

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

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Abstract Food industries are reformulating their products to lower total sugar and caloric content. Caloric sugars are often substituted by or combined with non-caloric sweeteners. Our study analyzed information about the presence, number and type, and content of different sweeteners displayed on the ingredient list of 10 key ultra-processed products (UPP), from 3 different categories. It also assessed consumers' opinions, perceptions and understanding of caloric and non-caloric sugars used in UPPs using data from 12 focus group discussions. Results indicate a large diversity in sweeteners, frequent use of a combination of multiple caloric and non-caloric sweeteners, often in the same product, and a lack of disclosure of the amounts of non-caloric sweeteners on the nutrition labels. Qualitative analysis reflected the inconsistency of information on nutrition labels and the challenges in compliance with regulations. Participants were unsure about the different types of sweeteners, examples of artificial sweeteners and their potential health consequences. Presenting clearer additive and nutrition information would facilitate consumer comprehension and support healthy food choices.

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

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 edulcorantes 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 com edulcorantes no mesmo produto e, frequentemente, ausência das quantidades dos edulcorantes nos rótulos nutricionais. Esses produtos voltados a crianças oferecem calorias reduzidas às custas do aumento da variedade e concentração desses edulcorantes. Os participantes mostraram-se confusos sobre os diferentes tipos de adoçantes e edulcorantes e suas possíveis consequências à saúde. Apresentar informações mais claras sobre os ingredientes e nutrição facilitariam a compreensão dos consumidores e os apoiariam em escolhas alimentares saudáveis.

Palavras-chave Alimentos ultraprocessados, Discussões de grupos focais, Rótulos nutricionais, Adoçantes, Brasil

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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 vegetables². UPP are ready-to-eat food and beverage formulations of processed substances derived from whole foods that generally include cosmetic additives³. The consumption of a greater than recommended amounts of dietary sugars is the hallmark of dietary patterns high in UPP and of low nutritional quality⁴.

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 monosaccharides 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 vegetables⁶. The World Health Organization (WHO) emphasises 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 less⁶. 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 men⁷. The Brazilian Dietary Guidelines (BDG) recommend avoiding added sugars for children up to two years old⁸. For adults, it recommends avoiding UPP and using added sugars in small amounts for culinary preparations⁹.

According to the 2008-2009 Household Budget Survey (*Pesquisa de Orçamentos Familiares - POF*), nearly 61% of the population consumed sugars above recommended levels¹⁰ at 16.4% of the total calories¹¹. 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 adults¹⁰. This pattern is reflected in other Brazilian samples¹² 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 add-

ed sugars) and intakes decreased with advancing age¹³. In previously published work, free sugars consumption was higher among low-income and disadvantaged households¹⁴. 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 households¹⁵.

Decreasing the sugar content of foods to lower their caloric content and meet dietary recommendations has encouraged the use of substitute sweeteners in packaged UPP¹⁶. 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 partially¹⁹. 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*) - MERCOSUR²⁰.

There are insufficient data to determine conclusively whether the use of NNS is better for health than their caloric counterparts¹⁸. 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 diabetes²³. 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 dyslipidaemia²⁶. Parents may choose to replace SSBs, perceived as unhealthy, with fruit juices or juice drinks containing NNS perceived as healthier²⁷. 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 diseases²⁸ and percentage body fat²⁹. This suggests that reducing sweetener intake, whether caloric or non-caloric is a good strategy for combating overweight and obesity, especially among children³⁰.

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 documented³¹. With over 56 different names to describe sugars^{32,33}, the diversity in the nomenclature of both caloric and non-caloric sweeteners is likely to further impede consumer understanding³⁴. 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 2008-2009¹⁰ 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 10 distinct brands of products were selected: three powdered juices, orange flavour (TANG®, MID®, FRESH®), three jellies, strawberry flavour (Royal®, Dr Oetker®, Sol®) and four chocolate flavoured milk drinks (Nescäu®, Toddynho®, PIRAKIDS®, ALPINO®). The cost of the powdered juices (10 g-25 g) varied from US\$ 0.18 to US\$ 0.25/packet, the jellies (20 g-35 g) from US\$ 0.25 to US\$ 0.31/packet, and the chocolate milk drinks (200 mL) from US\$ 0.25 to US\$ 0.35/container. One of the chocolate flavoured drinks, ALPINO®, was slightly larger and cost more (280 mL, US\$ 0.85).

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^{19,35-37}.

Product websites were searched for detailed nutritional information when necessary data was not present on the nutrition labels. Product help-lines were called to supplement missing information from nutrition labels and websites. Caloric and NNS content was standardized to facilitate a comparison with Anvisa's recommended Acceptable Daily Intake (ADI) (Table 1). NNS content in milligrams/kilogram body weight/day (mg/kgbw/day) was calculated for an average 7-year-old child weighing 20 kg and a 13-year-old adolescent weighing 45 kg and compared to ADIs. Quantities of the products required to be consumed to meet maximum ADIs were also estimated.

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 elsewhere³⁸. 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?", "What do you understand by the term non-ca-

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, taumantane	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”³⁶.

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 Moraes 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 data³⁹ 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 Moraes 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 (su-

cralose). 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 – Toddyho® 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 (n=3)			Jellies (n=3)			Chocolate flavored milks (n=4)				
	Brands	TANG	MID	FRESH	Royal	Dr Oetker	Sol	Nescau	Toddynho	PIRAKIDS	ALPINO
Proportions for preparation	25g to 1L	25g to 1L	10g to 1L	25g to 0.5L	20g to 0.5L	35g to 0.5L	200mL	200mL	200mL	280mL	
Total kcal/serving	19/5g	19/5g	7/2g	21/5.7g	17/5g	29/7.9g	130/200mL	167/200mL	156/200mL	168/280mL	
Caloric sweeteners											
Total sugars (g) serving	3.7/5g	4.7/5g	1.2/2g	3.5/5.7g	2.9/5g	5.8/7.9g	20/200mL	27/200mL	27/200mL	23/280mL	
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	x
Maltodextrin	x	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		Quantities required to be consumed in L to reach ADI levels	
			20kg ♂♀	45kg ♂♀	20kg ♂♀	45kg ♂♀
			TANG® orange	Aspartame	27	800
	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

healthier than non-claim carrying equivalents^{43,44} and potentially increasing product purchase and consumption⁴⁵.

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 adolescents⁴⁶. 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 saccharin⁴⁶.

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 attractiveness⁴⁷. 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^{48,49} – 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 children⁵⁰. 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 products⁵¹. To maintain the taste of their products food manufactures used NNS in combination with caloric sugars to decrease the concentration of added sugars in beverages⁵². 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 increased⁵³. Despite not being recommended for children²⁶, products with NNS like flavoured milk continue to be offered in many US National School Lunch and School Breakfast programs^{54,55}.

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 packages⁵⁶. Currently, manufacturers of non-alcoholic beverages may partially replace the sugar in low calorie products with NNS, in combination or individually³⁵. 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 uncertain⁵⁷. There is also limited knowledge of the health effect of these additives, individually and in combination, in pregnant women⁵⁸. 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 microbiota⁵⁹. There may also be other mechanistic pathways that influence a range of health hazards associated with the consumption of these UPP that need elucidating⁶⁰. 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-

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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