

# Types and Amounts of Nonnutritive Sweeteners Purchased by US Households: A Comparison of 2002 and 2018 Nielsen Homescan Purchases

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## ABSTRACT

**Background** Purchases of foods containing nonnutritive sweetener (NNS) alone or in combination with caloric sweeteners (CS) has increased in recent years in the United States. At the same time clinical evidence is emerging of different cardiometabolic effects of each NNS type.

**Objective** To examine the prevalence and volume purchased of commonly consumed types of NNS in packaged food and beverage products comparing 2002 and 2018 using data from nationally representative samples of US households.

**Participants/setting** Nielsen Homescan Consumer Panels (The Nielsen Company); 2002 and 2018.

**Main outcome measures** Prevalence and volume of foods and beverages purchased containing CS, NNS, both CS and NNS, or neither CS nor NNS, as well as prevalence and volume of products containing specific NNS types.

**Statistical analyses performed** Differences examined using Student *t* test, *P* value of <.05 considered significant.

**Results** Volume of products purchased containing CS decreased comparing 2002 and 2018 ( $436.6 \pm 1.6$  to  $362.4 \pm 1.3$  g/d;  $P < .05$ ), yet increased for products containing both CS and NNS ( $10.8$ - $36.2$  g/d;  $P < .05$ ). Regarding specific types of NNS, changes were noted in the prevalence of households purchasing products containing saccharin (1.3%-1.1%;  $P < .05$ ), aspartame (60.0%-49.4%;  $P < .05$ ), rebaudioside A (0.1%-25.9%) and sucralose (38.7%-71.0%). Non-Hispanic whites purchased twice the volume of products containing NNS compared to Hispanics and non-Hispanic blacks in both years. Beverages were predominantly responsible for larger volume per capita purchases of products containing only NNS as well as both CS and NNS.

**Conclusions** A decline in purchases of products containing CS occurred in tandem with an increase in purchases of products containing both CS and NNS, along with a large shift in the specific types of NNS being purchased by US households. New NNS types enter the market regularly, and it is important to monitor changes in the amount of NNS and products containing NNS that consumers purchase.

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THE UNITED STATES HAS ONE OF THE HIGHEST INTAKES of sugar globally,<sup>1</sup> and a significant proportion of packaged bar-coded foods in the United States contain some type of caloric sweetener (CS).<sup>2,3</sup> Alongside this,

interest from consumers and the food industry in reducing sugar consumption (and pressure from health-related bodies such as the World Health Organization) have led to an increase in intake of nonnutritive sweeteners (NNS; also termed artificial, low-calorie, or nonsugar sweeteners)<sup>4-6</sup> and wider availability of food products containing NNS.<sup>7</sup> Prevention policies such as sugar-sweetened beverage taxes and front-of-package labels may also be incentivizing companies to utilize NNS as a way of reducing CS.<sup>1,8</sup> In 2012, >40% of American adults and >20% of American children reported consuming NNS on a daily basis compared with 30% in 2008.<sup>9</sup> Based on sales data, purchases of foods containing either NNS alone or in combination with CS has increased dramatically over the past decade in the United States.<sup>10</sup> Moreover, a growing number of different types of NNS have become

available in the US food supply, with new variants of NNS appearing on the market each year.

Although the intake of added sugars, and sugar-sweetened beverages in particular, is commonly associated with poor health outcomes,<sup>11,12</sup> the association between NNS consumption and adverse health outcomes has remained relatively controversial in the academic literature.<sup>13,14</sup> A number of cohort studies have linked NNS consumption to increased body weight, type 2 diabetes, and other adverse cardiometabolic outcomes, but literature with the same cohorts has found the opposite effect when controlling for many measurement and causality issues linked with NNS used.<sup>12,13,15,16</sup> In addition, results from randomized controlled trials (RCTs) have failed to demonstrate a relationship between NNS and energy intake or increased consumption of sweet foods.<sup>17,18</sup> However, previous RCTs and meta-analyses have generally categorized all NNS together and have not examined differences in the effect of specific types of NNS on health outcomes, energy intake, or body weight, and the RCT of Higgins and Mattes suggests heterogeneity in health impacts of different NNS types.<sup>19</sup>

Both research and policy recommendations generally group all NNS together, suggesting that each type of NNS has the same effect on appetite, energy intake, and body weight.<sup>19</sup> However, not only does each NNS have its own unique chemical structure and therefore sensory properties (eg, sweetener intensities, mouth feel), a recent RCT that examined the effects of 4 commonly consumed NNS in the United States on body weight found differential responses between NNS types, indicating that consumption likely has effects beyond the contribution of sweetness to food and beverage products.<sup>19</sup> In particular, saccharin was found to significantly increase body weight, but aspartame, rebaudioside A (reb-A, which is predominantly found in stevia), and sucralose resulted in greater weight loss.

In this context, comprehensive nutrient databases capable of capturing newly introduced or reformulated products in the US food and beverage supply are critical to capture changes to both the amount and type of NNS to which consumers are exposed.<sup>20</sup> The level of NNS is not required to be displayed on nutrition labels in the United States, so obtaining accurate and direct measures of the concentration of different types of NNS in the food supply is problematic.<sup>10</sup> Alongside this, the US Department of Agriculture food composition tables are not updated frequently enough to capture the ongoing rapidly occurring changes in the food supply. Studies using data from the National Health and Nutrition Examination Surveys can only capture consumption of about 7,600 unique foods from over 85,000 products with unique formulations that US consumers purchase each year.<sup>7,21</sup> As a consequence, studies examining consumption of NNS generally rely on non-ingredient specific keywords, such as “low calorie,” to identify foods containing NNS. To the knowledge of the authors, no studies to date have examined the extent to which individual types of NNS are purchased and consumed by the US population.

In this study, the prevalence and volume purchased of commonly consumed types of NNS in packaged food and beverage products is examined using data from a nationally representative sample of US households. Comparisons between 2002 and 2018 among the types and volume of each NNS purchased by US consumers are analyzed to examine

## RESEARCH SNAPSHOT

**Research Question:** Has the prevalence and volume purchased of commonly consumed types of NNS in packaged food and beverage products changed between 2002 and 2018 in the United States?

**Key Findings:** The amount of products purchased containing caloric sweetener decreased between 2002 and 2018, yet increased for products containing both caloric sweetener and NNS. Regarding specific types of NNS, changes from 2002 to 2018 were noted in the prevalence of households purchasing products containing aspartame (reduced from 60.0% to 49.4%;  $P < .05$ ), rebaudioside A (increased from 0.1% to 25.9%), and sucralose (increased from 38.7% to 71.0%). Beverages were predominantly responsible for larger volume per capita purchases of products containing only NNS as well as both caloric sweetener and NNS.

trends of NNS use over time. Generalizations of added sweetener categories are also examined to determine whether there have been changes in the prevalence of foods and beverages purchased containing CS, NNS, both CS and NNS, or neither CS nor NNS.

## SUBJECTS AND METHODS

### Study Design and Population

The Nielsen Homescan Consumer Panels (The Nielsen Company) from 2002 and 2018 were used to examine food purchase data for the US population. This panel is an ongoing nationally representative longitudinal survey of between 35,000 and 60,000 households each year and contains information on purchases of packaged food and beverage items at the Universal Product Code (UPC) level (with close to 3 million bar-coded products included over this period). Participating households are given handheld scanners with which they record yearly food purchases from grocery, drug, mass merchandise, and convenience stores. Households also report sociodemographic and household information including gender, income, education, and race or ethnicity of the head of the household. Households included in Homescan are sampled and weighted to be nationally representative. The Homescan data set is used frequently by researchers to examine food consumption and purchasing patterns.<sup>22-24</sup> The Institution Review Board of University of North Carolina noted these were secondary data with no direct contacts, and the data were exempt from any review.

### Linkage of Barcodes Food Products With Nutrition Facts Panel Data

Each uniquely bar-coded product captured in Homescan was linked with Nutrition Facts Panel data and ingredient information using commercial nutrition databases (ie, Gladson, Label Insight, Product Launch Analytics, and Mintel). These commercial databases contain national brands and private label items at the UPC level, and data are generally updated regularly as new products enter the market. Further details regarding matching these commercial data sets at the UPC level and other methodological facts have been published

previously.<sup>2,25</sup> Products were classified as containing NNS in Homescan 2002 and 2018 to examine whether changes have occurred over time. Keyword searches were performed on ingredient lists provided for each UPC purchased by participating households. A detailed list of key terms is available in Figure 1 (available at [www.jandonline.org](http://www.jandonline.org)), but in brief, keyword searches were performed for the 4 most commonly consumed NNS (saccharin, aspartame, sucralose, and reb-A),<sup>19</sup> as well as all other known NNS used by US food and beverage manufacturers. The ingredient lists were also examined for CS to determine whether NNS were used alone, or in combination with CS. Estimates of total purchases per year were calculated to estimate total volume purchased per day (milliliters per day for beverages; grams per day for foods) by a household. Then, the total purchases of each household were divided by the number of people in the household to calculate a per capita estimate of purchases. The percent of households purchasing foods and beverages by sweetener type was determined. To define a consumer in a meaningful way and exclude unusual or 1-time purchases, the total purchases per year was divided by predefined portions: 100 for beverages and 50 for foods. For the purpose of this research, a household was considered a consumer in Homescan if purchases totaled at least 52 portions per year, or 1 portion per week.

### Food Grouping

Packaged products in the data are not grouped in a manner that lends themselves to nutrition-related analyses. Our University of North Carolina team of trained members with masters of public health or registered dietitian degrees created a food grouping system and worked through the major beverage and food groupings to create nutritionally meaningful food groups. Figure 2 (available at [www.jandonline.org](http://www.jandonline.org)) provides a description of the beverage and food groupings. Based on these groupings, we ranked the top 10 food and beverage groups based on the volume per capita per day of products purchased within these groups containing any nonnutritive sweetener.

### Statistical Analysis

All analyses were performed using SAS v9.4 (2013; SAS Institute) Results are presented overall and by demographic subgroup in both 2002 and 2018. Results are reported for households both with and without children, 3 race-ethnic groups (Hispanic, non-Hispanic white, and non-Hispanic black), 3 income groups (<185%, 185%-350% and >350% of the federal poverty level), and 3 head of household education groups (less than high school, high school diploma, and more than high school). Significant changes between 2002 and 2018 in prevalence of intake were examined using  $\chi^2$  tests. Results for volume per capita per day are reported mean ( $\pm$ standard error), and differences examined using Student *t* test. A *P* value of <.05 was considered significant for all reporting.

## RESULTS

In 2002, 39,300 households were included in analysis and 61,101 in 2018 (Table 1). The Homescan data in general had a higher proportion of households without children and non-Hispanic whites (Table 2, available at [www.jandonline.org](http://www.jandonline.org)).

**Table 1.** Sociodemographic characteristics of US households<sup>a</sup> analyzed for purchases of caloric and nonnutritive sweeteners from packaged foods and beverages in 2002 and 2018<sup>b</sup>

Characteristics	2002	2018
<b>No. of households</b>	39,300	61,101
<b>Households without children (%)</b>	63.5	67.5
<b>Households with children &lt;18 y old (%)</b>	36.5	32.5
<b>Race or ethnicity (%)</b>		
Hispanic	9.2	13.1
Non-Hispanic white	76.2	68.1
Non-Hispanic black	11.0	11.6
Non-Hispanic other	3.6	7.2
<b>Household income (% federal poverty level)</b>		
<185	24.5	25.3
185-350	33.2	31.9
>350	42.3	42.8
<b>Head of household education (%)</b>		
Less than high school diploma	3.4	1.9
High school diploma	26.2	25.5
More than high school diploma	70.4	72.6

<sup>a</sup>Household characteristics based on data reported by Nielsen through its Homescan Services for the years 2002 and 2018 from Nielsen Homescan Household Panel across the US market, The Nielsen Company, 2019. The conclusions drawn from the Nielsen data are those of the authors and do not reflect the views of Nielsen. Nielsen is not responsible for and had no role in, and was not involved in, analyzing and preparing the results reported herein.

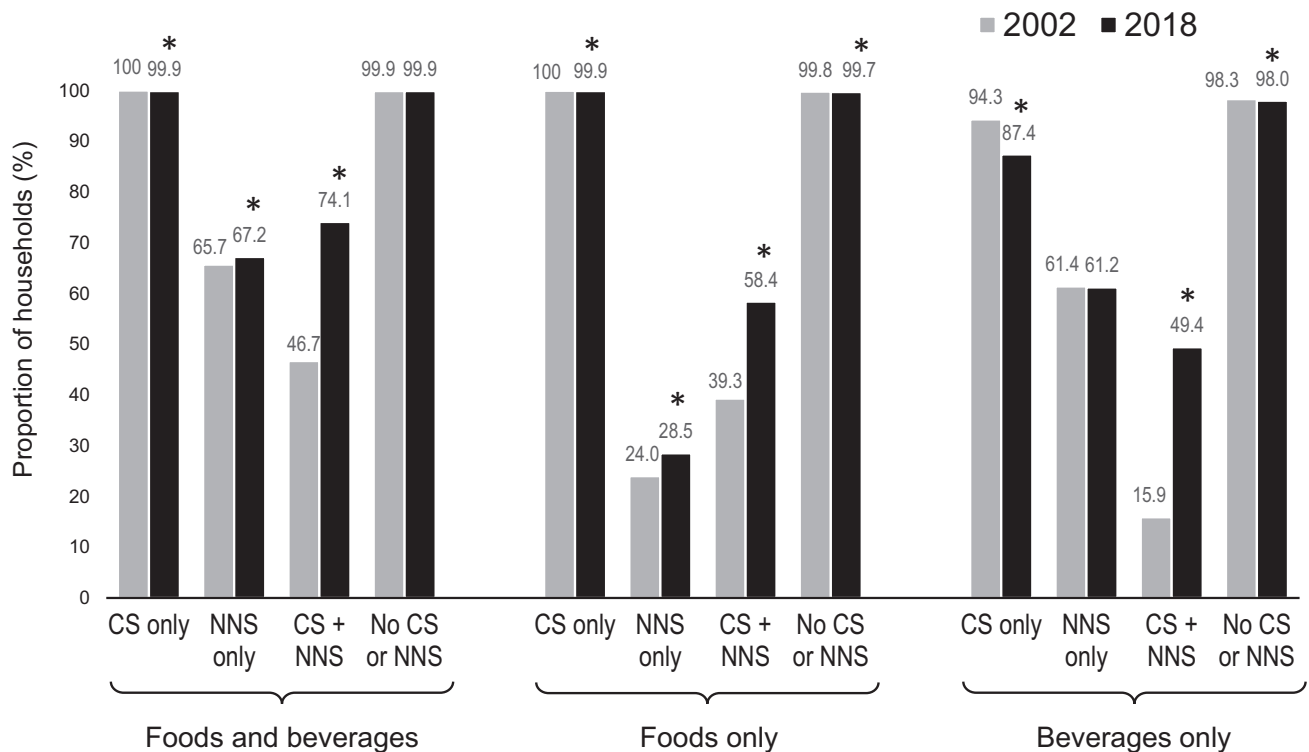
<sup>b</sup>All differences between 2002 and 2018 are significant at *P* < .05.

### Household Purchases of Products Containing CS

In 2002, 100% of households purchased products containing CS, which reduced slightly but significantly to 99.9% in 2018 (Figure 3). The volume of products purchased containing only CS also decreased significantly, from  $436.6 \pm 1.6$  g/d to  $362.4 \pm 1.3$  g/d (*P* < .05; Figure 4), although the decrease was due to a large decrease in purchases of beverages containing only CS, as food purchases slightly increased over the study period ( $227.8 \pm 0.7$  g/d to  $231.0 \pm 0.7$  g/d; Figure 4). All demographic subgroups showed a decrease in volume of foods and beverage purchases overall containing only CS (*P* < .05 for all; Table 2, available at [www.jandonline.org](http://www.jandonline.org)). Despite almost 100% of both households with and without children purchasing products containing CS in 2018, households with children purchased a considerably lower volume of products containing only CS ( $259.0 \pm 1.5$  g/d) than households without children ( $412.2 \pm 1.7$  g/d; Table 2, available at [www.jandonline.org](http://www.jandonline.org)).

### Household Purchases of Products Containing Both CS and NNS

The opposite trend to purchases containing only CS was seen for household purchases of products containing both CS and



**Figure 3.** The proportion of households purchasing products containing caloric sweeteners (CS) and nonnutritive sweeteners (NNS), a comparison of 2002 vs 2018. Sample sizes of households were 39,300 in 2002 and 61,101 in 2018. Authors' calculations are based in part on data reported by Nielsen through its Homescan Services for all food categories, including beverages and alcohol for the years 2002 and 2018 from Nielsen Homescan Household Panel across the US market, The Nielsen Company, 2019. The conclusions drawn from the Nielsen data are those of the authors and do not reflect the views of Nielsen. Nielsen is not responsible for and had no role in, and was not involved in, analyzing and preparing the results reported herein. \* $P < .05$ . CS only: products that contain caloric sweeteners as the only type of sweetener. NNS only: Products that contain nonnutritive sweeteners as the only type of sweetener. CS + NNS: products that contain both caloric and nonnutritive sweeteners. No CS or NNS: products that neither contain caloric sweeteners or nonnutritive sweeteners.

NNS together. The proportion of households purchasing products containing both CS and NNS increased almost 30% between 2002 and 2018 ( $P < .05$ ; Figure 3), with the increase driven mainly by beverages, which showed an increase from 15.9% in 2002 to 49.4% in 2018 ( $P < .05$ ; Figure 3). All demographic subgroups showed an increase in both the proportion of households (Table 3, available at [www.jandonline.org](http://www.jandonline.org)) and per capita volume purchased of products containing both CS and NNS (Table 2, available at [www.jandonline.org](http://www.jandonline.org)). In 2018, non-Hispanic whites purchased the highest volume of food products containing both CS and NNS (9.6 g/d vs 6.4 g/d for Hispanics and 5.9 g/d for non-Hispanic blacks; Table 4, available at [www.jandonline.org](http://www.jandonline.org)), and non-Hispanic blacks purchased the highest volume of beverage products (32.2 g/d vs 22.7 g/d for Hispanics and 28.4 g/d for non-Hispanic whites; Table 5, available at [www.jandonline.org](http://www.jandonline.org)). In fact, non-Hispanic black households showed a 42% increase in the prevalence of households purchasing beverage products containing both CS and NNS between 2002 (21.8%) and 2018 (56.6%) (Table 6, available at [www.jandonline.org](http://www.jandonline.org)). Interestingly, despite a larger proportion of households with children in 2018 purchasing products containing both CS and NNS (83.6%) than households without children (68.6%), households without children had a much higher volume purchased (40.9 g/d vs 26.3 g/d; Table 2, available at [www.jandonline.org](http://www.jandonline.org)).

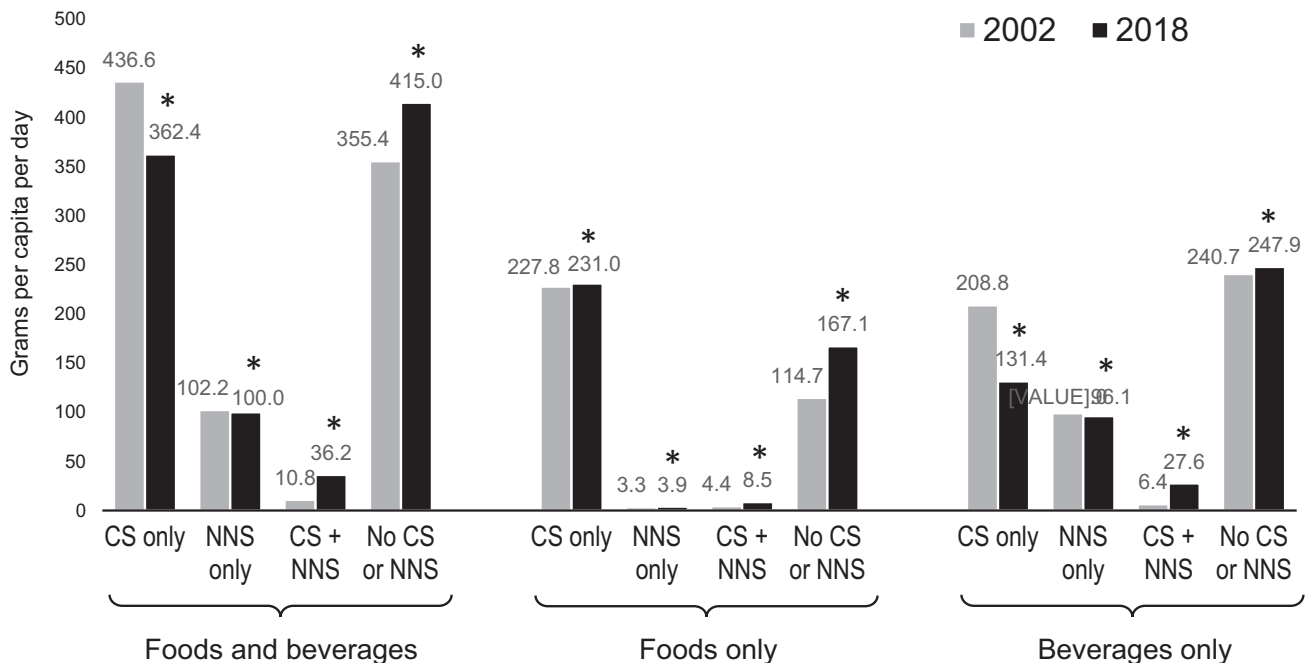
### Household Purchases of Products Containing Neither CS nor NNS

Almost 100% of households purchased products that contained neither CS nor NNS in both 2002 and 2018 (Figure 3). The volume purchased by households of products containing neither CS nor NNS increased between 2002 and 2018 (355.4 g/d to 415.0 g/d;  $P < .05$ ) (Figure 4), and this was driven by both an increase in food and beverage purchases. Interestingly, in 2002, US households purchased a higher volume of food and beverage products containing only CS (436.6 g/d) than neither CS nor NNS (355.4 g/d); however, this trend was reversed by 2018, with 362.4 g/d volume purchased of products containing CS only vs 415 g/d of products with neither CS nor NNS (Figure 5). In both 2002 and 2018, slightly more US households purchased products containing CS only than products containing neither CS nor NNS (Figure 3).

### Household Purchases of Products Containing NNS

A small but significant increase was observed in household purchases of products containing only NNS (65.7% in 2002 to 67.2% in 2018;  $P < .05$ ) (Figure 3). The increase was mainly driven by food products, with beverage products showing a smaller increase. However, when examining the volume per capita per day of products purchased that contained only





**Figure 4.** The volume per capita per day of products households purchase containing nonnutritive sweetener (NNS) and caloric sweetener (CS), a comparison of 2002 vs 2018. Sample sizes of households were 39,300 in 2002 and 61,101 in 2018. Authors' calculations are based in part on data reported by Nielsen through its Homescan Services for all food categories, including beverages and alcohol for the years 2002 and 2018 from Nielsen Homescan Household Panel across the US market, The Nielsen Company, 2019. The conclusions drawn from the Nielsen data are those of the authors and do not reflect the views of Nielsen. Nielsen is not responsible for and had no role in, and was not involved in, analyzing and preparing the results reported herein. \* $P < .05$ . CS only: products that contain caloric sweeteners as the only type of sweetener. NNS only: products that contain nonnutritive sweeteners as the only type of sweetener. CS + NNS: products that contain both caloric and nonnutritive sweeteners. No CS or NNS: products that neither contain caloric sweeteners or nonnutritive sweeteners.

NNS, a small but significant decrease was observed between 2002 and 2018 (102.2 g/d to 100.0 g/d;  $P < .05$ ) (Figure 4). Interestingly, non-Hispanic whites purchased almost twice the volume of products containing only NNS compared with Hispanics and non-Hispanic blacks in both survey years (Table 2, available at [www.jandonline.org](http://www.jandonline.org)). This finding was mainly due to non-Hispanic whites having higher volume purchases of aspartame (see next section). Households without children purchased more than double the volume of products containing only NNS compared with households with children in 2018 ( $125.9 \pm 1.3$  g/d vs  $46.3 \pm 0.8$  g/d; Table 2, available at [www.jandonline.org](http://www.jandonline.org)). In volume terms, these changes overall and by race-ethnic subpopulation group were driven mainly by shifts in beverage purchases

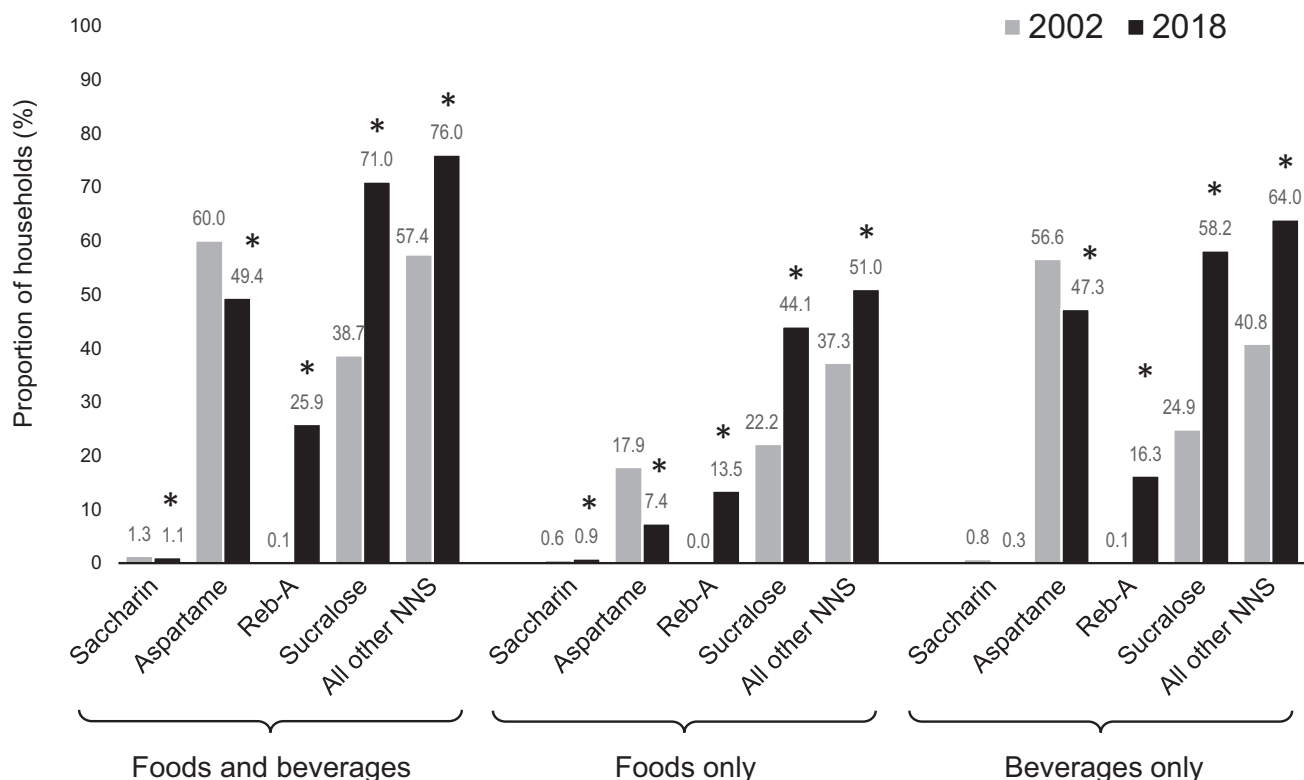
### Ranking of Food and Beverage Groups by Household Purchase of Products Containing Any NNS

For applicability, we present the top 10 food and beverage groups ranked based on volume of purchased products containing any NNS within each food or beverage group in Table 7. Most of the products containing NNS are found among beverages. Unsurprisingly, diet and low-calorie ( $\leq 20$  kcal/100 mL) soft and fruit drinks were the major source in 2002 and 2018, though there was a major drop in purchases of these beverages in 2018. This was partly made up by caloric soft and fruit drinks ( $> 20$  kcal/100 mL) shifting toward adding NNS in 2018 (moved in ranking from fifth place in 2002 to second place in 2018). In addition, there were important increases in the volume of

coffee and teas and water purchased containing NNS. In 2018, purchases of sports and energy drink products containing NNS showed up on the top 10. In the foods categories, there were notable but relatively small increases in the amount of the top 10 food groups with products containing NNS compared with what was seen for beverages. Nonetheless, it shows what food groups are beginning to have growth on NNS use over time and where future increase might be expected.

### Changes in Purchases of Specific NNS Types

Between 2002 and 2018 there was a large change in the prevalence of households purchasing specific NNS types. For example, between 2002 and 2018, the proportion of households purchasing products containing saccharin and aspartame decreased (1.3% to 1.1% for saccharin and 60.0% to 49.4% for aspartame;  $P < .05$ ; Figure 5), yet a large increase in the proportion of households purchasing reb-A and sucralose was observed (0.1% to 25.9% for reb-A and 38.7% to 71.0% for sucralose;  $P < .05$ ) (Figure 5). For all NNS types except for saccharin, products containing each NNS type were more often found among beverage purchases compared with foods. Aspartame had the highest volume per capita purchased of all NNS types, despite showing a significant decrease between 2002 and 2018 (94.7 g/d to 80.0 g/d;  $P < .05$ ) (Figure 6). A large increase in all other NNS was seen between 2002 to 2018 (40.3 g/d to 91.9 g/d;  $P < .05$ ), as well as large increases in reb-A (0 g/d in 2002 vs 7.6 g/d in 2018) and sucralose (15.4 g/d in 2002 vs 49.4 g/d in 2018). Saccharin contributed only



**Figure 5.** The proportion of households purchasing specific types of nonnutritive sweeteners (NNS), a comparison of 2002 vs 2018. Sample sizes of households were 39,300 in 2002 and 61,101 in 2018. Authors' calculations are based in part on data reported by Nielsen through its Homescan Services for all food categories, including beverages and alcohol for the years 2002 and 2018 from Nielsen Homescan Household Panel across the US market, The Nielsen Company, 2019. The conclusions drawn from the Nielsen data are those of the authors and do not reflect the views of Nielsen. Nielsen is not responsible for and had no role in, and was not involved in, analyzing and preparing the results reported herein. \* $P < .05$ . Reb-A = rebaudioside A.

<1 g/d in volume purchased per capita (Figure 6). It's also important to note the relative sweetness of each NNS examined compared with sucrose. Figure 7 (available at [www.jandonline.org](http://www.jandonline.org)) shows that sucralose has the highest relative sweetness, at 600× sweeter than sucrose, and reb-A the lowest, with 240× sweeter than sucrose.

## DISCUSSION

### Overall Results

Using measures of household purchases from nationally representative samples of US households, a large shift was found between 2002 and 2018 in how NNS were being purchased by US consumers. The current study observed, as previous studies have shown, that purchases of products containing CS have decreased in recent years,<sup>10,26,27</sup> yet the proportion of households purchasing products containing both CS and NNS together has increased by more than 30%. This increase was driven mainly by beverages rather than food, with the volume purchased per capita per day of beverage products with both CS and NNS increasing more than 4-fold from 2002 to 2018. At the same time, a decrease in volume purchased per capita per day of beverage products containing only NNS was observed. The most recent study examining household purchases of products containing NNS (between 2000 and 2010) found that purchases of products containing NNS increased between 2000 and 2006, and

began to decrease between 2006 and 2010.<sup>10,28</sup> Current results indicate that decline has continued through to 2018. In addition, most studies examining volume purchases or intake of NNS and CS have not also considered how to compare products containing neither CS nor NNS. The current study observed a changing trend, with US households in 2002 purchasing a higher volume of food and beverage products containing only CS vs neither CS nor NNS, with the opposite trend observed in 2018. This highlights the changing nature of both the US food supply and consumer purchasing behavior over the past 16 years.

Although the current study found that foods contributed a larger volume per capita of purchases of products containing only CS (231 g/d vs 131.4 g/d in 2018), it was also observed that beverages were predominantly responsible for larger volume per capita purchases of products containing only NNS (96.1 g/d for beverages vs 3.9 g/d for foods in 2018) as well as products containing both CS and NNS (27.6 g/d for beverages vs 8.5 g/d for foods in 2018). Volume per capita purchases of beverage products containing only NNS did not change significantly between 2002 and 2018; however, purchases increased significantly for products containing both CS and NNS. This is in line with previous research, which has shown that in both children and adults, consumption of reduced-calorie beverages (eg, reduced-calorie sport drinks) has been increasing while consumption of no-calorie beverages (eg, diet soda) has remained relatively stable.<sup>4,9</sup>

**Table 7.** The top 10 food and beverage groupings for purchased products containing any nonnutritive sweeteners (with or without caloric sweeteners) in US households: a comparison of 2002 vs 2018<sup>a</sup>

2002		2018	
Group	Mean (SE <sup>b</sup> )	Group	Mean (SE)
<b>Beverages<sup>c</sup></b>			
Soft drinks and fruit drinks diet or low calorie (≤20 kcal/100 g)	91.07 (1.12)	Soft drinks and fruit drinks diet or low calorie (≤20 kcal/100 g)	58.21 (0.74)
Coffee or tea caloric (>20 kcal/100 g)	5.83 (0.25)	Soft drinks and fruit drinks caloric (>20 kcal/100 g)	24.41 (0.35)
Water noncaloric (0 kcal/100 g)	3.02 (0.12)	Water noncaloric (0 kcal/100 g)	10.62 (0.20)
Coffee or tea noncaloric or low calorie (≤20 kcal/100 g)	1.29 (0.07)	Coffee or tea caloric (>20 kcal/100 g)	9.56 (0.30)
Soft drinks and fruit drinks caloric (>20 kcal/100 g)	1.19 (0.04)	Coffee or tea noncaloric or low calorie (≤20 kcal/100 g)	6.56 (0.18)
Cocoa and sweetened milk beverages powdered	1.16 (0.04)	Cocoa and sweetened milk beverages powdered	3.42 (0.16)
Water diet or low calorie (≤10 kcal/100 g)	0.67 (0.05)	Sports drinks diet or low calorie (≤20 kcal/100 g)	3.33 (0.10)
<100% fruit juice low calorie (≤20 kcal/100 g)	0.60 (0.03)	<100% fruit juice low calorie (≤20 kcal/100 g)	2.12 (0.07)
<100% vegetable juice low calorie (≤20 kcal/100 g)	0.20 (0.01)	Energy drinks diet or low calorie (≤20 kcal/100 g)	1.45 (0.06)
<100% vegetable juice caloric (>20 kcal/100 g)	0.18 (0.01)	<100% fruit juice caloric (>20 kcal/100 g)	1.15 (0.03)
<b>Food<sup>c</sup></b>			
Yogurt	1.82 (0.04)	Yogurt	2.47 (0.04)
Dairy-based desserts	1.31 (0.04)	Dairy-based desserts	1.82 (0.03)
Candy and sweet snacks	1.02 (0.03)	Dairy products, other	1.51 (0.03)
Grain-based bars	0.65 (0.01)	Candy and sweet snacks	1.43 (0.03)
Grain-based desserts	0.49 (0.01)	Bread and bread products	1.09 (0.02)
Sweeteners	0.46 (0.01)	Sweeteners	0.60 (0.01)
Salty snacks	0.36 (0.01)	Grain-based bars	0.57 (0.01)
Sauces, dips, and condiments	0.32 (0.01)	Grain-based desserts	0.56 (0.01)
Soups and stews	0.27 (0.01)	Fruit	0.47 (0.01)
Cereal	0.23 (0.01)	Sauces, dips, and condiments	0.41 (0.01)

<sup>a</sup>Source: Authors' calculations based in part on data reported by Nielsen through its Homescan Services for all food categories, including beverages and alcohol for the years 2002 and 2018 from Nielsen Homescan Household Panel across the US market, The Nielsen Company, 2019. The conclusions drawn from the Nielsen data are those of the authors and do not reflect the views of Nielsen. Nielsen is not responsible for and had no role in, and was not involved in, analyzing and preparing the results reported herein.

<sup>b</sup>SE = standard error.

<sup>c</sup>Ranked based on greatest volume per capita per day of purchased products containing any nonnutritive sweetener within each group).

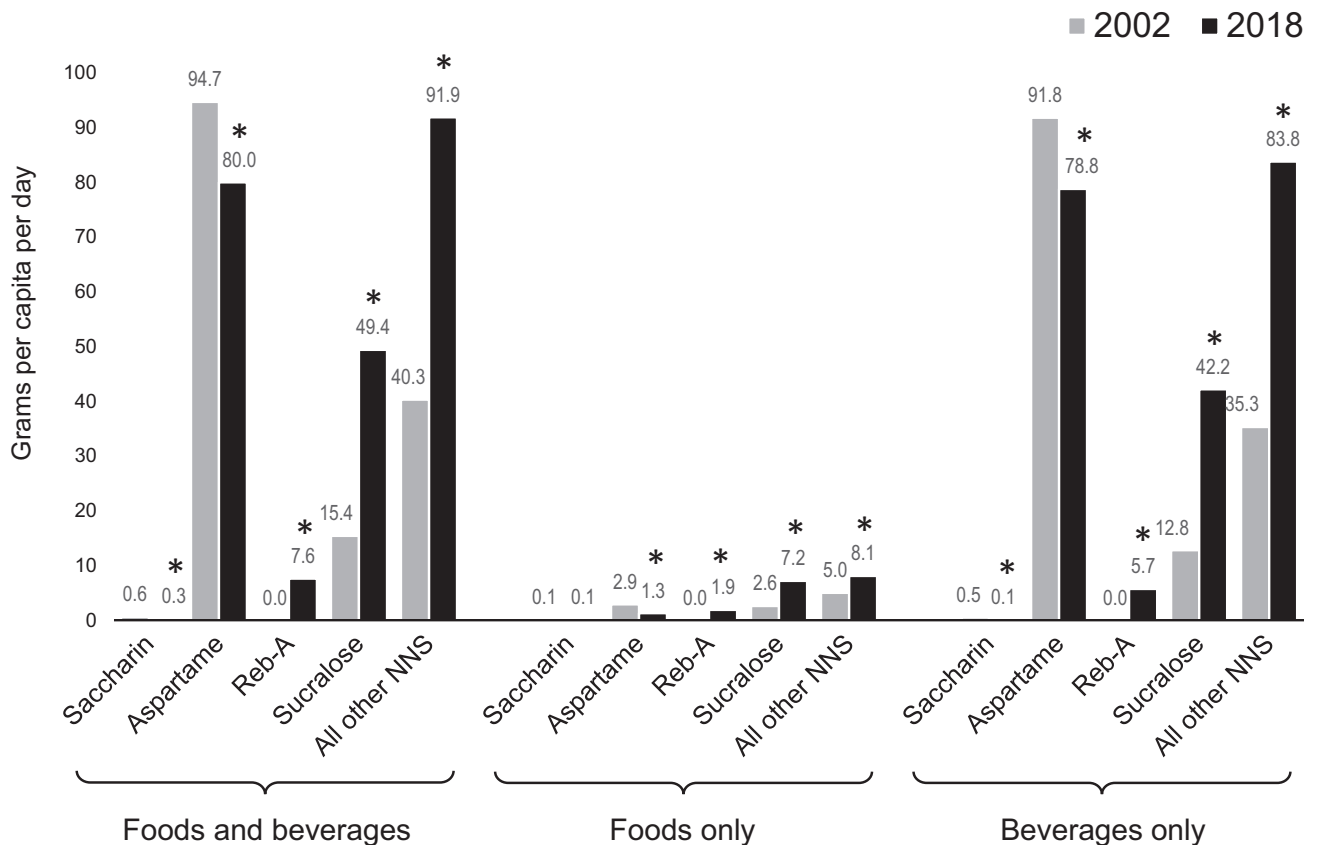
### Race-Ethnic Subpopulation Results

Although similar trends were observed when looking at specific demographic subgroups, non-Hispanic whites were found to purchase almost double the volume of products containing NNS compared with Hispanics and non-Hispanic blacks in both survey years. This supports research into consumption of NNS, which demonstrates that non-Hispanic whites in the United States have a higher prevalence of NNS consumption compared with non-Hispanic black and Hispanic race-ethnic groups.<sup>9,10,29</sup> Interestingly, though, it was

also found that non-Hispanic black households showed a 42% increase in the proportion of households purchasing beverage products containing both CS and NNS between 2002 and 2018, indicating that purchasing behavior may be changing for this race-ethnic group.

### Shifts in the Types of NNS

A change in the specific types of NNS that are being purchased by US households was also observed. For example, out of the 4 NNS types examined, both prevalence of households



**Figure 6.** The volume per capita per day of products containing specific types of nonnutritive sweeteners (NNS), a comparison of 2002 vs 2018. Sample sizes of households were 39,300 in 2002 and 61,101 in 2018. Authors' calculations are based in part on data reported by Nielsen through its Homescan Services for all food categories, including beverages and alcohol for the years 2002 and 2018 from Nielsen Homescan Household Panel across the US market, The Nielsen Company, 2019. The conclusions drawn from the Nielsen data are those of the authors and do not reflect the views of Nielsen. Nielsen is not responsible for and had no role in, and was not involved in, analyzing and preparing the results reported herein. \* $P < .05$ . Reb-A = rebudioside A.

purchasing and the volume per capita purchased of saccharin and aspartame decreased, and reb-A and sucralose increased. Reb-A and sucralose are relatively new to the market, and results indicate that these types of sweeteners may in fact be replacing the use of the more traditionally used NNS, such as aspartame. Interestingly, despite saccharin being noted in the literature as one of the most commonly consumed NNS in the United States,<sup>19</sup> it was found to contribute  $<1$  g/d in terms of purchased volume per capita. With the most recent RCT examining the differential effects of these 4 NNS types showing a negative effect of saccharin on body weight,<sup>19</sup> it is promising that it is not as widely consumed by US households and that other NNS types currently dominate the US food and beverage supply. That being said, saccharin is found in the common table-top sweetener Sweet'N Low (Cumberland Packing Corporation), and hence a substantial portion of saccharin intake may have been missed in the present study if predominately used outside the home.

Aspartame remains a dominant NNS type purchased (by more than 50% of households in 2018), although the proportion of households purchasing products containing aspartame decreased by just under 10% between 2002 and 2018. At the same time, purchases of sucralose increased by more than 30%, driven mainly by beverage products. Reports

suggest that sucralose accounts for the majority of the NNS market share in the United States (passing aspartame, which previously represented the majority).<sup>30</sup> New research conducted on 45 healthy adults found that the consumption of sucralose alongside carbohydrate (eg, in drinks that contain both sucralose and caloric sugars) rapidly impairs glucose metabolism, resulting in decreases in brain sensitivity to sweet taste.<sup>31</sup>

Research suggests that as consumer preferences continue to shift toward more "natural" products, consumption of NNS types such as reb-A will likely increase more rapidly compared with other NNS types.<sup>9</sup> The present study supports this, showing a large increase in both the proportion of households purchasing, and the volume purchased, of reb-A. In addition to its appeal as a "natural" NNS, reb-A is also touted as being more palatable than other NNS.

### Limitations

Home purchase data such as that found in Homescan do not provide measures of individuals' actual intake; however, these data are useful to characterize the variability in food consumption patterns at the population level. Another challenge of using Homescan is that estimates of per capita purchases might not be comparable with per capita intake



from dietary intake surveys (eg, National Health and Nutrition Examination Surveys). For example, in a given household all purchases of beverages containing NNS could be consumed by a single member of the household, rather than being consumed by all household members, affecting the per capita estimates made here. Homescan also does not capture food and drinks purchased from fast-food chains and other restaurants, which could have resulted in an underestimate of purchases in the present study.

Another limitation is the low proportion of households without a high school education. Although our weights adjust for this, the Nielsen Homescan data had a smaller sample of lower education households for whom data were collected.

Moreover, in the absence of a requirement that nutrition facts panels contain the amount of each NNS used, it was not possible to determine the actual amounts of each sweetener types present in products. Chile is one of the few if not the only country that has this requirement now.

### Strengths and Unique Contributions

To the knowledge of the authors, this is the first study to examine trends in purchases of US households on specific types of NNS and uses the most currently available household purchase data. Results indicate that a decline in purchases of products containing only CS is happening in tandem with an increase in purchases of products containing both CS and NNS. In addition, beverage purchases appear to be responsible for the majority of this change, and that this has occurred along with a large shift in the specific types of NNS that are being purchased by US households (and therefore being used by the food industry). New NNS types enter the market regularly, and it is important to monitor changes not only in the amount of products containing NNS that US consumers purchase, but also the types of NNS that are present in food and beverage products. A critical gap as NNS prevalence grows will be to add a legal requirement for amounts of NNS by type be added to nutrition facts panel as is done in Chile. Without such information, it would be very challenging to track intake of these mixes of NNS that are becoming more prevalent in our food supply to begin understanding if and what types of effects they may have on population health and in addressing disparities. Efforts to encourage or require food manufacturers to disclose the amounts of the various types of NNS in their products should be undertaken.

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## **STATEMENT OF POTENTIAL CONFLICT OF INTEREST**

No potential conflict of interest was reported by the authors.

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## **AUTHOR CONTRIBUTIONS**

E. K. Dunford, D. R. Miles, S. W. Ng, and B. Popkin designed and conducted this research. D. R. Miles analyzed data. E. K. Dunford drafted the paper. E. K. Dunford, S. W. Ng, and B. Popkin had joint primary responsibility for final content.

Saccharin	Aspartame	Reb-A	Sucralose	All other NNS
Necta Sweet	Aspartame	Enliten	Kaltame	Acesulfame
Saccharin	InstaSweet	Reb-a	Splenda	Advantame
Sweet'N Low	NatraTaste	Rebaudioside A	Sucralose	Alitame
Sugar Twin		Rebiana	Trichlorogalactosucrose	Brazzein
		Stevia	Altern	Curculin
		Sugarleaf		Cweet
		Candyleaf		Cyclamate
		Candy leaf		Cyclamic acid
		SweetLeaf		Erythritol
		Purevia		Galactitol
		Steviol glycoside		Glucitol
				Hydrogenated isomaltulose
				Isomalt
				Lactitol
				Lumbah
				Luo han guo
				Mabinlin
				Maltitol
				Mannitol
				Monatin
				Monellin
				Monk fruit extract
				Monk fruit
				Neohesperidin dihydrochalcone
				Osladin
				Oubli
				Pentadin
				Polyglycitol
				Sorbitol
				Sunett
				Sweet One
				Twinsweet
				Truvia

(continued on next page)

**Figure 1.** Keywords used to search for each nonnutritive sweetener (NNS) category.<sup>a</sup> Reb-A = rebaudioside A.

Saccharin	Aspartame	Reb-A	Sucralose	All other NNS
				Thaumatococcus
				Xylitol
<sup>a</sup> Manufacturer information: Necta Sweet (Necta Sweet, Inc); Sweet'N Low (Cumberland Packing Corp); Sugar Twin (B&G Foods); InstaSweet (Necta Sweet, Inc); NatraTaste (Cumberland Packing Corp); Enliten (Ingredion, ChemPoint); Sugarleaf (Wisdom Natural Brands); SweetLeaf (Wisdom Natural Brands); Purevia (Whole Earth Sweetener Co., Merisant); Kaltame (Hexagon Nutrition Pvt Ltd [India]); Splenda (Heartland Food Products Group); Advantame (Ajinomoto); Cweet (Natur Research Ingredients); Sunett (Celanese); Sweet One (Cumberland Packing Corp); Twinsweet (Holland Sweetener Co); Truvia (Cargill, Inc).				

**Figure 1.** (continued) Keywords used to search for each nonnutritive sweetener (NNS) category.<sup>a</sup> Reb-A = rebaudioside A.

Group Name	Group Description
<b>Beverages</b>	
Water, noncaloric	Includes water with 0 kcal/100 g (tap or bottled; carbonated or noncarbonated). Examples include tap water; plain bottled water; plain club soda, sparkling water, seltzer water, or sparkling mineral water; carbonated water sweetened with noncaloric sweetener.
Water, diet or low calorie	Includes bottled flavored waters (carbonated or noncarbonated) with $\leq 10$ kcal/100 g.
Water, caloric	Includes bottled flavored waters (carbonated or noncarbonated) with $> 10$ kcal/100 g. Examples include vitamin water; tonic water.
Coffee and tea, noncaloric and diet or low calorie	Includes coffee and tea with $\leq 20$ kcal/100 g (combined with milk, cream, or sweeteners). Examples include regular or decaf coffee from ground; regular or decaf coffee from instant (unsweetened or presweetened with LCS <sup>a</sup> or prelightened); tea brewed from leaves; herbal tea; instant tea (unsweetened or presweetened with LCS); tea presweetened with LCS.
Coffee and tea, caloric	Includes coffee and tea with $> 20$ kcal/100 g (combined with milk, cream, or sweeteners) and coffee beverages. Examples include presweetened tea; presweetened instant tea; regular or decaf coffee from ground or instant with caloric sweetener or milk added by the consumer; presweetened or prelightened coffee; coffee latte; cappuccino; mocha; blended coffee beverages.
SSB <sup>b</sup> , diet or low calorie	Includes soft drinks and fruit drinks with $\leq 20$ kcal/100 g. Examples include cola-type, fruit-flavored, or pepper-type sugar-free soft drinks; low-calorie fruit-flavored drinks from powdered mix; low-calorie fruit juice drinks or juice cocktail; low-calorie fruit-flavored drinks; sugar-free root beer, cream soda, or ginger ale; sugar-free fruit- or vanilla-flavored cola; low-calorie lemonade; low-calorie fruit and vegetable juice drink; low-calorie mixes for mixed alcoholic beverages (margaritas, daiquiris; liquid, powder, or frozen). Fruit drinks include beverages primarily composed of sugar or sweetener (as first or second ingredients) with fruit juice or fruit juice concentrate as a lesser ingredient. Fruit-flavored drinks contain fruit flavors but no fruit juice or fruit juice concentrate.
SSB, caloric	Includes soft drinks and fruit drinks with $> 20$ kcal/100 g. Examples include cola-type, fruit-flavored, or pepper-type soft drinks; fruit-flavored drinks from powdered mix; fruit juice drinks or juice cocktail; fruit-flavored drinks; root beer, cream soda, or ginger ale; reduced-sugar fruit juice drinks; fruit- or vanilla-flavored cola; fruit and vegetable juice drinks; lemonade; orangeade; light orange juice; grapeade; limeade; carbonated juice drinks; fruit punch; fruit-flavored frozen drink (slushie); mixes for mixed alcoholic beverages (margaritas, daiquiris; liquid, powder, or frozen). Fruit drinks include beverages primarily composed of sugar or sweetener (as first or second ingredients) with fruit juice or fruit juice concentrate as a lesser ingredient. Fruit-flavored drinks contain fruit flavors but no fruit juice or fruit juice concentrate.
<100% fruit juice, low calorie	Fruit juice, <100% with $\leq 20$ kcal/100 g, not from concentrate or from concentrate (orange, grapefruit, apple, grape, pineapple, prune juices; juice blends; coconut water); sweetened juice (sweetened cranberry juice, fruit nectars, and juice blends); frozen fruit juice concentrate.
<100% vegetable juice, low calorie	Vegetable juice, <100% with $\leq 20$ kcal/100 g, not from concentrate or from concentrate (tomato juice, tomato or vegetable juice blends, carrot juice); sweetened vegetable and fruit juice blends.
Milk—sweetened or flavoured	Fresh or shelf-stable chocolate, strawberry, or flavored milk; milk drinks (eg, containing oil, thickeners, or mostly water, such as milk shake drinks).
Cocoa and sweetened milk beverages—powdered	Hot chocolate or cocoa mix; powder for flavored milk; instant breakfast; coffee beverages (coffee with milk or creamer, such as latte, mocha, or cappuccino instant mixes), tea drinks (tea with milk or creamer, such as chai tea latte, instant mixes).
<i>(continued on next page)</i>	

**Figure 2.** Major food subcategories of foods and beverages in the major food and beverage group table.



<b>Group Name</b>	<b>Group Description</b>
Sports drinks, diet or low calorie	Includes sports drinks and fluid replacement beverages with $\leq 20$ kcal/100 g. Examples include low-calorie fruit-flavored sports drinks or thirst quenchers.
Energy drinks, diet or low calorie	Includes energy drinks with $\leq 20$ kcal/100 g.
<b>Food</b>	
Yogurt	Yogurt (plain or sweetened or flavored); yogurt drinks, shakes, or smoothies; kefir.
Dairy-based desserts	Ice cream; sherbet; ice milk; frozen yogurt; ice cream bars, cones, sandwiches; pudding; cheesecake; tiramisu; mousse.
Dairy products	Sour cream, cream, half-and-half, whipping cream, creamer (liquid or powdered), whipped cream, whipped topping, evaporated milk, sweetened condensed milk.
Candy and sweet snacks	Candy, chocolate, candy bars, marshmallows, fudge, toffee, baking chocolate, morsels, sprinkles, gum, mints, candy-making kits; fruit snacks, fruit leather, fruit bars, maraschino cherries, caramel apples, candied apples; popsicles, sorbet, ices, gelatin; fruit salads with gelatin, ambrosia; fried apple or banana chips, chocolate- or yogurt-covered fruit, chocolate- or yogurt-covered nuts or seeds, candy-coated nuts or seeds.
Grain-based bars	Granola bars, cereal bars, snack bars, crispy rice bars, meal replacement bars.
Grain-based desserts	Refrigerated ready-to-bake cookies, brownies, sweet rolls, Danish, pie crusts; frozen cake, pie, cobbler, turnovers, coffee cake, honey buns, toaster pastries, brownies, cookies, doughnuts, cream puffs, éclairs, tarts, muffins, pastry shells, pie crusts; shelf-stable ready-to-eat cookies, brownies, snack cakes, cupcakes, oatmeal cream pies, single-serve fruit snack pies, graham crackers, animal crackers, doughnuts, coffee cake, Danish, sweet rolls, honey buns, toaster pastries, scones, muffins, cake, turnovers, éclairs, tarts, croissants, puff pastry, prepared pie crusts, pastry shells, tart shells, ice cream cones or bowls; baking mixes for cake or cupcakes, brownies, cookies, muffins, coffee cake, gingerbread, dessert bars, cobblers or crisps, no-bake pies, pie crust, scones, shortcake.
Bread and bread products	Fresh bread, cinnamon or raisin bread, breadsticks, pita bread, rolls, hot dog or hamburger buns, sandwich rolls, bagels, English muffins, pizza crusts; refrigerated ready-to-bake rolls, breadsticks, garlic bread, pizza crusts, dough; frozen dough, bread, breadsticks, rolls, bagels, garlic bread, English muffins, hot dog or hamburger buns, pizza crusts; shelf-stable bread crumbs, canned brown bread, croutons, grain-based imitation bacon bits; mixes for bread, rolls, or pizza crust; breadings or batter mixes.
Sugars, sweeteners, syrups, and toppings	Granulated sugar, brown sugar, powdered sugar; honey, molasses, sorghum syrup, corn syrup, flavored granulated sugar, nonnutritive sweeteners, agave nectar; jam, preserves, marmalade, fruit or pumpkin butter, jelly, lemon curd; pancake syrup, pure maple syrup, flavored syrups for coffee drinks or Italian soda, fruit syrups, chocolate or fruit-flavored dessert or milk syrup, icing, dessert topping (eg, caramel, butterscotch, hot fudge, strawberry topping, marshmallow cream), hazelnut spread, cake decorations, pastry filling, marzipan.
Salty snacks	Potato chips, potato crisps, sweet potato chips, corn nuts, crispy green peas; crackers, snack crackers, corn chips, pretzels, tortilla chips, cheese-flavored tortilla chips, cheese puffs, pita chips, popcorn (unpopped kernels, microwaveable, or pre-popped), sandwich crackers, rice cakes, snack mixes with crackers; soy nuts, chocolate- or yogurt-covered soynuts; pork rinds.
<i>(continued on next page)</i>	

**Figure 2.** (continued) Major food subcategories of foods and beverages in the major food and beverage group table.

Group Name	Group Description
Sauces, condiments, and dips	Ready-to-heat shelf-stable or refrigerated tomato-based pasta sauces or spaghetti sauces (plain, marinara, mushroom, meat, Bolognese, 4 cheese); Alfredo sauce, cheese sauce, prepared gravy, pizza sauce, sloppy joe sauce, enchilada sauce, curry sauce, simmer sauce, white or red clam sauce, chili sauce, pesto sauce, béarnaise sauce, butter sauce, cooking wine, teriyaki sauce, marinades, glazes, stir fry sauce, and dry mixes for gravy; mayonnaise, sandwich spreads; salad dressing (shelf-stable and refrigerated); coleslaw dressing; ketchup, barbecue sauce; soy sauce, oyster sauce, fish sauce, hoisin sauce, tamari sauce, ponzu sauce; mustard, tartar sauce, cocktail sauce, hot sauce, tabasco sauce, vinegar, Worcestershire sauce, taco sauce, picante sauce, sweet and sour sauce, duck sauce, steak sauce, wing sauce, honey mustard sauce, horseradish, pickle relish, other vegetable relishes, fruit relish, fruit chutney, vegetable-based spreads and tapenades (olive tapenade, artichoke tapenade, eggplant tapenade or spread), yeast extract; salsa; guacamole; ready-to-heat cheese dip or salsa con queso; dairy-based chip or vegetable dip (eg, French onion, ranch, dill); black bean dip, hummus; spinach dip; crab dip, smoked salmon dip; caramel dip; chocolate dipping sauce or fondue.
Soups and stews	Noodle- or rice-based soups (eg, chicken noodle, chicken and rice, ramen noodles); meat-based soups (eg, meat-based chili, beef stew, beef vegetable soup); vegetable-based soups (eg, vegetable soup, tomato soup, French onion soup, cream of mushroom, gazpacho); starchy-vegetable based soups (eg, potato soup, corn chowder, cream of potato); legume-based soups (eg, split pea, lentil, black bean, bean-based chili); dairy-based soups (eg, cheddar cheese soup, broccoli cheese, clam chowder, cream of mushroom); broth, stock, bouillon.
Cereal	Ready-to-eat cereal including corn flakes, frosted flakes, raisin bran, frosted shredded wheat, toasted oat cereal, crispy rice, chocolate flavored cereals, bran flakes, fruit-flavored cereals, puffed rice, shredded wheat, granola; hot cereals including oatmeal, grits, cream of wheat, cream of rice.
Fruit	Fresh or refrigerated bags or containers of fresh apples, oranges, lemons, cherries, figs, grapes, berries, apricots, avocado, coconuts; refrigerated apple slices or fresh cut fruit (eg, melon, pineapple, or fruit mixtures), apple slices with caramel or peanut butter dip, packaged fruit with yogurt dip, packaged refrigerated sweetened cut fruit in juice or syrup (eg, peaches, pineapple, grapefruit, mandarin oranges, and fruit mixtures); frozen strawberries, raspberries, blueberries, blackberries, peaches, pineapple, melon, mango, cherries, cranberries, and fruit mixtures (unsweetened or sweetened); dried raisins, cranberries, dates, plums (ie, prunes), apricots, figs, mango, pineapple, cherries, blueberries, apples, coconut, and mixtures of dried fruit; dried or baked apple chips (unsweetened or sweetened); canned or shelf-stable peaches, pears, pineapple, mandarin oranges, apricots, grapefruit, cherries, plums, other fruits, fruit cocktail, fruit mixtures, fruit salads (in heavy syrup, light syrup, or juice, or water); canned coconut; canned or shelf-stable apple sauce, cranberry sauce, or pickled fruit.
<p><sup>a</sup>LCS = low-caloric sweetener.</p> <p><sup>b</sup>SSB = sugar-sweetened beverages.</p>	

**Figure 2.** (continued) Major food subcategories of foods and beverages in the major food and beverage group table.

**Table 2.** Volume per capita per day of products containing NNS<sup>a</sup> and CS<sup>b</sup> by demographic subgroup of US households: a comparison of 2002 vs 2018 foods and beverages combined<sup>c</sup>

Beverage Categories	CS Only <sup>d</sup>		NNS Only <sup>e</sup>		CS and NNS <sup>f</sup>		No CS or NNS <sup>g</sup>	
	2002	2018	2002	2018	2002	2018	2002	2018
<b>Household with children &lt;18 y old</b>	375.7 (2.2)	259.0 (1.5)	51.2 (1.0)	46.3 (0.8)	8.3 (0.2)	26.3 (0.4)	261.6 (1.7)	282.0 (1.6)
<b>Household without children</b>	471.6 (2.1)	412.2 (1.7)	131.7 (1.7)	125.9 (1.3)	12.2 (0.2)	40.9 (0.4)	409.5 (2.0)	479.1 (1.9)
<b>Head of household education</b>								
Less than high school	510.6 (13.9)	448.4 (16.0)	90.2 (7.2)	90.1 (9.5)	9.8 (1.2)	41.5 (2.9)	417.9 (17.8)	487.7 (19.8)
High school diploma	480.0 (3.7)	447.6 (3.7)	101.3 (2.4)	114.2 (2.6)	11.4 (0.4)	43.4 (0.9)	377.9 (3.2)	472.6 (4.1)
More than high school	416.8 (1.8)	330.2 (1.3)	103.2 (1.4)	95.3 (1.0)	10.6 (0.2)	33.5 (0.3)	344.0 (1.6)	392.9 (1.5)
<b>Household income (% federal poverty level)</b>								
<185	446.2 (4.3)	415.7 (3.5)	79.3 (2.5)	94.7 (2.4)	9.3 (0.4)	40.7 (0.8)	331.8 (3.4)	422.9 (3.7)
185-350	451.0 (2.9)	357.0 (2.0)	94.3 (1.8)	87.4 (1.4)	10.6 (0.3)	35.2 (0.5)	366.3 (2.8)	399.0 (2.4)
>350	419.5 (2.1)	334.8 (1.8)	121.8 (1.9)	112.6 (1.5)	11.7 (0.2)	34.2 (0.5)	360.6 (2.0)	422.3 (2.1)
<b>Race or ethnicity</b>								
Hispanic	381.0 (5.9)	284.2 (3.9)	57.1 (2.6)	56.5 (2.1)	9.8 (0.5)	29.2 (0.9)	289.5 (4.9)	355.7 (4.9)
Non-Hispanic white	448.0 (1.8)	385.2 (1.5)	117.7 (1.4)	120.9 (1.2)	11.2 (0.2)	38.1 (0.4)	376.1 (1.7)	438.0 (1.7)
Non-Hispanic black	423.9 (5.5)	365.5 (4.3)	46.3 (1.9)	57.4 (1.9)	9.4 (0.4)	38.1 (0.8)	287.8 (3.9)	389.6 (4.7)
<b>Total sample</b>	<b>436.6 (1.6)</b>	<b>362.4 (1.3)</b>	<b>102.2 (1.2)</b>	<b>100.0 (1.0)</b>	<b>10.8 (0.2)</b>	<b>36.2 (0.3)</b>	<b>355.4 (1.5)</b>	<b>415.0 (1.5)</b>

<sup>a</sup>NNS = nonnutritive sweetener.

<sup>b</sup>CS = caloric sweetener.

<sup>c</sup>Source: Authors' calculations based in part on data reported by Nielsen through its Homescan Services for all food categories, including beverages and alcohol for the years 2002 and 2018 from Nielsen Homescan Household Panel across the US market, The Nielsen Company, 2019. The conclusions drawn from the Nielsen data are those of the authors and do not reflect the views of Nielsen. Nielsen is not responsible for and had no role in, and was not involved in, analyzing and preparing the results reported herein.

<sup>d</sup>CS Only = products that contain caloric sweeteners as the only type of sweetener.

<sup>e</sup>NNS Only = products that contain nonnutritive sweeteners as the only type of sweetener.

<sup>f</sup>CS and NNS = products that contain both caloric and nonnutritive sweeteners.

<sup>g</sup>No CS or NNS = products that neither contain caloric sweeteners or nonnutritive sweeteners.

**Table 3.** Prevalence of NNS<sup>a</sup> consumption and CS<sup>b</sup> consumption by demographic subgroup of US households: a comparison of 2002 vs 2018 foods and beverages combined<sup>cd</sup>

Characteristics	CS Only <sup>e</sup>		NNS Only <sup>f</sup>		CS and NNS <sup>g</sup>		No CS or NNS <sup>h</sup>	
	2002	2018	2002	2018	2002	2018	2002	2018
<b>Household with children &lt;18 y old</b>	100.0	100.0	62.4	66.8	58.1	83.6	99.9	99.9
<b>Household without children</b>	100.0	99.9	62.5	63.9	39.0	68.6	99.9	99.7
<b>Head of household education</b>								
Less than high school diploma	100.0	99.7	48.9	61.3	34.0	72.2	100.0	99.9
High school diploma	100.0	100.0	62.7	66.6	45.8	76.1	99.9	99.8
More than high school diploma	100.0	99.9	63.1	64.4	46.6	72.6	99.9	99.8
<b>Household income (% federal poverty level)</b>								
<185	100.0	99.9	55.4	61.4	43.0	75.3	99.9	99.8
185-350	100.0	100.0	61.6	65.2	46.6	76.7	99.9	99.8
>350	100.0	99.9	67.4	66.7	47.1	70.1	99.9	99.8
<b>Race or ethnicity</b>								
Hispanic	100.0	99.9	60.3	62.3	49.9	75.3	99.9	99.6
Non-Hispanic white	100.0	99.9	65.4	68.2	46.9	73.9	99.9	99.8
Non-Hispanic black	100.0	100.0	47.5	56.9	37.3	74.6	99.8	99.7
<b>Total sample</b>	100.0	99.9	62.5	64.9	46.0	73.5	99.9	99.8

<sup>a</sup>NNS = nonnutritive sweetener.

<sup>b</sup>CS = caloric sweetener.

<sup>c</sup>Source: Authors' calculations based in part on data reported by Nielsen through its Homescan Services for all food categories, including beverages and alcohol for the years 2002 and 2018 from Nielsen Homescan Household Panel across the US market, The Nielsen Company, 2019. The conclusions drawn from the Nielsen data are those of the authors and do not reflect the views of Nielsen. Nielsen is not responsible for and had no role in, and was not involved in, analyzing and preparing the results reported herein.

<sup>d</sup>All comparisons between 2002 and 2018 were significant ( $P < .05$ ).

<sup>e</sup>CS Only = products that contain caloric sweeteners as the only type of sweetener.

<sup>f</sup>NNS Only = products that contain nonnutritive sweeteners as the only type of sweetener.

<sup>g</sup>CS and NNS = products that contain both caloric and nonnutritive sweeteners.

<sup>h</sup>No CS or NNS = products that neither contain caloric sweeteners or nonnutritive sweeteners.

**Table 4.** Volume per capita per day of products containing NNS<sup>a</sup> and CS<sup>b</sup> by demographic subgroup of US households: a comparison of 2002 vs 2018 foods<sup>c</sup>

Characteristics	CS Only <sup>d</sup>		NNS Only <sup>e</sup>		CS and NNS <sup>f</sup>		No CS or NNS <sup>g</sup>	
	2002	2018	2002	2018	2002	2018	2002	2018
<b>Household with children &lt;18 y old</b>	179.4 (0.8)	162.7 (0.8)	1.5 (0.0)	1.9 (0.0)	3.2 (0.0)	5.4 (0.1)	81.2 (0.4)	112.3 (0.6)
<b>Household without children</b>	255.7 (0.9)	263.9 (0.9)	4.3 (0.1)	4.9 (0.1)	5.1 (0.1)	10.0 (0.1)	134.0 (0.5)	193.5 (0.6)
<b>Head of household education</b>								
Less than high school diploma	246.9 (5.4)	272.6 (8.9)	3.4 (0.4)	4.5 (1.0)	3.6 (0.3)	8.3 (1.0)	126.9 (3.2)	174.5 (6.2)
High school diploma	247.5 (1.5)	276.1 (1.9)	3.5 (0.1)	4.4 (0.1)	4.5 (0.2)	9.4 (0.2)	123.3 (0.9)	181.0 (1.3)
More than high school diploma	219.5 (0.7)	214.1 (0.7)	3.2 (0.1)	3.7 (0.0)	4.4 (0.1)	8.3 (0.1)	110.9 (0.4)	162.0 (0.6)
<b>Household income (% federal poverty level)</b>								
<185	217.0 (1.7)	249.1 (1.7)	2.4 (0.1)	3.4 (0.1)	3.5 (0.1)	7.9 (0.2)	107.3 (1.0)	156.9 (1.2)
185-350	237.2 (1.2)	226.8 (1.1)	3.5 (0.1)	3.7 (0.1)	4.2 (0.1)	8.0 (0.1)	117.3 (0.7)	158.2 (0.8)
>350	226.7 (0.9)	223.4 (1.0)	3.6 (0.1)	4.4 (0.1)	5.0 (0.1)	9.3 (0.1)	116.9 (0.5)	179.8 (0.8)
<b>Race or ethnicity</b>								
Hispanic	179.5 (2.3)	178.3 (2.1)	2.1 (0.1)	2.8 (0.1)	3.0 (0.1)	6.4 (0.2)	94.8 (1.4)	138.22 (1.6)
Non-Hispanic white	240.9 (0.7)	249.6 (0.8)	3.6 (0.1)	4.4 (0.1)	4.8 (0.1)	9.6 (0.1)	120.4 (0.4)	178.0 (0.6)
Non-Hispanic black	192.1 (2.1)	213.1 (2.1)	2.2 (0.1)	3.0 (0.1)	2.7 (0.2)	5.9 (0.1)	99.1 (1.3)	150.0 (1.6)
<b>Total sample</b>	227.8 (0.7)	231.0 (0.7)	3.3 (0.1)	3.9 (0.0)	4.4 (0.1)	8.5 (0.1)	114.7 (0.4)	167.1 (0.5)

<sup>a</sup>NNS = nonnutritive sweetener.

<sup>b</sup>CS = caloric sweetener.

<sup>c</sup>Source: Authors' calculations based in part on data reported by Nielsen through its Homescan Services for all food categories, including beverages and alcohol for the years 2002 and 2018 from Nielsen Homescan Household Panel across the US market, The Nielsen Company, 2019. The conclusions drawn from the Nielsen data are those of the authors and do not reflect the views of Nielsen. Nielsen is not responsible for and had no role in, and was not involved in, analyzing and preparing the results reported herein.

<sup>d</sup>CS Only = products that contain caloric sweeteners as the only type of sweetener.

<sup>e</sup>NNS Only = products that contain nonnutritive sweeteners as the only type of sweetener.

<sup>f</sup>CS and NNS = products that contain both caloric and nonnutritive sweeteners.

<sup>g</sup>No CS or NNS = products that neither contain caloric sweeteners or nonnutritive sweeteners.



**Table 5.** Volume per capita per day of products containing NNS<sup>a</sup> and CS<sup>b</sup> by demographic subgroup of US households: a comparison of 2002 vs 2018 beverages<sup>c</sup>

Characteristics	CS Only <sup>d</sup>		NNS Only <sup>e</sup>		CS and NNS <sup>f</sup>		No CS or NNS <sup>g</sup>	
	2002	2018	2002	2018	2002	2018	2002	2018
<b>Household with children &lt;18 y old</b>	196.3 (1.7)	96.2 (1.0)	49.7 (0.9)	44.4 (0.8)	5.2 (0.2)	20.9 (0.4)	180.4 (1.4)	169.7 (1.3)
<b>Household without children</b>	216.0 (1.7)	148.3 (1.2)	127.4 (1.7)	121.0 (1.3)	7.1 (0.2)	30.9 (0.4)	275.5 (1.8)	285.6 (1.6)
<b>Head of household education</b>								
Less than high school diploma	263.6 (10.3)	175.8 (10.2)	86.8 (7.1)	85.5 (9.2)	6.2 (1.2)	33.2 (2.7)	291.0 (16.8)	314.2 (16.2)
High school diploma	232.5 (2.9)	171.5 (2.6)	97.8 (2.3)	109.8 (2.6)	6.8 (0.4)	34.0 (0.9)	254.6 (2.8)	291.5 (3.4)
More than high school diploma	197.2 (1.4)	116.1 (0.9)	100.0 (1.4)	91.6 (1.0)	6.2 (0.2)	25.2 (0.3)	233.1 (1.4)	230.9 (1.2)
<b>Household income (% federal poverty level)</b>								
<185	229.2 (3.4)	166.6 (2.5)	76.9 (2.5)	91.3 (2.4)	5.8 (0.4)	32.8 (0.8)	224.5 (2.9)	266.0 (3.0)
185-350	213.9 (2.3)	130.2 (1.3)	90.8 (1.8)	83.7 (1.3)	6.4 (0.3)	27.1 (0.5)	249.0 (2.5)	240.8 (2.0)
>350	192.9 (1.7)	111.4 (1.2)	118.3 (1.9)	108.2 (1.5)	6.7 (0.2)	24.9 (0.5)	243.7 (1.8)	242.5 (1.7)
<b>Race or ethnicity</b>								
Hispanic	201.5 (4.4)	105.9 (2.5)	55.0 (2.5)	53.7 (2.0)	6.8 (0.5)	22.7 (0.8)	194.7 (4.1)	217.5 (3.9)
Non-Hispanic white	207.2 (1.4)	135.6 (1.0)	114.0 (1.4)	116.5 (1.2)	6.4 (0.2)	28.4 (0.4)	255.8 (1.5)	260.0 (1.4)
Non-Hispanic black	231.8 (4.1)	152.3 (2.9)	44.2 (1.9)	54.4 (1.8)	6.7 (0.4)	32.2 (0.8)	188.8 (3.1)	239.6 (3.8)
<b>Total sample</b>	208.8 (1.3)	131.4 (0.9)	99.0 (1.2)	96.1 (0.9)	6.4 (0.2)	27.6 (0.3)	240.7 (1.3)	247.9 (1.2)

<sup>a</sup>NNS = nonnutritive sweetener.

<sup>b</sup>CS = caloric sweetener.

<sup>c</sup>Source: Authors' calculations based in part on data reported by Nielsen through its Homescan Services for all food categories, including beverages and alcohol for the years 2002 and 2018 from Nielsen Homescan Household Panel across the US market, The Nielsen Company, 2019. The conclusions drawn from the Nielsen data are those of the authors and do not reflect the views of Nielsen. Nielsen is not responsible for and had no role in, and was not involved in, analyzing and preparing the results reported herein.

<sup>d</sup>CS Only = products that contain caloric sweeteners as the only type of sweetener.

<sup>e</sup>NNS Only = products that contain nonnutritive sweeteners as the only type of sweetener.

<sup>f</sup>CS and NNS = products that contain both caloric and nonnutritive sweeteners.

<sup>g</sup>No CS or NNS = products that neither contain caloric sweeteners or nonnutritive sweeteners.

**Table 6.** Prevalence of NNS<sup>a</sup> consumption and CS<sup>b</sup> consumption by demographic subgroup of US households: a comparison of 2002 vs 2018 beverages<sup>cd</sup>

Characteristics	CS Only <sup>e</sup>		NNS Only <sup>f</sup>		CS and NNS <sup>g</sup>		No CS or NNS <sup>h</sup>	
	2002	2018	2002	2018	2002	2018	2002	2018
<b>Household with children &lt;18 y old</b>	99.3	95.4	58.3	60.2	22.8	65.5	99.4	99.3
<b>Household without children</b>	92.4	84.6	58.4	58.4	12.6	44.4	97.3	96.9
<b>Head of household education</b>								
Less than high school diploma	96.2	90.9	44.6	54.9	11.9	56.9	98.8	97.7
High school diploma	95.4	89.3	58.3	60.6	15.3	54.8	98.2	97.7
More than high school diploma	94.6	87.6	59.0	58.5	16.9	49.9	98.0	97.7
<b>Household income (% federal poverty level)</b>								
<185	95.6	90.8	51.3	55.7	15.1	57.6	97.8	97.6
185-350	95.5	90.2	57.2	59.0	16.8	55.2	98.1	98.0
>350	94.1	85.0	63.3	60.8	16.7	44.6	98.2	97.5
<b>Race or ethnicity</b>								
Hispanic	98.6	92.0	55.2	55.9	21.8	56.6	98.7	98.2
Non-Hispanic white	94.0	86.6	61.5	62.5	15.1	49.2	98.1	97.7
Non-Hispanic black	97.6	93.5	42.8	50.5	19.8	61.7	98.2	97.6
<b>Total sample</b>	94.9	88.1	58.4	58.9	16.3	51.2	98.1	97.7

<sup>a</sup>NNS = nonnutritive sweetener.

<sup>b</sup>CS = caloric sweetener.

<sup>c</sup>Source: Authors' calculations based in part on data reported by Nielsen through its Homescan Services for all food categories, including beverages and alcohol for the years 2002 and 2018 from Nielsen Homescan Household Panel across the US market, The Nielsen Company, 2019. The conclusions drawn from the Nielsen data are those of the authors and do not reflect the views of Nielsen. Nielsen is not responsible for and had no role in, and was not involved in, analyzing and preparing the results reported herein.

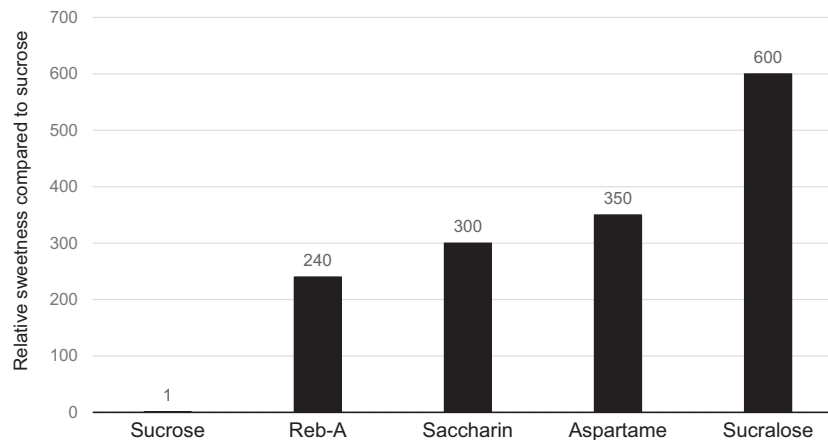
<sup>d</sup>All comparisons between 2002 and 2018 were significant ( $P < .05$ ). Sample sizes of households were 39300 in 2002 and 61,101 in 2018.

<sup>e</sup>CS Only = products that contain caloric sweeteners as the only type of sweetener.

<sup>f</sup>NNS Only = products that contain nonnutritive sweeteners as the only type of sweetener.

<sup>g</sup>CS and NNS = products that contain both caloric and nonnutritive sweeteners.

<sup>h</sup>No CS or NNS = products that neither contain caloric sweeteners or nonnutritive sweeteners.



**Figure 7.** Sweetness of nonnutritive sweeteners relative to sucrose. Reb-A = rebaudioside A.