Consumer perceptions of non-caloric sweeteners and the content of caloric and non-caloric sweeteners in ultra-processed products in Brazil

Percepções do consumidor sobre adoçantes não calóricos e o conteúdo de adoçantes calóricos e não calóricos em produtos ultraprocessados no Brasil

Resumo
Indústrias alimentícias estão reformulando produtos para reduzir a quantidade total de açúcar. Para reduzir a densidade calórica e manter o dulçor de seus produtos, açúcares são combinados com edulcorantes. Esse estudo teve como objetivo analisar as informações sobre a presença, número e tipo, e conteúdo de diferentes sweeteners exibidos na lista de ingredientes de 10 produtos ultraprocessados, de 3 categorias diferentes. O estudo também avaliou as percepções e entendimento dos consumidores sobre adoçantes calóricos e não calóricos usados em produtos ultraprocessados, através da análise de discussões com 12 grupos focais. Observou-se combinação de açúcares e de diferentes edulcorantes, com ausência de informações claras referentes ao uso de edulcorantes e suas possíveis consequências à saúde. Presentar informações mais claras sobre os ingredientes utilizados e a compreensão do consumidor sobre esses ingredientes facilitariam escolhas alimentares saudáveis.

Keywords
Ultra-processed foods, Focus group discussions, Nutrition labels, Sweeteners, Brazil
**Introduction**

Unhealthy diets are one of the main behavioural risk factors that contribute to non-communicable diseases (NCDs)\(^1\). In Brazil, unhealthy dietary patterns are characterized by higher intakes of ultra-processed products (UPP), and lower intakes of healthy, minimally processed foods such as whole grains, nuts, fish, fruits and vegetables\(^2\). UPP are ready-to-eat food and beverage formulations of processed substances derived from whole foods that generally include cosmetic additives\(^3\). The consumption of a greater than recommended amounts of dietary sugars is the hallmark of dietary patterns high in UPP and of low nutritional quality\(^4\).

Dietary sugars may either be categorized as total sugars, free sugars, or added sugars. Total sugars include all sources of mono- and disaccharides present in food including sucrose (table sugar), fructose, glucose (dextrose), and lactose (milk sugar)\(^5\). Free sugars are defined as mono- and disaccharides and disaccharides added to foods and beverages by the manufacturer, cook, or consumer, and include sugars naturally present in honey, syrups, juiced or pureed fruit and vegetables\(^6\). The World Health Organization (WHO) emphasizes a reduction in the intake of free sugars to less than 10% of total energy for both adults and children, while recommending intakes of 5% or less\(^6\). The American Heart Association (AHA) recommends daily intakes of no more than 25 g of added sugars for women and for children, two years and older, and up to 36 g for men\(^7\). The Brazilian Dietary Guidelines (BDG) recommend avoiding added sugars for children up to two years old\(^1\). For adults, it recommends avoiding UPP and using added sugars in small amounts for culinary preparations\(^8\).

According to the 2008-2009 Household Budget Survey (Pesquisa de Orçamentos Familiares - POF), nearly 61% of the population consumed sugars above recommended levels\(^10\) at 16.4% of the total calories\(^11\). The average daily intake of total sugars was higher among adolescents of both sexes, ranging from 105.4 g to 113.1 g among boys and from 106.8 g to 110.7 g among girls. Average daily total sugars consumption among adolescents was about 30% higher than the elderly (60 years and older), and 15%-18% higher than adults\(^10\). This pattern is reflected in other Brazilian samples\(^12\) and across eight Latin American countries. Among 9,218 individuals, aged 15-65 years, the mean total sugars intake for all countries was 99.4 g/day (65.5 g/day of added sugars) and intakes decreased with advancing age\(^13\). In previously published work, free sugars consumption was higher among low-income and disadvantaged households\(^14\). Non-Hispanic black and low-income households had higher absolute and relative amounts of added sugars from beverages than non-Hispanic white and high-income households\(^15\).

Decreasing the sugar content of foods to lower their caloric content and meet dietary recommendations has encouraged the use of substitute sweeteners in packaged UPP\(^16\). These non-nutritive sweeteners (NNS) provide an intense sweet taste with little or no calories, prompting food industries to reformulate their products by entirely substituting caloric sweeteners or by combining them with NNS\(^17,18\). In Brazil, NNS (edulcorantes, in Portuguese) are considered food additives that replace sugar, totally or partially\(^9\). The Brazilian Health Regulatory Agency (Agência Nacional de Vigilância Sanitária - Anvisa) regulates the use of food additives, in keeping with guidelines issued by the Joint Food and Agriculture Organization/World Health Organization Expert Committee on Food Additives (JECFA), the Codex Alimentarius Commission (CAC), and the Southern Common Market (Mercado Común del Sur) - MERCOSUR\(^20\).

There are insufficient data to determine conclusively whether the use of NNS is better for health than their caloric counterparts\(^19\). Some studies show an association between these additives and dysbiosis and metabolic abnormalities in adults\(^21,22\) and an increase in the incidence of type 2 diabetes\(^23\). Other studies show no conclusive evidence\(^24,25\). There is increasing public awareness of the negative impact of sugar-sweetened beverages (SSBs) on children’s health – evidence supports the association between added sugars and increased risk of dental caries, cardiovascular disease in children due to increased adiposity and dyslipidaemia\(^26\). Parents may choose to replace SSBs, perceived as unhealthy, with fruit juices or juice drinks containing NNS perceived as healthier\(^27\). However, exposing children to NNS at young ages could lead to sweet preferences that persist into adulthood. Additionally, evidence among children suggests a possible relationship between NNS and body mass index (BMI), and a non-significant association with other metabolic diseases\(^28\) and percentage body fat\(^29\). This suggests that reducing sweetener intake, whether caloric or non-caloric is a good strategy for combating overweight and obesity, especially among children\(^30\).
It is unclear if the current regulation for sweeteners adequately addresses public health concerns and if Brazilian consumers are aware of the different sweeteners used in products. The challenges with understanding the list of ingredients and nutritional information on packaged foods are well documented. With over 56 different names to describe sugars, the diversity in the nomenclature of both caloric and non-caloric sweeteners is likely to further impede consumer understanding. This study aimed to address these gaps by mapping the presence and types of sweeteners on select products in Brazil by comparing the information available with the current Brazilian regulation and capturing consumer understanding of these ingredients. It specifically aimed to: (1) evaluate the numbers and types of caloric and non-caloric sweeteners/NNS in UPP targeted at children; (2) compare the amounts of caloric and non-caloric sweeteners/NNS to current recommendations from Anvisa; and (3) determine consumers’ perceptions of the presence of caloric and non-caloric sweeteners/NNS.

Methods

A combination of data extraction methods and qualitative methods were used to achieve the study objectives. For aim 1, the POF survey of 2008-2009 was used to inform the selection of three categories of sweet UPP. Products that were consumed by children and adolescents were targeted, given that children are a group of particular concern. The products included powdered juices, jellies, and chocolate milk drinks (Chart 1). The most popular brands of each of these products were selected and purchased over 2 visits from a well-known supermarket in São Paulo city (August-November 2019). A total of 18 participants were parents to at least one child ≤ 18 years. FGDs were stratified by sex and socioeconomic status (SES), with 3 FGDs conducted for each combination (male/female + high SES/low SES). All sessions were conducted by a trained moderator using a pre-tested interview guide, and data was audio recorded and transcribed. The specific questions that relate to the present study were: “What is your opinion about the current nutrition label and how would you evaluate the ease of understanding?”, “What do you think are your challenges in using the nutrition label?”, “What do you understand by the term non-caloric sweeteners?”

To determine consumers’ perceptions of the presence of caloric and NNS, data from a previously conducted qualitative study was used. Twelve focus group discussions (FGDs) were held in four state capitals – Goiânia, Porto Alegre, Recife and, São Paulo – representing different regions of Brazil. Between July 13th and 18th 2017, a survey firm was contracted to recruit a diverse sample of adults who shopped for groceries regularly, to assess their perceptions of the current food label. The study methodology setting, sampling, consent forms, and procedures can be found elsewhere. Briefly, 48 men and 48 women, aged between 20-50 years who were responsible for grocery shopping in the household, were asked to share their opinions about the information on ingredient list, the presence of non-caloric sweeteners in UPP and their knowledge of the health risks of these ingredients. Sixty-three participants were parents to at least one child ≤ 18 years. FGDs were stratified by sex and socioeconomic status (SES), with 3 FGDs conducted for each combination (male/female + high SES/low SES). All sessions were conducted by a trained moderator using a pre-tested interview guide, and data was audio recorded and transcribed. The specific questions that relate to the present study were: “What is your opinion about the current nutrition label and how would you evaluate the ease of understanding?”, “What do you think are your challenges in using the nutrition label?”

To extract the necessary information, the list of ingredients and the nutrition facts panel of all products were scrutinized and information on the types and amounts of caloric and non-caloric sweeteners was recorded in an Excel sheet. Caloric sweetener information was present on the nutrition facts panel and the ingredient list, and NNS information was extracted from the ingredient list. The information on quantities of NNS was also extracted and compared to the current regulation on food labelling.
Chart 1. The ultra-processed products used to evaluate the types and amounts of caloric and non-caloric/non-nutritive sweeteners.

| UPP              | Brand | Websites accessed for gathering nutritional information                                                                 |
|------------------|-------|--------------------------------------------------------------------------------------------------------------------------|
| Powered juice    | TANG* | http://www.tang.com.br/#!/produtos/laranja/tabela-nutricional Accessed Nov 15, 2019                                   |
|                  | MID*  | https://www.ajinomoto.com.br/produtos/mid.php#informacao-nutricional Accessed Sept 15, 2019                          |
|                  | FRESH*| consumidores.br@mdlz.com Information was received from Mondelez International Consumer Service on Feb 7, 2020       |
| Jelly            | Royal*| consumidores.br@mdlz.com Information was received from Mondelez International Consumer Service on Feb 10, 2020      |
|                  | Dr Oetker* | https://www.oetker.com.br/gelatinas/index/gelatina-morango.html Accessed Nov 14, 2019                        |
|                  | Sol*  | http://www.jmacedo.com.br/sol/produtos/gelatina-de-morango/ Accessed Nov 14, 2019                                    |
| Chocolate flavoured milk drinks | Nescau* | https://www.nestle.com.br/nescau/produtos/nescau-prontinho Accessed Nov 15, 2019                                |
|                  | Toddynho* | https://www.toddynho.com.br/produtos.php Accessed Sept 29, 2019                                                        |
|                  | PIRA KIDS* | https://www.piracanjuba.com.br/produtos/pirakids-chocolate-200ml-628 Accessed Nov 15, 2019                     |
|                  | ALPINO* | https://www.nestle.com.br/marcas/alpino/bebida-lactea-alpino Accessed Nov 15, 2019                                    |

*Royal*® jelly had its formulation changed recently: the sodium cyclamate and sodium saccharin non-caloric sweeteners were removed. In phone call to Mondeley International Consumer Service on Feb 10, 2020, they informed that for the time being the two formulations continue to be commercialized. Here, the Royal® jelly has four non-nutritive sweeteners (additives) in their ingredient list.

Source: Authors.

Table 1. The maximum limits and Acceptable Daily Intake (ADI)* of non-caloric/ non-nutritive sweeteners, as defined by Anvisa.

| Additives                                    | Maximum limit (g/100g or g/100mL in food/beverage product) | ADI* (mg/kg of body weight per day) |
|----------------------------------------------|-------------------------------------------------------------|-------------------------------------|
| Sorbitol, isomalt, lactitol, mannitol, xylitol, maltitol, taumantine | Any                                                        | Any                                 |
| Erythritol                                   | Any                                                        | Any                                 |
| Neotame                                      | 0.0049                                                     | 2                                  |
| Acesulfame potassium                         | 0.026                                                      | 15                                 |
| Aspartame                                    | 0.056                                                      | 40                                 |
| Sodium cyclamate                             | 0.03                                                       | 11                                 |
| Saccharin                                    | 0.01                                                       | 2.5                                |
| Sucralose                                    | 0.02                                                       | 15                                 |
| Steviol glycosides                           | 0.045                                                      | 5.5                                |

*JECFA defines the ADI as “an estimate of the amount of a food additive in food or beverages expressed on a body weight basis that can be ingested daily over a lifetime without appreciable health risk to the consumer”.

Source: Anvisa, Joint Expert Commission on Food Additives of the World Health Organization and the Food and Agriculture Organization (http://www.codexalimentarius.net/web/jecfa.jsp).
loric sweetener and by the term artificial sweetener?”, “Does excessive intake of sugar or non-caloric sweetener have any effect on health?”. The average duration of the FGDs was 2h 45 minutes. Transcripts were read by Priscila de Morais Sato and as no relevant new information was identified in the last two FGDs, data saturation was considered reached. Qualitative data was analysed using an inductive content analysis approach to allow for new themes to emerge from the data without prior theoretical grounding. Terezinha E. M. de Carvalho read all transcripts, identified and grouped similar excerpts of the transcripts together, identified common themes, organized and discussed themes with Priscila de Morais Sato until consensus was reached. No differences were found in themes by sex, education, and income level. The data was analysed in Excel.

Results

Presence of sugars

All products included some form of sugar. In six of the 10 products (3 powdered juices and 3 jellies), sweeteners were the first ingredient on the ingredient list indicating that they were used in the greatest amounts in the manufacture of the product.

Number and types of sweeteners

A total of eight different types of sweeteners were identified in the 10 products. Three were caloric sweeteners – sugar, maltodextrin, dehydrated orange juice – and five were non-nutritive – aspartame, sodium cyclamate, acesulfame potassium, sodium saccharin and sucralose. Seventy percent of the products combined both caloric and non-caloric sweeteners, 60% combined at least one source of caloric sweetener with at least two different types of non-caloric sweeteners (Table 2).

All three powdered juices contained a mix of caloric and non-caloric sweeteners. All three jellies contained caloric sugars and either three (in one case) or four (in two cases) different types of non-caloric sweeteners. All chocolate flavoured milks contained “sugar” (most likely cane sugar). Three of the four chocolate flavoured milks contained only caloric sweeteners of which two contained only one type of sweetener. One contained maltodextrin in addition and only one product contained a source of non-caloric sweetener (sucralose). The total number of caloric plus NNS in the same product was as high as 7 (powdered juices) and 5 (jellies). One instance of erroneous listing was also identified – Toddynho® chocolate flavoured milk identified maltodextrin as a vitamin in its list of ingredients.

Amount of sweeteners

For all products, the energy provided by the caloric sweeteners was >10% of the total energy/serving. A comparison of the NNS content to the amount recommended by Anvisa for children weighing 20 kg and adolescents weighing 45 kg was only possible for two of the seven eligible products for which content of sweeteners was available. Multiple attempts to retrieve this information from websites and helplines proved futile. For the two powdered juices evaluated, the ADI for each individual non-caloric sweetener was generally within recommended limits for children and adolescents. However, for sodium cyclamate, a child weighing 20 kg would only have to consume 1 litre and an adolescent weighing 45 kg would have to consume 2.2 litres to reach the ADI (Table 3).

Perceptions of sweeteners

The qualitative data analysis revealed barriers to the access of information on caloric and non-caloric sweeteners including: (1) placement of information, (2) legibility, (3) unfamiliarity with the terms used, and (4) participants’ ability to distinguish between artificial sweeteners and non-caloric sweeteners.

The placement of information was the most frequently cited barrier. Concerns included the lack of standardization in the presentation on the ingredient list. This discouraged some participants as it took time and effort to access the information – “The list of ingredients does not follow a standard position on the food label and the consumer needs to find it to read it” (♀, high SES). In other cases, the lack of standardization made the reading of the information impossible, like when it was located in a part of the label that meant to be torn to access package contents – “Sometimes it is too close to the bar code and when we tear it up it compromises the location and we can’t read it” (♂, high SES). Legibility concerns included small font labels – “Small font makes labels hard to read” (♂, high SES).

Reasons for unfamiliarity with the terms used to describe sweeteners ranged from the use of
technical terms – “Several ingredients’ names are unknown” (#, low SES), “You have to go Google searching to know what it is” (#, low SES), to the presence of English words (in a Portuguese speaking country) – “Ingredient lists are too technical or in English” (#, high SES). The confusion resulting from the lack of familiarity with the terms was particularly problematic for people with special needs or underlying health conditions – “For example, in the matter of candy there

| Table 2. Presence of caloric and non-caloric/ non-nutritive sweeteners in the sample of ultra-processed products. |
|---------------------------------------------------------------|
| **Caloric and non-nutritive sweeteners** | **Powdered juices** | **Jellies** | **Chocolate flavored milks** |
| | (n=3) | (n=3) | (n=4) |
| **Brands** | **TANG** | **MID** | **FRESH** | **Royal Dr Oetker** | **Sol** | **Nescau** | **Toddynho** | **PIRAKIDS** | **ALPINO** |
| **Proportions for preparation** | 25g to 25g to 25g to | 25g to 10g to 25g to | 25g to 20g to 35g to | 200mL 200mL 200mL | 200mL 200mL 200mL |
| **Total kcal/serving** | 19/5g 19/5g 7/2g 21/5.7g 29/7.9g | 17/5g 130/200mL | 167/200mL 156/200mL 168/280mL |
| **Caloric sweeteners** | 3.7/5g 4.7/5g 1.2/2g 2.9/5g 5.8/7.9g | 3.5/5.7g 5.1 10 13.5 13.5 8.2 |
| **Total sugars (g) per serving** | 1.8 2.4 0.6 3.1 2.3 | 5.1 10 13.5 13.5 8.2 |
| **Total sugar/standardized portion (g/100mL)** | 1.8 2.4 0.6 3.1 2.3 | 5.1 10 13.5 13.5 8.2 |
| **Cane sugar** | x x x x x x x x x x |
| **Maltodextrin** | x x x |
| **Dehydrated orange juice** | x x x |

| Non-nutritive sweeteners, mg/100mL |
|-----------------------------------|
| **Aspartame** | 27 29.73 x x x x |
| **Sodium cyclamate** | 22 x x x x |
| **Acesulfame potassium** | 4.5 7.26 x x x |
| **Sodium saccharin** | 1.6 x x x x |
| **Sucralose** | x |
| **Total number of sweeteners present** | 7 5 7 5 5 4 1 2 1 2 |

x: represents the presence of the additive and the carbohydrates/sugars. Data on content was unavailable.

Source: Authors.

| Table 3. A comparison between the amounts of non-caloric/ non-nutritive sweeteners in powdered juices and the Acceptable Daily Intake (ADI) of these sweeteners for a person weighing 20 kg and 45 kg. |
|-----------------------------------------------|
| **Product** | **Non-nutritive sweetener** | **Amount present in product mg/100mL** | **ADI in mg/kg/day for people who weigh 20kg ** | **Quantities required to be consumed in L to reach ADI levels** |
| | | | 20kg | 45kg | 20kg | 45kg |
| **TANG® orange** | Aspartame | 27 | 800 | 1800 | 3 | 6.7 |
| | Sodium cyclamate | 22 | 220 | 495 | 1 | 2.2 |
| | Acesulfame K | 4.5 | 300 | 675 | 6.7 | 15 |
| **MID® orange** | Sodium saccharin | 1.6 | 50 | 112.5 | 3.1 | 7 |
| | Aspartame | 29.7 | 800 | 1800 | 2.7 | 6.1 |
| | Acesulfame K | 7.3 | 300 | 675 | 4.1 | 9.2 |

Source: Authors.
is information on ingredients that is disguised. I have diabetes, and sometimes it is written sucrose and, if my memory doesn’t fail me this is something like sugar; you think you are eating a food that has no sugar, but it has a lot just with another name” (♀, low SES).

Participants were unfamiliar with the general category of non-caloric sweeteners, what they meant, or what some specific examples might be – “Non-caloric sweetener? What is it? Probably it is a natural product” (♀, high SES); “It is a way to disguise sugar on the food labels” (♂, high SES); “I have no idea what non-caloric sweetener is. It is something that makes the product sweet. I do not know if it is sugar, if it is non-caloric sweetener, if it is honey” (♀, high SES); “There is chemical in it and it is sweet” (♂, low SES).

There was some agreement among participants that non-caloric sweeteners, like caloric sweeteners, were not good for health particularly in high doses – “You already have an idea that sugar is too bad, so imagine the artificial sweetener, it should be even worse” (♂, high SES); “I have no idea. If sweetener is bad, artificial sweetener is worse” (♀, low SES); “I heard a story that people who consume too much non-caloric sweeteners can have cancer because although there are instructions to use eight droplets, they squeeze it without even counting how many drops they are using. Therefore, it is causing as much damage to the health as sugar” (♂, low SES); “Non-caloric sweetener is a health risk because for a person with diabetes an excess of it is the same as if you were using sugar” (♂, low SES). On the other hand, some participants thought that non-caloric sweeteners could be better for health – “I think non-caloric sweetener is not so harmful for health” (♀, low SES).

Participants also expressed a desire to be better informed of any health hazards associated with non-caloric sweeteners by the food manufacturer – “I think they should speak our language. It is no use having a big label informing that there is a non-caloric sweetener if I do not know what kind of harm it can do. So, for me whatever information it has I do not care” (♀, high SES). “We can be deceived as layman. I’m buying something that is harming me without my knowledge. So if [the information] were there with a popular name like molasses... we already know that it is linked to sugar, but sucrose, I don’t know what it is, so I can consume it and it’s hurting me” (♀, low SES).

Discussion

This study was a first attempt at documenting the presence, number, type, and amount of caloric and non-caloric sweeteners in UPP targeted at children and adolescents in Brazil and at capturing perceptions of and barriers to the understanding of food labelling information on sweeteners faced by adults. It also highlighted the challenges in compliance of these products with existing regulations.

Results demonstrate the large diversity in caloric and non-caloric sweeteners, the frequent use of a combination of multiple caloric and non-caloric sweeteners, often in the same product, and the lack of disclosure of the amounts of non-caloric sweeteners on the nutrition information tables and list of ingredients in this sample of powdered juices, jellies, and chocolate flavoured milk. Published literature from Brazil reiterates these findings. Information collected from the labels of 409 Brazilian products targeted at children found a high presence of NNS in foods like gelatin (89%) and fruit-based drinks (31%)40. Similarly, of the 351 UPP consumed by children in Rio, 3.4% contained NNS41. These products included Sweetened beverages, Sweets and candies, Cakes, Milk-based beverages. In almost half the cases, Sweetened beverages and Sweets and candies (that included jellies) had four different NNS present in the same product, with one product containing six different NNS. Compared to the five different NNS found across all 10 UPP in the current study, Anastácio et al.41 found eight.

Combing multiple sources of caloric and NNS (as many as seven found in the current study) allows manufactures to reduce energy content while maintaining or even increasing sweetness. Food manufacturers used non-caloric substitutes without drawing much attention to their presence, or disclosing their content, and passing them off as the ‘regular’ version. Jensen and Sommer42 suggest that this form of “silent reformulation” may enhance the health profile of manufacturers’ corporate brand and be considered a part of its Corporate Social Responsibility by getting consumers to eat fewer calories. On the other hand, reformulation with NNS, alone or in combination, may also give food manufacturers the license to use health claims like “low in sugar” on these products, unless there exists regulation to the contrary. The presence of such claims can have a “health halo” effect, leading consumers to perceive these products as lower in calories and
The results from the current study demonstrate the inconsistent display of the quantity of NNS and the ease with which some of these additives could exceed permissible limits, especially among children. An Argentinian study showed that the consumption of beverages with NNS was common among children and adolescents. NNS were used not only in diet products but also in commonly consumed non-diet food and beverages. The high consumption of juices meant that a small proportion of the sample exceeded the ADI levels for sodium cyclamate and saccharin.

This study also highlights the confusion adult consumers face in accessing and understanding the labelling information on NNS. The results from the FGDs showed that consumers have difficulty reading and understanding the nomenclature on the ingredient list of labels. This finding was confirmed by a qualitative research study which showed that consumers and health professionals find it difficult to understand labels due to the complexity of their content, which is enhanced by the lack of standardization of presentation and visual attractiveness. Our results also point to the importance of strategic and standardized placements. Studies using eye tracker technology reinforce the importance of information location to assess nutritional facts panel viewing – label components located on the top of the package are viewed more often than in the bottom. However, just the location and legibility of information is not enough to assure label use. Participants in our study were confused about the different types of NNS, what constituted NNS and their potential health consequences. This confusion coupled with the inconsistent labelling of the presence and the quantity of NNS in products is very likely to reflect in uninformed product purchases by adults – both for themselves and their children. Qualitative data highlighted the need for appropriate consumer awareness and education efforts to increase label use and understanding and corroborated the importance of having nutrition labels that help identify NNS.

Policy implications

Evidence suggests that the penetration of NNS in the food supply is going to increase in Brazil in response to growing consumer concerns about the intake of caloric sugars. An increase in NNS was seen in Chile after the Chilean Government regulated to improve the local food environment and target obesity-related diseases, through initiatives like front-of-package labels on high-sugar products. To maintain the taste of their products food manufactures used NNS in combination with caloric sugars to decrease the concentration of added sugars in beverages.

A similar pattern was observed in the US. Between 2000 and 2010 there was a decrease in the purchase of added sugar foods and beverages by US households while purchases of products containing NNS or both caloric and NNS increased.

Despite not being recommended for children, products with NNS like flavoured milk continue to be offered in many US National School Lunch and School Breakfast programs. Anvisa is working towards improving nutrition labelling by mandating the display of total and added sugars content but these changes are unlikely to include any content disclosure of NNS on the nutrition facts panel or in front of the packages. Currently, manufacturers of non-alcoholic beverages may partially replace the sugar in low calorie products with NNS, in combination or individually. Since these are not considered diet products, the food industries are not obliged to disclose NNS concentrations on the ingredient list.

The ADI recommended by Anvisa are for individual NNS. There are no data on health outcomes associated with prolonged ingestion of combinations of two or more of these additives. Evidence of early exposure to NNS and long-term metabolic health effects in children are uncertain. There is also limited knowledge of the health effect of these additives, individually and in combination, in pregnant women. Evidence from mouse models, however, shows that just a six-month exposure to saccharin in drinking water can elevate inflammation in the liver due to altered gut microbiota. There may also be other mechanistic pathways that influence a range of health hazards associated with the consumption of these UPP that need elucidating. Therefore, applying the precautionary principle and labelling all products with NNS, preventing the use of health claims, disclosing NNS concentrations, restricting the sale and consumption of products containing NNS among children, and monitoring their prevalence in the food supply may be necessary.

Study limitations

This work was limited by the number and diversity of products studied. Future research cap-

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turing a more representative sample of products across Brazil would be needed to reflect the penetration of sweeteners in the food supply, and the percentage of non-diet products containing both caloric and NNS. Focusing on products popular among children and assessing the role that product price plays in predicting the presence of NNS might also be beneficial. Finally, assessing the health impact of NNS in different population groups was outside the scope of this study but must be the focus of future research.

Conclusion

Some non-diet UPP offer reduced calories at the expense of increasing the variety, concentration, and combination of caloric and non-caloric sweeteners in the same product. While products assessed in the study conformed with regulations on the ordering of ingredients by amounts present which captured the presence of caloric sweeteners, there were more inconsistencies with displaying amounts of non-caloric sweeteners. The results of this study also highlight that while consumers may be encouraged to identify the NNS present by consulting its ingredient list, this places an enormous cognitive burden on them, given the variety of names for these additives, the lack of standardization and the inconsistent disclosure of this information. Along with educating people about these additives, mandating the display of simple, consistent, clear, and complete nutrition information on food labels will be needed to facilitate consumer comprehension and support healthy choices.

Collaborations

LA Mais, APB Martins, PC Jaime, N Khandpur and PM Sato worked on research design. A Waisenberg and TEM Carvalho worked on data collection. A Waisenberg, TEM Carvalho and PM Sato worked on data analysis. TEM Carvalho and N Khandpur worked on manuscript writing. LA Mais, APB Martins, PC Jaime, PM Sato and A Waisenberg worked on manuscript critical review.
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