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Use of caloric and non-caloric sweeteners in US consumer packaged foods, 2005–9

Shu Wen Ng, PhD* [Research Assistant Professor], Meghan M. Slining, PhD* [Research Assistant Professor], and Barry M. Popkin, PhD* [Professor]

Shu Wen Ng: shuwen@unc.edu; Meghan M. Slining: slining@email.unc.edu; Barry M. Popkin: popkin@unc.edu

*Department of Nutrition, Carolina Population Center, University of North Carolina, 123 W. Franklin St, Chapel Hill, NC 27516

Abstract

Our understanding of the use of caloric (CS) and non-caloric sweeteners (NCS) in the US food supply is limited. This study utilizes full ingredient list and nutrition facts panel (NFP) data from Gladson Nutrition Database, and nationally representative purchases of consumer packaged foods from Nielsen Homescan in 2005 through 2009 to understand the use of CS (including FJC) and NCS in CPG foods.

Of the 85,451 uniquely formulated foods purchased during 2005–2009, 75% contain sweeteners (68% with CS only, 1% with NCS only, 6% with both CS and NCS). CS are in >95% of cakes/cookies/pies, granola/protein/energy bars, ready-to-eat cereals, sweet snacks, and sugar-sweetened beverages. NCS are in >33% of yogurts and sports/energy drinks, 42% of waters (plain or flavored), and most diet sweetened beverages. Across unique products, corn syrup is the most commonly listed sweetener, followed by sorghum, cane sugar, high fructose corn syrup and FJC. Also, 77% of all calories purchased in the US in 2005–2009 contained CS and 3% contained NCS, while 73% of the volume of foods purchased contained CS and 15% contained NCS. Trends during this period suggest a shift towards the purchase of NCS-containing products. Our study poses a challenge toward monitoring sweetener consumption in the US by discussing the need and options available to improve measures of CS and NCS, and additional requirements on NFPs on CPG foods.

Keywords

Caloric sweeteners; added sugars; fruit juice concentrate; packaged foods; United States

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Corresponding author and requests for reprints: Barry M. Popkin, Carolina Population Center, University of North Carolina, 123 W. Franklin St., Chapel Hill, NC 27516-3997, Phone: 919-966-1732, Fax: 919-966-9159, popkin@unc.edu.

AUTHOR CONTRIBUTIONS

SWN, MMS, BMP all contributed to the conceptualization and jointly wrote components of the manuscript. SWN, MMS and BMP drafted the methods section; SWN prepared the tables and figures and wrote the results section; MMS, BMP and SWN jointly wrote the introduction and discussion; and all contributed to reviews and revisions of the manuscript.

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INTRODUCTION

There is growing scientific interest in the role of sweeteners, both caloric (CS) and non-caloric (NCS), in the global food supply. In the US, there are a large variety of CS and NCS that are used in foods¹. Their potential adverse health effects have been suggested by numerous health authorities and scholars²⁻⁵. CS or added sugars (i.e., caloric or caloric sweeteners added to foods or beverages during processing or preparation)^{6,7}, represent sources of energy with little nutritional value. Dietary recommendations include efforts to reduce surplus energy intake, in particular, “energy from foods and beverages that provide empty calories”⁸. In addition to contributing excess calories, there is concern that increased exposure to sweeteners in the diet may influence taste preferences and dietary patterns^{9,10}. Controversy surrounds the effects of repeated exposure to NCS on appetite and energy intake¹¹⁻¹³.

While sweeteners have become a focal point of dietary recommendations and policy initiatives, little is known about the use of sweeteners in foods and beverages sold and consumed in the US. Currently there is no direct measurement of sweetener contents of foods and beverages. Since added sugars, or CS, cannot be chemically distinguished from intrinsic (naturally occurring) sugars, the primary food-composition databases in the US do not contain composition information for either intrinsic or added sugars. There are two supplementary sources of added sugars information available from the US Department of Agriculture (USDA). The USDA Database for the Added Sugars Content of Selected Foods, Release 1 (2006)¹⁴ provides data for the added sugars content of 2,038 commonly consumed foods, excluding brand name foods. A second source, the MyPyramid Equivalents Database (MPED), provides data on added sugars content of foods reported in Continuing Survey of Food Intakes of Individuals 1994–1996 and 1998, and the National Health and Nutrition Examination Survey 2001–2002 and 2003–2004¹⁵. Unfortunately neither source is available beyond 2006 and therefore unsuitable for monitoring the most current intakes and purchases of CS in the US. To our knowledge there is no monitoring of NCS in consumer packaged goods (CPG) foods and beverages sold and consumed in the US.

The goal of the current paper is to examine the extent of CS and NCS sweetener use in the CPG foods and beverages purchased by US households. We utilize unique commercial data that provides the full set of ingredients and nutrition facts panel information on 85,451 uniquely formulated CPG foods and beverages purchased by a nationally representative sample of households. We identify the most commonly used sweeteners and the foods that are sweetened with CS and NCS in US CPGs. In addition, we raise a number of questions regarding the measurement and labeling requirements of sweeteners in the US.

METHODS

Data

Nutrition Facts Panel (NFP) label and ingredient information for each uniquely barcoded food—The 2007 and 2010 versions of the commercial Gladson Nutrition Database¹⁶ have national brands and private label CPG items at the Universal Product Codes (UPCs) level with data on the nutrition facts panel and full ingredients lists¹⁷. Per the Food and Drug Administration (FDA) requirements, the NFP label needs to include serving measurement, total calories, calories from fat, total fat, saturated fat, *trans* fats, total sugars, total carbohydrate, protein, dietary fiber, sodium, cholesterol, vitamin A, vitamin C, calcium and iron.

Commercial Scanner Food Purchase data—The Nielsen Homescan (The Nielsen Co.)¹⁸ is a commercial data set that contains information on food products with a UPC that a household purchases over a year (acquired using scanners provided to participating households), along with important socio-demographic information and sampling weights. The households are sampled and weighted to be nationally representative and include between 40,000 to 55,000 households per year in the 2005–2009 panels. This data has been frequently used by researchers (particularly agricultural and marketing economists) to analyze food demand, consumption, branding and promotion strategies^{19–21}.

Linking Gladson NFP and Nielsen Homescan Food Purchase data—We matched the Gladson NFP data with the 2005–2009 Homescan data on household purchases at the UPC level in order to create a more complete measure of the nutritional content of UPCs reported purchased. This was successful for over 98% of the volume and dollar sales of foods reported purchased in Homescan. UPCs were then categorized into 41 food and 21 beverage groups based on critical dietary behaviors and consumption patterns as explained in Supplementary Table A1.

Identifying the use of sweeteners in US CPG products

To identify CPGs containing various types of CS and NCS, we conducted searches for key terms in the ingredients lists (listed in Supplementary Table A2). In this study, we include fruit juice concentrate (FJC) (not reconstituted) as a CS.

We then determined for each food and beverage group the proportion of the unique food products with various combinations of CS, NCS, and the average total sugar calories per 100g for unique products with various combinations. We are defining unique food products as those with unique formulations (e.g., a 1.5 liter bottle of Coca-cola Classic will be nutritionally equivalent to a 12 fl oz can of Coca-cola Classic and a 20 fl oz bottle of Coca-cola Classic, so even though they will have different barcodes, they only count as one food product). These sweetener categories are: no sweeteners (in which case total sugars are equal to intrinsic sugars); CS only (including FJC); NCS only; and both CS and NCS. To measure how frequently the various kinds of CS and NCS are used we ranked the top five sweetener types used within each food group. The categorization of the CS and NCS are provided in Supplementary Table A2.

Lastly, to understand how much of the US processed and packaged foods and beverages purchased contain CS and NCS, we determined the total calories and volume (or gram weight) of each product using the Homescan purchase and NFP data. We then calculated the proportion of total calories and total volume purchased by Americans that contain any CS, and any NCS for each food group and all food groups. We conducted z-tests to determine if the change in these proportions over time were statistically significant. All statistical work was conducted using Stata version 11²².

RESULTS

The use of sweeteners in unique US CPG products

From the commercial databases described above, we identified 85,451 unique processed and packaged food and beverage products that were not raw or single ingredient foods (see Table 1). Among these, 75% contain some sweetener (68% with CS only, 1% with NCS only, 6% with both CS and NCS).

Among vegetable juices (n=230), 22% have no sweeteners, 69% contain CS only, less than 1% contain NCS only and 8% contain both CS and NCS. There were 2,513 unique sugar

sweetened beverages, of which 84% contained CS only, 1% contained NCS only and 14% contained both CS and NCS.

Among diet-sweetened beverages (n=974), the majority (58%) contained both CS and NCS, with another 15% containing NCS only and 17% containing CS only. Among the 1,722 unique CPG fruit products (fresh 8%, frozen 6%, canned 34% or dried 52%), 37% are unsweetened, but 60% contain CS, 3% contain NCS and 1% contain both CS and NCS. As for the 2,526 uniquely formulated granola, protein or energy bars and 1,378 unique ready-to-eat cereals, 78% and 94% contain CS only, while less than 1% of contain NCS only, and 20% and 2% contain both CS and NCS. Of the 993 unique baby food formulas, nearly half do not have any sweeteners, but all of the other 53% contain CS. For salads dressings and dips (n=3,305), 73% are sweetened – 71% with CS only, 1.5% with NCS only, and <1% with both CS and NCS.

In Supplementary Table A3, we present additional breakdowns of the use of FJC compared to other CS across select food groups. Overall, 2% of unique products contain FJC as the only source of CS, and another 5% of unique products contain FJC combined with other sweetener/s, for a total of 7% containing any FJC.

In ranking the top five sweetener types included in ingredient lists within each food group, we found that between 2005 and 2009, across all unique food products corn syrup is the most commonly listed sweetener, followed by sorghum, cane, HFCS and FJC. Corn syrup is the most common sweetener used in baby food/formula, salad dressings and dips, sweet snacks, milk and milk/yogurt/soy drinks. HFCS is the most common for cakes/cookies/pies, fruit products, yogurt and sugar sweetened beverages and FJC came up top for fruit juice and vegetable juice. The NCSs, acesulfame potassium, aspartame and sucralose were the three most common sweeteners found in diet sweetened beverages, and both acesulfame potassium and sucralose were also highly ranked among water products. Unfortunately, since each unique food product's formulation is proprietary information, it is not possible to determine exactly how much of each sweetener is used, and therefore these rankings are based on frequency of occurrence, rather than volume.

Measuring how much CPG products with sweeteners are purchased in the US

While understanding the number of products with CS and NCS is important, each product is not purchased equally. Supplementary Table A4 provides the proportion of total calories and total volume of select food and beverage groups purchased during 2005–2009 that contain CS only, NCS only, and both CS and NCS. We found that 77% of all calories purchased from CPGs in the US in 2005–2009 contained CS, 3% contained NCS, and 23% did not contain any sweeteners. The use of CS is common across many food groups. Of all the calories purchased from processed and packaged baby foods and fruit juices, 60% and 63% respectively are from products that contain CS. Of all the calories purchased from processed and packaged fruit (fresh/frozen/canned/dried) and savory snacks, nearly three-quarters are from products that contain CS. Also, virtually all processed and packaged cakes/cookies/pies, granola/protein/energy bars, sports and energy drinks, sugar-sweetened beverages products contain CS. As for products that contain NCS, we found that of all the calories purchased from yogurt, 25% are from products that contain NCS. The use of NCS appears to be more common among beverages —of all the calories purchased from sports/energy drinks, vegetable juice, water (plain or flavored), and diet-sweetened beverage, 13%, 28%, 29% and 44% respectively are from products that contain NCS. We also found that certain food and beverage groups are less likely to contain sweeteners. For example, we see that 41% and 27% of calories in baby food and fruit (fresh/frozen/canned/dried) products respectively contain neither CS nor NCS. Among beverages, 60% and 37% of calories in

milk and milk/yogurt/soy drinks, and from fruit juices, 60% and 37% respectively do not have either CS or NCS.

Supplementary Table A4 show results based on volume of CPGs purchased during this period to better capture the prevalence of NCS, since products containing NCS will contribute no or fewer calories. Across all foods and beverages, 73% of the volume of foods purchased contained CS and 15% contained NCS. Of all sports/energy drinks, vegetable juice, water (plain or flavored), and diet-sweetened beverage purchases, 17%, 28%, 22% and 70% respectively are from products that contain NCS. Among food groups, we see that other than yogurt and granola/protein/energy bars, a very low proportion of purchases from other food groups contain NCS. In the case of baby food/formula and vegetable juice, it appears that there are no processed and packaged products that contain NCS.

Figure 1 shows the trends in the proportion of total calories and total volume of CPGs purchased during 2005–2009 that contain any CS (**panel a**) and any NCS (**panel b**). We see that both the proportion of calories and volume from products containing CS have fallen over time ($p<0.05$). Meanwhile, the proportion of calories from products containing NCS has not changed markedly, however we observe an upward trend in the volume of products containing NCS being purchased (13.3% in 2005 vs. 15.2% in 2009, $z=-9.01$, $p<0.01$).

DISCUSSION

To our knowledge, this is the first study to report the extent of sweetener use in the US CPG food supply. Three-quarters of uniquely formulated CPG foods and beverages in the US contain sweeteners, of which 73.5% contains CS and 1.5% contains NCS. From 2005–2009, 77% of the calories from CPGs purchased in the US contain CS and 3% contain NCS; while 73% of the volume purchased contained CS and 15% contained NCS. Trends suggest a shift towards the purchase of products containing NCS.

The large proportion of CPGs containing CS and/or NCS sweeteners is concerning. In 2009, the American Heart Association released a scientific statement calling for reductions in added sugar intake as a means of reducing obesity and cardiovascular disease risk⁷. Caloric sweeteners represent empty calories, or sources of energy with little nutritional value. Health authorities emphasize that prevention of obesity must include strategies to reduce surplus energy intake from foods and beverages that provide empty calories^{8, 23–26}.

In addition to the evidence on the relationship between intake of sweeteners and cardiovascular health^{7, 27}, there is concern that increased exposure to sweeteners in the diet may influence taste preferences, energy intake and dietary patterns^{9, 10}. While the use of NCS in processed and packaged foods and beverages has gained attention for its ability to reduce the energy content while maintaining the sweet taste of products^{13, 28}, the relationship between NCS consumption and energy intake is unclear^{8, 13, 29–32}. Previous research has shown that the greater the sweetness of a product, the higher the consumption of sweet foods or beverages³³. Further repeated exposure to NCS uncoupled with energy has been hypothesized to affect appetite and energy intake by disrupting hormonal and neurobehavioral pathways that control hunger and satiety¹¹.

Currently, US nutrition labels contain information on total sugars but do not distinguish between naturally occurring (intrinsic) sugars and those that are added. Consequently it is difficult for consumers, researchers and other health professionals to monitor sweetener intakes. Efforts to include added sugars as part of the NFP label have been considered by the FDA but never implemented³⁴. Given that food manufacturers have full knowledge of the

amount of sweeteners they include in their products, this information can be easily derived and added to the existing list of required nutrition information available to consumers.

Such a requirement will also likely spur food manufacturers to reduce the amount of CS (and possibly also NCS) that are added to their products. Such a requirement will also mean that definitions of what are considered CS or added sugars be properly defined. For example, even though FJC is currently recognized as a type of CS, FJC used as a sweetener is not measured as one in neither MPED nor national aggregates of consumption of sweeteners. Yet as this study shows, FJC is used as a sweetener in 7% of the 85,451 unique CPG products, and is used frequently in juices, sugar sweetened beverages, diet sweetened beverages, salad dressings, yogurt, granola/energy bars, ready-to-eat cereals and baby food (see Supplementary Table A3). It is also the fifth most commonly listed sweetener. Therefore, together with improvements in NFP labeling, clear official definitions of CS will also be crucial.

From a monitoring standpoint, given the lack of sweetener measurement in existing food composition databases, one way to estimate the use of sweeteners among CPGs in the US is to use commercial databases as we have done here. Should the addition of the added CS and/or NCS content be included in the NFP, our approach here will also still be applicable. Nonetheless, we note a number of limitations to this approach. While the commercial databases allow for identification of products that contain CS and NCS there are limitations with the use of NFP data. Nutrient declarations on nutrition labels may be rounded according to FDA rounding rules, limiting the precision of information provided (e.g., foods with <0.5 gram of sugar per serving meet the definition of "sugar free")³⁵; and by law the nutrient information only needs to be within 20% of the 'truth'³⁵. Further, while we are able to identify items that contain CS and NCS, with ingredient level data we are unable to know the precise amount of an ingredient.

In addition, commercial NFP label data are not updated equally, and their proprietary nature limits researchers' abilities to determine the frequency and comprehensiveness of collection and updating. Finally, due to the propriety nature of commercial data, this is an expensive proposition and can be challenging to undertake.

While currently, US nutrition labels do not contain information on added sweeteners a possible solution for researchers is to estimate the amount of CS via mathematical optimization techniques of linear programming (LP). LP nutrient estimation is performed by organizations such as USDA, the University of Minnesota Nutrition Coordinating Center (NCC), and Yale-Griffin. For example, USDA uses LP nutrient estimation to impute many of the nutrient values used for calculation by the Food and Nutrient Database for Dietary Studies and the NCC uses LP nutrient estimation to estimate added sugars^{36, 37}. We are fine-tuning these LP methods to estimate the amount of sweetener in each unique food product in our commercial data.

In summary, given that 77% of all calories purchased from CPGs in the US from 2005 to 2009 period contain CS, and that there is a trend towards purchase of NCS containing products, further research and regulatory focus on these topics are needed. While we have not yet derived the proportion of calories from CS, this paper lends support to what is seen by the nutrition profession as a critical issue – excessive consumption of foods with CS. Moreover, given the lack of current knowledge about the effects of NCS on sweet preferences and energy intake, it may also be important to start monitoring the prevalence of products containing NCS. This paper represents a call to focus legislative efforts and research on an important component of our diet and to improve both consumer knowledge and current public measurements of sweeteners consumed by Americans.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations

CPG	Consumer Packaged Goods
CS	Caloric sweeteners
FDA	Food and Drug Administration
FJC	Fruit juice concentrate
HFCS	High fructose corn syrup
LP	Linear programming
MPED	MyPyramid Equivalents Database
NCC	University of Minnesota Nutrition Coordinating Center
NCS	Non-caloric sweeteners
NFP	Nutrition Facts Panel
UPC	Universal product code
USDA	United States Department of Agriculture

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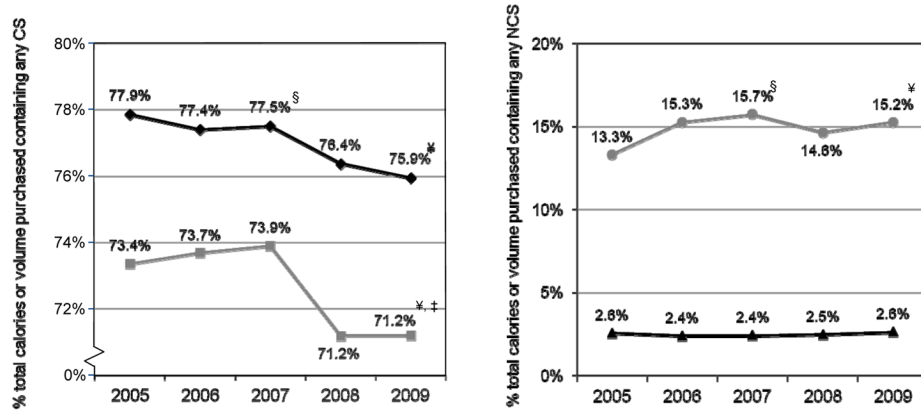


Figure 1. Total calories and volume of consumer packaged food and beverages purchased in the United States containing caloric sweeteners (CS) and non-caloric sweeteners (NCS), 2005–2009

a. Containing any Caloric Sweeteners (CS)

- ◆ % total calories purchased containing any CS (including FJC)
- % total volume purchased containing any CS (including FJC)

b. Containing any Non-Caloric Sweeteners (NCS)

- ▲ % total calories purchased containing any NCS
- % total volume purchased containing any NCS

Sources: Nielsen Homescan 2005-2009, Gladson Nutrition Database 2007 and 2010

[§] denotes statistical difference between 2005 and 2007 using two-tailed z-test ($p < 0.05$)

[¶] denotes statistical difference between 2005 and 2009 using two-tailed z-test ($p < 0.05$)

[†] denotes statistical difference between 2007 and 2009 using two-tailed z-test ($p < 0.05$)

Percentage of uniquely formulated consumer packaged food products purchased during 2005–2009 by sweetener category for select food groups

Table 1

Select Food or Beverage Group	Number of Unique Products	% among all unique products	% Unique Products within Food Group* containing		
			No sweetener	CS (including FIC) only	NCS only both CS & NCS
Baby food, formula	993	1.2%	47.5%	52.5%	0.0%
Cakes, cookies, pies	5592	6.5%	0.7%	95.3%	0.1%
Fruit, fresh, frozen, canned or dried	1722	2.0%	36.6%	59.9%	2.7%
Granola, protein or energy bars	2526	3.0%	3.0%	78.2%	0.0%
Ready-to-eat cereals	1378	1.6%	3.6%	94.0%	0.3%
Salad dressings and dips	3305	3.9%	26.9%	71.0%	1.5%
Savory Snacks	5734	6.7%	28.8%	69.9%	0.7%
Sweet breads and pastries	1440	1.7%	17.3%	79.3%	0.5%
Sweet snacks	6710	7.9%	0.6%	84.6%	0.6%
Yogurt	1152	1.3%	6.4%	60.8%	6.8%
Sports and Energy drinks	506	0.6%	1.2%	63.4%	6.9%
Sugar sweetened beverage	2513	2.7%	1.5%	83.6%	1.0%
Diet sweetened beverage †	974	1.4%	9.9%	17.2%	14.6%
Milk & milk/yogurt/soy drinks	1483	1.7%	32.4%	56.6%	2.4%
100% Fruit juice	1404	1.6%	33.6%	66.0%	0.0%
Vegetable juice	230	0.3%	22.2%	69.1%	0.4%
Water, plain or flavored	799	0.9%	36.4%	21.7%	22.3%
All Food and Beverage Groups	85451	100%	25.4%	67.9%	1.0%

Sources: Nielsen Homescan 2005–2009, Gladson Nutrition Database 2007 and 2010

Notes: CS = Caloric Sweetener; FIC = Fruit Juice Concentrate; NCS = Non-Caloric Sweetener

* The % of unique products within this food group (e.g., yogurt) with various types of sweeteners

† Not strictly products that contain zero-calories, rather items that are marketed as 'non-regular' or less calories than the regular version.

Table 2
Most common sweeteners used in unique consumer packaged food products purchased during 2005–2009 for select food groups

Select Food or Beverage Group	Most common	2 nd most common	3 rd most common	4 th most common	5 th most common
Baby food, formula	Corn syrup	FJC	Lactose	Sorghum	Cane
Cakes, cookies, pies	HFCS	Sorghum	Corn syrup	Cane	Molasses
Fruit, fresh, frozen, canned or dried	HFCS	Cane	FJC	Corn syrup	Sucralose
Granola, protein or energy bars	Sorghum	Cane	Corn syrup	Honey	Alcohol
Ready-to-eat cereals	Sorghum	Cane	Honey	Corn syrup	Molasses
Salad dressings and dips	Corn syrup	FJC	Cane	Sorghum	HFCS
Savory snacks	Sorghum	Corn syrup	Cane	HFCS	Lactose
Sweet breads and pastries	Sorghum	Corn syrup	Cane	HFCS	Honey
Sweet snacks	Corn syrup	Sugar alcohol	Sorghum	Lactose	Honey
Yogurt	HFCS	Fructose	Aspartame	Sucralose	FJC
Sports and Energy drinks	cane	sucrose	HFCS	sucralose	corn syrup
Sugar sweetened beverage	HFCS	FJC	Cane	Corn syrup	Fructose
Diet sweetened beverage [†]	Acesulfame potassium	Aspartame	Sucralose	Cane	FJC
Milk & milk/yogurt/soy drinks	Corn syrup	Cane	HFCS	Sucralose	Sorghum
100% fruit juice	FJC	HFCS	Cane	Fructose	Sorghum
Vegetable juice	FJC	HFCS	Sucralose	Cane	Fructose
Water, plain or flavored	Sucralose	Acesulfame potassium	Fructose	Cane	Sugar alcohol
All Food and Beverage Groups	Corn syrup	Sorghum	Cane	HFCS	FJC

Sources: Nielsen Homescan 2005–2009, Gladson Nutrition Database 2007 and 2010.

Notes: CS = Caloric Sweetener; FJC = Fruit Juice Concentrate; NCS = Non-Caloric Sweetener; Sweeteners were categorized based on these search terms listed in Supplementary Table A2.

[†] Not strictly products that contain zero-calories, rather it reflect products that are marketed as 'non-regular' or less calories than the regular versions