Perspective: The Role of Beverages as a Source of Nutrients and Phytonutrients

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ABSTRACT

The Dietary Guidelines for Americans (DGA) provide nutrition advice for Americans >2 y of age. The 2020–2025 DGA proposes a life stage approach, focusing on birth through older adulthood. Limited recommendations for beverages exist except for milk, 100% fruit juice, and alcohol. The goal of this article is to provide a better understanding of the role of beverages in the diet using current scientific evidence. A Medline search of observational studies, randomized controlled trials, and meta-analyses was undertaken using key beverage words. We highlight the role beverages can play as a part of the DGA and considered beverages not traditionally included, such as those that are phytonutrient dense. Our primary consideration for beverage consumption targeted healthy Americans aged ≥2 y. However, with the proposed expansion to the life span for the 2020–2025 DGA, we also reviewed evidence for infants and toddlers from birth to 24 mo. Examples are provided on how minor changes in beverage choices aid in meeting recommended intakes of certain nutrients. Guidance on beverage consumption may aid in development of better consumer products to meet broader dietary advice. For example, beverage products that are nutrient/phytonutrient dense and lower in sugar could be developed as alternatives to 100% juice to help meet the fruit and vegetable guidelines. Although beverages are not meant to replace foods, e.g., it is difficult to meet the requirements for vitamin E, dietary fiber, or essential fatty acids through beverages alone, beverages are important sources of nutrients and phytonutrients, phenolic acids and flavonoids in particular. When considering the micronutrients from diet alone, mean intakes of calcium (in women), potassium, and vitamins A, C, and D are below recommendations and sodium intakes are well above. Careful beverage choices could close these gaps and be considered a part of a healthy dietary pattern. *Adv Nutr* 2020;11:507–523.

Keywords: beverages, dietary guidelines, water, milk, juice, coffee, tea, sugar-sweetened beverages, alcohol

Introduction

The Dietary Guidelines for Americans (DGA) provide nutrition advice for Americans who are >2 y of age. The 2020–2025 DGA proposes a life stage approach, focusing on birth through older adulthood (1). The Guidelines are published every 5 y by the USDA, jointly with the US Department of Health and Human Services. The most recent edition, the 2015–2020 DGA, has not extensively considered specific beverage recommendations with the exception of milk, 100% fruit juice, and alcohol (2). The landscape of beverage consumption has changed markedly in recent years. Sugar-sweetened beverage (SSB) intake has fallen by 68 and 45 kcal/d from 1999–2000 to 2009–2010 for youths and adults, respectively (3, 4). The percentage of individuals consuming milk has decreased among all age groups (5). Specialty coffee and tea houses and beverages have become a cultural phenomenon and energy drinks keep growing in popularity (6). Thus, it is an appropriate time to consider how beverages contribute to intakes of essential nutrients with the potential to fill nutrient gaps and provide nonessential phytonutrients with evidence to promote health, as well as consider constituents to limit.

The overall goal of this article is to highlight the role of beverages as sources of nutrients and phytonutrients. We

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Abbreviations used: AAP, American Academy of Pediatrics; CAD, coronary artery disease; CVD, cardiovascular disease; DGA, Dietary Guidelines for Americans; GRAS, generally recognized as safe; LCS, low-calorie sweetened; RCT, randomized controlled trial; SSB, sugar-sweetened beverage.

consider the role beverages play as a part of the DGA and consider beverages not traditionally included in the DGA. Our considerations for beverage consumption target healthy Americans aged ≥2 y.

DGA

There are 5 key messages of the 2015–2020 DGA: *1*) a focus on healthy eating patterns; *2*) dietary shifts that may be needed to achieve such patterns; *3*) a focus on variety, nutrient density, and intake amounts; *4*) limited calories from added sugars and saturated fats and reduced sodium intake; and *5*) a supportive role in adopting a healthy dietary pattern in the home, school, work, and communities. The DGA provides guidance for choosing a healthy dietary pattern with a focus on meeting nutrient needs and preventing (rather than treating) major diet-related chronic diseases. One of the 3 dietary patterns recommended in the DGA is the Healthy US-Style Eating Pattern, which is based on the types of foods Americans typically consume, but in nutrient-dense forms and appropriate amounts [see Appendix 3 of US Department of Health and Human Services and USDA (2)]. The pattern considers 6 food groups (vegetables, fruits, grains, dairy, protein foods, and oils). Of these, the vegetables, fruits, and dairy groups relate to commonly consumed beverages.

Current DGA recommendations for beverages include:

1) Beverages that are calorie-free, especially water, or that contribute beneficial nutrients, such as fat-free and low-fat milk and 100% juice, should be the primary beverages consumed.
2) Milk and 100% fruit juice should be consumed within recommended food group amounts and calorie limits.
3) Coffee, tea, and flavored waters also can be selected, but calories from creams and milks, added sugars, and other additions (e.g., flavorings) should be accounted for within the eating pattern.
4) Limit caffeine intake to <400 mg/d.
5) SSBs, such as soft drinks, sports drinks, and fruit drinks that are <100% juice, can contribute excess calories while providing few or no key nutrients. If they are consumed, amounts should be within overall calorie limits and limits for calories from added sugars.
6) If alcohol is consumed, it should be in moderation—≤1 drink/d for women and ≤2 drinks/d for men—and only by adults of legal drinking age [1 alcoholic drink-equivalent = 14 g (0.6 fl oz) pure alcohol]. Alcohol is contraindicated during pregnancy; when doing activity that requires attention, skill, and coordination; and when using certain pharmaceutical drugs and/or undergoing therapeutic procedures that interact with alcohol.

The 2020–2025 DGA will also consider the importance of beverages as concerns their having a role in achieving nutrient and food group recommendations, a topic that was proposed for public comment (https://www.cnpp.usda.gov/dietary-guidelines).

About three-fourths of the US population falls short of meeting the recommendations for intakes of fruits, vegetables, and dairy (2, 7). Similarly, mean US intakes of potassium, fiber, calcium, and vitamin D are below recommendations (8–11). In addition, US intakes exceed recommendations for added sugars, saturated fats, and sodium with ≥70% of the population aged ≥1 y consuming more than the recommended limits (2). Therefore, the objective of this report is to describe how beverages may close such nutrient gaps or contribute to reductions in chronic disease risk. To meet this objective, this report will review the scientific evidence to date on nutrient content and health benefits/risks of various beverages via a Medline search of observational studies, randomized controlled trials (RCTs), and meta-analyses using key beverage words.

Water

Water is the principal chemical component of the body, making up ∼60% of body weight (12). Water is necessary for normal cellular metabolism as well as elimination of wastes through urination, perspiration, and bowel movements and has a role in temperature maintenance and lubrication of joints. Water consumption allows for the delivery of fluid without calories and provides little nutrient value, with the possible exception of fluoride. Drinking water is a major source of dietary fluoride in the United States. Approximately 74% of the US population receives water with sufficient fluoride for the prevention of dental caries (13). Most bottled waters contain suboptimal concentrations of fluoride, although this can vary (14).

Tap water may contribute to total calcium, magnesium, and sodium intakes. In a mineral analysis from municipal water authorities of 21 major US cities, half of the tap water sources examined contained 8–16% and 6–31% of the RDA for calcium and magnesium, respectively, for adults consuming 2 L/d (15). Furthermore, the role of water hardness as a risk factor for cardiovascular disease (CVD) has been investigated. In a meta-analysis of 7 case-control studies including 44,000 adult subjects, comparing those exposed to the highest concentration with those exposed to the lowest concentration of calcium and magnesium, there was a benefit of calcium intake as well as for magnesium (16). Water softening using a sodium salt is commonly used to reduce water hardness. Domestic water softeners can increase sodium concentrations to >300 mg/L in drinking water (17) and need to be considered to meet population-based sodium recommendations, and also recommendations for sodium-restricted diets.

Most healthy people meet their daily hydration needs by using thirst as a guide. Although there are no exact requirements (12), daily total water requirements increase with age from early infancy (∼0.6 L or 20 oz) through childhood (∼1.7 L or 57 oz) and general daily recommendations for healthy women and men are ∼2.7 L (91 oz) and ∼3.7 L (125 oz) of total water, respectively. These recommendations include fluids from water, other beverages, and food. For older adults, relying solely on thirst may not be sufficient to maintain hydration status. Short-term and long-term fluid intake in response to repeated dehydration stimuli appear to be reduced among older adults over the age of 65 y (18). Many factors may influence fluid intake, including cognitive ability, medication, and incontinence (19). Poor fluid status and dehydration can also alter medication function and effectiveness.

Factors that influence water needs include exercise, environment, and overall health (12). Additional fluid is needed with the loss of sweat that comes with exercise and hot or humid weather. Fluid loss may also occur with a fever, vomiting or diarrhea, or certain *medical* conditions.

Water as a part of the DGA

The DGA recognizes that water should be the primary beverage consumed to meet fluid needs. In addition:

- For most healthy people, thirst should be the guide for fluid needs.
- The amount of fluid needed will vary with age, gender, water loss from physical activity, heat exposure, fever, vomiting, or diarrhea.

Milk and Milk Substitutes

DGA recommendations include fat-free and low-fat (1%) dairy, including milk or fortified soy beverages (fortified with calcium, vitamin A, and vitamin D). The DGA recommendation for dairy intake for adults is 3 cup-equivalents/d (710 mL-equivalents/d). The dairy group contributes many nutrients, including high-quality protein, calcium, phosphorus, vitamin A, vitamin D (in products fortified with vitamin D), riboflavin, vitamin B-12, potassium, zinc, choline, magnesium, and selenium. Eight ounces of milk and milk substitutes are good sources of potassium and vitamin A and rich sources of calcium and vitamin D (**Table 1**; 20).

Milk intake has been linked to various health outcomes, including a decreased risk of diabetes (low-fat milk only) (21), colon cancer (22, 23), cognitive disorders (24), and stroke (25), and no increased risk of coronary artery disease (CAD) and mortality (26). In a meta-analysis in an adult population, there was no significant association between low-fat or whole milk intake and fatal prostate cancer (27). However, results from a recent meta-analysis of 11 population-based cohort studies in adults reported that whereas intake of total dairy products had no significant impact on increased all-cancer mortality risk, an increase of whole milk (1 serving/d) contributed to elevated prostate cancer mortality risk significantly, with an RR of 1.43 (95% CI: 1.13, 1.81, $P = 0.003$) (28). Research has linked dairy intake to improved bone health, especially in children and adolescents (29).

The market for plant-based milk substitutes continues to grow, with soy milk among the most popular (30). However, market share for soy milk is decreasing as other plant-based milk substitutes, e.g., almond, cashew, rice, and other plant-based milks, are increasing in popularity (31, 32). Although there is a growing debate on consumer recognition of these products as milk substitutes, the perception of these products is as a replacement for dairy. A consumer study found that the majority of adults surveyed believed alternative milk products are nutritionally equivalent to cow milk (33). The nutrient density of such milk substitutes can vary considerably depending on the raw material used, processing, fortification with vitamins and minerals, and addition of other ingredients such as sugars and oils. Soy milk is currently the only plant-based milk substitute that approximates the protein content of cow milk and is comparable in quality (34). Furthermore, calcium is the only nutrient from milk substitutes to be tested for equivalent bioavailability to cow milk, which was reported to be similar (35). To date, there is insufficient evidence to support health benefits of certain plant-based milk substitutes above those of cow milk.

Whole milk is not included in the DGA recommendations for dairy; dairy fat [2.3%, 1.1%, and 0.1% of saturated, monounsaturated, and polyunsaturated fats, respectively (36)] may not have the health risks associated with other animal fats. Although strong associations between saturated fat intake and occurrence of CVD have been reported (37), a review of observational studies found no relation between milk fat and risk of CVD, CAD, or stroke (38). In the Malmo Diet and Cancer cohort, there was a decreased risk of incident type 2 diabetes with a high intake of high-fat but not for low-fat dairy products (39). In the Observation of Cardiovascular Risk Factors in Luxembourg Study, whole-fat dairy food intake was inversely associated with obesity prevalence (40). In addition, longitudinal evaluation of milk type consumed and weight status in preschoolers found that 1% skim milk drinkers had higher BMI z scores than 2% whole milk drinkers. However, this may reflect the choice whereby parents give overweight/obese children low-fat milk to drink (41). Moreover, a recent controlled clinical study reported that whereas both cheese and butter diets high in dairy SFAs significantly increased LDL cholesterol compared with the effects of carbohydrates, MUFAs, and PUFAs, LDL-cholesterol concentrations were significantly lower in participants consuming a cheese diet than in those consuming a butter diet (42). In sum, the next DGA Committee is encouraged to review the evidence on whole milk and chronic disease risk in the context of achieving nutrient needs and not exceeding calorie needs.

Milk as a part of the DGA

The DGA dairy recommendation is 3 cups/d (710 mL/d) for a 2000-kcal/d diet. Milk can be considered as a part of meeting the requirements for high-quality protein, calcium, phosphorus, vitamin A, vitamin D, and potassium. In addition:

- When choosing milk substitutes, consider the nutrient content.
- To be in line with the DGA's recommendation, when milk and milk substitutes are consumed, account for calories from added sugars (e.g., flavored milks) and other additions within the eating pattern.

TABLE 1 Beverage nutrient composition[1]

Beverage[2]	Kcal	% Energy[3]	Protein, g (% DV)	Carbohydrate, g (% DV)	Fat, g (% DV)	SFA, g (% DV)	Fiber, g (% DV)	Sugar, g	Added sugar, g	Caffeine,[4] mg	Calcium, mg (% DV)	Sodium, mg (% DV)	Potassium, mg (% DV)	Vitamin A, IU (% DV)	Vitamin C, mg (% DV)	Vitamin D, IU (% DV)	Phytonutrients type, mg
Water (8 oz, 237 mL)	0[5]	0	0	0	0[6]	0[6]	0	0	0	0	7 (0)	0[7]	0	0	0	0	0
Tea and coffee																	
Black tea, brewed (8 oz)	0[5]	0	0	0.1 (0.0)	0[6]	0[6]	0	0	0	40–74	0	7[8] (0.3)	88 (1.9)	0	0	0	Flavonoid, 116
Black tea, brewed, decaffeinated (8 oz)	0[5]	0	0	0	0[6]	0[6]	0	0	0	2–5	0	7[8] (0.3)	88 (1.9)	0	0	0	Flavonoid, 57
Black tea, infusion, sweetened (8 oz)	79	4.0	0	21 (7.0)	0[6]	0[6]	0	20	20	NA	0	10[8] (0.4)	0	0	0	0	Flavonoid, 84
Green tea, brewed (8 oz)	0[5]	0	0	0	0[6]	0[6]	0	0	0	25–50	0	0[7]	0	0	0	0	Flavonoid, 138
Coffee, brewed (8 oz)	2[5]	0	0.7 (1.4)	0.4 (0.1)	0[6]	0[6]	0	0	0	95–330	5 (0.5)	2[7] (0.1)	124 (2.6)	0	0	0	Phenolic acids, 503
Coffee, brewed, espresso (1 oz)	2[5]	0	0.1 (0.2)	0	0.2[6] (0.3)	0[6]	0	0	0	50–150	0	0[7]	0	0	0	0	Phenolic acids, NA[4]
Coffee, sweetened, milk based (8 oz)	186	9.3	5.2 (10.4)	12.6 (4.2)	3.6[6] (5.5)	0[6]	0	10.7	10.7	95–330	194[9] (19.4)	68[10] (3.0)	458 (9.7)	0	0	3 (0.8)	Phenolic acids, NA
Coffee, brewed, decaffeinated (8 oz)	0[5]	0	0.2 (0.4)	0	0[6]	0[6]	0	0	0	3–12	5 (0.5)	5[8] (0.2)	128 (2.7)	0	0	0	Phenolic acids, 658
100% fruit & vegetable juices																	
Apple (8 oz)	110	5.5	0	28 (9.3)	0[6]	0[6]	0	28	0	0	0	36[10] (1.6)	300 (6.4)	0	0	0	Flavonoid, 7
Apple—vitamin C fortified (8 oz)	101	5.1	1.0 (2.0)	25	0[6]	0[6]	0	21	0	0	0	19[8] (0.8)	149 (3.1)	0	78[11] (130)	0	Flavonoid, 7
Carrot (8 oz)	70	3.5	2.0 (4.0)	14 (4.7)	0[6]	0[6]	2 (8)	11	0	0	0	240[9] (10.4)	590[9] (12.6)	19,999[11] (400)	0	0	Carotenoid, 33
Cranberry, unsweetened (8 oz)	116	5.8	1.0 (2.0)	31 (10.3)	0[6]	0[6]	0.3 (1)	31	0	0	20 (2.0)	5[8] (0.2)	195 (4.1)	0	24[11] (40)	0	Flavonoid, 53
Grapefruit (8 oz)	101	5.1	0	25 (8.3)	0[6]	0[6]	0	24	0	0	0	36[10] (1.6)	319 (6.7)	0	78[11] (130)	0	Flavanone, 61
Orange (8 oz)	110	5.5	2.0 (4.0)	26 (8.7)	0[6]	0[6]	0	22	0	0	19 (1.9)	0	451 (9.7)	0	72[11] (120)	0	Flavanone, 34
Orange—calcium and vitamin D fortified (8 oz)	110	5.5	2.0 (4.0)	26 (8.7)	0[6]	0[6]	0	22	0	0	350[12] (35.0)	0[7]	451 (9.7)	0	78[11] (130)	101[11] (25.3)	Flavanone, 34
Tomato (8 oz)	50	2.5	2.0 (4.0)	10 (3.3)	0[6]	0[6]	2 (8)	7	0	0	19 (1.9)	629[11] (27.3)	379 (8.1)	499[9] (10)	72[11] (120)	0	Carotenoid, 22
Tomato, low sodium (8 oz)	48	2.4	2.0 (4.0)	10 (3.3)	0[6]	0[6]	2 (8)	7	0	0	26 (2.6)	139[10] (6.0)	886[9] (18.9)	401[11] (8)	72[11] (120)	0	Carotenoid, 22
Dairy																	
Nonfat milk (8 oz)	91	4.6	8.8[9] (17.6)	12.3 (4.1)	0.6[6] (0.9)	0[6]	0	12.3	0	0	316[11] (31.6)	130[10] (5.7)	419 (8.9)	524[9] (10.5)	2.5 (3.3)	120[11] (30.0)	0
Low-fat milk, 1% (8 oz)	120	6.0	10.0[11] (20.0)	11.0 (3.7)	2.5[6] (3.8)	1.5 (6.8)	0	15.0	0	0	300[11] (30.0)	120[10] (5.2)	350 (7.4)	499[9] (10.0)	1.2 (2.0)	120[11] (30.0)	0
Low-fat milk, 2% (8 oz)	130	6.5	8.0[9] (16.0)	13.0 (4.3)	5.0 (7.6)	3.0 (13.5)	0	12.0	0	0	300[11] (30.0)	125[10] (5.4)	370 (7.9)	499[9] (10.0)	1.2 (2.0)	101[11] (25.3)	0
Whole milk, 3.25% (8 oz)	161	8.1	8.0[9] (16.0)	12.0 (4.0)	9.0 (13.8)	5.0 (22.2)	0	12.0	0	0	300[11] (30.0)	125[10] (5.4)	410 (8.7)	499[9] (10.0)	1.2 (2.0)	101[11] (25.3)	0
Chocolate milk, 2% (8 oz)	199	10.0	10[11] (20.0)	29.0 (9.7)	5.0 (7.6)	3.0 (13.5)	0	28.0	16	5	350[11] (35.0)	221 (9.6)	451 (9.6)	499[9] (10.0)	0	101[11] (25.3)	Flavonoid, 3
Milk substitutes																	
Soy milk, plain, unsweetened (8 oz)	79	4.0	7.0[9] (14.0)	4.0 (1.3)	4.0 (6.2)	2.3[6] (1.0)	1.0 (4.0)	1.0	0	0	300[11] (30.0)	84[10] (3.7)	300 (6.4)	499[9] (10.0)	0	120[11] (30.0)	Isoflavone, 6
Almond milk, unsweetened (8 oz)	79	4.0	1.0 (2.0)	14.0 (4.7)	2.5[6] (3.8)	0.9[6] (0.4)	1.0 (4.0)	13.0	0	0	451[11] (45.1)	14[8] (0.6)	170 (3.6)	499[11] (10.0)	0	101[11] (25.3)	NA
Coconut milk (8 oz)	335	16.8	0	9.1 (3.0)	33 (50.8)	30.3[13] (136.5)	0	3.0	0	0	0	39[10] (1.7)	0	0	0	0	NA

(Continued)

TABLE 1 (*Continued*)

Beverage[2]	Kcal	% Energy[3]	Protein, g (% DV)	Carbohydrate, g (% DV)	Fat, g (% DV)	SFA, g (% DV)	Fiber, g (% DV)	Sugar, g	Added sugar, g	Caffeine,[4] mg	Calcium, mg (% DV)	Sodium, mg (% DV)	Potassium, mg (% DV)	Vitamin A, IU (% DV)	Vitamin C, mg (% DV)	Vitamin D, IU (% DV)	Phytonutrients type, mg
Rice milk, unsweetened (8 oz)	113	5.7	0.7 (1.3)	22.0 (7.3)	2.3[6] (3.5)	0[6]	0.7 (2.8)	12.7	0	0	283[11] (28.3)	94[10] (4.1)	65 (1.4)	151 (3.0)	0	2.4 (0.6)	NA
Alcohol[13]																	
Beer, regular (12 fl oz, 14 g alcohol)	153	7.7	1.6 (3.2)	12.6 (4.2)	0[6]	0[6]	0	0	0	0	14 (1.4)	14[8] (0.6)	96 (2.0)	0	0	0	Flavonoid, 3
Beer light (12 fl oz, 12 g alcohol)	103	5.2	0.9 (1.8)	5.8 (1.9)	0[6]	0[6]	0	0.3	0	0	14 (1.4)	14[8] (0.6)	74 (1.6)	0	0	0	NA
Wine, red (3.5 oz, 8 g alcohol)	87	4.4	0.1 (0.2)	2.7 (0.9)	0[6]	0[6]	0	0	0	0	8 (0.8)	0[7]	0	0	0	0	Flavonoid, 34
Wine, white (3.5 oz, 8 g alcohol)	84	4.2	0.1 (0.2)	2.7 (0.9)	0[6]	0[6]	0	1	0	0	0	0[7]	0	0	0	0	Flavonoid, 2
Distilled beverages, 80 proof (1.5 oz, 14 g alcohol)	97	4.9	0	0	0[6]	0[6]	0	0	0	0	0	0[7]	1 (0.0)	0	0	0	0
Limit consumption																	
Ginger ale (7.5 oz)	80	4.0	0	21 (7.0)	0[6]	0[6]	0	21	42	0	0	40[10] (1.7)	0	0	0	0	0
Ginger ale, diet (7.5 oz)	0[4]	0	0	0	0[6]	0[6]	0	0	0	0	0	0	0	0	0	0	0
Soda, sweetened, caffeinated (8 oz)	110	5.5	0	29 (9.7)	0[6]	0[6]	0	29	58	22–69	0	36[10] (1.6)	0	0	0	0	0
Energy drinks with caffeine (8 oz)	130	6.5	0	33 (11.0)	0[6]	0[6]	0	32	64	33–400	0	170 (7.4)	0	0	0	0	0

[1]Data from the USDA, Agricultural Research Service, Nutrient Data Laboratory; National Nutrient Database for Standard Reference (20). DV, Daily Value; NA, not available.
[2]One ounce is equivalent to 29.6 mL.
[3]Relative to a 2000-kcal/d diet.
[4]Source: Mitchell et al. (101).
[5]Calorie-free: <5 kcal/serving.
[6]Low fat: ≤3 g/serving or saturated fat–free: <0.5 g/serving.
[7]Sodium-free: <5 mg/serving.
[8]Very low sodium: <35 mg/serving.
[9]Good source: 10–19% DV.
[10]Low sodium: <140 mg/serving.
[11]Rich source: >20% DV.
[12]Exceeds recommended limit (based on 2000-kcal/d diet) (2).
[13]If alcohol is consumed, it should be in moderation—≤1 drink/d for women and ≤2 drinks/d for men—and only by adults of legal drinking age [1 alcoholic drink-equivalent = 14 g (0.6 fl oz) pure alcohol] (2).

One Hundred Percent Fruit and Vegetable Juices

The DGA recommends 2 cup equivalents of fruit and 2.5 cup equivalents of vegetables daily. The DGA includes 100% fruit juice in the fruit group as counting toward daily fruit recommendations but recommends limiting 100% fruit juice to 1 cup (237 mL) with the remainder as whole or cut fruit. During 2007–2010 half of the total US population consumed <1 cup of fruit and <1.5 cups of vegetables daily; 76% did not meet fruit intake recommendations and 87% did not meet vegetable intake recommendations (43). Consumption of fruits and vegetables adds nutrients to diets and reduces the risks of heart disease, diabetes, age-related cognitive impairment, some cancers, and all-cause mortality (44–48). Several inverse associations have been reported between fruit and vegetable intake and prospective improvements in anthropometric parameters, and risk of adiposity (49). Specific to 100% fruit juice, a recent review of systematic reviews and meta-analyses in children and adults evaluated the association between juice consumption and various chronic health outcomes and concluded that aside from increased risk of tooth decay in children and small amounts of weight gain in young children and adults, there is no conclusive evidence that consumption of 100% fruit juice has other adverse health effects (50). The authors noted that the meta-analysis on tooth decay was limited in that most of the included studies were cross-sectional and hence were vulnerable to confounding and reverse-causation. The health outcomes included diabetes, CVD, glucose homeostasis, lipid concentrations, and blood pressure. The study also found no significant associations between juice and weight gain in adults, although an analysis of participants in the Nurses' Health Study, Nurses' Health Study II, and Health Professionals Follow-up Study found an association of 0.22 kg weight gain over 4 y with every serving of 100% fruit juice (240 mL) consumed daily (51). For children, 100% fruit juice consumption was not associated with a BMI z score increase in children aged 7–18 y (52). Drinking 1 serving of 100% fruit juice per day was associated with a small amount of weight gain in children aged 1–6 y (BMI z score change of 0.09 units over 1 y) (52). However, children who consumed ≥1 serving/d of 100% juice also had a greater risk of tooth decay than those with ≤1 serving/d consumption in a meta-analysis of children and adolescents that included 5 cross-sectional and 2 longitudinal studies (53).

Fruit and vegetable juices can be important sources of potassium; vitamins A, C, E, K, and B-6; thiamin; niacin; folate; and choline, as well as potassium, iron, manganese, and fiber (20). In addition, phytonutrients such as flavonoids (anthocyanins, flavonols) and carotenoids, contained in fruit and vegetable juices, have health benefit (54). Hence, fruit and vegetable juices are nutrient dense. For example, 8 oz (237 mL) of many 100% fruit and vegetable juices are good (10–19% daily value) or rich (≥20%) sources of potassium and vitamins A and C (Table 1). Indeed, consumption of 100% fruit juice was associated with improved nutrient intakes across the life span (55–60).

Although 100% fruit and vegetable juices are nutrient dense, sodium needs to be considered, particularly for certain vegetable juices, e.g., tomato. Keeping in mind there is no evidence for an optimal amount and the National Academies of Sciences, Engineering, and Medicine state that there remains insufficient evidence to establish sodium or potassium DRIs for adequacy as Estimated Average Requirements (EARs) and RDAs (61), the WHO guideline on sodium and potassium intake considered to be beneficial for health is a ratio of sodium to potassium of ∼1:1 (62). When considering the FDA definitions of sodium-free (<5 mg/serving), very low sodium (≤35 mg/serving), and low sodium (≤140 mg/serving), almost all commonly consumed beverages fall into one of these categories with perhaps the exceptions of almond milk and certain energy drinks (Table 1).

Although there are no specific guidelines in the current DGA for fruit and vegetable intake for children <2 y of age, the American Academy of Pediatrics (AAP) indicates that there is no nutritional indication to give fruit juice to infants younger than 6 mo and that it is optimal to avoid the use of juice in infants before 1 y of age. The AAP also recognizes that for older children, fruit is to be encouraged, and that up to half of the servings can be provided in the form of 100% fruit juice (but not fruit drinks, which are calorically sweetened beverages with a small percentage of fruit juice), with fruit juice offering no nutritional advantage over whole fruit (63).

One hundred percent fruit and vegetable juices as a part of the DGA

The DGA recommends that at least half of the recommended amount of fruit come from whole fruits. The DGA recognizes that 100% juice can be a part of meeting the recommendation for fruits and vegetables and can be a part of meeting the requirements for potassium, vitamins A and C, as well as fiber. Modeling food intake patterns showed that without 100% fruit juice diets would be substantially lower in vitamin C and potassium than for patterns including fruits plus 100% fruit juice (64). In addition:

- Consider 100% juice as a key source of phytonutrients (Table 1) including carotenoids (e.g., orange, carrot, and tomato juice) and phenolic acids (e.g., purple grape, cranberry, and apple juice).
- Consider fortified juices for key nutrients, e.g., vitamins C and D and calcium.
- Try to avoid introducing juice until the child is a toddler. If juice is introduced, wait until 12 mo and limit consumption to 4–6 oz (118–177 mL).
- Choose low-sodium juices.

Coffee and Tea

Coffee

Approximately 75% of the US population aged ≥20 y reported drinking coffee; 49% reported drinking coffee daily (65). Although coffee has very little nutrient content, it contributes ∼5% of the potassium intake in the United

States, which is similar to vegetables (excluding potatoes), fruit, and 100% juices (8), and can have low but variable concentrations of fluoride (14). There is evidence that, in healthy adults, moderate coffee consumption (4–5 cups/d or 946–1183 mL/d) has beneficial effects for a number of chronic diseases. A recent review evaluated the evidence from meta-analyses of observational studies and RCTs in adults relating to coffee intake and health outcomes (66). Of 59 unique outcomes examined in 112 meta-analyses of observational studies, coffee was associated with a probable decreased risk of breast, colorectal, colon, endometrial, and prostate cancers; CVD and all-cause mortality; Parkinson disease; and type 2 diabetes. Of 12 unique acute outcomes examined in 9 meta-analyses of RCTs, coffee was associated with a rise in serum lipids, but this result was affected by significant heterogeneity among the study designs and likely by coffee preparation methods. The authors concluded that the robustness of many of the results indicated that coffee can be part of a healthful diet. In part, the beneficial effects could be due to phenolic acids contained in coffee. Most negative impacts of serum lipids are driven by select sterols, including kahweol and cafesterol (67), that are present in percolated or boiled coffee but reduced greatly in paper-filtered drip coffee and espresso preparations (68, 69).

Tea

Brewed tea is a beverage made by hot water infusion of *Camellia sinesis* leaves. This is not to be confused with herbal "teas" that may contain other botanicals as ingredients. Tea is a major contributor to beverage intake in the US adult population with ~1 of 3 adults reporting regular consumption on any given day (70). Tea provides few nutrients (~2% of potassium intake in the United States) (8), although it is considered to be a significant contributor to total fluoride intake (14).

Meta-analyses of RCTs including 13 (71) and 20 (72) studies found that 3 cups (710 mL) of green tea reduced systolic and diastolic blood pressure by ~2 mm Hg. Similarly, a meta-analysis evaluating black tea consumption on blood pressure (73) reported that 4–5 cups (946–1183 mL) of black tea reduced systolic and diastolic blood pressure by 1.8 and 1.3 mm Hg, respectively. A meta-analysis of 14 cohort studies consisting of 513,804 participants with a median follow-up of 11.5 y reported that an increase of 3 cups/d (710 mL/d) in tea consumption was associated with a 13% decreased risk of stroke (74). Another meta-analysis of 9 studies including 259,267 adult individuals found that those who did not consume green tea had higher risks of CVD, intracerebral hemorrhage, and cerebral infarction than those consuming <1 cup (237 mL) of green tea per day. Those who drank 1–3 cups (237–710 mL) of green tea per day had a reduced risk of myocardial infarction and stroke compared with those who drank <1 cup/d (<237 mL/d). Those who drank ≥4 cups/d (>946 mL/d) had a reduced risk of myocardial infarction compared with those who drank <1 cup/d (<237 mL/d) (75).

The consumption of black tea or green tea has been reported to be associated with a lower risk of diabetes. A meta-analysis of 16 adult cohorts with 37,445 cases of diabetes among 545,517 participants reported a significant linearly inverse association between black tea consumption and diabetes risk. An increase of 2 cups/d (573 mL/d) in tea consumption was associated with a 4.6% reduced risk (95% CI: 0.9, 8.1%) (76). In addition, a dose-response meta-analysis of prospective cohort studies in adults reported that in 18 prospective studies, consisting of 12,221, 11,306, and 55,528 deaths from all cancers, CVD, and all causes, respectively, for all-cancer mortality the RRs for the highest compared with the lowest categories of green tea and black tea consumption were 1.06 (95% CI: 0.98, 1.15) and 0.79 (95% CI: 0.65, 0.97), respectively. For CVD mortality, the RR for the highest compared with the lowest categories of green tea and black tea consumption were 0.67 (95% CI: 0.46, 0.96) and 0.88 (95% CI: 0.77, 1.01), respectively. For all-cause mortality, the RRs for the highest compared with the lowest categories of green tea and black tea consumption were 0.80 (95% CI: 0.68, 0.93) and 0.90 (95% CI: 0.83, 0.98), respectively (77). The dose-response analysis indicated that a 1-cup/d (237-mL/d) increment of green tea consumption was associated with 5% lower risk of CVD mortality and with 4% lower risk of all-cause mortality. Green tea consumption was significantly inversely associated with CVD and all-cause mortality, whereas black tea consumption was significantly inversely associated with all-cancer and all-cause mortality.

Phytonutrients

Green coffee beans contain diverse groups of phenolic compounds, with chlorogenic acids and mixed diesters of caffeic and ferulic acids plus quinic acid being the primary forms (78). Black and green teas are rich sources of monomeric flavan-3-ols as well as complex oxidized flavan-3-ol forms including the theaflavins, thearubigins, and theabrownins (79, 80). Healthful benefits from consuming coffee and tea may be imparted by these phytonutrients, along with caffeine, trigonelline, diterpenes, and soluble fiber (81). Current evidence suggests that both chlorogenic acids and flavan-3-ols are absorbed primarily in the small intestine and appear in the circulation as glucuronide, sulfate, and methylated metabolites (82). Results from in vivo studies in animals and humans report that the phenolic and polyphenolic constituents of coffee and tea have biological activities including antioxidant activities (83–85), increase of fatty acid oxidation and insulin sensitivity (86, 87), and modulation of glucose absorption and utilization (88). In vitro studies have reported on their ability to modulate glucose metabolism (89, 90) as well as to stimulate nitric oxide production and vasodilation (91).

The evidence is accumulating that coffee and tea also have health benefits (see above) and are concentrated sources of dietary phytonutrients. For example, a mean intake of monomeric flavan-3-ols of 124 mg/d, compared with a mean intake of 25 mg/d, was associated with a 51% lower 10-y CAD mortality in the Zutphen Elderly Study (92). This amount is easily achieved with 3 oz (89 mL) of tea compared with two-thirds of a medium apple (93, 94). Although these compounds lack a DRI, their amounts from current intakes of fruits, vegetables, and whole grains fall short of such beneficial effects. Eight ounces (237 mL) of coffee and tea, being major contributors of these phytonutrients, provide amounts exceeding that found in 1 cup of commonly consumed fruits and vegetables (93, 94).

Caffeine

Much of the available evidence on the biological effects of coffee and tea includes an evaluation of both caffeinated and decaffeinated beverages, with both having demonstrated health benefits. However, intake of caffeine has been associated with a number of biological effects, mostly relating to the stimulation of the central and sympathetic nervous system, providing a feeling of alertness after consumption (66, 95–99). The content of caffeine in a serving of coffee is highly variable, depending on the source and type of coffee bean (robusta compared with arabica), the type of roasting (e.g., light, medium, or dark), the coffee-making method (boiling, steeping, filtered, pressure), and the ratio of coffee ground to water, with values ranging from 50 to >300 mg per 8 oz (237 mL) serving (100). Brewed tea has lower caffeine content (15–50 mg/8 oz or 237 mL) (101). Decaffeinated coffee and tea will contain ∼10 mg or less per 8 oz (237 mL) (102).

In the United States, caffeine consumption increases with age and intake is highest among 50- to 64-y-old consumers (226 mg/d). The mean across all age groups is ∼165 mg/d (101). Coffee is the primary source of caffeine (64%; 105.4 mg/d), followed by carbonated soft drinks (17%; 27.9 mg/d) and tea (17%; 27.9 mg/d). Energy drinks contributed <2% to total caffeine intake (2.6 mg/d). The greatest percentage of energy drink consumers were found among 13- to 17- and 18- to 24-y-olds (∼10% of caffeine consumers compared with 4.3% across all age groups). Children (2–12 y) and adolescents (13–17 y) metabolize caffeine more rapidly than adults (101, 103). At 180–200 mg/d, typical caffeine consumption can provide the desired benefit (i.e., mental alertness) with a low risk of adverse side effects such as agitation, anxiety, or sleep disturbance (101, 104). However, concern has been raised that caffeine may cause behavioral issues in children and adolescents (105). A systematic review of RCTs, observational studies, and expert panel guidelines found that high caffeine intakes (e.g., >5 mg $\cdot$ kg body weight^{-1} $\cdot$ d^{-1}) were associated with an increased risk of anxiety and withdrawal symptoms in children (106). The author concluded that lower contributors of caffeine at <2.5 mg $\cdot$ kg body weight^{-1} $\cdot$ d^{-1}, equating to 1 or 2 cups of tea or 1 small cup of coffee daily, may benefit cognitive function and sports performance based on adult studies. The author also suggested that caffeinated soft drinks may be less suitable options for children because of the acidity, higher caffeine content, presence of added sugar, and absence of bioactive compounds.

The DGA states that moderate coffee consumption [three to five 8-oz (237 mL) servings per day or ∼400 mg caffeine/d] can be incorporated into healthy eating patterns. Although caffeine is considered a safe substance by the FDA, possible adverse effects on children and adolescents are largely unknown because most research has been conducted in adult populations (107). A recent systematic review evaluated the data on potential adverse effects of caffeine in different demographic groups (adults, pregnant women, adolescents, and children) (108). The authors concluded that the evidence generally supports that consumption of ≤400 mg caffeine/d in healthy adults is not associated with adverse cardiovascular effects, behavioral effects, reproductive and developmental effects, acute effects, or bone status. In addition, consumption of ≤300 mg caffeine/d in healthy pregnant women was generally not associated with adverse reproductive and developmental effects and the available evidence for children and adolescents suggests that <2.5 mg caffeine $\cdot$ kg body weight^{-1} $\cdot$ d^{-1} remains an appropriate recommendation. The European Food Safety Authority in their "Scientific Opinion on Caffeine" advised that pregnant women should limit caffeine intake to 200 mg/d (109). The data support that for healthy individuals, lethality may, but does not always, occur after acute consumption of 10 g caffeine, an amount well above what is attainable in coffee and tea beverages. However, the systematic reviews and meta-analyses to date identify a potential research gap in the investigation of caffeine effects at amounts >2.5 mg $\cdot$ kg body weight^{-1} $\cdot$ d^{-1} on anxiety in children and at >400 mg/d in adults with pre-existing conditions.

Coffee and tea as a part of the DGA

The DGA recommends limiting caffeine intake to 400 mg/d. Pregnant women are advised to consume no more than 200 mg caffeine/d. In addition:

- Although the epidemiological evidence of health benefits is primarily based on brewed products, other coffee and tea products also contain phytonutrients but their contents can vary greatly.
- Adolescent and child caffeine consumption should not exceed 2.5 mg $\cdot$ kg body weight^{-1} $\cdot$ d^{-1}.
- Decaffeinated coffee and tea can also serve as healthy beverage choices because the phenolic acids and flavonoids associated with health benefits, although modestly reduced in amounts, are present in these products.
- When consuming coffee and tea, account for nutrients and calories from dairy, added sugars, and additions within the overall diet.

Of note, these recommendations are made based on brewed coffee and tea products because of the extent to which broader consumer products including instant and ready-to-drink product forms may have variable polyphenol profiles and/or calories from added sugars and additions. These amounts should be considered when evaluating or developing ready-to-drink or instant products to be included as part of a healthy diet.

Alcohol

Heavy and binge drinking increase the risk of chronic disease (110). A dose-response analysis from a meta-analysis of 84 prospective cohort studies in adults revealed that the lowest risk of CAD mortality occurred with 1–2 drinks/d, but for stroke mortality it occurred with ≤1 drink/d (∼15 g alcohol) (111). A meta-analysis evaluating the effects of alcohol reduction on blood pressure reported that decreasing alcohol intake was associated with a significant reduction in mean systolic and diastolic blood pressures (−3.31 and −2.04 mm Hg, respectively) (112). A dose-response relation was observed between mean percentage of alcohol reduction and mean blood pressure reduction. Low amounts of alcohol intake (<15 g/d) have also been reported to be associated with lower risks of heart disease (111, 113), diabetes (114–116), and dementia (117).

An increased intake of alcohol was also associated with a higher risk of breast cancer with the RR increasing by 7.1% (95% CI: 5.5, 8.7%) (118) and the HR increasing by 4.2% (95% CI: 2.7, 5.8%) (119) for each increase of 10 g alcohol/d. Others have reported that low alcohol intake was related to a higher risk of breast cancer than was little or no alcohol intake, with 1 study reporting intakes of >5 to 15 g/d being related to a 5.9% increase in breast cancer risk (95% CI: 1, 11%) (119). These findings are consistent with another study reporting a significant increase of the order of 4% in the risk of breast cancer at intakes of ≤1 alcoholic drink per day (120).

A pooled analysis of 8 cohort studies in adults reported an increased risk of colorectal cancer that was limited to persons with an alcohol intake of >30 g/d to <45 g/d (RR: 1.16; 95% CI: 0.99, 1.36) and a RR of 1.41 (95% CI: 1.16, 1.72) for those who consumed ≥45 g/d (121). The European Prospective Investigation into Cancer and Nutrition consisted of 347,237 study subjects free of cancer at enrollment and a follow-up averaging 12 y, during which 3759 colorectal cancer cases were observed (122). After adjustment for potential confounding factors, compared with alcohol intakes in women and men of >12 and >24 g alcohol/d, respectively, intakes less than these amounts had an HR of colorectal cancer of 0.87 (95% CI: 0.81, 0.94).

A meta-analysis of 16 prospective cohort studies in adults reported that average beer consumption of ≥1 drink/d (13 g alcohol/d) was associated with an increased risk of lung cancer (RR: 1.23; 95% CI: 1.06, 1.41) (123). This association was observed in both men and women, but only significant in men. An inverse association was observed for both average wine consumption of <1 drink/d and ≥1 drink/d. Average liquor consumption of ≥1 drink/d was found to be associated with increased lung cancer risk in men, with an RR of 1.33 (95% CI: 1.10, 1.62) (123). No association was observed for women. In addition, a pooled analysis of cohort studies reported a slightly greater risk of lung cancer with the consumption of ≥30 g alcohol/d than for no alcohol consumption (men: RR: 1.21; 95% CI: 0.91, 1.61; women: RR: 1.16; 95% CI: 0.94, 1.43) (124).

The HR of all-cause mortality comparing never with light drinkers (0.1–2.9 g alcohol/d) was 1.26 (95% CI: 1.18, 1.35) for women and 1.29 for men (95% CI: 1.10, 1.51) (125). When sources of alcohol were considered, beer use was more strongly related than wine to all-cause mortality for an intake of ≥3 g alcohol/d as compared with lower intakes (0.1–2.9 g alcohol/d). A meta-analysis of 34 prospective studies reported that consumption of alcohol, ≤4 drinks/d (40 g alcohol/d) in men and 2 drinks/d (20 g alcohol/d) in women, was inversely associated with total mortality, with maximum protection of 18% in women and 17% in men. Higher doses of alcohol were associated with increased mortality (126).

When consuming alcohol, it is important to keep in mind the diuretic effect that could lead to dehydration. Alcohol consumption should be within the recommended limits (≤1 drink/d for women and ≤2 drinks/d for men) (2). In addition, alcoholic drinks contain calories. For example, a standard (3.0-oz, 89-mL, 8-g alcohol) glass of red wine contains ∼87 kcal and 12 oz (355 mL, 12 g alcohol) of regular beer lager contain ∼153 kcal (Table 1).

Alcohol as a part of the DGA

The DGA recommends that if alcohol is consumed, it should be in moderation—≤1 drink/d for women and ≤2 drinks/d for men—with consideration for calories and within the limits of healthy eating patterns. Alcoholic beverages should be consumed only by adults of legal drinking age and are contraindicated during pregnancy; when doing activities that require attention, skill, and coordination; and when using certain pharmaceutical drugs and/or undergoing therapeutic procedures that interact with alcohol.

SSBs

SSBs, including soft drinks, non-100% juices, fruit drinks, sports drinks, and energy drinks, can contribute excess calories while providing few or no key nutrients. SSBs are significant sources of added sugars in the diet of US adults, accounting for approximately one-third of added sugar consumption, and are the primary source of added sugar in the diet of children and adolescents (127). In 2011–2014, 6 in 10 youth (63%) and 5 in 10 adults (49%) drank an SSB on a given day (128). On average, US youth consume 143 kcal from SSBs and US adults consume 145 kcal from SSBs on a given day (128). Among adults, consumption of SSBs at least once a day is associated with adverse health consequences, including obesity, type 2 diabetes, and CVD (129–131). In a dose-response meta-analysis of prospective studies in adults, the RR for incident hypertension was 1.08 (95% CI: 1.04, 1.12) for every additional 1 serving/d increase in SSB consumption. The RR for CAD was 1.17 (95% CI: 1.10, 1.24) for every 1 serving/d increase in SSB consumption. There was no significant association between SSB consumption and total stroke for every 1 serving/d increase in SSB consumption (132).

Sports drinks

Sports drinks are designed to help athletes replace water, electrolytes, and energy before and after exercise or competition. In an assessment of the evidence to support claims of improved water absorption during exercise and maintenance of endurance performance, Thompson et al. (133) reported limitations in the scientific evidence. Many of the studies had methodological limitations, such as lack of blinding. Furthermore, most studies were in young male endurance athletes, making difficult translation to other populations, e.g., women, children, and older people.

Energy drinks

Energy drinks are beverages that contain stimulants such as caffeine and are marketed to provide mental and physical stimulation. Energy drinks may also contain sugar or other sweeteners, herbal extracts, taurine, and B vitamins. The International Society of Sports Nutrition recently concluded the primary ergogenic nutrients in most energy drinks appear to be carbohydrate and/or caffeine (134). Energy drinks are particularly popular among adolescents and young adults with nearly two-thirds of teens reporting ever using energy drinks, 31% of 12- to 17-y-olds reporting consuming energy drinks regularly (134), and 5% of high school–age adolescents consuming energy drinks daily (135).

With the rising popularity of energy drinks among these age groups come safety concerns. Caffeine, the most physiologically active ingredient in energy drinks, is generally recognized as safe (GRAS) by the US FDA; however, adverse effects can occur with high intakes, the most common being effects on the cardiovascular and neurological systems (136). Guarana, which contains caffeine in addition to small amounts of theobromine, theophylline, and tannins, also has GRAS status, but when combined with caffeine in an energy drink may lead to caffeine toxicity (137). The position of the AAP is that "stimulant-containing energy drinks have no place in the diets of children and adolescents" (138).

Low-calorie sweetened beverages

Low-calorie sweetened (LCS) beverages use sweeteners that have a higher intensity of sweetness per gram than caloric sweeteners such as sucrose and high-fructose corn syrup. The recent AHA science advisory defines LCS beverages to include 6 high-intensity sweeteners currently approved by the US FDA (saccharin, aspartame, acesulfame-K, sucralose, neotame, and advantame), steviol glycoside extracted from the leaves of the stevia plant (*Stevia rebaudiana*), and monk fruit extract (also known as *Siraitia grosvenorii*, Swingle fruit, or luo han guo) (139). The 2015–2020 DGA recommends that the daily intake of calories from added sugars not exceed 10% of total calories. Given negligible to no calorie content, LCS beverages could be viewed as SSB alternatives to meet this guideline. In an analysis of household purchases and NHANES dietary intake (140), beverages were the main sources of low-calorie sweeteners and represented 32% of all beverages among adults and 19% among children.

Some observational studies have suggested that LCS beverages may increase certain disease risk factors. A recent meta-analysis including adolescents and adults evaluating the association between consumption of artificially sweetened soda and obesity reported that the pooled RR for obesity in individuals consuming artificially sweetened soda was 1.59 (95% CI: 1.22, 2.08) (141). A meta-analysis of prospective studies in adult cohorts examining the association between LCS beverages and hypertension reported that, in the 4 studies meeting the eligibility criteria (227,254 subjects and 78,177 incident cases of hypertension), the pooled RRs were 1.14 (95% CI: 1.10, 1.18) for highest compared with lowest intake analysis and 1.09 (95% CI: 1.06, 1.11) for every additional 1 serving/d increase in LCS beverage consumption (142). In addition, a meta-analysis of the association between LCS beverages and type 2 diabetes found that higher consumption of noncaloric beverages was associated with a greater incidence of type 2 diabetes, by 25% (95% CI: 18, 33%) and 8% (95% CI: 2, 15%) per 1 serving/d, before and after adjustment for adiposity, respectively (130). The authors indicated publication bias and residual confounding. Prospective longitudinal studies and clinical trials may provide evidence that circumvents the possibility of reverse causation. It was estimated that substituting 1 serving/d of LCS beverages for the same amount of SSBs was associated with 0.47 kg less weight gain over a 4-y period (51). A systematic review and a meta-analysis of trials and prospective cohorts concluded that replacing SSBs with LCS beverages could contribute to a modest weight loss (143, 144). However, existing findings from trials have been criticized for their lack of statistical power, short duration, participants being unblinded to the treatment groups, and conflicts of interest in research funding.

The AHA Nutrition Committee recently reviewed the evidence from observational studies and clinical trials assessing the cardiometabolic outcomes of LCS beverages and concluded that the use of other alternatives to SSBs, with a focus on plain, carbonated, or unsweetened flavored water, should be encouraged (139). They also concluded that with limited evidence on the adverse effects of LCS beverages on health, prolonged consumption of LCS beverages by children is not advised.

SSBs as a part of the DGA

The DGA recognizes that consumption of SSBs (soft drinks, energy drinks, and fruit drinks) should be limited. In addition:

- Among individuals who habitually consume SSBs and are habituated to sweet-tasting beverages, replacing SSBs with LCS beverages may provide a first step to reduce SSB consumption. However, replacing SSBs with water or other unsweetened beverages, such as tea and coffee, is strongly encouraged.

TABLE 2 Healthy US-Style Eating Pattern at the 2000-kcal/d level, with daily or weekly amounts from food groups, subgroups, and components[1]

Food group	Amount in the 2000-kcal level pattern	1 cup-eq or 1 oz-eq of food	1 cup-eq or 1 oz-eq of beverage
Vegetables			
Dark green	1.5 cup-eq/wk	1 cup raw or cooked vegetables,	1 cup 100% vegetable juice,
Red & orange	5.5 cup-eq/wk	2 cups green leafy salad greens,	e.g., tomato, carrot
Legumes	1.5 cup-eq/wk	0.5 cup dried vegetables	
Starchy	5.5 cup-eq/wk		
Other	4.5 cup-eq/wk		
Fruits	2.5 cup-eq/d	1 cup fresh fruits, 0.5 cup dried fruits	1 cup 100% fruit juice, e.g., orange, grapefruit
Grains	6 oz-eq/d		
Whole grains	≥3 oz-eq/d	1 oz dry pasta or rice,	NA
Refined grains	≤3 oz-eq/d	1 medium slice bread, 0.5 cup cooked rice, pasta, or cereal, 1 oz ready-to-eat cereal	
Dairy	3 cup-eq/d	1 cup yogurt, 1.5 oz natural cheese, e.g., cheddar, 1 oz processed cheese	1 cup milk or fortified soy milk
Protein foods	5.5 oz-eq/d		
Seafood	8 oz-eq/wk	1 oz seafood	
Meat, poultry, eggs	26 oz-eq/wk	1 oz lean meat or poultry, 1 egg	NA
Nuts, seeds, soy food products	5 oz-eq/wk	0.25 cup cooked beans or tofu, 1 tbsp peanut butter, 0.25 cup nuts or seeds	
Oils	27 g/d		NA
Limits on calories for other uses (%kcal)	<270 kcal/d (<14%)		

[1] 1 cup-eq = 237 mL; 1 oz-eq = 30 g; 1 tbsp = 14.8 mL. eq, equivalent; NA, not applicable.

Beverages Address Key DGA Messages

A key message of the DGA is healthy eating patterns. An example of a healthy eating pattern is the Healthy US-Style Eating Pattern at the 2000-calorie level (**Table 2**). The appropriate beverage choices can fit into such a dietary pattern (Table 2). For an understanding of how beverages can be better considered as part of the key messages set forth by the 2015–2020 DGA, commonly consumed beverages were characterized based on calories, macronutrients, caffeine, select minerals and vitamins, and phytonutrients (Table 1).

A focus on healthy eating patterns

A variety of beverages fit well into the 3 healthy eating patterns described in the current DGA. As shown in Tables 1 and 2, beverage choices fit into 3 food groups. For example, 8 oz of milk would meet 33% of the daily recommendation for dairy, ∼6 oz (∼177 mL) of 100% fruit juice would meet 30% of the recommendation for the daily intake of fruit, and 6 oz/d of 100% tomato or carrot juice would meet the weekly recommendation for red or orange vegetables. Problems with exceeding sugar and/or sodium intake recommendations may arise with the juice recommendation as with some existing 100% juice products; however, possible advances in food technology could bring this into alignment with the DGA (145).

Dietary shifts that may be needed to achieve such patterns

Modest shifts in beverage choices can help close the gaps between current intakes and dietary recommendations. Below are examples of shifting from SSBs to higher-nutrient-density beverage choices, as well as the impact this has on meeting nutrient recommendations:

1) *Replacing SSBs with water, low-sodium tomato juice, nonfat milk, or unsweetened coffee or tea*. Considering the current mean intake of added sugars in the United States for women and men (55 and 62.5 g/d, respectively) (146), which is >20% higher than recommendations (<10% of total calorie intake), substitution of one 8-oz (237 mL) SSB with water (or unsweetened, no-added-dairy coffee or tea) would bring these averages down to 17% and 34% below the recommended limits for men and women, respectively (**Figure 1**). A substitution of 8 oz (237 mL) of nonfat milk would bring this to 20% and 37% below the recommendation for men and women, respectively. A substitution of 100% low-sodium tomato juice would bring this to 18% and 36% below the recommendation for men and women, respectively.
2) *Replacing SSBs with nonfat milk or low-sodium tomato juice*. Mean intakes of potassium, calcium (women only), vitamin A, and vitamin D are below the RDAs (**Figure 2**A). Substituting 8 oz (237 mL) of SSB with 8 oz (237 mL) of nonfat milk would increase intakes of

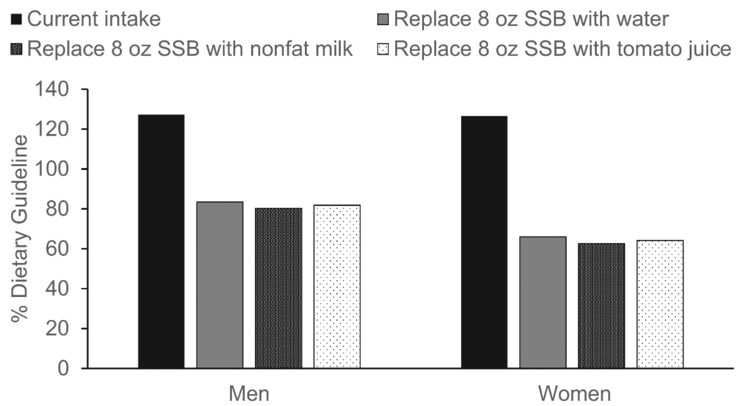

FIGURE 1 Mean added sugar intake (% Dietary Guideline) for adults when 8 oz (237 mL) of SSB is replaced with 8 oz (237 mL) of water, non/low-fat milk, or tomato juice. Data taken from (146). SSB, sugar-sweetened beverage.

potassium by 9% of the RDA (both men and women), calcium to 40% and 20% above the RDA (men and women, respectively), vitamin A by 8% and 23% of the RDA (men and women, respectively), and vitamin D by 20% of the RDA (both men and women) (Figure 2). A replacement with 8 oz (237 mL) of low-sodium tomato juice would increase intakes of fiber by ∼8% of current intakes, intake of potassium by ∼19% of the RDA, and vitamin A by 13–18% of the RDA for both men and women (Figure 2B).

3) *Replacing whole milk with nonfat or low-fat milk*. One serving of whole milk (8 oz, 237 mL) provides 161 kcal and 5 g SFAs. Given the DGA recommendation that <10% of total calories should come from SFAs, this would account for ∼22% of the recommended limit compared with 0%, 7%, and 14% for nonfat, 1% fat, and 2% fat milk, respectively (Table 1). Thus, saturated fat intake from whole milk ≤3 servings/d falls below the recommended limit but may restrict intake of SFAs as well as discretionary calories from other food sources. Replacing whole milk with nonfat or low-fat milk reduces saturated fat intake from dairy products.

A focus on variety, nutrient density, and intake amounts

Just as with foods, no one beverage will provide all the nutrients and phytonutrients needed for optimal health. And just like foods, variety is the key. Milk and milk substitutes (i.e., soy milk) are rich sources of high-quality protein (except some plant alternative milks) and vitamins A and D. One hundred percent juices are rich in potassium and vitamins A and C while being low in calories, fat, added sugars, and sodium. Although the amount of fiber contained in vegetable juice is relatively low (∼2 g/8 oz or 237 mL), 1 serving/d would increase current intakes in adults by >10%. Coffee, tea, and 100% fruit and vegetable juices are rich sources of

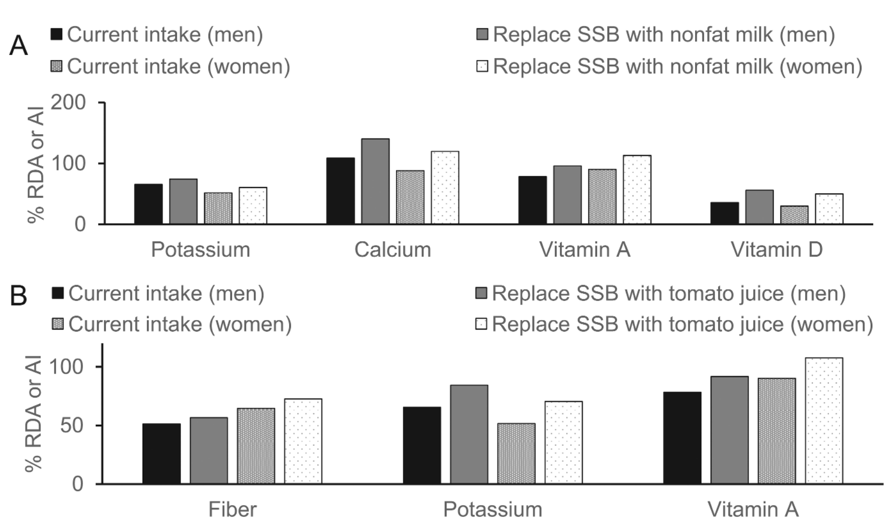

FIGURE 2 Mean fiber, potassium, calcium, vitamin A, and vitamin D intakes (% RDA or AI) for adults when 8 oz (237 mL) of SSB is replaced with 8 oz (237 mL) of non/low-fat milk (A) or tomato juice (B) (36, 70). AI, Adequate Intake; SSB, sugar-sweetened beverage.

phytonutrients. Most beverages listed in Table 1 are low fat (<3 g/serving), with the exception of whole milk and coconut milk, and can be considered as a part of a healthy eating pattern.

Discussion and Conclusions

The DGA was developed to provide guidance in choosing a healthy diet (2). Many Americans fall short of meeting many of these recommendations. The purpose of this report was to highlight the current and potential role of beverages as a part of the DGA. This was done with a consideration of the current scientific evidence as well as the nutrients and phytonutrients that commonly consumed beverages provide, with a focus on nutrient gaps in current intakes.

Beverages vary in nutrient and caloric content, each with health benefits (and, in the case of SSBs, possible health risks). Apart from hydration, LCS beverages and energy drinks may have limited health benefits and possible adverse effects (147). Although in some instances beverages cannot replace foods, e.g., it is difficult to meet the requirements for vitamin E, dietary fiber, or essential fatty acids through beverages alone, beverages have an important role in our diet being rich sources of nutrients and phytonutrients, phenolic acids and flavonoids in particular. When considering the micronutrients from diet alone, mean intakes of calcium (women), potassium, and vitamins A, C, and D are below recommendations and sodium intakes are well above (148). Modest beverage choices and substitutions could close these gaps. The graphics presented in this report provide select examples on how minor changes in beverage choices can aid in meeting recommended intakes of certain nutrients.

It is also important to encourage product innovation and reformulations that could be used to improve nutrient and/or phytonutrient profiles. For example, guidance is currently limited to 100% juice based on product standards of identity defined by soluble solids which are mostly sugar. As technologies evolve to develop products of improved nutritional profiles (i.e., reduced sugar or increased nutrient density) within dairy, dairy substitutes, fruit and vegetable juice, as well as coffee and tea, these products may not meet the current definitions used in the development of beverage guidance. Evaluation of these products and their incorporation into dietary guidance must consider the nutrient and perhaps phytonutrient density as primary factors which may allow for their consideration as a part of healthy food–based dietary patterns.

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