The Journal of Nutrition
Nutrient Requirements and Optimal Nutrition

Modeling Dairy-Free Vegetarian and Vegan USDA Food Patterns for Nonpregnant, Nonlactating Adults

Julie M Hess

USDA-ARS Grand Forks Human Nutrition Research Center, Grand Forks, ND, USA

ABSTRACT

Background: The 2020–2025 Dietary Guidelines for Americans (2020 DGA) recommend 3 dietary patterns for Americans, including a Healthy Vegetarian Dietary Pattern (HVDP).

Objectives: The objective of this study was to assess whether nutritionally adequate dairy-free and vegan adaptations to the HVDP can be modeled with foods already in the DGA.

Methods: Using similar food pattern modeling procedures as the 2020 DGA, the nutrient composition of 2 alternative models—dairy-free and vegan—of the 1800-, 2000-, 2200-, and 2400-kcal/d HVDPs was assessed. The dairy food group was replaced with a dairy alternative group comprised of soy milk and soy yogurt fortified with calcium, vitamin A, and vitamin D. For the vegan model, eggs were replaced with equal proportions of vegetarian protein foods.

Results: Dairy-free and vegan models required minimal changes to the HVDP. Cup-equivalents and/or ounce-equivalents of vegetables, fruits, grains, oils, and discretionary calories remained unchanged. Content of total fat, polyunsaturated fat, linoleic acid (18:2n–6), linolenic acid, iron, copper, vitamin D, riboflavin, vitamin B-12, and vitamin K increased in both models by ≥10% (all comparisons relative to the original HVDP). Choline increased ≥25% in the dairy-free models. Protein decreased 11% in both 1800-kcal/d models and 10% in both 2000-kcal/d models. Sodium, cholesterol, zinc, and phosphorus decreased across all energy levels in both models, and selenium decreased in the vegan model. Carbohydrate, fiber, saturated fat, EPA, DHA, calcium, magnesium, potassium, vitamin A, vitamin E, vitamin C, thiamin, folate, and vitamin B-6 changed ≤10%. Both models contained adequate nutrients to meet Dietary Reference Intakes (DRIs) for most age and sex groups for which 1800-, 2000-, 2200-, and 2400-kcal/d diets are appropriate. Zinc was the only nutrient below the DRI for males.

Conclusions: The dairy-free and vegan HVDP models could help adults who do not consume dairy foods and/or other animal products to meet nutrition recommendations. *J Nutr* 2022;152:2097–2108.

Keywords: nutrition guidelines, dietary patterns, vegan, dairy, nutrients

Introduction

The 2020–2025 Dietary Guidelines for Americans (2020 DGA) include 3 recommended healthy dietary patterns for Americans: the Healthy U.S.-Style Dietary Pattern, the Healthy Vegetarian Dietary Pattern (HVDP), and the Healthy Mediterranean-Style Dietary Pattern (1).

Despite including a vegetarian dietary pattern and discussing nutritional concerns for vegans, the 2020 DGA do not explicitly include a vegan dietary pattern, nor do they address how the HVDP can be adapted to accommodate the dietary restrictions of vegans, who do not consume any animal products. The 2020 DGA do mention that human milk will have insufficient vitamin B-12 if the breastfeeding parent eats a "strictly vegan diet without any animal source foods" (1). In addition, the 2020 DGA state that following a vegetarian or vegan dietary pattern during pregnancy and lactation requires special care to ensure adequate intake of iron and vitamin B-12 and, potentially, adequate intake of choline, zinc, iodine, DHA (22:6n–3), and EPA (20:5n–3) as well (1). Previous iterations of the DGA have devoted more attention to vegan diets. The 2015 DGA, which also include a Healthy Vegetarian Eating Pattern (HVEP), state that the HVEP can be vegan if all dairy choices are fortified soy

Supported by USDA Agricultural Research Service project grant #3062-51000-057-00D (to JMH).
Author disclosures: the author reports no conflicts of interest.
Address correspondence to JMH (e-mail: julie.hess@usda.gov).
Abbreviations used: AI, adequate intake; ALA, α-linolenic acid; cup eq, cup-equivalent; dairyALT, dairy alternative; DGA, Dietary Guidelines for Americans; DGAC, Dietary Guidelines Advisory Committee; HVDP, Healthy Vegetarian Dietary Pattern; HVEP, Healthy Vegetarian Eating Pattern; LA, linoleic acid; oz eq, ounce-equivalent; VRG, Vegetarian Resource Group.

Manuscript received February 11, 2022. Initial review completed March 16, 2022. Revision accepted April 26, 2022.
First published online April 29, 2022; doi: https://doi.org/10.1093/jn/nxac100.

TABLE 1 Eating pattern descriptions (3)

Type of diet	Restrictions
Omnivorous	None
Pescetarian	Avoid meat and poultry
Vegetarian	Avoid meat, poultry, seafood
Ovo-vegetarian	Avoid meat, poultry, seafood, dairy
Lacto-vegetarian	Avoid meat, poultry, seafood, eggs
Lacto-ovo vegetarian	Avoid meat, poultry, seafood
Vegan	Avoid all animal products

beverages or other plant-based dairy substitutes (2). However, this modified HVEP includes only a dairy substitute and lacks information on which foods should be used to substitute for eggs to ensure a nutritionally complete eating pattern. It also does not indicate that the HVEP with only a dairy substitute will be nutritionally complete. The 2010 DGA include a template for a vegan adaptation of their USDA Food Patterns, which does not include eggs and includes a "vegan dairy group" composed of "calcium-fortified soy beverage, calcium-fortified rice milk, tofu made with calcium-sulfate, and calcium-fortified soy yogurt" (3). A similar template or guide to a vegan dietary pattern is not included in the 2020 DGA.

Prevalence of vegetarians and vegans in the United States and popularity of "plant-based"

There are few data on the number of Americans who adhere to vegetarian or vegan diets. The National Health and Nutrition Examination Survey (NHANES) collected data on the percentage of Americans who were self-reported vegetarians and vegans between 2007–2008 and 2009–2010 but has not included this data point in its questionnaires since 2010 (4, 5). NHANES data from 2007–2010 indicated that ∼2.1% of Americans self-identified as vegetarian and, of that 2.1%, only 3% reported consuming no animal protein foods (6). Some previous studies have cited survey data generated by the Vegetarian Resource Group (VRG) to provide more recent estimates of the number of Americans who follow vegetarian or vegan diets (7, 8). The VRG's 2020 survey indicated that 6% of American adults were vegetarian and 3% of American adults were vegan (9). **Table 1** lists the dietary restrictions and preferences of different types of plant-based eating patterns.

Despite the relatively small percentage of American adults who report following a strict vegetarian or vegan diet, there has been increasing interest in, and research conducted about, "plant-based" diets (10–13). According to GoogleTrends data, the term "plant-based" has been steadily rising in frequency as a Google search term for the last 10 y (14). Interest in the search term "vegan" has also steadily increased in the last decade (14). Plant-based eating and plant-based foods continue to be popular, with sales of plant-based foods projected to continue increasing through 2024 (15).

Potential nutrition concerns for vegetarians and vegans

The 2010 Dietary Guidelines Advisory Committee (DGAC) Report states that its vegetarian patterns (lacto-ovo vegetarian and vegan) "meet almost all goals for nutrient adequacy," including sufficient protein, calcium, and vitamin B-12 (16). However, it does identify several potential nutrients of concern in a vegan diet, including choline, omega-3 fatty acids (EPA and DHA), and iron, a nutrient of concern for some children and women due to their higher risk of insufficiency when less bioavailable sources of iron, such as plant-based sources, are consumed. The 2010 DGAC report also states that care should be taken to include foods fortified with vitamin B-12, vitamin D, and calcium in vegan diets (16). Choline may also be a nutrient of concern (16). The 2010 DGA vegan adaptation of the USDA Food Pattern uses fortified foods to provide adequate calcium and vitamin B-12 (3), and it recommends the same number of ounce-equivalents (oz eq) of protein foods as both the nonvegetarian USDA Food Pattern and the lacto-ovo adaptation of the USDA Food Pattern (3).

Replacing nutrients found in eggs and dairy foods

An adaptation of the 2020 DGA's HVDP requires replacing both the animal-based dairy foods in the dairy group as well as eggs in the protein group, which also means finding alternate sources for the nutrients contained in these foods. Most of the dairy group foods consumed in the United States, according to data from NHANES 2015–2016, include milk and cheese with some yogurt and soy milk (17). Some dairy foods, like low-fat and fat-free milk and yogurt, are good or excellent sources of calcium, protein, phosphorus, riboflavin, vitamin B-12, pantothenic acid, and zinc (18). Milk is also a good source of vitamin D and iodine (18). Although infrequently consumed by Americans, soy milk has a similar nutrient profile and is a good or excellent source of many of the same nutrients (protein, calcium, vitamin B-12, vitamin A, riboflavin, and vitamin D) as well as choline, copper, and selenium (18). According to data from NHANES 2015–2016, eggs (whole, cooked, hardboiled) comprised 9.2% of the protein foods consumed by adults ages 19–70 y (17). Eggs are a good or excellent source of riboflavin, vitamin B-12, biotin, pantothenic acid, iodine, and selenium (18) and are also a leading food source of choline in the diet (17, 19). Beans, peas, and lentils are also important dietary sources of choline (17), but alternative plant-based foods that provide riboflavin, vitamin B-12, biotin, pantothenic acid, iodine, and selenium need to be identified.

Objective

The purpose of this study was to assess whether the HVDP in the 2020 DGA can be modeled for an entirely vegan diet, removing all animal products while retaining adequate amounts of essential nutrients for adults. The hypothesis was that a vegan adaptation of the HVDP with adequate nutrients could be modeled with the use of foods fortified in vitamin B-12, iron, vitamin D, and calcium, given that the 2020 DGA include plant-based alternatives in their dairy group and that the nutrients found in eggs can also be found in some plant sources.

Methods

The primary endpoint of this study was to assess whether nutritionally adequate ovo-vegetarian and vegan dietary patterns could be modeled with the foods already specified in the DGA. The secondary endpoint was to assess whether an alternative dairy group including only soy-based alternatives (fortified soy milk and soy yogurt) and containing a similar nutrient profile to the original dairy food group used in the 2020 DGA food pattern modeling could be developed using foods available in FoodData Central.

Selection of energy levels to model

The 2020 DGA include 12 different energy intake levels for the HVDP, ranging from 1000 kcal/d to 3200 kcal/d. Diets containing 1800, 2000, 2200, and 2400 kcal/d were modeled because these are the estimated energy levels appropriate for most males and females ages 19 y old and older, according to Table A2-2 in the 2020 DGA (1). Two models were generated—a dairy-free vegetarian dietary pattern and a vegan dietary pattern—for each of these energy levels.

Development of a dairy alternative food group

The 2020 DGA included soy milk and soy yogurt fortified with calcium and vitamins A and D in their dairy food group. Despite the proliferation of plant-based milks in retail, these fortified soy products are the only nondairy plant-based alternatives recommended in federal dietary guidance because they have the most similar nutrient profile to animal-based dairy products. To model the HVDP from the 2020 DGA without including any animal products, the representative foods used in the "dairy food" group (i.e. low-fat and fat-free milk, cheese, and yogurt) were replaced with fortified soy milk and soy yogurt. This changed group is referred to hereafter as the dairyALT group. Table 2 provides details on the nutrient profile of the dairyALTabT group and compares it with the nutrient profile of the original dairy food group used for developing the 2020 DGA dietary patterns.

The dairy food group nutrient profile was developed based on actual consumption data reported in the NHANES 2015–2016. Table 4.1 in the Food Pattern Modeling Report from the 2020 DGA (17) lists commonly selected dairy foods and the food used to represent the nutrient value of these foods in USDA food groups. For instance, the 2020 dairy food group was comprised of a composite of 49.6% milk (represented by nonfat milk and nonfat ice cream), 4.5% yogurt (represented by a variety of nonfat yogurts), 44.8% cheese (represented by reduced-fat, low-fat, and nonfat cheeses), and 1% soy milk (represented by unsweetened soy milk with added calcium and vitamins A and D). To generate the nutrient profile for a dairyALT group without animal-based products, the 1% soy milk in the original dairy food composite was retained. The representative food for dairy milk was replaced with soy milk and the representative food for yogurt was replaced with soy yogurt, but their contributions to the composite were retained in the same proportions. Because no dairy-free cheese alternative is currently included in the list of dairy foods recommended in the DGA, the cheese in the original dairy composite was replaced based on consumption shares of milk and yogurt (4.1% soy yogurt and 40.7% soy milk).

The fortified soy milk and fortified soy yogurt used for the development of the dairyALT composite and nutrient profile were the same products that the USDA's Center for Nutrition Policy and Promotion uses as reference foods for its list of "Food sources of calcium" (20).

Model 1

Model 1 replaced the 3 cup-equivalents (cup eq) of dairy foods in the HVDP with 3 cup eq of the dairyALT group, which included only dairy-free alternatives found in the 2020 DGA (fortified soy milk and soy yogurt).

Model 2

Model 2 replaced both the cup eq of dairy foods and the oz eq of eggs in the HVDP. Cup eq of dairy foods were replaced with cup eq of the dairyALT group and the 3 oz eq eggs/wk were replaced with 1 oz eq/wk of each of the other plant-based protein foods: soy products; nuts and seeds; and beans, peas, and lentils. Table 3 shows food group cup eq and oz eq in Models 1 and 2 in comparison with the original HVDP. Because the recommended amounts of vegetable subcategories and protein subcategories are provided in cup eq per week and oz eq per week, respectively, for the purposes of this study, we divided the amounts of each vegetable subcategory and protein food subcategory by 7 to achieve an approximate daily cup eq or oz eq amount and calculate nutrient adequacy on a daily basis.

Determining significance

For this study, changes of 10%–19% and ≥20% were used to denote meaningful changes in nutrient content between the original HVDP and Models 1 and 2. This categorization aligns with the method used by DGA food pattern modeling publications to indicate change (21, 22).

TABLE 2 Comparison between the dairy food group from the 2020 Dietary Guidelines for Americans Food Pattern Modeling Report and the dairyALT food group[1]

	Dairy food group (17)	DairyALT food group Soy milk (11320000)[2] Soy yogurt (175227)[2]
Macronutrients		
Calories, kcal	84.84	109.48
Protein, g	9.05	6.34
Carbohydrate, g	10.03	11.26
Fiber, total dietary, g	0.23	0.53
Total lipid (fat), g	0.98	3.64
SFAs, g	0.58	0.50
MUFAs, g	0.26	0.86[3]
PUFAs, g	0.06	1.92[3]
Linoleic acid (18:2n–6), g	0.04	1.30[3]
18:3 Linolenic acid, g	0.01	0.17[3]
EPA (20:5n–3), g	0	n/a
DHA (22:6n–3), g	0	n/a
Cholesterol, mg	7.39	0
Minerals		
Calcium, mg	306.98	301.59
Iron, mg	0.08	0.94[3]
Magnesium, mg	24.82	33.6[3]
Phosphorus, mg	220.6	96.41[3]
Potassium, mg	256.54	273.61[3]
Sodium, mg	193.7	108.16
Zinc, mg	1.23	0.58[3]
Copper, mg	0.05	0.37[3]
Selenium, μg	7.06	5.15[3]
Vitamins		
Vitamin A, μg RAE	102.8	123.03
Vitamin E, mg AT	0.04	0.25[3]
Vitamin D, IU	58.8	108.80
Vitamin C, mg	0.08	2.61
Thiamin, mg	0.08	0.07[3]
Riboflavin, mg	0.31	0.41[3]
Niacin, mg	0.39	0.95[3]
Vitamin B-6, mg	0.09	0.07[3]
Vitamin B-12, μg	0.92	1.90[3]
Folate, μg DFE	9.75	20.19[3]
Choline, mg	25.67	52.89[3]
Vitamin K, μg	0.25	6.72[3]

[1]Values are per cup-equivalent. 1 cup-equivalent = 2.37 dL. AT, alpha-tocopherols; DairyALT, dairy alternative; DFE, dietery folate equivalents; IU, international units; n/a, not available; RAE, retinol activity equivalents.
[2]Numbers denote food codes from the USDA FoodData Central database 2019 (18).
[3]These amounts in the dairyALT food group only reflect data from soy milk. Data on these nutrients were not available in FoodData Central for soy yogurt.

Results

Tables 4–8 show the impact of replacing dairy with nondairy alternatives (Model 1) and replacing eggs and dairy (Model 2) on the macro- and micronutrient content of the original HVDP. These tables also include columns containing DRIs corresponding to age and sex groups for which the estimated energy needs are 1800, 2000, 2200, and 2400 kcal/d. The DRIs

TABLE 3 From the 2020 Dietary Guidelines for Americans: daily or weekly amounts for each food group in the 2000-kcal/d HVDP compared with the modeled dietary patterns[1]

Food groups	HVDP	Model 1: dairy-free vegetarian pattern	Model 2: vegan pattern
Vegetables, cup eq/d	2.5	2.5	2.5
Dark Green Vegetables, cup eq/wk	1.5	1.5	1.5
Red and Orange, cup eq/wk	5.5	5.5	5.5
Beans, Peas, Lentils, cup eq/wk	1.5	1.5	1.5
Starchy Vegetables, cup eq/wk	5	5	5
Other Vegetables, cup eq/wk	4	4	4
Fruits, cup eq/d	2	2	2
Grains, oz eq/d	6.5	6.5	6.5
Whole Grains	3.5	3.5	3.5
Refined Grains	3	3	3
Dairy, cup eq/d	3	0	0
DairyALT, cup eq/d	0	3	3
Protein Foods, oz eq/d	3.5	3.5	3.5
Eggs, oz eq/wk	3	3	0
Beans, Peas, Lentils, oz eq/wk	6	6	7
Soy Products, oz eq/wk	8	8	9
Nuts, Seeds, oz eq/wk	7	7	8
Oils, g/d	27	27	27
Discretionary Calories, kcal/d	250	250	250

[1]One cup eq = 2.37 dL. 1 oz eq = 28.35 g. Cup eq, cup equivalent; DairyALT, dairy alternative; HVDP, Healthy Vegetarian Dietary Pattern; oz eq, ounce equivalent.

are included to illustrate where Models 1 and 2 do or do not align with nutrient recommendations. Tables 4–8 show the comparison of these models with DRIs for females 31–50 y old (1800 kcal/d), females 19–30 y old and males 51 y old and older (2000 kcal/d), males 31–50 y old (2200 kcal/d), and males 19–30 y old (2400 kcal/d), because the 2020 DGA list 1800 kcal/d as the approximate energy need estimate for females 31–50 y old, whereas 2000 kcal/d is the estimated need for females 19–30 y old and males 51 y old and older, 2200 kcal/d is the estimate for males 31–50 y old, and 2400 kcal/d is the estimate for males 19–30 y old.

Tables 4–8 show the percentage change in nutrient content between the HVDP and the 2 modeled alternatives (dairy-free and vegan) as well as the percentage of the DRIs met by the HVDP adaptations. As indicated in these tables, the amount of energy increased across all models from the baseline HVDP. In both models across all calorie levels, the energy increase from the HVDP did not exceed 5%. Other nutrients that changed ≤10% between the HVDP and modeled diets included carbohydrate, fiber, saturated fat, EPA, DHA, calcium, magnesium, potassium, vitamin A, vitamin E, vitamin C, thiamin, folate, and vitamin B-6. Nutrients that increased between 10% and 20% in the modeled HVDP when dairy was replaced with the plant-based dairyALT group included total fat, iron, riboflavin, and vitamin K. These same nutrients also increased when both dairy and eggs were replaced with plant-based foods. Monounsaturated fat increased in Model 1 at 1800 kcal/d but not in Model 2. Niacin increased 10%–12% in both models of the 1800- and 2000-kcal/d HVDP and in Model 2 of the 2200-kcal/d HVDP. Amounts of polyunsaturated fat, linolenic acid, linoleic acid (LA; 18:2n–6), copper, vitamin D, and vitamin B-12 all increased by ≥20% in Models 1 and 2. Choline increased by 25%–29% at all energy levels in the dairy-free models only. The vegan model with no eggs had no meaningful change in choline amounts from the original HVDP.

Some nutrients also decreased when eggs and dairy were replaced by other foods. Protein decreased by 10%–20% in Models 1 and 2 of the 1800- and 2000-kcal/d plans, and zinc amounts decreased in both models across all energy levels. Selenium decreased across all energy levels of Model 2. Sodium decreased across all energy levels in both models. The only dietary components that decreased by ≥20% across all energy levels in both models of the HVDP were cholesterol and phosphorus.

Both models, as well as the original HVDP, at all calorie levels assessed provided macronutrients—fat, protein, and carbohydrate—within the Acceptable Macronutrient Distribution Ranges (AMDRs). A few nutrients (vitamin D, vitamin E, and choline) were provided in amounts <90% of the DRIs in all models, including the original HVDP. One pattern, the 1800-kcal HVDP, provided ∼87% of the iron DRI for females 31–50 y old, and the 2000-kcal ovo-vegetarian and vegan models provided only ∼86% of the zinc DRI for males 51 y and older. Sodium was also low in these patterns. All other nutrients were provided in amounts meeting or exceeding 90% of the DRI.

Discussion

As shown in Table 3, modeling nutritionally adequate dairy-free and vegan dietary patterns involved minimal shifts to the existing HVDP and aligned with current DGA recommendations that indicate fortified soy beverages and soy milk are acceptable dairy choices. There were no changes required to the cup eq, grams, or kilocalories of vegetables, fruits, grains, oils, or discretionary calories. Dairy foods can be replaced with the plant-based dairy equivalents already included in the 2020 DGA dairy group, and each oz eq of eggs can be replaced with 1 oz eq of a vegetarian protein source—soy products; nuts and seeds; or beans, peas, and lentils (protein group)—with minimal impact on the overall nutrition profile of the recommended 2020 DGA HVDP.

Although the dairy-free and vegan modeled patterns added some energy (67–74 kcal more than the original HVDP), largely due to the replacement of the 85-kcal dairy group with the 109-kcal dairyALT group, the dairy composite was comprised almost entirely of fat-free products (17). However, most of the dairy foods that Americans consume are reduced-fat (2%) or whole-fat products, which are higher in both fat and energy (21). Previous work by Hess et al. (21) included developing reduced- and whole-fat dairy foods groups, and these groups contain 14% and 31% more energy, respectively, than the 109-kcal dairyALT model.

The dairy-free modeled dietary pattern could be a useful guide for adults who are sensitive to dairy foods or choose not to consume them. The public process surrounding the 2020 DGA indicated that some Americans are concerned about the dairy group being included in nutrition recommendations for healthy Americans (23). An analysis of 1645 of the 38,368 public comments submitted to the 2020 DGA (removing those comments hidden from public view because of vulgar or inappropriate language, comments sent only as uploaded files, and duplicate comments) found that the most frequently mentioned topic among the public comments was that "including dairy products as a broad recommendation is unwarranted" (23). However, some Americans, including those following dairy-free

TABLE 4 Impact of replacing dairy and eggs in the 1800-kcal/d HVDP with vegan alternatives[1]

	DRIs: females 31–50 y old	HVDP	Model 1: dairy-free vegetarian pattern	Change from HVDP, %	Change from DRI, %	Model 2: vegan pattern	Change from HVDP, %	Change from DRI, %
Macronutrients								
Calories, kcal	1800	1797	1871	4.11	103.92	1864	3.72	103.53
Protein, g	46	76	67	−10.74	146.61	67	−10.94	146.29
Carbohydrate, g	130	237	241	1.56	185.06	242	2.21	186.25
Fiber, g	25	28.6	29.5	3.12	117.87	30.1	5.29	120.34
Total fat, g	20%–35%	49.9	57.9	16.01	Within range	56.9	13.87	Within range
Saturated fat, g	<10%	9.6	9.4	−2.42	Meets criteria	8.8	−7.80	Meets criteria
MUFAs, g	n/a	17.9	19.7	10.07	n/a	19.4	8.40	n/a
PUFAs, g	n/a	18.7	24.3	29.77	n/a	24.4	30.09	n/a
Linoleic acid (18:2n–6), g	12	16.5	20.3	22.86	169.28	20.4	23.32	169.91
18:3 Linolenic acid, g	1.1	2.12	2.60	22.68	236.04	2.62	23.78	238.15
EPA (20:5n–3), g	n/a	0.00	0.00	0.00	n/a	0	0.00	n/a
DHA (22:6n–3), g	n/a	0.01	0.01	0.00	n/a	0	0.00	n/a
Cholesterol, mg	As low as possible	105	83	−21.08	n/a	3	−97.32	n/a
Minerals								
Calcium, mg	1000	1317	1301	−1.23	130.06	1301	−1.17	130.14
Iron, mg	18	16	18	16.52	101.07	18	17.82	102.20
Magnesium, mg	320	365	392	7.21	122.41	398	8.84	124.27
Phosphorus, mg	700	1557	1184	−23.93	169.17	1179	−24.29	168.38
Potassium, mg	2600	3102	3154	1.65	121.29	3164	1.99	121.70
Sodium, mg	2300	1421	1165	−18.06	50.64	1157	−18.59	50.31
Zinc, mg	8	11	9	−17.49	114.99	9	−17.71	114.69
Copper, mg	0.9	2	2	63.66	0.27	3	67.39	280.44
Selenium, μg	55	79	73	−7.30	132.35	67	−15.08	121.24
Vitamins								
Vitamin A, RAE, μg	700	839	899	7.24	128.49	867	3.42	123.91
Vitamin E, AT, mg	15	9.40	10.03	6.70	66.84	10.09	7.35	67.25
Vitamin D, IU	600	219	369	68.41	61.54	351	60.10	58.51
Vitamin C, mg	75	114	122	6.63	162.71	122	6.67	162.77
Thiamin, mg	1.1	1.75	1.72	−1.72	156.00	1.72	−1.39	156.52
Riboflavin, mg	1.1	1.78	2.08	16.85	189.15	1.98	11.30	180.18
Niacin, mg	14	16.0	18	10.49	126.35	17.9	11.86	127.91
Vitamin B-6, mg	1.3	1.74	1.68	−3.45	129.09	1.67	−3.79	128.64
Vitamin B-12, μg	2.4	3.85	6.79	76.35	282.95	6.55	70.09	272.92
Choline, mg	425	286	368	28.54	86.55	311	8.70	73.19
Vitamin K, μg	90	133	152	14.61	169.18	152	14.78	169.44
Folate, DFE, μg	400	594	625	5.22	156.25	629	5.89	157.25

[1]AT, alpha-tocopherols; DFE, dietery folate equivalents; HVDP, Healthy Vegetarian Dietary Pattern; IU, international units; n/a, not available; RAE, retinol activity equivalents.

TABLE 7 Impact of replacing dairy and eggs in the 2200-kcal/d HVDP with vegan alternatives for males 31–50 y old[1]

	DRIs: males 31–50 y old	HVDP	Model 1: dairy-free vegetarian pattern	Change from HVDP, %	Change from DRI, %	Model 2: vegan pattern	Change from HVDP, %	Change from DRI, %
Macronutrients								
Calories, kcal	2200	2201	2275	3.36	103.41	2271	3.17	103.23
Protein, g	56	85	77	−9.56	137.22	77	−9.40	137.45
Carbohydrate, g	130	277	281	1.33	216.14	283	2.05	217.66
Fiber, g	31	33.8	34.7	2.64	112.05	35.5	4.91	114.53
Total fat, g	20%–35%	58.5	66.5	13.65	Within range	65.5	11.87	Within range
Saturated fat, g	<10%	11.0	10.7	−2.12	Meets criteria	10.2	−6.80	Meets criteria
Monounsaturated fat, g	n/a	21.0	22.8	8.58	n/a	22.5	7.17	n/a
Polyunsaturated fat, g	n/a	22.3	27.9	25.02	n/a	27.9	25.33	n/a
Linoleic acid (18:2n–6), g	17	19.7	23.4	19.23	137.88	23.5	19.65	138.37
18:3 Linolenic acid, g	1.6	2.54	3.02	18.89	188.83	3.05	19.90	190.44
EPA (20:5n–3), g	n/a	0.00	0.00	0.00	n/a	0.00	0.00	n/a
DHA (22:6n–3), g	n/a	0.01	0.01	0.00	n/a	0.00	0.00	n/a
Cholesterol, mg	As low as possible	106	83	−20.99	n/a	3	−96.90	n/a
Minerals								
Calcium, mg	1000	1392	1375	−1.16	137.54	1377	−1.02	137.73
Iron, mg	8	18	21	14.00	262.62	21	15.43	265.93
Magnesium, mg	420	419	445	6.28	106.06	452	7.95	107.72
Phosphorus, mg	700	1718	1345	−21.69	192.19	1344	−21.79	191.93
Potassium, mg	3400	3575	3626	1.43	106.65	3644	1.93	107.18
Sodium, mg	2300	1573	1317	−16.31	57.24	1310	−16.71	56.97
Zinc, mg	11	12	10	−15.70	95.15	10	−15.70	95.15
Copper, mg	0.9	2	3	53.80	304.94	3	57.28	311.84
Selenium, μg	55	87	81	−6.61	147.26	75	−13.57	136.28
Vitamins								
Vitamin A, RAE, μg	900	916	977	6.63	108.54	945	3.13	104.98
Vitamin E, AT, mg	15	11.11	12	5.67	78.29	12	6.30	78.76
Vitamin D, IU	600	223	373	67.28	62.16	355	59.11	59.12
Vitamin C, mg	90	142	149	5.35	166.08	150	5.39	166.14
Thiamin, mg	1.2	2.01	1.98	−1.49	165.20	1.99	−1.02	165.98
Riboflavin, mg	1.3	1.93	2.23	15.58	171.23	2.13	10.52	163.74
Niacin, mg	16	18.6	20.2	9.05	126.55	20.5	10.28	127.98
Vitamin B-6, mg	1.3	2.03	1.97	−2.96	151.40	1.97	−3.10	151.18
Vitamin B-12, μg	2.4	3.98	6.92	73.95	288.16	6.68	67.89	278.13
Choline, mg	550	318	399	25.71	72.60	343	8.08	62.42
Vitamin K, μg	120	170	189	11.41	157.88	190	11.59	158.13
Folate, DFE, μg	400	697	729	4.59	182.25	735	5.45	183.75

[1] AT, alpha-tocopherols; DFE, dietery folate equivalents; HVDP, Healthy Vegetarian Dietary Pattern; IU, international units; n/a, not available; RAE, retinol activity equivalents.

TABLE 8 Impact of replacing dairy and eggs in the 2400-kcal/d HVDP with vegan alternatives for males 19–30 y old[1]

	DRIs: males 19–30 y old	HVDP	Model 1: dairy-free vegetarian pattern	Change from HVDP, %	Change from DRI, %	Model 2: vegan pattern	Change from HVDP, %	Change from DRI, %
Macronutrients								
Calories, kcal	2400	2404	2478	3.07	103.26	2474	2.92	103.10
Protein, g	56	91	83	−8.91	148.18	83	−8.86	148.25
Carbohydrate, g	130	297	301	1.24	231.52	303	1.92	233.06
Fiber, g	34	36.6	37.5	2.44	110.16	38.2	4.58	112.46
Total fat, g	20%–35%	63.2	71.2	12.64	Within range	70.3	11.09	Within range
Saturated fat, g	<10%	12	12	−1.98	Meets criteria	11	−6.26	Meets criteria
Monounsaturated fat, g	n/a	22.7	24.5	7.94	n/a	24.2	6.80	n/a
Polyunsaturated fat, g	n/a	24.2	29.8	23.08	n/a	29.8	23.43	n/a
Linoleic acid (18:2n–6), g	17	21.3	25.1	17.71	147.78	25.2	18.18	148.37
18:3 Linolenic acid, g	1.6	2.74	3.22	17.54	201.08	3.24	18.52	202.75
EPA (20:5n–3), g	n/a	0	0	0.00	n/a	0	0.00	n/a
DHA (22:6n–3), g	n/a	0	0	0.00	n/a	0	0.00	n/a
Cholesterol, mg	As low as possible	106	84	−20.90	n/a	4	−96.52	n/a
Minerals								
Calcium, mg	1000	1436	1420	−1.13	141.98	1422	−1.00	142.16
Iron, mg	8	20	23	12.68	286.61	23	13.90	289.72
Magnesium, mg	400	450	476	5.86	118.96	483	7.46	120.77
Phosphorus, mg	700	1822	1450	−20.45	207.10	1447	−20.57	206.78
Potassium, mg	3400	3704	3755	1.38	110.44	3774	1.89	110.99
Sodium, mg	2300	1684	1427	−15.24	62.05	1420	−15.68	61.73
Zinc, mg	11	13	11	−14.62	103.51	11	−14.63	103.51
Copper, mg	900	2	3	49.81	320.81	3	52.99	327.61
Selenium, μg	55	94	88	−6.09	160.62	82	−12.50	149.65
Vitamins								
Vitamin A, RAE, μg	900	935	996	6.49	110.69	964	3.07	107.13
Vitamin E, AT, mg	15	11.94	12.57	5.28	83.81	12.66	6.02	84.40
Vitamin D, IU	600	227	377	66.20	62.76	358	58.17	59.73
Vitamin C, mg	90	143	150	5.32	166.83	150	5.36	166.89
Thiamin, mg	1.2	2.18	2.15	−1.37	179.58	2.16	−0.94	180.36
Riboflavin, mg	1.3	2.00	2.30	14.97	177.21	2.21	10.13	169.74
Niacin, mg	16	20	22	8.31	136.86	22	9.50	138.36
Vitamin B-6, mg	1.3	2.13	2.07	−2.82	159.22	2.07	−2.93	159.04
Vitamin B-12, μg	2.4	4.10	7.04	71.69	293.37	6.80	65.82	283.33
Choline, mg	550	332	413	24.61	75.18	357	7.68	64.96
Vitamin K, μg	120	174	193	11.15	161.18	194	11.33	161.43
Folate, DFE, μg	400	766	798	4.18	199.5	804	4.96	201.00

[1] AT, alpha-tocopherols; DFE, dietery folate equivalents; HVDP, Healthy Vegetarian Dietary Pattern; IU, international units; n/a, not available; RAE, retinol activity equivalents.

TABLE 5 Impact of replacing dairy and eggs in the 2000-kcal/d HVDP with vegan alternatives for females 19–30 y old[1]

	DRIs: females 19–30 y old	HVDP	Model 1: dairy-free vegetarian pattern	Change from HVDP, %	Change from DRI, %	Model 2: vegan pattern	Change from HVDP, %	Change from DRI, %
Macronutrients								
Calories, kcal	2000	1998	2072	3.70	103.58	2065	3.37	103.26
Protein, g	46	80	72	− 10.17	128.07	72	− 10.20	128.02
Carbohydrate, g	130	250	254	1.48	195.00	255	2.10	196.19
Fiber, g	28	29.9	30.8	2.98	110.10	31.4	5.05	112.31
Total fat, g	20%–35%	54.3	62.3	14.71	Within range	61.3	12.76	Within range
Saturated fat, g	<10%	10.2	10.0	− 2.27	Meets criteria	9.5	− 7.30	Meets criteria
Monounsaturated fat, g	n/a	19.5	21	9.23	n/a	21	7.70	n/a
Polyunsaturated fat, g	n/a	20.6	26	27.06	n/a	26	27.36	n/a
Linoleic acid (18:2n–6), g	12	18.2	22	20.79	129.21	22	21.22	129.67
18:3 Linolenic acid, g	1.1	2.34	3	20.49	176.39	3	21.50	177.86
EPA (20:5n–3), g	n/a	0.00	0	0.00	n/a	0	0.00	n/a
DHA (22:6n–3), g	n/a	0.01	0	0.00	n/a	0	0.00	n/a
Cholesterol, mg	As low as possible	105	83	− 21.07	n/a	3	− 97.27	n/a
Minerals								
Calcium, mg	1000	1341	1325	− 1.21	132.46	1326	− 1.12	132.57
Iron, mg	18	16	19	15.71	105.59	19	17.06	106.82
Magnesium, mg	310	381	408	6.91	131.55	414	8.49	133.49
Phosphorus, mg	700	1609	1236	− 23.16	176.58	1232	− 23.44	175.94
Potassium, mg	2600	3272	3323	1.57	127.81	3334	1.89	128.22
Sodium, mg	2300	1461	1205	− 17.56	52.37	1198	− 17.99	52.10
Zinc, mg	8	11	10	− 17.02	118.83	9	− 17.18	118.60
Copper, mg	0.9	2	3	58.80	288.08	3	62.37	294.56
Selenium, μg	55	79	73	− 7.24	133.56	67	− 14.94	122.46
Vitamins								
Vitamin A, RAE, μg	700	847	907	7.17	129.64	875	3.39	125.07
Vitamin E, AT, mg	15	10.24	10.87	6.15	72.48	10.93	6.74	72.88
Vitamin D, IU	600	220	370	68.26	61.61	352	59.97	58.59
Vitamin C, mg	75	129	137	5.86	182.76	137	5.90	182.82
Thiamin, mg	1.1	1.79	1.76	− 1.68	159.87	1.76	− 1.34	160.42
Riboflavin, mg	1.1	1.82	2.12	16.45	193.03	2.02	11.05	184.07
Niacin, mg	14	16.5	18.2	10.18	129.88	18.4	11.52	131.46
Vitamin B-6, mg	1.3	1.83	1.77	− 3.27	136.32	1.77	− 3.59	135.88
Vitamin B-12, μg	2.4	3.85	6.79	76.35	282.95	6.55	70.09	272.92
Choline, mg	425	300	381	27.26	89.70	325	8.40	76.40
Vitamin K, μg	90	139	158	14.01	175.46	158	14.18	175.72
Folate, DFE, μg	400	612	644	5.23	161.00	648	5.88	162.00

[1] AT, alpha-tocopherols; DFE, dietery folate equivalents; HVDP, Healthy Vegetarian Dietary Pattern; IU, international units; n/a, not available; RAE, retinol activity equivalents.

TABLE 6 Impact of replacing dairy and eggs in the 2000-kcal/d HVDP with vegan alternatives for males 51 y old and older[1]

	DRIs: males 51 y old and older	HVDP	Model 1: dairy-free vegetarian pattern	Change from HVDP, %	Change from DRI, %	Model 2: vegan pattern	Change from HVDP, %	Change from DRI, %
Macronutrients								
Calories, kcal	2000	1998	2072	3.70	103.58	2065	3.37	103.26
Protein, g	56	80	72	−10.17	128.07	72	−10.20	128.02
Carbohydrate, g	130	250	254	1.48	195.00	255	2.10	196.19
Fiber, g	28	29.9	30.8	2.98	110.10	31.4	5.05	112.31
Total fat, g	20%–35%	54.3	62.3	14.71	Within range	61.3	12.76	Within range
Saturated fat, g	<10%	10.2	10.0	−2.27	Meets criteria	9.5	−7.30	Meets criteria
Monounsaturated fat, g	n/a	19.5	21	9.23	n/a	21	7.70	n/a
Polyunsaturated fat, g	n/a	20.6	26	27.06	n/a	26	27.36	n/a
Linoleic acid (18:2n–6), g	14	18.2	22	20.79	156.90	22	21.22	157.46
18:3 Linolenic acid, g	1.6	2.34	3	20.49	176.39	3	21.50	177.86
EPA (20:5n–3), g	n/a	0.00	0	0.00	n/a	0	0.00	n/a
DHA (22:6n–3), g	n/a	0.01	0	0.00	n/a	0	0.00	n/a
Cholesterol, mg	As low as possible	105	83	−21.07	n/a	3	−97.27	n/a
Minerals								
Calcium, mg	1000	1341	1325	−1.21	132.46	1326	−1.12	132.57
Iron, mg	8	16	19	15.71	237.58	19	17.06	240.36
Magnesium, mg	420	381	408	6.91	97.09	414	8.49	98.53
Phosphorus, mg	700	1609	1236	−23.16	176.58	1232	−23.44	175.94
Potassium, mg	3400	3272	3323	1.57	97.73	3334	1.89	98.05
Sodium, mg	2300	1461	1205	−17.56	52.37	1198	−17.99	52.10
Zinc, mg	11	11	10	−17.02	86.42	9	−17.18	86.25
Copper, mg	0.9	2	3	58.80	288.08	3	62.37	294.56
Selenium, μg	55	79	73	−7.24	133.56	67	−14.94	122.46
Vitamins								
Vitamin A, RAE, μg	900	847	907	7.17	100.83	875	3.39	97.27
Vitamin E, AT, mg	15	10.24	10.87	6.15	72.48	10.93	6.74	72.88
Vitamin D, IU	600	220	370	68.26	61.63	352	59.97	58.59
Vitamin C, mg	90	129	137	5.86	152.30	137	5.90	152.35
Thiamin, mg	1.2	1.79	1.76	−1.68	146.55	1.76	−1.34	147.05
Riboflavin, mg	1.3	1.82	2.12	16.45	163.33	2.02	11.05	155.75
Niacin, mg	16	16.5	18.2	10.18	113.65	18.4	11.52	115.03
Vitamin B-6, mg	1.7	1.83	1.77	−3.27	104.25	1.77	−3.59	103.91
Vitamin B-12, μg	2.4	3.85	6.79	76.35	282.95	6.55	70.09	272.92
Choline, mg	550	300	381	27.26	69.31	325	8.40	59.04
Vitamin K, μg	120	139	158	14.01	131.60	158	14.18	131.79
Folate, DFE, μg	400	612	644	5.23	161.00	648	5.88	162.00

[1] AT, alpha-tocopherols; DFE, dietery folate equivalents; HVDP, Healthy Vegetarian Dietary Pattern; IU, international unit; n/a, not available; RAE, retinol activity equivalents.

and vegan eating patterns, may not be aware that the "dairy group" already contains 2 nondairy alternatives (fortified soy milk and fortified soy yogurt) that have nutrient profiles similar to those of animal-based dairy products.

Models 1 and 2 contained adequate amounts of nutrients to meet most DRIs, although the amounts of some of these nutrients fell below what was contained in the original HVDP. For instance, both models contained 11% less protein, 24% less phosphorus, and 18% less zinc than the original HVDP. The lower amounts of phosphorus and zinc in the dairy-free models may be due to lower amounts of phosphorus and zinc in the dairyALT group than in the dairy group (Table 2). The dairyALT group was also lower in selenium than the dairy group. However, the modeled diets with the dairyALT group contained enough protein and phosphorus as well as selenium to meet the DRIs for healthy adults of all ages and enough zinc to meet the needs of healthy adult females who are not pregnant or lactating. The 2000- and 2200-kcal/d modeled patterns did not contain enough zinc to meet the DRIs for males 51 y old and older (2000 kcal/d) or for males 31–50 y old (2200 kcal/d).

Potential nutrients of concern for vegan diets include bioavailable iron, EPA, DHA, vitamin B-12, vitamin D, calcium, and choline (1). Both the modeled diets and the original HVDP were low in heme iron, EPA, and DHA. The amount of iron increased with Models 1 and 2 relative to the original HVDP, which does not contain adequate iron for females ages 19–50 y. The dairyALT nutrient profile contained nearly a milligram of iron due to fortification, and the soy product nutrient profile contained iron as well. Both modeled diets contained adequate iron for healthy adult males and females. However, meeting these needs requires careful adherence to this dietary pattern. Meeting iron needs on vegetarian or vegan diets, especially for menstruating people, requires understanding of foods that are good or excellent sources of iron and careful dietary planning to ensure adequate consumption of those foods.

The original HVDP and the dairy-free Model 1 diet contained 0.01 g DHA/d, coming exclusively from the egg food group, which contains 0.02 g DHA per 1 oz eq (17). The vegan modeled diet contained no EPA or DHA, due to the removal of eggs. In a diet with minimal to no animal products, α-linolenic acid (ALA; 18:3n–3) found in foods such as flax seed, hemp seed, and chia seeds, along with their respective oils (24), can be converted to EPA and DHA. There are many other sources of ALA, but these other sources are also abundant in LA, which can lead to difficulty balancing fatty acid intake. Some additional sources of ALA include canola oil, soybean oil, and walnut oil (24).

The National Academies and Institute of Medicine have set an adequate intake (AI) for ALA at 1.6 g/d for males between the ages of 19 and 70 y and 1.1 g/d for females between the ages of 19 and 70 y (25). This AI was set using data on "median intakes in the United States where an n-3 fatty acid deficiency is non-existent in healthy individuals" (25). ALA intake in vegetarians and vegans meets or is close to the AI (26, 27), and endogenous synthesis of EPA and DHA from ALA is enough to meet the ω-3 fatty acid needs in healthy individuals (28, 29). These nutrients (EPA, DHA) remain of concern for those following vegetarian diets, including the HVDP, as well as vegan diets.

The amount of vitamin B-12 nearly doubled (from ~4 μg to ~7 μg) from the original HVDP to Models 1 and 2. This increase was due to the added vitamin B-12 found in the dairyALT nutrient profile, which contained 1.9 μg vitamin B-12 compared with 0.92 μg in the original dairy food nutrient profile. An important caveat to this finding is that very few people meet dairy food recommendations, including the dairy alternatives (fortified soy milk and soy yogurt) found in the dairy group. Soy milk comprises only ~1% of the dairy group foods consumed by Americans ages 2 y and older (17), and Americans currently following a dairy-free or vegan diet who are not consuming adequate amounts of soy milk, soy yogurt, or other foods with added vitamin B-12 may not be meeting recommendations for vitamin B-12.

Although neither the original HVDP nor the modeled patterns provided adequate vitamin D, both modeled patterns provided 50%–70% more vitamin D than the original HVDP. As with vitamin B-12, this difference was due to the higher levels of vitamin D fortification in the soy milk and soy yogurt used as representative foods in this model than in dairy foods. As shown in Table 2, the dairyALT nutrient profile had more than double the vitamin D content of the original dairy food nutrient profile. Because vitamin D is a nutrient of concern for Americans owing to inadequate intake and associated health outcomes, the 2020 DGA acknowledge that it can be difficult to meet recommendations through diet alone and state that supplements may be appropriate for Americans whose sunlight exposure is limited owing to climate or sunscreen use (1).

The dairyALT nutrient profile had a nearly identical calcium content to the original dairy food group nutrient profile. Low intake of fortified soy milk and soy yogurts could also lead to insufficient calcium intake. However, if consumed in recommended amounts, these products provide an amount of calcium comparable with dairy foods. The dairyALT nutrient profile had roughly double the choline content of the original dairy food group nutrient profile, so amounts of choline increased in Model 1 relative to the original HVDP.

The variations of the HVDP in this article were modeled for healthy adults over the age of 19 y who are not pregnant or lactating, and there are challenges with extending these vegan and ovo-vegetarian modifications to the HVDP to other life stages, especially adolescence and early childhood. For instance, although not carried through to the 2020 DGA, the 2020 DGAC Report states that food patterns for toddlers are not vegan, because "it is not possible to meet all nutrient goals with a vegan diet" for children ages 12–24 mo (13). However, the (lacto-vegetarian) HVDP with animal products can be suitable for children and adults of all ages. Furthermore, unless followed perfectly, these modeled diets do not contain adequate nutrition for adolescents and teenagers, especially adolescent and teenage girls, who need higher amounts of iron than their male counterparts. Additional modifications would be needed to address nutrient gaps and specific needs of other life stages.

Limitations

There are some limitations to the methods in this study. This study relied on food pattern modeling. The food groups used in modeling had nutrient profiles that reflected the most nutrient-dense forms of foods in each category so, like the 2020 DGA recommended dietary patterns, the nutrient profiles were not based on typical, less nutrient-dense food choices.

In addition, this work was limited by the lack of information available for how Americans following ovo-vegetarian or vegan diets eat. The proportions of dairy foods used in the development of the dairy food group were reflective of the entire US population, most of whom do not follow an ovo-vegetarian or vegan diet. In addition, the proportions of milk, cheese, and yogurt in the dairy group composite were partially driven by dairy desserts. These data may not be the correct basis for a dairy alternative food group intended for an ovo-vegetarian or vegan population. Furthermore, soy milk is not a commonly selected dairy alternative and comprises only ∼1% of the dairy group foods consumed by Americans. Other dairy alternatives are more frequently consumed but are not currently included in the DGA dairy group, although some individual products may have a nutrient profile similar to dairy milk. Therefore, a major limitation to this study is that the dairyALT group was not based on actual intake, as the food group composites in the 2020 DGA are.

Another limitation of this food pattern modeling work is that, in relying on numerical DRIs to determine nutrient adequacy, it cannot account for potential bioactive components in foods nor can it fully account for potential variations in the bioavailability of nutrients from different foods, food combinations or mixed dishes. As one example, eating eggs alongside vegetable dishes enhances vitamin E absorption (30), and it is unknown what impact removing eggs from the diet may have on vitamin E uptake or on other factors. Health and nutrition impacts of replacing foods such as dairy and eggs in vegetarian diets cannot be fully anticipated with food pattern modeling.

The food pattern models in this study were limited by their exclusion of iodine. Iodine was not included in this model, because it is not in the nutrient profiles of the food groups listed in the Food Pattern Modeling Report of the 2020 DGAC. Iodine is not a nutrient available in the food composition databases used to develop the Food Pattern Modeling Report. Yet, iodine is important for maintenance of thyroid health and metabolism in all stages of life. Like folate, iodine is important for those who are seeking and/or able to become pregnant (31, 32). Sufficient iodine intake is important for fetal growth and neurodevelopment in utero (31, 32). It is also important during early childhood for optimal growth and cognition. Iodine concentration of plant-based foods is dependent on soil iodine concentration and may vary throughout the world (33). Vegetarian sources of iodine include iodized salt, and seaweed, but it may be found in small amounts throughout the food supply (34). Goitrogenic foods like soy, cruciferous vegetables, and sweet potatoes, which produce thiocyanates that inhibit uptake of iodine by the thyroid gland, may be of concern owing to the higher intakes of these foods by those who follow vegan or vegetarian diets (33). However, research indicates that cooking these foods (35) and consuming an adequate amount of iodine-containing foods (36) should be sufficient to overcome potential adverse impacts on thyroid regulation.

Acknowledgments

The USDA prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, SW, Washington, DC 20250-9410, or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer. The sole author was responsible for all aspects of this manuscript.

Data Availability

All data used in this article are publicly and freely available online, and all resources to acquire this information can be found in the References.

References

1 USDA and US Department of Health and Human Services (HHS). Dietary Guidelines for Americans, 2020–2025. 9th ed. Washington (DC): USDA and US DHHS; 2020.
2 US Department of Health and Human Services (HHS) and USDA. 2015–2020 Dietary Guidelines for Americans. 8th ed. Washington (DC): US DHHS and USDA; 2015.
3 USDA and US Department of Health and Human Services (HHS). Dietary Guidelines for Americans, 2010. 7th ed. Washington (DC): USDA and US DHHS; 2010.
4 National Health and Nutrition Examination Survey. 2007–2008 data documentation, codebook, and frequencies: diet behavior & nutrition (DBQ_E) [Internet]. Hyattsville (MD): National Center for Health Statistics; 2010. [Accessed Dec 2021]. Available from: https://wwwn.cdc.gov/nchs/nhanes/2007-2008/dbq_e.htm#DBQ915.
5 National Health and Nutrition Examination Survey. 2009–2010 data documentation, codebook, and frequencies: diet behavior & nutrition (DBQ_F) [Internet]. Hyattsville (MD): National Center for Health Statistics; 2012. [Accessed Dec 2021]. Available from: https://wwwn.cdc.gov/nchs/nhanes/2009-2010/dbq_f.htm.
6 Juan W, Yamini S, Britten P. Food intake patterns of self-identified vegetarians among the U.S. population, 2007–2010. Procedia Food Sci 2015;4:86–93.
7 Melina V, Craig W, Levin S. Position of the academy of nutrition and dietetics: vegetarian diets. J Acad Nutr Diet 2016;116(12):1970–80.
8 Radnitz C, Beezhold B, DiMatteo J. Investigation of lifestyle choices of individuals following a vegan diet for health and ethical reasons. Appetite 2015;90:31–6.
9 Vegetarian Resource Group. How many adults in the U.S. are vegan? How many adults eat vegetarian when eating out? 2020. [Internet]. [Access Nov 2021]. Available from: https://www.vrg.org/journal/vj2020issue4/2020_issue4_poll_results.php.
10 Kim H, Caulfield LE, Garcia-Larsen V, Steffen LM, Coresh J, Rebholz CM. Plant-based diets are associated with a lower risk of incident cardiovascular disease, cardiovascular disease mortality, and all-cause mortality in a general population of middle-aged adults. J Am Heart Assoc 2019;8(16):e012865.
11 Satija A, Bhupathiraju SN, Rimm EB, Spiegelman D, Chiuve SE, Borgi L, et al. Plant-based dietary patterns and incidence of type 2 diabetes in US men and women: results from three prospective cohort studies. PLoS Med 2016;13(6):e1002039.
12 Kim H, Caulfield LE, Rebholz CM. Healthy plant-based diets are associated with lower risk of all-cause mortality in US adults. J Nutr 2018;148(4):624–31.
13 Dietary Guidelines Advisory Committee. Scientific report of the 2020 Dietary Guidelines Advisory Committee: advisory report to the Secretary of Agriculture and the Secretary of Health and Human Services. Washington (DC): USDA Agricultural Research Service; 2020.
14 GoogleTrends. [Internet]. Mountain View (CA): Google; 2021; [cited 21 August, 2021]. Available from: https://trends.google.com/trends/?geo=US.
15 Sloan AE. What to watch for as the plant-based food market grows. Food Technol 2021;75(7):16–7.
16 Dietary Guidelines Advisory Committee 2010. Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans to the Secretary of Agriculture and the Secretary of Health and Human Services Washington (DC): USDA Agricultural Research Service; 2010.
17 2020 Dietary Guidelines Advisory Committee and Food Pattern Modeling Team. Added sugars: food pattern modeling: ages 2 years and older. 2020 Dietary Guidelines Advisory Committee Project. Washington (DC): USDA; 2020.

18 USDA Agricultural Research Service (ARS). FoodData central. Beltsville (MD): USDA ARS; 2019.

19 Papanikolaou Y, Fulgoni VL. Egg consumption in U.S. children is associated with greater daily nutrient intakes, including protein, lutein + zeaxanthin, choline, α-linolenic acid, and docosahexanoic acid. Nutrients 2019;11(5):1137.

20 USDA Agricultural Research Service (ARS). Food sources of calcium. [Internet]. Beltsville (MD): USDA ARS; 2019. [Accessed September 2021]. Available from: https://www.dietaryguidelines.gov/food-sources-calcium.

21 Hess JM, Cifelli CJ, Fulgoni VL, 3rd. Modeling the impact of fat flexibility with dairy food servings in the 2015–2020 dietary guidelines for americans healthy U.S.-Style eating pattern. Front Nutr 2020;7:595880.

22 Hess JM, Fulgoni VL, Radlowski EC. Modeling the impact of adding a serving of dairy foods to the healthy mediterranean-style eating pattern recommended by the 2015–2020 dietary guidelines for americans. J Am Coll Nutr 2019;38(1):59–67.

23 Lindquist J, Thomas DM, Turner D, Blankenship J, Kyle TK. Food for thought: a natural language processing analysis of the 2020 dietary guidelines publice comments. Am J Clin Nutr 2021;114(2):713–20.

24 Burns-Whitmore B, Froyen E, Heskey C, Parker T, San Pablo G. Alpha-linolenic and linoleic fatty acids in the vegan diet: do they require dietary reference intake/adequate intake special consideration? Nutrients 2019;11(10):2365.

25 Institute of Medicine. Dietary Reference Intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids. Washington (DC): The National Academies Press; 2005.

26 Mann N, Pirotta Y, O'Connell S, Li D, Kelly F, Sinclair A. Fatty acid composition of habitual omnivore and vegetarian diets. Lipids 2006;41(7):637–46.

27 Sanders TA, Ellis FR, Dickerson JW. Studies of vegans: the fatty acid composition of plasma choline phosphoglycerides, erythrocytes, adipose tissue, and breast milk, and some indicators of susceptibility to ischemic heart disease in vegans and omnivore controls. Am J Clin Nutr 1978;31(5):805–13.

28 Sanders TA. DHA status of vegetarians. Prostaglandins Leukot Essent Fatty Acids 2009;81(2–3):137–41.

29 Rosell MS, Lloyd-Wright Z, Appleby PN, Sanders TA, Allen NE, Key TJ. Long-chain n-3 polyunsaturated fatty acids in plasma in british meat-eating, vegetarian, and vegan men. Am J Clin Nutr 2005;82(2): 327–34.

30 Kim JE, Ferruzzi MG, Campbell WW. Egg consumption increases vitamin E absorption from co-consumed raw mixed vegetables in healthy young men. J Nutr 2016;146(11):2199–205.

31 Morreale de Escobar G, Obregon MJ, Escobar del Rey F. Role of thyroid hormone during early brain development. Eur J Endocrinol 2004;151(Suppl 3):U25–37.

32 Puig-Domingo M, Vila L. The implications of iodine and its supplementation during pregnancy in fetal brain development. Curr Clin Pharmacol 2013;8(2):97–109.

33 Combet E. Iodine status, thyroid function, and vegetarianism. In: Mariotti F, editor. Vegetarian and plant-based diets in health and disease prevention. Cambridge (MA): Academic Press; 2017. p. 769–90.

34 USDA, FDA, NIH. Database for the iodine content of common foods. Beltsville (MD): USDA; 2020.

35 Bajaj JK, Salwan P, Salwan S. Various possible toxicants involved in thyroid dysfunction: a review. J Clin Diagn Res 2016;10(1): FE01–3.

36 Messina M, Redmond G. Effects of soy protein and soybean isoflavones on thyroid function in healthy adults and hypothyroid patients: a review of the relevant literature. Thyroid 2006;16(3):249–58.