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original scientific paper

Evaluation of Commercially Available Complementary Foods in Slovenia: A Comparison with the Draft WHO Nutrient Profile Model[§]

Running head: Commercially Available Complementary Foods – Suitable for Infants and Toddlers?

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SUMMARY

Research background. After six months of life, breast milk alone is insufficient to meet infants' energy and nutritional needs, making the introduction of complementary foods (CF) necessary. Little is known globally about the quality of commercially available complementary foods (CACFs) and whether the ingredients, nutritional values, and labelling of CACFs are consistent with the draft WHO nutrient profile model from 2019 for CACFs for infants and young children up to 36 months old in the WHO European Region.

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Experimental approach. We examined 241 CACF samples available on the Slovenian market and recorded the target age group, the presence of added sugar or sweeteners, and the fat and sodium content indicated on the label. The results were compared with the draft WHO nutrient profile model from 2019.

Results and conclusions. The results showed that almost 40 % of the samples were labelled as suitable for infants under 6 months, which could undermine breastfeeding and contribute to the early introduction of nutritionally unsuitable foods. 37 % of the samples contained added sugars or sweetening agents. All samples met the draft WHO nutrient profile model criteria for fat content, indicating suitability for infants and young children up to 36 months in this respect. The upper limit for sodium content was exceeded in 19 % of samples from different categories. All beverages and 90 % of snacks were labelled as suitable for children under 36 months, which does not align with the draft WHO nutrient profile model.

Novelty and scientific contribution. Based on our findings and recognising that nutrition in the first 1,000 days of life is critical for growth and development, we conclude that CACFs should be reformulated and that a higher content of (bitter) vegetables should be encouraged. There is also a need to establish a legislative framework for CACFs, addressing both content and labelling.

Keywords: commercially available complementary foods; draft WHO nutrient profile; added sugars; sodium content; labelling; infants

INTRODUCTION

Nutrition is one of the most important external factors that have a strong influence on the development of infants' and toddlers' tissues, motor, social, and emotional skills, as well as cognitive development, which affects health in adulthood [1,2]. The first 1,000 days of life represent a "critical period" during which neuronal connections are formed in the brain at a rate that will not be repeated later in life. Preventing malnutrition is essential, as these conditions play a significant role in health and the development of non-communicable diseases (NCDs) in adulthood [3,4].

The World Health Organization (WHO), the United Nations Children's Fund (UNICEF), and the Slovenian National Institute of Public Health (NIJZ) recommend exclusive breastfeeding until six months of age, to be continued alongside complementary feeding up to two years or longer [5,6]. Unlike formula feeding, breastfeeding does not require intensive milk production, the procurement of drinking water, the manufacture of feeding bottles, or transport and storage [7]. This supports sustainable nutrition [8]. After the sixth month of life, babies become more active and typically double

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their birth weight. At this stage, breast milk alone is no longer sufficient to meet their energy and nutrient needs [9]. Therefore, it is necessary to introduce complementary foods (CF) in addition to breastfeeding [10].

When introducing complementary feeding (CF), parents and caregivers can choose to prepare meals at home or purchase commercially available complementary foods (CACFs). Home-prepared meals tend to be fresher, contain more nutrients, have greater flavour intensity, and vary in consistency, but require more time and effort to prepare [9]. Their shelf life is relatively short, so preparing them several days in advance is not practical. CACFs are more convenient to use, have a longer shelf life, are relatively affordable, and are easier to offer outside the home [1]. In addition, to these practical considerations, food safety is an important factor influencing this choice. A recent review of 46 studies by Roman and Sanches-Siles [11] found that commercial baby foods generally contained lower levels of pesticides, fertiliser residues, and toxins compared to homemade baby foods and common foods, while levels of heavy metals and environmental contaminants were comparable across all food types. Process-related contaminants and packaging substances were more prevalent in common foods than in commercial baby foods. These findings challenge the widespread perception that homemade complementary foods are inherently safer. Stricter regulatory limits, particularly in the European Union, apply to commercial baby foods but not to common foods used in home-prepared meals, which may result in higher contaminant exposure when infants consume homemade complementary foods.

In today's fast-paced society, it is therefore easier to feed infants and toddlers with CACFs, which is reflected in their increased use [12]. European countries represent one of the world's largest markets for commercially available complementary foods. Over the past decade, the CACF market has experienced significant growth worldwide, with global sales volumes expected to increase by around 20 % between 2019 and 2023. However, there are regional differences: the Asia and Pacific region have seen growth of almost 30 %, while Europe has seen a more modest increase of around 10 % over the same period. As the market grows, concerns about inappropriate marketing of these products have also increased, as this can compromise optimal nutrition for infants and young children. In response, the WHO and UNICEF have raised questions about the nutritional adequacy and suitability of certain CACF products for this vulnerable population [13,14]. The marketing of CACFs influences infant and toddler feeding behaviour, the development of childhood obesity, and the risk of developing non-communicable diseases (NCDs) [15]. Despite the growing CACF market, there is little literature on the quality of these foods. The few studies available have shown that many CACFs contain added sugar and salt and are high in fat. In addition, CACFs often mask the flavour of

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vegetables with sweet-tasting foods and are usually pureed, which is not suitable for older toddlers, as it can negatively impact children's learning about the taste and texture of food [1,16]. It must also be emphasised that labelling foods as suitable for infants under 6 months undermines recommended breastfeeding practices and contributes to NCDs and other health problems in children [10].

The influence of an obesogenic environment is clearly harmful to the long-term health of young people [17]. The USA, a country with a strong obesogenic environment, reports that from 2011 to 2023, the prevalence of chronic conditions among individuals aged 3 to 17 increased from 39.9 % to 45.7 %. Rates of obesity, early onset of menstruation, sleep difficulties, activity limitations, physical symptoms, depressive symptoms, and loneliness all increased during this period [18]. A new WHO 2025 strategy [19] for children and adolescents in Europe, »Children and Adolescent Health Country Profiles: A Healthy Start for a Healthy Life«, identifies key areas for action, with protection against commercial and digital harms among the five priorities. This area calls for stronger regulation to limit the marketing of unhealthy foods and beverages – particularly those high in fat, salt, and sugar – as well as breast milk substitutes [19].

The WHO [16] has proposed values for energy, fat, sodium, protein, added sugars, and water that foods for infants and toddlers up to 36 months should meet for each category of CACFs in a draft discussion paper (draft WHO nutrient profile model (2019)). The draft model also provides guidance on the appropriate age for consumption of each food category. Given the increasing use of CACFs and their potential impact on children's health and development, this study examines how products available on the Slovenian market align with the draft guidelines.

To provide a comprehensive and realistic assessment of compliance with the draft WHO nutrient profile model [16], we developed a special sampling protocol. This approach was chosen to ensure the sample's representativeness of the Slovenian market, coverage of a wide range of products, reduced bias in product selection, and comparability across individual categories and subcategories. Importantly, this methodology allows for a realistic picture of the availability of CACFs on the Slovenian market and offers new insights into the actual food environment faced by parents and caregivers.

The aim of this study is to critically evaluate the nutritional composition, labelling, and marketing practices of CACFs on the Slovenian market in relation to the draft WHO nutrient profile model [16] and to examine their potential impact on the health of infants and young children. By highlighting current gaps and challenges, this article aims to inform parents, health professionals, and policymakers, and to promote the importance of better regulation and guidance for early childhood nutrition.

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MATERIALS AND METHODS

Research questions

The main research questions were developed based on the aims and research objectives presented in the introduction:

RQ1: Are CACFs consistent with the draft WHO nutrient profile model from 2019?

RQ2: What is the target age group indicated on the label of commercially available complementary foods?

RQ3: What is the sugar, fat and salt content of commercially available complementary foods?

Samples

Recently, seven regular shops in Slovenia were included in this study: four from major food retail chains (Mercator, Spar, Hofer, and Lidl) and three specialised stores (Müller, DM, and Baby Center). Based on a review of the market analysis and the development of a special sampling protocol to ensure sample representativeness, we purchased 241 CACF (Table 1) and divided them into food categories and subcategories as recommended by the draft WHO nutrient profile model [16]. We focused on purchasing both domestic and foreign trademark products and manufacturer brands available in several different retailers. Private label products were collected first, followed by manufacturer brands available in several stores. The sampling method was adjusted according to the number of products available in each category on store shelves. Sampling was conducted as follows: if there were fewer than 10 samples on store shelves for a particular subcategory, we purchased every second product; if there were between 10 and 20 samples, we purchased every third product; if there were between 20 and 30 samples, we purchased every fourth product; and if there were more than 30 samples, we purchased every fifth product. If a selected product had already been purchased, we then selected a neighbouring product or did not purchase the product. This sampling method provided several samples for each category, reflecting the state of the food supply chain in the Slovenian market in terms of the availability of food from different categories or subcategories.

We first checked the target age group indicated on the label as suitable for the introduction of the food according to the manufacturer and compared it with the draft WHO nutrient profile model [16], which states that foods are suitable for introduction from 6 months. We then evaluated the ingredients, focusing on the added sugar content. We categorised the samples as containing added sugars if they included:

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- mono- and disaccharides (including those from fruit, sugar cane, palm or tuberous vegetables),
- syrups, nectars and honey,
- fruit juices or concentrates and fruit juice powders (except lemon juice),
- sweeteners such as saccharin, acesulfame, aspartame, sucralose or stevia.

If a product contained unsweetened whole fruit, fresh fruit purée, or fruit powder, we did not define it as a product with added sugar. We then evaluated the nutritional values, paying particular attention to total fat and sodium content. We used the nutritional value tables on the product label.

This analysis was based on the WHO discussion paper [16], which presents a draft or proposed nutrient profile model rather than a final, officially approved WHO standard. Therefore, all results reflect alignment with the draft thresholds and should be interpreted as indicative guidance, not as formal compliance with a final WHO model.

The recommendations for fat content in the draft WHO nutrient profile model [16] for profiling CACFs are given in g per 100 kcal, while the fat content on products is given in g per 100 g. To compare our results with the guidelines, we converted the values using the following equation:

$$\text{Fat content } \left(\frac{\text{g}}{100} \text{ kcal} \right) = \frac{100 \text{ kcal} \times \text{fat (g/100g)}}{\text{Energy value (kcal)}} \quad /1/$$

For some samples, only the salt content was given, so we converted the salt content into the sodium content. We used the following equation:

$$\text{Na (mg)} = \frac{\text{salt (g)}}{2,5 \times 1000} \quad /2/$$

Sodium content was also expressed in mg/100 kcal to allow comparison with the draft WHO model [16], using the following equation:

$$\text{Sodium content } \left(\frac{\text{mg}}{100} \text{ kcal} \right) = \frac{100 \text{ kcal} \times \text{Na (mg/100g)}}{\text{Energy value (kcal)}} \quad /3/$$

Statistical analysis

All statistical and spatial analyses were conducted in R version 4.5.2 [20]. Descriptive statistical analysis summarised the target age group for food introduction and the contents of sugars, salt, fat, and sodium in commercially available complementary foods. Continuous variables were assessed for distribution using graphical inspection and were found to be non-normally distributed;

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therefore, non-parametric statistical methods were applied. Comparisons between products labelled for infants aged <6 months and ≥ 6 months were conducted using the Wilcoxon rank-sum test for continuous variables and Fisher's exact test for categorical variables. To further explore associations, logistic regression analyses were performed with labelling for <6 months as the dependent variable. Two models were constructed: one included categorical predictors (food category, presence of added sugars, sodium content), and the other included continuous sugar content (g/100 g) instead of the binary added sugar variable. Results are presented as odds ratios (OR) with 95 % confidence intervals (CI). All statistical tests were two-sided, with $p < 0.05$ considered statistically significant.

RESULTS AND DISCUSSION

The target age group for the introduction of five food categories indicated on the labelling

The samples were initially divided into three groups according to the recommended age of introduction indicated on the label. The first group included samples recommended for introduction up to 6 months; the second group included samples recommended for 6 months or older; and the third group consisted of 9 samples with no age recommendation. Table 1 shows the 241 samples divided into five categories, based on the declared age of the children for whom the product is intended, as indicated on the label.

Although the draft WHO nutrient profile model [16] recommends that the packaging of CACFs and associated marketing and promotional materials should clearly indicate that the products are not suitable for infants under 6 months of age [16], 38 % (92 products) of the 241 samples had a recommended age of introduction of less than 6 months indicated on the label (labelled as suitable for children from 4 or 5 months). Most of these samples belonged to the second food category (29 %, $N=71$), followed by the first food category (5 %, $N=12$) and the fifth food category (4 %, $N=9$). Notably, 90 % of products in category 5 were labelled as suitable for infants under 6 months. Kök Şan and F. Gökçay [21] also found that fruit juices on the Turkish market were marketed for infants aged 4 months and older. The WHO [14] reports that fruit juices are not suitable for infants and young children up to 36 months of age. None of the samples in the third and fourth category were recommended for children less than 6 months of age. According to Padarath *et al.* [1], about 22 % of the 197 CACFs in New Zealand had a recommended age of introduction of 4 months on the label. A slightly lower proportion was observed in Turkey, where Kök Şan and F. Gökçay [20] reported that 15 % (29 out of 189) of commercial infant and toddler food products on the market were intended for ages 4+ and 5+ months. Labelling CACFs as suitable for infants under 6 months may give the impression that these products can replace breast milk. Early introduction of complementary foods may lead parents and

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caregivers to reduce breastfeeding, which provides optimal nutrition, and could result in nutritional inadequacy if formula feeding is suboptimal [22].

A total of 140 samples were categorised as suitable from 6 months. We would like to emphasise 26 samples from food group 2, which were classified as suitable from 10 or 12 months. These are soft, spoonable foods, usually packaged smooth or semi-pureed in jars or pouches, and can be spoon-fed. At around 10 months of age, infants develop the ability to chew, so meals with a denser texture and larger pieces are more suitable [23], as they stimulate jaw development, improve swallowing ability [24], and contribute to the perception of satiety through chewing [25]. This is why offering pureed food when children are already able to eat larger pieces can affect oral development, family meal recognition, chewing, and motor skills. Kök Şan and F. Gökçay [21] found that almost half of the products targeting the 12+ age group were pureed foods in squeeze pouches. In contrast, the study by Padarath *et al.* [1] in New Zealand found that more than half of the CACFs were packaged in squeeze pouches (52 %), but only a small proportion (3 %) were recommended for children aged 12 months and over.

Introducing foods with increasingly complex textures, from smooth and pureed to chunky or lumpy, before the age of nine or ten months enables children to accept new textures when challenged later in life and supports chewing and oral development [1]. Currently, there is no age limit on the labelling of CACFs indicating when these products are no longer suitable due to their pureed consistency. The draft WHO nutrient profile model (2019) has proposed clearer labelling of pureed CACFs in its recommendations and set an age limit of ≥ 6 and < 12 months. The guidelines also recommend that manufacturers produce fewer pureed foods and more foods with appropriate textures for infants and young children aged 6 to 12 months [16]. In our study, we purchased very few meals with larger pieces (2 % of all 241 samples), reflecting their limited availability on the market.

Added sugars, sweeteners and foods with sweetening properties

Of 241 samples, almost 40 % contained added sugar, sweeteners, or foods with sweetening properties (Fig. 1). The prevalence of added sugars varied significantly between categories ($p < 0.001$), with the highest prevalence of added sugars in category “Dry finger foods and snacks” (category 4) and “Juices and other beverages” (category 5). As juice is considered a food with sweetening properties, we labelled all samples from the category 5 as products with added foods with sweetening properties. Otherwise, foods from the category 4 most often (70 %) contained added sugars, sweeteners, or foods with sweetening properties (Fig. 1).

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Although research in this area is limited, our study's results are consistent with recent studies from other countries. For example, Padarath *et al.* [1] found that 34 % of CACFs in New Zealand contained free sugars, and the majority (69 %) contained ingredients with a sweet flavour. In Turkey, nearly half (49 %) of CACFs contained added sugar or sweeteners, 22 % contained added sugar, and one in three products contained sugar from fruit-based sources [21]. Previous studies have noted that products often combine vegetables with naturally sweet ingredients such as fruit, carrots, sweet potatoes, or pumpkin. While such formulations may increase palatability, their potential role in shaping acceptance of less sweet or more bitter flavours remains uncertain. [1]. In fact, all the vegetable first foods examined in the study by Kök Şan and F. Gökçay [21] contained sweet vegetables such as carrots and potatoes, as well as sweet varieties like fruit or fruit juice concentrate. This suggests that manufacturers should limit fruit- and sweet vegetable-based products and offer more options with bitter vegetables to increase exposure and thus acceptability among infants who primarily consume commercial infant food products.

In contrast, our study found that in food category 2, which includes various pureed meals, free sugars were added only in samples containing pureed fruits and were not present in pureed vegetable or meat and fish meals. This is a positive result regarding the masking of vegetable flavours with foods that have sweetening properties. However, evidence from broader international assessments indicates that the presence of sugars and other nutritionally undesirable components in CACFs remains widespread. These findings are consistent with previous research showing that a large proportion of commercial infant and toddler foods contain added sugars and high sodium levels, with some also contributing significant amounts of fat to the diet [27,28].

Supporting this concern, a recent cross-sectional assessment of commercial baby foods found that only about one-third of products met all nutritional criteria, while a substantial proportion contained sugar-contributing ingredients or exceeded recommended energy thresholds, highlighting the high prevalence of suboptimal nutrient profiles in CACFs [28]. Similar trends were observed across Europe. Hutchinson *et al.* [29] also recorded the number of CACFs in 10 European countries where added sugars, sweeteners, or foods with sweetening properties were labelled on the packaging. The percentage of such samples ranged from 21 % to 58 %, with 49 % of 152 samples in Slovenia containing added sugars, sweeteners, or foods with sweetening properties [29]. The percentage of CACFs with added sugars, sweeteners, or foods with sweetening properties was also assessed by the WHO [14] as part of a study on the availability, composition, and marketing of CACF in four cities in four countries (Vienna, Austria; Sofia, Bulgaria; Budapest, Hungary; Haifa, Israel). It found that the

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percentage of foods with added sugars, sweeteners, or foods with sweetening properties was 30 % in Austria, 41.4 % in Bulgaria, 37.5 % in Hungary, and 32.6 % in Israel [14].

The findings confirm the widespread use of added sugars in commercial infant and toddler food products and highlight concerns about early exposure to sweet flavours and their potential impact on long-term dietary habits. Products labelled for infants under 6 months had significantly lower sugar content than those labelled for 6 months and older ($p < 0.001$). Additionally, products labelled for 6 months and older were more likely to contain added sugars (OR=2.00, 95 % CI: 1.10–3.72, $p = 0.018$). These associations remained statistically significant in multivariable logistic regression analysis, where both the presence of added sugars ($p = 0.034$) and higher sugar content ($p = 0.020$) were associated with a lower likelihood of being labelled for infants under 6 months.

While these results raise concerns about early exposure to sweet flavours and potential long-term effects, the existing evidence on this relationship is still mixed. [30]. Some studies suggest that repeated exposure to certain sweet foods in childhood may increase preference for those foods, but this effect does not generalise to other sweet products. Consistent with this, Mueller *et al.* [31] found no significant association between early exposure to sweetness and children's overall preferences or consumption of sweet foods. This may reflect an innate preference for sweetness, which limits the observable impact of further exposure. In contrast, repeated exposure to flavours that are initially unfamiliar or naturally disliked – such as bitter or sour tastes – has been shown to increase the acceptance, preference, and intake of these foods over time. These findings suggest that while early dietary experiences can shape food preferences, this effect is more likely to apply to flavours that are not naturally appealing than to those that are already preferred, such as sweetness [31].

According to the draft WHO nutrient profile model (2019), CACFs from all proposed food categories, should not contain added sugars, sweeteners or foods with sweetening properties [16]. Fresh and dried fruit powders and fruit purees are allowed in some categories in limited quantities. The addition of all mono- and disaccharides (including those from fruits, sugar cane, palm or tuberous vegetables), syrups, nectars and honey, fruit juices or concentrated juices and fruit juice powders (except lemon juice), as well as sweeteners such as saccharin, acesulfame, aspartame, sucralose or stevia is undesirable [16]. As part of the study, we also examined forms of added sugars, sweeteners and foods with sweetening properties in products.

The most common form of added sugar in the samples was fruit juice (62 %), including apple, grape, pear, blueberry, orange, passion fruit, cherry, and raspberry juice, all of which have sweetening properties. Similarly, Santos *et al.* [28] reported fruit juice as the most common added sugar ingredient in CACFs. Hutchinson *et al.* [29] also reported similar findings, having analysed the added sugar

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content in 2618 CACFs samples from different categories. They found that fruit juice was the most common form of added sugar and was also present in savoury snacks. In our samples, 23 % contained added sugar, although the specific type was not always clearly indicated on the label. Added fruit juice concentrate was present in 6 % of the samples, 4 % were sweetened with various syrups, including rice, agave, and red grape syrup, and two samples contained added fructose. One sample was labelled as containing beet sugar. Similar types of free sugars were also found in CACFs available in New Zealand supermarkets. These included sugars (raw sugar, cane, grape), maltodextrin, fruit juices (apple, grape, pineapple, purple carrot, cherry, strawberry, passionfruit, and red beet), dextrose, fruit juice concentrates (apple, pear, grape, carrot, purple carrot, and elderberry), and glucose [1].

Products that are inappropriately marketed as suitable for babies and toddlers

According to the draft WHO nutrient profile model [16], products in category 5 and subcategory 4.1, include products that should not be marketed as primary foods for infants and young children under 36 months of age. Of the 40 samples in the subcategory 4.1, 15 (38 %) were unsuitable for infants and young children due to their high sugar content and low nutritional value, which can contribute to poor eating habits and increase the incidence of overweight and obesity [32]. Although most beverages are marketed as natural fruit juices or made from juice concentrates, they contained negligible amounts of dietary fibre. Therefore, there are no significant differences in the absorption of sugars from natural juices compared to nectars or other sweet drinks [33]. In addition, 100 % natural juices have relatively low nutritional value as they are high in energy but lack essential nutrients necessary for the growth and development of infants and toddlers [32]. Despite the widespread belief that fruit juice is a healthy choice, 100 % fruit juice offers no nutritional advantages over whole fruit because most of the fibre is lost during processing and it has a relatively high energy value; its effect on satiety and metabolism is therefore no better, or may even be worse, than that of consuming whole fruit [34]. “Juices and other drinks” for infants and toddlers make up a significant proportion of their daily energy intake [35]. Kay *et al.* [35] found that about half of children aged 1 to 4 years consume more than 240 mL of 100 % fruit juice per day. Some studies showed that toddlers aged 1 to 2 years met almost 6 % of their daily energy needs with juices, making juices the second most common source of energy after cow's milk [36].

The samples listed in **Table 2** should not be marketed as suitable for infants and toddlers under 36 months due to their added sugar content. Based on the sugar content per 100 g of each product, we calculated the energy a child would consume from one portion. For the subcategory

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“Confectionery, sweet spreads and fruit chews”, we used a portion size of 30 grams, and for the food category “juices and other drinks”, we used a portion size of 250 mL. These values were then converted into a percentage of the daily energy intake for a child aged 1 to 3 years [37].

The sugar from one portion of “Confectionery, sweet spreads and fruit chews” provides, on average, (4 ± 0.5) % of the daily energy requirement for a child aged 1 to 3 years. For juices, this value per portion is (7 ± 2) % (Table 2). For clarity, we also calculated the amount of energy a child consumes in a month if they have a daily portion of a snack or drink in addition to the recommended energy intake. In this case, a child consumes an average of (1516 ± 218) kcal ((6346 ± 912) kJ) from snacks and (2577 ± 755) kcal ((10777 ± 3157) kJ) from juices in a month (Table 2). The daily requirement of children aged 1 to 3 years with moderate physical activity is between 1200 kcal (5021 kJ) and 1300 kcal (5439 kJ). This means that a child aged 1 to 3 years consumes more than their entire daily energy requirement from snacks and the equivalent of two days’ energy requirement from drinks. Consistent with evidence that snacks can contribute around one-quarter (or more) of daily energy intake in young children, a daily portion of energy-dense sweet snacks may substantially increase total energy intake beyond requirements [38]. If a child's daily fluid requirement is met with juice or another sugary drink instead of water, these values are even higher. Evidence shows that sugar-sweetened beverages add “empty” calories and replacing them with water can reduce total energy intake in children [39]. If a child already meets their daily needs from more complete energy sources, snacks and sugary drinks represent additional energy that can lead to overweight and obesity in the long term [40].

Early consumption of 100 % juice has been associated with higher intakes of 100 % juice and sugar-sweetened beverages (SSBs) in early and middle childhood compared to those consuming no juice at all [41]. Longitudinal studies show that early or higher juice consumption can lead to increased juice intake later, supporting the idea that daily juice can become a habit and raise energy intake from drinks [42]. Unlike whole foods, juice and SSBs provide calories without eliciting comparable satiety signals. As a result, high sugar intake in infancy and childhood not only increases the risk of dental caries, obesity and metabolic diseases later in life, but can also displace nutrient-rich foods in the diet, which can affect overall diet quality [1,20,35].

Fat content in samples

Adequate fat intake in the diets of infants and toddlers is essential, as fats are an important source of essential fatty acids and energy during the first year of life. However, excessive intake (over 50 % of total energy) can lead to an unbalanced and unvaried diet [10].

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In the study, we obtained the fat content from the sample label for each sub-category and then calculated the average fat content. For each sub-category, we indicated the range of minimum and maximum fat content. For the category “Juices and other drinks” and the subcategory “Confectionery, sweet spreads and fruit chews”, there are no limits for fat content, as these should not be marketed as suitable for infants and toddlers up to 36 months according to the draft WHO nutrient profile model (2019). Therefore, we did not assess the fat content for these (sub)categories. For most subcategories, the upper limit for fat content is 4.5 g/100 kcal. We marked subcategories 2.5 and 2.8 with an asterisk, as these two subcategories have a different upper limit for fat content, namely 6 g/100 kcal. As shown in Fig. 2, all samples from all categories met the fat content thresholds indicated in the draft WHO nutrient profile model (2019), indicating that they would be considered suitable for feeding infants and toddlers up to 36 months according to these draft criteria. The highest fat content was observed in subcategory 2.8, which includes products with ingredients naturally higher in fat, such as meat, fish, and cheese. On average, the lowest fat content is found in the samples of subcategories 2.2 “Pureed fruit with or without added vegetables, cereals and milk”, 2.3 “Pureed vegetables” and 4.2 “Fruit (fresh or dried whole fruit or slices)”, whose products contain ingredients that naturally have less fat. This is consistent with other evaluations using the WHO Nutrient and Promotion Profile Model (NPPM) which typically report high compliance with fat criteria (98 %), in contrast to lower compliance for sugar or sodium [43].

Sodium content in samples

As with the assessment of fat content, the category 5 and the subcategory 4.1 were excluded from the assessment of sodium content, as these products are not intended to be marketed for infants and toddlers according to the draft WHO nutrient profile model (2019). Therefore, no sodium thresholds are provided for them. The draft model proposes two indicative criteria for sodium content in CACFs: milligrams per 100 grams and milligrams per 100 kcal. Compliance with both thresholds is used here to assess alignment with the draft recommendations. For most subcategories, the upper limit for sodium is 50 mg per 100 g and 50 mg per 100 kcal. Products in subcategories 2.5 and 3.2, which contain cheese, are an exception. Here, the upper limit is 100 mg per 100 g and 100 mg per 100 kcal. These two categories are shown in Fig. 3 on the far right and marked with an asterisk.

The prevalence of added salt varied significantly across product categories ($p < 0.001$). Products labelled for infants aged 6 months and older were more likely to contain added salt than those labelled for under 6 months ($p = 0.028$). However, sodium content was not a statistically significant predictor of age labelling in multivariable analysis.

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Nine (3.7 %) CACFs contained added salt and belonged to the following food subgroups: most samples (three) were from the subcategory meat, fish or cheese-based meals with chunky pieces; two samples were from vegetable-based meals with chunky pieces; and one sample each was from the following subgroups: dry or instant cereals/starch, pureed vegetables and cereals, pureed meals with meat or fish, and other snacks and finger foods. Our results were comparable to those of a study conducted in New Zealand, which found that only a few ($N=10.5$ %) CACFs in this market contained added salt [1]. However, Kök Şan and Gökçay [21] found that 1 in 10 products contained added salt ($N=18$, 9.5 %). A similar pattern has also been observed outside Europe and Oceania. Analyses of infant and toddler foods in the United States have shown that many products – particularly fruit-, vegetable- and cereal-based categories – are low in sodium, with higher sodium levels largely limited to specific savoury meal subgroups. Overall, these findings suggest that added salt is relatively uncommon in CACFs, but when present, it tends to be concentrated in meat- or fish-based meals and more textured foods, rather than in pureed fruit or cereal products [27].

Two limit values are highlighted on the graph for each subcategory (Fig. 3). The left value shows the average sodium content, with minimum and maximum values per 100 g, while the right value shows the average sodium content, with minimum and maximum values per 100 kcal. The sodium content of all products in subcategories 2.5, 2.6, and 2.8 is below the upper limit for both thresholds (per 100 g and per 100 kcal). This indicates that the sodium content of all products in these categories complies with the draft WHO nutrient profile model (2019) recommendations for CACFs. In contrast, subcategories 3.1 and 3.2 have average sodium content values that exceed the upper limit. The minimum and maximum values for these two subcategories indicate that all products in these subcategories exceed the draft WHO nutrient profile model (2019) thresholds for sodium, showing non-alignment with the model's recommendations. These subcategories also contain the most products with added salt. For some subcategories (namely 1.1, 2.1, 2.2, 2.3, 2.4, 2.7, 4.2, and 4.3), the average values are below the upper limits, while the maximum values exceed these limits. If the average values are below the limits, this indicates that most products in these subcategories comply with the draft WHO nutrient profile model [16]. Although the average values for many subcategories are below the upper limit, products should contain less than 50 mg and 100 mg sodium per 100 g and per 100 kcal, respectively, according to the draft WHO nutrient profile model [16], so not all samples can be considered suitable for the nutrition of infants and toddlers up to 36 months.

Some results of our study are comparable to the findings of Kök Şan and Gökçay [21], who reported that fruit and vegetable first foods represented the subgroup with the highest proportion of commercially available complementary foods meeting the sodium composition thresholds proposed

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in the draft WHO nutrient profile model [16]. Similarly, in our analysis, fruit and vegetable-based products (subcategories 2.2 and 2.3) had the lowest average salt content per 100 g of product (Fig. 3). However, as mentioned above, not all samples within these subcategories complied with the draft model's recommended limits. Despite the favourable average values, these results highlight the potential need for additional regulatory measures and continuous monitoring of sodium content at the individual product level to support the suitability of CACFs for infant and young child feeding.

High salt intake during infancy is associated with higher systolic blood pressure in childhood [44]. In this context, sodium levels in commercially available infant foods may be relevant to public health. National authorities and food manufacturers could play an important role in minimising unnecessary early exposure to salt, which might contribute to the development of a long-term preference for salty foods and increase the risk of non-communicable diseases later in life [21].

Strengths and limitations

A major strength of this study is its comprehensive market coverage, achieved by including domestic and international branded products, as well as manufacturers' own brands available in major retail chains and speciality shops throughout Slovenia. This approach ensured a solid representation of the CACFs accessible to Slovenian consumers. In addition, the study provides important insights into the current state of labelling and nutritional composition and highlights areas where regulatory oversight could be improved. However, the study is subject to several limitations that should be considered when interpreting the results, although these are unlikely to significantly affect their representativeness or overall validity. First, the nutrient composition data are derived from product labelling rather than chemical laboratory analysis, so the actual nutrient content may differ from the stated values. Nevertheless, reliance on label information reflects the real-life context in which consumers make purchasing decisions based solely on packaging information. Second, the analysis of dry cereals may not accurately reflect actual nutrient intake, as the nutrient values were given per 100 g of product reconstituted with water, infant formula, or breast milk, depending on the manufacturer's instructions. Third, cow's milk and milk alternatives with added sugar or sweetening agents were excluded from this study, limiting the completeness of the assessment.

Importantly, our evaluation is based on the draft WHO nutrient profile model (2019), not a final, officially approved standard. While thresholds for fat content and age-appropriateness are consistent between the draft and final model – so these aspects of our findings are unlikely to be affected – there are notable differences in other areas. For example, CACFs are classified into five product groups in the draft model, compared with eight groups in the final version, meaning some products in our study

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would probably not fall into the same categories under the official model. Sodium thresholds are also defined differently: the draft model specifies two limits, per 100 g and per 100 kcal, while the final model applies a single limit per 100 kcal (maximum sodium content 50 mg/100 kcal (or 100 mg if cheese is in the product name)). Therefore, our results should be interpreted as alignment with the draft model rather than compliance with the officially approved WHO standard, and some products that appear suitable under the draft may not fully meet the criteria in the final model, and vice versa.

CONCLUSIONS

This study presents a comprehensive overview of the nutritional composition and labelling characteristics of commercially available complementary foods (CACFs) on the Slovenian market with particular focus on their alignment with the draft WHO nutrient profile model (2019). The findings indicate that a considerable proportion of CACFs contain added sugars or ingredients with sweetening properties, and that some product subcategories exceed recommended sodium thresholds. While many products complied with WHO criteria for specific nutrients (e.g. fat), compliance was less consistent for sugar-related components and, in some cases, sodium content. These results suggest variability in the nutritional quality of CACFs currently available on the market. In addition, a significant proportion of products were labelled as suitable for introduction before 6 months of age, which does not align with the draft WHO nutrient profile model (2019), potentially undermining breastfeeding and contributing to the early introduction of nutritionally inappropriate foods.

The findings highlight the importance of continued monitoring of CACFs, particularly regarding sugar content, sodium levels, and age-related labelling. Future research should examine how these product characteristics relate to actual consumption patterns, caregiver decision-making, and potential health outcomes in infants and young children.

From a broader public health perspective, multiple stakeholders may support optimal infant and young child feeding practices. Paediatricians should provide evidence-based guidance on complementary feeding; parents and carers need to be empowered to read labels critically and prioritise home-made, varied and nutritious foods; and policy makers need to introduce and enforce more comprehensive standards for the composition, labelling and marketing of products.

Reducing the availability of products high in sugar and salt and creating a healthier food environment are essential steps towards supporting optimal child development. Ensuring the nutritional quality and appropriate marketing of complementary foods is therefore not only a policy imperative, but also an investment in the health of future generations.

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CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

AUTHORS' CONTRIBUTION

T. Prevc was responsible for data curation and writing the original draft and contributed to the review and editing of the manuscript. M. Gabrijelčič Blenkuš contributed to conceptualisation and methodology, performed data curation, and participated in the review and editing of the manuscript. S. Nartnik was involved in methodology development, formal analysis, and data curation. I. Rumora Samarin contributed to the formal analysis, review and editing of the manuscript and was responsible for visualisation. T. P. Žontar led the conceptualisation and methodology, wrote the original draft, contributed to the review and editing of the manuscript, and prepared the visualisations. All authors have read and agreed to the published version of the manuscript.

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Table 1. Number of commercially available complementary foods (CACFs), stratified by food categories ($N=241$), according to the recommended age (in months) stated on the label)

Food category	Age (months)									TOTAL
	1 st group	2 nd group							3 rd group N/A (age)*	
	4 m+	5 m+	6 m+	7 m+	8 m+	10 m+	12 m+	36 m+		
1. Dry, powdered and instant cereal/starchy food	5 (17 %)	7 (24 %)	10 (34 %)	0	4 (14 %)	0	2 (7 %)	0	1 (3 %)	29 (100 %)
1.1 Dry or instant cereals/starch	5	7	10	0	4	0	2	0	1	29
2. Soft-wet spoonable, ready-to-eat foods, typically smooth or semi-pureed packaged in jars or pouches and can be spoon-fed	36 (23 %)	35 (22 %)	43 (28 %)	1 (1 %)	13 (8 %)	3 (2 %)	23 (15 %)	0	2 (1 %)	156 (100 %)
2.1 Dairy-based desserts and cereal products	3	2	8	0	2	1	0	0	0	16
2.2 Fruit purée with or without addition of vegetables, cereals or milk	21	23	30	1	6	2	16	0	2	101
2.3 Vegetable only purée	6	2	0	0	0	0	0	0	0	8
2.4 Puréed vegetables and cereals	0	0	1	0	1	0	3	0	0	5
2.5 Puréed meal with cheese (but not meat or fish) mentioned in the name	0	0	0	0	1	0	1	0	0	2

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2.6 Puréed meal with meat or fish mentioned as first food in product name	0	2	0	0	0	0	0	0	0	2
2.7 Puréed meals with meat or fish (but not named as the first food in product name)	5	3	4	0	3	0	3	0	0	18
2.8 Purées with only meat, fish or cheese in name of product	1	3	0	0	0	0	0	0	0	4
3. Meals with chunky pieces, often sold in trays or pots for older infants and young children	0	0	0	0	0	0	5 (100 %)	0	0	5 (100 %)
3.1 Meat, fish or cheese-based meal with chunky pieces	0	0	0	0	0	0	3	0	0	3
3.2 Vegetable-based meal with chunky pieces	0	0	0	0	0	0	2	0	0	2
4. Dry finger foods and snacks	0	0	2 (3 %)	1 (3 %)	9 (23 %)	0	20 (50 %)	3 (8 %)	5 (13 %)	40 (100 %)
4.1 Confectionery, sweet spreads and fruit chews	0	0	0	0	0	0	15	0	0	15
4.2 Fruit (fresh or dry whole fruit or pieces)	0	0	0	0	0	0	1	2	1	4
4.3 Other snacks and finger foods	0	0	2	1	9	0	4	1	4	21
5. Juices and other drinks	8 (73 %)	1 (9 %)	1 (9 %)	0	0	0	0	0	1 (9 %)	11 (100 %)

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5.1 Single or mixed fruit juices, vegetable juices, or other non-formula drinks	8	1	1	0	0	0	0	0	1	11
TOTAL	49	43	56	2	26	3	50	3	9	241 (100 %)

(N/A (age)=not available)

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Table 2. Sugar content and energy value of products that should not be marketed as suitable for infants and toddlers up to 36 months due to their added sugar content and that meet the daily and monthly energy requirements of toddlers

Food category (number of samples)	Sugars (g/100 g) $\bar{x} \pm SD$	Energy value of a portion of sugar (kcal/30 g or 250 mL) ¹ $\bar{x} \pm SD$	Covering the daily energy intake of an infant with sugar (%) ² $\bar{x} \pm SD$	Energy consumed from sugar in one month (kcal) ³ $\bar{x} \pm SD$
4.1 Confectionery, sweet spreads and fruit chews (N=15)	42±6	50±7	4±0.5	1516±218
5. Juices and other drinks (N=11)	9±3	86±25	7±2	2577±755

¹The energy value of sugar is calculated per average product portion (30 g for sweet snacks, sweet spreads, fruit bars and 250 mL for juices and other drinks)

²The percentage of daily energy intake was determined using a cross-calculation, considering that children aged 1 to 3 years need 1200 kcal/day [37]

³The monthly energy intake was calculated by multiplying the energy value of sugar per portion (30 g/250 mL) by the number of days in the month (30)

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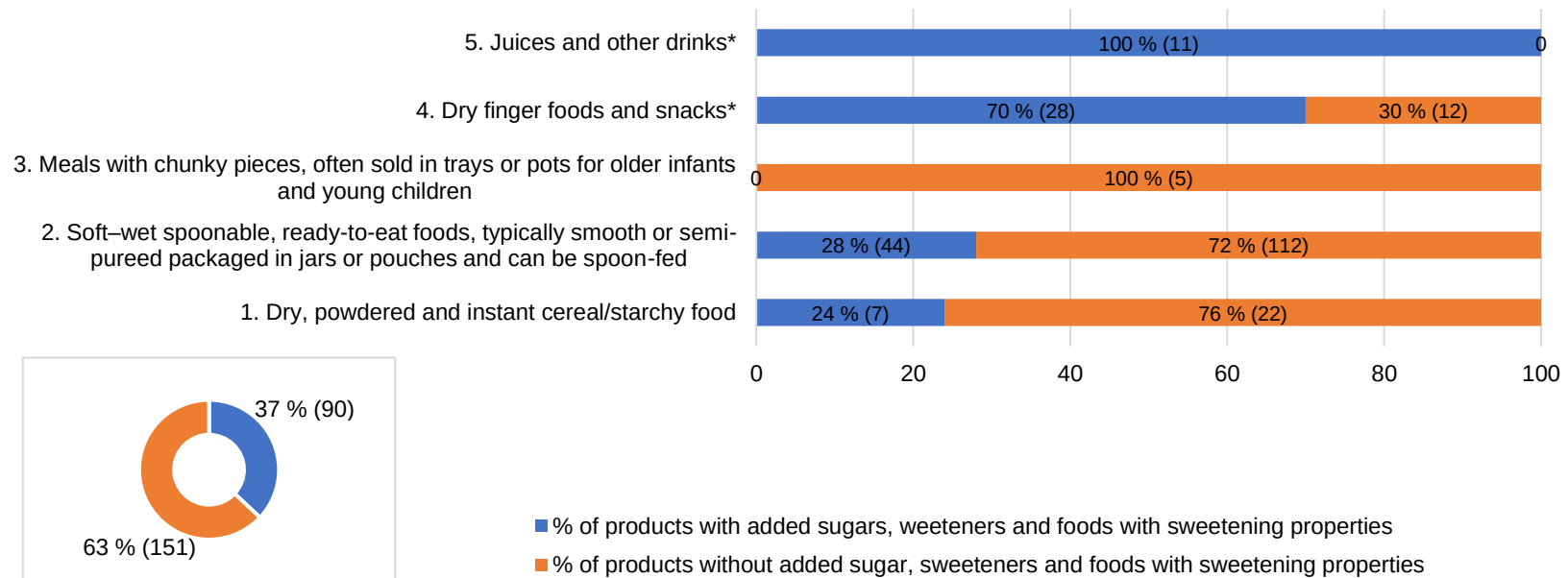


Fig. 1. The percentage of samples with and without added sugars, sweeteners, or sweetening ingredients (pie chart). Bar chart shows this breakdown by category. Categories marked with an asterisk (*) include products not recommended for children under 36 months [16]

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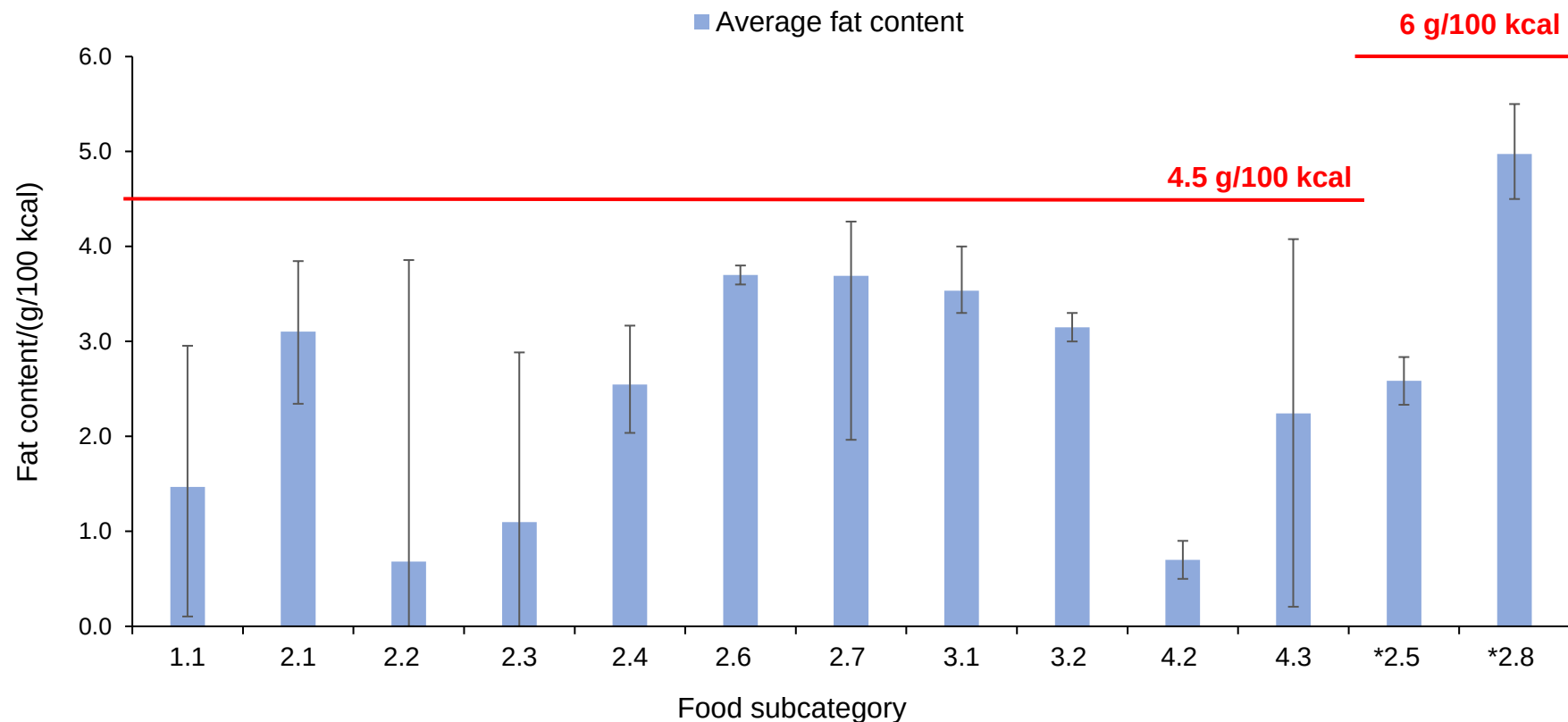


Fig. 2. Average fat content in products of food subcategories listed in [Table 1](#). The thick red line indicates the limit value per 100 kcal of the product

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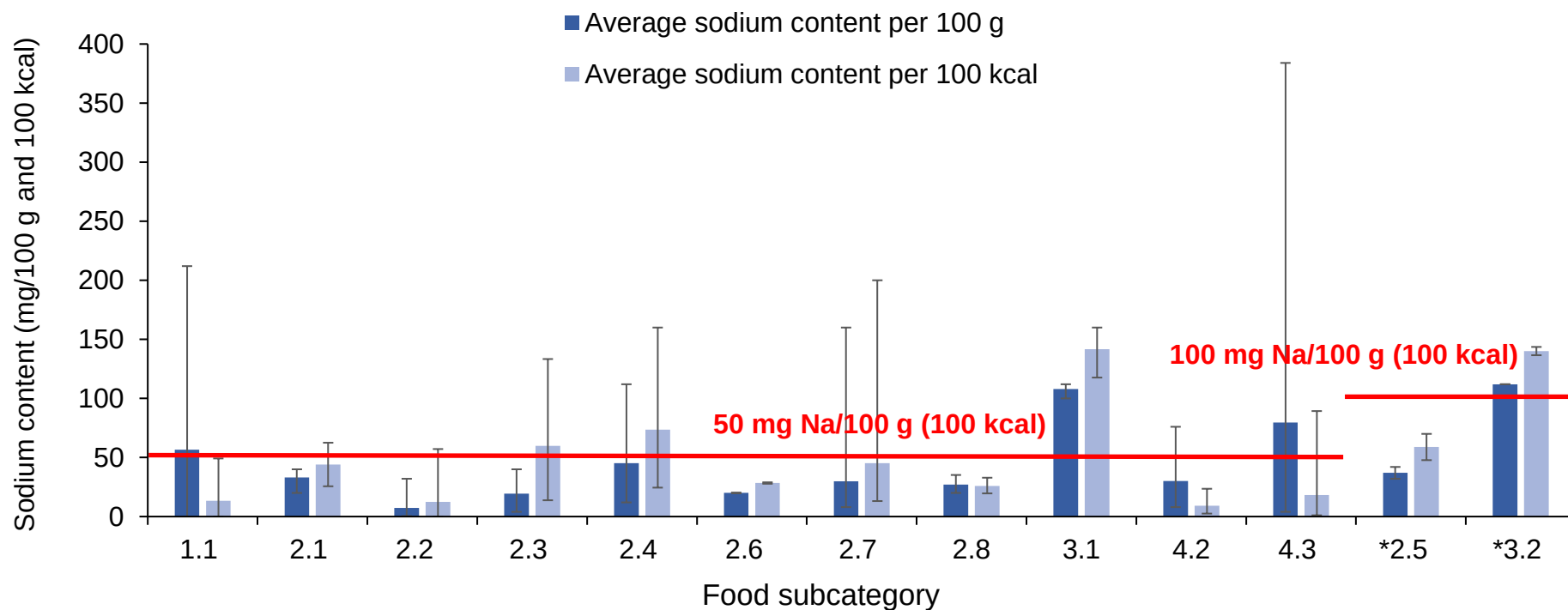


Fig. 3. Sodium content in products of food subcategories listed in [Table 1](#). The thick red line indicates the limit value per 100 kcal and 100 g of the product