



## Monitoring Trends in Packaged Food Supply for Added Sugar and Sweeteners: Are We Jumping out of the Frying Pan into the Fire?

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Excessive sugar intake can lead to poor health outcomes. The use of sweeteners is considered as a strategy to reduce added sugar consumption. The presence of sweeteners in food products has increased significantly in many countries. Therefore, the aim of this study was to identify the added sugars and sweeteners in packaged products. 1550 (57.9%) out of 2676 food products contained at least one added sugar. Confectionery and desserts (35.38±24.82 g/100 g), and snack foods (20.70±16.20 g/100 g) were the main categories containing the highest amount of added sugar. 229 (8.6%) out of 2676 food products contained various types of sweeteners. The most popular added sugar was sucrose (62.9%), while the most popular sweetener was sorbitol (28.2%). This is the most comprehensive study in the city center of Edirne province in Türkiye reporting on the types and frequency of added sugars and sweeteners in packaged products. This study offers monitoring to improve the legislation of Türkiye on added sugars and sweeteners used in the food supply.

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### Introduction

The Industrial Revolution brought the world some advantages of technological development, such as longer shelf-life, further palatability, easier availability, and high safety of foods. These advancements have provided enhanced food safety, increased food diversity, and reduced nutrient deficiencies (Rogers & Amer, 2022). However, excessive and chronic intake of industrial foods caused overweight and obesity, which are the risk factors of metabolic syndrome, cardiovascular diseases, diabetes mellitus and many cancers (Malik & Hu, 2022). The World Health Organization (WHO) reported that Türkiye has the highest obesity rate among European countries, with a prevalence of 32.1% (World Health Organization, 2022). Industrialization of the food supply has reduced the cost of energy-dense foods by adding sugar to commercial foodstuffs, and increased the availability of these foods; however, excessive and chronic consumption of foods containing added sugar has become one of the main causes of overweight and obesity. Therefore, it is recommended to consume added sugars at amounts below 5% of the total daily energy for additional health benefits (World Health

Organization, 2015). According to the Dietary Guidelines for Turkey (2022), nearly half of the Turkish population consumes added sugar above the recommended amount. Türkiye should take effective strategies to reduce the amount of added sugar in commercial foodstuff as soon as possible.

Sugar, which is currently at the center of human nutrition, is a generic term and often refers to sucrose. According to the WHO definition, the term “free sugars” refers to all monosaccharides and disaccharides added to foodstuffs as well as sugars naturally found in foods and beverages. However, the term added sugar only refers to sucrose, glucose, fructose, syrups (glucose or/and fructose), and other isolated sugar preparations added during food manufacturing (European Food Safety Authority, 2010; World Health Organization, 2015). Packaged foods, sugar-sweetened beverages and ice-creams are major sources of added sugar. Although sugar has substantial roles in nutrition, high sugar intake worsens diet quality and is associated with various chronic diseases, such as obesity, hepatic steatosis, type 2 diabetes,

cardiovascular diseases, and metabolic syndrome (Liu et al., 2022). A cross-sectional study in Türkiye showed that participants who checked food labels had higher levels of knowledge about sugar consumption and higher levels of attitudes towards protecting children from the harms of sugar (Celik & Bektas, 2020). Checking product ingredients directs consumers toward healthy foodstuff choices and improves their diets. Therefore, in addition to reducing the amount of added sugar in packaging products, educating consumers about the foods they consume by reading food labels is also an important goal in reducing sugar consumption.

Sweeteners are considered sugar alternatives and they are used in place of sugar to sweeten many foods and beverages. Most of these have a stronger sweetness and less energy content than sugar. Actually, the literature is inconsistent in defining and classifying sweeteners. The Food and Drug Administration (FDA) includes sucrose as a sweetener and defines sugar alternatives as high-intensity sweeteners, whereas the European Food Safety Authority (EFSA) classifies them into intense sweeteners and polyols, with sucrose as a separate category (European Parliament, 2008; Food and Drug Administration, 2014). There are nineteen authorized sweeteners in the Turkish Food Codex Regulation on Food Additives, which is regulated in parallel with the Regulation of the European Parliament and the Council numbered 1333/2008/EC. These are sorbitol (E-420), mannitol (E-421), acesulfame potassium (E-950), aspartame (E-951), cyclamate (E-952), isomalt (E-953), saccharines (E-954), sucralose (E-955), thaumatin (E-957), neohesperidine DC (E-959), steviol glycosides (E-960), neotame (E-961), salt of aspartame-acesulfame (E-962), polyglycitol syrup (E-964), maltitols (E-965), lactitol (E-966), xylitol (E-967), erythritol (E-968) and advantame (E-969), respectively. In accordance with the Turkish Food Codex, the label of any food product sold must include a declaration indicating the name, code, source and intended use of the sweetener permitted to be used. Furthermore, polyols must be labelled “excessive consumption may cause laxative effects” and aspartame/salt of aspartame-acesulfame must be labelled “contains phenylalanine” (Turkish Food Codex, 2013). Sweeteners are classified as nutritive and non-nutritive, caloric and non-caloric, or natural and artificial in the literature (Daher et al., 2019).

Packaged foods and beverages containing sweeteners have gained popularity with consumers due to various health benefits such as dental protection, weight control and glycaemic regulation (Wölnerhanssen et al., 2020). In the current food supply of Türkiye, natural and artificial sweeteners are used in a large number of food products. The types of sweeteners vary among countries and are considered safe with an Acceptable Daily Intake (ADI) level (Turkish Food Codex, 2013). However, these sweeteners, especially artificial ones, may not be as safe as previously reported. Findings from prospective cohort studies have recently shown that artificial sweeteners are associated with type 2 diabetes mellitus and cardiovascular disease (Fagherazzi et al., 2017; Mossavar-Rahmani et al., 2019). Moreover, aspartame has been classified as possibly carcinogenic to humans (Group 2B), even though the evidence is limited (Riboli et al., 2023). Given the hedonic eating patterns of the population, consumers can

unintentionally consume more sweeteners than recommended, which may pose serious health risks. Furthermore, manufacturers provide no labelling information on the added amount of sweeteners, although nutritional facts such as sugar are indicated on the label in packaged products sold in Türkiye. Therefore, using sweeteners to reduce dietary sugar intake may mean “jumping out of the frying pan into the fire”.

Although it is important to monitor the types and prevalence of both added sugars and sweeteners in commercial foodstuffs, limited studies have reported their presence in packaged products worldwide (Acton et al., 2017; Samaniego-Vaesken et al., 2018; Dunford et al., 2018). Therefore, the aim of this study was to determine the presence and types of added sugars and sweeteners in packaged products. To our knowledge, this is the most comprehensive study in the city center of Edirne province in Türkiye reporting on the types and frequency of added sugars and sweeteners in packaged products.

## Method

This was a cross-sectional study of almost all commercial packaged foods and beverages available in 12 leading retail stores and wholesale grocers in the city center of Edirne province in Türkiye. As the types of packaged products sold in these stores can vary in different chains of the same store, we visited each chain of stores across the city. We also visited local markets in high and lower-middle income neighborhoods to increase product variety.

### Packaged Product Collection

A total of 2676 packaged products, both domestic and imported, were collected between January-April 2023 in the present study. Information on the brand, name, nutritional facts and ingredients of packaged foods and beverages were obtained from the labels of the products. Products were excluded from the study if they did not have label information as required by the Turkish Food Codex. Photographs of the packaged products were taken and uploaded to a cloud-based server by the researcher to facilitate data collection. The information from these products was then extracted and manually recorded in Microsoft Office Excel 2016. Each product was registered separately according to the product categories identified by the researchers. Added sugar amounts of each product were calculated per 100 g or 100 ml.

### Categorisation of Packaged Products

All products included in the study met the criteria of the Turkish Food Codex Regulation on Food Labelling and Consumer Information, including brand, label, approval number, net amount of product, legible ingredients of the product, recommended date of consumption, and country of origin. The products were classified into 9 main food categories and 50 sub-categories by trained dietitians and nutritionists. This categorisation includes (a) milk and dairy products, (b) meat and meat products, (c) oils, oil seeds and nuts, (d) confectionery and sweets, (e) bread, cereals and bakery products, (f) snack foods, (g) non-alcoholic beverages, (h) sauces and broths, and (i) miscellaneous (Table 1).

Table 1. Food Categorization System

Food group	Food category	Description
Milk and dairy products	Milk	Flavored and unflavored dairy milk
	Yoghurt	Flavored, fruit and natural yoghurts (full fat, low fat and skim varieties)
	Ayran	A traditional drinks obtained by adding water and salt to yoghurt
	Kefir	Flavored and unflavored dairy fermented milk products
	Cheese	Kashar, Tulum, Feta, Ezine, Cheddar, Haloumi and all other cheese types
	Cream	Regular and sour cream products
	Kaymak	A traditional dairy product with a thick creamy texture, served with honey for breakfast.
	Butter	All salted and unsalted butters made from dairy milk
	Ice-cream	All dairy based ice cream varieties with fruit, cocoa, vanilla or mastic
Meat and meat products	Dessert	Dairy-based desserts (e.g. rice pudding, custards, keşkül, kazandibi)
	Red meat and its processed products	Packaged beef and lamb meats, packaged bacon products, soudjouk, sausages, salami, beef and lamb burgers (except for frozen meat products)
	Poultry and its processed products	Packaged chicken and turkey meats, chicken sausages, chicken salami, poultry products (except for frozen poltry products)
Oil, oil seeds and nuts	Sea products	All sea products (e.g. fish, calamari, shrimp), excluding canned sea products
	Oils	Olive oil, sunflower oil, corn oil, hazelnut oil, canola oil, margarines
	Oil seeds	Groundnut, pistachio, hazelnut, almond, walnut, cashew nut, sunflower seed, black sedd and sesame
	Oil emulsions	Oil-based emulsions (e.g. vinaigrette, mayonnaise, oil-based salad dressing and condiments)
Confectionery and sweets	Nut butters	Hazelnut paste, almond paste, peanut butter, sesame paste
	Confectionery	All chocolated-based confectionery (e.g. chocolate-covered confections, chocolate bars, and chocolate-covered fruits, and nuts) and all sugar-based confectionery (e.g. candy sticks, lollies, jelly tots, cotton candy)
	Chewing gums	All sugar-sweetened and sugar-free chewing gums and bubble gum products
	Pastry jelly and sweet sauces	All jellies and sauces with fruit, caramel or chocolate
	Powder dessert mixes	All types of powder dessert mixes (e.g. cakes, profiterole, pudding with fruit, vanilla, cocoa, chocolate, tres leches, pancake, muffin, tartlet, semolina cake, tiramisu)
	Jams and marmaleades	All jams and marmaleades with fruit and vegetable
	Pekmez	A traditional molasses-like syrup
	Honey	All mono and polyfloral honeys (e.g. blossom honey and chestnut honey)
Bread, cereals and bakery products	Other sweets	Turkish delight with fruit, pistachio, almond, cocoa and vanilla, chocolate-covered Turkish delight, halva, dried fruit roll-up, waffles, churchkhela
	Packaged breads	All types of wheat, rye or corn flour breads (including wholemeal and white bread)
	Cereals	Cornflakes, wheatflakes, oat flakes, granola, muesli, rice pops
Snack foods	Bakery products	Grissini, breadsticks, croissant, lavash, tortilla, cookies and pies
	Packaged cakes	Packaged snack cakes (e.g. twinkies, rolls and brownies)
	Biscuits	All types of sweet biscuits with or without cream
	Crackers	All salty or spicy crackers
	Chips	Potato, corn and chickpea crisps
	Wafers	All type of wafers filled with sweet creams or covered with chocolate
Non-alcoholic beverages	Bars	Cereal or fruit-based snack bars
	Carbonated drinks	Coke and plain and fruity fizzy drinks
	Fruit juices	Non-fresh sweetened juices
	Energy drinks	All types of energy drinks
	Mineral water	All sweetened or unsweetened mineral waters
	Ice tea and coffee	All sweetened ice tea and many types of cold coffe (e.g. latte, frappucino, macchiato, americano)
	Powdered drinks	All powdered drinks ready to drink (e.g. sahlep, chocolate, syrup, milkshake, tea, coffee, powdered milk and mixed fruit powders)
Sauces and broths	Other drinks	All types of sweetened beverages (e.g. smoothie, milkshake, malt, fruit and vegetable mixes, detox juices and vegetable juices)
	Sauces	Table sauces (e.g.tomato sauces and ketchups and BBQ sauces and sweet chilli), mustard products, marinade products, vegetable spreads, chilled and ambient dips and salsa, pâté spreads
Miscellaneous	Broths	All types of powdered stocks
	Ready to eat dishes	All types of food products ready to eat
	Baby foods	Jarred baby food (e.g. fruit purees, fruit blended yoghurt, vegetable soups and rice flour with milk)
	Canned foodstuff	All types of canned food products (e.g. side dishes, vegetables, boiled legumes, pickled vegetables, concentrated vegetable purees, meat products and sea products)
	Frozen foodstuff	All types of frozen food products (e.g. vegetables, boiled grains, desserts, pastries, vegetable croquettes, and meat products)
	Milk substitutes	All types of non-dairy milk (almond, rice, soy, oat, coconut and hazelnut)
	Dry fruits	All unprocessed dried fruits and dried fruit mixes
Sports bars	All types of ergogenic bars with high protein and energy	

Table 2. Authorized Sweeteners in the Turkish Food Codex Regulation on Food Additive

1. Sorbitol (E-420)	2. Mannitol (E-421)
3. Acesulfame potassium (E-950)	4. Aspartame (E-951)
5. Cyclamate (E-952)	6. Isomalt (E-953)
7. Saccharines (E-954)	8. Sucralose (E-955)
9. Thaumatin (E-957)	10. Neohesperidine DC (E-959)
11. Steviol glycosides (E-960)	12. Neotame (E-961)
13. Salt of aspartame-acesulfame (E-962)	14. Polyglycitol syrup (E-964)
15. Maltitols (E-965)	16. Lactitol (E-966)
17. Xylitol (E-967)	18. Erythritol (E-968)
19. Advantame (E-969)	

Table 3. Keyword variations for added sugar in the ingredients of food products

1. Sucrose	2. Fructose
3. Glucose	4. Dextrose
5. Table sugar	6. Corn sweetener
7. Corn syrup	8. Cane sugars
9. Sugar beet	10. Molasses
11. Glucose syrup	12. Fructose syrup
13. Caramel	14. Maltodextrin
15. White sugar	16. Brown sugar
17. Dextrose glucose	18. Invert sugar
19. Glucose-fructose syrup	20. Honey
21. Grape molasses	22. Fruit juices/Fruit juice concentrates

### Identification of Added Sugar and Sweeteners

Added sugar and sweeteners were identified from the ingredient lists in the photographs taken by the researchers. Types of sweeteners were identified according to the Turkish Food Codex Regulation on Food Additives, which is regulated in parallel with the Regulation of the European Parliament and the Council numbered 1333/2008/EC (Table 2). The added sugars were identified using the EFSA and WHO definitions. These include sucrose, glucose, fructose, syrups (glucose and fructose), and other isolated sugar preparations added during food manufacturing, but not polyols (European Food Safety Authority, 2010; World Health Organization, 2015). In Türkiye, total carbohydrate and sugar content are labelled on packaged products. However, added sugar content is not clearly labelled. Therefore, the proposed method was used to calculate the added sugar content of food products in the present study (Louie *et al.*, 2016). As the purpose of our study was also to identify the sources of added sugars, we searched for the following terms on the labels: sugar, white sugar, table sugar, invert sugar, brown sugar, molasses, honey, corn syrup, dextrose, glucose syrup, fructose syrup, glucose-fructose syrup, fruit juice concentrates, maltodextrin, beet and sugarcane (Table 3).

### Statistical Analysis

Mathematical calculations were performed using Excel® 2016 software (Microsoft Co., Redmond, Washington, DC, USA). The number and percentage of products were reported with the formula "COUNTIF" for added sugars and sweeteners, overall and by category. The average levels of added sugar were calculated for all main food categories as well as for all products. The top three uses of both added sugars and sweeteners were also presented for the main food categories.

### Results and Discussion

Eating patterns of the population have altered significantly due to changes in the global food supply and increased availability of processed foods. Changes in these eating patterns have undoubtedly played an important role in the near-tripling of the global prevalence of obesity over the past 50 years. One of the main factors contributing to the global rise in obesity is the excessive consumption of foods with a high sugar content (World Health Organization, 2021). Public health policies aim to progressively reduce global consumption of energy-dense and unhealthy foods. In this context, Türkiye has also taken effective actions in line with global developments. In Türkiye, which has the highest obesity rate in Europe, the Ministry of Health planned to gradually reduce the amount of sugar in packaged foods and beverages by 10 percent by 2025 (Ministry of Health of Turkey, 2021). Although reducing the amount of added sugars in packaged products is not a sufficient strategy to reduce the sugar consumption of the population, it may be important to periodically monitor the type and amount of added sugars used in the food supply to raise awareness and develop effective strategies.

As seen in Table 4, added sugars were present in 50 food subcategories and all main food categories contained added sugar. Among the food subcategories, only "ayran (a Turkish drink made from yogurt mixed with water and salt)", "butter", "pekmez (a molasses-like syrup)", "bars", "sports bars", "honey" and "dried fruits" had no added sugar content. In a previous study of the three largest supermarkets, representing 26.6% of the market share in Türkiye, only "cheese" and "meat and meat products" were reported to be free of added sugar (Bayram & Ozturkcan, 2022).

Table 4. Presence of added sugars and sweeteners in packaged products

Categories	P	SSFP	PSS	PSAS	PBS	ANS	AAS
Milk and dairy products							
Milk	111 (29.0)	66 (59.5)	45 (40.5)	0	0	0	1.67±2.21
Yoghurt	44 (11.5)	32 (72.7)	12 (27.3)	0	0	0	1.90±3.74
Ayran	7 (1.8)	7 (100)	0	0	0	0	0±0
Kefir	21 (5.5)	6 (28.6)	15 (71.4)	0	0	0	3.08±2.10
Cheese	144 (37.6)	138 (95.8)	6 (4.2)	0	0	0	0.26±1.62
Cream	8 (2.1)	5 (62.5)	3 (37.5)	0	0	0	1.75±1.65
Kaymak	9 (2.3)	6 (66.7)	3 (33.3)	0	0	0	0±0
Butter	11 (2.9)	11 (100)	0	0	0	0	0±0
Ice-cream	24 (6.3)	0	24 (100)	0	0	0	23.62±2.72
Dessert	4 (1.0)	0	4 (100)	0	0	0	25.42±4.84
Total	383	271 (70.8)	112 (29.2)	0	0	0	2.76±6.40
Meat and meat products							
Red meat products	45(43.3)	42(93.3)	3(6.7)	0	0	0	0.38±0.09
Poultry products	41(39.4)	38(92.7)	3(7.3)	0	0	0	0.06±0.01
Sea products	18(17.3)	15(83.3)	2(11.1)	0	1(5.6)	0.06±0.24	0.89±0.28
Total	104	95(91.3)	8(7.7)	0	1(1.0)	0.01±0.10	0.09±0.45
Oils, oil seeds and nuts							
Oils	36 (17.7)	35 (97.2)	1 (2.8)	0	0	0	0.02±0.1
Oil seeds	102 (50.3)	76 (74.5)	26 (25.5)	0	0	0	2.10±4.60
Oil emulsions	20 (9.8)	20 (100)	0	0	0	0	3.45±2.38
Nut butters	45 (22.2)	9 (20.0)	33 (73.4)	2 (4.4)	1 (2.2)	0.09±0.36	30.6±21.74
Total	203	140 (69.0)	60 (29.6)	2 (0.9)	1(0.5)	0.06±0.33	8.20±16.10
Confectionery and sweets							
Confectionery	162(36.7)	0	132 (81.5)	5(3.1)	25(15.4)	0.23±0.58	54.86±22.88
Chewing gums	66(14.9)	3(4.6)	15(22.7)	34(51.5)	14(21.2)	4.02±2.70	14.06±27.37
Pastry jelly and sweet sauces	21(4.8)	1(4.8)	20(95.2)	0	0	0±0	30.10±20.31
Powder dessert mixes	47(10.6)	3(6.4)	44(93.6)	0	0	0±0	20.43±12.56
Jams and marmalades	61(13.8)	5(8.2)	55(90.2)	1(1.6)	0	0.05±0.38	51.22±20.44
Pekmez	20(4.5)	20(100)	0	0	0	0±0	0±0
Honey	11(2.5)	11(100)	0	0	0	0±0	0±0
Other sweets	54(12.2)	2(3.7)	51(94.4)	1(1.8)	0	0.05±0.41	45.32±19.51
Total	442	45(10.2)	317(71.7)	41(9.3)	39(8.8)	0.70±1.78	35.38±24.82
Bread, cereals and bakery products							
Packaged breads	28 (28.0)	12 (42.9)	16 (57.1)	0	0	0	2.26±4.24
Cereals	27 (27.0)	10 (37.0)	17 (63.0)	0	0	0	11.85±13.72
Bakery products	45 (45.0)	20 (44.4)	25 (55.6)	0	0	0	5.96±11.06
Total	100	42 (42.0)	58 (58.0)	0	0	0	6.51±11.03
Snack foods							
Packaged cakes	65 (15.9)	1 (1.6)	13 (20.0)	0	51 (78.4)	0.79±0.41	32.20±7.13
Biscuits	111 (27.1)	5 (4.5)	100 (90.1)	0	6 (5.4)	0.05±0.23	26.30±10.01
Crackers	46 (11.3)	3 (6.5)	43 (93.5)	0	0	0	7.26±4.02
Chips	81 (19.8)	28 (34.6)	53 (65.4)	0	0	0	3.86±7.90
Wafers	74 (18.1)	0	72 (97.4)	1 (1.3)	1 (1.3)	0.05±0.33	37.82±10.33
Bars	32 (7.8)	30 (93.75)	0	2 (6.25)	0	0.06±0.25	0
Total	409	67 (16.4)	281 (68.7)	3 (0.7)	58 (14.2)	0.15±0.38	20.70±16.20
Non-alcoholic beverages							
Carbonated drinks	35 (7.1)	0	12 (34.3)	12 (34.3)	11 (31.4)	1.31±1.08	5.02±4.74
Fruit juices	166 (33.7)	37 (22.3)	108 (65.1)	3 (1.8)	18 (10.8)	0.27±0.80	6.37±4.46
Energy drinks	21 (4.3)	1 (4.8)	16 (76.2)	1 (4.8)	3 (14.3)	0.38±0.86	8.96±3.71
Mineral water	37 (7.5)	1 (2.7)	23 (62.2)	0	13 (35.1)	0.67±0.94	6.75±2.91
Ice tea and coffee	46 (9.3)	4 (8.7)	31 (67.4)	1 (2.2)	10 (21.7)	0.42±0.70	5.90±2.91
Powdered drinks	163 (33.1)	45 (27.6)	118 (72.4)	0	0	0	25.92±32.15
Other drinks	25 (5.1)	10 (40.0)	14 (56.0)	1 (4.0)	0	0	5.85±5.48
Total	493	98 (19.9)	322 (65.3)	18 (3.6)	55 (11.2)	0.28±0.74	12.81±20.92
Sauces and broths							
Sauces	55(88.7)	8(14.5)	47(85.5)	0	0	0±0	11.92±11.76
Broths	7(11.3)	0	7(100)	0	0	0±0	9.77±5.96
Total	62	8(12.9)	54(87.1)	0	0	0±0	11.68±11.24
Miscellaneous							
Ready to eat dishes	187 (38.9)	77 (41.2)	110 (58.8)	0	0	0	2.98±5.10
Baby foods	47 (9.8)	40 (85.1)	7 (14.9)	0	0	0	1.93±5.37
Canned foodstuff	140 (29.2)	120 (85.7)	20 (14.3)	0	0	0	0.10±0.60
Frozen foodstuff	68 (14.2)	25 (36.8)	32 (47.0)	0	11 (16.2)	0.15±0.36	9.40±15.99
Milk substitutes	7 (1.5)	3 (42.9)	4 (57.1)	0	0	0	2.34±1.15
Dry fruits	23 (4.8)	23 (100)	0	0	0	0	0
Sports bars	8 (1.6)	8 (100)	0	0	0	0	0
Total	480	296 (61.7)	173 (36.0)	0	11 (2.3)	0.06±0.27	2.74±7.60
TOTAL (all products)	2676	1062(39.7)	1385(51.7)	64(2.4)	165(6.2)	0.21±0.85	13.48±20.00

P: Product (n,%); SSFP: Sugar and sweetener-free products (n,%); PSS: Products with added sugar but not sweeteners (n,%); PSAS: Products with sweetener but not added sugar (n,%); PBS: Products with both sugar and sweeteners (n,%); ANS: Average number of sweetener (n,%); AAS: Average amount of added sugar (g/100g)

Table 5. Frequency of Added Sugars and Sweeteners in the List of Ingredients of Packaged Foods

Type of additives	Liquid form (n,%)	Solid form (n,%)	All products (n,%)
Added Sugars			
Sucrose	310(20.65)	1191(79.35)	1501(62.91)
Glucose syrup	3(1.0)	305(99.0)	308(12.91)
Maltodextrin	5(2.7)	182(97.3)	187(7.84)
Invert sugar	0	135(100)	135(5.66)
Glucose-fructose syrup	74(61.7)	46(38.3)	120(5.03)
Dextrose	1(1.2)	83(98.8)	84(3.52)
Fructose syrup	3(20.0)	12(80.0)	15(0.63)
Molasses	0	12(100)	12(0.50)
Honey	0	12(100)	12(0.50)
Fructose	3(33.3)	6(66.7)	9(0.38)
Corn syrup	0	3(100)	3(0.13)
Total	399(16.7)	1987(83.3)	2386(100)
Sweeteners			
Sorbitol	0	146(100)	146(28.24)
Acesulfame potassium	52(65.0)	28(35.0)	80(15.48)
Sucralose	40(54.0)	34(46.0)	74(14.31)
Aspartame	25(39.7)	38(60.3)	63(12.18)
Maltitol	0	46(100)	46(8.90)
Xylitol	0	44(100)	44(8.51)
Mannitol	0	19(100)	19(3.67)
Isomalt	0	14(100)	14(2.71)
Steviol glycosides	10(76.9)	3(23.1)	13(2.51)
Erythritol	0	6(100)	6(1.16)
Neohesperidine DC	5(100)	0	5(0.97)
Cyclamate	4(100)	0	4(0.77)
Saccharines	3(100)	0	3(0.59)
Total	139(26.9)	378(73.1)	517 (100)

In the present study, while “sauces and broths” was the main food category with the most products containing added sugar with 87.1%, “meat and meat products” was the main food category with the least products containing added sugar with 8.7%. In a sample of Australian packaged foods, these were “bread and bakery products” and “edible oils and oil emulsions”, with %97.9 and %2.6, respectively (Probst *et al.*, 2017). As in most countries, consumption of foods with added sugar has increased significantly in Türkiye, especially as snacks between meals (Akar Sahingoz, 2011; Turkey). As expected, many studies have identified candies, sweets and snacks as the foods with the highest added sugar content (Acton *et al.*, 2017; Bayram & Ozturkcan, 2022). Similarly, our results showed that confectionery and sweets, and snack foods were the main food categories containing the highest amount of added sugar, with  $35.38 \pm 24.82$  and  $20.70 \pm 16.20$  g/100 g, respectively.

To estimate the added sugar intake of a population, it is important to know which food products have higher or lower amounts of added sugar. In our study, confectionery, jams and marmalades, wafers, packaged cakes, nut butters, pastry jellies and sweet sauces, biscuits, powdered drinks, desserts and ice-creams were the food subcategories with the highest amount of added sugar, respectively. However, it should also be emphasized that the consumability of foods containing added sugars is important to determine the dietary intake of added sugar. Liu *et al.* (2022) reported that bakery products such as cakes and pies, carbonated drinks, and ice cream were the main dietary sources of added sugar in Chinese population (Liu *et al.*, 2022). The

main dietary sources of added sugars in the Chinese population were similar to the data from the National Health and Nutrition Examination Survey (NHANES) (Bailey *et al.*, 2018). Unfortunately, no population-based studies have reported the main dietary sources of added sugar in Türkiye. Turkish population, especially adolescents, consume at least one packet of processed foods containing added sugar such as chocolate, cakes, biscuits, and wafers per week (Akar Sahingoz, 2011). Furthermore, it is well known that carbonated drinks are consumed at least every other day by almost half of the population (Dietary Guidelines for Turkey, 2022). Although carbonated drinks contained less added sugars in our study, with an average of  $5.02 \pm 4.74$  g/100 g, they may be one of the main dietary sources of added sugars due to their high frequency of consumption.

An oversupply of food products containing added sugars may contribute significantly to the total energy intake of a population. According to our study, 1550 (57.9%) out of 2676 food products contained at least one added sugar and the frequency of sucrose in the ingredient list of these food products was 62.9% (Table 5). The Dietary Guidelines for Turkey (2022) reported that sucrose consumption alone currently contributed 14.8% of the total energy intake of the Turkish population. In Europe, this rate is ranked between 7 and 17%, which is similar to the data from Türkiye (Chatelan *et al.*, 2019). A number of studies have reported that sucrose is the most common type of added sugar in the food supply (Acton *et al.*, 2017; Probst *et al.*, 2017).

Table 6. Added sugar frequency and top three added sugars used in each of the main food categories

Categories	Frequency (n,%)	Top three added sugars								
		1			2			3		
		Type	n	%	Type	n	%	Type	n	%
Milk and dairy products	135(5.64)	Sucrose	94	69.6	Glucose syrup	9	6.7	Maltodextrin	9	6.7
Meat and meat products	9(0.38)	Sucrose	8	88.9	Dextrose	1	11.1	-	-	-
Oil, oil seeds and nuts	114(4.76)	Sucrose	71	62.3	Maltodextrin	20	17.6	Dextrose	7	6.1
Confectionery and sweets	555(23.17)	Sucrose	327	58.9	Glucose syrup	132	23.8	Maltodextrin	27	4.9
Bread, cereals and bakery products	84(3.51)	Sucrose	58	69.0	Glucose syrup	13	15.5	Dextrose	4	4.8
Snack foods	679(28.35)	Sucrose	278	40.9	Invert sugar	128	18.8	Maltodextrin	94	13.8
Non-alcoholic beverages	521(21.75)	Sucrose	333	63.9	Glucose syrup	77	14.8	Glucose-fructose syrup	74	14.2
Sauces and broths	74(3.09)	Sucrose	49	66.2	Glucose-fructose syrup	8	10.8	Glucose syrup	7	9.5
Miscellaneous	224(9.35)	Sucrose	181	80.8	Glucose syrup	22	9.8	Maltodextrin	9	4.0
Total	2395									

Table 7. Sweetener frequency and top three sweeteners used in each of the main food categories

Categories	Frequency (n,%)	Top three sweeteners								
		1			2			3		
		Type	n	%	Type	n	%	Type	n	%
Milk and dairy products	0	-	-	-	-	-	-	-	-	-
Meat and meat products	1(0.19)	Sorbitol	1	100	-	-	-	-	-	-
Oil, oil seeds and nuts	4(0.77)	Isomalt	2	50.0	Sorbitol	1	25.0	Sucralose	1	25.0
Confectionery and sweets	302(58.30)	Sorbitol	77	25.5	Xylitol	44	14.6	Maltitol	44	14.6
Bread, cereals and bakery products	0	-	-	-	-	-	-	-	-	-
Snack foods	61(11.78)	Sorbitol	57	93.4	Maltitol	2	3.8	Steviol glycosides	2	3.8
Non-alcoholic beverages	140(27.03)	Acesulfame K	52	37.1	Sucralose	40	28.6	Aspartame	25	17.8
Sauces and broths	0	-	-	-	-	-	-	-	-	-
Miscellaneous	10(1.93)	Sorbitol	10	100	-	-	-	-	-	-
Total	518									

Similar to previous studies, sucrose was the most common type of added sugar in all main food categories in our study, with a range of 40.9 to 88.9% (Table 6). In addition, food additives such as glucose syrup, fructose syrup, glucose-fructose syrup, dextrose, honey, molasses and maltodextrin are sugars added to many types of packaged products (Acton *et al.*, 2017). Among the non-sucrose types, glucose syrup and maltodextrin were the leading types of added sugars, with a frequency of 12.9% and 7.8%, respectively. Our results showed that the frequency of the leading types of added sugars was lower than the Canadian food supply (Acton *et al.*, 2017). Although there have been studies conducted on the presence of added sugars in food products, interestingly no studies to date have compared the leading types of added sugars between foods and beverages. In the present study, sucrose and glucose syrup were mostly found in foods (79.3 and 99.0%, respectively), whereas glucose-fructose syrup was mostly found in beverages (61.7%).

Sweeteners are considered as an alternative to added sugar and are used in packaged products to improve perceived taste and increase eating pleasure (Chen *et al.*, 2023). In fact, the use of these sweeteners is one of the key strategies to reduce the consumption of added sugars. High sugar consumption is associated with various health problems such as obesity, type 2 diabetes, cardiovascular diseases and dental caries (Liu *et al.*, 2022; Wölnerhanssen *et al.*, 2020). For these reasons, sweeteners are claimed to have several health benefits such as reducing the post-prandial glycaemic response, maintaining tooth mineralisation and controlling body weight (EFSA Panel on Dietetic Products & Allergies, 2011). The presence of sweeteners in foods and beverages has increased

substantially in many countries over the past three decades (Samaniego-Vaesken *et al.*, 2018). According to our study, representing the Türkiye's food supply, various types of these sweeteners were present in 229 out of 2676 food products (Table 4). We found that 2.4% of these food products contained only sweeteners, and 6.2% contained both sugar and sweeteners, giving a total of 8.6%. This was similar to the proportion of food products containing sweeteners consumed by Spanish population (Samaniego-Vaesken *et al.*, 2018). Dunford *et al.* (2018) reported that products containing sweeteners accounted for 0.86, 1.44 and 4.47% of total food products in Australia, New Zealand and the United States, respectively. Although these countries had a lower proportion of products containing sweeteners than Türkiye, the authors did not include polyols in the study and reported only data on non-nutritive sweeteners.

The food groups that contain sweeteners may vary from country to country; however, evidence from many countries showed that the most popular food groups containing sweeteners were non-alcoholic beverages, dairy products, candies and chewing gums (Samaniego-Vaesken *et al.*, 2019; Samba *et al.*, 2020). Our results are in line with those of many other countries, with the exception of dairy products. Most of these sweeteners, which are widely used in many food products, are generally recognised as safe by both the FDA and EFSA (European Parliament, 2008; Food and Drug Administration, 2014). Some countries have set recommendations for an ADI level in order to better control the consumption of sweeteners. However, manufacturers do not provide any information on the label about the amount of sweeteners in the food products on sale. Consumers around the world have

reported a wide range of side effects, including headaches, vomiting, mood changes and allergies, when they consume sweeteners above the recommended levels (Chen *et al.*, 2023). Moreover, recent studies have associated sweeteners, especially artificial ones, with type 2 diabetes mellitus, cardiovascular disease, and even cancer (Debras *et al.*, 2022; Fagherazzi *et al.*, 2017; Mossavar-Rahmani *et al.*, 2019). Therefore, some researchers remain concerned about the potential long-term health risks of consuming these sweeteners.

The most commonly used sweeteners were acesulfame potassium (20.1%) and sucralose (19.5%), according to findings from Brazil (Figueiredo *et al.*, 2018). In Spain, the trend for sweeteners on food labels was for sorbitol (19.5%) and sucralose (19.5%), respectively (Samaniego-Vaesken *et al.*, 2021). In a previous study by Bayram and Ozturkcan (2022), sorbitol (28.4%) and acesulfame potassium (16.3%) were the most popular sweeteners in food products sold in Türkiye. It is possible that the types of popular sweeteners in food products vary from region to region or country to country; however, there are also some underlying reasons for these differences. First, the type of food groups and the number of products included in these food groups vary between studies. Some researchers focus more on food products commonly consumed by children and adolescents and include more products from certain food groups in the study. Second, the literature is inconsistent in defining and classifying sweeteners. For example, while some studies consider sorbitol to be 'non-nutritive', others define it as 'nutritive' (Bayram & Ozturkcan, 2022; Dunford *et al.*, 2018; Figueiredo *et al.*, 2018). On the other hand, EFSA divides them into intense sweeteners and polyols (European Parliament, 2008; Daher *et al.*, 2019). For this reason, sweeteners were considered in the same way as EFSA and both intense sweeteners and polyols were defined as sweeteners in our study. Accordingly, we found that sorbitol, acesulfame potassium and sucralose were the most commonly used sweetener, accounting for 28.2, 15.5 and 14.3 %, respectively (Table 5).

The nature of sweeteners used in different food groups can vary widely. For example, many countries reported that acesulfame potassium was mainly found in liquid product forms, whereas sorbitol was almost exclusively found in solid product forms (Bayram & Ozturkcan, 2022; Samaniego-Vaesken *et al.*, 2021). Similarly, in our study, 65.0% of products containing acesulfame potassium were in liquid form and all products containing sorbitol were in solid form. Acesulfame potassium was the most popular sweetener in non-alcoholic beverages, while sorbitol was the most popular sweetener in the other main food categories (Table 7). The frequency of sweeteners in non-alcoholic beverages, confectionery and sweets, and snack foods accounted for 97.1% of the total. Furthermore, these main food categories, which accounted for the vast majority of sweetener frequency, also contained higher amounts of added sugars than other main food categories. In essence, the use of sweeteners have become popular with consumers as a way to avoid the adverse health outcomes of excessive consumption of added sugars, such as obesity and diabetes mellitus (Samaniego-Vaesken *et al.*, 2018). However, a systematic review and meta-analysis of controlled trials and observational studies by Toews *et al.* (2019) reported that there is no compelling

evidence that non-sugar sweeteners improve health or help with weight management. It should also be noted that some companies add excessive amounts of sweeteners and the amount added is not mandatory to be declared on the label. Given all this, wouldn't adding sweeteners to foods that already contain added sugars be like "jumping out of the frying pan into the fire" without better regulations against violations?

The study has some limitations. First, this study was conducted only in Edirne, located in European Türkiye. The results obtained may differ in different cities of the country. Second, the present study does not reflect the dietary pattern of the people in the region and does not provide information on the frequency of consumption of packaged food products. Third, we have not carried out a chemical analysis of added sugars and sweeteners in the composition of foods. The findings presented are based solely on the nutritional facts and list of ingredients declared on the product label. Fourth, some human error may have occurred despite the most careful analysis. Despite all these limitations, this is the most comprehensive study in Türkiye reporting on the types and frequency of both added sugars and sweeteners in packaged products. We analysed almost all packaged food products available from leading retail stores, wholesale grocers and also local markets in low- and middle-income neighbourhoods. Additionally, unlike many other studies, the present study also provides information on other sugar alternatives such as polyols (sorbitol, xylitol and maltitol etc.).

## Conclusion

The present study reported on the widespread presence of added sugars and sweeteners in some of the packaged food products that are available for sale in Türkiye. More than half of the food products analysed contained at least one type of added sugar. Ayran, butter, pekmez, bars, sports bars, honey and dried fruits had no added sugar content. On the other hand, confectionery, jams and marmalades, wafers, packaged cakes, nut butters, pastry jellies and sweet sauces, biscuits, powdered drinks, desserts and ice-creams were the food products with the highest amount of added sugar, respectively. Non-alcoholic beverages, confectionery and sweets, and snack foods were the vast majority of the main food categories containing sweeteners. The majority of food products containing sweeteners also contained high amounts of added sugar. Sucrose was the most common type of added sugar found in food products, followed by glucose syrup and maltodextrin. For sweeteners, it was sorbitol followed by acesulfame potassium and sucralose.

There is no doubt that excessive and chronic sugar intake is one of the major contributors to poor health outcomes. The Food Additives Regulation of the Turkish Food Codex, in line with the European Parliament Regulation, has therefore approved the use of authorized sweeteners when used as an alternative to sugar in the production of energy-reduced food products. However, it can not be excluded that the increase in the number of food products containing sweeteners and the possible increase in the consumption of these foods by the population may lead to an increase in the intake levels of these sweeteners. For these reasons, it may be important to periodically



monitor the prevalence of food products containing added sugars and sweeteners. Unfortunately, the comprehensive efforts to monitor products containing added sugars and sweeteners in the food supply are very limited throughout Türkiye. In addition, there is a lack of labelling information for consumers in Türkiye on the amount of added sugars and sweeteners in packaged foods. Therefore, Türkiye needs better food labelling regulations to meet the recommendations of the National Dietary Guidelines on reducing dietary sugar intake and to better control the amount of sweeteners used in the food industry.

## Declarations

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**Authors' Contributions:** Gürbüz, M: conceptualization, writing, editing, and interpretation of results; Demirel, S: data collection, drawing and analyses; Aykut MN: data collection, drawing and analyses; Erdoğan, EN: data collection, drawing and analyses; Balcı B: data collection and analyses; Özarslan G: data collection and analyses. All authors have read and approved the final manuscript.

## References

- Acton, R. B., Vanderlee, L., Hobin, E. P., & Hammond, D. (2017). Added sugar in the packaged foods and beverages available at a major Canadian retailer in 2015: a descriptive analysis. *Canadian Medical Association Journal Open*, 5(1), E1-E6. <https://doi.org/10.9778/cmajo.20160076>.
- Akar Sahingoz, S. (2011). Fast food and snack food consumption of adolescents in Turkey. *Healthmed*, 5, 378-387.
- Bailey, R. L., Fulgoni, V. L., Cowan, A. E., & Gaine, P. C. (2018). Sources of Added Sugars in Young Children, Adolescents, and Adults with Low and High Intakes of Added Sugars. *Nutrients*, 10(1), 102. <https://doi.org/10.3390/nu10010102>
- Bayram, H. M. and Ozturkcan, A. (2022). Added sugars and non-nutritive sweeteners in the food supply: Are they a threat for consumers? *Clinical Nutrition ESPEN*, 49, 442-448. <https://doi.org/10.1016/j.clnesp.2022.03.006>
- Celik, I., & Bektas, M. (2020). An Assessment of Turkish Adults' Knowledge Levels About Their Salt and Sugar Consumption, and Their Attitudes Toward Protecting Children from Excessive Salt and Sugar Consumption. *Journal of Pediatric Nursing*, 54, e17-e22. <https://doi.org/https://doi.org/10.1016/j.pedn.2020.04.009>
- Chatelan, A., Gaillard, P., Kruseman, M., & Keller, A. (2019). Total, Added, and Free Sugar Consumption and Adherence to Guidelines in Switzerland: Results from the First National Nutrition Survey menuCH. *Nutrients*, 11(5), 1117. <https://doi.org/10.3390/nu11051117>
- Chen, L., Zhang, Y., Zhou, Y., Shi, D., & Feng, X.-s. (2023). Sweeteners in food samples: An update on pretreatment and analysis techniques since 2015. *Food Chemistry*, 408, 135248. <https://doi.org/10.1016/j.foodchem.2022.135248>
- Daher, M. I., Matta, J. M., & Abdel Nour, A. M. (2019). Non-nutritive sweeteners and type 2 diabetes: Should we ring the bell? *Diabetes Research and Clinical Practice*, 155, 107786. <https://doi.org/10.1016/j.diabres.2019.107786>
- Debras, C., Chazelas, E., Srour, B., Druesne-Pecollo, N., Esseddik, Y., Szabo de Edelenyi, F., ... Touvier, M. (2022). Artificial sweeteners and cancer risk: Results from the NutriNet-Santé population-based cohort study. *PLoS Medicine*, 19(3), e1003950. <https://doi.org/10.1371/journal.pmed.1003950>
- Dietary Guidelines for Turkey. (2022). The Ministry of Health of Turkey and The General Directorate of Primary Health Care. "Dietary Guidelines for Turkey", Ankara: Ministry of Health; Ankara, Turkey; 2022. Publication No: 1031.
- Dunford, E. K., Taillie, L. S., Miles, D. R., Eyles, H., Tolentino-Mayo, L. & Ng, S. W. (2018). Non-Nutritive Sweeteners in the Packaged Food Supply-An Assessment across 4 Countries. *Nutrients*, 10(2), 257. <https://doi.org/10.3390/nu10020257>
- European Food Safety Authority. (2010). EFSA Panel on Dietetic Products Nutrition and Allergies (NDA). Scientific opinion on dietary reference values for carbohydrates and dietary fibre. *EFSA Journal*, 8(3), 1462. <https://doi.org/10.2903/j.efsa.2010.1462>
- European Food Safety Authority. (2011). EFSA Panel on Dietetic Products Nutrition and Allergies Scientific Opinion on the substantiation of health claims related to intense sweeteners and contribution to the maintenance or achievement of a normal body weight (ID 1136, 1444, 4299), reduction of post-prandial glycaemic responses (ID 4298), maintenance of normal blood glucose concentrations (ID 1221, 4298), and maintenance of tooth mineralisation by decreasing tooth demineralisation (ID 1134, 1167, 1283) pursuant to Article 13(1) of Regulation (EC) No 1924/2006. *EFSA Journal*, 9(6), 2229. <https://doi.org/10.2903/j.efsa.2011.2229>
- European Parliament, Council of the European Union. Regulation (EC) No 1333/2008 of the European Parliament and of the Council of 16 December 2008 on food additives (Text with EEA relevance). (2008), available at: <http://data.europa.eu/eli/reg/2008/1333/oj/eng>. [Accessed August 2, 2023].
- Fagherazzi, G., Gusto, G., Affret, A., Mancini, F. R., Dow, C., Balkau, B., ... Boutron-Ruault, M. C. (2017). Chronic Consumption of Artificial Sweetener in Packets or Tablets and Type 2 Diabetes Risk: Evidence from the E3N-European Prospective Investigation into Cancer and Nutrition Study. *Annals of Nutrition and Metabolism*, 70(1), 51-58. <https://doi.org/10.1159/000458769>
- Food and Drug Administration. (2014). Food Additives & Ingredients – Additional Information about High-Intensity Sweeteners Permitted for Use in Food in the United States, available at: <https://www.fda.gov/Food/IngredientsPackagingLabeling/FoodAdditivesIngredients/ucm397725.htm>. [Accessed August 21, 2023].
- Figueiredo, L. D. S., Scapin, T., Fernandes, A. C., & Proença, R. (2018). Where are the low-calorie sweeteners? An analysis of the presence and types of low-calorie sweeteners in packaged foods sold in Brazil from food labelling. *Public Health Nutrition*, 21(3), 447-453. <https://doi.org/10.1017/s136898001700283x>
- Liu, Y., Cheng, J., Wan, L., & Chen, W. (2022). Total and Added Sugar Intakes Are Increasing among Children and Adolescents in China: Findings from CHNS 1997-2011. *Nutrients*, 14(16), 3340. <https://doi.org/10.3390/nu14163340>

- Louie, J. C. Y., Lei, L., & Rangan, A. M. (2016). Reliability of a systematic methodology to estimate added sugars content of foods when applied to a recent Australian food composition database. *Journal of Food Composition and Analysis*, 46, 36-42. <https://doi.org/10.1016/j.jfca.2015.11.002>
- Malik, V. S., & Hu, F. B. (2022). The role of sugar-sweetened beverages in the global epidemics of obesity and chronic diseases. *Nature Reviews Endocrinology*, 18(4), 205-218. <https://doi.org/10.1038/s41574-021-00627-6>
- Ministry of Health of Turkey. (2021), “Türkiye Şeker Tüketimini/Kullanımını Azaltma Rehberi”. The Ministry of Health of Turkey and The General Directorate of Primary Health Care, Ankara: Ministry of Health; Ankara, Turkey; 2021. Publication No: 1201.
- Mossavar-Rahmani, Y., Kamensky, V., Manson, J. E., Silver, B., Rapp, S. R., Haring, B., ... Wassertheil-Smoller, S. (2019). Artificially Sweetened Beverages and Stroke, Coronary Heart Disease, and All-Cause Mortality in the Women’s Health Initiative. *Stroke*, 50(3), 555-562. <https://doi.org/10.1161/strokeaha.118.023100>
- Probst, Y. C., Dengate, A., Jacobs, J., Louie, J. C., & Dunford, E. K. (2017). The major types of added sugars and non-nutritive sweeteners in a sample of Australian packaged foods. *Public Health Nutrition*, 20(18), 3228-3233. <https://doi.org/10.1017/s136898001700218x>
- Riboli, E., Beland, F. A., Lachenmeier, D. W., Marques, M. M., Phillips, D. H., Schernhammer, E., ... Madia, F. (2023). Carcinogenicity of aspartame, methyleugenol, and isoeugenol. *Lancet Oncology*, 24(8), 848-850. [https://doi.org/10.1016/s1470-2045\(23\)00341-8](https://doi.org/10.1016/s1470-2045(23)00341-8)
- Rogers, M. A., & Amer, H. (2022). Food as we knew it: Food processing as an evolutionary discourse. *Trends in Food Science & Technology*, 128, 68-74. <https://doi.org/https://doi.org/10.1016/j.tifs.2022.07.015>
- Samaniego-Vaesken, M. d. L., González-Fernández, B., Partearroyo, T., Urrialde, R. and Varela-Moreiras, G. (2021). Updated Database and Trends of Declared Low- and No-Calorie Sweeteners From Foods and Beverages Marketed in Spain. *Frontiers in Nutrition*, 8, 670422. <https://doi.org/10.3389/fnut.2021.670422>
- Samaniego-Vaesken, M. d. L., Partearroyo, T., Cano, A., Urrialde, R., & Varela-Moreiras, G. (2019). Novel database of declared low- and no-calorie sweeteners from foods and beverages available in Spain. *Journal of Food Composition and Analysis*, 82, 103234. <https://doi.org/10.1016/j.jfca.2019.103234>
- Samaniego-Vaesken, M. L., Ruiz, E., Partearroyo, T., Aranceta-Bartrina, J., Gil, Á., González-Gross, M., Ortega, R. M., Serra-Majem, L., & Varela-Moreiras, G. (2018). Added Sugars and Low- and No-Calorie Sweeteners in a Representative Sample of Food Products Consumed by the Spanish ANIBES Study Population. *Nutrients*, 10(9), 1265. <https://doi.org/10.3390/nu10091265>
- Sambra, V., López-Arana, S., Cáceres, P., Abrigo, K., Collinao, J., Espinoza, A., Valenzuela, S., Carvajal, B., Prado, G., Peralta, R., & Gotteland, M. (2020). Overuse of Non-caloric Sweeteners in Foods and Beverages in Chile: A Threat to Consumers’ Free Choice? *Frontiers in Nutrition*, 7, 68. <https://doi.org/10.3389/fnut.2020.00068>
- Toews, I., Lohner, S., Küllenberg de Gaudry, D., & Meerpohl, J. (2019). Association between intake of non-sugar sweeteners and health outcomes: systematic review and meta-analyses of randomised and non-randomised controlled trials and observational studies. *British Medical Journal*, 364, k4718. <https://doi.org/10.1136/bmj.k4718>
- Turkish Food Codex. (2013), “Food additives communiqué. Turkey: Ministry of health of Turkey”, available at, <https://www.mevzuat.gov.tr/mevzuat?MevzuatNo1418532&MevzuatTur147&MevzuatTertip145>. [Accessed 2 August 2023].
- World Health Organization. (2015), “Guideline: sugar intake for adults and children”, available at, <https://www.who.int/publications/i/item/9789241549028>. [Accessed 01 August 2023].
- World Health Organization. (2021), “Obesity and overweight”, available at, <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>. [Accessed 05 August 2023].
- World Health Organization. (2022), “WHO European Regional Obesity Report”, Copenhagen: WHO Regional Office for Europe, 2022. Licence: CC BY-NC-SA 3.0 IGO.
- Wölnerhanssen, B. K., Meyer-Gerspach, A. C., Beglinger, C., & Islam, M. S. (2020). Metabolic effects of the natural sweeteners xylitol and erythritol: A comprehensive review. *Critical Reviews in Food Science and Nutrition*, 60,12, 1986-1998. <https://doi.org/10.1080/10408398.2019.1623757>