

Accuracy of volumetric vs. weight measurement in nutrient analysis for research

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Abstract

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Objective

The USDA standard release databases use food weight to determine nutrient content; many dietary self-assessment methods and emerging image-assisted technologies utilize estimated food volumes to assess dietary intake. Data are needed to understand the comparability of assessment using volumetric vs. weight measures. This study evaluates the accuracy of macronutrient content for foods estimated by volume compared to weight.

Materials and Methods

Weights and volumes of 37 food portions from 6 groups were measured. Each trial was comprised of 10 replicates; additional quality control trials were conducted for 10% of randomly chosen foods. Commonly consumed foods were selected to include variation in water content and shape. Foods were prepared and measured in an experimental nutrition laboratory. Nutrient information was extracted from the USDA SR 28 database for each food's weight and volume; differences in weight and macronutrients were computed for each trial.

Results

Significant differences in weight determined via volume by the USDA SR 28 (USDA weight) and experimental weight were found in 76% of trials. For 24% of all foods, calories estimated by

USDA weight were significantly greater than estimates by experimental weight; for 46% of foods, calories by USDA weight were significantly less than estimates by experimental weight. Protein content estimates by USDA and experimental weight differed significantly from each other for 100% of dairy and 69% of protein foods. Carbohydrate estimates differed significantly for 65% of foods; the highest was white rice, where estimates by USDA weight were 8.7 ± 0.48 g/serving lower than experimental weight estimates. Fiber content estimates differed significantly for 75% of fruit and vegetables. Lipid content estimates differed significantly for fat-dense foods and were as large as 4.85g/serving.

Significance

Many researchers are reliant on nutrient databases to accurately determine the nutrient content of various foods. It is important to ensure the accuracy of these databases to estimate nutrient content based on food volumes.

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1 BACKGROUND

Measurements of dietary intake can be completed by way of self-assessments, namely multiple-day food records and interviewer-assisted 24-hour recalls, or via emerging objective techniques to estimate food using images and scans. A major area of concern after food volume is determined is the accuracy of the nutrient content information extracted from food and nutrient databases when based on food volume, not weight. The United States Department of Agriculture National Nutrient Database for Standard Reference Release 28 (USDA SR 28) is the major source of food composition data in the US and is the foundation for most public and private food and nutrient databases.¹ The USDA SR 28, USDA Food and Nutrient Database for Dietary Studies (FNDDS), Nutrition Data System for Research (NDS-R) developed by the Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN², and similar databases are largely based on gram weights of food, not volumes, as food weight is considered the gold standard of measurement.^{1,3} The NDS-R is a compilation of the USDA SR and the USDA FNDDS with additional data from manufacturers.^{4,5} The USDA SR 28 was compiled from published sources, including scientific literature, and unpublished sources, including industry and government agency files, and studies conducted by the USDA and contractors. The FNDDS, which generally contains more portion weights than the USDA SR 28, provided information about non-household volumetric units, such as slices or relative size (S,M,L).⁶ Data collected from conducted studies was based on a revised probability-proportional-to-size food sampling plan was developed by the USDA Nutrient Data Laboratory (NDL) to determine nationally representative data for commonly-eaten foods.^{1,7} When newly generated data is introduced into the USDA SR 28, values are converted to measures per 100g, and nutrient values of household

volumetric measures are computed by multiplying the nutrient value per 100g by the gram weight of the volumetric portion in question, and dividing the product by 100.¹ Other values may be based on lab analyses, algorithms, factors, or recipes. Missing data may have been determined multiple ways: via recipe or formulation modules, or the NDL may estimate the values of any items lacking analytical data for any FNDDS nutrient from similar analyzed foods.^{1,8-10}

The overall goal of this project is to evaluate the accuracy of estimating the portion size and nutrient content of foods by volume compared to the gold standard of determining nutrient content of foods by weight. The USDA SR 28 will be used to determine the nutrient content of a food of a standard portion size by weight and by volume.

1.1 SPECIFIC AIMS

Aim 1. To determine the extent to which estimates of food portion sizes measured by weight differ from estimates of food portion sizes measured by volume.

Aim 2. To describe the differences in estimated nutritional content of food portion sizes when measured by volume and by weight.

2 RESEARCH DESIGN AND METHODS

2.1 FOOD CHOICES AND PREPARATION METHODS

Food categories were chosen based on the USDA MyPlate food groups, as the USDA SR 28 groups into 25 different food groups, including entrees, native foods, restaurant foods, beverages, and sauces. We chose to measure single foods, as opposed to mixed or combination foods such as sauces or entrees, in order to maximize comparability with the USDA database, as the recipe behind a mixed food prepared in our lab may be different from the one used by the

USDA. Thus, the food groupings selected for the experiments were fruits, vegetables, grains, dairy, proteins, and fats/oils. Within each food group, individual foods were chosen based on consumption by Americans, allowing for variation in water content and shape.¹¹⁻²³ All foods were chosen initially via multiple USDA sources: Economic Research Service (ERS) data, National Health and Nutrition Examination Surveys (NHANES), Continuing Survey of Food Intakes by Individuals, and the Agriculture Factbook.¹¹⁻²² Private sources were used to determine ice cream flavor popularity and popular condiment purchases.^{24,25}

Preparation methods were determined for each food individually. For foods made up of full edible portion needing no alteration, such as raspberries and whole nuts, no preparation methods were applied and the foods were measured ‘as purchased.’ Foods containing inedible portions, for instance bananas with a peel or whole chicken breasts to be cooked and chopped, were altered from the packaging or purchased state by the investigator. Alterations were first made to remove inedible portions, such as peels or rinds, then methods to manipulate size were applied, and, lastly, if foods were cooked, protocols provided by the Human Nutrition Lab (HNL) at the Fred Hutchinson Cancer Research Center or the packaging instructions were followed to properly cook foods. Preparation methods were chosen based on a combination of the methods available for measurement in the USDA SR 28 for each food and the LanguaL Thesaurus, which provides standardized food descriptions to encompass various forms of food preparation.²⁶ The LanguaL Thesaurus is utilized by the USDA databases to coordinate and equalize food description terms and definitions across all food research, food safety, nutrition monitoring, and food marketing realms.^{1,26,27} If applicable, foods were measured by multiple preparation methods. If a food was cut at a measured unit, parchment paper with markings of the measured cut size was used as a guide.

The standard preparation methods and their parameters are as follows:

Sliced: between .5cm and 1.5cm.²⁶ For consistency, the investigator measured slices to 1cm.

Cubed: >1.5cm. Considering the range within dicing, which is 1.2cm, cubes were defined as 1.5cm to 2.7cm equally cut on all sides. For consistency, the investigator attempted to cut each cube side to 2cm.

Chopped: Item is divided into pieces with a thickness <0.3cm.²⁶ For consistency, the investigator chopped items as close to .25cm as possible.

Portion sizes were determined for each food group based on standard USDA MyPlate recommended servings for adults.²⁸ The volumetric portion sizes, preparation and cooking methods, and details of each measured food are listed in **Table 1**.

2.1.1 Fruits

USDA ERS data determined that the most commonly eaten fruits in America in 2012 were bananas and grapes.¹¹ Additionally, *What We Eat in America* found that between 2001 and 2002, 15% of Americans ages 2+ chose to eat a banana, orange, apple, ¼ medium cantaloupe, or ¾ cup of strawberries at breakfast.²⁹ These fruits were thusly chosen based on these consumption patterns, and additional fruits were considered to add variety in water content and shape.²³

Considering fruits along a spectrum of water content, we chose bananas based on their popularity, but they also have a low water content (76%).²³ Raisins and avocados differed in shape and are lower in water content than bananas, 15.4% and 72.5%, respectively. Increasing in water content, grapes (81%), apples (84%), and oranges (86.4%) are popular foods. Raspberries have a different shape than all of the most popular foods are 86.6% water. While strawberries and cantaloupe were popular and highest in water content, 91.5% and 89.8%, respectively, peaches (88%) were also chosen to add variety in shape. While our original goal was to measure

all fruits as fresh fruits, peaches were out of season and unavailable at the time of testing. Instead, canned, sliced peaches packed in heavy syrup were measured to align with the USDA SR 28 options. For canned peaches, the only available method for measuring the peaches drained from liquid was to measure those in heavy syrup, as compared to measuring drained peaches packed in extra light syrup. Portion sizes of $\frac{1}{2}$ cup for all fruits were determined based on the MyPlate portion sizes suggested for adults in addition to the daily recommendation of 1.5-2 cups.²⁸ All fruits were measured by $\frac{1}{2}$ cup measurements, as all of the fruits chosen for our experiments that were listed on MyPlate are equivalent to $\frac{1}{2}$ cup of a daily fruit serving at the $\frac{1}{2}$ cup measurement, except raisins. Raisins were measured at $\frac{1}{4}$ cup, as $\frac{1}{4}$ cup of dried fruit is equivalent to $\frac{1}{2}$ cup of a fruit serving.²⁸ The fruits measured were strawberries, cantaloupe, peaches, oranges, raspberries, apples, grapes, bananas, avocados and raisins.

2.1.2 Vegetables

Potatoes, tomatoes, onions, and lettuce were the most commonly consumed vegetables among Americans in 2012, according to the USDA ERS.¹¹ These vegetables were chosen to be included in the trials, and other vegetables were then considered based on differing water content and shape. Iceberg lettuce was chosen over other varieties because lettuce was a commonly consumed vegetable and iceberg was the variety with the highest water content, at 96% water.^{11,23} Decreasing in water content, tomatoes and onions are 94% and 89.6% water, respectively, but are also highly consumed by Americans. Potatoes were chosen based on consumption by Americans, though are a vast array of potential preparation techniques available in the USDA SR 28.^{11,27} Potato chips were commonly eaten at home, and fried potatoes were commonly eaten away from home.³⁰ Fried potatoes were chosen based on their shape. Corn is 69.5 to 77% water, depending on the cooking method. Strained, yellow, canned corn was

measured in order to obtain an accurate measurement of the solids filling a $\frac{1}{2}$ cup, rather than solids and liquids. Although MyPlate recommends different serving sizes for vegetables depending on their characteristics, such as dark green, red and orange, or starchy,²⁸ to maintain consistency in measurement, all vegetables were measured at $\frac{1}{2}$ cup amounts, with the exception of potatoes, which were also measured per 10 fries because 10 fries is equivalent to a $\frac{1}{2}$ cup serving of vegetables.²⁸ Preparation methods were carried out as detailed above, with the exception of iceberg lettuce, which is listed in the USDA SR 28 as “Chopped ($\frac{1}{2}$ ” pieces, loosely packed)” and was thusly prepared as $\frac{1}{2}$ ” chopped pieces.^{26,27} The vegetables measured were iceberg lettuce, tomatoes, French fried potatoes, onions, and sweet corn.

2.1.3 Grains

Grains were initially chosen based on ERS data regarding the most commonly consumed grains. In 2000 and 2001, wheat flours, corn products, and rice were the most commonly eaten grains.^{13,29} These categories are broad and exclude foods not manufactured directly from wheat flour, corn products, or rice; these exclusions include brand cereals, packaged corn chips such as Doritos®, and packaged rice products such as rice cakes.¹³ To choose specific grains to measure, grains within the wheat flour group were chosen based on the results of NHANES data regarding popular breakfast foods. Between 2000 and 2001, ready-to-eat cereals and breads, bagels, rolls, and English muffins were among the most popular breakfast foods.²⁹ Additionally, according to 2009-2010 NHANES data, 44% of grains were consumed as part of mixed foods; of these, 11% were in sandwich form.²² Thus, sliced wheat bread was chosen based on its commonality at breakfast, the overall consumption of wheat flour, and the choices of sandwiches by Americans. Data from the USDA’s Continuing Survey of Food Intakes by Individuals in 1994 to 1996 was utilized to further specify grain choices. The results from this survey revealed that the order by

which highest to lowest mean quantities of grains were consumed per person per day was yeast breads, white breads, pastas, rice, rolls, pizza, and spaghetti with tomato sauce.³¹ To ensure variety between choices, yeast breads, white breads, and rolls were considered similar and were not measured because wheat bread slices were chosen. Additionally, as mixed foods are not included in this study, pasta and rice were chosen. Since spaghetti with tomato sauce was one of the most popular choices, spaghetti was the pasta style measured.³¹ According to MyPlate, the daily grain recommendation for adults ranges from five to eight ounce-equivalents and two regular slices of bread, one cup of cooked rice, and 1 cup of cooked pasta are all equivalent to two ounce-equivalents of grains.²⁸ As the aforementioned portion represents between 25 to 40% of recommended daily intake, grains were measured by two ounce-equivalents. Preparation methods utilized were those given by the packaging instructions for pasta and rice; bread was measured as purchased because it was pre-sliced. The grains measured in the experiment portion were yeast bread in the form of wheat bread, spaghetti pasta, and long grain white rice.

2.1.4 Dairy

Dairy products were chosen based on *What We Eat in America* of NHANES 2009-2010, and ERS 2000 data, both of which revealed dairy is consumed per capita, in order from highest to lowest, in the forms of milk, cheese, frozen dairy products, and yogurt.^{13,32} Milk is a beverage and was not measured. Among cheese, cheddar was chosen based on its standing as one of the most popular cheeses in 2012, according to ERS food availability and consumption data.^{11,32} Of frozen dairy products, regular ice cream was most popular according to the USDA's 2001-2002 Agriculture Fact Book.¹³ Among ice creams, 2012 sales trends revealed that vanilla was the most popular flavor, according to the International Dairy Foods Association's 2012 survey.¹³ To encapsulate the spectrum of various yogurts available, plain skim yogurt falling in the middle

range from non-fat to full fat was chosen. Dairy portions were chosen to meet one of the three cups per day recommended by MyPlate.²⁸ $\frac{1}{3}$ cup of shredded cheddar and one cup of yogurt meet the MyPlate 1-cup equivalent of dairy. Ice cream was measured by $\frac{1}{2}$ cup, even though 1.5 cups of ice cream is actually equal to 1-cup equivalent of dairy in MyPlate. We chose this because the recommended serving size on the nutrition panel was $\frac{1}{2}$ cup. Preparation methods were only applied to cheese, which was grated off the block and measured as equivalent to shredded. Of dairy products, medium cheddar cheese, vanilla ice cream, and skim yogurt were measured.

2.1.5 Protein

Proteins were chosen, initially, based on the most popular choices of Americans in 2009 and 2010.^{17,21} ERS data from 2000 and the Continuing Survey of Food Intakes by Individuals (1994-1996) were then considered in order to narrow down wide categories in *What We Eat in America*, NHANES 2009 and 2010 data.^{13,14,22,33} According to *What We Eat in America* and NHANES, in 2009 and 2010, meat (including, but not limited to, beef, bison, game meat, ham, and pork), poultry, eggs, and nuts and seeds were the most popular choices of Americans ages 2+.³² ERS 2000 data were used to specifically determine that the most popular meats among Americans were ground beef, pork, and chicken.¹³ Between 1994 and 1996, 54% of Americans ages 2+ reported having eaten ground beef at least once in two days, with 15.3% reporting they'd eaten ground beef on both days.³³ Within ground beef, burgers were especially popular among foods in sandwich form between 1994 and 1996 according the Continuing Survey of Food Intakes by Individuals.¹² Based on the aforementioned data, two beef patties, of differing fat content, were chosen. Lean beef patties, defined by the USDA as having less than 10g of fat, 4.5g or less of saturated fat, and less than 95mg of cholesterol per 100g of beef, were

measured.³⁴ To determine any portion or nutrient content differences between patties, burgers of a high fat content (30% fat) were measured as well. Chicken was consumed by 35.9% of Americans ages 2+ at least once in two days between 1994 and 1996, while 2009 to 2010 data showed that an average of 40.8g poultry was consumed daily in males and females ages 2+.^{21,33} Chicken portions are available by the skinless breast in the USDA SR 28 for both raw and cooked pieces; breasts and one cup of cooked chopped chicken were thusly chosen. Bacon was consumed by 14.3% of Americans at least once in two days between 1994 and 1996, and was chosen based on the popularity of pork products and because bacon is the most popular form of pork eaten by Americans.^{13,33} Further data from *What We Eat in America*, NHANES 2009-2010 found that two eggs were reported as consumed by 16% of Americans ages 2+.²⁹ The method of cooking was determined by USDA SR 28 availability and the eggs were measured raw without the shell, then measured cooked as scrambled eggs. Americans ages 2+ consumed an average of .6oz of nuts and seeds per day in 2009 and 2010. Between 2001 and 2004, the most popular nuts and seeds, in order of consumption, were peanuts, cashews, almonds, pistachios, pecans, and walnuts. Of respondents who reported consuming nuts as snacks, 25% reported eating nuts in mixed foods, 8% reported eating nuts as peanut butter, and 6% reported eating nuts as plain snacks.³⁵ Among the frequently reported nuts, cashews, almonds, pecans, and peanut butter were chosen based on shape and consistency differences. The daily recommendation of protein food intake for adults, according to MyPlate, is 5-6.5 ounce-equivalents depending on age and sex. In terms of meat portion sizing, meats, eggs, nuts, and seeds were measured between one and four ounce-equivalents. 1oz cooked lean beef is equivalent to one ounce-equivalent in the protein food group. Thus, ¼lb burger patties are equivalent to four ounce-equivalents and were measured. One small chicken breast is about three ounce equivalents.²⁸ Thus, single chicken

breasts were used as their own portion size, except when they were chopped and measured by one cup of chopped pieces. Bacon is not recommended by MyPlate as part of an American's healthy diet.²⁸ Thus, the portion size of three slices was chosen based on the number of slices listed as a serving on the nutrition panel of the packaging. Eggs were measured to one ounce-equivalent because the USDA database measures eggs singularly and would allow measurement and weight tracking of a singular egg raw then cooked as a scrambled egg. In terms of protein intake options, the nut and nut butter daily intake recommendation is between one and two ounce-equivalents.²⁸ One ounce of nuts is equal to two protein food ounce-equivalents in MyPlate and, depending on shape and weight, could be measured between $\frac{1}{8}$ cup and $\frac{1}{4}$ cup.²⁸ The average daily nut intake in 2009 and 2010 was .6oz per day; $\frac{1}{8}$ cup of nuts, the lower limit of measurement, was chosen as the portion size for nuts and seeds.²¹ Peanut butter was also measured by two ounce-equivalents, with 1 tablespoon (T) of nut butter being one ounce-equivalent. 2T of nut butter were measured, which is also the serving size on the nutrition panel of the peanut butter jar. Cooking protocols for beef, chicken, and eggs were based on the protocols used by the Human Nutrition Laboratory at the Fred Hutchinson Cancer Research Center. The protein foods measured were 7% fat and 30% fat cooked beef patties, raw and cooked chicken breasts, raw and cooked bacon, raw and cooked eggs, raw cashews, raw almonds, halved pecans, and peanut butter.

2.1.6 Fats/Oils

Margarine was chosen to represent solid fats, as it was the most-consumed solid fat, at an average of 37.4g per person per day between 2009 and 2010. Further, oils were consumed at an average of 21.6g per person per day in those same years.³² Unfortunately, reliable information on consumption trends for specific oils is unavailable and oil-based food choices were based on

private sources. Among condiments and miscellaneous foods, the USDA surveillance systems in place to track America's eating habits do not distinguish between various condiments. NHANES 2003-2006 data found that "salad dressings, mayonnaise" ranked 15th at 2.7% of total energy consumption in the diets of Americans ages 19+.¹⁶ However, consumer reports indicate many of the same condiments and dressings to be the most consumed by Americans. According to SymphonyIRI Group data presented by Bloomberg Business, the most-purchased condiments in the United States in 2010 were, in order, mayonnaise, salsa, ketchup, and mustard.²⁵

Additionally, in a 2002 market evaluation of salad dressings, the most popular were liquid dressings, mayonnaise, miracle whip-type foods, and reduced fat dressings.³⁶ The daily allowance for adult oil consumption, per MyPlate, is between 5tsp and 7tsp, or 1.6T and 2.3T.²⁸ 1T of margarine is equivalent to 2.5t of oil, per the MyPlate recommendation. Thus, 1T of margarine was measured to meet about half of the MyPlate recommendation. Further, 1T of vegetable oils, such as canola oil, are equivalent to 3t of oil. However, as canola oils are often used in other products such as dressings and cooking preparation, canola oil was measured by 2T portions, nearing the upper limit of the MyPlate recommendation of 7t, or 2.3T. The serving size listed on nutrition panels for the condiments chosen is between 1T and 2T. As 6t, which falls within the recommended MyPlate range, is equivalent to 2T, and 2T falls between the serving size amounts, 2T were measured for each miscellaneous food for consistency. Based primarily on NHANES data and secondarily on market research data, margarine, canola oil, mayonnaise, salsa, ketchup, regular Italian dressing, and reduced-fat Italian dressing were measured.

2.2 SAMPLE SIZE AND DATA COLLECTION

For 37 foods, 10 replicates at the set volumes and preparation methods referenced in sections 2.1.1-.6 and **Table 1** were measured for a total of 49 initial trials. 10 replicates per trial

were chosen based on the number of data points per nutrient measured by the USDA SR 28 and considerations for uniform trial numbers. The USDA SR 28 lists the number of data points available for each nutrient; in analyzing the data points collected for the foods in this study, the number of data points in the USDA SR 28 ranged from none available to 354. Additionally, for some foods, the number of data points were available for some but not all macronutrients or were vastly different between macronutrients. Taking this into consideration along with budgetary guidelines, 10 replicates per food preparation method were chosen. After initial trials, 10% of foods were randomly chosen to undergo quality control trials. Quality control foods were chosen using the “RAND()” function in excel applied to four groups: (1) fruits and vegetables, (2) proteins, (3) grains and dairy, and (4) fats and oils. The quality control foods chosen were French fries, chicken breasts, ice cream, and regular Italian dressing, for a total of 7 quality control trials. In total, 56 trials were completed.

All trials were labeled in a master spreadsheet as “NameOfFood Replicate#,” and quality control trials were labeled “NameOfFood QC Replicate#.” Predetermined protocols were followed and actions throughout the experimental phase were recorded if they differed from the protocols. The aforementioned master spreadsheet was used to record the date of each trial, volume at which the food was measured (in household and dimensions, if applicable), tare weight of the container or receptacle used to hold the food, the dry or raw weight plus container if the food was to be cooked by the investigator, and the cooked weight plus the tare weight. Final weight was determined by a spreadsheet function to subtract the tare weight from the dry or raw weight or the cooked weight, depending on the food being tested. After each trial, results written by hand were entered into the master spreadsheet and protocols followed to include any missing information were updated, such as the brand of measuring cup used. The protocols

completed for each trial and documentation of the spreadsheet functions used for each trial can be found in **Appendix A**.

Nutrient content was obtained from the USDA SR 28; the NDS-R Version 2012 was consulted and utilized only when the USDA SR 28 did not contain the necessary nutritional information. The NDS-R was consulted for $\frac{1}{2}$ cups of French fries, cooked 7% fat beef patties and $\frac{1}{8}$ cups of cashews. The USDA SR 28 was utilized to obtain the nutrient content based on the weights of the French fries, cooked 7% fat beef, and cashews, but NDS-R was utilized to obtain the nutrient content of the foods based on the volumes. Measuring French fry nutrient content per 10-fries was the only semi-volumetric or relative size option available in the USDA SR 28 database. Thus, measurements based on $\frac{1}{2}$ cup of French fries were determined via the NDS-R. The NDS-R was utilized to obtain nutrient content information based on volume using the volumetric unit “medium patty” for 7% fat beef and “ $\frac{1}{8}$ cup” for cashews, as the only volumetric measurement unit available for both foods in the USDA SR 28 was ounces. For all other nutrient content information by weight and volume, USDA SR 28 was utilized. To extract nutrient content from USDA SR 28, the experimental weight of each food replicate was entered in factor form into the ‘value per 100g’ column on each food’s basic report page in the USDA SR 28. On the same basic report page, the volumetric unit used was entered in the column depicting the appropriate preparation method. The experimental weight was previously recorded while trials were carried out; when nutrient content information was extracted from the USDA SR 28, the weight determined according to volume, or the USDA weight, was then recorded. Water, calorie, protein, total lipid, carbohydrate, and fiber contents determined for each trial via experimental weight and USDA weight were also recorded. Water content information was subsequently removed due to its potential variability. According to the USDA Food Safety and

Inspection Service, poultry products not labeled ‘marinated’ may still contain an unregulated amount of flavoring solution.³⁷ The inability to know if and how much aqueous solution was injected into the chicken breasts utilized in this study introduced an unknown amount of potential variability, prompting the investigator and committee to remove water content information from the data set. The final dataset utilized for statistical analyses contained original and quality control trial values for all 37 foods. The variables included were experimental weight, USDA weight, and calorie, protein, carbohydrate, fiber, total lipid, saturated fat, MUFA, and PUFA contents determined by experimental weight and USDA weight.

2.3 STATISTICAL ANALYSIS

Statistical analyses were conducted using STATA 2014 software. All analyses were determined for individual foods, and foods were grouped into their respective food groups outlined in section 2.1. For each individual food, the means and standard deviations of the 10 replicates for experimental weight were calculated. Based on the measured volume, which was the same for each food, the USDA weight was determined via the USDA SR 28; thus, each USDA weight assigned to the volume was the same for all replicates. The mean difference between experimental weight and USDA weight was calculated as the average of differences of all replicates and was computed by generating a difference variable for each food and reporting its summary statistics; standard error was also reported. For each trial, one-sample t-tests were used to evaluate whether the mean difference between experimental and USDA weights were significantly different from zero.

Macronutrient values were assigned to each replicate corresponding to the experimental weight and to the USDA weight. For each food trial, the mean of the macronutrient values by

experimental weight and USDA weight from 10 replicates was reported. The mean and standard error of the differences between macronutrient contents determined by experimental weight and by USDA weight were calculated for all 10 replicates and reported. One-sample t-tests were used to evaluate whether these mean differences were significantly different from zero.

3 RESULTS

Table 2 summarizes the mean differences in experimental weight and USDA weight of food portions; these differences are represented by experimental weight subtracted from USDA weight. For 76% of trials, weight differences of food portions were significant, ranging from .2g to 59g. 65% of fruit and vegetable weights were significantly different from each other. USDA weight was estimated to be significantly less than experimental weight for sliced apples (-32.8 ± 1.6 g) and sliced onions (-59.4 ± 4.9 g), whereas USDA weight was estimated to be significantly more than experimental weight for 10 French fries (21.2 ± 1.5 g) and canned sweet corn (17.5 ± 1.8 g). The weights of $\frac{2}{3}$ of grains and all dairy products were estimated to be significantly different from each other. The USDA weights of ice cream, rice, and yogurt were estimated to be significantly less than their experimental weights, with differences of 29.3 ± 1.5 g, 24.7 ± 5.6 g, and 15.8 ± 0.4 g, respectively. The USDA weight of $\frac{1}{3}$ cup of cheddar cheese was estimated 14.6 ± 0.5 g over its experimental weight. 77% of protein food weights were significantly different from each other. The USDA weight of whole, roasted chicken breasts was estimated 34.2 ± 9.8 g below its experimental weight, while all nuts were estimated 7.6 g below their experimental weight. The largest USDA weight estimation above the experimental weight was made for one large scrambled egg (17.1 ± 0.8 g). The estimated weights of all fats/oils were

significantly different; for >70% of fats/oils, USDA weights were estimated an average of 1.02g below the experimental weight.

Table 3 provides average differences between calorie, protein, carbohydrate, fiber, and lipid contents determined by USDA and experimental weight. Differences in calorie estimates ranged from 1-60 calories per serving; 24% of all calorie estimates by USDA weight were significantly estimated above the value by experimental weight. 46% of calorie estimates by USDA weight were estimated below the value by experimental weight. The largest calorie values determined by USDA weight that were significantly less than those determined by experimental weight, by food group, were for sliced onions (-24 ± 2 cal), cubed avocado (-24 ± 4 cal), white rice (-41 ± 2), ice cream (-60 ± 3 cal), nuts (-47 cal), roasted chicken breasts (-56 ± 16 cal), and mayonnaise (-9 ± 1 cal). The largest significant calorie estimations by USDA weight that were greater than those determined by experimental weight were made for 10 French fries (36 ± 3 cal), shredded cheddar (59 ± 2 cal), pan-fried bacon (35 ± 8 cal), scrambled eggs (26 ± 1 cal), and canola oil (22 ± 1 cal).

Protein content estimations by USDA and experimental weight were significantly different for 100% of dairy products and 69% of protein foods. Protein content estimations by USDA weight significantly higher than estimates by experimental weight ranged from 0.45g to 3.14g per serving. For all estimations by USDA weight that were significantly less than estimations by experimental weight, protein content estimations were between 0.68g and 1.6g below the protein content determined by experimental weight, except for chicken breasts. Chicken breast protein content, when determined based on the USDA weight of “1 breast, bone and skin removed,”²⁷ was estimated 10.61 ± 3.03 g below the protein content determined by the experimental weight of the breast.

Significant differences in carbohydrate values were found for 65% of foods. For 62% of fruit servings, carbohydrates estimated by USDA weight were estimated 0.26g to 4.76g less than estimates by experimental weight. For vegetables, <50% of carbohydrates estimated by USDA weight were between 6.01g less than and 6.24g greater than the carbohydrate estimates by experimental weight. For white rice (-8.7 ± 0.48 g) and ice cream (-6.92 ± 0.35 g), the carbohydrate contents estimated by USDA volume were significantly lower than when estimated by experimental weight. The largest differences in carbohydrate estimations that were significantly greater by USDA weight compared to experimental weight were made for 10 French fries (5.82 ± 0.42 g) and corn (3.39 ± 0.35 g).

Fiber content was estimated differently for 75% of fruits and vegetables; estimates by USDA weight ranged from 1.19g below to 0.38g above experimental weight estimates. Excluding avocado, 67% of fruit, vegetable and grain lipid contents were estimated differently by experimental and USDA weight, to a maximum of 1.6g per serving. When lipid content was determined by USDA weight, pecan lipid content was 5.64 ± 0.3 g less than the estimate by experimental weight, followed by cashews (-3.58 ± 0.27 g), almonds (-3.46 ± 0.29 g), ice cream (-3.23 ± 0.03 g), and cubed avocado (-2.19 ± 0.34 g). Shredded cheddar was the largest lipid content estimation by USDA weight greater than the estimate by experimental weight (4.85 ± 0.16 g), followed by bacon (2.68 ± 0.58 g) and canola oil (2.46 ± 0.1 g).

4 DISCUSSION

In this study evaluating the accuracy of food portions and nutrient contents estimated using the USDA SR 28, the principal finding across all food groups was that > 75% of weight

estimates and >65% of macronutrient value estimates were significantly different from each other when determined via weight and volume.

Many current dietary intake measurement methods utilize relative volume estimation, and new tools are emerging to estimate food volumes from images and scans; nutrient databases then provide nutrient content information based on food volumes.³⁸ In the present study, differences between experimental and USDA weight ranged from 0.2g and 59.4g per serving. In a study by Zhu et al. of a volumetric image analysis tool, differences in food weight estimations by volume compared to experimental weight were as large as 32g.³⁹ The use of volumetric imaging technologies to estimate food volume would allow objective measurement of food portions. While many of these technologies are in-development, Zhu et al. present promising initial assessments that suggest estimating food volume by imaging is an accurate and convenient form of dietary assessment. In their study, some food volumes were estimated more accurately than others, with error margins ranging from 0.51% to 10% volume error.³⁹

Differences in portion weight estimates by volume carry over into nutrient content estimates, with many nutrient content estimation differences reflecting the differences in their weight estimation differences. All fruits and vegetables with significant differences between experimental and USDA weight also exhibited significant differences between all macronutrient values determined by USDA weight and experimental weight. Lower nutrient content estimations by USDA weight compared to experimental weight were most prevalent amongst prepared fruits and vegetables compared to those measured as purchased. This variability may be due, in part, to generalized grouping of preparation methods; the USDA SR 28 combines quartered and chopped apples, and chopped and sliced tomatoes, therefore returning the same nutrient content for ½ cup of each, though the preparation methods are different.²⁷

Differences in the weight estimates of grains increased as the experimental weight of the portion size increased; rice was heaviest and resulted in the largest carbohydrate content estimation by USDA weight below the experimental weight estimation ($-8.7 \pm 0.48\text{g}$). USDA weights of creamy dairy products were significantly estimated below experimental weights, which carried over to calorie (-34.7cal/serving) and protein (-4.44g/serving) content estimations. Of note is vanilla ice cream, estimated by USDA weight to be 130 calories per $\frac{1}{2}$ cup serving, but, when calorie content was determined by experimental weight, was found to be 197cal/serving. Ice cream melt may have been a factor in these weight and calorie differences and the same issues may apply to volumetric imaging technologies. In a systematic review of image-assisted dietary assessments, Gemming et al. found that liquid-like foods were sometimes skipped by users due to image analysis issues while other studies left liquid-like foods out due to measurement concerns.^{40,41} The lipid contents of all fats/oils by USDA weight were significantly different from experimental weight estimates. Notably, the difference between USDA and experimental weight for one 2T serving of canola oil was 2.5g and 22cal from fat. Due to their high-fat and -calorie nature, small differences in weight estimations of fats/oils can have significant impacts on nutrient content results. It appears that the weight and nutrient contents of small portions, less than $\frac{1}{3}$ cup, of high-protein nuts, cheese, and peanut butter were significantly different when determined via USDA and experimental weight. Most cooked proteins demonstrated significant differences in weight, leading to differences in lipid, protein, and calorie estimates. Differences in weight estimations for 7% fat and 30% fat beef patties were significant, but nutrient content estimations for 30% fat beef patties exhibited differences, while 7% fat beef patties did not.

4.1 STRENGTHS AND LIMITATIONS

Foods were systematically selected based on commonality, and were measured and prepared by USDA methods, aligning with the sampling method used to add foods to the USDA SR.⁷ However, this study was restricted to unmixed foods and may not be representative of values for mixed foods. Multiple replicates were completed for various preparation methods, allowing for comparison. One possible limitation of this study is the lack of available replicate weights in the USDA database. The USDA database estimates of weight and nutrients are mean values based on varying numbers of replicates; data from individual replicates is not publicly available.²⁷ Thus, our estimates of mean differences between the experimental and USDA, which rely on a single mean value from USDA, may be anti-conservative.

4.2 CONCLUSION & FUTURE IMPLICATIONS

This study across multiple food groups concludes that weight and macronutrient values determined via volume and weight using the USDA SR 28 database or any private affiliate databases it composes may be estimated differently depending on the type of food or nutrient in question. These findings delineate key areas of potential measurement error when volumetrics or relative portions are used to determine nutrient content and are especially pertinent to nutrient-specific studies. Many researchers are reliant on the USDA SR databases and their affiliates to accurately determine the nutrient content of various foods regardless of the method by which food size is identified. Thus, this study is relevant to understanding the accuracy of all current and future dietary assessment tools utilizing volumetric or common portion measurements. If image-estimated food volumes prove to be more accurate and user-friendly for estimating food intake over self-report, these tools could further improve our ability to assess dietary intake.

TABLES AND FIGURES

Table 1. Characteristics Of Food Items Measured.

	Measured Volume	Preparation Method	As Purchased or Edible Portion	USDA Food Description	USDA #
Fruits					
Strawberries	½ cup	Halves	Edible Portion	Strawberries, raw	09316
Cantaloupe	½ cup	Cubed	Edible Portion	Melons, cantaloupe, raw	09181
Peaches	½ cup	Sliced	Drained of Liquids	Peaches, canned, heavy syrup, drained	09370
Oranges	½ cup	Sections with membranes, Sections without membranes	Edible Portion	Oranges, raw, all commercial varieties	09200
Raspberries	½ cup	Whole	As Purchased	Raspberries, raw	09302
Apples	½ cup	Quartered, Sliced, and Chopped	Edible Portion	Apples, raw, with skin	09003
Seedless Grapes	½ cup	Whole	Edible Portion	Grapes, red or green (European type, such as Thompson seedless), raw	09132
Bananas	½ cup	Sliced	Edible Portion	Bananas, raw	09040
Avocados	½ cup	Cubed	Edible Portion	Avocados, raw, all commercial varieties	09037
Raisins	¼ cup	Packed	As Purchased	Raisins, seedless	09298
Vegetables					
Iceberg Lettuce	½ cup	Chopped (½” pieces, loosely packed)	Edible Portion	Lettuce, iceberg (includes crisphead types), raw	11252
Tomatoes	½ cup	Chopped	Edible Portion	Tomatoes, red, ripe, raw, year round average	11529
Potatoes, French fries	½ cup & 10 fries	Oven-heated	As purchased, heated	Potatoes, French fried, crinkle or regular cut, salt added in processing, frozen, oven-heated	11360
Onions	½ cup	Sliced & Chopped	Edible Portion	Onions, raw	11282
Sweet Corn	½ cup	Drained of	As Prepared	Corn, sweet, yellow,	11176

		liquids		canned, vacuum pack, regular pack		
Grains						
Bread	1 slices, dimensions	Pre-Sliced	As Purchased	Bread, wheat	18064	
Pasta	1 cup not packed	Boiled	As Purchased	Pasta, cooked, enriched, without added salt	20121	
Rice	1 cup cooked	Boiled	As Purchased	Rice, white, long-grain, regular, enriched, cooked	20045	
Dairy						
Cheese	1/3 cup	Shredded	As Purchased	Cheese, cheddar	01009	
Ice Cream	1/2 cup	None	As Purchased	Ice creams, vanilla	19095	
Yogurt	1 cup	None	As Purchased	Yogurt, plain, skim milk, 13 grams protein per 8 ounce	01118	
Protein						
Beef , ground	7% fat	4" diameter patty	Pan-broiled	As Purchased	Beef, ground, 93% lean meat / 7% fat, patty, cooked, pan-broiled	23474
	30% fat	4" diameter patty	Pan-broiled	As Purchased	Beef, ground, 70% lean meat/ 30% fat, patty cooked, pan-broiled	13496
Chicken Breast, without skin	Raw	1 breast	Raw	As Purchased	Chicken, broiler or fryers, breast, skinless, boneless, meat only, raw	05062
	Roasted	1 breast	Roasted whole, Chopped	As Purchased	Chicken, broilers or fryers, breast, meat only, cooked, roasted	05064
Egg, large	Raw	1 L Egg	None	Edible Portion	Egg, whole, raw, fresh	01123
	Scrambled	1 L Egg	Scrambled	Edible Portion	Egg, whole, cooked, scrambled	01132
Bacon	Raw	3 slices	None	As Purchased	Pork, cured, bacon, unprepared	10123
	Pan-fried	3 slices	Pan-fried	As Purchased	Pork, cured, bacon, pre-sliced, cooked, pan-fried	10862
Cashews	1/8 cup	Raw, whole	As Purchased	Nuts, cashew nuts, raw	12087	
Almonds	1/8 cup	Raw, whole	As Purchased	Nuts, almonds	12061	
Pecans	1/8 cup	Raw, halves	As Purchased	Nuts, pecans	12142	

Peanut Butter		2T	None	As Purchased	Peanut butter, smooth style, with salt	16098
Fats and Oils						
Margarine		1T	None	As Purchased	Margarine, regular, hard, soybean (hydrogenated)	04073
Canola Oil		2T	None	As Purchased	Oil, canola	04582
Mayonnaise		2T	None	As Purchased	Salad dressing, mayonnaise, regular	04025
Dressing, Italian	Regular	2T	None	As Purchased	Salad dressing, Italian dressing, commercial, regular	04114
	Fat-free	2T	None	As Purchased	Salad dressing, Italian dressing, fat-free	04636
Salsa		2T	None	As Purchased	Sauce, salsa, ready-to-serve	06164
Ketchup		2T	None	As Purchased	Catsup	11935

Table 2. Mean weights of foods at set volume by weight obtained in-lab (Experimental Weight) and USDA weight obtained determined by volume from USDA SR 28 (n=46).

		Experimental Measurements		USDA Weight per Volume (g): mean ^a	Difference (USDA Weight – Experimental Weight) (g): mean±se
		Volume	Experimental Weight (g): mean±sd		
Fruits					
Strawberries, halved		½ cup	75.8 (5.5)	76	0.2 (1.8)
Cantaloupe, cubed		½ cup	85.7 (8)	80	-5.7 (2.5)*
Peaches, sliced		½ cup	110.6 (4.4)	111	0.4 (1.4)
Orange sections	Membrane	½ cup	98.9 (5.1)	90	-20.6 (1.4)***
	No Membrane	½ cup	98.9 (3.9)	90	-8.9 (1.2)***
Raspberries, whole		½ cup	61.8 (3.8)	61.5	-0.3 (1.2)
Apples	Quartered	½ cup	76.7 (5.1)	62.5	-14.2 (1.6)***
	Sliced	½ cup	87.3 (5.2)	54.5	-32.8 (1.6)***
	Chopped	½ cup	67.31 (2.5)	62.5	-4.8 (0.8)**
Grapes, seedless, whole		½ cup	91.8 (2.8)	75.5	-16.3 (0.9)***
Bananas, sliced		½ cup	76.7 (4.5)	75	-1.7 (1.4)
Avocados, cubed		½ cup	90.0 (7.3)	75	-15.0 (2.3)***
Raisins, packed		½ cup	44.2 (2.2)	41.25	-2.9 (0.7)**
Vegetables					
Iceberg Lettuce, chopped		½ cup	30.0 (2.9)	28.5	-1.5 (0.9)
Tomatoes, chopped		½ cup	107.1 (4.1)	90	-17.1 (1.3)***
Potatoes, French fries		10	47.9 (6.8)	69	21.2 (1.5)***
		½ cup	51.6 (3.6)	52	0.5 (0.8)
Onions, raw	Sliced	½ cup	116.9 (15.5)	57.5	-59.4 (4.9)***
	Chopped	½ cup	81.3 (3.9)	80	-1.3 (1.2)
Sweet Corn, canned, drained		½ cup	87.5 (5.7)	105	17.5 (1.8)***
Grains					
Bread, wheat, sliced		2 Slices	58.4 (2.7)	58	-0.4 (0.8)
Pasta, enriched, spaghetti		1 cup	119.0 (3.4)	124	5.0 (1.1)**
Rice, white, long grain, enriched		1 cup	182.7 (17.7)	158	-24.7 (5.6)**
Dairy					
Cheddar cheese, shredded		⅓ cup	23.1 (1.5)	37.6	14.6 (0.5)***
Ice Cream, vanilla		½ cup	95.3 (6.5)	66	-29.3 (1.5)***

Yogurt, skim		1 cup	260.8 (1.2)	245	-15.8 (0.4)***
Protein					
Beef, patty	7% fat	4" patty	84.2 (3.2)	81.6	-2.5 (1)*
	30% fat	4" patty	71.2 (3.4)	77	5.8 (1.1)***
Chicken Breast, without skin	Raw	1 breast	260.0 (49)	272	12.1 (11)
	Roasted	1 breast	206.2 (43.8)	172	-34.2 (9.8)**
	Chopped	1 cup	139.1 (3.9)	140	0.9 (0.9)
Egg, large	Raw	1 L egg	51.1 (3.9)	50	-1.1 (1.2)
	Scrambled	1 L egg	43.9 (2.5)	61	17.1 (0.8)***
Bacon, regular cut	Raw	3 slices	70.8 (6.6)	84	13.2 (2.1)***
	Pan-fried	3 slices	26.9 (5.3)	34.5	7.6 (1.7)**
Cashews, raw, whole		1/8 cup	24.3 (1.9)	16.1	-8.2 (0.6)***
Almonds, raw, whole		1/8 cup	24.8 (1.9)	17.9	-6.9 (0.6)***
Pecans, raw, halved		1/8 cup	20.2 (1.3)	12.4	-7.83 (0.4)***
Peanut Butter, smooth		2 T	29.7 (.9)	32	2.3 (0.3)***
Fats and Oils					
Margarine		1 T	14.3 (.2)	14.1	-0.2 (0.1)*
Canola Oil		2 T	25.5 (.3)	28	2.5 (0.1)***
Mayonnaise		2 T	29.0 (.4)	27.6	-1.4 (0.1)***
Dressing, Italian	Regular	2 T	30.6 (.9)	29.4	-1.2 (0.2)***
	Fat-free	2 T	30.0 (.5)	28	-2.0 (0.2)***
Salsa		2 T	32.9 (1.5)	36	3.2 (0.5)***
Ketchup		2 T	34.3 (0.3)	34	-0.3 (0.1)**

Table 3. Mean Macronutrient Values Obtained From USDA SR 28 Based on the Weight Obtained In-Lab (Exp Wt) And USDA Volume (USDA Vol) And Their Differences (Value by USDA Vol – Value by Exp Wt).

Macronutrient Value		Calories (kcal)			Protein (g)			Carbohydrate (g)		
		Exp Wt	USDA Vol	Diff: mean±se	Exp Wt	USDA Vol	Diff: mean±se	Exp Wt	USDA Vol	Diff: mean±se
Fruits										
Strawberries, halved		24.3	24	-0.3 (0.56)	0.51	0.51	0 (0.01)	5.82	5.84	0.02 (0.13)
Cantaloupe, cubed		29.3	27	-2.3 (0.9)*	0.72	0.67	-0.05 (0.02)*	7	6.53	-0.47 (0.21)*
Peaches, sliced		79.6	80	0.4 (0.99)	0.58	0.58	0 (0.01)	20.38	20.46	0.08 (0.26)
Orange sections	Membrane	46.4	42	-4.4 (0.76)***	0.93	0.85	-0.08 (0.02)***	11.62	10.58	-1.04 (0.19)***
	No Membrane	46.5	42	-4.5 (0.56)***	0.93	0.85	-0.08 (0.01)***	11.62	10.58	-1.04 (0.15)***
Raspberries, whole		32	32	0 (0.67)	0.74	0.74	0 (0.01)	7.38	7.34	-0.04 (0.14)
Apples	Quartered	39.9	32	-7.9 (0.81)***	0.2	0.16	-0.04 (0)***	10.59	8.63	-1.96 (0.22)***
	Sliced	45.4	28	-17.4 (0.87)***	0.3	0.14	-0.09 (0)***	12.06	7.53	-4.53 (0.23)***
	Chopped	35	32	-3 (0.37)***	0.17	0.16	-0.01 (0)***	9.3	8.63	-0.67 (0.11)***
Grapes, seedless, whole		63.3	69	5.7 (0.58)***	0.66	0.72	0.06 (0.01)***	16.62	18.1	1.48 (0.16)***
Bananas, sliced		68.3	67	-1.3 (1.26)	0.86	0.82	-0.02 (0.02)	17.52	17.13	-0.39 (0.32)
Avocados, cubed		144.1	120	-24.1 (3.73)***	1.8	1.5	-0.3 (0.05)***	7.68	6.4	-1.28 (0.2)***
Raisins, packed		132.1	123	-9.1 (2.09)**	1.36	1.27	-0.09 (0.02)**	34.96	32.66	-2.3 (0.56)**
Vegetables										
Iceberg Lettuce, chopped		4.1	4	-0.1 (0.1)	0.27	0.26	-0.01 (0.01)	0.89	0.85	-0.04 (0.03)
Tomatoes, chopped		19.3	16	-3.3 (0.26)***	0.94	0.79	-0.15 (0.01)***	4.17	3.5	-0.67 (0.05)***
Potatoes, French fries	10	79.4	115	35.6 (2.5)***	1.2	1.73	0.53 (0.04)***	13.16	18.98	5.82 (0.42)***
	½ cup	85.6	85	-0.55	1.29	1.23	-0.06	14.18	14.43	0.25 (0.22)

				(1.35)			(0.02)**			
Onions, raw	Sliced	46.7	23	-23.7 (1.94)***	1.29	0.63	-0.66 (0.05)***	10.92	5.37	-5.55 (0.46)***
	Chopped	32.4	32	-0.4 (0.52)	0.89	0.88	-0.01 (0.01)	7.59	7.47	-0.12 (0.12)
Sweet Corn, canned, drained		69.1	83	13.9 (1.39)***	2.11	2.53	0.42 (0.04)***	17.02	20.41	3.39 (0.35)***
Grains										
Bread, wheat, sliced		155.7	155	-0.7 (2.19)	6.26	6.22	-0.04 (0.09)	28.41	28.23	-0.18 (0.41)
Pasta, enriched, spaghetti		188.2	196	7.8 (1.7)*	6.90	7.19	0.29 (0.06)**	36.74	38.27	1.53 (0.33)**
Rice, white, long grain, enriched		245.5	205	-40.5 (2.24)***	5.08	4.25	-0.83 (0.05)***	53.21	44.51	-8.7 (0.48)***
Dairy										
Cheddar cheese, shredded		93.2	152	58.8 (1.9)***	5.28	8.61	3.34 (0.11)***	0.71	1.16	0.45 (0.01)***
Ice Cream, vanilla		197.3	137	-60.25 (3.02)***	3.34	2.31	-1.03 (0.05)***	22.50	15.58	-6.92 (0.35)***
Yogurt, skim		146.2	137	-9.2 (0.2)***	14.94	14.04	-0.9 (0.02)***	20.03	18.82	-1.21 (0.03)***
Protein										
Beef, patty ^a	7% fat	153.2	155	1.8 (1.83)	21.51	22.07	0.56 (0.26)	0.05	0	-0.05 (0)
	30% fat	169.5	183	13.5 (2.53)***	16.29	17.6	1.32 (0.24)***	0	0	0
Chicken Breast, without skin	Raw	311.9	326	14.1 (13.16)	58.49	61.2	2.71 (2.46)	0	0	0
	Roasted	340.3	284	-56.3 (16.14)**	63.96	53.35	-10.61 (3.03)**	0	0	0
	Chopped	229.7	231	1.3 (1.45)	43.15	43.43	0.28 (0.27)	0	0	0
Egg, large	Raw	73.1	72	-1.1 (1.75)	6.42	6.28	-0.14 (0.15)	0.37	0.36	-0.01 (0.01)
	Scrambled	65.2	91	25.8 (1.15)***	4.39	6.09	1.7 (0.08)***	0.71	0.98	0.27 (0.01)***
Bacon, regular cut	Raw	295	350	55 (8.7)***	8.93	10.6	1.67 (0.26)***	0.91	1.08	0.17 (0.03)***
	Pan-fried	125.8	161	35.2 (7.83)**	9.12	11.7	2.58 (0.56)**	0.46	0.59	0.13 (0.03)**
Cashews, raw, whole ^a		134.4	89	-45.4 (3.35)***	4.43	2.94	-1.49 (0.11)***	7.34	4.87	-2.47 (0.19)***
Almonds, raw, whole		143.5	103	-40.5 (3.39)***	5.24	3.78	-1.47 (0.12)***	5.35	3.85	-1.5 (0.13)***

Pecans, raw, halved	139.7	86	-53.7 (2.8)***	1.85	1.13	-0.72 (0.04)***	2.8	1.72	-1.08 (0.06)***	
Peanut Butter, smooth	177.7	191	13.3 (1.8)***	6.59	7.11	0.52 (0.07)***	6.62	7.14	0.52 (0.07)***	
Fats and Oils										
Margarine	103.1	101	-2.1 (0.5)**	0.13	0.13	0	0.13	0.13	0	
Canola Oil	225.9	248	22.1 (0.85)***	0	0	0	0	0	0	
Mayonnaise	197.4	188	-9.4 (0.79)***	0.28	0.26	-0.02 (0)***	0.17	0.16	-0.01 (0)*	
Dressing, Italian	Regular	73.4	71	-2.4 (0.5)***	0.13	0.12	-0.01 (0)***	3.71	3.56	-0.15 (0.02)***
	Fat-free	14	13	-1 (0)	0.29	0.27	-0.02 (0)***	2.62	2.45	-0.17 (0.02)***
Salsa	9.5	10	0.5 (0.17)*	0.5	0.55	0.05 (0.01)***	2.18	2.39	0.21 (0.03)***	
Ketchup	34.7	34	-0.7 (0.15)**	0.36	0.35	-0.01 (0)**	9.41	9.32	-0.09 (0.02)**	

Macronutrient Value	Fiber (g)			Total Lipid (g)			
	Exp Wt	USDA Vol	Diff: mean±se	Exp Wt	USDA Vol	Diff: mean±se	
Fruits							
Strawberries, halved	1.52	1.5	-0.02 (0.04)	0.23	0.23	0 (0.01)	
Cantaloupe, cubed	0.77	0.7	-0.07 (0.03)*	0.16	0.15	-0.01 (0)*	
Peaches, sliced	1.32	1.3	-0.02 (0.02)	0.2	0.2	0	
Orange sections	Membrane	2.38	2.2	-0.18 (0.04)**	0.12	0.11	-0.01 (0)**
	No Membrane	2.39	2.2	-0.19 (0.03)***	0.12	0.11	-0.01 (0)***
Raspberries, whole	4.02	4	-0.02 (0.08)	0.4	0.4	0	
Apples	Quartered	1.84	1.5	-0.34 (0.04)***	0.13	0.11	-0.02 (0)***
	Sliced	2.11	1.3	-0.81 (0.04)***	0.15	0.09	-0.06 (0)***
	Chopped	1.62	1.5	-0.12 (0.02)***	0.12	0.11	-0.01 (0)*
Grapes, seedless,	0.82	0.9	0.08	0.15	0.16	0.01	

whole			(0.01)***			(0)***	
Bananas, sliced	1.98	2	0.02 (0.04)		0.25	0.25	0
Avocados, cubed	6.03	5	-1.03 (0.16)***		13.19	0.11	-2.19 (0.34)***
Raisins, packed	1.65	1.5	-0.15 (0.03)***		0.21	0.19	-0.02 (0)**
Vegetables							
Iceberg Lettuce, chopped	0.35	0.3	-0.05 (0.02)*		0.04	0.04	0
Tomatoes, chopped	1.27	1.1	-0.17 (0.02)***		0.21	0.18	-0.03 (0)***
Potatoes, French fries	10	1.11	1.6	0.5 (0.03)***	2.46	3.54	1.08 (0.08)***
	½ cup	1.19	1.48	0.29 (0.02)***	2.65	2.71	0.07 (0.04)
Onions, raw	Sliced	1.99	1	-0.99 (0.08)***	0.12	0.06	-0.06 (0)***
	Chopped	1.39	1.4	0.01 (0.02)	0.08	0.08	0
Sweet Corn, canned, drained	1.76	2.1	0.34 (0.04)***		0.44	0.52	0.08 (0.01)***
Grains							
Bread, wheat, sliced	2.36	2.3	-0.06 (0.03)		1.89	1.88	-0.01 (0.03)
Pasta, enriched, spaghetti	2.14	2.2	0.06 (0.02)*		1.11	1.15	0.04 (0.01)**
Rice, white, long grain, enriched	0.76	0.6	-0.16 (0.02)***		0.53	0.44	-0.09 (0)***
Dairy							
Cheddar cheese, shredded	0	0	0		7.69	12.53	4.85 (0.16)***
Ice Cream, vanilla	0.67	0.5	-0.17 (0.01)***		10.49	7.26	-3.23 (0.16)***
Yogurt, skim	0	0	0		0.47	0.44	-0.03
Protein							
Beef, patty ^a	7% fat	0	0	0	6.74	6.75	0.01 (0.08)
	30% fat	0	0	0	11.07	11.97	0.9 (0.17)***
Chicken Breast,	Raw	0	0	0	6.81	7.13	0.32 (0.29)

without skin	Roasted	0	0	0	7.36	6.14	-1.22 (0.35)**
	Chopped	0	0	0	4.97	5	0.03 (0.03)
Egg, large	Raw	0	0	0	4.86	4.76	-0.1 (0.12)
	Scrambled	0	0	0	4.82	6.7	1.88 (0.09)***
Bacon, regular cut	Raw	0	0	0	28.09	33.34	5.26 (0.83)***
	Pan-fried	0	0	0	9.43	12.11	2.68 (0.58)**
Cashews, raw, whole ^a		0.81	0.53	-0.28 (0.02)***	10.66	7.07	-3.58 (0.27)***
Almonds, raw, whole		3.1	2.2	-0.9 (0.07)***	12.38	8.92	-3.46 (0.29)***
Pecans, raw, halved		1.93	1.2	-0.73 (0.04)***	14.55	8.91	-5.64 (0.3)***
Peanut Butter, smooth		1.48	1.6	0.12 (0.02)***	15.25	16.44	1.19 (0.15)***
Fats and Oils							
Margarine		0	0	0	11.53	11.35	-0.18 (0.06)*
Canola Oil		0	0	0	25.54	28	2.46 (0.1)***
Mayonnaise		0	0	0	21.71	20.66	-1.05 (0.08)***
Dressing, Italian	Regular	0	0	0	6.46	6.21	-0.25 (0.04)***
	Fat-free	0.2	0.2	0	0.26	0.24	-0.02 (0)***
Salsa		0.62	0.7	0.08 (0.01)***	0.06	0.06	0.003 (0)
Ketchup		0.1	0.1	0	0.03	0.03	0

APPENDIX A: Experimental Protocols

All measurements were taken using a Mettler-Toledo balance in the Human Nutrition Laboratory in the Fred Hutchinson Cancer Research Center. Before using the scale, the investigator checked the balance and made sure to re-balance the scale if necessary. If a measuring tool was used, the exact same tool was used for each trial. Each set of 10 trials was completed consecutively.

The investigator measured halved, fresh strawberries. The investigator noted the blue, Rubbermaid $\frac{1}{2}$ cup measuring tool in the spreadsheet and weighed the $\frac{1}{2}$ cup measuring tool before each trial to record its weight in grams in the “Tare Weight (Container Weight)” column. The investigator first washed and dried the whole strawberries. Then, strawberries were sliced in half by first slicing off the stem and leaves, then standing the strawberry up on the flat sliced portion and slicing the strawberry down center, vertically. Halves were added to the $\frac{1}{2}$ cup until it was full. The weight of the measuring cup and the strawberries will be entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.” The measuring cup was wiped out with a damp paper towel between trials. This procedure for measuring a $\frac{1}{2}$ cup of halved strawberries was repeated 10 times.

Fresh cantaloupe was measured by the $\frac{1}{2}$ cup of cubed pieces. The investigator noted the $\frac{1}{2}$ cup measuring tool in the spreadsheet. A $\frac{1}{2}$ cup stainless steel Vollrath cup was used its weight in grams was recorded before each trial in the “Tare Weight (Container Weight)” column. To cut the cantaloupe, the investigator first the cantaloupe in half from stem to blossom end and

removed the seeds with a large spoon. Then, the investigator quartered the cantaloupe by slicing each half down the center from the stem to the blossom end. The rind was removed from the quarters and the cantaloupe was cut into 2cm cubes, as equally as possible. Parchment paper with 2cm markings was used as a guide. The cantaloupe cubes were deposited in the measuring cup and the weight of the measuring cup and the cantaloupe was entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.” The measuring cup was wiped out with a damp paper towel between trials. This procedure for measuring cubed cantaloupe was repeated 10 times.

Canned, sliced peaches, packed in heavy syrup, were measured by the $\frac{1}{2}$ cup. The peaches measured were Kroger brand yellow cling peaches sliced and packed in heavy syrup. The investigator noted the $\frac{1}{2}$ cup, blue, Rubbermaid measuring tool in the spreadsheet and weighed the $\frac{1}{2}$ cup measuring tool and recorded its weight in grams in the “Tare Weight (Container Weight)” column. The peaches were separated from the liquid using a slotted spoon and the drained peaches were then added to the cup until full. Once full, the weight of the measuring cup and the peaches were entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.” The $\frac{1}{2}$ cup measuring cup was wiped out with a damp paper towel between trials. This procedure for measuring a $\frac{1}{2}$ cup of sliced, drained, canned peaches was repeated 10 times.

Fresh, medium (defined by NDS-R as being 2 5/8" in diameter) oranges were measured by the ½ cup of orange sections. Two measurements were taken, one of the orange sections with the membrane on, and one of the sections with the membrane removed. A ½ cup, stainless steel Vollrath measuring cup was used. The weight of the measuring cup was taken and entered in the "Tare Weight" column before each trial. The peel and all portions besides the membrane were removed off the oranges, then the sections separated out. The sections were added to the measuring cup until full. After 10 trials of the orange sections with membranes on, the membranes were removed by hand and using a knife and 10 trails were conducted to measure the orange sections with the membranes removed. The weight of the measuring cup and the sections as be entered in the "Cooked Weight or Measured Weight for Uncooked Foods" column and the "Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight) " updated automatically with a function to subtract "Tare Weight" from "Cooked Weight or Measured Weight for Uncooked Foods." The measuring cup was wiped out with a damp paper towel between trials. This procedure for measuring orange sections was repeated 10 times for membranes on and 10 times with membranes removed

Whole, fresh raspberries were measured using a blue, Rubbermaid ½ cup measuring cup. The investigator noted the measuring tool in the spreadsheet and weighed the ½ cup measuring tool and record its weight in grams in the "Tare Weight (Container Weight)" column before each trial. Whole raspberries were washed and dried, then added to the measuring cup and the weight of the measuring cup and the raspberries was entered in the "Cooked Weight or Measured Weight for Uncooked Foods" column and the "Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight) " updated automatically with a function to subtract "Tare Weight" from "Cooked Weight or Measured

Weight for Uncooked Foods.” The measuring cup was wiped out with a damp paper towel between trials. This procedure for measuring a ½ cup of raspberries was repeated 10 times.

Fresh, raw apples with the skin on were quartered and weighed in a ½ cup, then sliced and weighed in a ½ cup, then chopped and weighed in a ½ cup. The investigator noted the blue, Rubbermaid ½ cup measuring tool in the spreadsheet and weighed the ½ cup measuring tool before each trial. Its weight in grams was recorded in the “Tare Weight (Container Weight)” column. All apples were washed and dried whole after the stem was removed. Apples were then sliced in half down the center from stem to base. The halves were quartered and the seed area cut out. Quarters were added to the measuring cup until full and the weight was entered into the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.” 10 trials were conducted to measure apple quarters. Once completed, the quarters were further sliced into 1 cm slices from stem to base, where a 1cm measurement was made perpendicularly from the halfway point of the apple between stem and base. The apple was sliced parallel to the previous slice at the center mark to meet the previous cut at the stem and base. The investigator used a piece of parchment paper with 1cm markings as a guide. Once full, the weight of the measuring cup and the apple slices was entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.” Once completed, the slices were further chopped into .25cm pieces. The investigator used a piece of parchment paper

with .25cm markings as a guide. However, since ‘chopped’ is defined by the LanguaL Thesaurus as <.3cm, the investigator was able to chop smaller sections if need be, for example at the fleshy end of slice where the slice cuts meet.²⁶ The measuring cup was filled by scooping the chopped pieces out of a plastic food container. Once full of loosely packed chopped apple pieces, the weight of the measuring cup and the chopped apple pieces was entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight) ” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.” The measuring cup was wiped out with a damp paper towel between each trial. This procedure for measuring apple quarters was repeated 10 times, the procedure for measuring apple slices was repeated 10 times, and the procedure for measuring chopped apple was repeated 10 times.

Whole, seedless grapes were washed and dried, then measured in a blue, Rubbermaid $\frac{1}{2}$ cup measuring cup. The measurement unit was recorded as $\frac{1}{2}$ cup and its weight recorded in grams in the “Tare Weight (Container Weight)” column before each trial. Whole grapes were added to the $\frac{1}{2}$ cup until it was full. The weight of the grapes and the measuring cup were entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight) ” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.” The measuring cup was wiped out with a damp paper towel between trials. This procedure for measuring $\frac{1}{2}$ cup of whole, seedless grapes was repeated 10 times.

Fresh, medium (defined by NDS-R as being 7" to 7 7/8" in length) bananas with the peel removed were sliced and weighed to the gram. The measurement unit, a blue Rubbermaid ½ cup measuring cup, was recorded in the spreadsheet as a ½ cup. Before any weights were taken, 1cm markings were made on a piece of parchment paper, which was then flipped over and placed on the cutting board. The investigator then weighed the ½ cup measuring tool and recorded its weight in grams in the "Tare Weight (Container Weight)" column before each trial. Each banana was peeled and placed on the cutting board. 1 cm slices were made along the length of the banana using the markings on the parchment paper as a guide. The banana pieces were then added to the measuring cup. The weight of the banana slices and the measuring cup were entered in the "Cooked Weight or Measured Weight for Uncooked Foods" column and the "Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)" updated automatically with a function to subtract "Tare Weight" from "Cooked Weight or Measured Weight for Uncooked Foods." The measuring cup was wiped out with a damp paper towel between trials. This procedure for measuring banana slices was repeated 10 times.

Fresh avocados were peeled, pitted, cubed, and measured by the ½ cup. The measurement unit, a stainless steel Vollrath cup, was recorded as ½ cup. The investigator weighed the ½ cup measuring tool between trials and recorded its weight in grams in the "Tare Weight (Container Weight)" column. Avocados were first sliced in half, and the pit removed. Once the pit was removed, the halves were sliced in parallel slices, 2cm apart, long-ways from the stem attachment to the base. Then, perpendicular 2cm slices were made to cube the avocado. All measurements were be guided by parchment paper with 2cm markings. The avocado cubes were carefully removed from the avocado with a spoon and added to the measuring cup. The weight of

the avocados and the measuring cup was entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight) ” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.” The measuring cup was wiped out with a damp paper towel between trials. This procedure for measuring $\frac{1}{2}$ cup of avocado cubes was repeated 10 times.

One $\frac{1}{4}$ cup portion of seedless raisins were measured whole and lightly packed into the measuring cup. The investigator noted the $\frac{1}{4}$ cup, blue, Rubbermaid measuring tool in the spreadsheet and the weight of the measuring tool was recorded in grams in the “Tare Weight (Container Weight)” column before each trial. This procedure for measuring $\frac{1}{4}$ cup portions, chosen for dried fruit because dried fruit portions determined by MyPlate are half the size of fresh fruit portions, was repeated 10 times and raisins were deposited back into a plastic storage container following each repetition.²⁸ The weight of the measuring cup and the raisins was entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight) ” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.” Before the next repetition, the contents of the container were thoroughly mixed by shaking the container and mixing with a spoon. The measuring tool was wiped out with a damp cloth between trials.

One $\frac{1}{2}$ cup portion of fresh iceberg lettuce was measured chopped. The USDA measurement and preparation is noted as “chopped ($\frac{1}{2}$ ” pieces, loosely packed).”²⁷ Thus, for this measurement alone, $\frac{1}{2}$ ” pieces are considered chopped. The investigator noted the measuring tool in the spreadsheet; a white Rubbermaid $\frac{1}{2}$ cup measuring cup was used for every trial. The

investigator weighed the $\frac{1}{2}$ cup measuring tool before each trial and recorded that weight in grams in the “Tare Weight (Container Weight)” column. The leaves were then removed from the head of lettuce and washed and dried individually. No more than 4 leaves at a time were laid flat on the cutting board and cut in parallel lines $\frac{1}{2}$ ” apart, using markings on parchment paper as a guide. Then, the parchment paper guide was moved to run parallel to the cut ends and the lettuce strips were again cut at $\frac{1}{2}$ ” intervals. The chopped lettuce was then added to the measuring cup and loosely packed. The weight of the $\frac{1}{2}$ cup of lettuce was entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight) ” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.” The measuring cup was wiped out with a dry towel between trials. This procedure for measuring one $\frac{1}{2}$ cup of chopped iceberg lettuce was repeated 10 times.

Red, ripe tomatoes were measured by the $\frac{1}{2}$ cup of chopped pieces. The investigator noted the $\frac{1}{2}$ cup, blue, Rubbermaid measuring tool in the spreadsheet and weighed the $\frac{1}{2}$ cup measuring tool to record its weight in grams in the “Tare Weight (Container Weight)” column before each trial. The stickers were removed from the tomatoes and they were rinsed and dried, then the investigator chopped each tomato by first slicing it in half from root to base. Placing the tomato on its flat side, the investigator cut .25 cm slices cut perpendicularly to the line running from stem to base. The slices were then laid flat, and sliced from cut edge to the end at .25cm. The long pieces were laid next to each other and sliced, again, .25 cm apart to form .25cm chopped pieces. All cuts were made using markings on parchment paper as a guide. The tomato pieces were added to the measuring cup until full. The weight of the measuring cup and the

tomatoes was entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight) ” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.” The measuring cup was wiped out with a paper towel between each trial. The procedure for measuring a ½ cup of chopped tomatoes was repeated 10 times.

Potatoes were measured as French fries, the most commonly eaten form of potato. Kroger brand, regular French fries with added oil and salt were purchased frozen and oven-heated before measurement. The French fries were re-heated in the oven, per the packaging instructions. The oven was heated to 450° and frozen fries were arranged in a single layer in a shallow baking pan. They were timed and remained in the oven for 17 minutes and 30 seconds, as the packaging instructions indicated to cook for 15-20 minutes. The potatoes were left to cool for 10 minutes before they were measured. First, fries were weighed per 10 fries. The measuring unit was recorded as 10 fries. The fries were placed on a plate; the weight of the empty plate was first recorded in the “Tare Weight (Container Weight)” column. The weight of the plate and fries were recorded in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight) ” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.” The plate was wiped off with a damp paper towel between trials. The fries were then placed back on the tray and carefully mixed by hand once 10 trials of measuring 10 French fries was complete. Then, the fries were measured by the ½ cup portion. The investigator noted the ½ cup, blue Rubbermaid measuring tool in the spreadsheet. Before each trial, the investigator weighed the ½ cup

measuring tool and recorded its weight in grams in the “Tare Weight (Container Weight)” column. The fries were added to the measuring cup; fries of all sizes were added, which includes fry pieces. The weight of the measuring cup and the fries was entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.” The measuring cup was wiped out with a damp paper towel between trials. This procedure for measuring 10 French fries and $\frac{1}{2}$ cup of French fries was repeated 10 times each.

Raw onions were measured by the $\frac{1}{2}$ cup. They were sliced first, then chopped. The measurement tool was recorded as a $\frac{1}{2}$ cup, white, Rubbermaid measuring cup and its weight was recorded in grams in the “Tare Weight (Container Weight)” column before each trial. The root and tip of the each onion was sliced off, then the onion was peeled. The onion was then stood up on a cut end and sliced down the middle. The onion half was then laid on the cutting board and slices were made 1cm apart away from the root end toward the tip end using 1cm markings on parchment paper as a guide. The sliced pieces were then added to the $\frac{1}{2}$ cup measuring cup until full. The weight of the measuring cup and the onion slices were entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods. This process was repeated 10 times. The sliced onion pieces were then further chopped to $<.3$ cm, using parchment paper with .25cm markings as a guide. The chopped onion was then added to the $\frac{1}{2}$ cup measuring cup. The weight

of the measuring cup and the onion was entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight) ” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods. The measuring cup was wiped out with a paper towel between each trial. This procedure for measuring ½ cup of raw, sliced onion will be repeated 10 times and the procedure for measuring ½ cup of raw, chopped onion was repeated 10 times.

Canned, drained yellow sweet corn was measured by ½ cup portions. The investigator noted the ½ cup, white, Via brand measuring tool in the spreadsheet and weighed the ½ cup measuring tool and recorded its weight in grams in the “Tare Weight (Container Weight)” column before each trial. The drained corn was added to measuring cup. The weight of the measuring cup and the corn was entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight) ” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.” The measuring cup was wiped out with a damp paper towel between trials. Santian Golden Sweet Whole Kernel Corn was purchased and 3 cans were drained and used to carefully fill the measuring cup. Corn was measured, re-added to the bowl and mixed, then the next trial was completed. The procedure for measuring ½ cup of canned yellow sweet corn was repeated 10 times.

Two enriched, wheat, Shh... brand wheat bread slices were measured. The measurement unit was recorded as 2 slices. As the slices were taken from a loaf, the pre-sliced pieces were measured. Tare Weight (Container Weight) was entered as the weight of the plate the slices were

placed on, and the weight of the bread and plate was entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.” The slices were then measured for dimensions. Height was measured as the shorter distance between the end that sits on the table to the top of the loaf following a line perpendicular to the table in the center of the loaf. The length was the longer distance measured along a line from the center point of the line perpendicular to the table. The width was then measured as the short, crust end of the 2 slices stacked on top of each other. These dimensional measurements were recorded in the spreadsheet under “Dimensions...” for each 2 slices used. The plate the slices were placed on was wiped off with a damp paper towel between trials. This procedure for measuring two wheat bread slices was repeated 10 times.

1 cup of spaghetti pasta was measured after cooking. The spaghetti purchased was Psst... brand enriched Spaghetti made with durum wheat. The spaghetti was cooked per the packaging directions. 2 packages, each 1lb, were cooked by bringing 8 quarts of water to a rapid boil and adding the packages to water and returning to a boil. The pasta was then cooked, uncovered for 10 minutes, as the packaging instructions stated 9-11 minutes. The pasta was stirred occasionally throughout the 10 minutes and drained in a strainer immediately when the timer went off. The pasta was then drained and cooled for about 10 minutes in a plastic container on a cooling rack in the refrigerator. Once ready to be measured, the investigator noted the EKCO plastic 1 cup measuring tool in the spreadsheet and recorded its weight in grams in the “Tare Weight (Container Weight)” column. Spaghetti was then carefully added to the measuring cup until full. The weight of the measuring cup and the pasta was entered in the “Cooked Weight or Measured

Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight) ” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.” The measuring cup was wiped out with a damp paper towel between trials. The procedure for measuring 1 cup of cooked pasta was repeated 10 times.

1 cup of long-grain, enriched white rice was cooked using the directions on the package purchased was measured. 5 cups of Kroger brand rice were placed in a cooking pot with 10 cups of water and the water was brought to a boil. Once boiling, the heat was turned to low and the pot was covered. The rice was simmered for 15 minutes. After cooking, the rice was placed on a large sheet tray and spread out using a spatula. The tray was placed in the cooler and rice was cooled for about 15 minutes. The investigator noted the 1 cup, Via brand, rounded measuring tool in the spreadsheet and recorded its weight in grams in the “Tare Weight (Container Weight)” column. Once removed from the refrigerator and mixed to break up the cooled rice, rice was then carefully added to the measuring cup and lightly packed into the cup until it was full. The rice was leveled with a knife and packed using a spatula. The weight of the measuring cup and the rice was entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight) ” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.” The measuring cup was wiped out with a damp cloth towel between each trial. This procedure for measuring 1 cup of rice was repeated 10 times.

1/3 cup of shredded, medium cheddar cheese was measured. The investigator noted the measuring tool in the spreadsheet and weighed the 1/3 cup, blue, Rubbermaid measuring tool,

recording its weight in grams in the “Tare Weight (Container Weight)” column before each trial. The investigator began by shredding cheddar off of the block using a stand-up cheese grater. The smaller of the 2 grate sizes was used. Cheese was added to the measuring cup and lightly packed until full. The weight of the measuring cup and the cheese was entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight) ” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.” The measuring cup was wiped out with a damp paper towel between trials. This procedure for measuring 1/3 cup of shredded cheddar cheese was repeated 10 times.

A ½ cup and then 1.5 cups of Kroger brand plain vanilla ice cream were measured by way of measuring ½ cup of ice cream first, then adding 1 cup of ice cream to the same bowl and recording that weight. The investigator first noted the measuring units in the spreadsheet. The investigator recorded the bowl’s weight in grams in the “Tare Weight (Container Weight)” column. The investigator began by scooping ice cream into a ½ cup, stainless steel, Vollrath measuring cup, packing it into the measuring cup and smoothing it off with the back of a knife. Once full, the measuring cup was emptied using a spatula into the bowl. The weight of the first ½ cup of ice cream and the bowl will be recorded under “Ice Cream 1/2c 1,” etc. The cup will then be filled with another cup of ice cream until the bowl contains 1.5 cups of ice cream. The weight of the bowl and the ice cream was entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight) ” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for

Uncooked Foods.” The original weight of the bowl will be the tare weight for the 1.5 cup measurement as well. Before each trial, a new bowl was used as a receptacle for the ice cream. This procedure for measuring ½ and 1.5 cups of vanilla ice cream will be repeated 10 times.

Plain, skim, Fred Meyer brand yogurt was measured by the 1 cup portion. The weight of the silver, Vollrath 1 cup measuring tool was recorded in grams before each trial in the “Tare Weight (Container Weight)” column. Before yogurt was taken from a container, the yogurt in the original container was mixed with a spoon. The investigator then began by scooping yogurt from the container into the measuring cup and using the back of a knife to remove excess yogurt from over the edge of the cup. The weight of the measuring cup and the yogurt was entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.” The measuring cup was rinsed and dried between trials. This procedure for measuring 1 cup of nonfat, plain yogurt was repeated 10 times.

Medium sized beef burger patties were formed to 4” diameter using 114g (¼ pound) of raw meat. Extra lean 7% fat meat beef patties and 30% fat beef patties were both measured using the same protocols. First, 114g of raw meat was weighed to the gram directly on the scale. Thus, the values in the “Tare Weight (Container Weight)” were entered as 0. The measuring unit was noted as “medium patty” and the weight of the raw meat was entered into the “Dry or Raw Weight (if cooked)” column. Then, using a 4” diameter circle stenciled on parchment paper (the circle was drawn on the back side of the parchment paper), 4” diameter, evenly rounded and flattened patties were formed and placed on pre-weighed and labeled plates on top of a piece of parchment paper. The dimensions of the raw patties were taken in centimeters, with length and

height at ,10.16 cm or 4 in and the width was measured from bottom of the patty on the tabletop to the top of the patty, from the center. All cooking protocols were obtained from the HNL. No more than 2 patties were broiled at the same time and the patties were tracked in order to match Raw Beef 93/7 1 to Cooked Beef 93/7 1, etc. First, the small frying pans used were heated for 30 seconds over medium heat before patties were added. Timers were used to keep track of cooking and rest times. All patties were cooked for 3.5 minutes on each side. At the end of the 7 minutes, the internal temperature were measured and the patties were kept in the pan until the temperature reached at least 160°F, the UDSA minimum internal temperature recommendation.⁴² At 7 minute mark, all patties were only around 120°F or 140°F. Thus, all patties were kept on between 9-12 minutes until internal temperatures reached 160°F. Once the patties were thoroughly cooked, the patties were placed on the aforementioned pre-weighed and labeled plates and drippings were collected in pre-weighed and labeled bowls. Between each trial, the small frying pans used to pan broil the burgers were wiped out with dry cloth towels. Patties were left to cool for 10 minutes before they were weighed and measured for dimensions. Cooked patties were weighed to the gram on a plate and the weight of the plate was previously recorded in the “Tare Weight (Container Weight)” column. The weight of the plate and cooked meat was entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.” 93/7 patties were cooked first and 70/30 were cooked second. The investigator conducted 10 trials for 93/7 raw beef, 10 trials for 70/30 raw beef, 10 trials for 93/7 cooked beef, and 10 trials for 70/30 cooked beef.

Deboned, skinless chicken breasts were weighed raw then roasted in the oven. The measurement unit was recorded as 1 breast in the “Measurement Unit” column in the spreadsheet. The breasts were weighed on a plate, with the plate’s tare weight being recorded in the “Tare Weight (Container Weight)” column. The weight of the raw chicken breast and plate were entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.” The plate was wiped off with a paper towel between trials and the raw breasts were placed in shallow baking pans on parchment paper labeled with their number so as to match Chicken, Raw 1 to Chicken, Cooked 1. The breasts were also measured for volumetrics by dimension, in cm, after being placed on the parchment paper. The breasts were measured long-ways from end to end for height. The length was recorded as the shorter distance in the center of the breast from end to end at the center. The width was the distance from the table up to the top of the breast taken at the center. After being weighed and measured raw, and matched with their number and placed in the baking pan, all breasts, split between 2 baking pans to ensure no breasts were touching, were put into the pre-heated oven at the same time and roasted at 325° for 20 minutes, at which the until the internal temperature of the largest breast reached 165°F, the USDA minimum internal temperature recommendation for poultry.⁴² Before they were weighed for cooked weight, the chicken breasts rested for 10 minutes on a cooling rack. The weights were recorded on a plate that was weighed before each trial and wiped off between trials with a paper towel. The dimensions of the breasts were measured in the same fashion as they were when measured raw. After individual breasts were measured, the chicken was chopped to .25cm pieces using parchment paper markings as a

guide and measured by the 1 cup. Pieces from breast 1 were added to the cup until full. The cup was wiped out with a damp paper towel between trials. Each cup corresponded to the breast that was added to it. Through the original, non-QC chicken trials, 1 cup of chicken was not measured. In the QC round of chicken measurements, chicken was measured as raw breasts, cooked breasts, and 1 cup chopped chicken. The average weight of the cup of chopped chicken from the QC trials was then applied to the original trials. Timers were used to track all times. The procedure for measuring chicken breasts raw, roasted, and chopped was carried out for 10 chicken breasts.

Large eggs were purchased and measured raw, then scrambled. Fred Meyer brand, large, AA eggs were purchased. The protocol used was based on the scrambled egg protocol, without additions, taught by Chef Scott Swartz from the Culinary Institute of America.⁴³ However, three test trials to determine the correct consistency of a scrambled egg pre-cooking as well as to determine a proper time to heat the pan and cook the singular eggs to the proper doneness as described by Chef Scott Swartz. Each trial was conducted by a different person and their results in scrambling and cooking the egg were compared. The measurement unit for both raw and scrambled was recorded as 1 L egg. The raw eggs were measured by cracking an egg into a bowl on the scale. The gram weight of the bowl alone, before cracking the egg into the bowl, was recorded in the “Tare Weight (Container Weight)” column. The weight of the raw egg and bowl was entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods”. Each bowl was labeled 1 through 10 in order to keep track of the raw eggs and make sure that when the egg was cooked, “Egg, Raw 1” was the same egg as “Egg, Scramble 1.” After conducting test trials and

comparing it to Chef Swartz's standards, the protocol used was to pour the egg into a previously-weighed bowl and whip with a fork until the yellow and white of the egg are evenly mixed, about 15 seconds. During that same time, the non-stick pan was heated on medium heat for about 15 seconds. Then, the egg was added to the pan and was stirred on a continual basis until the egg was in little pieces that look shiny and moist, about 45 to 50 seconds. The scrambled eggs were placed on previously-weighed and labeled plates that had been weighed to the gram and the weights recorded in the "Tare Weight (Container Weight)" column. Between each trial, the egg was removed the pan and placed on the plate using a spatula. Then the pan was wiped out with a dry towel to remove any residue. The weight of each cooked egg and plate was entered in the "Cooked Weight or Measured Weight for Uncooked Foods" column and the "Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)" updated automatically with a function to subtract "Tare Weight" from "Cooked Weight or Measured Weight for Uncooked Foods." This procedure for measuring 1 egg raw then scrambled was repeated 10 times for L eggs.

Bacon strips were pan-fried and measured in 3-strip servings. Bacon used was Fred Meyer brand, traditional cut, hardwood smoked and sugar cured. Before cooking, the 3 strips were weighed raw. In order to maintain consistency when recording "Bacon, Raw 1" then "Bacon, Cooked 1," the investigator labeled the bowls from 1 to 10, weighed them and entered the weight into the "Tare Weight (Container Weight)" column. The raw bacon strips were then added to the bowls and weights of the bacon and bowl were recorded in the "Dry or Raw Weight (if cooked)" column and the "Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)" updated automatically with a function to subtract "Tare Weight" from "Dry or Raw Weight (if cooked)." The measurement

unit was noted as 3 strips for raw and cooked bacon. The strips were pan-fried based on the cooking instructions on the package and Culinary Institutes of America standards. Since the package instructions were too cook at medium to desired crispness, the investigator followed more descriptive instructions per the Culinary Institute of America Chef Shaun Edwards.⁴⁴ Each trial to cook the bacon was executed individually, with only 3 strips in one pan. The pan was heated to medium heat, the bacon strips were added to the pan and a timer was set to 6:30. Halfway, at 3:15, the strips were flipped over with a tongs. At 6:30, the strips were removed from the pan, shaken for about 5 seconds to have drippings fall into the pan, and the strips were placed on previously-weighed plates whose weights were recorded in the “Tare Weight (Container Weight)” column. Then, the drippings from the pan were poured into a previously-weighed and labeled bowl whose weight was recorded in the “Tare Weight (Container Weight)” column. The bacon grease and residue will be scraped into the bowl using a spatula in order to pour as much of the grease as possible into the bowl. Then, the weight of the plate with the cooked bacon and the bowl with the drippings will be weighed and entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.” The pan was wiped clean with dry paper towels between trials. The plates and bowls were never re-used. They were labeled and kept organized to track the trials. The investigator conducted 10 trials for all steps: raw weight, cooked weight, and dripping weight.

One $\frac{1}{8}$ cup portion of cashews was measured. The investigator measured using a 1T stainless steel measuring spoon. Two scoops of whole, raw cashews, purchased in bulk, were

added to a rubber, Le Creuset, blue bowl. The investigator noted the 2T measuring unit in the spreadsheet and recorded the bowl's weight in grams in the "Tare Weight (Container Weight)" column before each trial. The weight of the bowl and the cashews was entered in the "Cooked Weight or Measured Weight for Uncooked Foods" column and the "Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)" updated automatically with a function to subtract "Tare Weight" from "Cooked Weight or Measured Weight for Uncooked Foods." This procedure for measuring $\frac{1}{8}$ cup of cashews was repeated 10 times and cashews were deposited back into the original container following each repetition. Before the next repetition, the bowl was wiped out with a damp paper towel and the contents of the container were thoroughly mixed.

One $\frac{1}{8}$ cup portion of almonds was measured. The investigator measured using a 1T stainless steel measuring spoon. Two scoops of Whole Natural Blue Diamond Almonds were added to a rubber, Le Creuset, blue bowl. The investigator noted the 2T measuring unit in the spreadsheet and recorded the bowl's weight in grams in the "Tare Weight (Container Weight)" column before each trial. The weight of the measuring cup and the almonds was entered in the "Cooked Weight or Measured Weight for Uncooked Foods" column and the "Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)" updated automatically with a function to subtract "Tare Weight" from "Cooked Weight or Measured Weight for Uncooked Foods." This procedure for measuring $\frac{1}{8}$ cup of almonds was repeated 10 times and almonds were deposited back into the original container following each repetition. Before the next repetition, the bowl was wiped out with a damp paper towel and the contents of the container were thoroughly mixed.

One $\frac{1}{8}$ cup portion of shelled, halved pecans were measured. The investigator measured using a 1T stainless steel measuring spoon. Two scoops of Diamond of California Shelled Pecans were added to a plastic, Gessner ramekin. The investigator noted the 2T measuring unit in the spreadsheet and recorded the ramekin's weight in grams in the "Tare Weight (Container Weight)" column before each trial. The weight of the ramekin and the pecans was entered in the "Cooked Weight or Measured Weight for Uncooked Foods" column and the "Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)" updated automatically with a function to subtract "Tare Weight" from "Cooked Weight or Measured Weight for Uncooked Foods." This procedure for measuring $\frac{1}{8}$ cup of pecans was repeated 10 times and the pecans were deposited back into a plastic container following each trial. Before the next repetition, the ramekin was wiped out with a damp paper towel and the contents of the container were thoroughly mixed by shaking.

One 2T portion of Fred Meyer brand natural creamy peanut butter from fresh roasted peanuts (with salt added) was measured using a 1T measuring spoon. The measurement unit was recorded as "2T" and the investigator recorded the weight of the plate the peanut butter was scooped onto in the "Tare Weight (Container Weight)" column before each trial. Peanut butter was scooped into a 1T measuring spoon and the flat backside of a knife was used to evenly remove the peanut butter overflowing from the measuring spoon. Then, the peanut butter was dumped onto a plate on the scale and a spatula was used to remove the peanut butter thoroughly from the measuring spoon. This process was repeated twice per trial. The weight of the plate and peanut butter was entered in the "Cooked Weight or Measured Weight for Uncooked Foods" column and the "Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)" updated automatically with a function to

subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods. The measuring spoon was wiped out between trials and a clean plate was used for each trial. This procedure for measuring 2T of peanut butter was repeated 10 times.

Investigator measured 1 tablespoon of margarine. The investigator noted the Rubbermaid, plastic 1 tablespoon measuring tool in the spreadsheet as “1T) and weighed the 1T measuring tool before each trial then recorded its weight in grams in the “Tare Weight (Container Weight)” column. Margarine was removed from the refrigerator by the half-stick (8-tablespoon stick). The investigator scooped margarine onto the spoon and pressed it into the spoon to prevent any air from getting in, then used the back of a knife to remove excess margarine. The measuring tool and margarine were then placed on the scale and the weight of the tool and margarine was recorded in the “Cooked Weight or Measured Weight for Uncooked Foods” column. The spreadsheet updated automatically to determine “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight) ” with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.” The margarine from each trial was discarded, the measuring tool was rinsed and dried, and the next trail was conducted using fresh, previously unmeasured margarine. This procedure for measuring 1T of margarine was repeated 10 times.

Investigator measured 2 tablespoons of Kroger brand canola oil. The measurement was recorded as “measuring cup.” The tool used was a small, glass measuring tool with a 2T marking. For each trial, the investigator recorded the clean measuring cup’s weight in grams in the “Tare Weight (Container Weight)” column. Canola oil was then poured into the measuring cup until the level of the oil reached the 2T marking. The weight of the measuring cup and canola oil was entered in the “Cooked Weight or Measured Weight for Uncooked Foods”

column. The canola oil in the glass was then discarded and the measuring glass was rinsed and dried between each trial. The spreadsheet updated automatically to determine “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)” with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods.”. This procedure for measuring 2T canola oil was repeated 10 times.

Fred Meyer brand Real Mayonnaise was measured in 2T portions. The measurement was conducted using a 1T, stainless steel Vollrath measuring tool and two scoops were deposited in a small, blue, rubber, Le Creuset bowl. The measurement unit was recorded as “2T” and the weight of the bowl was recorded in the “Tare Weight (Container Weight)” column. For each scoop made, the mayo was leveled off using the back of a knife. The mayo in the measuring spoon was placed in the bowl, using a spatula to move as much of the mayo as possible to the bowl. The weight of the bowl and 2T of mayo was entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods. The measuring spoon and bowl were thoroughly wiped out with a dry cloth towel between trials. This procedure for measuring 2T of mayonnaise will be repeated 10 times.

Fred Meyer brand, Zesty Italian, regular liquid salad dressing was measured first, and the fat-free version of the same dressing was measured second. They were measured using the exact same protocol below. The dressings were measured in 2T portions using a glass ramekin with 2T markings on the side. The measurement unit was recorded as “2T” and the weight of the ramekin

was recorded in the “Tare Weight (Container Weight)” column. Once the investigator filled the ramekin, the weight of the ramekin and 2T of dressing was entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods. Between each trial, the cap to the dressing bottle was replaced and the bottle was shaken to thoroughly mix the dressing and the ramekin was thoroughly wiped out with a dry cloth towel between trials. This procedure for measuring 2T of liquid salad dressing was repeated 10 times for regular dressing and 10 times for fat-free dressing.

Commercial variety, Pace brand, picante medium salsa was measured in 2T portions. The measurement was made using a glass ramekin with 2T markings on the side. Salsa was added from the original jar with a spoon to the ramekin. The measurement unit was recorded as “2T” and the weight of the ramekin was recorded in the “Tare Weight (Container Weight)” column. The weight of the ramekin and 2T of salsa was entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight)” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods. The ramekin was thoroughly rinsed and dried between trials. This procedure for measuring 2T of salsa was repeated 10 times.

Commercial variety, Fred Meyer brand, original tomato ketchup was measured in 2T portions. The measurement was made using measuring spoons and pouring the tablespoons into a glass ramekin. The measurement unit was recorded as “2T” and the weight of the ramekin was

recorded in the “Tare Weight (Container Weight)” column. Each tablespoon of ketchup was leveled off using a knife and was then poured into the ramekin and a spatula was used to transfer as much ketchup as possible from the spoon to the ramekin. The weight of the ramekin and 2T of ketchup was entered in the “Cooked Weight or Measured Weight for Uncooked Foods” column and the “Final Weight (Cooked Weight or Measured Weight for Uncooked Foods OR Dry or Raw Weight (if cooked) - Tare Weight) ” updated automatically with a function to subtract “Tare Weight” from “Cooked Weight or Measured Weight for Uncooked Foods. The measuring spoon, ramekin, and spatula were wiped clean with a dry cloth towel between trials. This procedure for measuring 2T of ketchup was repeated 10 times.

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