It is strongly recommended to reduce the intake of free sugar, and as a general rule, the intake of free sugar should be below 10 % of total energy intake for both children and adults. There is a conditional recommendation to reduce total energy intake from sugar to 5 % (WHO 2015).

According to the European Society for Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN), the recommended sugar intake of total energy from aged 2 to 18 years should be minimised to <5 %, and even less in smaller children. To prevent negative health effects later in life, they should learn a healthy approach to dietary consumption and beverages. Preferably sugar should be consumed in a natural form in milk, fresh fruits and unsweetened dairy products instead of smoothies, fruit juices and sweetened milk products (Fidler et al. 2017).

The American Heart Association (AHA) recommends that children <2 years avoid added sugar and other children consume less than 25 g a day. The basis is to decrease the risk of cardiovascular diseases (CVDs) among children (Fidler et al. 2017).

### 2.4.2 Sugar Intake in Europe

Studies conducted in Europe show that the WHO recommendation for added sugar intake is often exceeded. The total sugar intake in Europe is suggested to be 15 – 25 % of daily energy supply. 7.5 – 17 % represent added sugar or non-milk extrinsic sugars (NMES), and children and teenagers have the highest intake, exceeding the recommendations. When comparing children and adults, added sugar contributes 30 % more to total energy intake in children than in adults, e.g. in Ireland 32 % more, or in the Netherlands up to 50 % more. The sugar intake is higher in men but with variations from country to country. For adults, the total intake of added sugar is between 7 and 11 % of total energy intake in European countries (Azaïs-Braesco et al. 2017).

In another study, the HELENA-study, where 1630 children and teenagers between 12.5 and 17.5 years of age participated from 10 European countries, the daily added sugar intake was 19.0 energy percent on average (110 g/d). The recommendation to consume less than 10 % of the daily energy intake as added sugar was exceeded by 94 % of the participants. Usually the added sugar was consumed by soft drinks, sweets and coming from other sources such as honey, marmalade and syrup (Mesana et al. 2018).

Surveys from Finland report other numbers. However, they only report the sucrose intake, where adults aged 25-50 years consumed sucrose contributing to 9 % of total energy intake. Teenagers between 13 and 14 received 11 % for girls and 10 % for boys. In Finland, women aged 24-64 received 5.1 % of energy from sucrose and men 9.7 %. In the Netherlands 45 % of the adults and 10 % of the children received less than 10 % of total energy from free sugar (Azaïs-Braesco et al. 2017).

In Austria people are also consuming a lot of sugar. According to the Austrian Nutrition Report, 80 % of men and > 90 % of women consume too much sugar. Men consume between 38 and 51 g of products from the food group sweets, sugar and chocolate per day, whereas women consume between 37 to 41 g per day. In addition, women in Austria have a total daily energy intake consisting of 17.6 % free sugars on average, whereas men have an intake of 16.5 % on average (Department für Ernährungswissenschaften der Universität Wien 2017). This is more than the recommended intake of 10 % by the WHO.

There is a high consumption of added sugar in European children both during the week and on weekends according to a study by Svensson et al. 2014. The intake was generally higher during the weekend except for Fridays. Among children in Germany the intake was quite high, 30 % of the total sugar intake was added sugar, whereas in Estonia the number was 19 % (Svensson et al. 2014).

### 2.4.3 Sources of Sugar Intake

There are many possible sources for sugar in foods. Many products contain a lot of added sugar, even products seen as healthy such as yoghurts. Sugar-sweetened products are the biggest contributors to total and added sugar intake. Other food groups contributing to total sugar intake are dairy products, fruits and vegetables and beverages. For added sugar, beverages are the second highest contributor (Azaïs-Braesco et al. 2017)

The numbers from the review by Azaïs-Braesco et al. 2017 are shown in table 2. In table 3 the percentage of each food group is illustrated for total sugar intake.

| Country | | Adults | | | | | | | | Children | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Belgium [23, 53] | France (adapted from [25]) | | Italy [22, 29] | | Spain [32, 33] | The Netherlands (adapted from [30]) | | France (adapted from [25]) | | Italy [22, 29] | | Spain [32, 33] | The Netherlands (adapted from [30]) | |
| Age | | >15 | 18 to 74 | | 18–65 | | 18–64 | 19 to 69 | | 3 to 17 | | 10 to 18 | | 13 to 17 | 7 to 18 | |
| Gender | | Both | Women | Men | Women | Men | Both | Women | Men | Girls | Boys | Girls | Boys | Both | Girls | Boys |
| Dairy | Total dairy | 14* | 17 | 14 | 12 | 8 | 23 | 19 | 17 | 21 | 23 | 12 | 11 | 24 | 18 | 17 |
| | *Milk, dairy beverages* | 4 | 5 | 4 | 7 | 6 | 12 | 9 | 9 | 9 | 9 | 9 | 9 | 13 | 10 | 8 |
| | *Dairy desserts* | 3 | 4 | 4 | 1 | 0 | 3 | 3 | 3 | 5 | 6 | 0 | 0 | 5 | 2 | 3 |
| | *Yoghurt* | 4 | 8 | 6 | 3 | 1 | 7 | 6 | 5 | 7 | 8 | 2 | 1 | 6 | 6 | 6 |
| | *Cheese* | NA | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| Sweet products | Total sweet | 27 | 32 | 32 | 35 | 38 | 21 | 32 | 34 | 32 | 31 | 36 | 38 | 24 | 35 | 32 |
| | *Cake & cookies* | 11 | 12 | 11 | 9 | 8 | 7 | 12 | 10 | 15 | 15 | 13 | 14 | 8 | 10 | 9 |
| | *Syrups, sugar, honey, jam* | 10 | 15 | 17 | 21 | 23 | 10 | 10 | 13 | 7 | 7 | 12 | 13 | 4 | 9 | 9 |
| | *Confectionary* | 6 | | | 2 | 2 | 0 | 3 | 3 | | | 1 | 1 | 1 | 5 | 5 |
| | *Chocolate* | | 3 | 2 | 1 | 2 | 4 | 5 | 6 | 7 | 6 | 6 | 5 | 11 | 8 | 7 |
| | *Ice cream* | NA | 2 | 2 | 2 | 3 | NA | 2 | 2 | 3 | 3 | 4 | 5 | NA | 3 | 2 |
| Beverages | Total Bev. | 30 | 15 | 19 | 8 | 11 | 23 | 23 | 27 | 21 | 22 | 16 | 20 | 29 | 30 | 33 |
| | *F&V juices* | 6 | 6 | 5 | 3 | 3 | 6 | 9 | 7 | 9 | 7 | 9 | 9 | 12 | 9 | 8 |
| | *Soft drinks* | 19 | 5 | 7 | 3 | 4 | 11 | 11 | 16 | 9 | 11 | 5 | 8 | 17 | 21 | 25 |
| | *Hot beverages* | NA | 2 | 3 | 1 | 1 | 2 | 1 | 2 | 4 | 4 | 2 | 3 | 0 | 0 | 0 |
| | *Alcoholic bev* | 5 | 2 | 4 | 1 | 3 | 4 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fruits & vegetables | | 18 | 25 | 22 | 34 | 31 | 24 | 16 | 11 | 14 | 12 | 25 | 19 | 12 | 9 | 7 |
| Others | | 11 | 12 | 13 | 11 | 12 | 9 | 10 | 11 | 11 | 12 | 11 | 12 | 11 | 10 | 11 |

[a]In % of daily intake of added sugars- NA: not available- See text for details
*total is higher that the sum of dairy items, as reported in the quoted source

**TABLE 2 CONTRIBUTION (%) OF FOOD GROUPS TO THE TOTAL SUGAR INTAKE IN CHILDREN AND ADULTS (AZAÏS-BRAESCO ET AL. 2017).**

Dairy products contribute 14-24 % to total sugar intake varying for gender, age group and country. Beverages and sweets contribute most to the total sugar intake. In table 3 the values for added sugar are illustrated.

| | | Adults | | | | | | Children | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Country | | The Netherlands (adapted from [30]) | | France (adapted from [25]) | | UK [34] | | The Netherlands (adapted from [30]) | | France (adapted from [25]) | | UK [34] | |
| Type of sugars | | Added | | Added | | NMES | | Added | | Added | | NMES | |
| Age | | 19 to 69 | | 18 to 79 | | 19 to 64 | | 7 to 18 | | 3 to 17 | | 4 to 18 | |
| Gender | | Women | Men | Women | Men | Women | Men | Girls | Boys | Girls | Boys | Girls | Boys |
| Food group | *Category* | | | | | | | | | | | | |
| Dairy | Total dairy | 12 | 11 | 16 | 14 | 5 | 4 | 12 | 12 | 16 | 18 | 6 | 6 |
| | *Milk & dairy beverages* | 3 | 2 | 0 | 0 | 1 | 1 | 4 | 3 | 0 | 0 | 2 | 2 |
| | *Dairy desserts* | 4 | 4 | 8 | 8 | 4 | 3 | 3 | 3 | 8 | 9 | 4 | 4 |
| | *Yoghurt* | 4 | 4 | 8 | 6 | | | 5 | 5 | 8 | 9 | | |
| | *Cheese* | 1 | 1 | 0 | 0 | NA | NA | 0 | 1 | 0 | 0 | | |
| Sweet products | Total sweet products | 53 | 47 | 60 | 61 | 44 | 42 | 49 | 45 | 50 | 46 | 44 | 40 |
| | *Cake & cookies* | 16 | 12 | 23 | 20 | 17 | 13 | 12 | 10 | 24 | 22 | 18 | 16 |
| | *Sugar, honey, jam, syrup* | 17 | 18 | 27 | 32 | 16 | 19 | 12 | 13 | 11 | 11 | 8 | 8 |
| | *Confectionary* | 6 | 5 | | | 2 | 1 | 9 | 8 | | | 6 | 6 |
| | *Chocolate* | 10 | 9 | 5 | 5 | 7 | 7 | 11 | 10 | 10 | 9 | 8 | 7 |
| | *Ice cream* | 4 | 3 | 5 | 4 | 2 | 2 | 5 | 4 | 5 | 4 | 4 | 3 |
| Beverages | Total beverage | 24 | 31 | 12 | 16 | 29 | 39 | 31 | 34 | 20 | 21 | 35 | 37 |
| | *F&V juices* | 3 | 3 | 1 | 0 | 8 | 8 | 5 | 4 | 0 | 0 | 11 | 12 |
| | *Soft drinks* | 18 | 26 | 7 | 10 | 15 | 16 | 26 | 30 | 13 | 15 | 22 | 24 |
| | *Coffee, tea* | 1 | 1 | 2 | 3 | 0 | 1 | 0 | 0 | 7 | 6 | 1 | 0 |
| | *Alcoholic beverages* | 2 | 1 | 2 | 3 | 6 | 14 | 0 | 0 | 0 | 0 | 1 | 1 |
| Fruits & vegetables | | 1 | 1 | 6 | 3 | 4 | 5 | 1 | 1 | 4 | 4 | 2 | 3 |
| Others | | 10 | 10 | 7 | 6 | 18 | 10 | 7 | 8 | 10 | 11 | 13 | 14 |

[a]In % of daily intake of added sugars- NA: not available- See text for details

**TABLE 3 CONTRIBUTION (%) OF FOOD GROUPS TO THE INTAKE OF ADDED AND NME SUGAR IN CHILDREN AND ADULTS (AZAÏS-BRAESCO ET AL. 2017.)**

It is shown that dairy products contribute to 12-18 % of the daily intake of added sugar, whereas sweets naturally contribute more with a percentage of 53-61 % dependent on age, sex and country. Fruit and vegetables do not contribute much. Although the daily intake of added sugar is less from dairy products than from some other food groups, it has still unnecessary added sugar. Therefore the amount of sugar in dairy products will be investigated in this paper.

## 2.5 Models for Calculation of Added Sugar

### 2.5.1 Methodology by Louie JCY. et al. 2015

Different attempts have been made to calculate the amount of added sugars in products. One methodology by Louie JCY et al. was developed in Australia to estimate added sugars based on ingredients of foods and analytical data. Quite important is to distinguish between naturally occurring sugars and added sugars. A 10-step protocol was created based on objective and subjective estimation. The aim was to develop a standardised cross-country comparison for added sugars in foods and it was applied to an Australian food composition table. "Added sugars" were here defined similar to the USDA definition. Considered as added sugar was: *"sugar [granulated (sucrose), brown, powdered and maple]; mono- and disaccharides [e.g., fructose, lactose, maltose, glucose (dextrose)]; single ingredient syrups (light corn, dark corn, high fructose corn, maple, malt, sorghum); honey and molasses; maltodextrin."* (Louie JCY. et al. 2015). Sugar alcohols were not included as added sugar together with diluted fruit juices. Undiluted juice was considered as added sugar.

The steps to be followed are mentioned in detail in figure 1 as well as the procedure to estimate added sugar.

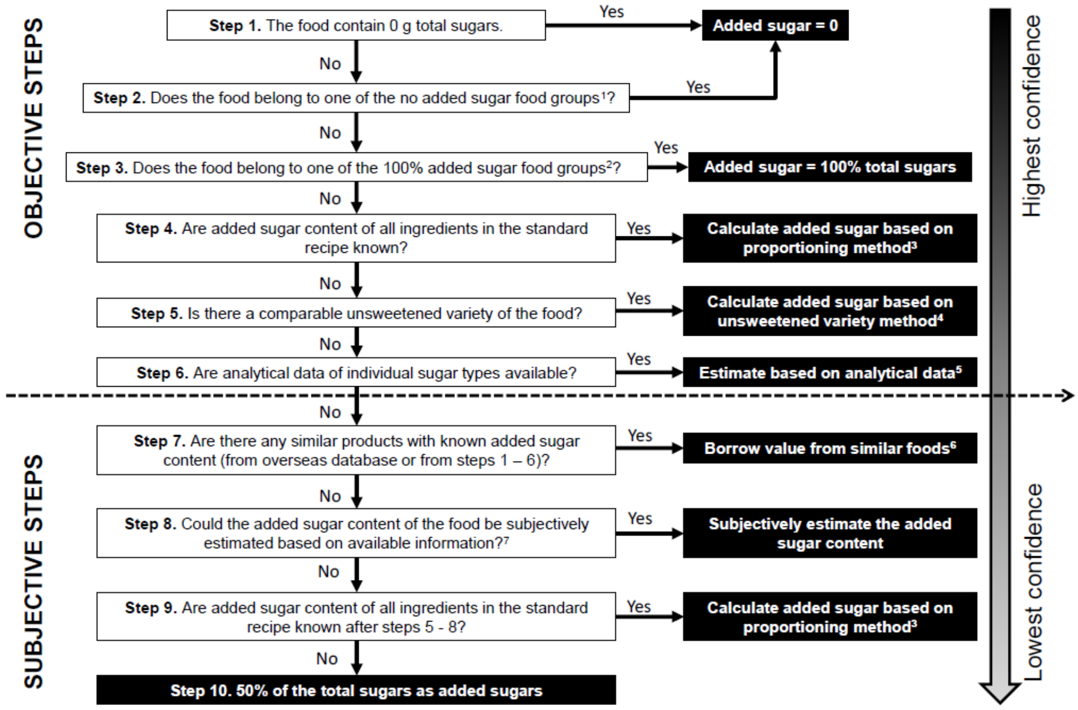


**Figure 1 Calculation of added sugar in foods (Louie JCY et al. 2015).**

1. Step: foods with 0 g added sugar are assigned with 0 g added sugars.
2. Step: foods in the following groups are assigned 0 g sugar: "*Non-sugar sweetened milk and buttermilk; breast milk, non-sugar-sweetened dairy products (including yoghurts sweetened with artificial sweeteners only)*" and groups of other foods not included in this thesis such as eggs and fats.
3. Step: 100 % of total sugars are assigned as added sugars. This would be for example for processed meat, soft drinks, and all confectionary except those with dairy products.
4. Step: Calculation based on standard recipe found in the food composition table. This step is based on the proportion of ingredients, so the sugar content of all ingredients have to be available.

5. Step: Compare values to unsweetened variety. The formula used for finding the amount of added sugar which was used to sweeten the unsweetened product is
   $AS_{100g}$ = 100 x ($S_{us}$-$S_{total}$) / $S_{us}$-100
   AS = added sugar
   $S_{us}$ = total sugar content in 100 g of the unsweetened variety.
   $S_{total}$ = total sugar content in the sweetened product.
   This would be the same as the sugar content on the label.
6. Step: Decision based on analytical data when available for the individual sugars such as lactose and maltose. The list of ingredients could not include malted cereals or dried fruits. Added sugar could be calculated as total sugars minus lactose, or total sugar minus maltose.
7. Step: Values should be "borrowed" from products with a similar nutritional composition found in the food composition table. The proportion of the added sugar in the similar food is calculated and multiplied by total sugar content of the target food. Similar products with a known added sugar content calculated by step 1-6 could be used too.
8. Step: Subjective estimation based on ingredients. The proportion of the ingredient containing sugar is estimated in percentage, such as the amount of sweetened strawberry in a strawberry yoghurt.
9. Step: Calculation based on standard recipe for products with ingredients where values have been estimated at step 5-8 by using the proportioning method. Step 4 should be repeated here with those ingredients.
10. Step: 50 % added sugar assigned to products, as products with a low or high amount of added sugar would have already been estimated by one of the other steps.

Step 1-6 are counted as objective steps, step 7-10 are subjective steps (Louie JCY et al. 2015). This method will be compared to two other methods aiming to estimate added sugars in dairy products.

### 2.5.2 Methodology by the Federal Food Safety and Veterinary Office in Switzerland, 2018

The Federal Food Safety and Veterinary Office (BLV) in Switzerland estimates annually the amount of added sugars in dairy products and cereals on the Swiss market since 2016. In 2015, the Federal Councillor Alain Berset and ten Swiss companies signed a form in Milan agreeing to reduce the amount of added sugar in their dairy products and cereals within the next few years. Added sugar is here defined according to the EFSA definition. The calculation is performed annually in order to see if anything is changed over one year and if the companies follow their agreement. The BLV calculates added sugar differently than the method described in chapter 2.5.1. The instructions are as followed: the ingredients are divided into three separate groups in order to estimate the amount of added sugars. An explanation of the groups is given in table 4 (Schweizer Bundesamt für Lebensmittelsicherheit und Veterinärwesen BLV 2018).

| Categories | | |
|---|---|---|
| **Group 1, dried or powdered ingredients from sugars**<br>Added sugar: 100 % | **Group 2, ingredients containing sugars**<br>Count the amount of mono- and disaccharides | **Group 3, Mixed ingredients containing ingredients from group 1 and/or 2**<br>Amount of mono- and disaccharides from the ingredients in category 1 and 2 are counted as added sugars |
| **Glucose, dextrose** | Fluid sugar | Sweetened pieces of fruit |
| **Fructose, fruit sugar** | Sugar beet syrup | Sweetened cereal |
| **D-Tagatose** | Simple syrup, thick sugar syrup, sugar cane juice | Marmalades |
| **Saccharose, household sugar, powdered sugar, cane sugar, beet sugar** | Fruit sweetener | Etc. |
| **Maltose, maltobiose, malt sugar** | Starch syrup, glucose syrup, fructose syrup, glucose-fructose syrup, corn syrup, high-fructose-corn-syrup | |
| **Isomaltulose** | Caramel syrup | |
| **Sugar aroma: caramel sugar, vanilla sugar, vanillin sugar, cinnamon sugar** | Honey | |
| **Etc*** | Invert sugar | |
| | Molasses | |
| | Malt extract* | |
| | Fruit juices and fruit concentrates | |
| | Thick juices | |
| | Syrups | |
| | Fruit powder, pulp, puree | |
| | Etc. | |

**Table 4 Explanation of groups of added sugars in the method by BLV. * does not need to be listed when it is used as a flavour and mentioned in the list of ingredients (Schweizer Bundesamt für Lebensmittelsicherheit und Veterinärwesen BLV 2018)**

However, not every ingredient can be clearly identified as added sugar. When in doubt, count as added sugar.

**How to calculate the amount of added sugar in a product:**

Step 1: Identify the ingredients and amounts in % from the recipe

Step 2: Allocate the ingredients in one of the categories

Step 3: Calculate the amount of added sugars per category and ingredient

**Category 1:**

Amount of ingredient count as 100 % added sugar.

**Category 2:**

Identify the amount of mono- and disaccharides based on the specifications on the ingredient list and calculate the amount in the final product.

**Category 3:**

Identify the amount of mixed sugars with specifications of relevant ingredients and the amount in % on the ingredient list, thereafter, follow the description of either category 1 or 2 and calculate the amount in the final product.

Step 4: Add the amounts of sugar calculated in all categories.

In order to use this method, it is important to have access to the full recipes of the products.

(Schweizer Bundesamt für Lebensmittelsicherheit und Veterinärwesen BLV 2018)

### 2.5.3 Methodology by Amoutzopoulos B. et al. 2018

This is a newer methodology which can be used to estimate the amount of free and added sugars in products. This method is based on recipe disaggregation and can be applied to different definitions of added sugars. Total sugars are defined as *"the total amount of sugars (mono- and disaccharides) from all food sources, without distinguishing between free and non-free sugars."* This is the amount of sugar in g declared on food labels.

Definitions of free and added sugars were described in chapter 2.3 In addition, in the UK the term free sugars excludes lactose in milk and sugars inside the cellular structures of foods. Another term used in the UK is "non-milk extrinsic sugars" (NMES) meaning *"sugars not contained within the cellular walls of plants, all sugars added to foods, and 50 % of the sugars in canned, stewed, dried, or preserved foods."*

This method was developed to have a flexible and adaptable way to calculate the amount of free and added sugars in products. In order to use this method, it is crucial to know the ingredients, their proportion in the food and information on the sugar content of all ingredients. Thereafter, the ingredients are assigned to subcategories such as sugar from juice, sugar from honey etc. In total they use seven sugar components.

1. Sugar in table sugar
2. Sugar from other sources (glucose syrup, malt syrup, maple syrup etc.)
3. Sugar in honey
4. Sugar in fruit and vegetable juice
5. Sugar in fruit puree
6. Sugar in stewed fruit
7. Sugar in dried food

At the end it is all calculated according to different definitions of free and added sugar. This method is visualised in figure 2.

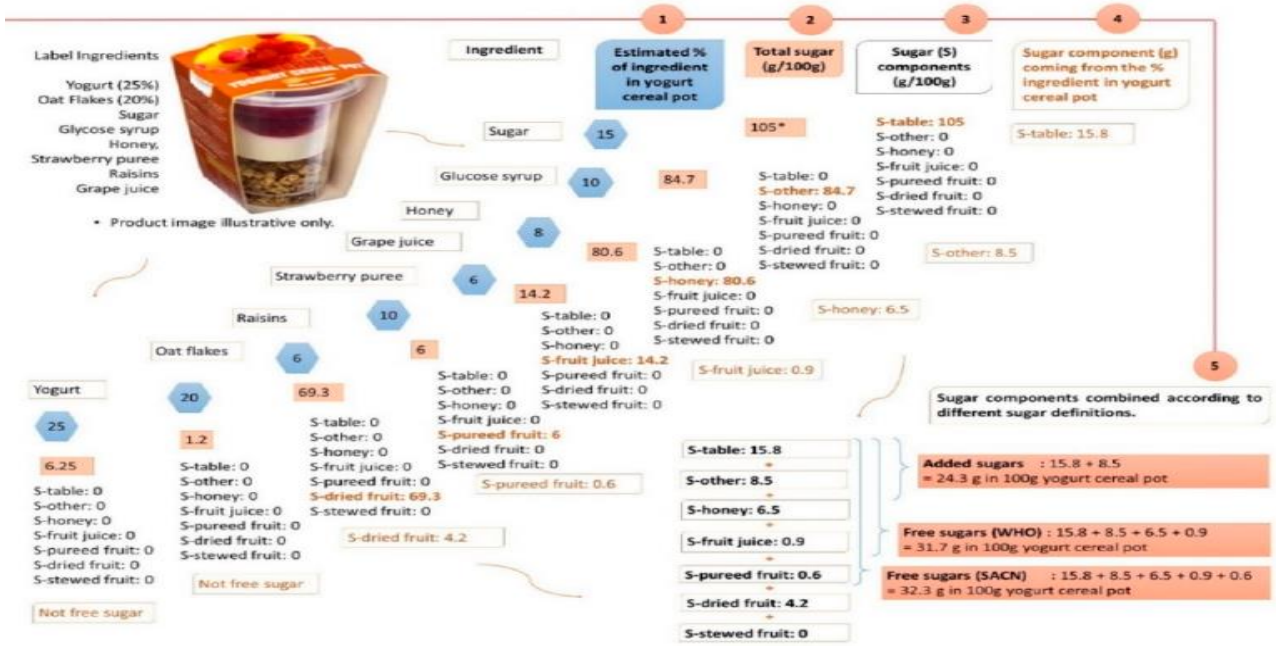


**FIGURE 2 STEPS TO ESTIMATE ADDED AND FREE SUGARS (AMOUTZOPOULOS B. ET AL. 2018).**

1. Step: Ingredients including proportions are identified from the nutritional information and ingredient list on the product label.
2. Step: Total sugar value assigned per 100 g ingredient (by using food composition tables)
3. Of each ingredient, 100 % of total sugar is assigned to a “sugar component.”
4. Proportion of each ingredient used to calculate a value in g for each “sugar component”.

The formula used to calculate g sugar component in 100 g food is

$$\sum_{i=1}^{n} \%\ \text{ingredient} \times \text{g sugar component in 100 g ingredient}$$

5. Step: The answer obtained from the formula is summarised in combinations, to give an estimation of g “free sugar” and “added sugar” content in 100 g foods.

In order to gain the information needed, two databases were used to obtain total sugar values and ingredients of all foods: the FSA Recipes Database and the UK NDNS Nutrient Database (Amoutzopoulos B. et al. 2018). This could also be a very useful method if the recipes are available or entered in the food composition table.

## 2.6 Physiological Aspects and Development of Sweet Taste

### 2.6.1 Glucose

Glucose C6H12O6 is a monosaccharide which is also a part of sucrose along with fructose. Glucose is the most important energy substrate for tissues in the body, and the foetus utilises glucose as an energy supply in the perinatal period. Uptake of glucose in the cells is a very fundamental process for growth, homeostasis and metabolism and plays an important role in cell signalling. The brain needs approximately 25 % of total glucose supply to function properly (Deng D. and Yan N. 2016).

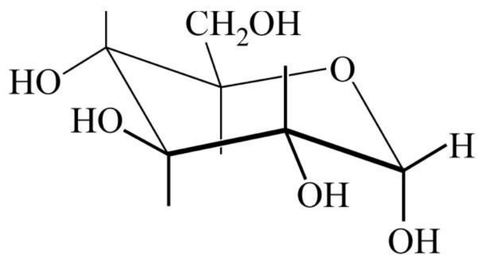


**FIGURE 3 GLUCOSE MOLECULE IN THE CHAIR CONFORMATION.**

Glucose is usually absorbed across the intestinal brush-border membrane predominantly SGLT1 mediated. This protein couples one molecule of glucose with two molecules of $Na^+$. The GLUT2 then allows the glucose through a facilitated diffusion to move from the intestinal epithelial cells into the extracellular medium close to the blood capillaries (Chen L. et al. 2016).

Glycogen is the store of energy when no food is consumed and consists of a branched polymer of glucose. This is present in all kinds of organisms. Most of the glycogen is stored in liver and muscles although other organs are also capable of synthesis. Glycogen synthesis usually occurs after a meal or after exercise. The former due to elevated glucose and insulin levels in the blood, the latter due to depleted glycogen stores during exercise (Roach PJ. et al. 2012).

Excessive glucose uptake can in the long-term cause hyperinsulinemia and type 2 diabetes (T2D) which both are symptoms of the metabolic syndrome. Hyperinsulinemia increases the gene transcription of lipogenic enzymes in the liver which again causes an increased production of triglycerides. Due to the resistance to insulin in the liver, the body produces more in order to achieve the same effect. This causes its effect on the suppression of glucose production. Almost 90 % of obese children and adolescents express one or more of the symptoms related to the metabolic syndrome (Al-Hamad D. and Raman V. 2017).

### 2.6.2 Fructose

Fructose is a monosaccharide found in honey, fruits and vegetables and is often added to processed food and beverages due to its sweetness and palatability. High-fructose corn syrup is a common food ingredient in soft drinks, breakfast cereals and baked goods particularly in the US (Zhang DM. et al. 2017). Food and drinks can also contain fructose as part of the disaccharide as sucrose. Free fructose is usually absorbed directly from the intestinal lumen, whereas larger carbohydrate molecules must be digested. GLUT5/SLC2A5 are the glucose transporter on the luminal side and GLUT2/SLCA2 on the basolateral side facilitating fructose transport. Transported fructose is then delivered into the systemic circulatory system and absorbed by the liver where more than 50% of it is metabolised via fructolysis. Most of the fructose is converted into glucose, whereas parts are also converted into lactate and fatty acids (Horst KW. and Serlie MJ. 2017).

Dietary fructose consumption is linked to an increased rate of associated diseases of the metabolic syndrome, such as T2D, non-alcoholic fatty liver disease (NAFLD) and cardiovascular disease (CVD) (Legeza B. et al. 2017). In the US in the past the usual daily fructose intake was between 16 and 20 g/d, mostly originating from fruits. Now the daily intake has increased significantly to 60 and 150 g/d, mostly originating from sucrose (Dornas WC. et al. 2015). This could cause negative consequences for people’s health leading to diseases of the metabolic syndrome as described above.

### 2.6.3 Lactose

The disaccharide lactose is the main carbohydrate in milk, and dairy products are affected by its physiochemical properties and its use in food technology. Lactose is crucial in the fermentation process by lactic acid bacteria, and it can be isolated and applied in a wide range of non-dairy and dairy food products. It is also used as a source for different derivatives such as lactulose, lactitol and galacto-oligosaccharides. Lactose is an important dairy ingredient and is present in almost all dairy products in a low or a high concentration. It can also take part in the Maillard reaction and has a strong influence on the stickiness and baking behaviour during drying and storage (Huppertz T. and Gazi I. 2016).

However, there are subjects who do not tolerate lactose. Lactase activity is usually present in the intestine during the first months of life when the baby is being breastfed. However, many people, except in Europe, develop an intolerance towards lactose due to decreased lactase activity in the intestine. When lactose then enters the colon, it is fermented by bacteria to the main metabolites gas and short-chain fatty acids (SCFAs). It could cause various gastrointestinal symptoms such as bloating or diarrhoea, that could be prevented when consuming lactose less than 25 g/day (Wahlqvist ML. 2015).

| Food | Lactose (g/100 g of Food) |
|---|---|
| Skimmed cow's milk | 4.7 |
| Low-fat cow's milk | 4.6 |
| Whole cow's milk | 4.5 |
| Buttermilk | 4.1 |
| Free lactose milk | 0.5 |
| Whole powdered milk | 35.1 |
| Skimmed powdered milk | 50.5 |
| Goat's milk | 4.2 |
| Buffalo milk | 4.9 |
| Yogurt | 3.2 |
| Butter | 4.0 |
| Cottage cheese | 2.6 |
| Mozzarella cheese | 1.5–2.0 |
| Goat cheese | 1.5–2.0 |
| Ricotta cheese | 4.0 |
| Parmigiano Reggiano | 0–0.9 |
| Cream cheese | 6.0 |
| Taleggio cheese | 0 |
| Fontina cheese | 0 |
| Provolone cheese | 0 |
| Gorgonzola cheese | 0 |

**TABLE 5 LACTOSE CONTENT OF SOME DAIRY PRODUCTS (CANANI RB ET AL. 2016).**

### 2.6.4 Oligosaccharides

Inulin is an important oligosaccharide in the fructan carbohydrate group often found in food and as an ingredient in various products. Inulin has been used to form gels, increase viscosity, as a low-calorie sweetener and as fibre. In dairy products it is often used as prebiotic or as a replacement for sugar or fat. Some colonic bacteria such as Lactobacilli can break down the bonds which causes a targeting of inulin in the colon (Mensink MA. et al. 2015). Some people suffer from abdominal pain when consuming fructo-oligosaccharides, similar to those lactose intolerant people suffer form after lactose consumption. Oligosaccharides, fructose and lactose can all be a reason for gastrointestinal pain, and by excluding those sugars of the diet, the pain of patients could be relieved for those suffering from the irritated bowel syndrome. This diet is also known as the FODMAP-diet (Gibson PR. 2017).

### 2.6.5 Sugar Alcohols and Artificial Sweeteners

Artificial sweeteners are becoming increasingly popular and are very important to the food industry. They are used to *"impart a sweet taste to foods or in table-top sweeteners"* (EU 2008) and there are two categories: polyols defined as "alcohols containing more than two hydroxyl groups" and high-intensity sweeteners which contain no calories and have an intense sweet taste (EU 2020). Different kinds of sweeteners are added because no sweetener is applicable for every product. The most commonly used sugar alcohols are xylitol, lactitol, sorbitol, mannitol, erythritol, isomaltose and maltitol. They are polyols found naturally in vegetables and fruits. The sweetness could be anything between 25 % to 100 % compared with table sugar. The percentages are represented in table 10. These polyols cannot be completely digested and have thus a lower total energy of 2 kcal/g than table sugar 4 kcal/g (Grembecka M. 2015).

There are also artificial sweeteners which has no or a very low energy content. They include aspartame, acesulfame K, saccharin, cyclamate and sucralose and are usually hundred to thousand times sweeter than table sugar. The use of alternatives is controversial because there is no conclusive evidence for neither harmful nor beneficial effects when health factors such as the risk of diabetes, risk of cancer and risk of obesity are investigated (Lohner S. et al. 2017). The European Food Safety Authority (EFSA) classifies the authorised sweeteners as safe (EU 2020).

| Sweetener | Regulatory status | Brand names | Sweetness compared to table sugar (Sucrose) | ADI (mg/kg body weight/day) | Number of tabletop sweetener packets equivalent to ADI |
|---|---|---|---|---|---|
| Acesulfame Potassium (Ace-K) | Approved as a sweetener and flavor enhancer in foods (except in meat and poultry) | Sweet One<br>Sunett | 200× | 15 | 23 |
| Advantame | Approved as a sweetener and flavor enhancer in foods (except in meat and poultry) | No Brand Name | 20,000× | 32.8 | 4920 |
| Aspartame | Approved as a sweetener and flavor enhancer in foods generally | Nutrasweet<br>Equal<br>Sugar Twin | 200× | 50 | 75 |
| Neotame | Approved as a sweetener and flavor enhancer in foods (except in meat and poultry) | Newtame | 7000–13,000× | 0.3 | 23 |
| Saccharin | Approved as a sweetener only in certain special dietary foods | Sweet and Low<br>Sweet Twin<br>Sweet'N Low<br>Necta Sweet | 200–700× | 15 | 45 |
| Siratia grosvenorii swingle (Luo Han Guo) fruit extracts | SFGE containing 25%, 45%, or 55% of Mogroside V is GRAS | Nectresse<br>Monk Fruit in the Raw<br>PureLo | 100–250× | Not Specified | Not Determined |
| Steviol glycosides | 95% pure glycosides considered GRAS | Truvia<br>PureVia<br>Enliten | 200–400× | 4 | 9 |
| Sucralose | Approved as a sweetener in foods generally | Splenda | 600× | 5 | 23 |

**TABLE 6 COMPARISON OF SOME HIGH INTENSITY SWEETENERS (MOORADIAN AD. ET AL. 2017).**

| Sugar Alcohol Name | Sweetness compared to table sugar (Sucrose) | Kcal/g |
|---|---|---|
| Erythritol | 70% | 0.2 |
| Glycerol (also known as glycerin or glycerine) | 40% | 4 |
| Hydrogenated starch hydrolysates | 33% | 2.8 |
| Isomalt | 55% | 2.1 |
| Lactitol | 35% | 2 |
| Maltitol | 75% | 2.7 |
| Sorbitol | 60% | 2.5 |
| Xylitol | 100% | 2.5 |

**TABLE 7 COMPARISON OF SUGAR ALCOHOLS AND SWEETENERS (MOORADIAN AD ET AL. 2017).**

### 2.6.6 Development of Sweet Taste

Taste is very important throughout life, even foetuses experience taste through the amniotic fluid. After birth the taste of the breastmilk is affected the diet of the mother. Olfactory and taste receptors are developed already at week 7-8 of gestation and are important in the evolution to avoid poisons. The mother's diet very much affects the taste preferences of the child (Podzimek S. et al. 2018). The mechanism of taste differs between the five accepted tastes. For sweet taste, after binding to the receptor, adenylyl cyclase is activated, and cAMP elevated which again causes a phosphorylation of $K^+$ channels. Transmitter release is then caused by $Ca^{2+}$entering the cell. There is a threshold to perceive each taste which is genetically determined. Sucrose has a threshold of 10 mmol/l (Podzimek S. et al. 2018). Sweet taste receptors are across the body and children have more taste receptors than adults.

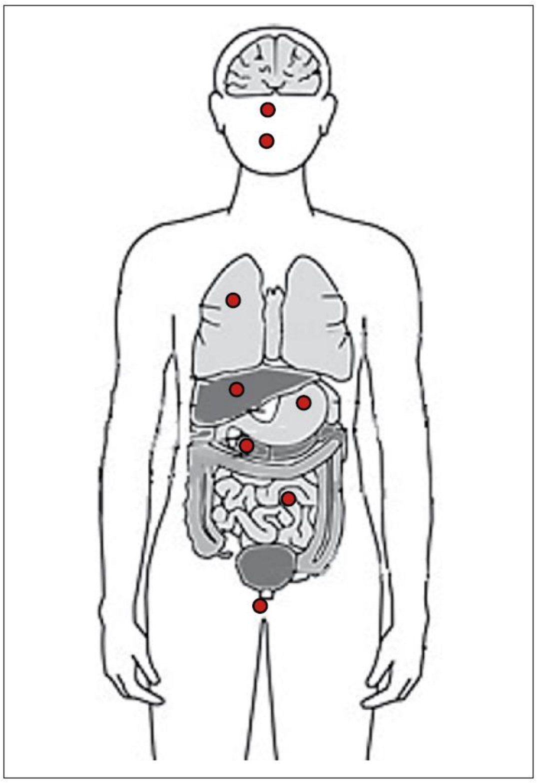

**FIGURE 4 LOCALISATION OF SWEET TASTE RECEPTORS IN HUMANS (SYLVETSKY AC. ET AL. 2017).**

Sweetness of taste signals that nutrition and calories are present to the body, which could be the reason for the innate likeness of sweet taste in humans. However, the preference for sweet taste is highest in children (Sylvetsky AC. et al. 2017). Studies with infants who were often fed sweetened water after birth, showed a bigger preference for sweetened water than infants with no experience of sweetened water at both 6 months and at 2-10 years of age when tested. Feeding sweetened water may be an indication that foods and beverages sweetened with sugar are part of the family diet (Mennella JA. et al. 2016).

In the weaning period it is important to experience different foods and the texture is also of importance. Infants usually increase their acceptance of a food after being exposed to that food repeatedly. For example, varying the types of fruits served influences a general acceptance for fruits, but not for other food groups such as vegetables (Ross ES. 2017). It is then important for the child to get accustomed to various types of foods so it can have the possibility to choose healthier products later in life. The perception of taste changes through life due to factors such as smoking or environmental causes or illnesses such as cancer or Alzheimer. Surgery and medication could also contribute to the change in taste and aging itself causes a declining amount of taste receptors (Schiffman SS. 1997). As a result, sweet taste preference also declines with advancing age (Hoffman AC. et al. 2016).

## 2.7 Dairy Products

### 2.7.1 Definition of Dairy Products

The general definition of dairy products is *"food produced from the milk of mammals"* (Bordoni A. et al. 2017). Humans usually consume dairy products from the milk of goats, sheep, cows and camels, often in the form of butter, yoghurt and cheese (Definitions.net 2020). These products consist of milk amended and technologically transformed to produce fermented products such as cheese, yoghurt and kefir. This can happen through the fermentation of lactic acid bacteria. Dairy products support the immune system, deliver anti-oxidative protection and inhibit bacterial growth (Bordoni A. et al. 2017).

### 2.7.2 Nutrient Composition Table of Dairy Products

Milk and dairy products deliver on average 14 % total energy intake in developed countries (Bordoni A. et al. 2017). Dairy products deliver, in addition to vitamins and minerals, prebiotics and probiotics such as Lactobacilli, which modulate the bacterial flora in the colon.

Milk consist of different proteins, the most common are Lactalbumin with β-lactoglobulin and casein. The sugar lactose is also present (Lucey JA. et al. 2017). Dairy fat found in these products are saturated fats of different chain lengths, monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA) and trans-fatty acids (Astrup A. et al. 2016). However, the most interesting are the minerals present in milk and dairy products. An important mineral is iodine which is found in milk, especially in industrialised countries. The concentration of this mineral shows broad variety and ranges from 33 to 534 µg/L in industrialised countries, which is dependent on the goitrogen intake, season, teat dipping, intake of dairy cows and the type of farming and processing. The contribution to the total intake of daily iodine is estimated to 25-70 % in industrialised countries. Iodine is important to produce $T_3$ (triiodothyronine) and $T_4$ (thyroxine) which are crucial thyroid hormones in metabolism and for growth (van der Reijden OL. et al. 2017).

There is also a certain amount of vitamin $B_{12}$ in bovine milk which is dependent on season, feed, breed and stage of lactation. However, much of vitamin $B_{12}$ can be lost due to processing. During cheese production, much of the vitamin is lost due to its water solubility. Vitamin $B_{12}$ is important for blood cells, DNA synthesis and for a normal function of the nervous system (Gille D. and Schmid A. 2015). The recommended intake of vitamin $B_{12}$ is 4.0 µg per day for adults and 1.5-4,0 µg per day for children (D-A-CH 2019). This is not possible to achieve through milk and dairy products.

A glass of milk (200 ml) delivers 250 mg calcium, the same does 30 g of hard cheese or 180 g yogurt. Calcium is also important for vitamin D bioavailability (Rizzoli R. and Biver E. 2018). Dairy products and milk only contain a fraction of vitamin D, which is also important for bone health together with calcium, but many western countries fortify those products voluntarily with extra vitamin D (Al-Daghri NM. et al. 2015). Phosphorus is another mineral in milk essential for bone health.

Different dairy products contain different amounts of nutrients. Table 8 compares natural milk, hard cheese, soft cheese, yoghurt, curd cheese and butter. Hard cheese contains the least amount of sugar, whereas curd cheese the most amount of protein. Cheese also has a significant higher amount of fat than other dairy products. Milk and yoghurt contain the most carbohydrates compared to the other products in table 8 below.

| | **kJ** | **Kcal** | **Fats** | **Saturated fats** | **Carbohydrates** | **Sugar** | **Protein** | **Salt** |
|---|---|---|---|---|---|---|---|---|
| **Whole milk (3.6 %)** | 279.1 | 66.8 | 3.6 | 2.3 | 4.9 | 4.9 | 3.4 | 0.1 |
| **Low-fat milk (0.9 %)** | 146.4 | 34.5 | 0.9 | 0.5 | 4.9 | 4.9 | 3.5 | 0.1 |
| **Hard cheese** | 1232.6 | 295.3 | 18.2 | 11.0 | 0.0 | 0.0 | 31.9 | 2.0 |
| **Soft cheese** | 1409.0 | 340.7 | 31.5 | 19.5 | 2.6 | 2.6 | 11.3 | 0.9 |
| **Yoghurt** | 279.9 | 66.9 | 3.6 | 2.3 | 4.5 | 4.5 | 3.9 | 0.1 |
| **Curd cheese** | 303.5 | 71.4 | 0.2 | 0.2 | 3.2 | 3.2 | 13.5 | 0.1 |
| **Butter** | 3056.8 | 743.4 | 82.0 | 52.9 | 0.7 | 0.7 | 0.7 | 0.0 |

**TABLE 8 NUTRITIONAL VALUE OF SOME DAIRY PRODUCTS (NUT.S).**

In addition, dairy products can be a good source for calcium and phosphorus which are important for growth. However, many dairy products consumed by children contain a high amount of sugar. The recommended daily intake of total sugar should not exceed 10 % of the daily energy intake (WHO 2015).

### 2.7.3 Recommendation

According to the Austrian nutrition pyramid, three portions of dairy products should be consumed per day. This includes yogurt, cheese and milk and should preferably be low-fat products with no added sugar. Ideally, two portions of “white” products such as milk, yoghurt or quark, and one portion of “yellow” products such as cheese should be consumed. One portion means one cup of 200 mL liquid or two thin slices of cheese (BMASGK 2020).

# 3 Materials and Methods

## 3.1 Evaluation Criteria

In this thesis the applicability of five different methods for calculating added sugar in dairy products were evaluated according to defined criteria:

- Information available such as ingredients declared in % on the label, the number of components the product consisted of, whether all necessary information was available in nut.s nutritional.software (nut.s science, 2010) etc.
- Time requirement
- Applicability, meaning to how many subgroups each method could be applied.
- Practicability, meaning when it would be possible to apply each method and which information was required.
- Suitability, meaning whether each method was suitable for the purpose of calculating added sugar content.
- Reliability, meaning the trustworthiness of each method to estimate the true value
- Advantages
- Disadvantages
- Target group (consumers/experts)

## 3.2 Methods for Calculating Added Sugar

### 3.2.1 Method 1 – Louie et al. 2015

This method was based on a 10-step protocol developed in order to calculate the amount of added sugar in a product where step 1-6 were subjective evaluations and step 7-10 were objective evaluations. The suitable step was applied to each product. Fruits were counted as added sugar due to the fact that they were almost exclusively concentrated juices, purees or other mixtures of sugar. This method is too difficult to apply for consumers without any background knowledge. The first four steps could not be applied, as they were for products consisting of 100 % sugar, 0 % sugar and products with a detailed ingredient list. The detailed ingredient list with proportions of each ingredient was not available.

Step 5 was based on comparison with values from the unsweetened variety of the product such as natural yoghurt for yoghurts with flavour. For some dairy groups this could be found by doing a search in the nutritional software (nut.s). Nut.s contains products from the Austrian Nutrition Table (ÖNWT) and the German Nutrient Data Base (BLS). The different fat contents of the dairy were also taken into consideration. It was important that the products had the same content of fat and protein. For available products in nut.s a comparison of sugar content of the unsweetened and sweetened variety was possible. The formula $AS_{100g} = 100 \times (S_{us}-S_{total}) / S_{us}-100$ was then applied to calculate added sugar, where $S_u$ is the amount of sugar in the unsweetened variety. However, for many products it was not possible to find the same unsweetened natural variety in nut.s, and then step 5 could not be performed.

Step 6 was applied when no unsweetened variety could be identified in nut.s. This step could be used when the proportion of each individual sugar of the product was available in nut.s. When lactose or maltose content was known, they could be subtracted from the total amount of sugar declared on the label. Maltose could be found in products with malted cereals.

Step 7 was applied if step 1-6 failed. In this step one product could be compared to another with similar nutritional value from the same group of foods in the nutritional database when added sugar was known. This information was not available in nut.s. Values from similar products with a known content of added sugar calculated by step 1-6 were used when possible. The added sugar content of the food could be estimated by calculating total sugars × proportion of sugars, which was calculated from the “borrowed” food. When no similar product existed, step 8 was carried out. This step could be applied if there was a detailed ingredient list with the proportion of each ingredient. This was rarely the case. Step 9 could not be applied as the full recipes were not known. If it was not possible to calculate the amount of sugar by the first 9 steps, the resolution of this method was step 10, to assign 50 % added sugar to the product. In this way it was possible to estimate an amount of added sugar for every product in all dairy groups.

### 3.2.2 Method 2 – Simplified Method to Estimate Added Sugar Based on Milk, Fat and Lactose Content

This method was developed by the author of this thesis and is based on the estimation of milk or yoghurt content in the product. In order to estimate the proportion of milk or yoghurt, the following product information was taken into consideration: ingredient list, product specification and nutrients (fat content). This is an indirect estimation performed by calculating the proportion of dairy in the product and by estimating the lactose content of the milk or yoghurt content. At the end the lactose content is subtracted from total sugar content.

When the fat content of a product only originates from the dairy, it is possible to estimate the amount of dairy, such as yoghurt, in a product. By knowing the amount of dairy, it would be possible to estimate the lactose content in the product. For this estimation the databank nut.s was used to get the lactose content of an unsweetened variety. With a few exceptions, the proportion of each ingredient was not mentioned on the label of the recorded products. An example of how this estimation was performed is as follows: on the product label for a specific yoghurt, the fat content is listed as 1.3 g per 100 g product. Information on the label tells us that the yoghurt contains milk with 1.5 % fat. In order to estimate the amount of added sugar in this product, we need to first estimate the amount of yoghurt present in the product, so that we can use this number to estimate how much lactose it contains. Since the values on the label are given per 100 g, 100 g yoghurt thus contains 1.5 g fat. However, the label also tells us that the product contains only 1.3 g fat, so the yoghurt content in the product must be less than 100 g.

Thus, the calculation will be

$$\frac{100\ g\ yoghurt}{1.5\ g\ fat} \times 1.3\ g\ fat = 86.7\ g\ yoghurt\ in\ the\ product.$$

100 g yoghurt divided by 1.5 g fat multiplied by 1.3 g fat, a number which was taken from the label, makes up a total of 86.7 g yoghurt in the product. This amount of yoghurt is multiplied by the amount of lactose in the unsweetened variety, in this case 4.5 g per 100 g. This value

was found by using nut.s. 4.5 g lactose divided by 100 % makes 0.045 g. This number is multiplied by 86.7 g, which was the amount of yoghurt in the product. The result would be the amount of lactose in the sweetened product, and this would then be subtracted from the total amount of sugar declared on the label.

$\frac{4.5\ g}{100} = 0.045\ g \times 86.7\ g = 3.9\ g\ lactose.$

If the label tells us that the total amount of sugar is 5.6 g. then the added sugar would be:

5.6 g – 3.9 g lactose = 1.7 g added sugar.

Added sugar would include all kinds of sugar in the product except for the estimated lactose content. It was not always possible to apply this method; only for products with a short ingredient list and no other sources of fat.

### 3.2.3 Method 3 – Simplified Method to Estimate Added Sugar Based on Lactose Content

A simplified way to estimate added sugar was developed by the author of this thesis in order to compare different methods. This method is called method 3 and is based on lactose content, which would be an easy way for consumers to estimate added sugar as little information is required. The amount of lactose per 100 g, which was identified in unsweetened products by using nut.s, was here subtracted from the total sugar declared on the label of each product. The amount of yoghurt or milk was not taken into consideration. This method could only be applied to products which had only one source of lactose, except if there existed an unsweetened variety of the product in nut.s. It was not possible to do this with cream cheese, for instance, as it is a combination of yoghurt and cream cheese both containing different amount of lactose and no unsweetened variety was found. The proportion of each ingredient in the products was not known and the sugar from fruits was included in the added sugar content. The table for lactose content of unsweetened products used in this calculation is shown in table 9.

| Amount of fat (%) in product per 100g | Amount of lactose(g) in product per 100g |
|---|---|
| Kefir 1.5 % | 3.6 |
| Kefir 10 % | 3.4 |
| Buttermilk 0.5 % | 4.0 |
| Buttermilk 1 % | 3.6 |
| Butter milk lactose free | 4.1 |
| Yoghurt 1.5 %, 3.2 %, 3.6 % | 4.5 |
| Yoghurt 0.1 %, 3.5 %, 3.8 % | 4.4 |
| Yoghurt 1.8 % | 4.2 |
| Yoghurt 4 % | 4.0 |
| Yoghurt 10 % | 3.7 |
| Yoghurt made of sheep milk 5 % | 3.7 |
| Yoghurt made of goat milk 5.5 % | 3.7 |
| Whey | 4.7 |
| Cream | 4.1 |
| Cow's milk 1.5 % and 1.8 % | 4.8 |
| Cow's milk 3.5 % | 4.7 |
| Sour milk | 4.0 |
| Sour cream 10 % | 3.5 |
| Sour cream 15 % | 3.2 |
| Whole milk | 4.9 |

TABLE 9 THE AMOUNT OF LACTOSE IN NATURAL DAIRY PRODUCTS (NUT.S, 2010).

### 3.2.4 Method 4 – The Federal Food Safety and Veterinary Office in Switzerland, 2018

The Federal Food Safety and Veterinary Office calculates added sugar by dividing the ingredients into three separate groups. Then they identify the ingredients and amounts in % from the recipe**,** allocate the ingredients in one of the categories and at the end calculate the amount of added sugars per category and ingredient. An access to full recipes was necessary in order to apply this method but they were not available for this thesis. Thus, it was not possible to use this method.

### 3.2.5 Method 5 – Amoutzopoulos et al. 2018

This method was developed as a flexible way to calculate the amount of free and added sugars. To use this method the ingredients must be known, in addition to their proportion in the food and information on the sugar content. The ingredients are then assigned to subcategories and then the sugar content can be calculated according to different definitions of free and added sugar. This method was also not applicable since the access to full recipes was necessary here as well.

## 3.3 Data for the Evaluation

### 3.3.1 Product Groups

936 dairy products were recorded in total and divided into subgroups illustrated in table 10.

| Dairy product | Number of products recorded |
|---|---|
| **Buttermilk with flavour** | 17 |
| **Desserts** | 227 |
| **Cream cheese with flavour** | 67 |
| **Drinks made of milk protein** | 4 |
| **Yoghurt with flavour** | 375 |
| **Yoghurt drinks with flavour** | 53 |
| **Cocoa and chocolate milk** | 44 |
| **Kefir with flavour** | 4 |
| **Milk with flavour** | 33 |
| **Milk snacks** | 25 |
| **Whey with flavour** | 31 |
| **Milk with muesli / porridge with flavour** | 5 |
| **Probiotics with flavour** | 30 |
| **Curdled milk with flavour** | 21 |
| **Total amount of products** | 936 |

**TABLE 10 DAIRY PRODUCTS SUBGROUPS AND NUMBER OF PRODUCTS RECORDED.**

The categorisation of products was not always clear. For example, one product had a designation as dessert, but it was shown that the product consisted partly of cream cheese and could thus belong in this group as well. The products were divided according to their product name and, if not possible, the detailed description. The list of ingredients and the amount of nutrients were all registered. Duplicates were omitted and only products with a known amount of nutrients in g and ingredient list were included.

### 3.3.2 Data Collection and Data Management

In the period between March and April in 2018 various supermarkets in Vienna were visited in order to make smartphone pictures of the nutrition labels, list of ingredients and amount of product in g or mL. The exceptions were natural products without additional flavours such as cheese, natural yoghurt or sour cream. In order to perform the market survey, all supermarkets were informed about the project in order to give permission to take pictures and record their products. The aim was to record all flavoured milk and dairy products on the market in a total of 13 supermarkets. Online shops were used to complement with new products on the market which had appeared after our survey in the supermarkets.

### 3.3.3 Statistics

IBM SPSS Statistics version 26 was used to perform statistical evaluations, which included paired sample t-tests, in order to calculate the difference in methods, and independent samples t-tests to compare differences in subgroups for added sugar.

Paired sample t-tests were performed in order to compare the amount of sugar for each method, and the p-values were taken into consideration. For this, the sugar content of one group of dairy products calculated by one method, was compared to the same group of dairy products calculated by another method. Paired sample tests could only be applied when more than one method could be used for a subgroup. This test was therefore not possible for desserts, cream cheese with flavour and milk snacks.

For the independent samples tests, the calculated amount of added sugar for the products of two different subgroups by method 1 were used. An example would be the subgroups yoghurt with flavour and milk with flavour calculated by method 1. The result would be significant when $p<0.05$. The conditions for the independent samples test were validated, which included the conditions for the independence of samples, the homogeneity of variances and the non-existence of outliers. It was not necessary to pass the normality test because the number of products was bigger than 50. For the paired sample tests the samples had to be related in the sense that the same subgroup was chosen from both methods. For example, the calculated amount of added sugar in yoghurt with flavour by method 1 and method 2. The test would then compare the results of both methods. It was also important that there were no outliers. All samples had more than 30 products, thus the normality test did not have to be passed. All results were given with mean, standard deviation, median, maximum and minimum values.

# 4 Results and Discussion

## 4.1 General Overview

Some subgroups had products containing artificial sweeteners either as a substitute for sugar or in addition to sugar. Six subgroups did not have any product with sweeteners, and those were buttermilk, cream cheese, milk snacks, milk with muesli, curdled milk and kefir. Drinks made of milk protein did not have any products without sweeteners. 49 out of 935 products contained sweeteners which makes a total of 5.2 %. For desserts there were only 15 out of 227 products which contained artificial sweeteners. For yoghurt the number was 9 and for yoghurt drinks, 5 products. The subgroup cocoa had 4 products, which was the same for milk with flavour, whey had 7 and probiotics 5 products with artificial sweeteners. The information on total sugar content for products with and without sweeteners is found in table 11.

| Product group | n | total sugar content (g) [1] | | | | total sugar content of products with artificial sweeteners (g) | | | | | Total sugar content of products without artificial sweeteners (g) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *M ± SD* | *min* | *max* | *mdn* | *n* | *M ± SD* | *min* | *max* | *mdn* | *n* | *M ± SD* | *min* | *max* | *mdn* |
| Buttermilk with flavour | 17 | 11.0 ± 1.4 | 7.7 | 13.0 | 11.0 | 0 | - | - | - | - | 17 | 11.0 ± 1.4 | 7.7 | 13.0 | 11.0 |
| Desserts | 227 | 14.8 ± 4.9 | 3.7 | 35.0 | 14.0 | 15 | 8.6 ± 6.0 | 3.7 | 19.7 | 5.3 | 212 | 15.3 ± 4.6 | 7.0 | 35.0 | 14.0 |
| Cream cheese with flavour | 67 | 12.4 ± 3.6 | 3.3 | 17.6 | 12.6 | 0 | - | - | - | - | 67 | 12.4 ± 3.6 | 3.3 | 17.6 | 12.6 |
| Drinks made of milk protein with flavour | 4 | 4.6 ± 0.2 | 4.5 | 4.8 | 4.5 | 0 | 4.6 ± 0.2 | 4.5 | 4.8 | 4.5 | 4 | - | - | - | - |
| Yoghurt with flavour | 375 | 13.2 ± 2.4 | 4.3 | 22.6 | 13.0 | 9 | 6.8 ± 2.4 | 4.3 | 11.0 | 6.0 | 366 | 13.3 ± 2.2 | 6.8 | 22.6 | 13.0 |
| Yoghurt drinks with flavour | 53 | 10.3 ± 3.2 | 3.3 | 14.2 | 11.0 | 5 | 4.5 ± 1.7 | 3.7 | 7.6 | 3.8 | 48 | 10.9 ± 2.7 | 3.3 | 14.2 | 11.0 |
| Cocoa and chocolate milk | 44 | 9.3 ± 2.0 | 2.4 | 12.0 | 10.0 | 4 | 4.3 ± 1.3 | 2.4 | 5.4 | 4.7 | 40 | 9.8 ± 1.2 | 6.1 | 12.0 | 10.0 |
| Milk with flavour | 33 | 9.6 ± 2.7 | 2.5 | 12.0 | 9.9 | 4 | 4.7 ± 1.5 | 2.5 | 5.8 | 5.3 | 29 | 9.8 ± 1.9 | 2.5 | 12.0 | 10.0 |
| Milk snacks | 25 | 31.4 ± 5.2 | 22.0 | 41.0 | 32.0 | 0 | - | - | - | - | 25 | 31.4 ± 5.2 | 22.0 | 41.0 | 32.0 |
| Whey with flavour | 31 | 8.9 ± 3.0 | 1.8 | 13.0 | 9.9 | 7 | 3.7 ± 1.3 | 1.8 | 4.9 | 3.9 | 24 | 10.4 ± 1.0 | 9.3 | 13.0 | 10.0 |
| Milk with muesli / Porridge | 5 | 8.5 ± 1.3 | 6.2 | 9.6 | 8.9 | 0 | - | - | - | - | 5 | 8.5 ± 1.3 | 6.2 | 9.6 | 8.9 |
| Probiotics with flavour | 30 | 10.8 ± 2.0 | 2.7 | 14.0 | 11.0 | 5 | 8.1 ± 3.9 | 2.7 | 13.3 | 7.4 | 25 | 11.4 ± 0.9 | 10.0 | 14.0 | 11.0 |
| Curdled milk with flavour | 21 | 13.0 ± 1.3 | 10.0 | 15.0 | 13.0 | 0 | - | - | - | - | 21 | 13.0 ± 1.3 | 10.0 | 15.0 | 13.0 |
| Kefir with flavour | 4 | 12.2 ± 0.7 | 11.6 | 13.2 | 11.9 | 0 | - | - | - | - | 4 | 12.2 ± 0.7 | 11.6 | 13.2 | 11.9 |

**TABLE 11 TOTAL SUGAR CONTENT (G) OF EACH SUBGROUP WITH AND WITHOUT ARTIFICIAL SWEETENERS.**

[1] **Total sugar content declared on label**

The subgroup milk snack showed the highest average amount of added sugar with 31.4 g, whereas cocoa and milk with flavour had the least with 9.8 g. Products containing artificial sweeteners had a lower mean amount of total sugar in their products than products without. This is expected as they often are used as a substitute for sugar.

Saccharose was the sugar most frequently added to the products and most of the products with added sugar contained saccharose. There were also quite a few products containing syrups. Other forms of sugar such as glucose, fructose and honey were rarely present in products.

## 4.2 Evaluation Criteria for Each Method

The results of each method according to the listed criteria will be shown.

- Information available
- Time requirement
- Applicability
- Practicability
- Suitability
- Reliability
- Advantages
- Disadvantages
- Target group (consumers/experts)

### 4.2.1 Applicability

Applicability is an important criterion, because a method should be suitable for as many subgroups as possible in order to be efficient. In table 12 the applicability of each method for every subgroup is illustrated.

| Method | 1. Louie et al. 2015 | 2. Simplified lactose and fat method | 3. Simplified lactose method | 4. Swiss Method[1] | 5. Amoutzopoulos et al. 2018[1] |
|---|---|---|---|---|---|
| **All subgroups** | ✓ | × | × | × | × |
| **Buttermilk with flavour** | ✓ | ✓ | ✓ | × | × |
| **Desserts** | ✓ | × (More than one source of fat or lactose) | × (More than one source of lactose) | × | × |
| **Cream cheese with flavour** | ✓ | × (More than one source of fat or lactose) | × (More than one source of lactose) | × | × |
| **Drinks made of milk protein** | ✓ | × More than one source of fat or lactose | ✓ | × | × |
| **Yoghurt with flavour** | ✓ | ✓ (Only suitable for products with only one source of fat) | ✓ | × | × |
| **Yoghurt drinks with flavour** | ✓ | ✓ | ✓ | × | × |
| **Cocoa and chocolate milk** | ✓ | × (Only suitable for products with only one source of fat) | ✓ | × | × |
| **Milk with flavour** | ✓ | ✓ (Only suitable for products with only one source of fat) | ✓ | × | × |
| **Milk snacks** | ✓ | × (More than one source of fat or lactose) | × (More than one source of lactose) | × | × |
| **Whey with flavour** | ✓ | × (Only suitable for products with only one source of fat) | ✓ | × | × |
| **Muesli / Porridge** | ✓ | ✓ (Only suitable for products with only one source of fat) | ✓ | × | × |
| **Probiotics with flavour** | ✓ | ✓ (Only suitable for products with only one source of fat) | ✓ | × | × |
| **Curdled milk with flavour** | ✓ | ✓ | ✓ | × | × |
| **Kefir with flavour** | ✓ | ✓ | ✓ | × | × |

**TABLE 12 APPLICABILITY OF METHODS FOR ESTIMATING ADDED SUGAR FOR INDIVIDUAL DAIRY GROUPS.**

[1] **Not applicable, because the recipes were not available.**

Since methods 4 and 5 could not be applied, the next results will only be shown for methods 1, 2 and 3. In table 13 a more detailed result of the applicability is shown.

| **Method** | **1. Louie et al. 2015** | **2. Simplified lactose and fat method** | **3. Simplified lactose method** |
|---|---|---|---|
| **Applicability subgroups** | All (14) | 8 (Some subgroups only partially) | 11 |
| **Applicability in % for subgroups** | 100 | 57 | 79 |

**TABLE 13 APPLICABILITY OF DIFFERENT SUGAR ESTIMATION METHODS FOR DAIRY PRODUCTS.**

As can be seen in table 13, method 1 could be applied to each subgroup. Method 2 could only be applied to subgroups with products containing only one source of fat, as the fat content is used to calculate the amount of added sugar. This method could not be applied to desserts, cream cheese, drinks made of milk protein, cocoa and chocolate milks, milk snacks or whey with flavour. Chocolate contain as many other products fat and that could be found in many products, which made it impossible to know the fat content of the milk or yoghurt. Method 3 could only be applied to products containing one source of dairy product, as here the lactose content was needed in order to calculate added sugar, except if there existed an unsweetened variety of the same product. In table 14 the applicability in % for each subgroup for methods 2 and 3 is illustrated.

| Method | 2. Simplified lactose and fat method | 3. Simplified lactose method |
|---|---|---|
| **Buttermilk with flavour** | 94.1 % | 100 % |
| **Desserts** | 0 % | 0 % |
| **Cream cheese with flavour** | 0 % | 0 % |
| **Drinks made of milk protein** | 0 % | 100 % |
| **Yoghurt with flavour** | 74.7 % | 100 % |
| **Yoghurt drinks with flavour** | 71.7 % | 100 % |
| **Cocoa and chocolate milk** | 0 % | 100 % |
| **Milk with flavour** | 57.6 % | 100 % |
| **Milk snacks** | 0 % | 0 % |
| **Whey with flavour** | 0 % | 100 % |
| **Milk with muesli / Porridge** | 100 % | 100 % |
| **Probiotics with flavour** | 80.0 % | 100 % |
| **Curdled milk with flavour** | 100 % | 100 % |
| **Kefir with flavour** | 100 % | 100 % |

**TABLE 14 APPLICABILITY OF METHOD 2 AND 3 TO SUBGROUPS.**

Method 3 was either 100 % applicable or not applicable at all, whereas method 2 varied much depending on the subgroup. Method 2 worked well on buttermilk, milk with muesli, curdled milk and kefir because they had only one source of fat. Other products such as cocoa, had fat originating from chocolate as well as from milk.

Method 1 (Louie et al. 2015) consisted of 10 steps. Step 1-6 were objective, whereas step 7-10 were subjective. In order to determine whether most of the products were subjectively or objectively evaluated, the number of times each step was applied was counted. Every subgroup was included. The results are shown in table 15.

| | Step | Number of products for which the step was applied (n) | Percentage % of products for which the step was applied | Percentage % of objective/subjective steps |
|---|---|---|---|---|
| Objective steps | 1 | 0 | 0 | 61.3 |
| | 2 | 0 | 0 | |
| | 3 | 0 | 0 | |
| | 4 | 0 | 0 | |
| | 5 | 502 | 53.6 | |
| | 6 | 72 | 7.7 | |
| **Subjective steps** | 7 | 318 | 34.0 | 38.7 |
| | 8 | 17 | 1.8 | |
| | 10 | 27 | 2.9 | |
| **TOTAL** | | 936 | 100 | 100 |

**TABLE 15 STEPS APPLIED IN NUMBER OF PRODUCTS AND PERCENTAGE.**

Most products were objectively evaluated which means that the method by Louie et. al could be a good way to estimate added sugar. It was easy to estimate the amount of sugar when an unsweetened variety was available, which was often the case for yoghurt and milks with flavour. Desserts, on the other hand, did not have any unsweetened varieties. They have a long ingredient list and contain much sugar originating from different sources. The frequency of each step for every subgroup is illustrated in figure 5.

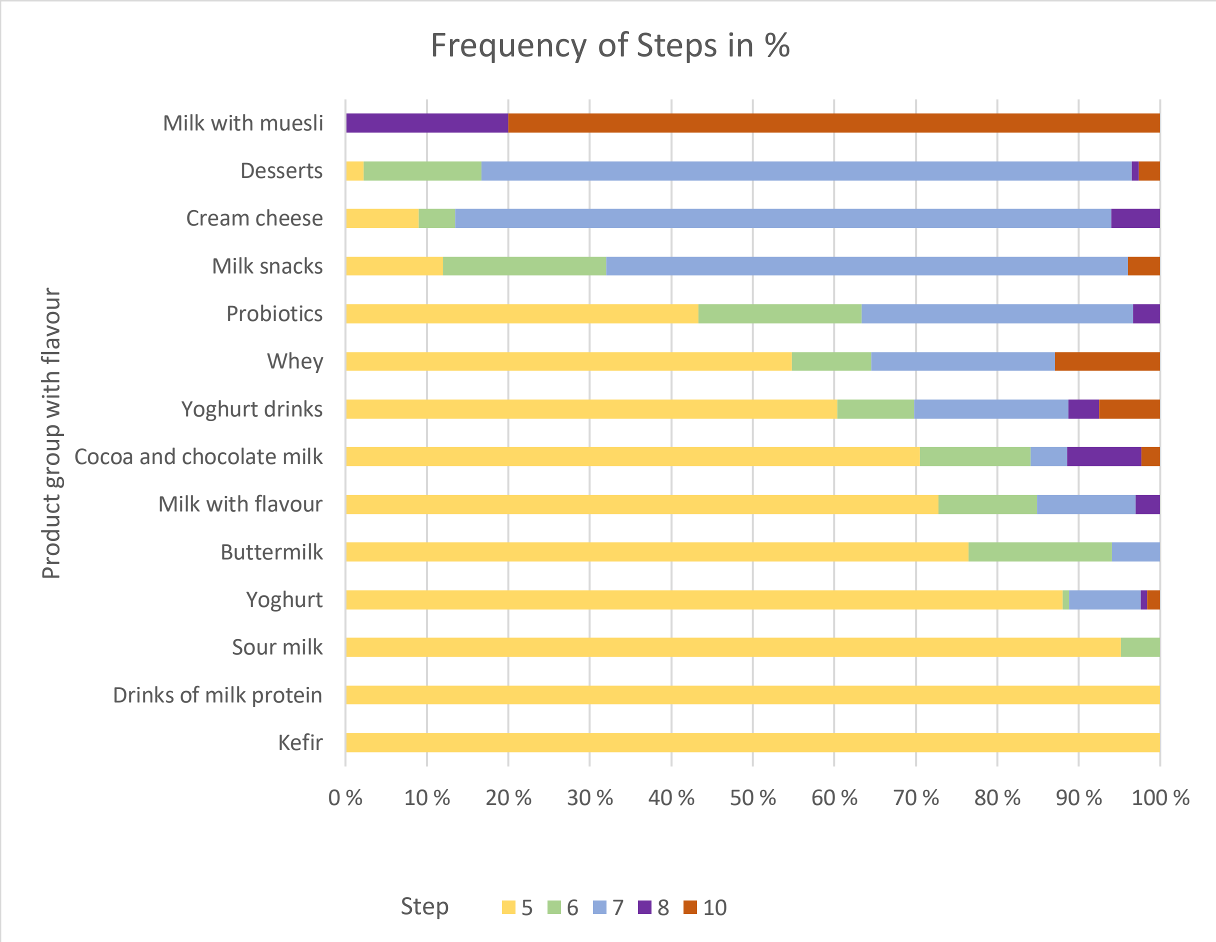


**FIGURE 5 SUBGROUPS AND THE FREQUENCY OF STEPS APPLIED IN % ACCORDING TO LOUIE ET AL. 2015.**

Figure 5 illustrates well that step 5 was used more frequently than other steps, but also that step 7 often had to be applied to some subgroups such as dessert and cream cheese, because they did not have an unsweetened variety. Moreover, step 5 couldn't be applied to every product in groups such as yoghurt, butter milk and cocoa because some products had a long ingredient list, such as yoghurt with mascarpone or yoghurt with chocolate balls, and for this there were no suitable unsweetened variety. For milk with flavour it was not always possible to find the unsweetened product with the same amount of fat. Attempts were made to avoid step 10, as step 10 was used more as an emergency solution where it was not possible to estimate the amount of added sugar any other way. Assuming that added sugar is 50 % of the total sugar content is often not the case for some subgroups such as desserts. An exception is a product with artificial sweeteners. Desserts and milk snacks contain many sources of added sugar which are close to the total sugar content. As mentioned above, step 6 was applied when step 5 failed. However, the identical product in nut.s should be more accurate than the unsweetened variety, as the lactose content usually differ slightly in the unsweetened and sweetened products. If an identical product could be identified, step 6 should have been applied before step 5. There were few milk with muesli products, and mostly step 10 had to be applied as it was not possible to find similar products in nut.s. In addition, the products often have a long ingredient list containing many sources of sugar.

### 4.2.2 Practicability

Method 1 requires a lot of knowledge and could only be applied by experts, which means it is time consuming and not very practical for consumers. Method 2 requires less information, but the calculation is more complex than method 3, which would be an easy way for consumers to estimate added sugar in a product as not too much knowledge is required to apply it.

The practicability is summarised in table 16.

| **Method** | **1. Louie et al. 2015** | **2. Simplified lactose and fat method** | **3. Simplified lactose method** |
|---|---|---|---|
| **Information readily available** | × | ✓ | ✓ |
| **Time requirement** | High | Medium | Low |
| **Practicability** | Low | Medium | High |

**TABLE 16 PRACTICABILITY OF DIFFERENT SUGAR ESTIMATION METHODS FOR DAIRY PRODUCTS.**

The time requirement for method 1 was high because of the detailed list of steps with different calculations. If the first step didn't work, the next step was tried until the suitable one was found. Method 2 required less time than method 1 because the same calculation was carried out each time. Method 3 had an easier calculation than method 2 because it is only based on the lactose content, thus it required little time to perform the calculations.

Information was easily available for method 2 and 3. The amount of fat in g was declared on the product label which was needed for method 2. As for method 3, the amount of lactose in natural products without flavour could be easily found in nut.s. Method 1 has many steps to follow in order to calculate added sugar, and only the amount of carbohydrates and total sugar are declared on the label. Thus, it required more information not easily available in order to apply the steps.

### 4.2.3 Suitability

Method 1 was classified as high for suitability, because it could be applied to every subgroup, and, regardless of product, it was always possible to achieve an estimation of added sugar. The suitability of method 2 was low, because it is an estimation based on both fat and lactose content, and the estimation may not be very reliable. It could not be used on every product and is not suitable for scientific purposes. Method 3 was classified as medium due to the easy way for consumers to use the method to calculate added sugar. It is, however, not suitable for scientific purposes. The results are illustrated in table 17.

| **Method** | **1. Louie et al. 2015** | **2. Simplified lactose and fat method** | **3. Simplified lactose method** |
|---|---|---|---|
| **Suitability** | High | Low | Medium |

**TABLE 17 SUITABILITY OF DIFFERENT SUGAR ESTIMATION METHODS FOR SCIENTIFIC RESEARCH.**

### 4.2.4 Reliability

Regarding the reliability, method 1 was classified as high. The 10 steps were created in order to achieve the closest estimation possible to the true content of added sugar, and it has steps for products with a known and detailed ingredient list and recipe, as well as products without. Method 2 was classified as low because the indirect way of calculating added sugar based on fat content could only be used as a vague estimation.

Method 3 was classified as medium because it gives a good indication on how much added sugar is in a product, but it is not as reliable as method 1, which has detailed steps for every product. A summary is found in table 18.

| **Method** | **1. Louie et al. 2015** | **2. Simplified lactose and fat method** | **3. Simplified lactose method** |
|---|---|---|---|
| **Reliability** | High | Low | Medium |

**TABLE 18 RELIABILITY OF DIFFERENT SUGAR ESTIMATION METHODS FOR DAIRY PRODUCTS.**

### 4.2.5 Advantages, Disadvantages and Target Group

Method 1 is a scientific approach to estimate added sugar and is very detailed and complex. This would be too difficult for consumers to perform and is only suitable for experts. The advantages are manyfold such as the possibility of applying the method to every subgroup regardless of knowing recipes or nutrition information. It thus gives a more reliable calculation of added sugar content, which would be close to the true value, or even the exact value when the possibility of using step 1-4 exists. However, because of the complexity of the method it is very time-consuming and requires a lot of knowledge in the field.

Method 2 is an easier way to estimate added sugar based on fat and lactose content. It could be used by consumers who have an interest in nutrition and health and want to estimate added sugar without having access to the detailed recipe. However, the method is only suitable for subgroups without other sources of fat than milk and yoghurt and cannot be used for scientific purposes as the results are not very reliable. Method 3 is an easy way requiring little time for consumers to estimate added sugar and it is possible to do so without knowing the recipe here as well. A disadvantage is that it cannot be used for every subgroup and also not scientifically. The results are summarised in table 19.

| Method | 1. Louie et al. 2015 | 2. Simplified lactose and fat method | 3. Simplified lactose method |
|---|---|---|---|
| **Advantages** | Steps for every product, gives a more reliable estimation, can be used for scientific purposes | Possible to estimate added sugar without knowing the recipe | Possible to estimate added sugar by knowing lactose content, easy for consumers, little time required |
| **Disadvantages** | Time-consuming, not suitable for consumers | Partly complicated calculation, only suitable for some products, not for scientific purposes | Only suitable for some products, not for scientific purposes |
| **Target group** | Experts | Consumers | Consumers |

**TABLE 19 ADVANTAGES, DISADVANTAGES AND TARGET GROUP OF DIFFERENT SUGAR ESTIMATION METHODS FOR DAIRY PRODUCTS.**

## 4.3 Results of Added Sugar by Methods

### 4.3.1 Method 1 – Louie et al. 2015

The mean amount of total and added sugar, in addition to the percentage of added sugar for each dairy product subgroup are shown in table 20, including standard deviation, maximum value, minimum value and the median.

| Product group | n | total sugar content in g/100 g or ml/100ml[1] | | | | added sugar in g/100 g or ml/100ml[2] | | | | percentage of added sugar | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *M ± SD* | *min* | *Max* | *Mdn* | *M ± SD* | *min* | *max* | *Mdn* | *M ± SD* | *min* | *max* | *Mdn* |
| Buttermilk with flavour | 17 | 11.0 ± 1.4 | 7.7 | 13.0 | 11.0 | 7.6 ± 1.5 | 4.3 | 9.8 | 7.7 | 67.6 ± 8.0 | 49.3 | 80.0 | 70.0 |
| Desserts | 227 | 14.8 ± 4.9 | 3.7 | 35.0 | 14.0 | 11.3 ± 5.0 | 0 | 30.1 | 10.2 | 73.3 ± 15.6 | 0 | 94.7 | 73.3 |
| Cream cheese with flavour | 67 | 12.4 ± 3.6 | 3.3 | 17.6 | 12.6 | 10.1 ± 3.9 | 0 | 15.7 | 11 | 76.4 ± 20.4 | 0 | 90.0 | 85.5 |
| Drinks made of milk protein with flavour | 4 | 4.6 ± 0.2 | 4.5 | 4.8 | 4.5 | 0.6 ± 0.2 | 0.5 | 0.8 | 0.5 | 12.5 ± 2.8 | 11.1 | 16.7 | 11.1 |
| Yoghurt with flavour | 375 | 13.2 ± 2.4 | 4.3 | 22.6 | 13.0 | 9.2 ± 2.4 | 1.1 | 19.0 | 9 | 68.7 ± 8.5 | 22.5 | 86.8 | 69.2 |
| Yoghurt drinks with flavour | 53 | 10.3 ± 3.2 | 3.3 | 14.2 | 11.0 | 6.8 ± 2.6 | 1.1 | 10.3 | 7.6 | 64.8 ± 13.0 | 29.0 | 90.0 | 65.0 |
| Cocoa and chocolate milk | 44 | 9.3 ± 2.0 | 2.4 | 12.0 | 10.0 | 5.2 ± 2.4 | 0.2 | 11.3 | 5.4 | 53.2 ± 19.7 | 3.7 | 100.0 | 54.0 |
| Milk with flavour | 33 | 9.6 ± 2.7 | 2.5 | 12.0 | 9.9 | 5.8 ± 2.0 | 0.3 | 8.8 | 6.1 | 68.6 ± 49.8 | 6.0 | 100.0 | 60.0 |
| Milk snacks | 25 | 31.4 ± 5.2 | 22.0 | 41.0 | 32.0 | 25.4 ± 4.6 | 14.5 | 33.0 | 25.7 | 80.8 ± 7.0 | 50.0 | 85.8 | 82.0 |
| Whey with flavour | 31 | 8.9 ± 3.0 | 1.8 | 13.0 | 9.9 | 5.8 ± 2.1 | 1.9 | 9.6 | 6.1 | 74.6 ± 52.7 | 19.8 | 100.0 | 57.6 |
| Milk with muesli / Porridge | 5 | 8.5 ± 1.3 | 6.2 | 9.6 | 8.9 | 4.3 ± 0.7 | 3.1 | 5.0 | 8.9 | 50.3 ± 3.8 | 44.8 | 55.6 | 50.6 |
| Probiotics with flavour | 30 | 10.8 ± 2.0 | 2.7 | 14.0 | 11.0 | 7.2 ± 2.1 | 1.4 | 12.1 | 7.3 | 65.6 ± 10.1 | 39.2 | 86.4 | 67.2 |
| Curdled milk with flavour | 21 | 13.0 ± 1.3 | 10.0 | 15.0 | 13.0 | 9.0 ± 1.3 | 6.3 | 11.5 | 9.4 | 71.4 ± 3.4 | 63.0 | 76.8 | 72.3 |
| Kefir with flavour | 4 | 12.2 ± 0.7 | 11.6 | 13.2 | 11.9 | 8.0 ± 1.8 | 6.3 | 10.1 | 7.9 | 73.6 ± 2.3 | 71.6 | 76.5 | 73.1 |

**TABLE 20 NAME OF DAIRY GROUP AND THE MEAN AMOUNT OF TOTAL AND ADDED SUGAR, PERCENTAGE, STANDARD DEVIATION, MAX, MIN AND MEDIAN FOR METHOD 1.**

**1 Total sugar content declared on label 2 Added sugar calculated according to the method by Louie et al. 2015.**

936 products were analysed in total, the biggest subgroups were dessert and yoghurt with 227 and 375 products respectively. Milk snacks was the group with the highest amount of sugar, with 31.4 g of total sugar content and 25.4 g of added sugar per 100 g on average. It also contains the highest maximum amount of added sugar of all product groups with 33.0 g, followed by desserts with a maximum of 30.1 g.
The least amount of added sugar was found in some desserts and cream cheese products. These were products with artificial sweeteners. A very small amount of minimum added sugar is also in milk with flavour and cocoa milk, which both have a minimum of 0.3 g.

The subgroups with the highest percentage of added sugar on average are cream cheese and milk snacks, with 76 and 80 % of the sugar originating from added sugar. These groups are followed by desserts with 73 %, then by sour milk, yoghurt and butter milk consisting of about 70 %. The products with the least percentage of added sugar are kefir and drinks made of milk protein. However, both of these subgroups have small sample sizes, which is a limitation. It seems as they would be good alternatives when opting for dairy products with less added sugar, but due to the small sample size no conclusion can be drawn.

Method 1 is practical in order to estimate the amount of added sugar in dairy products, but as with other methods, it is limited and not completely accurate. For some subgroups many products were subjectively evaluated. Most of them were those with a long ingredient list such as desserts.
Statistical tests were performed to look for differences in the added sugar content between subgroups. Independent samples t-tests showed that there was a statistically significant difference between the amount of added sugar in yoghurt and yoghurt drinks ($p < 0.001$). The mean amount of added sugar was higher in yoghurt (9.2 ± 2.4 g) than in yoghurt drinks (6.8 ± 2.6 g.) There was also a significant difference between yoghurt and probiotics ($p < 0.001$) with yoghurt having a higher mean value of added sugar than probiotics (9.2 ± 2.4 g and 7.2 ± 2.1 g). In addition, there was also a statistically significant difference for added sugar content between yoghurt and desserts ($p < 0.001$) as would be expected. Desserts (11.3 ± 5.0 g) had

more added sugar than yoghurt (9.2 ± 2.4 g.) When comparing yoghurt drinks and milk with flavour there was no statistically significant difference in the amount of added sugar between the two subgroups ($p = 0.065$). The mean amount of added sugar in yoghurt drinks was 6.8 ± 2.6 g. and in milk with flavour 5.8 ± 2.0 g.

### 4.3.2 Method 2 - Simplified Lactose and Fat Method

The information on the mean amount of total and added sugar, in addition to the percentage of added sugar and statistics for method 2 is shown in table 21.

| Product group[3] | n | total sugar content in g/100 g or ml/100ml[1] | | | | added sugar content in g/100 g or ml/100ml[1] | | | | percentage of added sugar | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *M ± SD* | *min* | *max* | *mdn* | *M ± SD* | *min* | *max* | *mdn* | *M ± SD* | *min* | *max* | *mdn* |
| Buttermilk with flavour | 16 | 10.9 ± 1.4 | 7.7 | 13.0 | 11.0 | 7.7 ± 1.4 | 4.3 | 9.8 | 7.7 | 70.3 ± 4.4 | 62.3 | 75.8 | 71.4 |
| Desserts[4] | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Cream cheese with flavour[4] | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Drinks made of milk protein with flavour[4] | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Yoghurt with flavour | 279 | 13.1 ± 1.7 | 8.0 | 20.5 | 13.0 | 9.7 ± 1.8 | 4.5 | 17.1 | 9.5 | 73.6 ± 5.4 | 43.6 | 90.0 | 73.1 |
| Yoghurt drinks with flavour | 38 | 10.3 ± 3.2 | 3.3 | 14.2 | 11.0 | 6.9 ± 3.2 | 0.1 | 10.7 | 8.0 | 60.0 ± 23.8 | 0 | 79.1 | 68.2 |
| Cocoa and chocolate milk[4] | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Milk with flavour | 19 | 9.6 ± 2.0 | 2.5 | 11.7 | 10.0 | 5.6 ± 1.3 | 2.3 | 7.2 | 5.7 | 56.6 ± 10.1 | 40.5 | 92.0 | 55.5 |
| Milk snacks[4] | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Whey with flavour[4] | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Milk with muesli / Porridge | 3 | 8.3 ± 1.8 | 6.2 | 9.6 | 9.0 | 4.3 ± 1.9 | 2.2 | 5.6 | 5.2 | 50.5 ± 13.0 | 35.5 | 58.3 | 57.8 |
| Probiotics with flavour | 24 | 10.8 ± 1.2 | 7.4 | 12.5 | 11.0 | 7.5 ± 1.3 | 3.9 | 9.4 | 7.6 | 68.6 ± 5.4 | 52.7 | 75.2 | 68.8 |
| Curdled milk with flavour | 21 | 12.8 ± 1.3 | 10.0 | 15.0 | 13.0 | 9.7 ± 1.2 | 6.9 | 11.9 | 9.9 | 75.3 ± 2.9 | 69.0 | 80.5 | 75.6 |
| Kefir with flavour | 4 | 12.2 ± 0.7 | 11.6 | 13.2 | 11.9 | 9.3 ± 0.9 | 8.5 | 10.5 | 9.1 | 76.4 ± 2.7 | 73.3 | 79.6 | 76.5 |

**TABLE 21 NAME OF DAIRY GROUP AND THE MEAN AMOUNT OF TOTAL AND ADDED SUGAR, PERCENTAGE, STANDARD DEVIATION, MAX, MIN AND MEDIAN FOR METHOD 2.**

**1 Total sugar content declared on label**

**2 Added sugar calculated according to the method based on fat and lactose content**

**3 n = number of products where method 2 could be applied**

**4 more than one source of fat in the product**

It was only possible to estimate the amount of sugar for eight groups of dairy products. This was for groups with few ingredients such as yoghurt and milk with flavour. It was not possible to estimate the sugar content for every product within a subgroup. In order to use this method, the products could not contain more than one source of fat, so it was impossible to calculate the amount of added sugar for desserts and milk snacks, as they usually contain various sources of fat. Yoghurt with flavour had the highest maximum amount of added sugar with a total of 17.1 g, whereas yoghurt drinks with flavour had the least amount of added sugar with 0.1 g. Yoghurt and curdled milk both had a mean amount of added sugar of 9.7 g per 100 g product. Kefir had the highest percentage of added sugar with 76 % but because of the small sample size the results are inconclusive. Products with a similar percentage were yoghurt and curdled milk. This is a very high amount of added sugar and above the daily recommendations.

### 4.3.3 Method 3 – Simplified Lactose Method

The same calculations and statistics were performed for method 3 and the results are shown in table 22.

| Product group[3] | n | total sugar content in g/100 g or ml/100ml[1] | | | | added sugar content in g/100 g or ml/100ml[2] | | | | percentage of added sugar | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *M ± SD* | *min* | *max* | *mdn* | *M ± SD* | *min* | *max* | *mdn* | *M ± SD* | *min* | *max* | *mdn* |
| Buttermilk with flavour | 17 | 11.0 ± 1.4 | 7.7 | 13.0 | 11.0 | 7.1 ± 1.5 | 3.6 | 9.4 | 7.4 | 64.1 ± 7.2 | 45.8 | 72.3 | 65.8 |
| Desserts[4] | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Cream cheese with flavour[4] | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Drinks made of milk protein with flavour | 4 | 4.6 ± 0.2 | 4.5 | 4.8 | 4.5 | 0.5 ± 0.2 | 0.5 | 0.8 | 0.5 | 12.5 ± 2.8 | 11.1 | 16.8 | 11.1 |
| Yoghurt with flavour | 374 | 13.2 ± 2.4 | 4.3 | 22.6 | 13.0 | 8.9 ± 2.4 | 0 | 18.2 | 8.6 | 66.2 ± 9.1 | 0.0 | 83.2 | 67.0 |
| Yoghurt drinks with flavour | 53 | 10.3 ± 3.2 | 3.3 | 14.2 | 11.0 | 6.0 ± 3.0 | 0 | 9.8 | 6.6 | 50.9 ± 24.3 | 15.8 | 69.0 | 60.0 |
| Cocoa and chocolate milk | 44 | 9.3 ± 2.0 | 2.4 | 12.0 | 10.0 | 4.6 ± 1.8 | 0 | 7.3 | 5.1 | 46.7 ± 14.3 | 0 | 60.8 | 51.8 |
| Milk with flavour | 33 | 9.2 ± 2.5 | 2.5 | 12.0 | 9.9 | 4.6 ± 2.2 | 0 | 7.2 | 5.1 | 45.1 ± 17.8 | 0 | 60.0 | 51.5 |
| Milk snacks[4] | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Whey with flavour | 31 | 8.9 ± 3.0 | 1.8 | 13.0 | 9.9 | 4.2 ± 3.0 | 0 | 8.3 | 5.2 | 42.2 ± 22.9 | 0 | 63.9 | 52.5 |
| Milk with muesli / Porridge | 5 | 8.5 ± 1.3 | 6.2 | 9.6 | 8.9 | 3.6 ± 1.3 | 1.4 | 4.8 | 4.0 | 41.6 ± 10.9 | 22.6 | 50.0 | 44.9 |
| Probiotics with flavour | 30 | 10.8 ± 2.0 | 2.7 | 14.0 | 11.0 | 6.5 ± 1.8 | 0 | 9.6 | 6.6 | 57.7 ± 12.5 | 0 | 70.0 | 60.0 |
| Curdled milk with flavour | 21 | 12.8 ± 1.3 | 10.0 | 15.0 | 13.0 | 8.8 ± 1.3 | 6.0 | 11.0 | 9.0 | 68.5 ± 3.3 | 60.0 | 73.3 | 69.2 |
| Kefir with flavour | 4 | 12.2 ± 0.7 | 11.6 | 13.2 | 11.9 | 8.6 ± 0.7 | 8.0 | 9.6 | 8.0 | 70.3 ± 1.7 | 69.0 | 72.7 | 69.7 |

**TABLE 22 NAME OF DAIRY GROUP AND THE MEAN AMOUNT OF TOTAL AND ADDED SUGAR, PERCENTAGE, STANDARD DEVIATION, MAX, MIN AND MEDIAN FOR METHOD 3.**

**1 Total sugar content declared on label**

**2 Added sugar calculated according to the method based on lactose content**

**3 n = number of products where method 2 could be applied**

**4 more than one source of lactose or no available unsweetened product**

It was possible to calculate more groups of dairy products with method 3 than with method 2. It is also impossible to apply this method to products with more than one source of lactose, such is often the case with desserts, except when the same product exists in a natural variety. The proportion of each ingredient was not known. The values calculated by this method are generally lower than those calculated by method 1 and 2. Yoghurt with flavour had in this case the highest maximum amount of added sugar with 18.2 g, which is 1.1 g more than estimated by method 2. Yoghurt drinks with flavour, whey with flavour and cocoa milk with flavour were some of the subgroups having 0 g as the minimum amount of added sugar. Drinks of milk protein showed an amount of 0.5 g added sugar, but this sample was small. Kefir had, similar to method 2, the highest percentage of added sugar with 70 %, but the calculated percentage here was less than in methods 1 and 2. This was followed by curdled milk with 68.5 % and yoghurt with 66.0 %.

Dessert was a subgroup containing much sugar as expected. Desserts are considered a sweet treat once in a while. The same cannot be said for yoghurt, yoghurt drinks and buttermilk as they are part of the nutrition pyramid and recommended to be consumed daily. The recommendations mention low-fat dairy products but should also mention dairy products with low sugar content or natural products. Milk snacks contain a high amount of added sugar too, but they are also a kind of dessert. In general, every dairy product subgroup contains much added sugar, although variations exist.

### 4.3.4 Comparison of Method 1, 2 and 3

A comparison of the three methods is illustrated in figure 6.

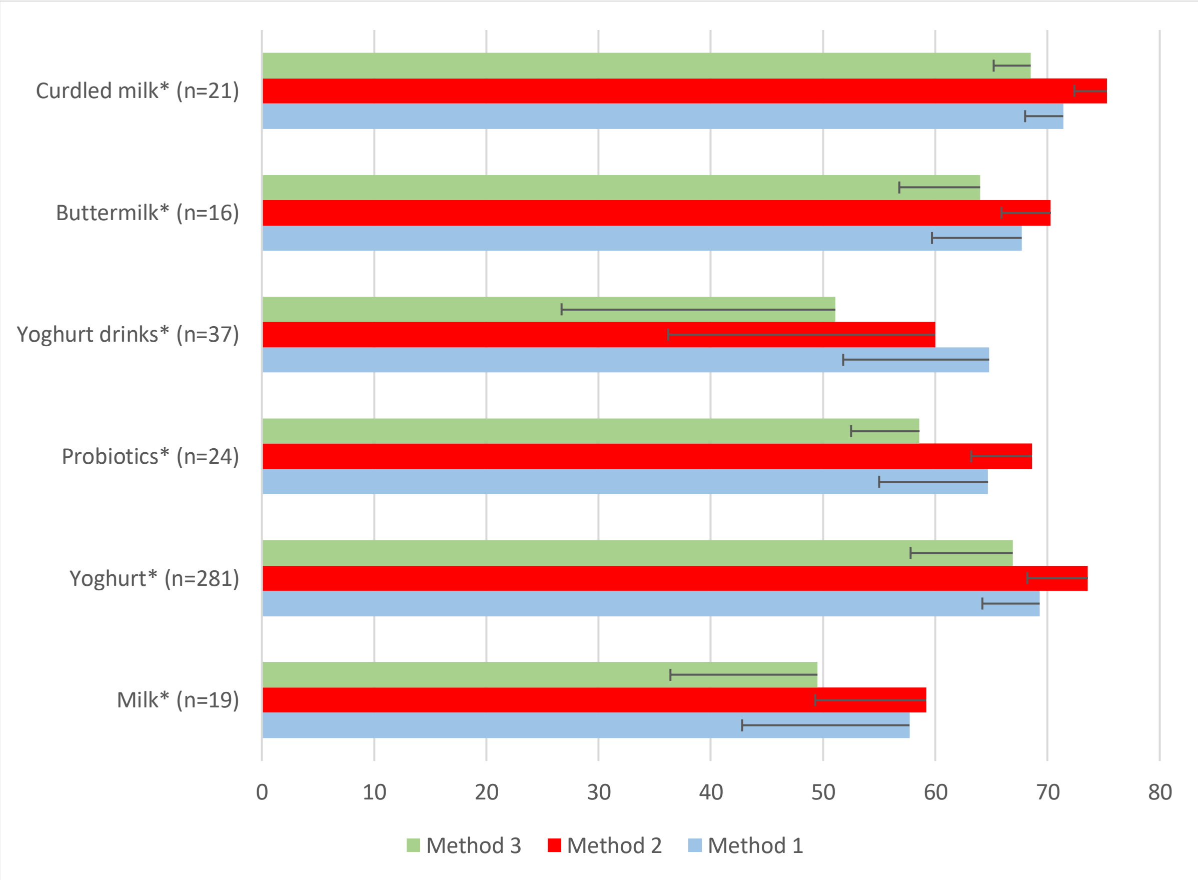


**FIGURE 6 COMPARISON OF THE MEAN AMOUNT (± STD) OF ADDED SUGAR IN PERCENTAGE BETWEEN METHOD 1, 2 AND 3 (ONLY PRODUCTS TO WHICH ALL THREE METHODS COULD BE APPLIED ARE INCLUDED). *with flavour**

The comparison was performed with the subgroups and products which all three methods could be applied to. The estimated amount of added sugar differed to some extent between the methods. Method 2 tends to calculate a higher amount of added sugar compared to the two others. It estimated that the added sugar in yoghurt consists of around 74 % of total sugar content, whereas method 1 estimated 69 % and method 3 67 %. For yoghurt drinks method 1 calculated the highest amount of added sugar, and the difference between the methods were big, which was also the case for milk with flavour. Kefir was the subgroup which differed the least with 74 % for method 1, 76 % for method 2 and 70 % for method 3.

For the subgroup yoghurt, method 1 showed a significant less amount of mean added sugar than method 2 ($p < 0.001$) and method 3 ($p < 0.001$). One obvious difference is that method 1 consisted of 10 steps, whereas method 2 and 3 only one. It is difficult to compare this method with the other two. For yoghurt, mostly step 5 was applied as there was often an unsweetened variety available. As for method 2, the first step was to estimate the amount of yoghurt in the product indirectly through the amount of fat per 100 g, and then multiply the amount of lactose per 100 g with the amount of yoghurt in the product in order to subtract this value from the total amount of sugar. Method 2 takes into consideration the amount of dairy in a product although it is only a vague estimation. This might be the reason why method 1 shows lower mean amounts of added sugar than method 2. Method 2 has a low reliability because it is only an indirect estimation of added sugar content based on fat content. Method 3 was the easiest method of the three, only subtracting the amount of lactose per 100 g from the total amount of sugar in each product. There was also a significant difference between method 2 and 3 ($p < 0.001$) for the subgroup yoghurt.

For buttermilk there was no significant difference between method 1 and 2 ($p = 0.113$), whereas for the comparison of method 1 and 3, method 3 had estimated a significant lower amount of added sugar ($p < 0.001$). Method 3 also estimated a significant lower amount than method 2 ($p < 0.001$).
The results for curdled milk were similar. There was a significant difference between method 3 and method 1 ($p < 0.001$), between method 1 and method 2 ($p < 0.001$) and method 2 and 3 ($p < 0.001$). When looking at the subgroup yoghurt drinks, method 3 estimated a significant lower amount of added sugar than method 1 ($p < 0.001$), and method 3 estimated a significant lower amount of added sugar than method 2 as well ($p < 0.001$). Between method 1 and 2 there was no significant difference ($p = 0.352$).

For probiotics there was no significant difference between method 1 and method 2 (p = 0.871), as well as none between method 3 and method 1 (p = 0.052). Method 3 estimated a significant lower amount of added sugar than method 2 (p < 0.001).

Method 3 calculated a significant lower amount of added sugar in milk with flavour than method 2 (p < 0.001). It also calculated a lower amount than method 1 (p < 0.001). There was no significant difference between method 1 and method 2 (p = 0.693).

The significances are summarised in table 23.

| Subgroup | Significances[1] (p) Between Methods | | |
|---|---|---|---|
| | **Method 1 and 2** | **Method 1 and 3** | **Method 2 and 3** |
| **Yoghurt[2]** | < 0.001 | < 0.001 | < 0.001 |
| **Buttermilk[2]** | 0.113 | < 0.001 | < 0.001 |
| **Curdled milk[2]** | < 0.001 | < 0.001 | < 0.001 |
| **Yoghurt drinks[2]** | 0,352 | < 0.001 | < 0.001 |
| **Probiotics[2]** | 0.871 | 0.052 | < 0.001 |
| **Milk[2]** | 0.693 | < 0.001 | < 0.001 |

**TABLE 23 SIGNIFICANCES (P-VALUE) OF COMPARISONS BETWEEN METHOD 1, 2 AND 3.**

**[1] Significant when p < 0,05**

**[2] with flavour**

The mean amount of added sugar in percentage ± STD is illustrated in table 24.

| Subgroup | Mean amount (± STD) of added sugar in % | | |
|---|---|---|---|
| | Method 1 | Method 2 | Method 3 |
| Yoghurt[1] | 69.3 ± 5.1 | 73.6 ± 5.4 | 66.2 ± 9.1 |
| Buttermilk[1] | 67.7 ± 8.0 | 70.3 ± 4.4 | 64.1 ± 7.2 |
| Curdled milk[1] | 71.4 ± 3.4 | 75.3 ± 2.9 | 68.5 ± 3.3 |
| Yoghurt drinks[1] | 64.8 ± 13.0 | 60.0 ± 23.8 | 51.1 ± 24.4 |
| Probiotics[1] | 64.7 ± 9.7 | 68.6 ± 5.4 | 58.6 ± 6.1 |
| Milk[1] | 57.7 ± 14.9 | 59.2 ± 9.9 | 49.5 ± 13.1 |

**TABLE 24 COMPARISON OF THE MEAN AMOUNT OF ADDED SUGAR (± STD) IN SUBGROUPS.**

**[1]with flavour**

A limitation was, however, that it was not possible to estimate the amount of added sugar with each method for every product. It was only possible to use all three methods on products with a short ingredient list. As a result, it was impossible to compare all subgroups to each other and their individual values by each method. Moreover, some subgroups had small sample sizes, which would have given inconclusive answers. Thus, yoghurt and yoghurt drink were often used for comparison because they are similar products, and yoghurt showed the biggest sample size of the subgroups.

# 5 Conclusion

Dairy products may contain a high amount of added sugar. Even products which are considered as healthy because they contain a low amount of fat or they provide vitamins and minerals and can have a high amount of added sugar. Three methods were used for the calculations of added sugar, which included the scientific method by Louie et al. 2015 (method 1). This method could be applied to every subgroup and is a reliable method due to the detailed steps to be followed. Method 3, “Simplified Method to Estimate Added Sugar Based on Lactose Content”, was limited to less products with a shorter ingredient list. However, this method would be easy and practical for consumers. Method 2, “Simplified Method to Estimate Added Sugar Based on Milk, Fat and Lactose Content”, did not give as reliable estimations as the other two and was also only applicable to some subgroups. It may, however, be used by consumers to estimate the added sugar content. Both method 2 and 3 are not suitable for scientific purposes and they do require some nutritional knowledge and interest to be understood by consumers.

The criteria of the applied methods are listed in table 23.

| Method | 1. Louie et al. 2015 | 2. Simplified Method to Estimate Added Sugar Based on Milk, Fat and Lactose Content | 3. Simplified Method to Estimate Added Sugar Based on Lactose Content |
|---|---|---|---|
| **Information readily available** | × | ✓ | ✓ |
| **Time requirement** | High | Medium | Low |
| **Applicability** | All (14) | 8 (some subgroups only partially) | 11 |
| **Applicability in % for subgroups** | 100 | 57 | 79 |
| **Practicability** | Low | Medium | High |
| **Suitability** | High | Low | Medium |
| **Reliability** | High | Low | Medium |
| **Advantages** | Steps for every product, reliable results, can be used for scientific purposes | Possible to estimate added sugar without knowing the recipe | Possible to estimate added sugar by knowing lactose content, easy for consumers, little time required |
| **Disadvantages** | Time consuming, not suitable for consumers | Partially complicated estimation, only suitable for some products, not for scientific purposes | Only suitable for some products, not for scientific purposes |
| **Target group** | Experts | Consumers | Consumers |

TABLE 25 EVALUATION OF CRITERIA FOR EACH METHOD.

The amount of sugar added to dairy products included in this thesis ranged from 0 g, in products with artificial sweeteners, to a maximum of 33.0 g per 100 g product. Dessert (11.3 ± 5.0 g/100 g) and milk snacks (25.4 ± 4.6 g/100 g) were the subgroups with the highest mean amount of added sugar, whereas drinks with milk protein (0.6 ± 0.2/100 g) was the subgroup with the lowest mean value. With the method by Louie et al. 2015, the mean amount of added sugar could be calculated in yoghurts with flavour as 9.2 ± 2.4 g/100 g (= 68.7 % of total sugar content) and in yoghurt drinks with flavour (n=53) as 6.8 ± 2.6 g/100 g (= 64.8 % of total sugar content). These are popular products often consumed by both adults and children and they contain a lot of sugar. The amount of added sugar varied based on whether method 2 or 3 was used (yoghurts: $p<0.001$, yoghurt drinks: $p<0.001$). For yoghurts, where method 2 could be applied, the proportion of added sugar was around 73.6 % in relation to the total sugar content, whereas for method 3, the added sugar content was 66.2 % and both values differed from the one calculated by method 1 (68.7 %).

Dairy products often contain a high amount of added sugar, and it would be useful for consumers to know how much sugar is added to a product. A declaration of added sugar on the product label would make it much easier for consumers to make healthier choices, as they could compare products, and they wouldn't need to calculate added sugar content themselves. Products, which are expected to be healthy, are often not that healthy at all. There is a high potential to reduce added sugar in dairy products and make them healthier. They contain important nutrients such as calcium, but the added sugar content makes dairy products with flavour a less desirable choice. The awareness of this for consumers could eventually put pressure on producers to change their recipes or offer variations with a less amount of added sugar. A more detailed declaration of nutrients would be an important health policy action which should be further discussed at European level.

# 6 Summary

*Introduction:* In Austria the sugar intake of both children and adults is too high. Sugar is added to many foods because of flavour and technological reasons. Even products considered by consumers as healthy, such as dairy products, often have added sugar. However, the content of added sugar cannot be identified on the food label. The aim of this master's thesis was to estimate the content of added sugar in dairy products on the Austrian market by applying different models.

*Materials and Methods:* The survey of the dairy products on the Austrian market was conducted in year 2018 in 13 Viennese supermarkets. A total of 936 products made of milk and dairy, such as desserts and snacks, yoghurt drinks, curdled milk and whey, were recorded with their specific product information (nutrients, ingredients etc.). They were all included in the estimation of added sugar content.

Three published scientific methods (Louie et al. 2015; Schweizerische Eidgenossenschaft – Bundesamt für Lebensmittelsicherheit und Veterinärwesen BLV 2018; Amoutzopoulos et al. 2018) were considered in order to calculate the amount of added sugar. In addition, two simplified methods were developed by the author of this thesis. In one of the simplified methods, the amount of milk or dairy in the product was estimated, and its lactose content was then subtracted from the total amount of sugar in the product. In the other simplified method, the lactose content of 100 mL pure milk or 100 g pure yoghurt was subtracted from the total sugar content. The methods were validated according to their applicability on the basis of the recorded information which was declared on the product label.

*Results:* The systematic method by Louie et al. 2015 was possible to apply to all products due to the 10-step protocol starting with six objective steps of measurement followed by four subjective steps of estimation. The method by the BLV (2018) and the method by Amoutzopoulos et al. 2018 could not be applied since the access to the exact recipes would have been necessary. Both of the self-developed simplified methods could only be applied to product groups with a simple mixture of ingredients (few ingredients or only one source of lactose). They could be used by consumers as a rough estimation of added sugar content, but

they are not suitable for scientific purposes. The calculated amount of added sugar differed significantly from the method by Louie et al. 2015 in some subgroups (i.e. yoghurt: $p<0.001$). Based on the method by Louie et al. 2015, the mean amount of added sugar could be estimated in yoghurts with flavour (n=375) with a mean level of 9.2 ± 2.4 g/100 g (= 69 % of total sugar content) and in yoghurt drinks with flavour (n=53) having a mean of 6.8 ± 2.6 g/100 g (= 65 % of total sugar content). In cocoa and chocolate milk (n=44) the average added sugar content was 5.2 ± 2.4 g/100 g (= 53 % of total sugar content), in other milks with flavour (n=33) the average was 5.8 ± 2.0 g/100 g (= 69 % of total sugar content) and in whey with flavour (n=31) 5.8 ± 2.1 g/100 g (= 75 % of total sugar content.)
Butter- and curdled milk with flavour (n=17 and n=21) contained 7.6 ± 1.5 g/100 g and 9.0 ± 1.3 g/100 g (= 68 % and 71 % of total sugar content) of added sugar on average respectively. Cream cheese (n=67) had a mean amount of 10.1 ± 3.9 g/100 g (= 76 % of total sugar content), desserts such as pudding (n=227) a mean of 11.3 ± 5.0 g/100 g (= 73 % of total sugar content) and snacks containing milk (n=25) had a mean of 25.4±4.6 g /100 g (=81 % of total sugar content).

*Conclusion:* Sweetened dairy products have a high amount of added sugar, and thus contribute significantly to the total sugar intake. The method by Louie et al. 2015 makes it possible to perform a reliable estimation of the added sugar content in dairy products and it is suitable for scientific purposes. The simplified methods for consumers give a rough estimation but require a high interest and nutritional knowledge. To support a better buying decision and a healthy food choice, the information should be made available in such a way that products may be compared quickly and easily. A more detailed declaration of nutrients including „added sugar“ would be an important health policy action which should be further discussed at European level.

# 7 Zusammenfassung

*Einführung:* In Österreich ist die Aufnahme an Zucker sowohl bei Kindern als auch Erwachsenen deutlich zu hoch. Zucker wird vielen Lebensmitteln aus geschmacklichen und technologischen Gründen zugesetzt. Auch in, von Konsumentinnen und Konsumenten als gesund betrachteten Lebensmitteln wie beispielsweise Milchprodukten, ist häufig Zucker zugesetzt. Der Gehalt an zugesetztem Zucker ist anhand der Nährwertkennzeichnung jedoch nicht erkennbar. Ziel dieser Masterarbeit war es, anhand verschiedener Modelle, den Gehalt an zugesetztem Zucker von in Österreich erhältlichen Milchprodukten abzuschätzen.

*Methoden:* Die Erfassung der in Österreich erhältlichen Milchprodukte erfolgte im Jahr 2018 in 13 Wiener Supermarktfilialen. Insgesamt wurden von 936 Milchmischerzeugnissen, Topfencremen, Molkemischerzeugnissen und milchhaltigen Desserts bzw. Snacks produktbezogene Informationen (Nährwerte, Zutaten etc.) gesammelt, die für die Abschätzung des Gehalts an zugesetztem Zucker herangezogen wurden.

Als Berechnungsrundlage dienten drei wissenschaftlich publizierte Modelle (Louie et al. 2015; Schweizerische Eidgenossenschaft – Bundesamt für Lebensmittelsicherheit und Veterinärwesen BLV 2018; Amoutzopoulos et al. 2018) sowie zwei eigens entwickelte, vereinfachte Methoden. Bei einer der vereinfachten Methoden wurde der Milchproduktanteil des Produkts geschätzt und anschließend der Laktosegehalt des Milchproduktanteils vom Gesamtzucker subtrahiert. Bei der anderen vereinfachten Methode wurde der Laktosegehalt von 100 ml „purer" Milch bzw. 100 g „purem" Milchprodukt vom Gesamtzuckergehalt des Produkts subtrahiert. Auf Basis der gesammelten Produktkennzeichnungsinformationen wurden die Modelle in Bezug auf ihre Anwendbarkeit überprüft.

*Ergebnisse:* Die systematische Methode von Louie et al. 2015 war, aufgrund des 10-stufigen Protokolls – beginnend mit objektiven Messungen (6 Stufen), gefolgt von subjektiven Schätzungen (4 Stufen) – bei allen Milchprodukten anwendbar. Nicht angewendet werden konnten das Modell des Schweizer BLV (2018) sowie das Modell von Amoutzopoulos et al. 2018, da hierfür exakte Rezepturen erforderlich gewesen wären. Die beiden selbst entwickelten, vereinfachten Methoden konnten nur bei Produktgruppen mit einfacher

Zusammensetzung (z. B. wenigen Zutaten oder nur einer Laktosequelle) angewendet werden. Sie liefern für Konsumentinnen und Konsumenten eine grobe Schätzung, sind aber für wissenschaftliche Zwecke wenig geeignet. Die berechneten Gehalte an zugesetztem Zucker unterscheiden sich bei einigen Untergruppen signifikant zur Methode von Louie et al. 2015 (Beispiel Joghurt: $p<0{,}001$).

Basierend auf dem Modell von Louie et al. 2015 konnte der durchschnittliche Gehalt an zugesetztem Zucker für Joghurts mit Geschmack (n=375) auf 9,2±2,4 g/100 g (=69 % des Gesamtzuckergehalts) und für Joghurtdrinks mit Geschmack (n=53) auf 6,8±2,6 g/100 g (=65 % des Gesamtzuckergehalts) geschätzt werden. Kakao- und Schokolademilchen (n=44) enthielten im Durchschnitt 5,2±2,4 g/100 g zugesetzten Zucker (=53 % des Gesamtzuckergehalts), andere Milchen mit Geschmack (n=33) 5,8±2,0 g/100 g (=69 % des Gesamtzuckergehalts), Butter- und Sauermilchen mit Geschmack (n=17 bzw. 21) 7,6±1,5 g/100 g bzw. 9,0±1,3 g/100 g (=68 % bzw. 71 % des Gesamtzuckergehalts) und Fruchtmolken (n=31) 5,8±2,1 g/100 g (=75 % des Gesamtzuckergehalts). Bei Topfencremen (n=67) lag der Gehalt an zugesetztem Zucker im Durchschnitt bei 10,1±3,9 g/100 g (=76 % des Gesamtzuckergehalts), bei milchhaltigen Desserts (n=227) bei 11,3±5,0 g/100 g (=73 % des Gesamtzuckergehalts) und bei milchhaltigen Snacks (n=25) bei 25,4±4,6 g/100 g bzw. (=81 % des Gesamtzuckergehalts).

*Conclusio:* Gesüßte Milchprodukte können einen hohen Gehalt an zugesetztem Zucker aufweisen und damit wesentlich zur Gesamtzuckeraufnahme beitragen. Die Methode von Louie et al. 2015 lässt eine zuverlässige Abschätzung des Gehalts an zugesetztem Zucker von Milchprodukten vor allem für wissenschaftliche Zwecke zu. Die für Konsumentinnen und Konsumenten vereinfachten Methoden geben zwar einen groben Anhaltspunkt, setzen aber ein großes Maß an Interesse und Ernährungswissen voraus. Um eine informierte Kaufentscheidung zu fördern und eine gesunde Lebensmittelauswahl zu erleichtern, sollten Informationen so bereitgestellt werden, dass Produkte einfach und schnell verglichen werden können. Eine erweiterte Nährwertdeklaration um „zugesetzten Zucker“ würde eine wichtige gesundheitspolitische Maßnahme darstellen, die auf europäischer Ebene weiter diskutiert werden sollte.

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