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Dietary Guidelines Meet NOVA: Developing a Menu for A Healthy Dietary Pattern Using Ultra-Processed Foods

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A B S T R A C T

Background: A proposed topic for the 2025 Dietary Guidelines for Americans (DGA) Scientific Advisory Committee to address is the relationship between dietary patterns with ultra-processed foods (UPF) and body composition and weight status. Implementing the NOVA system, the most commonly applied framework for determining whether a food is "ultra-processed," in dietary guidance could omit several nutrient-dense foods from recommended healthy diets in the DGA.

Objective: The purpose of this proof-of-concept study was to determine the feasibility of building a menu that aligns with recommendations for a healthy dietary pattern from the 2020 DGA and includes ≥80% kcal from UPF as defined by NOVA.

Design: To accomplish this objective, we first developed a list of foods that fit NOVA criteria for UPF, fit within dietary patterns in the 2020 DGA, and are commonly consumed by Americans. We then used these foods to develop a 7-d, 2000 kcal menu modeled on MyPyramid sample menus and assessed this menu for nutrient content as well as for diet quality using the Healthy Eating Index-2015 (HEI-2015).

Results: In the ultra-processed DGA menu that was created, 91% of kcal were from UPF, or NOVA category 4. The HEI-2015 score was 86 out of a possible 100 points. This sample menu did not achieve a perfect score due primarily to excess sodium and an insufficient amount of whole grains. This menu provided adequate amounts of all macro- and micronutrients except vitamin D, vitamin E, and choline.

Conclusions: Healthy dietary patterns can include most of their energy from UPF, still receive a high diet quality score, and contain adequate amounts of most macro- and micronutrients.

Keywords: ultra-processed food, food processing, dietary guidelines, diet quality, NOVA

Introduction

One question to be addressed during the 2025-2030 Dietary Guidelines for Americans (DGA) process reads, "what is the relationship between consumption of dietary patterns with varying amounts of ultra-processed foods and growth, size, body composition, risk of overweight and obesity, and weight loss and maintenance?"[1]. One challenge the upcoming Dietary Guidelines Advisory Committee (DGAC) will face in conducting a literature review on this question is how to define ultra-processed foods (UPF).

At least 6 classification frameworks that characterize foods by degree of processing have been proffered in the literature [2,3]. Of these frameworks, the most frequently utilized system is NOVA (not an acronym) [4,5]. Since 2009, when NOVA first appeared in the literature [6], over 1,000 papers indexed in PubMed have used the term "ultra-processed." Despite its

Abbreviations: AHA, American Heart Association; AMDR, Acceptable Macronutrient Distribution Range; DGA, Dietary Guidelines for Americans; DGAC, Dietary Guidelines Advisory Committee; DRI, Dietary Reference Intake; FNDDS, Food and Nutrient Database for Dietary Studies; FPM, Food Pattern Modeling Report; HEI-2015, Healthy Eating Index-2015; HHS, Department of Health and Human Services; HUSDP, Healthy US-Style Dietary Pattern; IFIC, International Food Information Council; IFPRI, International Food Policy and Research Institute; NHANES, National Health and Nutrition Examination Survey; RDN, Registered Dietitian Nutritionist; SWAP-MEAT, Study With Appetizing Plantfood-Meat Eating Alternative Trial; UPF, Ultra-Processed Food; USDA, United States Department of Agriculture.

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popularity, frequent use in the scientific literature [5,7–10], and incorporation into official dietary guidance in several countries, including Brazil and Israel [5], NOVA scoring can be inconsistent. Some studies highlight the challenges that researchers and consumers face in determining whether foods are processed, minimally processed, unprocessed, or ultra-processed per NOVA. Consistency of NOVA classification by food and nutrition experts was low in one study [11], and another study [7] found that consumers miscategorized some unprocessed and minimally processed foods as "ultra-processed." These studies illustrate the challenge the upcoming DGAC faces in determining guidance about UPF since UPF are not consistently defined by the research community, other food and nutrition professionals, or consumers [12].

In addition, some foods that are considered UPF in the NOVA system are nutrient-dense, despite their level of processing [8, 11]. All yogurts with added sugars are classified as UPF, according to NOVA. However, yogurt is a good or excellent source of nutrients of concern for Americans, such as calcium and potassium [13], and eating yogurt is not associated with higher added sugar intake [13]. Packaged whole grain breads are another example [1]. Breads, rolls, and tortillas are the most frequently consumed whole grain products [14] and the top subcategories of food contributing to energy and nutrient intake [15]. Sweetened yogurts and whole grain breads are UPF, according to NOVA but are still nutrient-dense, accessible, and affordable sources of nutrients for Americans.

This evidence that some UPF (per NOVA) are nutrient-dense provided the impetus for this proof-of-concept study. The objective of this study was to determine the feasibility of building a sample 2000 kcal menu for 7 d that aligns with recommendations in the 2020 DGA Healthy US-Style Dietary Pattern (HUSDP) while also providing most of its energy (defined as ≥80% kcal [16]) from UPF according to NOVA. This menu was assessed for both nutrient adequacy and diet quality to determine the possibility of following 2020 DGA recommendations consuming primarily UPF. Our hypothesis was that the construction of a menu containing ≥80% kcal UPF and aligned with DGA recommendations would be possible and provide adequate amounts of most macro- and micronutrients; however, we also hypothesized that this menu would exceed current recommendations for sodium and added sugars. Therefore, while we posit that this diet will be nutritionally adequate, its HEI score is likely to be <80 due to the amounts of sodium and sugars commonly found in many NOVA-defined UPF [17].

Methods

Due to the variability of interpretations possible for both NOVA [18] and foods belonging to dietary patterns recommended in the DGA [1], we first drafted a list of potential food options for our sample menus. These lists were then separately and independently evaluated for their NOVA classification scores and for their "fit" within DGA food groups by 2 experts each in NOVA and the DGA—our "first-line" graders—as described below. A third professional served on each group as a tiebreaker ("second-line" grader) in the case of disagreements between the 2 first-line graders.

Our 2 NOVA first-line graders were selected based on previous publications using the NOVA system and/or participation in a public discussion of NOVA [19]. Our 2 DGA first-line "graders" are both PhD-level registered dietitian nutritionists (RDN), one of whom served on the 2010 DGAC [20]. The second-line NOVA grader, a PhD-level RDN, reviewed reference materials to develop familiarity with NOVA, and the second-line DGA grader is a research RDN with several years of experience developing DGA-compliant menus. See Figures 1 and 2 for an overview of the study schematic.

Use of NOVA Scale

The NOVA scale is a food classification system for categorizing foods by degree of processing [6]. The NOVA system classifies all foods into 1 of 4 groups 1) unprocessed or minimally processed foods, 2) processed culinary ingredients, 3) processed foods, and 4) UPF [9]. Because the definitions of these levels have changed over time, NOVA graders for this study were provided a standard set of reference materials to review as needed. This set of reference materials included 4 publications from the developers of NOVA [9,21–23] as well as a handout adapted from previous publications [22–24] (Supplemental Figure 1).

Determination of the list of foods to include

To select foods that are both aligned with DGA recommendations and reflective of foods that Americans typically consume, food items for the surveys were taken from the Food Pattern Modeling (FPM) report from the 2020 DGAC [25]. The FPM report lists the most commonly selected food items from each of the food groups and subgroups in the DGA according to results from the 2015-2016 National Health and Nutrition Examination Survey (NHANES). For example, this report includes the most

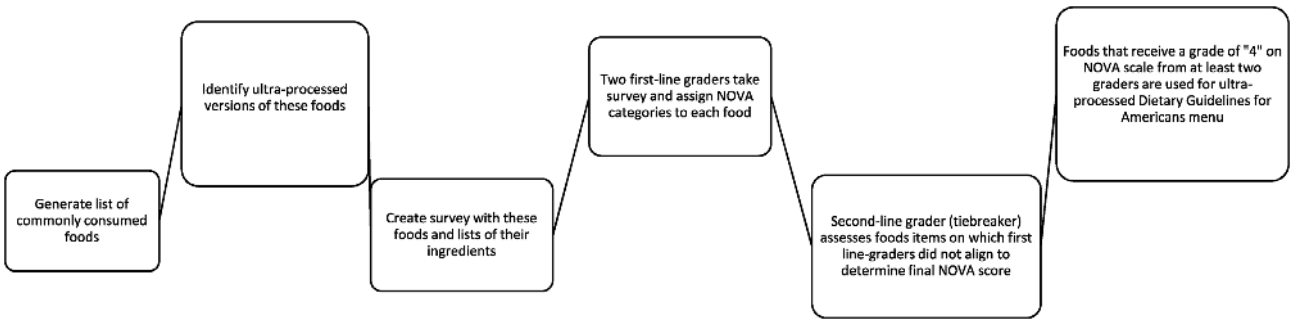

FIGURE 1. Study schematic for determination of foods that are ultra-processed (NOVA Category 4)

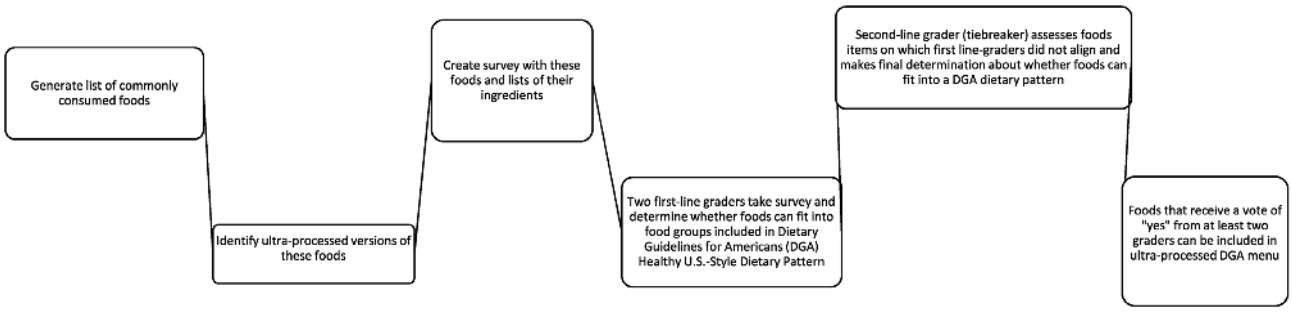

FIGURE 2. Study schematic for determination of foods that fit into dietary guidelines healthy US-style dietary pattern

commonly consumed vegetables, fruit, dairy, protein foods, and oils, as well as the most commonly consumed items in each subcategory, such as dark green vegetables, red and orange vegetables, whole fruits, fruit juice, and others.

The top 10 most commonly consumed foods from each category and subcategory among adults 19 to 70 years old were identified from the FPM report (Supplemental Table 1). An ultra-processed version of each of these commonly consumed food items was then identified by searching the websites of national retail grocery chains. This process generated a list of approximately 200 food items. Ingredient lists for these products determined which products were included in the surveys developed for our first- and second-line graders. A complete list of food products included in these surveys can be found in Supplemental Table 2 and Supplemental Table 3.

Surveys

Determination of fit for DGA healthy US-style dietary pattern

Survey development. This survey was developed in Qualtrics and sent to first-line graders. Graders were asked to determine whether the versions of the commonly consumed food items listed in the survey (item name and ingredient list) would fit into recommended food groups and eating patterns in the DGA (Supplemental Figure 2). All collaborators were provided with the same reference materials (Supplemental Figure 3) to review, as needed, prior to completing the survey of food items. All foods were described as being from a grocery store, and no brand names were provided—only a generic food item name and ingredient list.

For the DGA survey, graders selected from "yes" or "no" options. In cases of uncertainty, participants were instructed to select "no." A sample prompt from this survey is below:

> "Could these **canned whole tomatoes** be considered part of the vegetable group in the Healthy US-Style Eating Pattern from the 2020 DGA?"
>
> **Whole tomatoes:** tomatoes, tomato juice, less than 2% of salt, citric acid, calcium chloride."

Determination of fit for the "Ultra-processed" category in NOVA

This survey was developed in Qualtrics. Graders were asked to categorize versions of commonly consumed food items according to their level of processing based on the 4-level NOVA scale. Participants were given the item name and ingredient list with instructions to rate the food item as category 1, 2, 3, or 4, per NOVA criteria. In addition to the approximately 200 items in the survey as UPF, 19 foods from other NOVA categories (i.e., unprocessed, minimally processed culinary ingredients, and processed foods) were also added to help protect data quality by ensuring graders read thoroughly through each prompt [26].

Because multiple iterations of the NOVA scale have been published since 2009 [6], all graders were provided with the same reference materials to review, as needed, prior to completing the survey of food items (Supplemental Figure 4) [9, 21–23]. All foods in the survey were described as being from a grocery store, and, in cases of uncertainty, participants were instructed to select the more conservative (less-processed option) [17].

A sample prompt from this survey is below:

> **"Shaved smoked turkey:** turkey breast, water, white turkey, modified food starch, contains less than 2% of salt, dextrose, sodium phosphates, carrageenan, sodium propionate, sodium diacetate, sodium benzoate, sodium ascorbate, sodium nitrate."
>
> **Rating options:** 1, 2, 3, 4

Menu development

A list of food items approved by at least 2 graders as aligned with DGA recommendations and category 4 on the NOVA scale was developed. These food items (Supplemental Table 2) were used to draft a menu, using a MyPyramid sample menu for a 7-d, 2000-calorie food pattern as a model [27]. The MyPyramid sample menu was used as a guide instead of the MyPlate sample menu, as the MyPyramid menus were readily available in the public domain at the time this research was conducted.

Determination of nutrient content and alignment with DRI recommendations for 2000 kcal diet

The macro- and micronutrient content of the menu was determined using the USDA National Nutrient Database for Standard Reference, Release 27 [28] via a customized in-house nutrient analysis program at the USDA Agricultural Research Service Grand Forks Human Nutrition Research Center. Each menu item was individually matched with its equivalent in the proprietary analysis program via close evaluation of ingredients, energy, macronutrient, and micronutrient content by trained research staff. Certain items that did not have an equivalent in this database, including liquid egg whites, light orange juice, frozen grilled potatoes, lemon pepper salmon, toasted nori, ultrafiltered milk, black pepper tuna, brown rice, and quinoa with garlic, salt and pepper cashews, strawberry kefir, and

honey-roasted chickpeas, were added separately using nutrition information specific to the exact products we identified as ultra-processed versions of these foods.

Determination of HEI-2015 scores

The menu was also assessed for average diet quality score across 7 d. Food codes in the proprietary database were matched with their equivalents in the 2017-2018 Food and Nutrient Database for Dietary Studies (FNDDS). Due to changes in some food codes between the development of the proprietary nutrient analysis program and the release of the 2017-18 FNDDS food codes, foods with discontinued or updated food codes were hand-matched with equivalents in the most recent FNDDS iteration by trained research staff.

Servings of each food group from each menu food item were then determined, as FNDDS converts foods and beverages into the 37 USDA food pattern components (grains, total fruit, protein foods, dairy foods, vegetables, and subcategories as well as oils and added sugars) [29]. These food group equivalents were averaged across the daily menus and used to calculate HEI-2015 scores, an indicator of diet quality. HEI-2015 scores are a sum of "scores" for 13 different dietary components (total fruits, whole fruits, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood, and plant proteins, fatty acids, refined grains, sodium, added sugars, and saturated fats) [30]. Scores for the amount of refined grains, sodium, added sugars, and saturated fat in the menu reflect the maximum amount that can be in a healthful diet (for instance, to get a perfect score of "10" for saturated fat content, ≤8% of total energy can be calories from saturated fat) [30]. Scores for the other 9 components reflect a minimum amount as part of a healthy diet on a per 1000 kcal basis (for instance, to get a score of "10" for whole grains, the dietary pattern must contain ≥1.5-ounce equivalent of whole grain foods per 1000 kcal) [30].

Statistical analysis

Tie-corrected Kendall's coefficient of concordance (*W*) was used to quantify the inter-rater reliability of DGA food group fitness and NOVA categorizations between graders [17]. All statistical analyses were performed using R software [31] with the irr package [32].

Results

Menu and energy from ultra-processed foods

Graders aligned on 17 out of the 19 quality assurance items as not being UPF. Agreement between graders for DGA-compliant

TABLE 1
2000 kcal Dietary Guidelines for Americans 7-d menu with >80% kcal from ultra-processed foods (NOVA category 4) days 1–4

	DAY 1	DAY 2	DAY 3	DAY 4
BREAKFAST	Breakfast Burrito *1 flour tortilla 7" in diameter* *¼ c. liquid egg whites (in 1 tsp soft margarine)* *1/3 c. canned black beans* *1 oz shredded cheddar cheese* 1 c. orange juice 1 c. nonfat ultrafiltered milk	Hot cereal *½ c. instant oatmeal* *2 tbsp raisins* *1 tsp soft margarine* ½ c. nonfat ultrafiltered milk 1 c. apple juice	Cold cereal *1 c. honey nut oat cereal* *1 c. nonfat ultrafiltered milk* *1 small banana** 1 slice whole wheat toast 1 tsp soft margarine 1 c. grapefruit juice	1 whole wheat English muffin *2 tsp soft margarine* *1 tbsp jam** 1 c. grapefruit juice 1 hard-boiled egg
LUNCH	Turkey sandwich *2 slices whole wheat bread* *3 oz deli turkey* *2 slices tomato** *¼ c. shredded romaine lettuce** *1/8 c. mushrooms** *1 ½ oz shredded mozzarella* *1 tsp yellow mustard** 3/4 c. frozen grilled potatoes 12 oz sparkling water*	Taco salad *2 oz flavored tortilla chips* *2 oz ground turkey, sauteed in 1 tbsp sunflower oil** *½ c. canned black beans* *½ c. iceberg lettuce** *1 tbsp canned diced tomato* *1 oz shredded cheddar* *2 tbsp salsa* *½ c. guacamole* 12 oz sparkling water*	Tuna fish sandwich *2 slices rye bread* *3 oz cracked black pepper tuna* *2 tsp mayonnaise* *1 tbsp diced celery** *¼ c. shredded romaine lettuce** *2 slices tomato** 1 c. pear slices 1 c. nonfat ultrafiltered milk	2 ¾ c. canned black bean soup 2 oz whole wheat bread/dinner roll ½ c. canned, sliced carrots 1 c. nonfat ultrafiltered milk
DINNER	Salmon rice bowl *2 packets lemon pepper salmon* *½ c. white rice** *1 tbsp chopped scallions** *¼ c. diced cucumber** *1 tbsp sesame seeds* *3 tsp mayonnaise* *1 tsp hot sauce** *Toasted nori* (4g package)* ½ c. steamed broccoli* 1 c. nonfat ultrafiltered milk	Spinach pasta bake 1 c. gluten-free pasta 2/3 c. cooked spinach* ½ c. skim milk ricotta ½ c. diced tomatoes* 1 oz mozzarella cheese 1 oz whole wheat dinner roll 1 c. nonfat ultrafiltered milk	3 oz rotisserie chicken 1 c. mixed greens 1.5 c. yams ½ c. sweet peas 1 oz whole wheat dinner roll	Pasta with meat sauce *1 c. gluten-free pasta* *½ c. tomato sauce** *3 oz extra lean group beef), in 2 tsp vegetable oil** *3 tbsp grated Parmesan cheese* Spinach salad 1 c. baby spinach leaves* 1 c. mandarin oranges ½ oz glazed walnuts 3 tsp thousand island salad dressing 1 c. nonfat ultrafiltered milk
SNACK	1 c. fruit cocktail	½ oz roasted almonds ¼ c. mandarin oranges 2 tbsp raisins	¼ c. dried apricots 6 oz low-fat strawberry yogurt	1 c. low-fat vanilla yogurt

* denotes foods from NOVA Categories 1-3 (ie, unprocessed or minimally processed) or items added to the menu not on surveys for DGA or NOVA graders

foods was low (W=0.48, p=0.678), and for NOVA, categorization was high (W=0.82, p<0.001). The final DGA-compliant and primarily NOVA category 4 menu can be found in Tables 1 and 2. This menu included approximately 91% kcal from UPF. Food items that are NOVA categories 1, 2, or 3 are noted in Tables 1 and 2 with an asterisk, and a complete list can be found in Supplemental Table 4.

TABLE 2
2000 kcal Dietary Guidelines for Americans 7-d menu with >80% kcal from ultra-processed foods (NOVA category 4) days 5–7

	DAY 5	DAY 6	DAY 7
BREAKFAST	Cold cereal *1 c. shredded wheat cereal* *1 tbsp raisins* *1 c. nonfat ultrafiltered milk* ½ c. peach slices 1 slice whole wheat toast 1 tsp soft margarine 1 tsp jelly*	2 slices whole wheat toast 2 tsp soft margarine 2 tbsp peanut butter ½ c. peach slices 1 c. nonfat ultrafiltered milk	*1 pkg Instant oatmeal* *2 tbsp raisins* ½ c. nonfat ultrafiltered milk 1 c. pear slices
LUNCH	Chicken Sandwich *2 oz whole wheat pita bread* *¼ c. romaine lettuce** *2 slices tomato** *3 oz deli-style chicken* *1 tbsp thousand island dressing* *1 tsp yellow mustard** ½ c. applesauce* 1 c. tomato juice	Chili on a Baked potato *1 c. vegetarian chili* *2 oz ground turkey sauteed in 1 tbsp canola oil** *1 medium baked potato** ½ c. pear slices ¾ c. mixed fruit juice	Clam chowder *1 c. soup* *½ c. mushrooms** *½ c. onions** ¾ c. mixed vegetables 10 whole wheat crackers 1 c. nonfat ultrafiltered milk
DINNER	5 oz grilled top loin steak* ¾ c. frozen potatoes ½ c. honey-glazed carrots 2 oz whole wheat dinner roll *1 tsp soft margarine* 1 c. nonfat ultrafiltered milk	Pizza *2 7-inch tortillas (7")* *2 oz shredded mozzarella cheese* *¼ c. tomato sauce** *1 oz hot pork sausage* *¼ c. roasted red bell peppers* *2 tbsp mushrooms** *2 tbsp onions** Green salad 1 c. leafy greens* 3 tsp Italian salad dressing 1 c. nonfat ultrafiltered milk	Vegetable stir fry *4 oz firm tofu* *½ c. water chestnuts* *¼ c. canned carrots* *1 c. brown rice and quinoa with garlic* 1 c. cran-raspberry juice
SNACK	1 c. strawberry kefir	5 whole wheat crackers 1 oz honey-roasted chickpeas ½ c. fruit cocktail	1 oz salt and pepper cashews 1 c. sliced peaches 1 c. vanilla Greek yogurt

* denotes foods from NOVA Categories 1-3 (ie unprocessed or minimally processed) or items added to the menu not on surveys for DGA or NOVA graders

Macro- and micronutrient content

Table 3 lists the macro- and micronutrient content of the sample menu, as well as energy density. Tables 4 and 5 compare Dietary Reference Intakes (DRIs) appropriate for those populations for whom the DGA considers 2000 kcal appropriate, namely, females 19 to 30 years and males 51 years and older [1], to the nutrients provided by the ultra-processed DGA menu.

The energy provided by our menu averaged 2025 kcal per day. Amounts of all macronutrients were within the Acceptable Macronutrient Distribution Ranges (AMDRs), with approximately 22% of kcal from protein (AMDR: 10-35% kcal), 54% of kcal from carbohydrates (45-65% kcal), and 26% kcal from fat (20-35% kcal). The menu also provided approximately 7% kcal from saturated fat, also within the recommended <10% kcal from saturated fat in the DGA. Added sugars (~5% total kcal) also remained within DGA recommendations to consume <10% of total calories from added sugars.

TABLE 3
Nutrient profile of ultra-processed Dietary Guidelines for Americans (DGA) menu

Nutrients	Ultra-processed DGA Menu Nutrient Values
MACRONUTRIENTS	
Calories (kcal)	2025
Energy density (kcal/g)	0.936
Protein (g)	112
Carbohydrate (g)	275
Added sugars (g)	28.04
Added sugar (teaspoon equivalents)	6.68
Fiber, total dietary (g)	37.0
Total lipid, fat (g)	57.9
Saturated fatty acids (g)	15.0
Monounsaturated fatty acids (g)	20.4
Polyunsaturated fatty acids (g)	17.4
Omega-3 fatty acids (g)[1]	0.965
Omega-6 fatty acids (g)[2]	6.84
EPA (g)	0.1
DHA (g)	0.2
Cholesterol (mg)	167
MINERALS	
Calcium (mg)	1589
Iron (mg)	21
Magnesium (mg)	466
Phosphorus (mg)	1993
Potassium (mg)	3948
Sodium (mg)	4569
Zinc (mg)	16
Copper (mg)	2
Selenium (mg)	137
VITAMINS	
Vitamin A, RAE (mcg)	1519
Vitamin E, AT (mg)	11.76
Vitamin D (IU)	397.7
Thiamin (mg)	146
Riboflavin (mg)	1.83
Niacin (% eq, mg)	45.79
Vitamin B6 (mg)	2.53
Vitamin B12 (mcg)	7.95
Choline (mg)	351
Vitamin K (mcg)	340
Folate, DFE (mcg)	480

[1] Omega-3 fatty acids include the sum of amounts of alpha-linolenic acid (ALA), docosahexaenoic acid (DHA), and eicosatetraenoic acid (EPA)

[2] Omega-6 fatty acids include the sum of amounts of linoleic acid (LA), gamma-linolenic acid (GLA), and arachidonic acid (AA)

TABLE 4
Comparison of the nutrient profile of ultra-processed (UP) Dietary Guidelines for Americans (DGA) Menu with dietary reference intakes for females 19-30y

Nutrients	Dietary Reference Intakes, Females 19-30 y	% of Dietary Reference Intakes in UP DGA Menu
MACRONUTRIENTS		
Calories (kcal)	2000	101
Energy density (kcal/g)	n/a	n/a
Protein (g)	112	201
Protein (% total calories)	10-35 of total calories	Within AMDR range (22)
Carbohydrate (g)	130	211
Carbohydrate (% total calories)	45-65 of total calories	Within AMDR range (54)
Fiber, total dietary (g)	28	133
Added sugars (% total calories)	<10 of total calories	Within limit (6)
Total lipid, fat (% total calories)	20-35 of total calories	Within AMDR range (26)
SFAs (% total calories)	<10 of total calories	Within limit (7)
MINERALS		
Calcium (mg)	1000	159
Iron (mg)	18	114
Magnesium (mg)	310	150
Phosphorus (mg)	700	285
Potassium (mg)	2600	152
Sodium (mg)	2300	199
Zinc (mg)	8	199
Copper (mg)	0.9	227
Selenium (mcg)	55	249
VITAMINS		
Vitamin A, RAE (mcg)	700	217
Vitamin E, AT (mg)	15	78
Vitamin D (IU)	600	64
Vitamin C (mg)	75	194
Thiamin (mg)	1.1	167
Riboflavin (mg)	1.1	223
Niacin (mg)	14	327
Vitamin B-6 (mg)	1.3	195
Vitamin B-12 (mcg)	2.4	331
Choline (mg)	425	83
Vitamin K (mcg)	90	378
Folate, DFE (mcg)	400	120

TABLE 5
Comparison of nutrient profile of ultra-processed (UP) Dietary Guidelines for Americans (DGA) menu with dietary reference intakes for males 51y and older

Nutrients	Dietary Reference Intakes, Males 51y and older	% of Dietary Reference Intakes in UP DGA Menu
MACRONUTRIENTS		
Calories (kcal)	2000	101
Energy density (kcal/g)	n/a	n/a
Protein (g)	112	201
Protein (% total calories)	10-35% of total calories	Within AMDR range (22)
Carbohydrate (g)	130	211
Carbohydrate (% total calories)	45-65 of total calories	Within AMDR range (54)
Added sugars (% total calories)	<10 of total calories	Within limit (6)
Fiber, total dietary (g)	28	133
Total (% total calories)	20-35 of total calories	Within range
SFAs (% total calories)	<10 of total calories	Within limit (7)
MINERALS		
Calcium (mg)	1000	159
Iron (mg)	8	256
Magnesium (mg)	420	111
Phosphorus (mg)	700	285
Potassium (mg)	3400	116
Sodium (mg)	2300	199
Zinc (mg)	11	144
Copper (mg)	0.9	227
Selenium (mcg)	55	249
VITAMINS		
Vitamin A, RAE (mcg)	900	169
Vitamin E, AT (mg)	15	78
Vitamin D (IU)	600	64
Vitamin C (mg)	90	162
Thiamin (mg)	1.2	153
Riboflavin (mg)	1.3	189
Niacin (mg)	16	286
Vitamin B-6 (mg)	1.7	149
Vitamin B-12 (mcg)	2.4	331
Choline (mg)	550	64
Vitamin K (mcg)	120	283
Folate, DFE (mcg)	400	120

Three of the 4 nutrients of concern for the US population according to the 2020 DGA (calcium, fiber, and potassium) were provided in adequate amounts, as this menu averaged 1588 mg calcium, 37 g fiber, and 3948 mg potassium per day. The menu provided 397 IU of Vitamin D, the fourth nutrient of public health concern, which is less than the current recommendations of 600 IU daily. The only other nutrients provided below DRIs were vitamin E (likely because the menu was relatively low in added fats) and choline. The menu provides 11.76 mg of vitamin E, whereas current recommendations are 15 mg/d for adults 14 y and older. For choline, the menu provides 351 mg, but 425 mg/d and 550 mg/d are recommended for females and males 19 y and older, respectively.

Diet quality

The average HEI-2015 score for our sample menu was 86 out of a possible score of 100 (Figure 3). As depicted in Figure 4, the reasons for the less-than-perfect score were that sodium content exceeded recommendations and whole grain content was below recommendations. Amounts of other food groups or nutrients reflected in the HEI-2015 scoring system (eg fruit, greens, beans, whole fruit, dairy, protein foods, refined grains, and saturated fats) were provided in recommended amounts over the seven-d average.

Discussion

This study shows that it is possible to develop menus that align with recommendations in the DGA, contain adequate amounts of most macro- and micronutrients, and include calories primarily from foods classified by NOVA as ultra-processed. Although the amounts of vitamin D, choline, and vitamin E were below the DRIs for females 19 to 30 y and males 51+ y, the amounts provided align with the amounts provided by the Healthy Vegetarian Dietary Pattern in the DGA [33].

HEI-2015 scores between 80 and 89 out of 100 receive a "B" grade for alignment with the DGA, whereas scores ≥90 earn an

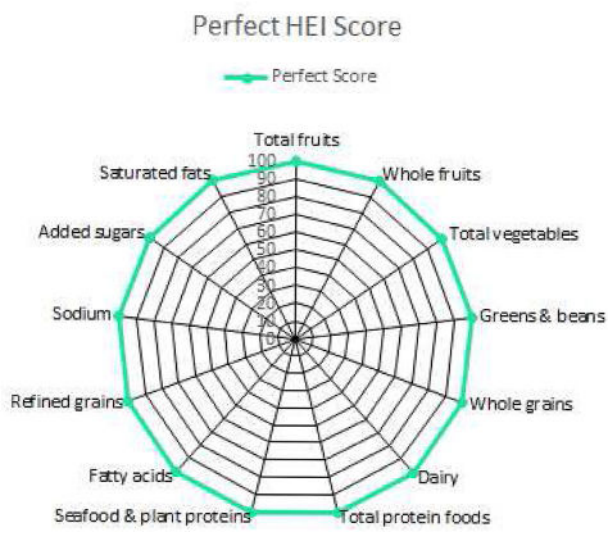

FIGURE 3. Radar plot depicting a perfect score (100 points) of diet quality according to the Healthy Eating Index-2015 score

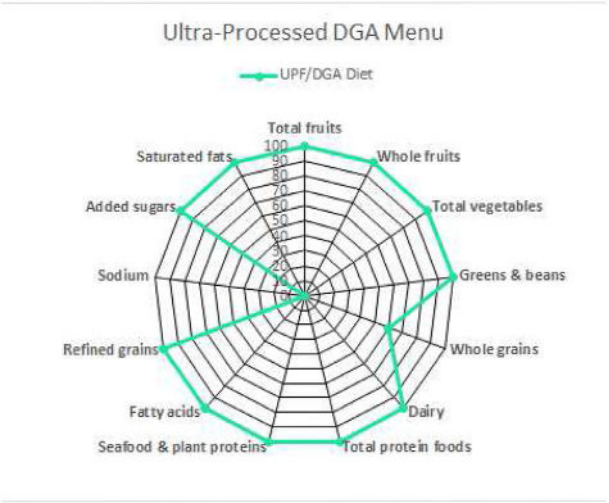

FIGURE 4. Radar plot depicting diet quality score of ultra-processed foods (UPF) Dietary Guidelines for Americans (DGA) menu according to the Healthy Eating Index-2015 score

"A" [30]. According to this criterion, the HEI-2015 score garnered by our menu does not meet the criteria for excellent DGA alignment. However, the diet quality score of this 91% UPF menu of 86 out of 100 is greater than the current average American HEI-2015 score of 59 (Figure 5) [15].

This study highlights the challenges with categorizing foods as "unprocessed," "minimally processed," or "ultra-processed," as well as the potential consequences of cautioning against the consumption of all UPF in the interest of public health. Further, the results show that, despite its wide usage, NOVA is not useful for determining the healthfulness of either individual foods or dietary patterns when current DGA recommendations are used as context to indicate healthfulness. This study indicates that recommended dietary patterns in the DGA can include primarily UPF. NOVA scores are not proxy markers for dietary quality. The results of this study also indicate that the current measure for diet quality used by the DGA—the HEI-2015—would have to be replaced if UPF are discouraged by future iterations of US dietary guidance. NOVA categorizations do not consider nutrient content or food group, which are the basis of HEI scoring. The finding in this manuscript that healthy dietary patterns can meet DGA recommendations while being primarily composed of UPFs provides important context for future research to consider. That is, the purported relationships between UPF and increased risk of chronic disease may depend on factors other than processing levels identified by NOVA. Generating physiological data using this menu is necessary to ensure that the impact of this eating pattern mirrors that of other dietary patterns with high HEI-2015 scores.

Although some Americans believe that processed food or food containing "artificial ingredients" is unhealthy, average population-wise diet quality scores remain low. According to the 2022 IFIC Food & Health Survey, approximately 20% of Americans believe that minimal processing is an important determinant of healthy food [34]. Thirty-nine percent of Americans believe that a product that does not contain artificial ingredients is somewhat or highly likely to be healthier than a product that does contain artificial ingredients. Yet, although Americans purport to pay attention to the processing status of their food and 52% of Americans indicate they are knowledgeable about the DGA [34], the average HEI-2015 score for all Americans 2 years and older remains around 59. In fact, HEI "scores have not changed substantially across time since the HEI was developed" [1]. Encouraging Americans to avoid UPF seems unlikely to improve diet quality.

Other studies highlight challenges with concluding that food items containing ingredients and additives not commonly used at home are detrimental to health [7,35]. Plant-based meats and alternative proteins are good examples. Plant-based eating and plant-based foods are popular among Americans [36], yet many plant-based meats have a long ingredient list and are considered UPFs. Nonetheless, a recently published randomized clinical trial that employed a cross-over design, the Study With Appetizing Plantfood-Meat Eating Alternative Trial (SWAP-MEAT) [37] trial, found that, when ultra-processed plant-based meats replaced their animal-based counterparts, body weight significantly decreased among participants despite overall energy intake and physical activity being similar between the 2 diet phases.

One controlled feeding study [16] and several cross-sectional studies [10,38–44] have used the NOVA categorization system to investigate the associations between the consumption of UPF and health outcomes. A randomized controlled trial conducted by the National Institutes of Health compared a diet containing ≥80% kcal from an unprocessed/minimally processed (NOVA group 1) foods diet to one containing ≥80% kcal from UPF [12,16]. These two diets were matched for presented energy (kcal), energy density, fat, sodium, fiber, and macronutrients when both foods and beverages were considered [16]. Hall et al. found that energy intake and weight gain were higher on the UPF diet than on the unprocessed foods diet [16]. However, the research team did not match the UPF and unprocessed foods eating patterns for diet quality, micronutrient content, or energy density of non-beverage foods. A 2019 analysis of data from Mexico's National Health and Nutrition Survey (Encuesta Nacional de Salud y Nutrición) found that increased energy from UPF (per NOVA) was positively associated with intake from added sugars, total

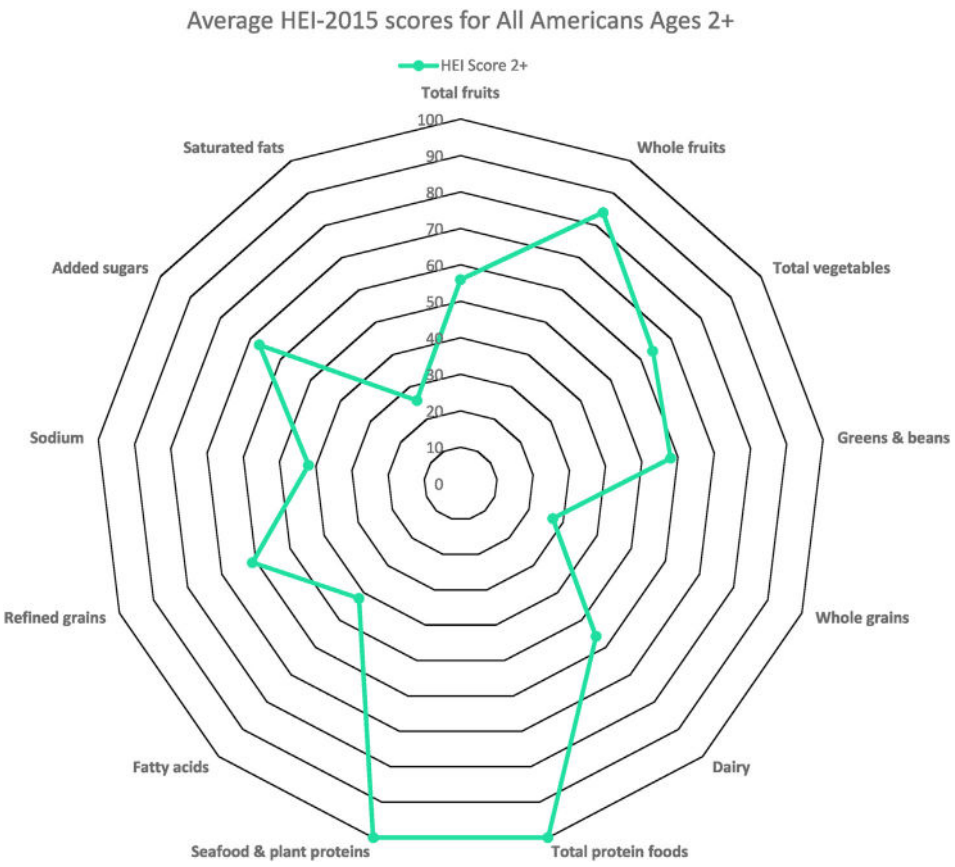

FIGURE 5. Radar plot depicting the average Healthy Eating Index-2015 score for all Americans ages 2+, WWEIA, NHANES 2017-2018

fat, and saturated fat as well as higher energy density [38]. Analyses of US National Health and Nutrition Examination Survey (NHANES) data similarly concluded that decreasing intake of UPF per NOVA would improve dietary quality in the United States [39], decrease intake of added sugars [10], and decrease excess weight gain, especially among adult females [40]. Cross-sectional studies in other countries [41], including Chile [42], Canada [43], and Brazil [44], have reported similar findings.

Despite these discrepancies and challenges with the implementation of food processing evaluations, there is literature about the harms associated with the intake of UPF, and some sets of dietary guidance caution against consuming UPF. The 2016 Brazilian dietary guidelines, dietary guidance from Uruguay, and 2021 Dietary Guidance from the American Heart Association (AHA) are 3 examples [4,24,45]. Although the AHA guidance acknowledges that "there is no commonly accepted definition for ultra-processed foods, and some healthy foods may exist within the UPF category," Brazil and Uruguay's guidance recommend avoiding all UPF [4]. Monitoring intake of UPF through food purchasing data has even been proffered as a novel method for diet quality assessment [46]. One manuscript states that the "poor nutritional quality, novel physical structure, and content of food additives and neo-formed contaminants of ultra-processed foods" may be responsible for the negative health outcomes associated with UPF [46]. Therefore, in lieu of utilizing the freely available tools to calculate HEI scores, Vadiveloo et al. [46] suggest using the percentage of energy provided by processed foods as a substitute method to determine diet quality. A review by Juul et al., which noted that consuming UPF increases the risk of cardiovascular disease, states that UPF "bring poor-quality nutrients and ingredients" to the diet and "displace healthy whole foods, such as fruits and vegetables" [47]. In contrast, the results of the current study indicate that UPF include nutrient-dense foods, such as fruits and vegetables, and that a diet containing over 90% energy from UPF can also be of moderate- to high quality. Although our menu has not yet been tested in a human population for its impact on health outcomes, the results of this study show that all UPF—as designated by the NOVA system—cannot be broadly described as detrimental to health.

The value of this study is to encourage an examination of how foods are classified as UPF, acknowledging that there is no consistency in rating diet quality within the NOVA categories. Moving forward, a clear definition of UPF and inclusion of nutrient density is needed before labeling UPF as healthful or not.

Limitations

This study is limited by its design in that it only creates a sample menu of how to follow a DGA-style dietary pattern while consuming mostly foods classified by NOVA as ultra-processed. We do not know the physiological responses this diet might elicit in humans, and there is a need to generate that data using these menus to confirm that an ultra-processed DGA menu provokes similar responses to those of other dietary patterns with high HEI-2015 scores. This study represents a model of what a healthy dietary pattern comprised of UPF could look like but does not necessarily utilize the most commonly eaten UPFs. This

study does not address the social, economic, or nutritional drives that may be responsible for the greater purchase and consumption of UPFs. For instance, this study does not address what a mostly UPF diet may look like on a fixed budget, for a family, or for someone with limited access to a wide variety of foods, ultra-processed or otherwise. More research is needed to explore these factors.

Conclusions

This study shows that recommended healthy dietary patterns can include most of their energy from NOVA-classified UPF and still receive high diet quality scores and contain adequate amounts of most macro- and micronutrients. Implementing the NOVA system, the most commonly applied framework for determining whether a food is "ultra-processed," in dietary guidance could omit nutrient-dense foods from recommended healthy diets in the DGA.

Author contributions

The authors' responsibilities were as follows—JMH and SC designed the research (project conception, development of overall research plan, and study oversight); JMH, MEC, SC, and AJS: conducted the research; JMH, MEC, SC, JLS, GHJ, MM, SR, AJS, AB, and DGP provided essential materials; JMH, MEC, SC, AJS, and DGP analyzed data; JMH and MEC wrote the paper. All authors: edited, read, and approved the final manuscript.

Conflicts of Interest

MM serves as the Director of Nutrition Science and Research for the Soy Nutrition Institute (SNI) Global. The SNI Global receives funding from soybean farmers via the soybean national checkoff program and via membership dues from companies involved in manufacturing and/or selling soy ingredients and/or soyfoods. GHJ serves as Senior Advisor to the McCormick Science Institute. JLS serves on advisory/consultant boards for Simply Good Foods, Quality Carbohydrates Coalition, and the Sustainable Nutrition Scientific Board and has received funding from the National Institutes of Health, Taiyo, Barilla Foods, and the USDA in the past 12 mo. The other authors report no conflicts of interest.

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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 reference section.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tjnut.2023.06.028.

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