

Original research article

Estimating added sugars in US consumer packaged goods: An application to beverages in 2007–08

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Supplementary Appendices

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Appendix A. Calculating Z, the total model error for a chocolate milk example

Nutrient or weight parameters	NFL amount/100 g	LP estimated amount/100 g	Absolute difference	Value equivalent to 1 tolerance unit (from Table 1)	Tolerance units (error)
Weight (g)	100	100	0	±5	0.000
Calories (kcal)	52.73	54.71	1.98	±85	0.023
Total fat (g)	1.22	1.08	0.14	±2.5	0.056
Saturated fat (g)	0.81	0.66	0.15	±2.5	0.060
Cholesterol (mg)	4.05	5.38	1.33	±30	0.044
Sodium (mg)	113.58	113.58	0	±100	0.000
Carbohydrate (g)	8.11	8.09	0.02	±10	0.002
Total Sugar (g)	7.3	7.3	0	±10	0.000
Fiber (g)	0.41	0.38	0.03	±2.5	0.012
Protein (g)	3.65	3.65	0	±5	0.000
Potassium (mg)	182.53	182.53	0	±100	0.000
Sum of tolerance units, Z (total model error)					0.198
Mean error per nutrient and weight parameter					0.018

Appendix B. Macronutrient values (LP estimated to NFL) and added sugar estimates across beverage categories

Beverage category	Caloric sodas & energy drinks			Sports drinks			Flavored water – carbonated & still			Fruit & vegetable juice drinks			Fruit flavored drinks		
	n	mean	SD	n	mean	SD	n	mean	SD	n	mean	SD	n	mean	SD
# of unique products in 2007-08															
with NFL total sugar >0g	1711			290			331			1649			183		
with estimated added sugar >0g	1695			290			297			1524			183		
LP to NFL macronutrient comparisons															
Absolute Differences (per 100g) [†]															
Calories (kcal)	1711	2.26	2.64	290	1.78	1.32	335	1.05	1.48	1652	2.05	5.99	183	3.92	19.98
Total fat (g)	7	0.01	0.03	0			6	0.11	0.17	44	0.73	1.06	1	0.05	
Saturated fat (g)	2	0.08	0.07	0			2	0.05	0.07	22	0.49	0.33	0		
Carbohydrate (g)	1711	0.06	0.52	290	0.01	0.06	335	0.04	0.18	1652	0.13	0.99	183	0.68	5.08
Total sugar (g)	1711	0.16	0.62	290	0.07	0.08	331	0.09	0.34	1649	0.21	0.65	183	0.38	3.81
Protein (g)	61	0.34	0.39	1	0.00		14	0.05	0.12	220	0.22	0.28	4	0.42	0.04
Nutrient Ratios (LP/NFL)															
Calories	1711	1.03	0.07	290	1.08	0.14	335	1.04	0.20	1652	1.01	0.16	183	1.06	0.69
Total fat	7	0.86	0.37	0			6	0.78	0.40	44	1.98	2.21	1	0.02	
Saturated fat	2	1.36	0.64	0			2	1.16	0.23	22	3.31	2.77	0		
Carbohydrate	1711	1.00	0.04	290	1.01	0.07	335	1.01	0.06	1652	1.01	0.10	183	1.08	0.75
Total sugar	1711	0.99	0.05	290	0.99	0.07	331	0.97	0.22	1649	1.00	0.24	183	1.04	0.70
Protein	61	0.19	0.35	1	1.00		14	0.98	0.47	220	0.73	0.65	4	0.00	0.00
Added sugar estimate (per 100g)															
Among all UPCs	1711	10.79	2.31	290	5.21	1.63	335	4.26	3.25	1652	7.98	3.86	191	7.70	5.06
Among UPCs with NFL total sugar >0g	1711	10.79	2.31	290	5.21	1.63	331	4.31	3.23	1649	8.00	3.84	183	8.03	4.90
Added sugar as % of :															
total sugar among UPCs with total sugar >0g	1711	95.86%		290	97.41%		331	93.37%		1649	75.21%		183	101.91%	
calories among UPCs with total sugar >0g	1711	98.25%		290	101.46%		331	91.54%		1649	71.06%		183	97.53%	
calories among UPCs with added sugar >0g	1695	98.60%		290	101.46%		297	95.43%		1524	75.51%		183	97.53%	
Other Diagnostics															
% with LP added sugar ≤ NFL total sugar		98.95%			99.66%			99.40%			98.55%			98.95%	
Median total error per nutrient and weight		0.008			0.006			0.003			0.010			0.004	

Notes: LP= Linear programming; NFL= Nutrition Facts Label; UPC= Universal Product Code; SD= Standard deviation.

Estimated values from LP model when fruit juice and fruit juice concentrate not considered an added sugar. Added sugar (g) values only include the proportion of added sugar ingredients that are sugar. Some beverage categories contain both regular and low calorie products. Ns represent products with non-missing or non-zero NFP values. [†] in order to be consistent with the sample sizes presented for the Nutrient Ratios, we have limited these to the same products.

Appendix B (cont.) Macronutrient values (LP estimated to NFL) and added sugar estimates across beverage categories

Beverage category	Sweetened dairy & dairy alternatives			Ready-to-drink coffees and teas			Concentrated fruit drinks			Powdered beverage mixes			Cocktail mixes		
	n	mean	SD	n	mean	SD	n	mean	SD	n	mean	SD	n	mean	SD
# of unique products in 2007-08															
with NFL total sugar >0g	860			742			130			942			183		
with estimated added sugar >0g	829			712			124			901			174		
LP to NFL macronutrient comparisons															
Absolute Differences (per 100g) [†]															
Calories (kcal)	867	3.80	5.47	769	2.19	6.37	130	7.04	11.03	942	19.69	22.44	184	4.35	10.14
Total fat (g)	836	0.18	0.33	140	0.16	0.24	7	0.31	0.38	493	1.05	3.47	18	0.65	0.69
Saturated fat (g)	749	0.11	0.20	131	0.10	0.14	5	0.04	0.05	389	2.22	2.71	10	0.53	0.30
Carbohydrate (g)	867	0.32	0.90	769	0.19	1.61	130	0.87	2.58	942	2.72	8.30	184	0.36	1.97
Total sugar (g)	860	0.46	1.01	742	0.24	1.64	130	1.09	2.85	942	1.50	3.48	183	0.41	2.00
Protein (g)	849	0.46	0.51	152	0.33	0.39	50	1.27	0.50	504	0.94	1.40	28	0.18	0.26
Nutrient Ratios (LP/NFL)															
Calories	867	1.01	0.13	769	1.02	0.18	130	1.00	0.08	942	0.99	0.29	184	1.00	0.09
Total fat	836	1.05	0.31	140	0.96	0.32	7	0.97	0.46	493	1.10	0.33	18	0.59	0.47
Saturated fat	749	0.96	0.25	131	0.92	0.30	5	1.01	0.07	389	0.89	0.39	10	0.71	0.42
Carbohydrate	867	1.01	0.15	769	1.00	0.16	130	1.01	0.07	942	1.01	0.28	184	1.01	0.08
Total sugar	860	0.93	0.19	742	0.99	0.19	130	1.01	0.08	942	1.00	0.16	183	1.02	0.19
Protein	849	1.06	0.27	152	0.89	0.39	50	0.23	0.32	504	1.03	0.28	28	1.08	0.74
Added sugar estimate (per 100g)															
Among all UPCs	867	6.22	3.64	769	7.18	4.88	130	36.11	14.41	942	66.17	26.23	184	19.25	11.26
Among UPCs with NFL total sugar >0g	860	6.27	3.61	742	7.44	4.77	130	36.11	14.41	942	66.17	26.23	183	19.36	11.20
Added sugar as % of :															
total sugar among UPCs with total sugar >0g	860	65.58%		742	90.52%		130	81.38%		942	91.28%		183	93.19%	
calories among UPCs with total sugar >0g	860	33.80%		742	79.62%		130	77.64%		942	67.73%		183	84.40%	
calories among UPCs with added sugar >0g	829	34.58%		712	82.68%		124	81.53%		901	70.34%		174	85.33%	
Other Diagnostics															
% with LP added sugar ≤ NFL total sugar		97.23%			98.57%			91.54%			93.95%			95.11%	
Median total error per nutrient and weight		0.034			0.008			0.065			0.136			0.012	

Notes: LP= Linear programming; NFL= Nutrition Facts Label; UPC= Universal Product Code; SD= Standard deviation.

Estimated values from LP model when fruit juice and fruit juice concentrate not considered an added sugar. Added sugar (g) values only include the proportion of added sugar ingredients that are sugar. Some beverage categories contain both regular and low calorie products. Ns represent products with non-missing or non-zero NFP values. [†] in order to be consistent with the sample sizes presented for the Nutrient Ratios, we have limited these to the same products.

Appendix C. Results of small validation test and 'manufacturer $\leq 2\%$ ' constraint sensitivity test based on 15 known formulations.

A. Chocolate Milk	Formula 1			Formula 2			Formula 3		
	Actual grams	Without $\leq 2\%$ LP grams	With $\leq 2\%$ LP grams	Actual grams	Without $\leq 2\%$ LP grams	With $\leq 2\%$ LP grams	Actual grams	Without $\leq 2\%$ LP grams	With $\leq 2\%$ LP grams
Ingredient (per 100g of product)									
1% Lowfat Milk	95.65	95.90	93.81	93.5	93.70	91.67	90.65	90.95	88.83
Sugar ‡	2.50	2.48	2.54	5.00	5.02	5.12	7.50	7.70	7.88
Alkalized cocoa	1.50	0.93	1.10	1.50	0.86	0.85	1.50	0.93	0.97
Salt	0.15	0.14	0.15	0.15	0.14	0.13	0.15	0.14	0.13
Carrageenan	0.10	0.14	0.07	0.10	0.14	0.23	0.10	0.14	0.18
Artificial Chocolate Flavor	0.10	0.14	2.00	0.10	0.14	2.00	0.10	0.14	2.00
Vitamin A Palmitate	0.0008	0.14	0.00	0.0008	0.00	0.00	0.0008	0.00	0.00
Vitamin D3	0.00004	0.14	0.33	0.00004	0.00	0.00	0.00004	0.00	0.00
Added Sugar	2.50	2.48	2.54	5.00	5.018	5.12	7.50	7.70	7.88
Total Sugar	7.30	7.30	7.30	9.64	9.64	9.64	11.94	12.19	12.16
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B. Cranberry Grape Drink	Formula 1			Formula 2					
	Actual grams	Without $\leq 2\%$ LP grams	With $\leq 2\%$ LP grams	Actual grams	Without $\leq 2\%$ LP grams	With $\leq 2\%$ LP grams			
Ingredient (per 100g of product)									
Water	74.19	76.24	75.91	50.69	52.21	50.34			
Grape Juice from Concentrate	12.50	12.95	11.55	40.50	32.86	32.88			
Sugar ‡	10.50	10.38	10.40	6.00	6.32	6.32			
Cranberry Juice from Concentrate	2.50	0.15	2.00	2.50	6.32	6.32			
Black Carrot Juice (for color)	0.16	0.15	0.00	0.16	2.00	2.00			
Sodium Citrate	0.13	0.15	0.15	0.13	0.14	0.14			
Ascorbic Acid	0.03	0.00	0.00	0.03	0.14	2.00			
Added Sugar	10.50	10.38	10.39	6.00	6.32	6.32			
Total Sugar	12.47	12.47	12.47	12.09	12.31	12.31			

Appendix C (cont.) Results of small validation test and ‘manufacturer $\leq 2\%$ ’ constraint sensitivity test based on 15 known formulations

C. Egnog	Formula 1			Formula 2		
	Actual grams	Without $\leq 2\%$ LP grams	With $\leq 2\%$ LP grams	Actual grams	Without $\leq 2\%$ LP grams	With $\leq 2\%$ LP grams
Milk	63.00	63.60	63.53	50.00	45.66	49.01
Sugar ‡	9.00	10.94	10.82	18.00	19.42	18.72
Cream	9.00	10.94	10.82	12.00	14.87	14.51
Skim Milk	8.80	4.69	4.70	7.80	4.89	4.84
Corn Syrup ‡	5.00	4.69	4.70	7.00	4.89	4.84
Egg yolks	5.00	4.69	4.70	5.00	4.89	4.84
Water	0.11	0.16	0.02	0.11	4.89	2.00
Carrageenan	0.05	0.16	0.16	0.05	0.17	0.15
Nutmeg	0.04	0.16	0.55	0.04	0.17	0.00
Vitamin A Palmitate	0.0008	0.00	0.00	0.0008	0.17	1.09
Added Sugar	11.53	13.30	13.19	21.54	21.87	21.15
Total Sugar	16.58	16.58	16.58	26.51	24.38	24.04

D. Vegetable juice drink	Formula 1			Formula 2		
	Actual grams	Without $\leq 2\%$ LP grams	With $\leq 2\%$ LP grams	Actual grams	Without $\leq 2\%$ LP grams	With $\leq 2\%$ LP grams
Water	44.41	34.43	34.43	76.39	71.83	71.83
Tomato Juice from Concentrate	40.00	34.43	34.43	10.00	11.27	11.27
Carrot Juice from concentrate	10.00	26.27	26.27	7.00	10.30	10.30
Sugar ‡	5.50	4.88	4.88	6.52	6.21	6.21
Citric Acid	0.04	0.00	0.00	0.04	0.20	0.00
Malic Acid	0.03	0.00	0.00	0.03	0.20	0.39
Ascorbic Acid	0.03	0.00	0.00	0.03	0.00	0.00
Added Sugar	5.50	4.87	4.87	6.52	6.21	6.21
Total Sugar	7.37	7.02	7.02	6.98	6.98	6.98

Appendix C (cont.) Results of small validation test and ‘manufacturer $\leq 2\%$ ’ constraint sensitivity test based on 15 known formulations

E. Smoothie concentrate	Formula 1			Formula 2		
	Actual grams	Without $\leq 2\%$ LP grams	With $\leq 2\%$ LP grams	Actual grams	Without $\leq 2\%$ LP grams	With $\leq 2\%$ LP grams
Ingredient (per 100g of product)						
Strawberry Puree	45.00	38.61	38.61	30.00	29.91	29.91
Sugar ‡	39.00	38.61	38.61	29.00	29.91	29.91
Apple Juice Concentrate	10.00	10.20	10.20	27.00	24.13	24.14
Water	5.72	10.11	10.20	13.72	10.44	8.85
Natural Strawberry Flavor	0.10	1.24	0.00	0.10	2.00	2.00
Xanthan Gum	0.07	1.24	1.24	0.07	1.20	1.20
Ascorbic Acid	0.06	0.00	0.00	0.06	1.20	2.00
Black Carrot Juice (for color)	0.05	0.00	1.15	0.05	1.20	2.00
Green Tea Powder	0.001	0.00	0.00	0.001	0.00	0.00
Added Sugar	39.00	38.58	38.58	29.00	29.88	29.88
Total Sugar	48.19	47.42	47.42	48.19	47.12	47.12

F. Fruit punch drink	Formula 1			Formula 2			Formula 3			Formula 4		
	Actual grams	Without $\leq 2\%$ LP grams	With $\leq 2\%$ LP grams	Actual grams	Without $\leq 2\%$ LP grams	With $\leq 2\%$ LP grams	Actual grams	Without $\leq 2\%$ LP grams	With $\leq 2\%$ LP grams	Actual grams	Without $\leq 2\%$ LP grams	With $\leq 2\%$ LP grams
Ingredient (per 100g of product)												
Water	87.74	88.11	88.11	85.54	86.05	86.05	85.44	85.79	85.79	81.99	82.96	82.96
Sugar ‡	11.20	11.42	11.42	7.30	7.59	7.59	7.10	7.11	7.11	1.00	1.58	1.58
White Grape Juice Concentrate	1.00	0.48	0.48	7.10	6.37	6.37	7.40	7.11	7.11	16.95	15.19	15.19
Citric Acid	0.04	0.00	0.00	0.04	0.00	0.00	0.04	0.00	0.00	0.04	0.26	0.26
Ascorbic Acid	0.03	0.00	0.00	0.03	0.00	0.00	0.03	0.00	0.00	0.03	0.00	0.00
Added Sugar	11.20	11.41	11.41	7.30	7.58	7.58	7.10	7.10	7.10	1.00	1.58	1.58
Total Sugar	11.72	11.71	11.71	11.72	11.66	11.66	11.72	11.65	11.65	11.30	11.30	11.30

Notes: LP= Linear programming

‡ denotes defined as an added sugar; fruit juice and fruit juice concentrate not considered an added sugar. Added sugar (g) values only include the proportion of added sugar ingredients that are sugar.