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Critical vulnerabilities of food selections based on nutrient content claims and reference amounts of food and creating a reliable procedure

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Abstract

Computing the food component (nutrient) amount in 100 kilocalories, 100 grams or 100 milliliters, the reference amount customarily consumed (RACC), or 50 grams of food demonstrates the food component amount of some foods unsuitably. So, selecting some foods based on them may elevate the hazards of some chronic diseases. Computing the food component amount and assessing suitable levels of food components and the nutritional quality according to the Codex Alimentarius Commission (CAC), the United States Food and Drug Administration (FDA), and the suggested procedure were implemented on 8,596 food cases, 29 food components, and 25 food categories. Selecting some foods under the FDA and CAC to reach sufficient intakes of positive food components surpassed energy demands. Selecting some foods under the CAC did not satisfy the demands of positive food components. Some foods that satisfied the demands of positive food components were not suitable food selections under the CAC. Selecting some foods under the FDA or CAC surpassed the demands of negative food components (including cholesterol, energy, fat, saturated fat, and sodium). Some foods that did not surpass the demands of negative food components were not suitable food selections under the CAC or FDA. Due to the vulnerabilities of selecting foods on the basis of the reference amounts of food, fast foods under the CAC and FDA in serving size (the serving size or serving is obtained from the RACC), spices and herbs under the CAC in 100 grams or 100 milliliters, and vegetables and vegetable products under the CAC in 100 kilocalories obtained the highest average scores for nutritional quality based on positive food components (including vitamins, protein, dietary fiber, and minerals, excluding sodium) among food categories for children aged four years and older and adults.

Keywords Food choice, Nutritional quality, Nutritional value, Nutrient profiling, Nutrition facts label, Dietary guidance, Nutrient-rich foods, Food analysis, Obesity, Vitamins, Minerals

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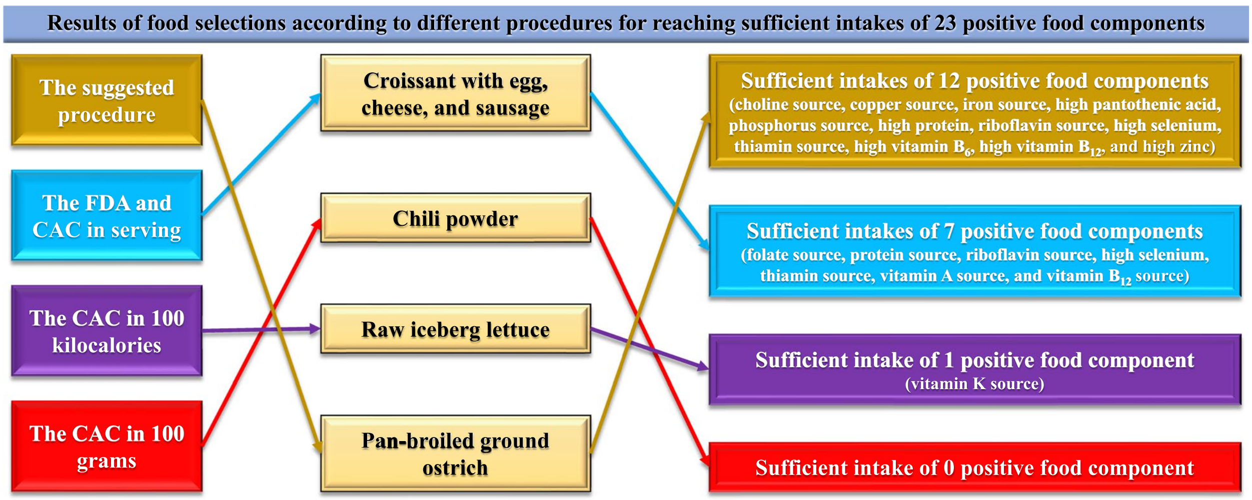
Graphical Abstract



Introduction

Food components (nutrients) are vital to humans, and humans obtain their nutrients mainly from foods. However, many people travail from diet-related chronic diseases due to unsuitable food selections. In addition to health problems, diet-related chronic diseases are also associated with a significant economic cost (Dee et al. 2014; Marques et al. 2018; Meier et al. 2015; Tsai et al. 2011). Thus, authorities created regulatory requirements for food components to assist consumers in selecting healthier foods, and manufacturers have located them on foods as nutrition facts labels.

Food components can be classified generally into two categories: positive food components and negative food components. Positive food components such as vitamins, minerals (excluding sodium), dietary fiber, and protein should be encouraged in the diet, and negative food components such as cholesterol, energy, fat, saturated fat, sodium, and sugars should be restricted in the diet.

Food components are mainly computed in reference amounts of food, including 100 milliliters (for liquids) or 100 grams (for solids), 100 kilocalories, and RACC. Amounts of 100 grams or 100 milliliters and RACC are usually used to compute the positive food component and the negative food component, and the amount of 100 kilocalories is usually used to compute the positive food component. The food component amount is directly associated with the food amount, so increasing the food amount enhances the food component amount, and decreasing the food amount reduces the food component amount (excluding food without food components).

Computation of the food component in 100 grams or 100 milliliters allows comparing foods based on the food component amount in the same amount of 100 grams of solid foods or in the same volume of 100 milliliters of liquid foods. Computing the food component in 100 grams or 100 milliliters demonstrates the food component amount of some foods unsuitably high or low because some foods are customarily consumed in amounts smaller or greater than 100 grams or 100 milliliters at each eating occasion. For instance, computing the food components of dried chervil (NDB number 2008) and chunky minestrone soup (NDB number 6039) in 100 grams demonstrates the food component amount of dried chervil unsuitably high and the food component amount of minestrone soup unsuitably low because the dried chervil and chunky minestrone soup are customarily consumed 0.2 gram and 245 grams at each eating occasion, respectively.

Computation of the food component in 100 kilocalories allows comparing foods based on the food component amount in the same energy amount of 100 kilocalories of foods. Computing the positive food component in 100 kilocalories demonstrates the amount of the positive food component of some foods unsuitably high because some foods are customarily consumed in amounts smaller than 100 kilocalories at each eating occasion. For instance, computing the positive food component of pepper or hot sauce (NDB number 6168; energy = 11 kcal/100 g) in 100 kilocalories demonstrates the amount of the positive food component of the pepper or hot sauce unsuitably high because 100 kilocalories of the pepper or hot sauce is 909 grams, but the pepper or hot sauce is customarily consumed 4.7 grams at each eating occasion.

Since consumption of some foods in 100 grams or 100 milliliters or RACC leads to obtaining extensive energy at each eating occasion, the positive food component of those foods should be computed in amounts smaller than 100 grams or 100 milliliters or RACCs. Satisfying the demands of positive food components should not surpass energy demands as it can lead to overweight or obesity. For instance, computing the positive food component of cheese quesadilla (NDB number 36051; RACC = 195 grams) in RACC or 100 grams demonstrates the amount of the positive food component of the cheese quesadilla unsuitably high because consumption of that cheese quesadilla in RACC and 100 grams leads to obtaining 768 kilocalories and 394 kilocalories of energy, respectively, which are extensive energy intakes at each eating occasion. So, the positive food component of the cheese quesadilla should be computed in an amount smaller than the RACC and 100 grams.

Since the RACC for some foods is small and surpassing the RACC can simply happen for small RACCs, computing the negative food component in RACC demonstrates the amount of the negative food component of small RACCs unsuitably small, and extensive intake of negative food components can elevate the hazards of some chronic diseases. For instance, beef tallow (NDB number 4001; RACC = 12.8 grams) is recognized as food rich in energy, fat, saturated fat, and cholesterol. However, if the energy, fat, saturated fat, and cholesterol components of the beef tallow are computed in RACC, the energy, fat, saturated fat, and cholesterol components of the beef tallow are demonstrated unsuitably small due to the small RACC. So, the negative food component of the beef tallow should be computed in an amount greater than the RACC.

According to the regulatory requirements, selecting foods to reach sufficient intake of any positive food component or to restrict intake of any negative food component should be based on nutrient content claims using amounts of food components and amounts of nutrient content claims. Nutrient content claims specify the level of a food component in food with descriptive terms such as high, source, low, very low, and free (Rowlands & Hoadley 2006). The high (excellent source) and source (good source) claims are used to reach sufficient intake of any positive food component, and the free, low, and very low claims are used to restrict intake of any negative food component. The high, source, low, very low, and free claims for food components demonstrate the presence of food components at high, mid, low, very low, and insignificant levels, respectively. If one food satisfies the description of the high, source, low, very low, or free claim for a food component, that food is introduced high component (such as high vitamin D or high in vitamin D), component source (such as protein source or source of protein), low component (such as low energy or low in energy), very low component (such as very low sodium or very low in sodium), or component free (such as cholesterol free or free of cholesterol), respectively. Foods that satisfy the free, low, or very low claim for a negative food component are recognized as foods containing suitable levels of negative food components (to restrict intake of any negative food component). Also, foods that satisfy the high or source claim for a positive food component are recognized as foods containing suitable levels of positive food components (to reach sufficient intake of any positive food component).

Nutrient content claims were created by multiple authorities, and the FDA and CAC are the most outstanding among them. Computing the food component amount of foods and assessing nutrient content claims for positive food components are implemented in 100 grams or 100 milliliters, serving size (the serving size or serving is obtained from the RACC), or 100 kilocalories under the CAC regulatory requirements and in serving (the serving is obtained from the RACC) under the FDA regulatory requirements. Also, computing the food component amount of foods and assessing nutrient content claims for negative food components are implemented in 100 grams or 100 milliliters under the CAC regulatory requirements and in serving (the serving is obtained from the RACC, 100 grams, or 50 grams) under the FDA regulatory requirements.

Although nutrient content claims can assist consumers in reaching sufficient intake of any positive food component or restricting intake of any negative food component, they do not reflect the nutritional quality (also recognized as nutrient profiling or nutritional value) of foods. In contrast to concentrating on a single food component, summary indicator systems (also recognized as nutrient profile models) try to assess the nutritional quality of a given food by considering amounts or percent daily values of many different food components that should be either restricted or encouraged (IOM 2010). So far, multiple summary indicator systems have been created to assess the nutritional quality of foods (Fulgoni et al. 2009; Hercberg et al. 2022; Katz et al. 2009, 2010), but they do not use suitable levels of food components (nutrient content claims) to assess the nutritional quality of foods. Since the food component amount is directly associated with the amount of food, the amount of food can affect nutrient content claims and the nutritional quality (excluding food without food components).

There are one or more major shortcomings in the existing summary indicator systems as follows: (1) the existing summary indicator systems use reference amounts of food to compute the food component amount of foods, and computing the food component amount of foods based on reference amounts of food demonstrates the food component amount of some foods unsuitably high or low; (2) since some existing summary indicator systems use the food component amount of foods or percent daily values (instead of suitable levels of food components), the high amount of few food components can unsuitably elevate the nutritional quality of a given food. For instance, if food A has 0.5% of the daily value for any of eight positive food components and 150% of the daily value for any of two positive food components, and food B has 20% of the daily value for any of the 10 positive food components, the nutritional quality of food A is assessed higher than the nutritional quality of food B based on some existing summary indicator systems. However, food A and food B can be used to reach sufficient intakes of 2 and 10 positive food components, respectively; and (3) some existing summary indicator systems assess the nutritional quality of a given food by considering the presence of some food categories or food groups in the given food, while foods within a food category or food group can have significant differences from each other. For instance, fruits and fruit juices are important sources of vitamin C and dietary fiber. However, 50.42% (Forouzesh et al. 2022a) and 33.13% (Forouzesh et al. 2023a) of fruits and fruit juices can be used to reach sufficient intakes of vitamin C and dietary fiber, respectively.

This study examined computing the food component amount and assessing suitable levels of food components according to the CAC and FDA in serving, CAC in 100 grams or 100 milliliters, and CAC in 100 kilocalories and presented a novel procedure for computing the food component amount and assessing suitable levels of food components in foods. Also, the existing study presented a novel procedure to assess the nutritional quality of foods based on suitable levels of food components. The usefulness of the suggested procedure was recorded by computing amounts and assessing suitable levels of calcium (Forouzesh et al. 2022b), thiamin (Forouzesh et al. 2021a), copper (Forouzesh et al. 2021b), dietary fiber (Forouzesh et al. 2023a), and fat (Forouzesh et al. 2023b) in foods.

Methods

Food cases and food components

Information on food and food component profiles was prepared from the USDA National Nutrient Database for Standard Reference, release 28 (SR28) (USDA ARS 2016). Twenty-nine food components derived from the SR28, including calcium (8,260 food cases), cholesterol (8,068 food cases), choline (4,691 food cases), copper (7,379 food cases), dietary fiber (8,027 food cases), energy (8,596 food cases), fat (8,596 food cases), folate (6,621 food cases), iron (8,463 food cases), magnesium (7,887 food cases), manganese (6,489 food cases), pantothenic acid (6,411 food cases), phosphorus (8,037 food cases), potassium (8,192 food cases), protein (8,596 food cases), riboflavin (8,008 food cases), saturated fat (8,252 food cases), selenium (6,961 food cases), sodium (8,515 food cases), sugars (6,810 food cases), thiamin (7,990 food cases), vitamin A (7,110 food cases), vitamin B_6 (7,725 food cases), vitamin B_{12} (7,445 food cases), vitamin C (7,808 food cases), vitamin D (5,435 food cases), vitamin E (5,784 food cases), vitamin K (5,132 food cases), and zinc (7,911 food cases), were employed in this study.

Food categories

Food categories were not prepared in the data file SR28. Therefore, food categories were assigned to food cases of SR28 employing the FoodData Central website (https://fdc.nal.usda.gov).

Meals and main dishes

Meals and main dishes were not determined in the data file SR28. The amounts of negative food components of meals and main dishes for the very low and low claims are computed in 100 grams according to the FDA in serving. Therefore, meals and main dishes in the food cases of SR28 were determined by employing the main dish product and meal product descriptions created in 21CFR101.13 (revised as of April 1, 2018).

RACCs

RACC values demonstrate the amount (edible portion) of food customarily consumed at each eating occasion (FDA 2018). RACCs were not prepared in the data file SR28. Therefore, RACCs were assigned to food cases of SR28 employing the guideline created by the Office of Nutrition and Food Labeling (FDA 2018). RACCs were assigned to 8,596 food cases, and 194 food cases were omitted because of the absence of density or RACC.

Nutrient reference values, daily values, and daily reference values for food components

Nutrient reference values (NRVs), daily values (DVs), and daily reference values (DRVs) for food components are provided in Table 1.

Number of daily servings

Creating amounts of the low, very low, and free claims for negative food components according to the suggested procedure necessitated specifying the number of daily servings. The number of daily servings at three energy levels (1,600 kilocalories, 2,200 kilocalories, and 2,800 kilocalories) was 15–26 servings: vegetables, 3–5 servings;

Table 1 Nutrient reference values, daily values, and daily reference values for food components

Food component (nutrient)	Daily value (Khan et al. 2019; 21CFR101.9)	Nutrient reference value or daily reference value (CAC 2017; IOM 1998; Khan et al. 2019; Nishida et al. 2004; 21CFR101.9)
Calcium	1,300 mg (and 700 mg for children 1 through 3 years)	1,000 mg (and 700 mg for children 1 through 3 years)
Cholesterol	300 mg	300 mg
Choline	550 mg (and 200 mg for children 1 through 3 years)	450 mg (and 200 mg for children 1 through 3 years)
Copper	0.9 mg (and 0.3 mg for children 1 through 3 years)	0.9 mg (and 0.3 mg for children 1 through 3 years)
Dietary fiber	28 g (and 14 g for children 1 through 3 years)	30 g (and 14 g for children 1 through 3 years)
Energy	2,000 kcal (and 1,000 kcal for children 1 through 3 years)	2,000 kcal (and 1,000 kcal for children 1 through 3 years)
Fat	77.78 g (and 38.9 g for children 1 through 3 years)	66.667 g (and 38.9 g for children 1 through 3 years)
Folate	400 µg DFE (and 150 µg DFE for children 1 through 3 years)	400 µg DFE (and 150 µg DFE for children 1 through 3 years)
Iron	18 mg (and 7 mg for children 1 through 3 years)	18 mg (and 7 mg for children 1 through 3 years)
Magnesium	420 mg (and 80 mg for children 1 through 3 years)	310 mg (and 80 mg for children 1 through 3 years)
Manganese	2.3 mg (and 1.2 mg for children 1 through 3 years)	3 mg (and 1.2 mg for children 1 through 3 years)
Pantothenic acid	5 mg (and 2 mg for children 1 through 3 years)	5 mg (and 2 mg for children 1 through 3 years)
Phosphorus	1,250 mg (and 460 mg for children 1 through 3 years)	700 mg (and 460 mg for children 1 through 3 years)
Potassium	4,700 mg (and 3,000 mg for children 1 through 3 years)	3,500 mg (and 3,000 mg for children 1 through 3 years)
Protein	50 g (and 13 g for children 1 through 3 years)	50 g (and 13 g for children 1 through 3 years)
Riboflavin	1.3 mg (and 0.5 mg for children 1 through 3 years)	1.2 mg (and 0.5 mg for children 1 through 3 years)
Saturated fat	20 g (and 10 g for children 1 through 3 years)	20 g (and 10 g for children 1 through 3 years)
Selenium	55 µg (and 20 µg for children 1 through 3 years)	60 µg (and 20 µg for children 1 through 3 years)
Sodium	2,300 mg (and 1,500 mg for children 1 through 3 years)	2,000 mg (and 1,500 mg for children 1 through 3 years)
Sugars	133 g (and 66.5 g for children 1 through 3 years)	133 g (and 66.5 g for children 1 through 3 years)
Thiamin	1.2 mg (and 0.5 mg for children 1 through 3 years)	1.2 mg (and 0.5 mg for children 1 through 3 years)
Vitamin A	900 µg RAE (and 300 µg RAE for children 1 through 3 years)	800 µg RAE (and 300 µg RAE for children 1 through 3 years)
Vitamin B_6	1.7 mg (and 0.5 mg for children 1 through 3 years)	1.3 mg (and 0.5 mg for children 1 through 3 years)
Vitamin B_{12}	2.4 µg (and 0.9 µg for children 1 through 3 years)	2.4 µg (and 0.9 µg for children 1 through 3 years)
Vitamin C	90 mg (and 15 mg for children 1 through 3 years)	100 mg (and 15 mg for children 1 through 3 years)
Vitamin D	20 µg (and 15 µg for children 1 through 3 years)	15 µg
Vitamin E	15 mg (and 6 mg for children 1 through 3 years)	9 mg (and 6 mg for children 1 through 3 years)
Vitamin K	120 µg (and 30 µg for children 1 through 3 years)	60 µg (and 30 µg for children 1 through 3 years)
Zinc	11 mg (and 3 mg for children 1 through 3 years)	12.5 mg (and 3 mg for children 1 through 3 years)

fruits, 2–4 servings; grains, 6–11 servings; dairy, 2–3 servings; and protein foods, 5–7 ounces to prepare a sum of 2–3 servings (Bowman et al. 1998). Based on the number of daily servings at three energy levels, the number of daily servings at the 2,000 kilocalories level was specified as 17.8–20 servings. Since surpassing the number of daily servings could lead to surpassing the DVs, NRVs, or DRVs for some foods low in a negative food component, the number of daily servings was specified as 20 in the present study. Since an ordinary consumer eats 20 or fewer servings of food per day (HHS 1991; Kessler et al. 2003), the description of "low" should enable that consumer to remain at or under 100 percent of the DV, NRV, or DRV for a certain food component (Kessler et al. 2003).

Computation of food component amount in 100 milliliters

The densities of liquid food cases were computed by Rule 1. Next, the food component amount of liquid food cases was transformed from 100 grams to 100 milliliters by Rule 2. Liquid and solid foods mention foods that are typically scaled by volume and weight, respectively.

$$\text{Density}_{\,(g/mL)} = \text{mass}_{\,(g)} \div \text{volume}_{\,(mL)} \tag{1}$$

$$\text{Food component amount in 100 milliliters (for liquids)} = \text{density}_{\,(g/mL)} \times \text{food component amount in 100 grams} \tag{2}$$

Computation of food component amount in 100 kilocalories

The food component amount of food cases was transformed from 100 grams to 100 kilocalories by Rule 3.

$$\text{Food component amount in 100 kilocalories} = \left(100 \div \text{energy}_{\ (\text{kcal}/100\ \text{g})}\right) \times \text{food component amount in 100 grams} \quad (3)$$

Computation of food component amount in RACC

The food component amount of food cases was transformed from 100 to RACC by Rule 4 for solids and Rule 5 for liquids.

$$\text{Food component amount in RACC (for solids)} = \left(\text{RACC}_{\ (\text{g})} \div 100\right) \times \text{food component amount in 100 grams} \quad (4)$$

$$\text{Food component amount in RACC (for liquids)} = \left(\text{RACC}_{\ (\text{mL})} \div 100\right) \times \left(\text{density}_{\ (\text{g/mL})} \times \text{food component amount in 100 grams}\right) \quad (5)$$

Computing the amount of negative food component according to the suggested procedure in situations of suitable RACC

If the RACC is not small, the amount of the negative food component of foods is computed in RACC. Also, if the RACC is not small, the free, very low, and low claims are assessed in RACC. According to the suggested procedure, the small RACC demonstrates the RACC smaller than 30 grams.

Computing the amount of negative food component according to the suggested procedure in situations of small RACC

Some foods have small RACCs, and surpassing the RACC can simply happen for small RACCs. Therefore, if the RACC is smaller than 30 grams, the amount of the negative food component of food is computed in 30 grams of food. Also, if the RACC is smaller than 30 grams, the free, very low, and low claims are assessed in 30 grams of food. The amount of the negative food component of food in 30 grams of food was computed by Rule 6. The 30 grams criterion mentions the prepared form of the food. The process of computing the amount of the negative food component of foods according to the suggested procedure is demonstrated in Fig. 1.

$$\text{Food component amount in 30 grams} = \text{food component amount in 100 grams} \times 0.3 \quad (6)$$

Computing the amount of positive food component according to the suggested procedure in situations of suitable energy amount

If the energy amount in RACC of all foods, excluding baby foods, is 200 kilocalories or smaller, the amount of the positive food component of foods (according to the reference energy intake of 2,000 kilocalories) is computed in RACC, and if the energy amount in

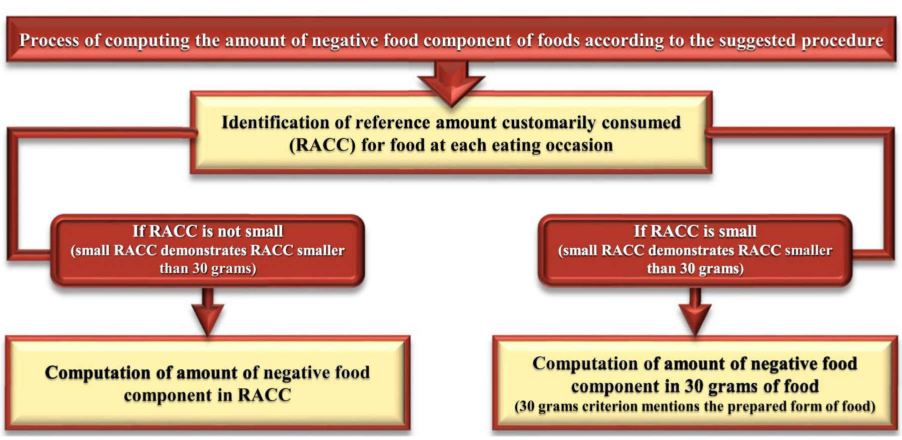


Fig. 1 The process of computing the amount of the negative food component of foods according to the suggested procedure

RACC of baby foods is 100 kilocalories or smaller, the amount of the positive food component of baby foods (according to the reference energy intake of 1,000 kilocalories) is computed in RACC. Also, if the energy amount in RACC of all foods, excluding baby foods, is 200 kilocalories or smaller, the source and high claims for a positive food component are described respectively as 10–19% and 20% or greater of the DV for the positive food component in RACC, and if the energy amount in RACC of baby foods is 100 kilocalories or smaller, the source and high claims for a positive food component are described respectively as 10–19% and 20% or greater of the DV for the positive food component in RACC. The energy amount in RACC of solid and liquid foods was computed by Rules 7 and 8, respectively.

$$\text{Energy amount}_{\,(\text{kcal})} \text{ in RACC (for solids)} = \left(\text{RACC}_{\,(\text{g})} \div 100\right) \times \text{energy}_{\,(\text{kcal/100 g})} \tag{7}$$

$$\text{Energy amount}_{\,(\text{kcal})} \text{ in RACC (for liquids)} = \left(\text{RACC}_{\,(\text{mL})} \div 100\right) \times \left(\text{density}_{\,(\text{g/mL})} \times \text{energy}_{\,(\text{kcal/100 g})}\right) \tag{8}$$

Computing the amount of positive food component of foods (excluding baby foods) according to the suggested procedure in situations of unsuitable energy amount

If the energy amount in RACC of all foods, excluding baby foods, is greater than 200 kilocalories, the amount of the positive food component of foods (according to the reference energy intake of 2,000 kilocalories) is computed in 200 kilocalories of RACC. Also, if the energy amount in RACC of all foods, excluding baby foods, is greater than 200 kilocalories, the source and high claims for a positive food component are described respectively as 10–19% and 20% or greater of the DV for the positive food component in 200 kilocalories of RACC. If the energy amount in RACC is greater than 200 kilocalories, 200 kilocalories of RACC for solid and liquid foods is computed by Rules 9 and 10, respectively. The process of computing the amount of the positive food component of foods (excluding baby foods) according to the suggested procedure is demonstrated in Fig. 2.

$$200 \text{ kilocalories of RACC}_{\,(\text{g})} \text{(for solids)} = \frac{200 \times \text{RACC}_{\,(\text{g})}}{\left(\text{RACC}_{\,(\text{g})} \div 100\right) \times \text{energy}_{\,(\text{kcal/100 g})}} \text{ or } \frac{200}{\text{energy}_{\,(\text{kcal/100 g})}} \times 100 \tag{9}$$

$$200 \text{ kilocalories of RACC}_{\,(\text{mL})} \text{(for liquids)} = \frac{200 \times \text{RACC}_{\,(\text{mL})}}{\left(\text{RACC}_{\,(\text{mL})} \div 100\right) \times \left(\text{density}_{\,(\text{g/mL})} \times \text{energy}_{\,(\text{kcal/100 g})}\right)} \text{ or } \frac{200}{\text{energy}_{\,(\text{kcal/100 mL})}} \times 100 \tag{10}$$

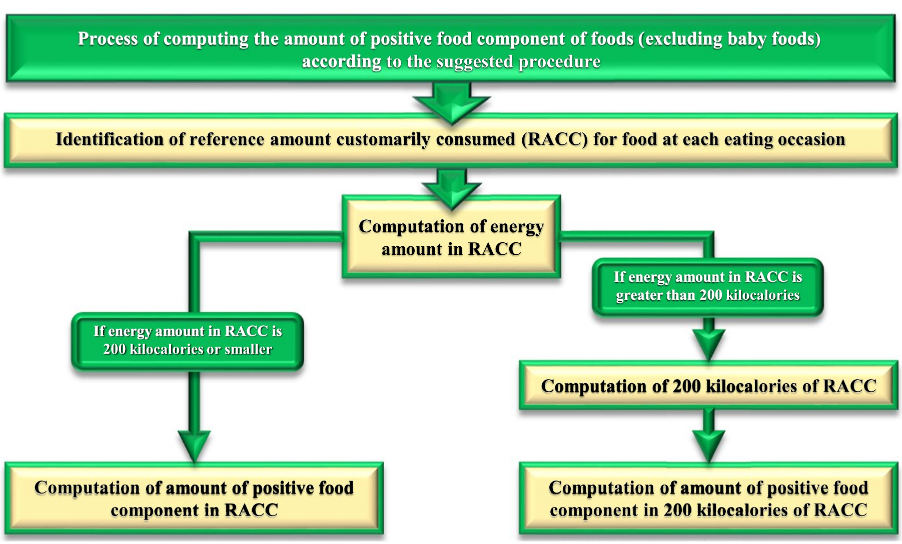


Fig. 2 The process of computing the amount of the positive food component of foods (excluding baby foods) according to the suggested procedure

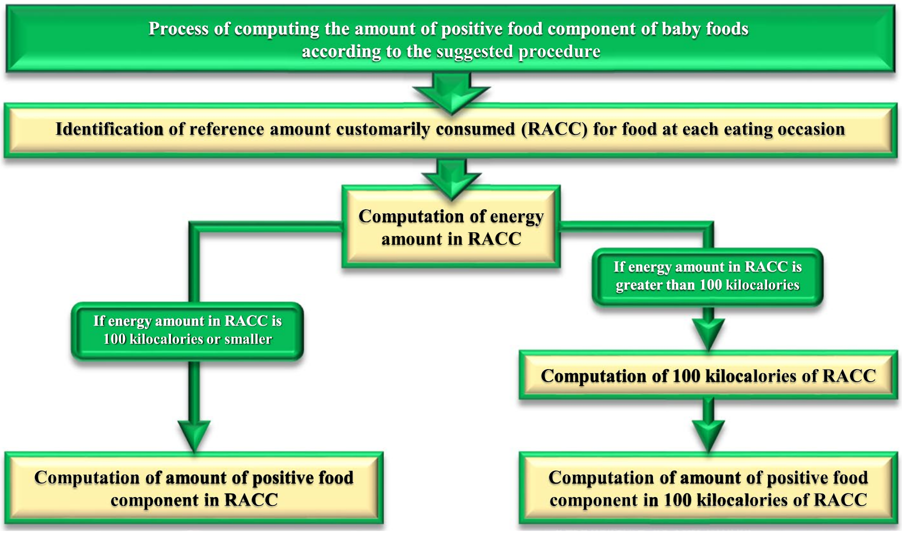


Fig. 3 The process of computing the amount of the positive food component of baby foods according to the suggested procedure

Computing the amount of positive food component of baby foods according to the suggested procedure in situations of unsuitable energy amount

If the energy amount in RACC of baby foods is greater than 100 kilocalories, the amount of the positive food component of baby foods (according to the reference energy intake of 1,000 kilocalories) is computed in 100 kilocalories of RACC. Also, if the energy amount in RACC of baby foods is greater than 100 kilocalories, the source and high claims for a positive food component are described respectively as 10–19% and 20% or greater of the DV for the positive food component in 100 kilocalories of RACC. If the energy amount in RACC of baby foods is greater than 100 kilocalories, 100 kilocalories of RACC for solid and liquid baby foods is computed by Rules 11 and 12, respectively. The process of computing the amount of the positive food component of baby foods according to the suggested procedure is demonstrated in Fig. 3.

$$\text{100 kilocalories of RACC}_{(g)}\text{(for solids)} = \frac{100 \times \text{RACC}_{(g)}}{(\text{RACC}_{(g)} \div 100) \times \text{energy}_{(kcal/100\,g)}} \text{ or } \frac{100}{\text{energy}_{(kcal/100\,g)}} \times 100 \quad (11)$$

$$\text{100 kilocalories of RACC}_{(mL)}\text{ (for liquids)} = \frac{100 \times \text{RACC}_{(mL)}}{(\text{RACC}_{(mL)} \div 100) \times (\text{density}_{(g/mL)} \times \text{energy}_{(kcal/100\,g)})} \text{ or } \frac{100}{\text{energy}_{(kcal/100\,mL)}} \times 100 \quad (12)$$

High, source, low, very low, and free claims for food components

Table 2 presents the high and source claims for positive food components according to the suggested procedure, CAC and FDA in serving, CAC in 100 grams or 100 milliliters, and CAC in 100 kilocalories. The low, very low, and free claims for negative food components according to the suggested procedure, FDA in serving, and CAC in 100 grams or 100 milliliters are provided in Table 3.

Computation of the nutritional quality of foods

The suggested procedure uses suitable levels of food components (nutrient content claims) to assess the nutritional quality of foods. According to the suggested procedure, the nutritional quality of foods can be evaluated from three aspects, including positive food components (to reach sufficient intake of any positive food component), negative food components (to restrict intake of any negative food component), and a combination of positive and negative food components (to reach sufficient intake of any positive food component and to restrict intake of any negative food component). The nutritional quality of foods according to positive food components, negative food components, and a combination of positive and negative food components can be computed by Rules 13, 14, and 15, respectively. Each food is given a numeric score from 0 to 100 to demonstrate the nutritional quality for each of those three aspects. A higher score is preferred to a lower

Table 2 High and source claims for positive food components according to the suggested procedure, CAC and FDA in serving, CAC in 100 grams or 100 milliliters, and CAC in 100 kilocalories

Food component (nutrient)	Claim	Suggested procedure	FDA in serving (IOM 2010)	CAC in 100 g or 100 mL, 100 kcal, and serving (CAC 2007, 2013)
Vitamins and minerals (excluding sodium)	Source	2,000 kcal: 10–19% of DV for food component in RACC (and in 200 kcal of RACC if RACC is greater than 200 kcal) 1,000 kcal: 10–19% of DV for food component in RACC (and in 100 kcal of RACC if RACC is greater than 100 kcal)	10–19% of DV for food component in RACC	100 g: 15–29% of NRV for food component in 100 g 100 mL: 7.5–14% of NRV for food component in 100 mL 100 kcal: 5–9% of NRV for food component in 100 kcal Serving: 15–29% of NRV for food component in RACC
	High	2,000 kcal: 20% or greater of DV for food component in RACC (and in 200 kcal of RACC if RACC is greater than 200 kcal) 1,000 kcal: 20% or greater of DV for food component in RACC (and in 100 kcal of RACC if RACC is greater than 100 kcal)	20% or greater of DV for food component in RACC	100 g: 30% or greater of NRV for food component in 100 g 100 mL: 15% or greater of NRV for food component in 100 mL 100 kcal: 10% or greater of NRV for food component in 100 kcal Serving: 30% or greater of NRV for food component in RACC
Dietary fiber	Source	2,000 kcal: 10–19% of DV for dietary fiber in RACC (and in 200 kcal of RACC if RACC is greater than 200 kcal) (Forouzesh et al. 2023a) 1,000 kcal: 10–19% of DV for dietary fiber in RACC (and in 100 kcal of RACC if RACC is greater than 100 kcal) (Forouzesh et al. 2023a)	10–19% of DV for dietary fiber in RACC	100 g: 10–19% of DRV for dietary fiber in 100 g 100 kcal: 5–9% of DRV for dietary fiber in 100 kcal Serving: 10–19% of DRV for dietary fiber in RACC
	High	2,000 kcal: 20% or greater of DV for dietary fiber in RACC (and in 200 kcal of RACC if RACC is greater than 200 kcal) (Forouzesh et al. 2023a) 1,000 kcal: 20% or greater of DV for dietary fiber in RACC (and in 100 kcal of RACC if RACC is greater than 100 kcal) (Forouzesh et al. 2023a)	20% or greater of DV for dietary fiber in RACC	100 g: 20% or greater of DRV for dietary fiber in 100 g 100 kcal: 10% or greater of DRV for dietary fiber in 100 kcal Serving: 20% or greater of DRV for dietary fiber in RACC
Protein	Source	2,000 kcal: 10–19% of DV for protein in RACC (and in 200 kcal of RACC if RACC is greater than 200 kcal) 1,000 kcal: 10–19% of DV for protein in RACC (and in 100 kcal of RACC if RACC is greater than 100 kcal)	10–19% of DV for protein in RACC	100 g: 10–19% of NRV for protein in 100 g 100 mL: 5–9% of NRV for protein in 100 mL 100 kcal: 5–9% of NRV for protein in 100 kcal Serving: 10–19% of NRV for protein in RACC
	High	2,000 kcal: 20% or greater of DV for protein in RACC (and in 200 kcal of RACC if RACC is greater than 200 kcal) 1,000 kcal: 20% or greater of DV for protein in RACC (and in 100 kcal of RACC if RACC is greater than 100 kcal)	20% or greater of DV for protein in RACC	100 g: 20% or greater of NRV for protein in 100 g 100 mL: 10% or greater of NRV for protein in 100 mL 100 kcal: 10% or greater of NRV for protein in 100 kcal Serving: 20% or greater of NRV for protein in RACC

score. A higher score for nutritional quality based on positive food components demonstrates that a specified amount of food contains suitable levels (source and high levels) of many positive food components, and a lower score demonstrates that it contains suitable levels of few positive food components. A higher score for nutritional quality based on negative food components demonstrates that a specified amount of food contains suitable levels (free, very low, and low levels) of many negative food components, and a lower score

Table 3 Low, very low, and free claims for negative food components according to the suggested procedure, FDA in serving, and CAC in 100 grams or 100 milliliters

Food component (nutrient)	Claim	Suggested procedure	FDA in serving (IOM 2010)	CAC in 100 g or 100 mL (CAC 2007, 2013)
Cholesterol	Low	2,000 kcal: 15 mg (5% of DV) or smaller of cholesterol and 1 g (5% of DV) or smaller of saturated fat in RACC (and in 30 g of food if RACC is smaller than 30 g) 1,000 kcal: 15 mg (5% of DV) or smaller of cholesterol and 0.5 g (5% of DV) or smaller of saturated fat in RACC (and in 30 g of food if RACC is smaller than 30 g)	All foods, excluding meals and main dishes: 20 mg (6.67% of DV) or smaller of cholesterol (and in 50 g of food if RACC is 30 g or smaller or 2 tablespoons or smaller) and 2 g (10% of DV) or smaller of saturated fat in RACC Meals and main dishes: 20 mg (6.67% of DV) or smaller of cholesterol and 2 g (10% of DV) or smaller of saturated fat in 100 g	Solids: 20 mg (6.67% of NRV) or smaller of cholesterol and 1.5 g (7.5% of NRV) or smaller of saturated fat in 100 g and not greater than 10% of energy from saturated fat Liquids: 10 mg (3.333% of NRV) or smaller of cholesterol and 0.75 g (3.75% of NRV) or smaller of saturated fat in 100 mL and not greater than 10% of energy from saturated fat
	Free	2,000 kcal: 1.5 mg (0.5% of DV) or smaller of cholesterol and 1 g (5% of DV) or smaller of saturated fat in RACC (and in 30 g of food if RACC is smaller than 30 g) 1,000 kcal: 1.5 mg (0.5% of DV) or smaller of cholesterol and 0.5 g (5% of DV) or smaller of saturated fat in RACC (and in 30 g of food if RACC is smaller than 30 g)	All foods, excluding meals and main dishes: Smaller than 2 mg (0.667% of DV) of cholesterol and 2 g (10% of DV) or smaller of saturated fat in RACC and in labeled serving Meals and main dishes: Smaller than 2 mg (0.667% of DV) of cholesterol and 2 g (10% of DV) or smaller of saturated fat in labeled serving	Solids: 5 mg (1.667% of NRV) or smaller of cholesterol and 1.5 g (7.5% of NRV) or smaller of saturated fat in 100 g and not greater than 10% of energy from saturated fat Liquids: 5 mg (1.667% of NRV) or smaller of cholesterol and 0.75 g (3.75% of NRV) or smaller of saturated fat in 100 mL and not greater than 10% of energy from saturated fat
Energy	Low	2,000 kcal: 100 kcal (5% of DV) or smaller of energy in RACC (and in 30 g of food if RACC is smaller than 30 g) 1,000 kcal: 50 kcal (5% of DV) or smaller of energy in RACC (and in 30 g of food if RACC is smaller than 30 g)	All foods, excluding meals and main dishes: 40 kcal (2% of DV) or smaller of energy in RACC (and in 50 g of food if RACC is 30 g or smaller or 2 tablespoons or smaller) Meals and main dishes: 120 kcal (6% of DV) or smaller of energy in 100 g	Solids: 40 kcal (2% of DRV) or smaller of energy in 100 g Liquids: 20 kcal (1% of DRV) or smaller of energy in 100 mL
	Free	2,000 kcal: 10 kcal (0.5% of DV) or smaller of energy in RACC (and in 30 g of food if RACC is smaller than 30 g) 1,000 kcal: 5 kcal (0.5% of DV) or smaller of energy in RACC (and in 30 g of food if RACC is smaller than 30 g)	Smaller than 5 kcal (0.25% of DV) of energy in RACC and in labeled serving	Solids and liquids: 4 kcal (0.2% of DRV) or smaller of energy in 100 g (for solids) or 100 mL (for liquids)
Fat	Low	2,000 kcal: 3.889 g (5% of DV) or smaller of fat in RACC (and in 30 g of food if RACC is smaller than 30 g) and 35% or smaller of energy from fat (Forouzesh et al. 2023b) 1,000 kcal: 1.945 g (5% of DV) or smaller of fat in RACC (and in 30 g of food if RACC is smaller than 30 g) and 35% or smaller of energy from fat (Forouzesh et al. 2023b)	All foods, excluding meals and main dishes: 3 g (3.857% of DV) or smaller of fat in RACC (and in 50 g of food if RACC is 30 g or smaller or 2 tablespoons or smaller) Meals and main dishes: 3 g (3.857% of DV) or smaller of fat in 100 g and 30% or smaller of energy from fat	Solids: 3 g (4.5% of NRV) or smaller of fat in 100 g Liquids: 1.5 g (2.25% of NRV) or smaller of fat in 100 mL
	Free	2,000 kcal: 0.389 g (0.5% of DV) or smaller of fat in RACC (and in 30 g of food if RACC is smaller than 30 g) and 35% or smaller of energy from fat (Forouzesh et al. 2023b) 1,000 kcal: 0.195 g (0.5% of DV) or smaller of fat in RACC (and in 30 g of food if RACC is smaller than 30 g) and 35% or smaller of energy from fat (Forouzesh et al. 2023b)	All foods, excluding meals and main dishes: Smaller than 0.5 g (0.643% of DV) of fat in RACC and in labeled serving Meals and main dishes: Smaller than 0.5 g (0.643% of DV) of fat in labeled serving	Solids: 0.5 g (0.75% of NRV) or smaller of fat in 100 g Liquids: 0.5 g (0.75% of NRV) or smaller of fat in 100 mL

Table 3 (continued)

Food component (nutrient)	Claim	Suggested procedure	FDA in serving (IOM 2010)	CAC in 100 g or 100 mL (CAC 2007, 2013)
Saturated fat	Low	2,000 kcal: 1 g (5% of DV) or smaller of saturated fat in RACC (and in 30 g of food if RACC is smaller than 30 g) and 9% or smaller of energy from saturated fat 1,000 kcal: 0.5 g (5% of DV) or smaller of saturated fat in RACC (and in 30 g of food if RACC is smaller than 30 g) and 9% or smaller of energy from saturated fat	All foods, excluding meals and main dishes: 1 g (5% of DV) or smaller of saturated fat in RACC and 15% or smaller of energy from saturated fat Meals and main dishes: 1 g (5% of DV) or smaller of saturated fat in 100 g and smaller than 10% of energy from saturated fat	Solids: 1.5 g (7.5% of NRV) or smaller of saturated fat in 100 g and 10% or smaller of energy from saturated fat Liquids: 0.75 g (3.75% of NRV) or smaller of saturated fat in 100 mL and 10% or smaller of energy from saturated fat
	Free	2,000 kcal: 0.1 g (0.5% of DV) or smaller of saturated fat in RACC (and in 30 g of food if RACC is smaller than 30 g) and 9% or smaller of energy from saturated fat 1,000 kcal: 0.05 g (0.5% of DV) or smaller of saturated fat in RACC (and in 30 g of food if RACC is smaller than 30 g) and 9% or smaller of energy from saturated fat	All foods, excluding meals and main dishes: Smaller than 0.5 g (2.5% of DV) of saturated fat and smaller than 0.5 g of *trans* fat in RACC and in labeled serving Meals and main dishes: Smaller than 0.5 g (2.5% of DV) of saturated fat and smaller than 0.5 g of *trans* fat in labeled serving	Solids: 0.1 g (0.5% of NRV) or smaller of saturated fat in 100 g Liquids: 0.1 g (0.5% of NRV) or smaller of saturated fat in 100 mL
Sodium	Low	2,000 kcal: 115 mg (5% of DV) or smaller of sodium in RACC (and in 30 g of food if RACC is smaller than 30 g) 1,000 kcal: 75 mg (5% of DV) or smaller of sodium in RACC (and in 30 g of food if RACC is smaller than 30 g)	All foods, excluding meals and main dishes: 140 mg (6.09% of DV) or smaller of sodium in RACC (and in 50 g of food if RACC is 30 g or smaller or 2 tablespoons or smaller) Meals and main dishes: 140 mg (6.09% of DV) or smaller of sodium in 100 g	Solids and liquids: 120 mg (6% of NRV) or smaller of sodium in 100 g
	Very low	2,000 kcal: 57.5 mg (2.5% of DV) or smaller of sodium in RACC (and in 30 g of food if RACC is smaller than 30 g) 1,000 kcal: 37.5 mg (2.5% of DV) or smaller of sodium in RACC (and in 30 g of food if RACC is smaller than 30 g)	All foods, excluding meals and main dishes: 35 mg (1.522% of DV) or smaller of sodium in RACC (and in 50 g of food if RACC is 30 g or smaller or 2 tablespoons or smaller) Meals and main dishes: 35 mg (1.522% of DV) or smaller of sodium in 100 g	Solids and liquids: 40 mg (2% of NRV) or smaller of sodium in 100 g
	Free	2,000 kcal: 11.5 mg (0.5% of DV) or smaller of sodium in RACC (and in 30 g of food if RACC is smaller than 30 g) 1,000 kcal: 7.5 mg (0.5% of DV) or smaller of sodium in RACC (and in 30 g of food if RACC is smaller than 30 g)	All foods, excluding meals and main dishes: Smaller than 5 mg (0.218% of DV) of sodium in RACC and in labeled serving Meals and main dishes: Smaller than 5 mg (0.218% of DV) of sodium in labeled serving	Solids and liquids: 5 mg (0.25% of NRV) or smaller of sodium in 100 g
Sugars	Low	2,000 kcal: 6.65 g (5% of DV) or smaller of sugars in RACC (and in 30 g of food if RACC is smaller than 30 g) 1,000 kcal: 3.325 g (5% of DV) or smaller of sugars in RACC (and in 30 g of food if RACC is smaller than 30 g)		
	Free	2,000 kcal: 0.665 g (0.5% of DV) or smaller of sugars in RACC (and in 30 g of food if RACC is smaller than 30 g) 1,000 kcal: 0.3325 g (0.5% of DV) or smaller of sugars in RACC (and in 30 g of food if RACC is smaller than 30 g)		

demonstrates that it contains suitable levels of few negative food components.

$$\text{Nutritional quality according to positive food components (to reach sufficient intake of any positive food component)} = \left[\left(\frac{100}{a \times 2}\right) \times b\right] + \left[\left(\frac{100}{a \times 2}\right) \times (c \times 2)\right] \quad (13)$$

a = number of high claims; b = number of source food components (number of satisfied source claims); c = number of high food components (number of satisfied high claims).

$$\text{Nutritional quality according to negative food components (to restrict intake of any negative food component)} = \left[\left(\frac{100}{d \times 2}\right) \times (e \times 2)\right] + \left[\left(\frac{100}{d \times 2}\right) \times (f \times 1.5)\right] + \left[\left(\frac{100}{d \times 2}\right) \times g\right] \quad (14)$$

d = number of free claims; e = number of free food components (number of satisfied free claims); f = number of very low food components that are not free (number of satisfied very low claims that did not satisfy their free claims); g = number of low food components that are not free or very low (number of satisfied low claims that did not satisfy their free or very low claims).

$$\text{Nutritional quality according to } a \text{ combination of positive and negative food components (to reach sufficient intake of any positive food component and to restrict intake of any negative food component)} = \left[\left(\frac{100}{i \times 2}\right) \times (j \times 2)\right] + \left[\left(\frac{100}{i \times 2}\right) \times (f \times 1.5)\right] + \left[\left(\frac{100}{i \times 2}\right) \times (b + g)\right] \quad (15)$$

b = number of source food components (number of satisfied source claims); f = number of very low food components that are not free (number of satisfied very low claims that did not satisfy their free claims); g = number of low food components that are not free or very low (number of satisfied low claims that did not satisfy their free or very low claims); i = number of high and free claims; j = number of high and free food components (number of satisfied high and free claims).

Results

Vulnerabilities of computing the amount of positive food component and assessing suitable levels of positive food components according to the FDA in serving

Since consumption of some foods in RACC leads to obtaining extensive energy at each eating occasion, the amount of the positive food component of those foods should be computed in amounts smaller than RACCs. According to the FDA in serving, since computing the amount of the positive food component and assessing suitable levels of positive food components are implemented in RACC (without considering the energy amount of foods), selecting some foods under the FDA in serving to reach sufficient intakes of positive food components satisfied the demands of positive food components but surpassed energy demands. For instance, if pecan pie (NDB number 18325) contains 412 kilocalories of energy in 100 grams, RACC of 125 grams, and 1.85 milligrams of iron in RACC, is it described as high in iron or source of iron according to the suggested procedure and FDA in serving? Since that pecan pie contains 1.85 milligrams of iron in RACC, it is described as the source of iron according to the FDA in serving. Consumption of 9.73 RACCs of the pecan pie satisfies the DV for iron but leads to obtaining 5,010.8 kilocalories of energy, which is 3,010.8 kilocalories greater than the DV or DRV for energy. Since the serving of that pecan pie according to the suggested procedure is 48.54 grams and this amount of pecan pie contains 0.72 milligram of iron, that pecan pie is not described as high in iron or source of iron under the suggested procedure.

Since consumption of some foods in RACC leads to obtaining extensive energy at each eating occasion, the nutritional quality according to positive food components should be evaluated in amounts smaller than RACCs for those foods. Computing the amount of the positive food component of some foods in large amounts (without considering the energy amount of foods) under the FDA in serving elevated the average scores for nutritional quality based on positive food components in 22 food categories as compared with the suggested procedure. For instance, the average scores for nutritional quality based on positive food components in fast foods, restaurant foods, and meals, entrees, and side dishes were respectively 44.7, 33.45, and 34.5 under the FDA in serving (Figure S1) and 23.75, 19.79, and 23.09 under the suggested procedure (Fig. 4). According to the FDA in serving, fast foods had the highest average scores for

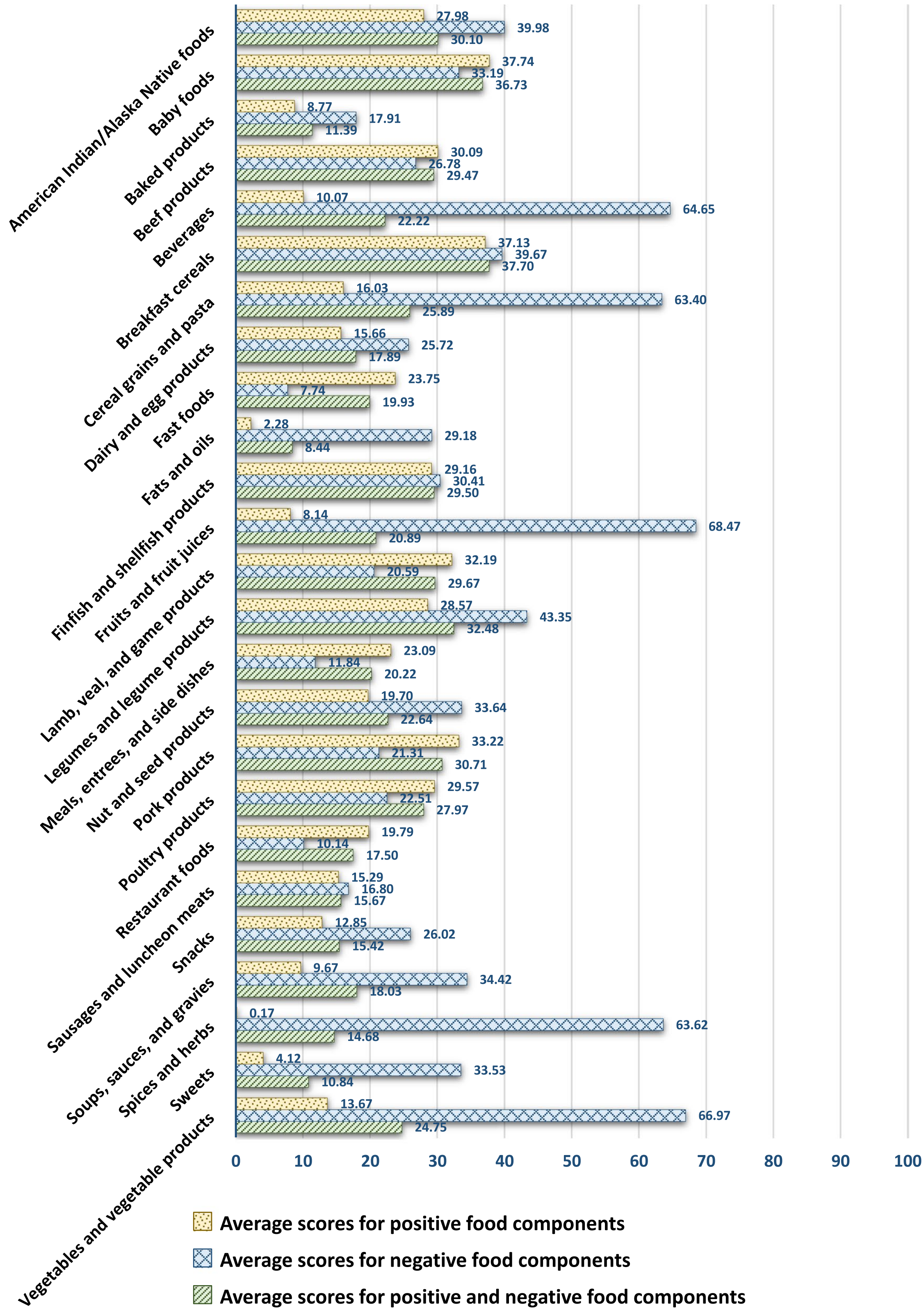


Fig. 4 Average scores of foods for nutritional quality based on positive food components (to reach sufficient intake of any positive food component), negative food components (to restrict intake of any negative food component), and a combination of positive and negative food components (to reach sufficient intake of any positive food component and to restrict intake of any negative food component) under the suggested procedure in food categories

nutritional quality based on positive food components among 25 food categories (ranked first among food categories). According to the suggested procedure, the rank of fast foods for nutritional quality based on positive food components was 10th among 25 food categories because computing the amount of the positive food component and assessing suitable levels of positive food components under the suggested procedure are implemented by considering RACCs and the energy amount of foods.

Vulnerabilities of computing the amount of negative food component and assessing suitable levels of negative food components according to the FDA in serving

Computing the amount of the negative food component in 100 grams demonstrates the amount of the negative food component of meals and main dishes unsuitably low because meals and main dishes are customarily consumed in amounts greater than 100 grams at each eating occasion. According to the FDA in serving, since the energy, saturated fat, cholesterol, and sodium amounts of meals and main dishes are computed in 100 grams (without considering RACCs) and foods low in food components are assessed by employing the high amounts of the low claims for cholesterol, energy, and sodium in meals and main dishes, selecting some foods under the FDA in serving to restrict intakes of cholesterol, energy, saturated fat, and sodium surpassed the demands of energy, saturated fat, cholesterol, and sodium. For instance, if chicken and dumplings (NDB number 22952; main dish product) contains 14 milligrams of cholesterol in 100 grams, 34.58 milligrams of cholesterol in RACC, 1.822 grams of saturated fat in 100 grams, and 4.5 grams of saturated fat in RACC, is it described as low in cholesterol according to the suggested procedure and FDA in serving? Since that chicken and dumplings contains smaller than 20 milligrams of cholesterol in 100 grams and smaller than 2 grams of saturated fat in 100 grams, it is described as low in cholesterol according to the FDA in serving. However, consumption of 20 RACCs of the chicken and dumplings leads to obtaining 691.6 milligrams of cholesterol and 90 grams of saturated fat, which are 391.6 milligrams and 70 grams greater than the DVs for cholesterol and saturated fat, respectively. Since that chicken and dumplings contains greater than 15 milligrams of cholesterol in RACC and greater than 1 gram of saturated fat in RACC, it is not described as low in cholesterol according to the suggested procedure.

Computing the amount of the negative food component in 50 grams demonstrates the amount of the negative food component of some foods unsuitably high because some foods are customarily consumed in amounts smaller than 50 grams at each eating occasion. Since computing the cholesterol, energy, and sodium amounts and assessing the low claims for cholesterol, energy, and sodium in small RACCs according to the FDA in serving are implemented in 50 grams of food, some foods that did not surpass the demands of cholesterol, energy, and sodium were not suitable food selections under the FDA in serving to restrict intakes of cholesterol, energy, and sodium. According to the FDA in serving, the small RACC demonstrates the RACC of 30 grams or smaller or two tablespoons or smaller (IOM 2010). For instance, if balsamic vinegar (NDB number 2069) contains RACC of 16 grams and 14.08 kilocalories of energy in RACC, is it described as low in energy according to the suggested procedure and FDA in serving? Since that vinegar contains 44 kilocalories of energy in 50 grams, it is not described as low in energy according to the FDA in serving. Consumption of 2272.8 grams of the vinegar leads to surpassing the DV for energy, and that vinegar is customarily consumed 320 grams per day in 20 eating occasions. Since the serving of that vinegar according to the suggested procedure is 30 grams and this amount of vinegar contains 26.4 kilocalories of energy, that vinegar is described as low in energy under the suggested procedure.

Since the cholesterol and saturated fat amounts of the low cholesterol claim according to the FDA in serving are high for all foods, selecting some foods under the FDA in serving to restrict cholesterol and saturated fat intakes surpassed cholesterol or saturated fat demands. For instance, if pork luxury loaf (NDB number 7060) contains 19.8 milligrams of cholesterol in RACC and 0.869 gram of saturated fat in RACC, is it described as low in cholesterol according to the suggested procedure and FDA in serving? Since that luxury loaf contains smaller than 20 milligrams of cholesterol in RACC and smaller than 2 grams of saturated fat in RACC, it is described as low in cholesterol according to the FDA in serving. However, consumption of 20 RACCs of the luxury loaf leads to obtaining 396 milligrams of cholesterol, which is 96 milligrams greater than the DV for cholesterol. Since that luxury loaf contains greater than 15 milligrams of cholesterol in RACC, it is not described as low in cholesterol according to the suggested procedure.

Since the energy amount of the low energy claim according to the FDA in serving is low for all foods, excluding meals and main dishes, some foods that did not surpass energy demands were not suitable food selections based on the FDA in serving to restrict energy intake. For instance, if vanilla or lemon yogurt (NDB number 1184; made from fat free milk with low calorie sweetener) contains RACC of 170 grams, 43 kilocalories of energy in 100 grams, and 73.1 kilocalories of energy in RACC, is it described as low in energy or free of energy according to the suggested procedure and FDA in serving? Since that yogurt contains greater than 40 kilocalories of energy in RACC, it is not described as low in energy or free of energy according to the FDA in serving. Consumption of 4,652 grams of the yogurt leads to surpassing the DV for energy, and that yogurt is customarily consumed 3,400 grams per day in 20 eating occasions. Since that yogurt contains 73.1 kilocalories of energy in RACC, it is described as low in energy according to the suggested procedure.

Since the energy and sodium amounts of small RACCs according to the FDA in serving are computed in RACC and in labeled serving for the free claims and in 50 grams of food for the low claims, some foods were free of, but not low in, energy or sodium, even though the amounts of the free claims were much lower than the amounts of the low claims. For instance, according to the FDA in serving, one food in the category of spices and herbs (NDB number 2066) and two foods in the category of sweets (NDB numbers 19909 and 43158) were free of, but not low in, sodium (Table S1). Also, according to the FDA in serving, since foods free of saturated fat are assessed without considering the percentage of energy from saturated fat and foods low in saturated fat are assessed by employing the percentage of energy from saturated fat, some foods were free of, but not low in, saturated fat, even though the saturated fat amount of the saturated fat free claim was much lower than the saturated fat amount of the low saturated fat claim. For instance, according to the FDA in serving, one food in the category of fats and oils (NDB number 4631), five foods in the category of soups, sauces, and gravies (NDB numbers 6324, 6326, 6997, 6332, and 6470), and one food in the category of sweets (NDB number 19916) were free of, but not low in, saturated fat (Table S2).

Since the RACC for some foods is small and surpassing the RACC can simply happen for small RACCs, computing the saturated fat amount in RACC demonstrates the saturated fat amount of small RACCs unsuitably low. According to the FDA in serving, since computing the saturated fat amount and assessing the low saturated fat claim for small RACCs are implemented in RACC, selecting some foods under the FDA in serving to restrict saturated fat intake surpassed saturated fat demands. Some foods have small RACCs, and surpassing the RACC can simply happen for small RACCs. Therefore, if the RACC is smaller than 30 grams, computing the saturated fat amount and assessing suitable levels of saturated fat according to the suggested procedure are implemented in 30 grams of food. For instance, if industrial canola oil (NDB number 4698) contains RACC of 14 grams, 6.787 grams of saturated fat in 100 grams, 0.95 gram of saturated fat in RACC, and 6.8% of energy from saturated fat, is it described as low in saturated fat according to the suggested procedure and FDA in serving? Since that canola oil contains smaller than 1 gram of saturated fat in RACC and smaller than 15% of energy from saturated fat, it is described as low in saturated fat according to the FDA in serving. Since the serving of that canola oil according to the suggested procedure is 30 grams due to the small RACC and this amount of canola oil contains 2.036 grams of saturated fat, that canola oil is not described as low in saturated fat under the suggested procedure. Consumption of 20 servings (serving of 30 grams) of the canola oil leads to obtaining 40.7 grams of saturated fat, which is 20.7 grams greater than the DV for saturated fat.

According to the FDA in serving, since foods free of saturated fat are assessed without considering the percentage of energy from saturated fat and foods low in saturated fat are assessed by employing the high percentage of energy from saturated fat, some foods that had high percentages of energy from saturated fat were suitable food selections based on the FDA in serving to restrict saturated fat intake. For instance, if margarine-like vegetable oil spread with salt (NDB number 4633; 20% fat) contains 2.87 grams of saturated fat in 100 grams, 0.43 gram of saturated fat in RACC, and 14.76% of energy from saturated fat, is it described as low in saturated fat according to the suggested procedure and FDA in serving? Since that margarine-like spread contains smaller than 1 gram of saturated fat in RACC and smaller than 15% of energy from saturated fat, it is described as low in saturated fat under the FDA in serving. However, according to the DV for saturated fat, the percentage of energy from saturated fat should be a maximum of 9%. Since that margarine-like spread contains greater than 9% of energy from saturated fat, it is not described as low in saturated fat according to the suggested procedure.

Vulnerabilities of computing the amount of positive food component and assessing suitable levels of positive food components according to the CAC in 100 grams or 100 milliliters

Computing the amount of the positive food component in 100 or 100 milliliters demonstrates the amount of the positive food component of some foods unsuitably high because some foods are customarily consumed in amounts smaller than 100 grams or 100 milliliters at each eating occasion. Since computing the amount of the positive food component and assessing suitable levels of positive food components according to the CAC in 100 grams or 100 milliliters are implemented without considering RACCs, selecting some foods under the CAC in 100 grams or 100 milliliters to reach sufficient intakes of positive food components did not satisfy the demands of positive food components. For instance, if dried marjoram

(NDB number 2023) contains RACC of 0.2 gram and 1.69 milligrams of vitamin E in 100 grams, is it described as high in vitamin E or source of vitamin E according to the suggested procedure and CAC in 100 grams? Since that dried marjoram contains 1.69 milligrams of vitamin E in 100 grams, it is described as the source of vitamin E according to the CAC in 100 grams. Consumption of 532.54 grams of the dried marjoram satisfies the NRV for vitamin E, but that dried marjoram is customarily consumed 2 grams in 10 eating occasions. Since the serving of that dried marjoram according to the suggested procedure is 0.2 gram and this amount of dried marjoram contains 0.003 milligram of vitamin E, that dried marjoram is not described as high in vitamin E or source of vitamin E under the suggested procedure.

Computing the amount of the positive food component in 100 grams or 100 milliliters demonstrates the amount of the positive food component of some foods unsuitably low because some foods are customarily consumed in amounts greater than 100 grams or 100 milliliters at each eating occasion. According to the CAC in 100 grams or 100 milliliters, since the amounts of positive food components of some foods are computed in small amounts and foods high in food components and source of food components (excluding liquid foods) are assessed by employing the high amounts of the source and high claims for positive food components, some foods that satisfied the demands of positive food components were not suitable food selections under the CAC in 100 grams or 100 milliliters to reach sufficient intakes of positive food components. For instance, if watermelon (NDB number 9326) contains RACC of 280 grams and 8.1 milligrams of vitamin C in 100 grams, is it described as high in vitamin C or source of vitamin C according to the suggested procedure and CAC in 100 grams? Since that watermelon contains 8.1 milligrams of vitamin C in 100 grams, it is not described as high in vitamin C or source of vitamin C according to the CAC in 100 grams. Consumption of 1,234.6 grams of the watermelon satisfies the NRV for vitamin C, and that watermelon is customarily consumed 2,800 grams in 10 eating occasions. Since the serving of that watermelon according to the suggested procedure is 280 grams and this amount of watermelon contains 22.68 milligrams of vitamin C, that watermelon is described as high in vitamin C under the suggested procedure.

Since consumption of some foods in 100 grams or 100 milliliters leads to obtaining extensive energy at each eating occasion, the amount of the positive food component of those foods should be computed in amounts smaller than 100 grams or 100 milliliters. According to the CAC in 100 grams or 100 milliliters, since computing the amount of the positive food component and assessing suitable levels of positive food components are implemented without considering the energy amount of foods, selecting some foods under the CAC in 100 grams or 100 milliliters to reach sufficient intakes of positive food components surpassed energy demands. For instance, if flaxseed oil (NDB number 42231) contains 884 kilocalories of energy in 100 grams, RACC of 13.6 grams, and 9.3 micrograms of vitamin K in 100 grams, is it described as high in vitamin K or source of vitamin K according to the suggested procedure and CAC in 100 grams? Since that flaxseed oil contains 9.3 micrograms of vitamin K in 100 grams, it is described as the source of vitamin K according to the CAC in 100 grams. Consumption of 645.16 grams of the flaxseed oil satisfies the NRV for vitamin K but leads to obtaining 5,703 kilocalories of energy, which is 3,703 kilocalories greater than the DV or DRV for energy. Since the serving of that flaxseed oil according to the suggested procedure is 13.6 grams and this amount of flaxseed oil contains 1.26 micrograms of vitamin K, that flaxseed oil is not described as high in vitamin K or source of vitamin K under the suggested procedure.

Since consumption of some foods in 100 grams or 100 milliliters leads to obtaining extensive energy at each eating occasion and some foods are customarily consumed in amounts smaller or greater than 100 g or 100 ml at each eating occasion, assessing the nutritional quality based on positive food components in 100 grams or 100 milliliters demonstrates the nutritional quality based on positive food components unsuitably high or low for some foods. Computing the amount of the positive food component of some foods in small amounts and some other foods in large amounts and employing strict criteria of the source and high claims for positive food components under the CAC in 100 grams or 100 milliliters elevated the average scores for nutritional quality based on positive food components in 14 food categories (spices and herbs; nut and seed products; snacks; baked products; breakfast cereals; cereal grains and pasta; sausages and luncheon meats; dairy and egg products; sweets; fats and oils; American Indian/Alaska Native foods; baby foods; legumes and legume products; beverages) and reduced the average scores for nutritional quality based on positive food components in 11 food categories (meals, entrees, and side dishes; soups, sauces, and gravies; lamb, veal, and game products; pork products; vegetables and vegetable products; poultry products; fruits and fruit juices; restaurant foods; beef products; finfish and shellfish products; fast foods) as compared with the suggested procedure. For instance, the average scores for nutritional quality based on positive food components in spices and herbs, nut and seed products, snacks, baked products, and meals, entrees, and side dishes were respectively 48.69, 43.77, 34.84, 24.47, and 13.69 under the CAC in 100 grams or 100 milliliters (Figure S2) and 0.17, 19.7, 12.85, 8.77, and 23.09 under the suggested procedure (Fig. 4). According to the CAC in 100 grams or 100 milliliters, spices and herbs had the highest average scores for nutritional quality based on positive food components among food categories. According to the suggested procedure, spices and herbs had the lowest average scores for nutritional quality based on positive food components among food categories because spices and herbs are customarily consumed in small quantities. Spices and herbs make sensory features including flavor, aroma, and color to food (Kubra et al. 2016).

Vulnerabilities of computing the amount of negative food component and assessing suitable levels of negative food components according to the CAC in 100 grams or 100 milliliters

Computing the amount of the negative food component in 100 grams or 100 milliliters demonstrates the amount of the negative food component of some foods unsuitably low because some foods are customarily consumed in amounts greater than 100 grams or 100 milliliters at each eating occasion. According to the CAC in 100 grams or 100 milliliters, since the cholesterol, saturated fat, and sodium amounts of foods are computed in 100 grams or 100 milliliters (without considering RACCs) and solid foods low in negative food components are assessed by employing the high amounts of the low claims for cholesterol, saturated fat, and sodium, selecting some foods under the CAC in 100 grams or 100 milliliters to restrict intakes of cholesterol, saturated fat, and sodium surpassed the demands of cholesterol, saturated fat, and sodium. For instance, if potato salad with egg (NDB number 22971) contains 17 milligrams of cholesterol in 100 grams, 23.8 milligrams of cholesterol in RACC, 1.437 grams of saturated fat in 100 grams, 8.238% of energy from saturated fat, and 2.01 grams of saturated fat in RACC, is it described as low in cholesterol according to the suggested procedure and CAC in 100 grams? Since that potato salad contains smaller than 20 milligrams of cholesterol in 100 grams, smaller than 1.5 grams of saturated fat in 100 grams, and smaller than 10% of energy from saturated fat, it is described as low in cholesterol according to the CAC in 100 grams. However, consumption of 20 RACCs of the potato salad leads to obtaining 476 milligrams of cholesterol and 40.2 grams of saturated fat, which are 176 and 20.2 grams greater than the NRVs for cholesterol and saturated fat, respectively. Since that potato salad contains greater than 15 milligrams of cholesterol in RACC and greater than 1 gram of saturated fat in RACC, it is not described as low in cholesterol according to the suggested procedure.

Computing the amount of the negative food component in 100 grams or 100 milliliters demonstrates the amount of the negative food component of some foods unsuitably high because some foods are customarily consumed in amounts smaller than 100 grams or 100 milliliters at each eating occasion. According to the CAC in 100 grams or 100 milliliters, since the cholesterol, energy, saturated fat, and sodium amounts of some foods are computed in large amounts and foods low in energy are assessed by employing the low energy amounts of the low energy claim, some foods that did not surpass the demands of cholesterol, energy, saturated fat, and sodium were not suitable food selections under the CAC in 100 grams or 100 milliliters to restrict intakes of cholesterol, energy, saturated fat, and sodium. For instance, if raw lime juice (NDB number 9160) contains RACC of 5 milliliters and 25.57 kilocalories of energy in 100 milliliters, is it described as low in energy or free of energy according to the suggested procedure and CAC in 100 milliliters? Since that lime juice contains greater than 20 kilocalories of energy in 100 milliliters, it is not described as low in energy or free of energy according to the CAC in 100 milliliters. Consumption of 7,822 milliliters of the lime juice leads to surpassing the DRV for energy, and that lime juice is customarily consumed 100 milliliters per day in 20 eating occasions. Since the serving of that lime juice according to the suggested procedure is 30 grams and this amount of lime juice contains 7.5 kilocalories of energy, that lime juice is described as free of energy under the suggested procedure.

According to the CAC in 100 grams or 100 milliliters, since foods free of saturated fat are assessed without considering the percentage of energy from saturated fat and foods low in saturated fat are assessed by employing the percentage of energy from saturated fat, some foods were free of, but not low in, saturated fat, even though the saturated fat amount of the saturated fat free claim was much lower than the saturated fat amounts of the low saturated fat claim. For instance, according to the CAC in 100 grams or 100 milliliters, three foods in the category of soups, sauces, and gravies (NDB numbers 6475, 6476, and 6480) were free of, but not low in, saturated fat (Table S3).

According to the CAC in 100 grams or 100 milliliters, since foods free of saturated fat are assessed without considering the percentage of energy from saturated fat and foods low in saturated fat are assessed by employing the high percentage of energy from saturated fat, some foods that had high percentages of energy from saturated fat were suitable food selections under the CAC in 100 grams or 100 milliliters to restrict saturated fat intake. For instance, if chocolate malt powder prepared with 1% fat milk (NDB number 14164) contains 0.668 gram of saturated fat in 100 milliliters and 9.947% of energy from saturated fat, is it described as low in saturated fat according to the suggested procedure and CAC in 100 milliliters? Since that malted milk drink contains smaller than 0.75 gram of saturated fat in 100 milliliters and smaller than 10% of energy from saturated fat, it is described as low in saturated fat according to the CAC in 100 milliliters. However, based on the NRV for saturated fat, the percentage of energy from saturated fat should be a maximum of 9%. In addition, consumption of 20 RACCs of the malted milk drink leads to obtaining 32 grams of saturated fat, which is 12 grams greater than the NRV for saturated fat. Since that malted milk drink contains 1.6 grams of saturated fat in RACC and greater than 9% of energy from saturated fat, it is not described as low in saturated fat according to the suggested procedure.

Employing the high sodium amount of the low sodium claim for liquid foods and assessing the low sodium claim for liquid foods in 100 grams elevated the average of liquid foods low in sodium. According to the CAC in 100 grams or 100 milliliters, the low claims for cholesterol, energy, fat, and saturated fat are assessed in 100 grams of solid foods or in 100 milliliters of liquid foods, but the low sodium claim is assessed in 100 grams of solid and liquid foods. In addition, the amounts of low claims for energy, fat, cholesterol, and saturated fat in liquid foods are half of the solid foods, but the sodium amount of the low sodium claim in liquid and solid foods is the same. For instance, if the sodium amount of the low sodium claim for liquid foods was 60 milligrams or smaller in 100 milliliters, 83.27% of liquid foods would be low in sodium. Since the sodium amount of the low sodium claim for liquid foods according to the CAC is 120 milligrams or smaller in 100 grams, 96.83% of liquid foods are low in sodium.

Vulnerabilities of computing the amount of positive food component and assessing suitable levels of positive food components according to the CAC in serving

Since consumption of some foods in RACC leads to obtaining extensive energy at each eating occasion, the amount of the positive food component of those foods should be computed in amounts smaller than RACCs. According to the CAC in serving, since computing the amount of the positive food component and assessing suitable levels of positive food components are implemented in RACC (without considering the energy amount of foods), selecting some foods under the CAC in serving to reach sufficient intakes of positive food components satisfied the demands of positive food components but surpassed energy demands. For instance, if a croissant with sausage and cheese (NDB number 21384) contains 376 kilocalories of energy in 100 grams, RACC of 140 grams, and 9.1 micrograms of vitamin K in RACC, is it described as high in vitamin K or source of vitamin K according to the suggested procedure and CAC in serving? Since that croissant with sausage and cheese contains 9.1 micrograms of vitamin K in RACC, it is described as the source of vitamin K according to the CAC in serving. Consumption of 6.593 RACCs of the croissant with sausage and cheese satisfies the NRV for vitamin K but leads to obtaining 3,471 kilocalories of energy, which is 1,471 kilocalories greater than the DV or DRV for energy. Since the serving of that croissant with sausage and cheese according to the suggested procedure is 53.19 grams and this amount of croissant with sausage and cheese contains 3.46 micrograms of vitamin K, that croissant with sausage and cheese is not described as high in vitamin K or source of vitamin K under the suggested procedure.

According to the CAC in serving, since foods considered as the source of food components are assessed by employing the high amounts of the source claims for positive food components, some foods that satisfied the demands of positive food components were not suitable food selections under the CAC in serving to reach sufficient intakes of positive food components. For instance, if Braunschweiger liver sausage (NDB number 7207) contains RACC of 55 grams, 1.87 milligrams of zinc in RACC, and 331 kilocalories of energy in 100 grams, is it described as high in zinc or source of zinc according to the suggested procedure and CAC in serving? Since that Braunschweiger liver sausage contains smaller than 1.875 milligrams of zinc in RACC, it is not described as high in zinc or source of zinc according to the CAC in serving. Consumption of 367.6 grams of the Braunschweiger liver sausage satisfies the NRV for zinc, and that Braunschweiger liver sausage is customarily consumed 550 grams in 10 eating occasions. Since the serving of that Braunschweiger liver sausage according to the suggested procedure is 55 grams and this amount of Braunschweiger liver sausage contains 1.87 milligrams of zinc, that Braunschweiger liver sausage is described as the source of zinc under the suggested procedure.

Since consumption of some foods in RACC leads to obtaining extensive energy intakes at each eating occasion, the nutritional quality based on positive food components should be evaluated in amounts smaller than RACCs for those foods. Computing the amount of the positive food component of some foods in large amounts (without considering the energy amount of foods) under the CAC in serving elevated the average scores for nutritional quality based on positive food components in three food categories (fast foods; restaurant foods; meals, entrees, and side dishes) as compared with the suggested procedure. Also, employing strict criteria of the source and high claims for positive food components according to the CAC in serving reduced the average scores for nutritional quality based on positive food components in 21 food categories as compared with the suggested procedure. For instance, the average scores for nutritional quality based on positive food components in baby foods, fast foods, legumes and legume products, and restaurant foods were respectively 26.17, 34.7, 22.75, and 24.89 under the CAC in serving (Figure S3) and 37.74, 23.75, 28.57, and 19.79 under the suggested procedure (Fig. 4). According to the CAC in serving, fast foods had the highest average scores for nutritional quality based on positive food components among 25 food categories (ranked first among food categories). According to the suggested procedure, the rank of fast foods for nutritional quality based on positive food components was 10th among 25 food categories because computing the amount of the positive food component and assessing suitable levels of positive food components under the suggested procedure are implemented by considering RACCs and the energy amount of foods.

Vulnerabilities of computing the amount of positive food component and assessing suitable levels of positive food components according to the CAC in 100 kilocalories

Computing the amount of the positive food component in 100 kilocalories demonstrates the amount of the positive food component of some foods unsuitably high because some foods are customarily consumed in amounts smaller than 100 kilocalories at each eating occasion. Since computing the amount of the positive food component and assessing suitable levels of positive food components according to the CAC in 100 kilocalories are implemented without considering RACCs, selecting some foods under the CAC in 100 kilocalories to reach sufficient intakes of positive food components did not satisfy the demands of positive food components. For instance, if canned butterbur (NDB number 11108) contains 3 kilocalories of energy in 100 grams, RACC of 130 grams, and 0.11 gram of protein in 100 grams, is it described as high in protein or source of protein according to the suggested procedure and CAC in 100 kilocalories? Since that canned butterbur contains 3.66 grams of protein in 100 kilocalories, it is described as the source of protein according to the CAC in 100 kilocalories. Consumption of 45,454.5 grams of the canned butterbur satisfies the NRV for protein, but that canned butterbur is customarily consumed 1,300 grams in 10 eating occasions. Since the serving of that canned butterbur according to the suggested procedure is 130 grams and this amount of canned butterbur contains 0.14 gram of protein, that canned butterbur is not described as high in protein or source of protein under the suggested procedure.

The assessment of nutritional quality based on positive food components in 100 kilocalories demonstrates the nutritional quality based on positive food components unsuitably high for some foods because some foods are customarily consumed in amounts smaller than 100 kilocalories at each eating occasion. Computing the amount of the positive food component of some foods in large amounts under the CAC in 100 kilocalories elevated the average scores for nutritional quality based on positive food components in 24 food categories as compared with the suggested procedure. For instance, the average scores for nutritional quality based on positive food components in spices and herbs, vegetables and vegetable products, baby foods, and soups, sauces, and gravies were respectively 54.2, 62.17, 66.08, and 31.87 under the CAC in 100 kilocalories (Figure S4) and 0.17, 13.67, 37.74, and 9.67 under the suggested procedure (Fig. 4). According to the CAC in 100 kilocalories, vegetables and vegetable products and spices and herbs had the highest average scores for nutritional quality based on positive food components among food categories for children aged four years and older and adults. According to the suggested procedure, spices and herbs had the lowest average scores for nutritional quality based on positive food components among food categories because spices and herbs are customarily consumed in small quantities. Also, according to the suggested procedure, the rank of vegetables and vegetable products for nutritional quality based on positive food components was 17th among 25 food categories because only some positive food components with suitable levels (including vitamin C, copper, vitamin K, manganese, dietary fiber, folate, vitamin B_6, and vitamin A) were abundant in vegetables and vegetable products.

Foods containing suitable levels of food components based on the suggested procedure

This section was presented in the Supplementary Material.

Averages of foods containing suitable levels of two food components according to the suggested procedure in food categories

Food containing suitable levels of two positive food components can be used to reach sufficient intakes of two positive food components. Food containing suitable levels of two negative food components can be used to restrict intakes of two negative food components. Food containing suitable levels of a positive food component and a negative food component can be used to reach sufficient intake of a positive food component and restrict intake of a negative food component. For instance, food containing suitable levels of potassium and sodium can be used to reach sufficient potassium intake and restrict sodium intake.

Averages (%) of foods containing suitable levels of two food components according to the suggested procedure in food categories are provided in Tables S4-S28.

Assessment of the nutritional quality of foods according to the suggested procedure

Breakfast cereals, baby foods, legumes and legume products, pork products, American Indian/Alaska Native foods, lamb, veal, and game products, finfish and shellfish products, beef products, and poultry products had the highest average scores for nutritional quality based on positive food components (to reach sufficient intake of any positive food component) and a combination of positive and negative food components (to reach sufficient intake of any positive food component and to restrict intake of any negative food component). In contrast, fats and oils, sweets, baked products, spices and herbs, snacks, and sausages and luncheon meats had the lowest average scores for nutritional quality based on a combination of positive and negative food components (Fig. 4).

Fruits and fruit juices, vegetables and vegetable products, beverages, spices and herbs, cereal grains and pasta, legumes and legume products, American Indian/Alaska Native foods, and breakfast cereals had the highest average scores for nutritional quality based on negative food components (to restrict intake of any negative food component). In contrast, fast foods, restaurant foods, meals, entrees, and side dishes, sausages and luncheon meats, and baked products had the lowest average scores for nutritional quality based on negative food components (Fig. 4).

The highest average scores for nutritional quality based on a combination of positive and negative food components were detected in nutrition shake (fortified), protein shake (fortified), formulated bar (fortified), breakfast cereal (fortified), infant or child formula (fortified), moose liver, fruit juice (fortified), lamb liver, pork liver, lambsquarters, chicken liver, vegetable juice (fortified), beef liver, tofu (fortified), spinach, veggie burgers (fortified), duck liver, veal liver, turkey liver, chicken giblets, goose liver, potherb jute, emu meat, instant breakfast drink (fortified), beef kidney, beet greens, elk meat, amaranth leaves, buffalo top round steak, fireweed leaves, caribou meat, leafy tips of bitter gourd, seal meat, cuttlefish, dried goji berries, lamb kidney, rose hips, sea lion liver, sea lion heart, waffles (fortified), whole grain pasta, adzuki beans, white beans, pork kidney, whelk, chia seeds, soy milk (fortified), cowpeas, elk meat, malted milk drink (fortified), turkey giblets, protein bar (fortified), edamame, ostrich meat, kidney beans, lima beans, blue mussel, veal kidney, beef spleen, cranberry beans, quail meat, soy yogurt (fortified), deer meat, green soybeans, pink beans, lentils, taro leaves, soybeans, juice drink (fortified), pork heart, yardlong beans, winged bean leaves, drumstick leaves, bluefin tuna, yellow beans, immature seeds of pigeon pea, turkey heart, bison chuck shoulder clod, beef heart, sea lion meat, lamb heart, veal heart, hyacinth beans, goose meat (without skin), veal spleen, bison top round, pork ham with natural juices, moth beans, Pacific oyster, spinach spaghetti, chicory greens, dandelion greens, turnip greens, amaranth grain, chicken heart, black turtle beans, collards, bison top sirloin, lamb spleen, lamb lungs, quinoa, pork pancreas, wild Atlantic salmon, polar bear meat, pigeon peas, whole sesame seeds, octopus, papad, oats, burbot, king mackerel, mamey sapote, teff, cottonseed flour (low fat), mungo beans, conch, raccoon meat, beef pancreas, walleye pike, beaver meat, and carrot juice.

Scores of foods for nutritional quality based on positive food components, negative food components, and a combination of positive and negative food components under the suggested procedure are presented in Table S29.

Discussion

The FDA in serving and CAC in 100 grams, in contrast to the suggested procedure, described pasta with sliced franks in tomato sauce as a food case containing a suitable cholesterol level. However, consumption of 20 RACCs of pasta with sliced franks in tomato sauce (NDB number 22522; main dish product; 9 milligrams of cholesterol in 100 grams; 22.68 milligrams of cholesterol in RACC; 0.791 gram of saturated fat in 100 gramsg; 1.99 grams of saturated fat in RACC) leads to obtaining 454 milligrams of cholesterol and 40 grams of saturated fat, which are 154 milligrams and 20 grams greater than the DVs or NRVs for cholesterol and saturated fat, respectively.

The FDA in serving, in contrast to the suggested procedure, CAC in 100 grams, Dalorima et al. (2019), and Proietti et al. (2008), described watermelon (NDB number 9326; 30 kilocalories of energy in 100 grams; 84 kilocalories of energy in RACC) as food containing an unsuitable energy level. Consumption of 7,001 grams of the watermelon leads to surpassing the DV or DRV for energy, and that watermelon is customarily consumed 5,600 grams per day in 20 eating occasions.

The CAC in 100 grams, in contrast to the suggested procedure, FDA in serving, and some scientific literature (Bongers et al. 2015; Chao et al. 2020; Jenkins et al. 1997; Swaffield & Guo 2020), described raw carrots (NDB number 11124; 41 kilocalories of energy in 100 grams; 34.85 kilocalories of energy in RACC) as a food case containing an unsuitable energy level. Consumption of 4,879 grams of the carrots leads to surpassing the DV or DRV for energy, and those carrots are customarily consumed 1,700 grams per day in 20 eating occasions.

The CAC in 100 grams, Khan et al. (2020), and Yasmin and Nehvi (2013), in contrast to the suggested procedure and FDA in serving, described saffron as food containing an unsuitable sodium level. Consumption of 1,554.1 grams of saffron (NDB number 2037; 148 milligrams of sodium in 100 grams; 0.296 milligram of sodium in RACC) leads to surpassing the DV for sodium. Also, the consumption of 1,351.4 grams of the saffron leads to surpassing the NRV for sodium, and that saffron is customarily consumed 4 grams per day in 20 eating occasions.

Some scientific literature, in contrast to the suggested procedure, described chickpeas (Hussain et al. 2020), eggplant (Kumar & Chopra 2016), pumpkin (Nor et al. 2013), and yam (Vaillant et al. 2005) as foods containing unsuitable levels of sugars (to restrict sugars intake). Consumption of 1,244 grams of raw chickpeas (NDB number 16056; 10.7 grams of sugars in 100 grams; 3.745 grams of sugars in RACC), 3,768 grams of raw eggplant (NDB number 11209; 3.53 grams of sugars in 100 grams; 3 grams of sugars in RACC), 4,820 grams of raw pumpkin (NDB number 11422; 2.76 grams of sugars in 100 grams; 2.346 grams of sugars in RACC), or 26,602 grams of raw yam (NDB number 11601; 0.5 gram of sugars in 100 grams; 0.55 gram of sugars in RACC) leads to surpassing the DV or NRV for sugars, and those chickpeas, eggplant, pumpkin, and yam are customarily consumed 700 grams, 1,700 grams, 1,700 grams, and 2,200 grams per day in 20 eating occasions, respectively.

Some scientific literature, in contrast to the suggested procedure, described watermelon (Sinojiya et al. 2015) and acerola juice (Fernandes et al. 2019; Santos et al. 2018) as foods containing suitable levels of sugars (to restrict sugars intake). However, consumption of 20 RACCs of raw watermelon (NDB number 9326; 6.2 grams of sugars in 100 grams; 17.36 grams of sugars in RACC) and 20 RACCs of raw acerola juice (NDB number 9002; 4.603 grams of sugars in 100 milliliters; 11.047 grams of sugars in RACC) leads to obtaining 347 grams and 221 grams of sugars, which are 214 grams and 88 grams greater than the DV or NRV for sugars, respectively.

The CAC in 100 kilocalories and some scientific literature, in contrast to the suggested procedure, FDA and CAC in serving, and CAC in 100 grams, described table salt, cucumber (IOM 2006; Manjunatha & Anurag 2014), eggplant (IOM 2006; Kumar et al. 2016), strawberries (Adorno et al. 2017; Bajwa et al. 2003; Gil-Giraldo et al. 2018; Hakala et al. 2003; Khan et al. 2010; Yang et al. 2016), and apple (Appel 2013; Koutsos et al. 2015; Manchanda et al. 2015; Todea et al. 2014) as foods containing suitable potassium levels. Consumption of 58,750 grams of table salt (NDB number 2047; 8 milligrams of potassium in 100 grams; 0 kilocalorie of energy in 100 grams), 3,197.3 grams of cucumber with peel (NDB number 11205; 147 milligrams of potassium in 100 grams; 15 kilocalories of energy in 100 grams), 2,052.4 grams of raw eggplant (NDB number 11209; 229 milligrams of potassium in 100 grams; 25 kilocalories of energy in 100 grams), 3,071.9 grams of raw strawberries (NDB number 9316; 153 milligrams of potassium in 100 grams; 32 kilocalories of energy in 100 grams), or 4,392.5 grams of raw apple with skin (NDB number 9003; 107 milligrams of potassium in 100 grams; 52 kilocalories of energy in 100 grams) satisfies the DV for potassium. Also, the consumption of 43,750 grams of the table salt, 2,381 grams of the cucumber with peel, 1,528.4 grams of the raw eggplant, 2,287.6 grams of the raw strawberries, or 3,271 grams of the raw apple with skin satisfies the NRV for potassium, but those table salt, cucumber, raw eggplant, raw strawberries, and raw apple are customarily consumed 15 grams, 850 grams, 850 gramsg, 1,400 grams, and 1,400 grams in 10 eating occasions, respectively.

The CAC in 100 milliliters, in contrast to the suggested procedure, CAC and FDA in serving, CAC in 100 kilocalories, and some scientific literature (Freeland-Graves et al. 2016; Hall et al. 1989; Hope et al. 2006; Powell et al. 1998), did not describe brewed black tea as food containing a suitable manganese level. Consumption of 1,046.9 milliliters of brewed black tea prepared with tap water (NDB number 14355; 0.2197 milligram of manganese in 100 milliliters; 1.003 kilocalories of energy in 100 milliliters) satisfies the DV for manganese. Also, the consumption of 1,365.5 milliliters of the brewed black tea satisfies the NRV for manganese, and that brewed black tea is customarily consumed 3,600 milliliters in 10 eating occasions.

The CAC in serving, in contrast to the suggested procedure, FDA in serving, CAC in 100 grams, CAC in 100 kilocalories, and some scientific literature (Hung et al. 2006; Robbins et al. 2005; Wilson et al. 2003, 2007), did not describe broccoli as food containing a suitable folate level. Consumption of 634.9 grams of raw broccoli (NDB number 11090; 63 micrograms of DFE in 100 grams; 34 kilocalories of energy in 100 grams) satisfies the DV or NRV for folate, and that broccoli is customarily consumed 850 grams in 10 eating occasions.

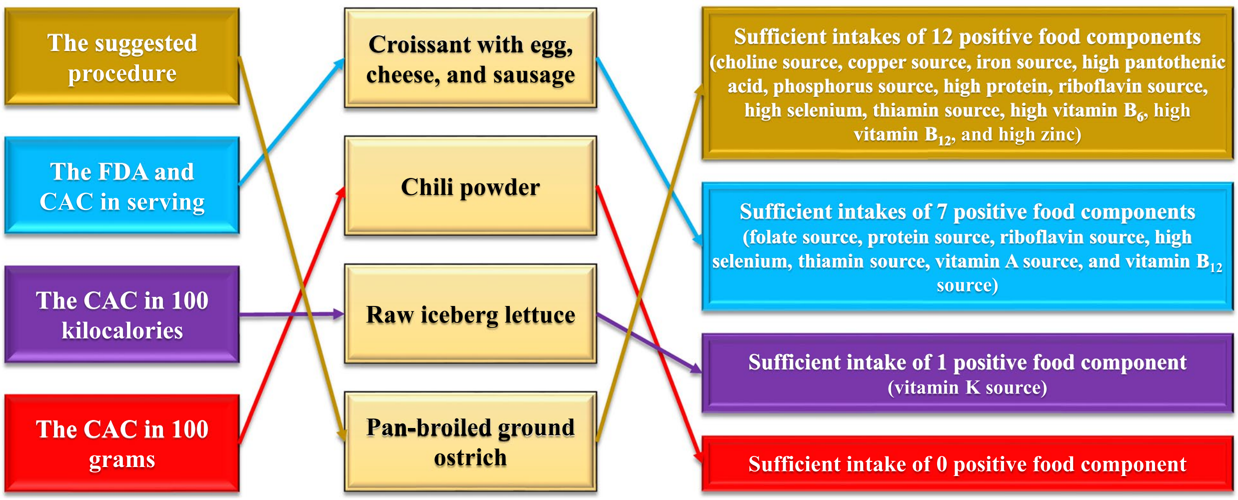


Fig. 5 Results of food selections according to different procedures for reaching sufficient intakes of 23 positive food components

The CAC in 100 grams, Kubant et al. (2015), and Swami et al. (2016), in contrast to the suggested procedure, CAC and FDA in serving, and CAC in 100 kilocalories, described lard as food containing a suitable vitamin D level. Consumption of 800 grams of lard (NDB number 4002; 2.5 micrograms of vitamin D in 100 grams; 902 kilocalories of energy in 100 grams) satisfies the DV for vitamin D. Also, the consumption of 600 grams of the lard satisfies the NRV for vitamin D. However, that lard is customarily consumed 128 grams in 10 eating occasions. In addition, consumption of 800 grams of the lard leads to obtaining 7,216 kilocalories of energy, which is 5,216 kilocalories greater than the DV or DRV for energy. Also, the consumption of 600 grams of the lard leads to obtaining 5,412 kilocalories of energy, which is 3,412 kilocalories greater than the DV or DRV for energy.

The FDA and CAC in serving and some scientific literature (Alyaqoubi et al. 2015; Kandan et al. 2010), in contrast to the suggested procedure, CAC in 100 milliliters, and CAC in 100 kilocalories, described coconut milk as food containing a suitable protein level. Consumption of 2,152.4 milliliters of raw coconut milk (NDB number 12117; 2.29 grams of protein in 100 grams; 5.57 grams of protein in RACC; 230 kilocalories of energy in 100 grams; RACC of 240 milliliters) satisfies the DV or NRV for protein but leads to obtaining 5,022 kilocalories of energy, which is 3,022 kilocalories greater than the DV or DRV for energy.

The assessment of 4 food cases based on different methods demonstrated that the croissant with egg, cheese, and sausage (NDB number 21014; 308 kilocalories of energy in 100 grams; RACC of 140 grams) under the FDA and CAC in serving, chili powder (NDB number 2009; 282 kilocalories of energy in 100 grams; RACC of 0.7 gram) under the CAC in 100 grams, raw iceberg lettuce (NDB number 11252; 14 kilocalories of energy in 100 grams; RACC of 85 grams) under the CAC in 100 kilocalories, and pan-broiled ground ostrich (NDB number 5642; 175 kilocalories of energy in 100 grams; RACC of 85 grams) under the suggested procedure obtained the highest scores for nutritional quality based on 23 positive food components (including zinc, vitamin K, vitamin E, vitamin D, vitamin C, vitamin B_{12}, vitamin B_6, vitamin A, thiamin, selenium, riboflavin, protein, potassium, phosphorus, pantothenic acid, manganese, magnesium, iron, folate, dietary fiber, copper, choline, and calcium) among 4 food cases. However, due to computing amounts and assessing suitable levels of 23 positive food components according to the suggested procedure, croissant with egg, cheese, and sausage, chili powder, raw iceberg lettuce, and pan-broiled ground ostrich can be used to reach sufficient intakes of 7 positive food components (folate source, protein source, riboflavin source, high selenium, thiamin source, vitamin A source, and vitamin B_{12} source), 0 positive food component, 1 positive food component (vitamin K source), and 12 positive food components (choline source, copper source, iron source, high pantothenic acid, phosphorus source, high protein, riboflavin source, high selenium, thiamin source, high vitamin B_6, high vitamin B_{12}, and high zinc), respectively (Fig. 5). Scores of 4 food cases for nutritional quality based on 23 positive food components under the suggested procedure, CAC and FDA in serving, CAC in 100 grams, and CAC in 100 kilocalories are provided in Table S30.

In the suggested procedure, 23 positive food components and 6 negative food components have been taken into consideration to assess nutritional quality. Also, this procedure can be used in assessing the nutritional quality for any specific situation in future studies. For this purpose, the positive and negative food components that play a role in a specific situation are identified, and then, the nutritional quality is determined based on suitable levels of these food components by considering their DVs and servings provided in the suggested procedure. So far, some investigations (Kris-Etherton et al. 2002; Martins 2015, 2016; Shahidi 2004) have been focused on the role of food components in human health, which can be considered for assessing nutritional quality in future studies.

Conclusion

According to the suggested procedure, computing the food component amount and assessing suitable levels of food components for negative food components in foods are implemented by considering RACCs, small RACCs, and the number of daily servings. Therefore, selecting foods under the suggested procedure to restrict intakes of negative food components did not surpass the demands of negative food components. Also, foods that did not surpass the demands of negative food components were suitable food selections under the suggested procedure to restrict intakes of negative food components.

Due to the vulnerabilities of selecting foods on the basis of the reference amounts of food, fast foods under the CAC and FDA in serving, spices and herbs under the CAC in 100 grams or 100 milliliters, and vegetables and vegetable products under the CAC in 100 kilocalories obtained the highest average scores for nutritional quality based on positive food components among food categories for children aged four years and older and adults.

According to the suggested procedure, computing the food component amount and assessing suitable levels of food components for positive food components in foods are implemented by considering RACCs and the energy amount of foods. Therefore, selecting foods under the suggested procedure satisfied the demands of positive food components and did not surpass energy demands.

On the basis of the suggested procedure, foods containing suitable levels of potassium (4.61%), vitamin D (5.21%), vitamin E (11.23%), calcium (11.38%), vitamin K (12.08%), vitamin A (12.63%), magnesium (13.81%), vitamin C (13.81%), and dietary fiber (16.75%) to reach sufficient intakes of those food components were few. Also, foods containing suitable levels of choline, iron, and folate to reach sufficient intakes of those food components were 21.91%, 22.12%, and 22.62%, respectively. In addition, foods containing suitable levels of energy to restrict energy intake were 22.54%.

Abbreviations

CAC	Codex Alimentarius Commission
FDA	United States Food and Drug Administration
USDA	United States Department of Agriculture
RACC	Reference amount customarily consumed
DV	Daily value
NRV	Nutrient reference value
DRV	Daily reference value
DFE	Dietary folate equivalent
RAE	Retinol activity equivalent
NDB number	Nutrient databank number

Supplementary Information

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Additional file 1.

Additional file 2.

Additional file 3.

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Authors' contributions
Conceptualization, A.F., S.S.F. and F.F.; Methodology, A.F., F.F. and S.S.F.; Validation, A.F., S.S.F., F.F. and A.F.; Investigation, A.F., F.F., S.S.F. and A.F.; Resources, A.F., S.S.F., F.F. and A.F.; Data Curation, A.F., S.S.F., F.F. and A.F.; Writing – Original Draft Preparation, A.F., F.F., S.S.F. and A.F.; Writing – Review & Editing, A.F., F.F., S.S.F. and A.F.

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Declarations

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Not applicable, because this article does not contain any studies with human or animal subjects.

Consent for publication
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Competing interests
The authors declare no competing financial interests.

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