

A New Method for Calculating Dietary Fiber Content and Determining Appropriate Dietary Fiber Levels in Foods

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Abstract- Calculation of dietary fiber quantity (content or amount) at 100 mL or 100 g, 100 kcal, or the reference amount customarily consumed (RACC) improperly indicates the quantity of dietary fiber for some foods. So, choosing some foods in accordance with those quantities may raise the risk of some chronic diseases. Calculation of dietary fiber quantity and assessment of proper dietary fiber levels in accordance with the Codex Alimentarius Commission (CAC), U.S. Food and Drug Administration (FDA), and the suggested method were accomplished in 8,027 foods. Choosing some foods in accordance with the CAC at 100 g or CAC and FDA at serving (the serving is taken from the RACC) to attain enough dietary fiber overstepped energy necessities and could cause obesity or overweight. Choosing some foods in accordance with the CAC at 100 g or CAC at 100 kcal to attain enough dietary fiber did not fulfill dietary fiber necessities and could cause dietary fiber deficits. Some foods that fulfilled dietary fiber necessities were not proper food options in accordance with the CAC at 100 g to attain enough dietary fiber. In the suggested method, the calculation of dietary fiber quantity and assessment of proper dietary fiber levels in foods are accomplished with consideration of RACCs and the energy quantity of foods. Hence, choosing foods in accordance with the suggested method fulfilled dietary fiber necessities and did not overstep energy necessities.

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Introduction

Dietary fiber comprises indigestible carbohydrates and lignin, which are inherent and intact in plants (1). Fibers have various attributes that lead to different physiological effects, such as being laxative, normalizing serum cholesterol levels, and lowering blood glucose levels (2,3). Despite the significant functions of dietary fiber, many people all over the world do not fulfill the daily necessity for dietary fiber (4-10).

Calculation of dietary fiber quantity at (per) 100 g or 100 mL, 100 kcal, or the reference amount customarily consumed (RACC) improperly indicates the quantity of dietary fiber for some foods. So, choosing some foods in

accordance with those quantities may raise the risk of some chronic diseases. In accordance with the regulatory necessities for nutrient claims, proper dietary fiber levels in foods must be assessed on the basis of the high (excellent source), and source (good source) claims for dietary fiber. The high and source claims for dietary fiber show the existence of dietary fiber at high and mid-levels, respectively. If a food fulfills the definition of high or source claim for dietary fiber, this food is determined as high dietary fiber (excellent source of dietary fiber or high in dietary fiber) or dietary fiber source (good source of dietary fiber or source of dietary fiber), respectively. Foods that fulfill the high or source claim for dietary fiber are considered as foods comprising proper dietary fiber

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levels. Nutrient claims were made by various authorities, and the FDA and CAC are the most prominent among them. According to the CAC, the high and source claims for dietary fiber are defined in reference amounts of serving size (serving), 100 g, and 100 kcal. Also, according to the FDA, the high and source claims for dietary fiber are defined in a reference amount of serving. Furthermore, the serving is taken from the RACC in accordance with the high and source claims for dietary fiber in the CAC and FDA at serving.

The present study evaluated the calculation of the dietary fiber quantity and assessment of proper dietary fiber levels in accordance with the CAC and FDA at serving, CAC at 100 g, and CAC at 100 kcal and demonstrated a new method for the calculation of dietary fiber quantity and assessment of proper dietary fiber levels in foods. In the suggested method, the calculation of dietary fiber quantity and assessment of proper dietary fiber levels in foods are accomplished with consideration of RACCs and the energy quantity of foods. The suggested method was employed for the calculation of quantities and assessment of proper levels of calcium (11), thiamin (12), and copper (13) in foods.

Materials and Methods

Foods

Data on foods and dietary fiber profiles were supplied by the USDA National Nutrient Database for Standard Reference, issue 28 (SR28) (14). Of 8,790 foods in the SR28, data on the dietary fiber quantity of 594 foods were absent.

Food classes

No food classes were supplied in the Excel data file for SR28. However, in order to provide study results based on food classes, it was necessary to dedicate food classes to food. Hence, food classes were dedicated to SR28 foods by utilizing the FoodData Central website (<https://fdc.nal.usda.gov>).

RACCs

RACC values show the quantity (edible portion) of the food customarily consumed at an eating occasion (15). RACCs were not supplied in the Excel data file for SR28. However, in order to provide study results based on the serving, it was necessary to dedicate RACCs to foods. Hence, RACCs were dedicated to SR28 foods through the instruction manual published by the Office of Nutrition and Food Labeling (15). RACCs were dedicated to 8,596 foods, and 194 foods were removed

owing to the absence of RACC or density.

Calculation of dietary fiber quantity at 100 kcal

As the dietary fiber quantity of foods on the basis of the CAC at 100 kcal must have been supplied at 100 kcal, the dietary fiber quantity of foods was converted from 100 g to 100 kcal by formula 1.

$$\text{Formula 1: Dietary fiber quantity at 100 kcal (g/100 kcal)} \\ = \frac{100}{\text{energy quantity (kcal/100 g)}} \times \text{dietary fiber quantity (g/100 g)}$$

Calculation of dietary fiber quantity at RACC

As the dietary fiber quantity of foods on the basis of the CAC and FDA at serving must have been supplied at RACC, the dietary fiber quantity was converted from 100 g to RACC by formula 3 for solids and formula 4 for liquids. In general, solid and liquid foods are measured by weight and volume, respectively. The densities of liquid foods were calculated by formula 2.

$$\text{Formula 2: Density (g/mL)} = \frac{\text{mass (g)}}{\text{volume (mL)}}$$

$$\text{Formula 3: Dietary fiber quantity at RACC (g/RACC) (for solids)} = \frac{\text{RACC (g)}}{100} \times \text{dietary fiber quantity (g/100 g)}$$

$$\text{Formula 4: Dietary fiber quantity at RACC (g/RACC) (for liquids)} \\ = \frac{\text{RACC (mL)}}{100} \times (\text{density (g/mL)} \times \text{dietary fiber quantity (g/100 g)})$$

Daily values (DVs) for dietary fiber

DVs for dietary fiber were determined 28 g for all foods, excluding baby foods, and 14 g for baby foods in accordance with the suggested method and FDA at serving (21 CFR101.9, revised as of April 1, 2018).

Daily reference values (DRVs) for dietary fiber

DRVs for dietary fiber were determined 30 g (16,17) for all foods, excluding baby foods, and 14 g (21 CFR101.9, revised as of April 1, 2018) for baby foods in accordance with the CAC at 100 g, CAC at serving, and CAC at 100 kcal.

DVs or DRVs for energy

DVs or DRVs for energy were determined 2,000 kcal (18) (21 CFR101.9, revised as of April 1, 2018) for all foods, excluding baby foods, and 1,000 kcal (21 CFR101.9, revised as of April 1, 2018) for baby foods in the present study.

Source and high claims for dietary fiber

Table 1 shows the high and source claims for dietary

Foods comprising proper dietary fiber levels

fiber in accordance with the suggested method, CAC and FDA at serving, CAC at 100 g, and CAC at 100 kcal.

Table 1. High (excellent source) and source (good source) claims for dietary fiber in accordance with the suggested method, CAC and FDA at serving, CAC at 100 g, and CAC at 100 kcal

Claim	Suggested method	FDA at serving (19)	CAC at 100 g, 100 kcal, and serving (17)
Claim of dietary fiber source	2,000 kcal: 10-19% of dietary fiber DV at RACC (and at two hundred kcal of RACC if RACC > two hundred kcal)	10-19% of dietary fiber DV at RACC	100 g: 10-19% of dietary fiber DRV at 100 g
	1,000 kcal: 10-19% of dietary fiber DV at RACC (and at one hundred kcal of RACC if RACC > one hundred kcal)		100 kcal: 5-9% of dietary fiber DRV at 100 kcal Serving: 10-19% of dietary fiber DRV at RACC
Claim of high dietary fiber	2,000 kcal: 20% or higher of dietary fiber DV at RACC (and at two hundred kcal of RACC if RACC > two hundred kcal)	20% or higher of dietary fiber DV at RACC	100 g: 20% or higher of dietary fiber DRV at 100 g
	1,000 kcal: 20% or higher of dietary fiber DV at RACC (and at one hundred kcal of RACC if RACC > one hundred kcal)		100 kcal: 10% or higher of dietary fiber DRV at 100 kcal Serving: 20% or higher of dietary fiber DRV at RACC

Calculating the dietary fiber quantity of foods in accordance with the suggested method in the status of proper energy quantity

If the quantity of energy is equal to or lower than two hundred kcal at RACC, the quantity of dietary fiber of all foods (assuming the daily reference energy intake of two thousand kcal), excluding baby foods, is calculated at RACC, and if the quantity of energy is equal to or lower than one hundred kcal at RACC, the quantity of dietary fiber of baby foods (assuming the daily reference energy intake of one thousand kcal) is calculated at RACC. Also, if the quantity of energy is equal to or lower than two hundred kcal at RACC, the source and high claims for dietary fiber are determined respectively as 10-19% and 20% or higher of the dietary fiber DV at RACC in all foods, excluding baby foods, and if the quantity of energy is equal to or lower than one hundred kcal at RACC, the source and high claims for dietary fiber are determined respectively as 10-19% and 20% or higher of the dietary fiber DV at RACC in baby foods. The quantity of energy at RACC was calculated for solid and liquid foods by formulas 5 and 6, respectively.

$$\text{Formula 5: Energy quantity at RACC (kcal/RACC) (for solids)} = \frac{\text{RACC}_{(g)}}{100} \times \text{energy quantity (kcal/100 g)}$$

$$\text{Formula 6: Energy quantity at RACC (kcal/RACC) (for liquids)} = \frac{\text{RACC}_{(mL)}}{100} \times (\text{density}_{(g/mL)} \times \text{energy quantity (kcal/100 g)})$$

Calculating the dietary fiber quantity of foods (except baby foods) in accordance with the suggested method in the status of improper energy quantity

If the quantity of energy is higher than two hundred kcal at RACC, the quantity of dietary fiber of all foods (assuming the daily reference energy intake of two

thousand kcal), excluding baby foods, is calculated at two hundred kcal of RACC. Also, if the quantity of energy is higher than two hundred kcal at RACC, the source and high claims for dietary fiber are determined respectively as 10-19% and 20% or higher of the dietary fiber DV at two hundred kcal of RACC in all foods, excluding baby foods. If the quantity of energy is higher than two hundred kcal at RACC, two hundred kcal of RACC is calculated for solid and liquid foods by formulas 7 and 8, respectively.

$$\text{Formula 7: Two hundred kcal of RACC (g) (for solids)} = \frac{200 \times \text{RACC}_{(g)}}{(\text{RACC}_{(g)} \div 100) \times \text{energy quantity (kcal/100 g)}} \times 100 \text{ or } \frac{200}{\text{energy quantity (kcal/100 g)}} \times 100$$

$$\text{Formula 8: Two hundred kcal of RACC (mL) (for liquids)} = \frac{200 \times \text{RACC}_{(mL)}}{(\text{RACC}_{(mL)} \div 100) \times (\text{density}_{(g/mL)} \times \text{energy quantity (kcal/100 g)})} \times 100 \text{ or } \frac{200}{\text{energy quantity (kcal/100 mL)}} \times 100$$

Calculating the dietary fiber quantity of baby foods in accordance with the suggested method in the status of improper energy quantity

If the quantity of energy is higher than one hundred kcal at RACC, the quantity of dietary fiber of baby foods (assuming the daily reference energy intake of one thousand kcal) is calculated at one hundred kcal of RACC. Also, if the quantity of energy is higher than one hundred kcal at RACC, the source and high claims for dietary fiber are determined respectively as 10-19% and 20% or higher of the dietary fiber DV at one hundred kcal of RACC in baby foods. If the quantity of energy is higher than one hundred kcal at RACC, one hundred kcal of RACC is calculated for solid and liquid baby foods by formulas 9 and 10, respectively.

$$\text{Formula 9: One hundred kcal of RACC (g) (for solids)} = \frac{100 \times \text{RACC (g)}}{(\text{RACC (g)} \div 100) \times \text{energy quantity (kcal/100 g)}} \text{ or } \frac{100}{\text{energy quantity (kcal/100 g)}} \times 100$$

$$\text{Formula 10: One hundred kcal of RACC (mL) (for liquids)} = \frac{100 \times \text{RACC (mL)}}{(\text{RACC (mL)} \div 100) \times (\text{density (g/mL)} \times \text{energy quantity (kcal/100 g)})} \text{ or } \frac{100}{\text{energy quantity (kcal/100 mL)}} \times 100$$

Results

Foods comprising proper dietary fiber levels in accordance with the suggested method

Approximately 58% of the foods contained dietary fiber. In accordance with the suggested method, the mean (%) of foods comprising proper dietary fiber levels in food classes was 16.75%, of which 11.85% was the mean of dietary fiber source (good source of dietary fiber) foods, and 4.9% was the mean of high dietary fiber (excellent source of dietary fiber) foods. Breakfast cereals with 57.67%, legumes and legume products with 54.44%, meals, entrees, and side dishes with 38.64%, American Indian/Alaska Native foods with 37.66%, nut and seed

products with 35.29%, vegetables and vegetable products with 34.01%, fruits and fruit juices with 33.13%, and cereal grains and pasta with 32.92% had the highest means of foods comprising proper dietary fiber levels (Figure 1).

The highest amounts of dietary fiber were detected in rose hips, breakfast cereal (made with bran, added fiber, or whole grain), chokecherries, purple passion-fruit, agave, navy beans, white beans, yellow beans, pinon nuts, French beans, kidney beans, corn bran, pinto beans, black beans, meat extender, cranberry beans, black turtle beans, split peas, refried beans, raspberries, nance fruit, chia seeds, lentils, lima beans, waffles with added fiber, mung beans, bean soup, elderberries, adzuki beans, prairie turnips, papad, chickpeas, kumquats, great northern beans, winged beans, fireweed leaves, baked beans, pears, feijoa, hyacinth beans, fava beans, pigeon peas, rowal fruit, veggie burgers, cowpeas, mungo beans, immature seeds of cowpea, flaxseed, barley, guavas, mamey sapote, prickly pears, blackberries, boysenberries, loganberries, sapodilla, abiyuch (sacred garlic pear), artichokes, snack cakes with added fiber, oat bran bread, green peas, dark rye flour, and pumpkin pie mix.

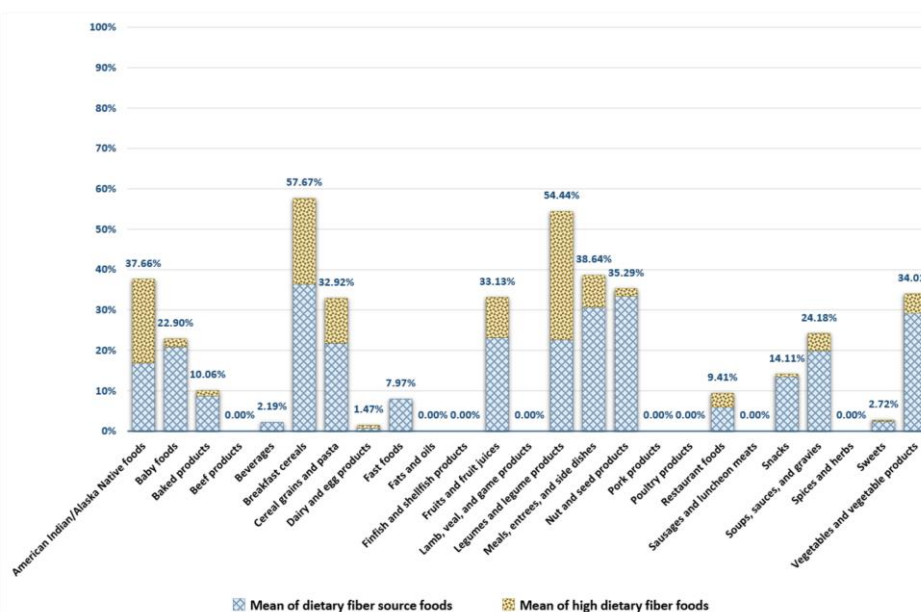


Figure 1. Means (%) of foods comprising proper dietary fiber levels in accordance with the suggested method in food classes. All foods high in dietary fiber (excellent source of dietary fiber) and source of dietary fiber (good source of dietary fiber), excluding baby foods high in dietary fiber and source of dietary fiber, are assumed at the daily reference energy intake of two thousand kcal for adults and children aged 4 years and older. Baby foods high in dietary fiber and source of dietary fiber are assumed at the daily reference energy intake of one thousand kcal for children 1 through 3 years of age

Foods comprising proper dietary fiber levels were not detected in eight food classes (finfish and shellfish

products; beef products; fats and oils; lamb, veal, and game products; poultry products; pork products; spices

Foods comprising proper dietary fiber levels

and herbs; sausages and luncheon meats) and were very few in three food classes (dairy and egg products; beverages; sweets). The lack of foods comprising proper dietary fiber levels in spices and herbs is owing to the fact that spices and herbs are customarily consumed in low quantities. Spices and herbs supply sensory properties, including aroma, color, and flavor, with food (20).

Attaining the DVs for dietary fiber by eating foods high in dietary fiber needed a mean of eating 3.7 servings. So, the DVs for dietary fiber are simply attained by eating foods high in dietary fiber. Attaining the DVs for dietary fiber by eating foods source of dietary fiber needed a mean of eating 7.6 servings. So, the DVs for dietary fiber are mildly attained by eating foods source of dietary fiber. As attaining the DVs for dietary fiber without eating foods high in dietary fiber and source of dietary fiber needed eating higher than 10 servings (or higher than 20 servings in 68.8% of foods), it is hard to attain the DVs for dietary fiber without eating foods high in dietary fiber and source of dietary fiber. In accordance with the suggested method, the serving is taken from two hundred kcal of RACC or the RACC for all foods, excluding baby foods, and one hundred kcal of RACC or RACC for baby foods.

Means (%) of foods comprising proper dietary fiber levels in accordance with the suggested method in food classes are indicated in Figure 1.

Foods comprising proper dietary fiber levels in accordance with the FDA at serving

As the calculation of the dietary fiber quantity and assessment of proper dietary fiber levels in accordance with the FDA at serving are accomplished without consideration of the energy quantity of foods, choosing some foods in accordance with the FDA at serving to attain enough dietary fiber fulfilled dietary fiber necessities but overstepped energy necessities. As an example, if one cheese quesadilla (NDB number 36051) comprises RACC of 195 g, 394 kcal of energy at 100 g, and 4.29 g of dietary fiber at RACC, is it determined as a food high in dietary fiber or source of dietary fiber in accordance with the suggested method and FDA at serving? As this cheese quesadilla comprises 4.29 g of dietary fiber at RACC, it is determined as a food source of dietary fiber in accordance with the FDA at serving. Eating 6.527 RACCs of the cheese quesadilla fulfills the dietary fiber DV but eventuates in getting 5,015 kcal of energy, and that energy quantity is 3,015 kcal higher than the energy DV or energy DRV. As the serving of this cheese quesadilla in accordance with the suggested method is 50.76 g, and this quantity of cheese quesadilla

comprises 1.1 g of dietary fiber, this cheese quesadilla is not determined as a food high in dietary fiber or source of dietary fiber in accordance with the suggested method.

The mean (%) of similarities between the FDA at serving and the suggested method was 98.05% for foods high in dietary fiber and source of dietary fiber in food classes. Both the FDA at serving and the suggested method had identical high dietary fiber and dietary fiber source foods in 16 food classes and 13 food classes, respectively. However, the calculation of dietary fiber quantity of some foods in high quantities (owing to not paying attention to the energy quantity of foods) in accordance with the FDA at serving raised means (%) of foods comprising proper dietary fiber levels in 12 food classes (fast foods; restaurant foods; meals, entrees, and side dishes; nut and seed products; baked products; breakfast cereals; beverages; cereal grains and pasta; fruits and fruit juices; baby foods; soups, sauces, and gravies; vegetables and vegetable products) as compared with the suggested method. As an example, means (%) of foods comprising proper dietary fiber levels in fast foods, restaurant foods, and meals, entrees, and side dishes were respectively 31.56%, 28.24%, and 50% in accordance with the FDA at serving and 7.97%, 9.41%, and 38.64% in accordance with the suggested method.

Foods comprising proper dietary fiber levels in accordance with the CAC at serving

As the calculation of the dietary fiber quantity and assessment of proper dietary fiber levels in accordance with the CAC at serving are accomplished without consideration of the energy quantity of foods, choosing some foods in accordance with the CAC at serving to attain enough dietary fiber fulfilled dietary fiber necessities but overstepped energy necessities. As an example, if one sandwich with cheese (NDB number 21255) comprises RACC of 195 g, 266 kcal of energy at 100 g, and 3.12 g of dietary fiber at RACC, is it determined as a food high in dietary fiber or source of dietary fiber in accordance with the suggested method and CAC at serving? As this sandwich with cheese comprises 3.12 g of dietary fiber at RACC, it is determined as a food source of dietary fiber in accordance with the CAC at serving. Eating 9.615 RACCs of the sandwich with cheese fulfills the dietary fiber DRV but eventuates in getting 4,987.5 kcal of energy, and that energy quantity is 2,987.5 kcal higher than the energy DV or energy DRV. As the serving of this sandwich with cheese in accordance with the suggested method is 75.19 g, and this quantity of sandwich with cheese comprises

1.2 g of dietary fiber, this sandwich with cheese is not determined as a food high in dietary fiber or source of dietary fiber in accordance with the suggested method.

The mean (%) of similarities between the CAC at serving and the suggested method was 97.6% for foods high in dietary fiber and source of dietary fiber in food classes. Using difficult criteria of the high and source claims for dietary fiber in accordance with the CAC at serving (quantities of high and source claims for dietary fiber in accordance with the CAC at serving are higher than quantities of high and source claims for dietary fiber in accordance with the suggested method and FDA at serving) diminished means (%) of foods comprising proper dietary fiber levels in 10 food classes (soups, sauces, and gravies; American Indian/Alaska Native foods; vegetables and vegetable products; fruits and fruit juices; nut and seed products; breakfast cereals; snacks; legumes and legume products; cereal grains and pasta; sweets) as compared with the suggested method. Also, the calculation of dietary fiber quantity of some foods in high quantities (owing to not paying attention to the energy quantity of foods) in accordance with the CAC at serving raised means (%) of foods comprising proper dietary fiber levels in six food classes (fast foods; restaurant foods; meals, entrees, and side dishes; baby foods; beverages; baked products) as compared with the suggested method. As an example, means (%) of foods comprising proper dietary fiber levels in fast foods, restaurant foods, and soups, sauces, and gravies were respectively 25.58%, 21.18%, and 14.32% in accordance with the CAC at serving and 7.97%, 9.41%, and 24.18% in accordance with the suggested method.

Foods comprising proper dietary fiber levels in accordance with the CAC at 100 g

As the calculation of the dietary fiber quantity and assessment of proper dietary fiber levels in accordance with the CAC at 100 g are accomplished without consideration of RACCs, choosing some foods in accordance with the CAC at 100 g to attain enough dietary fiber did not fulfill dietary fiber necessities. Using a constant food quantity of 100 g may be high for some foods. Hence, the calculation of dietary fiber quantity at 100 g of food in accordance with the CAC indicates the improperly high dietary fiber quantity for some foods. As an example, if prepared horseradish (NDB number 2055) comprises 3.3 g of dietary fiber at 100 g and RACC of 5 g, is it determined as a food high in dietary fiber or source of dietary fiber in accordance with the suggested method and CAC at 100 g? As this horseradish comprises 3.3 g

of dietary fiber at 100 g, it is determined as a food source of dietary fiber in accordance with the CAC at 100 g. Eating 909 g of the horseradish fulfills the dietary fiber DRV, but this horseradish is customarily consumed 50 g at 10 eating occasions. As the serving of this horseradish in accordance with the suggested method is 5 g, and this quantity of horseradish comprises 0.17 g of dietary fiber, this horseradish is not determined as a food high in dietary fiber or source of dietary fiber in accordance with the suggested method.

As the calculation of the dietary fiber quantity and assessment of proper dietary fiber levels in accordance with the CAC at 100 g are accomplished without consideration of RACCs, some foods that fulfilled dietary fiber necessities were not proper food options in accordance with the CAC at 100 g to attain enough dietary fiber. Using a constant food quantity of 100 g may be low for some foods. Hence, the calculation of dietary fiber quantity at 100 g of food in accordance with the CAC indicates the improperly low dietary fiber quantity for some foods. As an example, if chunky minestrone soup (NDB number 6039) comprises 2.4 g of dietary fiber at 100 g and RACC of 245 g, is it determined as a food high in dietary fiber or source of dietary fiber in accordance with the suggested method and CAC at 100 g? As this chunky minestrone soup comprises 2.4 g of dietary fiber at 100 g, it is not determined as a food high in dietary fiber or source of dietary fiber in accordance with the CAC at 100 g. Eating 1,250 g of the chunky minestrone soup fulfills the dietary fiber DRV, and this chunky minestrone soup is customarily consumed 2,450 g at 10 eating occasions. As the serving of this chunky minestrone soup in accordance with the suggested method is 245 g, and this quantity of soup comprises 5.88 g of dietary fiber, this chunky minestrone soup is determined as a food high in dietary fiber in accordance with the suggested method.

As the calculation of the dietary fiber quantity and assessment of proper dietary fiber levels in accordance with the CAC at 100 g are accomplished without consideration of the energy quantity of foods, choosing some foods in accordance with the CAC at 100 g to attain enough dietary fiber overstepped energy necessities. As an example, if cashew butter (NDB number 12588) comprises RACC of 32 g, 609 kcal of energy at 100 g, and 3 g of dietary fiber at 100 g, is it determined as a food high in dietary fiber or source of dietary fiber in accordance with the suggested method and CAC at 100 g? As this cashew butter comprises 3 g of dietary fiber at 100 g, it is determined as a food source of dietary fiber in accordance with the CAC at 100 g. Eating 1,000 g of

Foods comprising proper dietary fiber levels

cashew butter fulfills the dietary fiber DRV but eventuates in getting 6,090 kcal of energy, and that energy quantity is 4,090 kcal higher than the energy DV or energy DRV. As the serving of this cashew butter in accordance with the suggested method is 32 g, and this quantity of cashew butter comprises 0.96 g of dietary fiber, this cashew butter is not determined as a food high in dietary fiber or source of dietary fiber in accordance with the suggested method.

Utilizing the high dietary fiber quantities of the dietary fiber source claim for liquid foods and assessment of the dietary fiber source claim for liquid foods at 100 g diminished the dietary fiber source liquid foods. In accordance with the CAC at 100 mL or 100 g, the high and source claims for minerals (except sodium), vitamins, and protein are defined at 100 mL of liquid foods or at 100 g of solid foods, but the high and source claims for dietary fiber are defined at 100 g of liquid and solid foods. In addition, the quantities of high and source claims for minerals (except sodium), vitamins, and protein in liquid foods are half of the solid foods, but the dietary fiber quantities of high and source claims in liquid and solid foods are identical. As an example, if the dietary fiber source claim for liquid foods was 5-9% of the dietary fiber DRV at 100 mL, 1.49% of liquid foods would be of foods source of dietary fiber. As the dietary fiber source claim for liquid foods in accordance with the CAC is 10-19% of the dietary fiber DRV at 100 g, 0% of liquid foods are foods source of dietary fiber.

The mean (%) of similarities between the CAC at 100 g and the suggested method was 84.65% for foods high in dietary fiber and source of dietary fiber in food classes. Calculation of dietary fiber quantity of some foods in high quantities and some other foods in low quantities and using difficult criteria of the high and source claims for dietary fiber in accordance with the CAC at 100 g raised means (%) of foods comprising proper dietary fiber levels in 14 food classes (spices and herbs; snacks; nut and seed products; baked products; cereal grains and pasta; sweets; breakfast cereals; legumes and legume products; restaurant foods; beverages; baby foods; American Indian/Alaska Native foods; fast foods; fats and oils) and diminished means (%) of foods comprising proper dietary fiber levels in five food classes (meals, entrees, and side dishes; soups, sauces, and gravies; fruits and fruit juices; vegetables and vegetable products; dairy and egg products) as compared with the suggested method. As an example, means (%) of foods comprising proper dietary fiber levels in spices and herbs, snacks, nut and seed products, and meals, entrees, and side dishes were respectively 84.38%, 78.53%, 95.1%, and 18.18% in

accordance with the CAC at 100 g and 0%, 14.11%, 35.29%, and 38.64% in accordance with the suggested method.

Foods comprising proper dietary fiber levels in accordance with the CAC at 100 kcal

As the calculation of the dietary fiber quantity and assessment of proper dietary fiber levels in accordance with the CAC at 100 kcal are accomplished without consideration of RACCs, choosing some foods in accordance with the CAC at 100 kcal to attain enough dietary fiber did not fulfill dietary fiber necessities. Using a constant energy quantity of 100 kcal may be high for some foods. Hence, the calculation of dietary fiber quantity at 100 kcal of food in accordance with the CAC indicates the improperly high dietary fiber quantity for some foods. As an example, if raw lime juice (NDB number 9160) comprises RACC of 5 mL, 25 kcal of energy at 100 g, and 0.4 g of dietary fiber at 100 g, is it determined as a food high in dietary fiber or source of dietary fiber in accordance with the suggested method and CAC at 100 kcal? Since this lime juice comprises 1.6 g of dietary fiber at 100 kcal, it is determined as a food source of dietary fiber in accordance with the CAC at 100 kcal. Drinking 7332.3 mL of lime juice fulfills the dietary fiber DRV, but this lime juice is customarily consumed 50 mL at 10 eating occasions. As the serving of this lime juice in accordance with the suggested method is 5 mL, and this quantity of lime juice comprises 0.02 g of dietary fiber, this lime juice is not determined as a food high in dietary fiber or source of dietary fiber in accordance with the suggested method.

The mean (%) of similarities between the CAC at 100 kcal and the suggested method was 88.49% for foods high in dietary fiber and source of dietary fiber in food classes. Calculation of dietary fiber quantity of some foods in high quantities in accordance with the CAC at 100 kcal raised means (%) of foods comprising proper dietary fiber levels in 18 food classes (spices and herbs; vegetables and vegetable products; fruits and fruit juices; soups, sauces, and gravies; baby foods; cereal grains and pasta; nut and seed products; legumes and legume products; snacks; baked products; American Indian/Alaska Native foods; sweets; beverages; breakfast cereals; fats and oils; restaurant foods; dairy and egg products; fast foods) as compared with the suggested method. As an example, means (%) of foods comprising proper dietary fiber levels in spices and herbs, vegetables and vegetable products, fruits and fruit juices, and soups, sauces, and gravies were respectively 85.94%, 91.8%, 68.98%, and 48.12% in accordance with the CAC at 100 kcal and 0%, 34.01%,

33.13%, and 24.18% in accordance with the suggested method.

Discussion

Some scientific writings, similar to the suggested method, CAC and FDA at serving, CAC at 100 kcal, and CAC at 100 g, determined wheat (21-25), oat (25,26), corn (25,27), barley (22,25,28), bulgur (25,29), rye (23,25,30,31), split peas (32), chickpeas (32,33), soybeans (32,34), lentils (32,34), pinto beans (32), kidney beans (32,35), and sesame seeds (36,37) as foods comprising proper dietary fiber levels.

Charoensiddhi and Anprung (38) and Sultana and Bari (39), unlike the suggested method, CAC and FDA at serving, CAC at 100 kcal, and CAC at 100 g, determined watermelon as food comprising a proper dietary fiber level. Eating 7,000 g of watermelon (NDB number 9326; 0.4 g of dietary fiber at 100 g; 30 kcal of energy at 100 g) fulfills the dietary fiber DV. Also, eating 7,500 g of watermelon fulfills the dietary fiber DRV. However, this watermelon is customarily consumed at 2,800 g at 10 eating occasions. In addition, eating 7,000 g of watermelon eventuates in getting 2,100 kcal of energy, and that energy quantity is 100 kcal higher than the energy DV or energy DRV. Also, eating 7,500 g of the watermelon eventuates in getting 2,250 kcal of energy, and that energy quantity is 250 kcal higher than the energy DV or energy DRV.

Bajpai *et al.* (40), Kang *et al.* (41), Kapusta-Duch *et al.* (42), Sarwar *et al.* (43), and the CAC at 100 kcal, unlike the suggested method, CAC and FDA at serving, and CAC at 100 g, determined cucumber as food comprising a proper dietary fiber level. Eating 5,600 g of cucumber with peel (NDB number 11205; 0.5 g of dietary fiber at 100 g; 15 kcal of energy at 100 g) fulfills the dietary fiber DV. Also, eating 6,000 g of cucumber with peel fulfills the dietary fiber DRV. However, this cucumber is customarily consumed 850 g at 10 eating occasions.

The CAC and FDA at serving and CAC at 100 g,

unlike the suggested method and CAC at 100 kcal, determined toaster pastries as a food comprising a proper dietary fiber level. Eating 848.5 g of toaster pastries (NDB number 28178; 3.3 g of dietary fiber at 100 g; 3.63 g of dietary fiber at RACC; 391 kcal of energy at 100 g; RACC of 110 g) fulfills the dietary fiber DV but eventuates in getting 3,318 kcal of energy, and that energy quantity is 1,318 kcal higher than the energy DV or energy DRV. Also, eating 909.1 g of the toaster pastries fulfills the dietary fiber DRV but eventuates in getting 3,555 kcal of energy, and that energy quantity is 1,555 kcal higher than the energy DV or energy DRV.

It is well-recognized that extreme energy intake can cause obesity or overweight. However, the calculation of dietary fiber quantity and assessment of proper dietary fiber levels in accordance with the CAC and FDA at serving and CAC at 100 g are accomplished without consideration of the energy quantity of foods. Hence, choosing some foods in accordance with the CAC and FDA at serving or CAC at 100 g to attain enough dietary fiber overstepped energy necessities and could cause obesity or overweight.

RACC values show the quantity of the food customarily consumed at an eating occasion (15). However, the calculation of dietary fiber quantity and assessment of proper dietary fiber levels in accordance with the CAC at 100 kcal and CAC at 100 g are accomplished without consideration of RACCs. Hence, choosing some foods in accordance with the CAC at 100 g or CAC at 100 kcal to attain enough dietary fiber did not fulfill dietary fiber necessities and could cause dietary fiber deficits. Also, some foods that fulfilled dietary fiber necessities were not proper food options in accordance with the CAC at 100 g to attain enough dietary fiber.

In the suggested method, the calculation of dietary fiber quantity and assessment of proper dietary fiber levels in foods are accomplished with consideration of RACCs and the energy quantity of foods. Hence, choosing foods in accordance with the suggested method fulfilled dietary fiber necessities and did not overstep energy necessities (Figure 2).

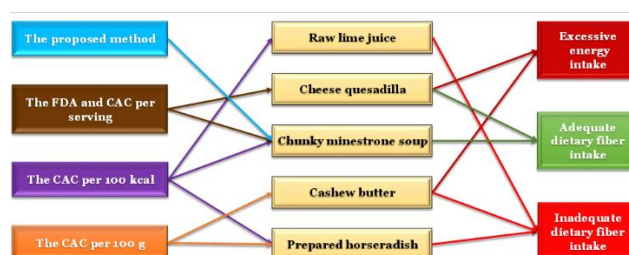


Figure 2. Results of food options in accordance with different methods for attaining enough dietary fiber

References

1. Institute of Medicine. Dietary reference intakes: proposed definition of dietary fiber. Washington (DC): National Academies Press (US); 2001.
2. Institute of Medicine. Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids. Washington (DC): National Academies Press (US); 2005.
3. Institute of Medicine. Dietary reference intakes: the essential guide to nutrient requirements. Washington (DC): National Academies Press (US); 2006.
4. Bingham S, Cummings JH, McNeil NI. Intakes and sources of dietary fiber in the British population. *Am J Clin Nutr* 1979;32:1313-9.
5. European Food Safety Authority. Scientific opinion on dietary reference values for carbohydrates and dietary fibre. *EFSA J* 2010;8:1462.
6. U.S. Department of Health and Human Services and U.S. Department of Agriculture. 2015–2020 Dietary Guidelines for Americans, 8th ed. Washington, DC: U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015. (Accessed January 1, 2021, at https://www.dietaryguidelines.gov/sites/default/files/2019-05/2015-2020_Dietary_Guidelines.pdf.)
7. King DE, Mainous AG, Lambourne CA. Trends in dietary fiber intake in the United States, 1999-2008. *J Acad Nutr Diet* 2012;112:642–8.
8. McGill CR, Fulgoni VL, Devareddy L. Ten-year trends in fiber and whole grain intakes and food sources for the United States population: National Health and Nutrition Examination Survey 2001–2010. *Nutrients* 2015;7:1119-30.
9. Reicks M, Jonnalagadda S, Albertson AM, Joshi N. Total dietary fiber intakes in the US population are related to whole grain consumption: results from the National Health and Nutrition Examination Survey 2009 to 2010. *Nut Res* 2014;34:226-34.
10. Sardinha AN, Canella DS, Martins APB, Claro RM, Levy RB. Dietary sources of fiber intake in Brazil. *Appetite* 2014;79:134-8.
11. Forouzesh A, Forouzesh F, Samadi Foroushani S, Forouzesh A, Zand E. A new method for calculating calcium content and determining appropriate calcium levels in foods. *Food Anal Methods* 2022;15:16-25.
12. Forouzesh A, Forouzesh F, Samadi Foroushani S, Forouzesh A. A new method for calculating thiamin content and determining appropriate thiamin levels in foods. *J Food Compos Anal* 2021;104:104188.
13. Forouzesh A, Forouzesh F, Samadi Foroushani S, Forouzesh A, Zand E. A new method for calculating copper content and determining appropriate copper levels in foods. *Rev Chil Nutr* 2021;48:862-73.
14. U.S. Department of Agriculture ARS. USDA National Nutrient Database for Standard Reference, release 28. Washington, DC: U.S. Department of Agriculture ARS, 2016. (Accessed January 1, 2021, at <https://www.ars.usda.gov/Services/docs.htm?docid=8964>.)
15. U.S. Food and Drug Administration. Reference amounts customarily consumed: list of products for each product category: guidance for industry. Washington, DC: U.S. Food and Drug Administration, 2018. (Accessed January 1, 2021, at <https://www.fda.gov/media/102587/download>.)
16. Codex Alimentarius Commission. Food labelling, 5th ed. Rome: Food and Agriculture Organization of the United Nations and World Health Organization, 2007.
17. Codex Alimentarius Commission. Guidelines for use of nutrition and health claims (CAC/GL 23-1997 as last amended 2013). Rome: World Health Organization and the Food and Agriculture Organization of the United Nations, 2013. (Accessed January 1, 2021, at <http://www.fao.org/ag/humannutrition/32444-09f5545b8abe9a0c3baf01a4502ac36e4.pdf>.)
18. Codex Alimentarius Commission. Guidelines on nutrition labelling (CAC/GL 2-1985 as last amended 2017). Rome: World Health Organization and the Food and Agriculture Organization of the United Nations, 2017. (Accessed January 1, 2021, at http://www.fao.org/fao-who-codexalimentarius/sh-proxy/en/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252Fstandards%252FCXG%2B2-1985%252FCXG_002e.pdf.)
19. Institute of Medicine. Examination of front-of-package nutrition rating systems and symbols: phase I report. Washington (DC): National Academies Press (US); 2010.
20. Kubra IR, Kumar D, Jagan Mohan Rao L. Emerging trends in microwave processing of spices and herbs. *Crit Rev Food Sci Nutr* 2016;56:2160-73.
21. Koehler P, Hartmann G, Wieser H, Rychlik M. Changes of folates, dietary fiber, and proteins in wheat as affected by germination. *J Agric Food Chem* 2007;55:4678-83.
22. McIntosh GH, Whyte J, McArthur R, Nestel PJ. Barley and wheat foods: influence on plasma cholesterol concentrations in hypercholesterolemic men. *Am J Clin Nutr* 1991;53:1205-9.
23. McIntosh GH, Noakes M, Royle PJ, Foster PR. Whole-grain rye and wheat foods and markers of bowel health in overweight middle-aged men. *Am J Clin Nutr* 2003;77:967-74.

24. Rakszegi M, Molnár I, Lovegrove A, Darkó É, Farkas A, Láng L, *et al.* Addition of *Aegilops* U and M chromosomes affects protein and dietary fiber content of wholemeal wheat flour. *Front Plant Sci* 2017;8:1529.
25. Surampudi P, Enkhmaa B, Anuurad E, Berglund L. Lipid lowering with soluble dietary fiber. *Curr Atheroscler Rep* 2016;18:75.
26. Manthey FA, Hareland GA, Huseby DJ. Soluble and insoluble dietary fiber content and composition in oat. *Cereal Chem* 1999;76:417-20.
27. Balch PA. Prescription for dietary wellness: using foods to heal. Second ed. New York: Avery Publishing/Penguin Publishing Group; 2003.
28. Dongowski G, Huth M, Gebhardt E, Flamme W. Dietary fiber-rich barley products beneficially affect the intestinal tract of rats. *J Nutr* 2002;132:3704-14.
29. Bayram M, Öner MD. Bulgur milling using roller, double disc and vertical disc mills. *J Food Eng* 2007;79:181-7.
30. Bondia-Pons I, Aura AM, Vuorela S, Kolehmainen M, Mykkänen H, Poutanen K. Rye phenolics in nutrition and health. *J Cereal Sci* 2009;49:323-36.
31. Karppinen S, Myllymäki O, Forssell P, Poutanen K. Fructan content of rye and rye products. *Cereal Chem* 2003;80:168-71.
32. Bahadoran Z, Mirmiran P. Potential properties of legumes as important functional foods for management of type 2 diabetes: a short review. *Int J Nutr Food Sci* 2015;4:6-9.
33. Khan AR, Alam S, Ali S, Bibi S, Khalil IA. Dietary fiber profile of food legumes. *Sarhad J Agric* 2007;23:763-6.
34. Eashwarage IS, Herath HMT, Gunathilake KGT. Dietary fibre, resistant starch and *in-vitro* starch digestibility of selected eleven commonly consumed legumes (mung bean, cowpea, soybean and horse gram) in Sri Lanka. *Res J Chem Sci* 2017;7:27-33.
35. Kan L, Nie S, Hu J, Wang S, Cui SW, Li Y, *et al.* Nutrients, phytochemicals and antioxidant activities of 26 kidney bean cultivars. *Food Chem Toxicol* 2017;108:467-77.
36. Elleuch M, Bedigian D, Zitoun A. Sesame (*Sesamum indicum* L.) seeds in food, nutrition, and health. In: Preedy VR, Watson RR, Patel VB, Eds. *Nuts and seeds in health and disease prevention*. London: Academic Press/Elsevier; 2011:1029-36.
37. Hwang SH, Sung CJ, Kim JI. Analysis of dietary fiber content of common Korean foods. *J Korean Soc Food Nutr* 1995;24:396-403.
38. Charoensiddhi S, Anprung P. Bioactive compounds and volatile compounds of Thai bael fruit (*Aegle marmelos* (L.) Correa) as a valuable source for functional food ingredients. *Int Food Res J* 2008;15:287-95.
39. Sultana RS, Bari MA. Effect of different plant growth regulators on direct regeneration of watermelon (*Citrullus lanatus* Thumb.). *Plant Tissue Cult* 2003;13:173-7.
40. Bajpai VK, Kim NH, Kim JE, Kim K, Kang SC. Protective effect of heat-treated cucumber (*Cucumis sativus* L.) juice on alcohol detoxification in experimental rats. *Pak J Pharm Sci* 2016;29:1005-9.
41. Kang SM, Radhakrishnan R, You YH, Khan AL, Park JM, Lee SM, *et al.* Cucumber performance is improved by inoculation with plant growth-promoting microorganisms. *Acta Agric Scand B Soil Plant Sci* 2015;65:36-44.
42. Kapusta-Duch J, Leszczyńska T, Borczak B. Influence of packages on nutritional quality of pickled chilled stored cucumbers. *Ecol Chem Eng A* 2016;23:357-71.
43. Sarwar M, Amjad M, Ayyub CM. Alleviation of salt stress in cucumber (*Cucumis sativus*) through seed priming with triacontanol. *Int J Agric Biol* 2017;19:771-8.