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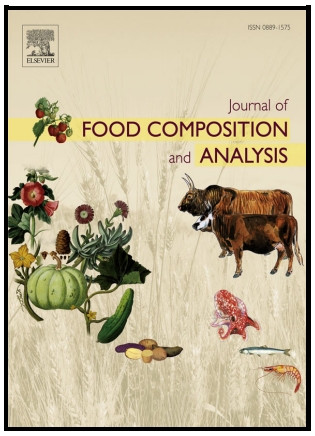

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Packaged foods containing non-nutritive sweeteners also have high added sugar content: a Brazilian survey

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Abstract

This study investigated the use of added sugars and non-nutritive sweeteners (NNS) in 4,805 packaged foods (including non-alcoholic beverages) sold in a major supermarket in Brazil. The ingredient lists of all products were searched for the presence of added sugars and NNS. The added sugar content was estimated and compared between products containing added sugar, with and without NNS. Using criteria set by the new Brazilian food label rules, we determined whether foods with added sugars and NNS were classified as “high in added sugar”. Most products (66.7%) contained at least one type of sweetener (added sugars or NNS). Of the products containing NNS (n

= 597), 81.5% also contained added sugar. Products containing both NNS and added sugar ingredients showed a lower overall added sugar content than products containing added sugars only. However, for a few food categories (chocolates, dairy and non-dairy dessert mixes and candies), the added sugar content did not differ significantly between products with and without NNS. Sixty-three percent of products containing both added sugar and NNS were classified as "high in added sugar".

Keywords:

sweeteners; sugars; processed foods; food label; food composition; food labelling.

1. Introduction

In Brazil, 56% of adults (≥18 years) are overweight and 20% are obese (Ministry of Health of Brazil, 2019). High intakes of added sugars – defined as sugars and syrups added to foods by the manufacturer, cook or consumer (Food and Drug Administration, 2014; Scapin et al., 2017) – have been associated with an increased risk of obesity (Ruanpeng et al., 2017) and other non-communicable diseases (NCDs) (Malik, 2017; Khan et al., 2019). Because of this, health guidelines recommend limiting intakes of added sugars (Erickson & Slavin, 2015). The World Health Organization (WHO) recommends that intakes of free sugars (added sugars plus sugars naturally present in honey, syrups, and fruit juices) should be less than 10% of total energy intakes, with a further recommendation of less than 5% for oral health benefits (World Health Organization, 2015). In Brazil, added sugar intakes exceed these recommendations, since adolescents and adults consume 15% and 13% of energy from added sugar, respectively (Monteiro et al., 2020).

Growing concerns over added sugar consumption has led to the development of a range of policy actions to reduce added sugar intakes, including food reformulation (Russell et al., 2020). This has resulted in the increased availability of foods that contain non-nutritive sweeteners (NNS; also known as low-calorie sweeteners and artificial sweeteners), which are substitutes for sugars

that contain little to no calories but still impart sweetness when added to a product (Fujimaru et al., 2012; Food and Drug Administration, 2018; Hutchings et al., 2019).

The safety of some NNS to be used in foods have been determined by regulatory bodies based on the establishment of acceptable daily intakes (European Food Safety Authority, 2011; Food and Drug Administration, 2018). However, the type and amount of NNS approved for use, and the products to which they can be added, varies between countries. In the US, for example, the Food and Drug Administration (FDA) has approved six types of NNS for use in the food supply (Food and Drug Administration, 2018). In Brazil, the Brazilian Health Regulatory Agency (*Agência Nacional de Vigilância Sanitária – ANVISA*), which is responsible for determining which NNS are permitted for use in food and beverages, has currently approved fifteen types of NNS: acesulfame potassium, sucralose, aspartame, sorbitol, cyclamate, saccharin, maltitol, stevia, isomalt, mannitol, lactitol, xylitol, neotame, erythritol and thaumatin. However, for eight of them (sorbitol, isomalt, mannitol, maltitol, lactitol, xylitol, erythritol, thaumatin), the maximum limit of use is declared as '*quantum satis*', which means food manufacturers can decide the maximum limit of use (Brazilian Health Regulatory Agency, 2008). In addition, there is no obligation for food manufacturers to declare the amount of NNS used in their product on the food label. According to Brazilian food labelling regulation, any food additives – including NNS – should be declared at the end of the ingredient list, regardless of the amount used (Mercosur, 2003).

While use of NNS can help to significantly reduce the sugar content of products (Dunford et al., 2018), there are still many concerns about the use of NNS. These include evidence suggesting that NNS intakes can impact the gut microbiota and cause neuroendocrine effects (Toews et al., 2019; Deo et al., 2020; Moriconi et al., 2020), the low methodological quality of current evidence demonstrating potential health benefits of NNS intake (Toews et al., 2019), and conflict of interest with the food industry declared in studies about NNS (Mandrioli, Kearns & Bero, 2016). Also, there is inconclusive evidence of very low certainty regarding the effects of NNS consumption in people with diabetes (Lohner et al., 2020), target population for which the use of NNS is frequently

recommended. Although information on the use of NNS at national levels is still limited, some evidence suggests that NNS are frequently consumed in the diet (Tennant, 2019; Dunford et al., 2020), particularly in Central and South America (Agúero et al., 2015).

Prior studies have explored the prevalence of NNS use (Probst et al., 2017; Figueiredo et al., 2018; Chazelas et al., 2020) and have estimated added sugar levels in packaged foods (Bernstein et al., 2016; Acton et al., 2017; Scapin et al., 2018; Zupanic et al., 2018). Findings demonstrated that NNS are not always used to replace the sugar content of sweetened foods entirely; rather, they are often used to replace some of the added sugar ingredients (Dunford et al., 2018; Samaniego-Vaesken et al., 2018). However, no studies to date have looked at NNS and added sugar used together in packaged foods sold in Brazil. Such research would help to understand the extent to which NNS are replacing added sugars in the Brazilian food supply, which is particularly important considering Brazil has the second-highest production and the fourth highest consumption of sugar in the world (International Sugar Organisation, 2020). In addition, Brazil's Ministry of Health has recently approved, in October 2020, new labelling rules that will make it mandatory for manufacturers to indicate if their product has a "high added sugar" content (Brazilian Health Regulatory Agency, 2020). Because of this, it is expected that some food manufacturers will reduce the added sugar content of their products by replacing some of the added sugars with NNS. Obtaining baseline data about use of NNS and added sugars in Brazil is necessary to monitor potential changes when these new labelling rules come into effect by end of 2023.

Within this context, this study aimed to: (a) investigate the presence of NNS, added sugars, or both components in products sold in Brazil; (b) estimate and compare the added sugar content of products with both components and with added sugar only; and (c) apply the approved Brazilian food label criteria for foods with a "high added sugar" content.

2. Methods

2.1 Study Design and Data Collection

This cross-sectional study analysed information of 4,805 packaged foods available for sale in a major supermarket in Brazil in 2013. The supermarket was chosen because it belongs to one of the largest supermarket chains in the country (Brazilian Association of Supermarkets, 2013). Food brands sold in the store are well-known and commonly found in other large supermarkets throughout Brazil. Data was collected through an in-store audit, and all packaged food products (including national and own-supermarket brands) subject to Brazilian and Mercosur Food Labelling Regulation were included (Mercosur, 2003). Information was collected for each product including product name, nutrition information, serving size and ingredients. Additional details of data collection are reported elsewhere (Rodrigues et al., 2016; Scapin et al., 2018). During analyses, foods and beverages were classified into seven major groups and further divided into 32 minor categories according to their nutritional composition based on the Brazilian and Mercosur resolution (Mercosur, 2003). This is similar to other food system classifications previously reported in the literature (Ng et al., 2012; Bernstein et al., 2016; Zupanic et al., 2018).

2.2 Identification of NNS and Added Sugar Ingredients

The ingredient lists of all foods were searched for the presence of NNS and added sugars. Terms for NNS were determined as stated in the Brazilian food label rule (Brazilian Health Regulatory Agency, 2008), while the terms for added sugars were compiled from a previous study (Scapin et al., 2018). A list of all sweeteners and added sugar ingredients included in the analysis is provided in Supplementary Tables S1 and S2. Products were then classified as (1) containing only added sugar ingredients, (2) containing only NNS, (3) containing a combination of both or (4) containing neither component. In addition, we identified the most prevalent type of NNS in each food category. The purpose of the NNS use in the food (e.g., sweetness agent, flavour enhancer, stabilizer) was not evaluated in this study as the intention was to identify the presence or not of NNS regardless their technological purpose of use.

2.3 Determining the Added Sugar Content of Products

Brazilian food manufacturers are not currently required to display the added sugar content (nor total sugar) on the nutrition information panel (NIP) of their products. For this reason, we applied a validated 8-step systematic methodology (Scapin et al., 2021) to estimate the added sugar content (g / 100g or 100ml) of foods and beverages. Briefly, this methodology uses the ingredient list, the total sugar content (where voluntarily displayed) and the carbohydrate content of foods. The 8-steps consist of objective estimations (three steps) and more subjective estimations (five steps), which are applied where objective data is not available. We were unable to calculate the amount of NNS contained in foods as this information is not provided on the NIP (rather NNS are listed at the end of the ingredient list regardless of the amount used) and no estimation methods are currently available to estimate NNS content using food label information. Because of this, we have only determined the number of different NNS types used in individual products.

2.4 Identifying "High in Added Sugar" Products

To put into context how much the added sugar content of products containing NNS and added sugar ingredients represents compared with the new "high in added sugar" food label rule approved for use in Brazil (Brazilian Health Regulatory Agency, 2020), we calculated the proportion of products that met this "high in added sugar" criteria. For foods, a product is "high in added sugar" if the added sugar content (g) is equal to or more than 15 g per 100 g. For beverages, a product must have an added sugar content equal to or more than 7.5 g per 100 g to be classified as "high in added sugar".

2.5 Statistical Analysis

The proportion of products containing NNS, added sugar, both, or neither components were determined using descriptive statistics and are presented overall and by food category. For foods containing added sugar only and foods containing both added sugars and NNS, the added sugar content [mean, standard deviation (SD), median and quartiles (25th and 75th)] was estimated and expressed as grams per 100 grams (g/100 g) or 100 ml (g/100 ml) by minor food category.

Comparative analyses on the added sugar content of products containing added sugars only and products containing both added sugar and NNS were performed using Mann-Whitney or independent sample t-tests with the significance level set at $p < 0.05$.

For products containing both NNS and added sugars, the proportions of "high in added sugar" products were presented across each of the minor food categories (subgroups). Median numbers of NNS types across each minor food category and overall were calculated (minimum and maximum). Statistical analyses were performed using Microsoft Excel 2016 (Redmond, WA, USA) and R software version 3.6.2 (R Foundation for Statistical Computing, Vienna, Austria).

3. Results

Of the 4,805 packaged foods analysed, 66.7% (*n* = 3,203) contained at least one type of added sugar or NNS. Of the total sample, 110 (2.3%) products contained only NNS, 2,606 (54.3%) contained only added sugar ingredients, 487 (10.1%) contained both ingredients, and 1,602 (33.3%) contained neither ingredient (Figure 1 and Table 1). Of the 3,093 products containing added sugar, 15.7% (*n* = 487) also had NNS ingredients. By comparison, of the 597 products containing NNS, 81.5% (*n* = 487) also had added sugar ingredients. Analyses by major food category demonstrated that the sugary products category, which contained foods including biscuits and soft drinks, had the highest proportions of products with added sugar, NNS, and both components. Processed fruits and juices had the second highest proportion of products with added sugars, although bakery goods and related products had the second highest proportion of products with both added sugars and NNS. Surprisingly, processed meats and seafood, which are foods that are not traditionally associated with the presence of sweeteners, had the third highest proportion of products containing added sugar ingredients (Figure 1), primarily due to the use of sugar ingredients in burgers and sausages.

[Insert Table 1 and Figure 1 around here]

Across the 32 minor food categories (subgroups), only two categories (minimally processed vegetables and oils and milk creams) had neither NNS or added sugar ingredients in any of their products. Twenty-one food categories had at least one product with both NNS and added sugars. The highest proportions of products containing NNS and added sugars were found for non-dairy dessert mixes (68.9%), coffee mixes and powdered drinks (65.6%), soft drinks (39.4%), cakes (38.0%), cereal bars (33.8%), and dairy dessert mixes (23.5%) (Table 1).

Across the 21 food categories with products containing NNS, 487 products had both NNS and added sugar ingredients. For these products, the overall median added sugar content per 100 g/ml was 26.7 g (IQR 5.6–64.5). Food categories with the highest median added sugar content included coffee mix and powdered drinks (78.6 g, IQR 71.7 – 85.0), non-dairy dessert mixes (66.2 g, IQR 26.7 – 70.5) and chocolate (62.7 g, IQR 54.9 – 66.5), with more than 50% of the product weight as added sugars (Table 2). Across these food categories, a total of 1,889 products contained added sugar only, and the overall median added sugar content was 30.7 g (IQR 12.0 – 55.8) per 100g or 100 ml. Our analyses comparing the added sugar content of products containing added sugar with or without NNS demonstrated that, overall, products with NNS had a significantly lower added sugar content. Food categories for which products containing NNS and added sugars had a lower median added sugar content than without NNS included: cakes (30.2 g vs. 38.1 g), cereal bars (26.5 g vs. 33.0 g), baby food and formulas (15.2 g vs. 52.5 g), biscuits (13.0 g vs. 31.6 g), popsicles and ice creams (12.9 g vs. 23.0 g), jams (7.8 g vs. 60.9 g), fruit juices (4.5 g vs. 12.5 g), dairy drinks and yogurts (4.4 g vs. 10.5 g), soft drinks (4.4 g vs. 10.5 g), breakfast cereals (3.8 g vs. 28.5 g), and breads (2.6 g vs. 5.3 g). There were no differences in the added sugar content for four food categories: non-dairy dessert mixes, dairy dessert mixes, chocolates and candies. However, there were no differences in the added sugar content for four food categories: non-dairy dessert mixes, dairy dessert mixes, chocolates and candies. Moreover, for the coffee mixes and powdered drinks category, the added sugar content of the products containing added sugar and NNS was significantly higher than for products with added sugar only. In addition, this same food category

plus the non-dairy dessert mixes group had more products with both added sugars and NNS ingredients than products with added sugars only, a different pattern from the other food groups (Table 2).

[Insert Table 2 around here]

Overall, the median number of different NNS used in products containing added sugar was two, ranging from one to six. Fifty-eight per cent (*n* = 280) of the 487 products with both added sugars and NNS had at least two types of NNS in each product. The most commonly used NNS overall was acesulfame-k followed by sorbitol, but this varied according to the minor food category (Table 3). Erythritol and thaumatin were not detected in any products analysed in this study, while neotame and xylitol were detected in less than five products. In terms of the Brazilian criteria for front-of-package warnings, 63.0% (*n* = 307) of the 487 products with both NNS and added sugar were regarded as "high in added sugar" (Table 3). For the 21 food categories with added sugar and NNS ingredients, 12 have more than 50% of their products with a "high added sugar" content.

[Insert Table 3 around here]

4. Discussion

This study found that approximately two-thirds of packaged foods available for sale in a Brazilian supermarket in 2013 contained some type of sweetener. These results are in line with data from Canada (Acton et al., 2017), Australia (Probst et al., 2017), and Mexico (Dunford et al., 2018). Overall, about 10% of products contained both added sugars and NNS, which is twice as many as previous studies, including a retrospective study that analysed the US food supply from 2005 to 2009 (6%) (Ng et al., 2012), a study from Spain using data from 2013 (5.1%) (Samaniego-Vaesken et al., 2018), and a study from New Zealand with data collected in 2016 (1.4%) (Dunford et al.,

2018). Consistent with these prior studies and a recent review on trends of NNS use worldwide (Russell et al., 2020), we found that products containing added sugars and NNS were more commonly found in the dessert, non-alcoholic beverage, and bakery categories.

Our study also found that among products containing both added sugar and NNS, almost 60% contained at least two types of NNS, and the most commonly used NNS overall was acesulfame-K. Our study also found that among products containing both added sugar and NNS, almost 60% contained at least two types of NNS, and the most commonly used NNS overall was acesulfame-K. In general, for food categories in which acesulfame-k was the most frequently used NNS, products had a greater number of different NNS combinations compared to when sucralose or sorbitol were the primary NNS used. This finding is similar with the outcomes of previous analyses in Chile and Slovenia (Sambra et al., 2020; Hafner et al., 2021). A recent review examining global intakes of NNS noted that in some populations, intakes of acesulfame-K exceeded the acceptable daily intake (Martyn et al., 2018), which can be partially attributed to intakes of packaged foods. Originally, NNS were developed as a sugar substitute, targeted for people who experience issues metabolising sugars, such as people with diabetes (Inglett, 1976). However, following the trend of consumers seeking lower-sugar and lower-calorie foods products (Ramachandran et al., 2018), manufacturers are increasingly substituting added sugars with NNS to reduce both the total sugar content and calorie content of their products (Edwards et al., 2016; Sylvetsky & Rother, 2016; Luo et al., 2019). Our study also found that a greater proportion of products contained both added sugar and NNS, rather than NNS only. Considering people usually have a lower acceptance for NNS due to the residual bitterness (Kamerud & Delwiche, 2007), it is possible that manufacturers are choosing to use a mix of added sugar and NNS to reduce calories while still maintaining palatability.

According to the Pan-American Health Organization, the use of sweeteners in food products is not recommended and either NNS presence or excessive addition of sugars should be clearly labelled on pack (Pan American Health Organization, 2016). The findings from this study showed

that 63% of products that contained both NNS and added sugar met the "high in added sugar" classification according to the new Brazilian food label rules, even though many contained two types of NNS. Although the added sugar content of products containing both NNS and added sugar was significantly lower than products with added sugars only, the use of NNS had not created products with low added sugar content as most of them are still considered "high in added sugars". Additionally, for some food categories, products with both added sugar and NNS had a similar added sugar content to products with added sugars only, which, again, indicates that use of NNS is not helping to achieve meaningful reductions in the added sugar content. It is relevant to mention that the food categories with largest content of added sugar included powdered mix products, which requires further preparation (e.g., reconstitution with water or milk) before consumption. These powdered mix products had around 50% of their dry weight from added sugars, which is considerably higher than ready-to-eat products, such as cakes and cereal bars, with around 30% of their weight from added sugars. Thus, the added sugar content consumed from these powdered products might be lowered after their preparation, and probably similar to ready-to-eat products' sugar content. The identification of both NNS and sugars on the labels of packaged foods can be challenging for consumers. In the case of NNS, they are only mentioned as a food additive at the end of the ingredient list and are typically reported using unusual or confusing names, such as acesulfame-k. As such, many consumers do not recognise these names and therefore they are often unaware they are consuming NNS (Tierney et al., 2017). In fact, previous research conducted in the US found that only one in four adults correctly identified packaged foods containing NNS (Sylvetsky et al., 2014). However, it is important that consumers are able to identify NNS in foods, particularly as exposure to these sweeteners during early development may influence sweet taste preferences, increasing the motivation to consume sweet foods (Yunker et al., 2020). In a recent paper from Chile, all children included in the study (n = 250) had consumed at least one NNS during the previous month of life (Martínez et al., 2020). In our study, although the proportion of baby food and formulas containing NNS was small (3.8%, n = 3), many food categories containing

high proportion of products with NNS, such as cakes, dairy drinks, and candies, are frequently eat by children in Brazil (Vieira-Ribeiro et al., 2019). Similarly, in an analysis of food products sold in Chile, researchers found that more than 90% of the products in food categories usually oriented to children (powder juices, jellies, and flavoured milks) had at least one type of NNS in their composition (Sambra et al., 2020). Considering the potential health risks of the early-life exposure to NNS, the European Union prohibits the use of these sweeteners in infant's and children's foods (The European Parliament and of the Council of the European Union, 2013).

In the case of sugars, the only way for consumers to currently identify whether or not a product contains added sugars is to look at the list of ingredients; which relies on consumers' knowledge of the added sugar terms. In Brazil, a study found more than 170 different names for added sugars presented on the ingredient lists of packaged foods (Scapin et al., 2018). Moreover, a study in the UK which surveyed 445 adults found that only 4% of participants correctly identified ten or more added sugars from a list of 13 added sugar ingredients, and 50% of participants failed to identify unfamiliar names of sugars, such as invert sugar (Tierney et al., 2017). In Brazil, there is a strong need to change food label legislation in order to improve the identification of added sugars and NNS in foods. To date, the US is currently the only country that has enforced the declaration of added sugars on the NIP (Food and Drug Administration, 2016). Although Brazil has recently approved the inclusion of this information on the NIP, food manufacturers have 24 to 36 months (depending on the food manufacturer category) before they are required to comply with these new labelling rules (Brazilian Health Regulatory Agency, 2020). In addition, no changes were made regarding how ingredients should be presented on ingredient lists. This means that several added sugar ingredients and their different names can still be declared without any standardisation. By comparison, new food label rules in Canada require manufacturers to group sugar-based ingredients under the name "sugar" in the ingredient lists of their products (Canadian Food Inspection Agency, 2020). In terms of NNS, there were no changes in labelling requirements with the recently approved rules in Brazil. Food manufacturers are only required to declare NNS types at the end of the

ingredient list, and are not required to state the amount of NNS used. They are also not required to indicate NNS presence on the front of the package, as has been mandated in Mexico (White & Barquera, 2020). The changes in added sugar labelling in Brazil, without corresponding changes in NNS labelling, may further accentuate the scenario found in our study whereby NNS are broadly used in products that also contain added sugars.

Some limitations of this study need to be mentioned. First, a small number of products (7%, n = 347) included in our analyses were powder products that require further preparation (e.g., reconstitution with water or milk) before consumption (e.g., coffee mixes). As the nutritional information declared on the Brazilian food labels is based on the 'as sold' form rather than 'as consumed', the added sugar content estimated for these products might not reflect the actual amount that would be consumed. This study used data from 2013 and it is likely that the presence and quantity of added sugars and NNS have changed somewhat in recent years. Nonetheless, our data provides an important baseline assessment that will be vital for monitoring the trends in added sugar and NNS use in the future, particularly considering the upcoming changes in the food labels laws in Brazil. Finally, this study was carried out in a single Brazilian supermarket with a national market share of 3% for the year when data was collected. Although this supermarket is part of a large supermarket chain with stores in several Brazilian states, findings may not be generalisable to the entire Brazilian food supply. Nonetheless, there is a need for additional studies capturing information about packaged foods sold across a broader range of supermarket chains as own-brand products can vary between chains.

5. Conclusion

This study found that 66.7% of the packaged foods sold in Brazil had at least one type of sweetener (added sugars or NNS) in their composition. Most of the products with NNS (81.5%) also contained added sugar ingredients, and 63.0% of these products contained a high level of added sugar. Some products with added sugars and NNS had an equal or higher added sugar content than

similar products with added sugar only. Considering the unclear health effects of NNS, reducing the added sugar of products by replacing them with NNS may not be the most appropriate approach to achieve public health goals. Changes in food label rules to make labelling of added sugar and NNS ingredients clearer is needed. This study can be used as a starting point compare changes in added sugar and NNS use in the food supply in coming years.

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Disclosure statement

The authors declare no conflict of interest.

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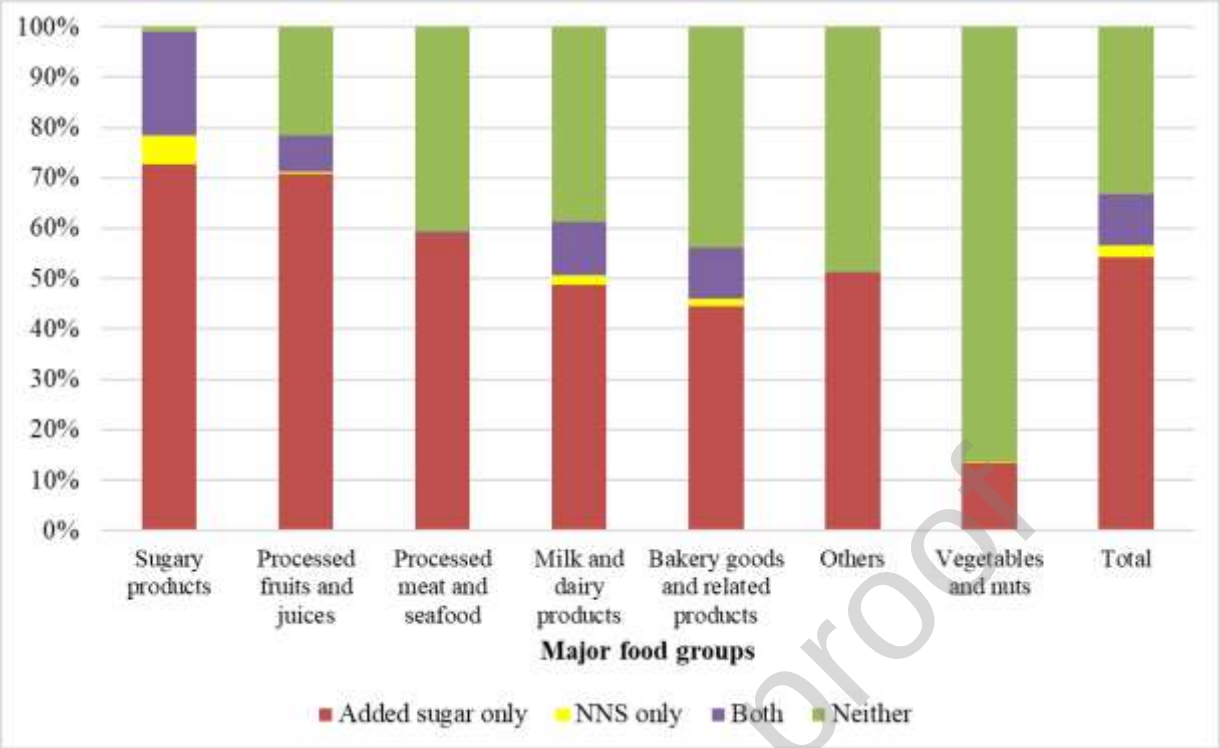

FIGURE CAPTION

Figure 1 Proportion (%) of packaged foods containing added sugar ingredients, non-nutritive sweeteners (NNS), a combination of both, or neither, by major food category and overall (n = 4,805). "Others" category includes seasonings, gravies and sauces, oils and creams, and ready-to-eat dishes.

CRediT authorship contribution statement

T.S., A.C.F. and R.P.C.P. designed the research. T.S. and L.S.F analysed the data. S.P., D.H.C, A.C.F, and A.P.G.G. provided interpretation of data for the work. All authors provided critical feedback on the manuscript and read and approved the final version of the manuscript.

Declaration of Competing 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.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Highlights:

- An 8-steps methodology was used to estimate added sugar content of packaged foods
- Mostly of products containing NNS also had added sugar ingredients
- High-in-sugar products presented both added sugar and NNS ingredients
- The most commonly used NNS overall was acesulfame-k