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Food Label Accuracy of Common Snack Foods

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Abstract

Nutrition labels have raised awareness of the energetic value of foods, and represent for many a pivotal guideline to regulate food intake. However, recent data have created doubts on label accuracy. Therefore we tested label accuracy for energy and macronutrient content of prepackaged energy-dense snack food products. We measured “true” caloric content of 24 popular snack food products in the U.S. and determined macronutrient content in 10 selected items. Bomb calorimetry and food factors were used to estimate energy content. Macronutrient content was determined according to Official Methods of Analysis. Calorimetric measurements were performed in our metabolic laboratory between April 20th and May 18th and macronutrient content was measured between September 28th and October 7th of 2010. Serving size, by weight, exceeded label statements by 1.2% [median] (25th percentile −1.4, 75th percentile 4.3, p=0.10). When differences in serving size were accounted for, metabolizable calories were 6.8 kcal (0.5, 23.5, p=0.0003) or 4.3% (0.2, 13.7, p=0.001) higher than the label statement. In a small convenience sample of the tested snack foods, carbohydrate content exceeded label statements by 7.7% (0.8, 16.7, p=0.01); however fat and protein content were not significantly different from label statements (−12.8% [−38.6, 9.6], p=0.23; 6.1% [−6.1, 17.5], p=0.32). Carbohydrate content explained 40% and serving size an additional 55% of the excess calories. Among a convenience sample of energy-dense snack foods, caloric content is higher than stated on the nutrition labels, but overall well within FDA limits. This discrepancy may be explained by inaccurate carbohydrate content and serving size.

Introduction

During the past three decades the obesity epidemic has spread at a tremendous pace in both adults and children (1;2). Simultaneously, available food in the U.S. population increased by 16% and this has been estimated to continue to accelerate in coming years (3;4). Consumption of food outside the home increased between the 1970s and 1990s with one study suggesting that nearly all increase in calorie consumption during this time was due to increased snack food consumption (5). Furthermore, a national multicity study demonstrated that the ubiquity of energy-dense snack foods was alarmingly high in retail stores throughout the U.S., with candy being the most commonly offered snack food mostly within arms reach of the cash register queue (6). Cohen et al. identified consumption of these snack foods as a primary target for obesity prevention in low-income U.S. communities (7).

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Food labels can be helpful for individuals to monitor caloric intake and ensure successful weight loss or maintenance (8). Nutrition labels have been developed specifically to help consumers identify foods that will comprise a healthful diet (9). As specified by the Code of Federal Regulations (10), calories on food labels represent metabolizable energy, i.e. total (gross) calories minus calories that are excreted in stool and urine. However, doubts regarding the accuracy of energy content labeling of packaged foods have been expressed. A study from the early 1990s showed that measured energy in packaged food differed by approximately 25% from the label (11). Additionally, a recent study investigated the food label accuracy of reduced-energy restaurant foods and frozen ready-to-eat meals and reported that some restaurant foods contained up to 200% of stated calories and the average energy content of frozen meals was 8% higher than originally stated (12).

This report investigates the accuracy of label-stated caloric contents of energy-dense snack food products in the United States. Using bomb calorimetry and food factors, we measured the energy content of 24 types of snack foods and in a subset determined the macronutrient content for comparison with label statements.

Methods and Procedures

To investigate label accuracy of popular energy-dense snack foods in North America, we used a convenience sample of well-known snack food brands from the following eight categories: 1) candy bars, 2) chips, 3) cereal bars and pastries, 4) cookies, 5) crackers, 6) ice cream, 7) nuts & nut mixes and 8) yogurt. The full list of purchased and analyzed snack foods including nutrition facts is given in Supplemental Table 1. Snack products were purchased from a single chain of grocery stores in the Phoenix metropolitan area (Safeway Inc.). Snack products were purchased on three different occasions (April 4th, 27th and May 10th of 2010) and analyzed during three subsequent periods (April 20th-23rd, April 30th-May 10th and May 10th-18th of 2010), except Lays Potato Chips (see Legend of Supplemental Figure 1). Lot numbers varied at least once in 18 of the 24 analyzed snack products.

Sample preparation for bomb calorimetry

One serving size was determined by the amount of food as given on the nutrition label, for example: crackers, chips or packages and not by weight. This food weight was measured and compared to serving size weight on the nutrition label. Then for preparation for bomb calorimetry a variable amount of water (between 50 and 200 g) was added to the sample to make an evenly distributed slurry. To further ensure homogeneity, samples with a high amount of nut content were soaked in water for 24 hours prior to processing. Processed samples were frozen at −20 °C and subsequently underwent lyophilization at −77°C using a Freezemobile 12XL (Virtis, Gardina N.Y., U.S.A.). After completion of the drying process, the samples were weighed and 1 g pellets were produced with a pellet press (PARR Instrument Co, Moline, IL U.S.A.).

Bomb calorimetry

To measure the energy content of each snack food sample, a pellet was combusted using the Isoperibol Calorimeter 6200 with a model 1108 oxygen bomb (Parr Instrument Co, Moline IL). Details about this method are described elsewhere (13). Benzoic acid standards run once every 10 burns were within acceptable limits of the known heat of combustion. Energy content of the pellet (E_S) was calculated as follows: $E_S = W \times \Delta T$/exact weight of pellet. Each sample was run in duplicate taking the mean of both runs as final energy content. However, if the difference in energy content between first and second pellet exceeded 0.05 kcal, the samples were run in quadruplets.

Macronutrient Content

In a post-hoc analysis, macronutrient content (carbohydrate, fat and protein) was determined in a subset of the analyzed snack foods (n=10) between September 28th and October 7th of 2010. Due to the limited availability of left-over freeze-dried material (pooled from all three bomb calorimetry runs) the following snack items were analyzed for macronutrient content: Doritos Nacho Cheese Flavored Tortilla Chips, Dreyer's Dibs Vanilla Ice Cream with Crunch Coating, Kellogg's Strawberry Frosted Pop Tarts, Klondike Vanilla Ice Cream Sandwiches, Little Debbie Fudge Brownies with Walnuts, Nabisco Chips Ahoy Chocolate Chip Cookies, Nabisco Ritz Crackers, Snickers Bar, Tostitos White Corn Tortilla Chips, Yoplait Smoothie Triple Berry. This analysis was performed by Covance Inc., Madison, Wisconsin, USA. Number-coded freeze-dried pellets were sent out for macronutrient measurements and the identity of the material was at no time released to Covance Inc. to ensure blinding. Fat content was quantified by acid hydrolysis as described in detail elsewhere (14). Protein quantification was accomplished by multiplying the amount of nitrogen in the sample by 6.25 (15). Carbohydrate content was calculated as total weight subtracting weight of fat, protein, moisture and ash. Moisture and ash were determined by methods explained in (16;17).

Calculations used to determine energy content

In addition to gross calories from bomb calorimetry, we calculated gross calories of the snack foods based on macronutrient weights as reported on the food labels using specific heats of combustion (fat: 9.4 kcal/g, carbohydrate 4.1, protein 5.65) and metabolizable calories applying general factors to label macronutrients (fat: 9 kcal/g, carbohydrate 4, protein, 4) as specified in the Code of Federal Regulations (18).

Statistical analyses

Variables are shown as mean (95% confidence interval). Statistical data analysis was carried out using SAS Enterprise Guide Version 4.1. Variables were tested for normal distribution using the Kolmogorov-Smirnov Test and visual evaluation of histograms and quantile plots. For comparison with label data, differences in serving size and caloric content (Δ in total and percent) were evaluated using Wilcoxon signed rank sum tests. Data in the text are presented as median (25th, 75th percentile) independent of the distribution for reasons of consistency. General linear models were used to determine whether calorie deviation from label (dependent variable) can be explained by differences in serving size (covariate 1) and/or macronutrient content (covariate 2). Alpha was set at $p<0.05$ (2-sided).

Results

Median serving size weight (g) of the tested snack foods deviated from the weights per serving given on the label by 0.5g (25th percentile: −0.6, 75th percentile: 2.0, p=0.12) or 1.2% (−1.4, 4.3, p=0.10). The deviation of actual serving size from the stated serving size for each snack is shown in Figure 1. When accounting for the deviation in serving size, median estimated metabolizable energy was 6.8 kcal (0.5, 23.5, p=0.0003) or 4.3% (0.2, 13.7, p=0.001) higher than the label calories. Data for individual snack foods and groups are shown in Figure 2. Gross calories did not significantly deviate from calories estimated using specific heats of combustion (−5.1 kcal [−15.6, 5.7]; p=0.18) or −3.3 % [−6.7, 2.8]; p=0.18), see Supplemental Figure 1.

In a post-hoc analysis, macronutrients were measured in a subgroup (n=10) of the snack foods. As shown in Table 1, median carbohydrate content was significantly higher than stated on the label in total grams and as a percentage (2.2g [0.2, 5.2], p=0.03; 7.7% [0.8, 16.7], p=0.01), while fat and protein content were not significantly different from the label

statements (fat: −1.4g [−2.4, 0.8], p=0.11; −12.8% [−38.6, 9.6], p=0.23; protein: 0.1g [−0.1, 0.7], p=0.28; 6.1% [−6.1, 17.5], p=0.32). In a general linear model, the difference in carbohydrate content accounted for 40% of the caloric difference from the label. Adding the difference in serving size to the model almost completely explained the calorie deviation from the label as shown in Table 2.

Discussion

This report demonstrates that the caloric content in a sample of the most commonly consumed energy-dense snack foods in the United States is overall slightly higher than stated on the nutrition label. As determined by more detailed testing of macronutrient content in a subset of these foods the carbohydrate content was measurably higher compared to the label statements. Together, carbohydrate and serving size deviation from the label explained 95% of the excess calories.

Measured energy values exceeded label statements by 8% on average in pre-packaged convenience meals (12), which is slightly higher but consistent with the label disparity of 4.3% in packaged snack foods. Also consistent with this study, most products in our sample fell within the allowable limit of 20% over the label calories per Food and Drug Administration (FDA) regulations (19). In an earlier study by Allison et al., while caloric content of items described as regionally distributed substantially exceeded label statements, the caloric content of nationally advertised items was more accurate with no statistical difference from the label (11). This is further supported by our data, showing that, although there was a large variability in label accuracy between items, the total calorie difference from the label (6.8 kcal) was relatively small. The discrepancy of label accuracy between restaurant foods or locally prepared food items and nationally distributed products may indicate that the more standardized procedures of large scale food manufacturers may lead to lower error margins in food labeling.

Energy-dense savory snack food products are preferentially consumed by overweight and obese pre-pubertal children who are already at risk for obesity-associated co-morbidities in young adulthood (20). Specifically, individuals who use nutrition label calories as their guideline to control caloric intake could be affected by inaccurate calorie reporting. Furthermore, Rolls et al. have shown that an increase in portion size of snack foods also leads to an increase in overall caloric intake (21). Although the discrepancies between nutrient content or serving size and label statements appear minor, there was considerable variation between the tested products. This needs to be taken into consideration and may represent an underestimated source of excess calories.

Of note, it is important to distinguish that food label calories actually represent metabolizable energy, which is total caloric content minus calories that are presumably not absorbed by the body and excreted as waste. Therefore, the absolute amount of calories in food is higher than the calories stated on the label and this was evident in our sample of snack food items (6.7 kcal [−4.9, 31.9], $p<0.05$). Since nutrient absorption has a high inter-individual variability in humans (22), it may be of more value to report gross calories on food labels as a more reproducible measure of caloric content in prepackaged snack food items.

We also show that 40% of the excess calories were explained by higher carbohydrate content compared to the label. This observation underscores previous criticism on the accuracy of carbohydrate content measurements (by subtraction, as stated above) and factorial values that determine energy derived from carbohydrates (23). Therefore, more

precise regulations of analytical procedures regarding macronutrient content determination specifically in energy-dense food products may be necessary.

The results presented in this report are limited to snack products that are commonly sold and cannot be generalized to all snack foods sold in the United States as this was not a random sample. Furthermore, food lots and retail stores were not randomly sampled and therefore our data are based on the assumption that nutrient content and serving size may not vary by distribution lot or retail location. Finally, macronutrient content was measured in a small convenience sample of the tested snacks but not all products.

In this study we demonstrate that accuracy of labeled calories in a convenience sample of popular snack food products is variable. While overall the caloric content of these snacks is higher than stated on the label, the difference is relatively small. Inaccuracy in carbohydrate content and serving size deviation are the main contributors to this deviation from the label. Nevertheless, consumption of these energy dense snack foods is common and consumers should be aware that accuracy of labeling (though within FDA guidelines) varies, in some cases leading to greater than expected caloric intake.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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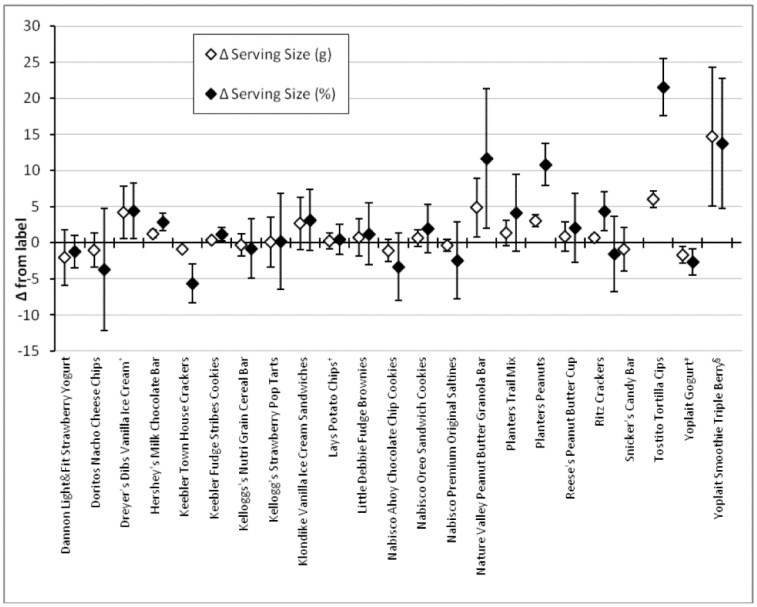

Figure 1. Serving Size Deviation from Label

Error bars represent 95% confidence interval. The y-axis depicts serving size deviation in total grams and as % of label statements. Serving size was determined by weights of item count as shown on nutrition labels (for example: *Tostitos Tortilla Chips* - serving size 24 chips) and compared to the label serving size weight. Serving size was not determined for *Dreyer's Grand Vanilla Ice Cream* due to the difficulty of ascertaining exactly how 1/2 cup (as the stated serving size) of ice cream should be determined. Serving size by weight (28g) as stated on the label was therefore used for further analysis. *In other parts of the country Dreyer's Ice Cream is sold under the name Edy's. † During the first purchase of snack products, a large bag (containing 11 serving by label) of Lays Potato Chips was purchased. Due to the difficulty of choosing 15 equally sized chips (=serving size), we excluded the data from the first run and henceforth purchased smaller bags (1 bag = 1 serving size), thus only data from the last two runs were included in the analysis. ‡ Two different flavors (Strawberry Banana Burst & Watermelon) with identical macronutrient and caloric content (by label) were used for analysis (2 each: n=4). # Product was measured 4 times (2 unprepared, 2 prepared), all data were used for analysis.

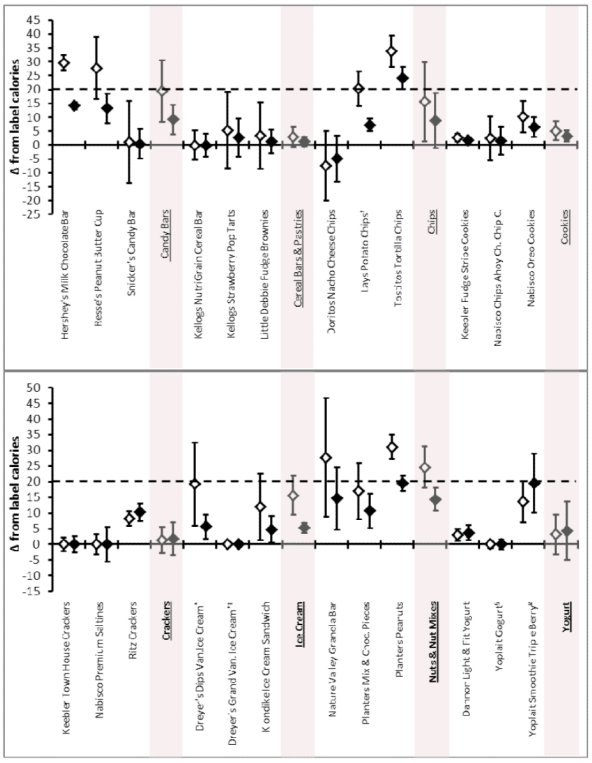

Figure 2. Deviation of metabolizable calories from label calories

Diamonds represent mean values and error bars 95% confidence interval. The Y-axis shows the difference from label calories. Open diamonds represent mean difference in total calories and closed triangles represent mean difference in % from label calories. Group means are gray shaded. The Food and Drug Administration (FDA) allows calorie content to exceed label calories by up to 20%, shown here as dashed lines. *In other parts of the country Dreyer's Ice Cream is sold under the name Edy's. † During the first purchase of snack products, a large bag (containing 11 serving by label) of Lays Potato Chips was purchased. Due to the difficulty of choosing 15 equally sized chips (=serving size), we excluded the data from the first run and henceforth purchased smaller bags (1 bag = 1 serving size), thus only data from the last two runs were included in the analysis. ‡ Serving size was not determined for *Dreyer's Grand Vanilla Ice Cream* due to the difficulty of ascertaining exactly how 1/2 cup (as the stated serving size) of ice cream should be determined. § Two different flavors (Strawberry Banana Burst & Watermelon) with identical macronutrient and caloric content (by label) were used for analysis (2 each: n=4). # Product was measured 4 times (2 unprepared, 2 prepared), all data were used for analysis.

Table 1

Deviation of macronutrient content from label statements

Macronutrient content was measured in a subgroup (n=10) of all snack foods. Total difference in g and difference from label in % are shown for carbohydrates (CARB), fat (FAT) and protein (PROT). CI: confidence interval. P-values derive from Wilcoxon signed rank sum tests.

Product Name	Δ CARB from label		Δ FAT from label		Δ PROT from label	
	total (g)	%	total (g)	%	total (g)	%
Doritos Nacho Cheese Flavored Tortilla Chips	0.8	4.9	−1.1	−13.6	−0.1	−6.1
Dreyer's Dibs Vanilla Ice Cream*	5.0	16.7	−9.3	−38.6	2.8	139.4
Kellogg's Frosted Pop Tarts Strawberry	−0.6	−1.6	−0.2	−4.7	0.2	11.6
Klondike Vanilla Ice Cream Sandwiches	4.0	14.0	1.3	9.6	0.1	2.1
Little Debbie Fudge Brownies with Walnuts	−0.2	−0.5	−2.1	−17.7	−0.5	−18.2
Nabisco Chips Ahoy Chocolate Chip Cookies	0.2	0.8	−4.7	−58.9	−0.3	−12.6
Nabisco Ritz Crackers	0.2	2.1	−2.4	−52.3	0.0	2.6
Snickers Bar	3.6	10.4	−1.7	−12.0	0.7	17.5
Tostitos White Corn Tortilla Chips	6.0	33.4	0.8	11.0	0.2	9.7
Yoplait Smoothie Triple Berry	22.0	157.1	1.3	87.1	3.7	370.5
Total Group (median) 25th, 75th percentile	2.2 (0.2, 2.0)	7.7 (0.8, 16.7)	−1.4 (−2.4, 0.8)	−12.8 (−38.6, 9.6)	0.1 (−0.1, 0.7)	6.1 (−6.1, 17.5)
P-value	0.03	0.01	0.11	0.23	0.28	0.32

Table 2

Caloric deviation from label is explained by carbohydrate and serving size deviation

Caloric deviation from label statements in % is the dependent variable. Δ carbohydrates is the deviation of carbohydrates from the label statement and Δ serving size is the deviation of serving size from the label statement (both in %).

General Linear Regression Models	Covariate(s)	β-Coefficient	95% CI	Model r^2	Model *p*
Reduced Model	Δ carbohydrates	0.12	0.00,0.24	0.40	<0.05
Full Model	Δ carbohydrates	0.02	−0.03,0.07	0.95	<0.0001
	Δ serving size	1.03	0.74,1.32		