# MyPyramid Food Intake Pattern Modeling for the Dietary Guidelines Advisory Committee

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## ABSTRACT

Modeling analyses using the MyPyramid intake patterns were conducted in collaboration with the 2005 Dietary Guidelines Advisory Committee in response to their research questions and to determine likely effects of possible recommendations on overall dietary adequacy. Scenarios modeled included the feasibility of using the food patterns for lacto-ovo-vegetarian diets, of varying fat levels within the patterns, and of increasing dietary flexibility through food group substitutions. Food pattern modeling was a useful tool to identify possible impacts on diet quality of potential Dietary Guidelines recommendations. Modeling analyses can help researchers explore the overall effect of specific dietary recommendations on intake patterns.

**Key Words:** MyPyramid, Dietary Guidelines for Americans, food intake patterns, dietary guidance

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## INTRODUCTION

In January 2005, the U.S. Departments of Agriculture (USDA) and Health and Human Services (HHS) jointly released the *Dietary Guidelines for Americans* (Dietary Guidelines), which form the basis of federal food and nutrition policy. Shortly thereafter, USDA released the MyPyramid Food Guidance System (MyPyramid). MyPyramid is a system of food patterns and interactive nutrition education tools and materials designed to help Americans implement the Dietary Guidelines. MyPyramid's food intake patterns were developed through an iterative process of modifying suggested intake levels from each food group to meet established nutritional goals for nutrient adequacy and moderation. The process has been described in detail in accompanying articles.[1,2]

The Dietary Guidelines and MyPyramid development processes occurred simultaneously, with collaboration among the Dietary Guidelines Advisory Committee (DGAC) as a whole, individual subcommittees, and federal staff from USDA and HHS. Several collaborative sessions took place during the DGAC's 5 formal meetings, which were open to the public. Table 1 shows a brief side-by-side timeline of the 2 development processes and key points of collaboration.

The 2005 DGAC was charged to critically review scientific evidence relating diet and physical activity to health across the lifespan (excluding infancy) and make recommendations to the secretaries of USDA and HHS concerning the 2005 edition of the *Dietary Guidelines for Americans*. The DGAC's evaluation extended beyond the dietary concerns of "strictly healthy persons" because increasing numbers of Americans have chronic health problems such as obesity, high blood pressure, and abnormal blood lipid values.[3] To accomplish its mission, the DGAC developed and prioritized a large number of research questions and formed subcommittees to tackle key topic areas such as carbohydrates, energy, fats, fluid and electrolytes, ethanol, food safety, macronutrients, and nutrient adequacy. The subcommittees conducted extensive, systematic literature searches, prepared summary tables, analyzed national data sets, modeled food patterns, developed scientific rationales, and drafted conclusive statements. Their body of work was presented to the full DGAC for review and discussion.[3,4,5]

Following extensive deliberations on each key topic area, the DGAC developed a report, which presented its findings as an integrated set of conclusions and dietary guidance recommendations for the general American public.[3] The DGAC report served as the basis for the *2005*

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**Table 1.** Side-by-side Timelines for Development of 2005 Dietary Guidelines for Americans and MyPyramid Food Guidance System

| Date | Dietary Guidelines for Americans 2005 | MyPyramid Food Guidance System | |
|---|---|---|---|
| | | Technical Update | Consumer Presentation |
| Sep 03 | First Dietary Guidelines Advisory Committee (DGAC) meeting in Washington, DC | *Federal Register* notice of proposed food intake patterns requested peer review and public comment[7] | |
| Jan 04 | Second DGAC meeting included oral testimony from the public and presentations from invited experts | Proposed food intake patterns and public comments discussed with Federal partners (USDA and HHS) and with 2005 DGAC | |
| Mar – May 04 | Third and fourth DGAC meetings | Food pattern modeling to analyze the impacts of potential DGAC subcommittee recommendations on overall diet quality | Developed concept for a new system approach to the consumer presentation of food guide |
| Aug 04 | Fifth and final DGAC meeting | Finalized food intake patterns | *Federal Register* notice requested public comments on the proposed "Food Guidance System" consumer presentation |
| Sep 04 | DGAC presented its advisory report to the secretaries of USDA and DHHS, with recommendations for the 2005 Dietary Guidelines | Food intake patterns and reports of each modeling analysis included in DGAC report | Developed prototype consumer awareness, motivational and educational materials |
| Oct 04 | *Federal Register* notice solicited public comment on the DGAC report | | |
| Oct – Dec 04 | Departments drafted DG policy document based on the DGAC report | Updated final food intake patterns using USDA's SR17 nutrient database and '99-00 NHANES data | Tested and revised prototype consumer materials |
| Jan 05 | USDA and HHS jointly published and released the sixth edition of the *Dietary Guidelines for Americans* | Food intake patterns included in appendix to DG policy document | |
| Apr 05 | | | USDA released *MyPyramid Food Guidance System* |

*Dietary Guidelines for Americans*, which was jointly developed and published by USDA and HHS in January 2005.[6]

One of the DGAC's overarching goals was to evaluate and synthesize the science regarding many individual nutrients and food components and develop recommendations for an overall pattern of eating that could be adopted by the public.[3] The food intake patterns that were in the process of being developed by the USDA Center for Nutrition Policy and Promotion (CNPP) for the MyPyramid Food Guidance System[7] provided one such solution. These patterns, designed to integrate Institute of Medicine (IOM) nutrient recommendations into food-based recommendations, included nutritional goals consistent with the recommendations under consideration for the Dietary Guidelines. The patterns also had a structure that allowed for their modification to test various dietary recommendation scenarios. Early in their deliberations, DGAC members requested that CNPP staff undertake food pattern modeling and analyses to evaluate the impact of potential recommendations on diet quality. Subcommittees' specific requests included developing a lacto-ovo-vegetarian food pattern that met nutrient goals; comparing the nutrient contributions of whole fruit with those of 100% fruit juices; assessing the adequacy of patterns with varying levels of fat; and identifying the impact of recommending a specified amount of fish per week. The subcommittees also sought to increase the flexibility of some aspects of the food intake patterns, while achieving recommended nutrient intakes.[4,5] Enhancing flexibility was considered important for a variety of reasons, such as accommodating cultural food choices, individual preferences, food cost, and availability. Iterations of food pattern analyses and modeling exercises built on the previous ones; and all of the analyses were considered in the context of the total diet.[1]

The complete set of food pattern modeling analyses is published in Appendix G-2 of the *Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans, 2005*.[3] The MyPyramid Food Guidance System was finalized after the release of the Dietary Guidelines. This finalization allowed CNPP to incorporate the Dietary Guidelines recommendations into the education materials and to refine the food intake patterns using the most current food composition and national food consumption data. This work is presented in accompanying articles.[1,2] The final refinements and updates to the nutrient profiles and food patterns resulted in minor differences in the precise amounts from those used in the analyses and published in the DGAC report. The general results and conclusions from all of the analyses, however, remain valid and support Dietary Guidelines recommendations. The purpose of this article is to describe the analytical approach that was used and the conclusions that were drawn from several of these analyses, and to identify the impact of this work on the DGAC's deliberations and on the final food intake patterns.

## FOOD PATTERN MODELING ANALYSES

### Lacto-ovo-vegetarian Food Intake Patterns

The MyPyramid food intake patterns group animal and plant protein sources into a single food group: the Meat, Poultry, Fish, Dry Beans, Eggs, and Nuts (MPFEN) group. (The term "dry beans" is used in this manuscript to represent all legumes, including dry beans, dry peas, and soybean products.) The nutrients that can be expected from eating foods in this group (the nutrient profile) are calculated assuming an intake of foods within the group that is proportionate to the distribution of foods in the group consumed by the population (Table 2). The DGAC was interested in exploring if the food intake patterns were appropriate for consumers choosing vegetarian diets. They requested an analysis of the adequacy of the food intake patterns if no meat, poultry, or fish were consumed.

Although the initial food intake patterns theoretically included the option of lacto-ovo-vegetarian choices, calculations of nutrient contributions from the MPFEN group and adequacy of the overall patterns had been made using proportionate intakes of meat, poultry, fish, eggs, and nuts. It had been assumed that vegetarians could use the food intake patterns, selecting only the protein sources from the group that were acceptable to them. However, the adequacy of this approach had never been fully explored.

Possible food choices for vegetarians in the MPFEN group include eggs (for ovo-vegetarians), nuts, seeds, and dry beans. Dry beans have a unique place in the food intake patterns. Since they contain key nutrients similar to other vegetables as well as to MPFEN and are commonly used both as a vegetable and as a main dish, they have been considered part of both the Vegetable and the MPFEN groups. The Dietary Guidelines recommend consuming dry beans several times per week. MyPyramid recommendations include specific amounts of cooked dry beans to consume weekly as a vegetable subgroup. Therefore, for the purpose of calculating the MyPyramid nutrient profiles, dry

**Table 2.** Proportionate Meat, Poultry, Fish, Egg, and Nut (MPFEN) Consumption in a Typical American Diet and Presumed Intake in the MyPyramid Food Intake Patterns[a]

| | | **Presumed Intake[d]** | | |
|---|---|---|---|---|
| **Components of MPFEN Nutrient Profile[b]** | **Percent of Total Food Group Consumption[c]** | **Food Pattern with 5-oz eq Intake from Group** | **Food Pattern with 6-oz eq Intake from Group** | **Food Pattern with 7-oz eq Intake from Group** |
| Meats (beef, ground beef, pork, lamb, ham, luncheon meats, and liver)[e] | 53.0% | 2.65 oz | 3.18 oz | 3.71 oz |
| Poultry (chicken and turkey)[e] | 23.2% | 1.16 oz | 1.39 oz | 1.62 oz |
| Fish (finfish and shellfish)[e] | 8.0% | 0.40 oz | 0.48 oz | 0.56 oz |
| Eggs[e] | 7.4% | 0.37 eggs | 0.44 eggs | 0.52 eggs |
| Nuts and seeds[e] | 8.3% | 0.21 oz nuts | 0.25 oz nuts | 0.29 oz nuts |

[a] Table adapted from DGAC report, appendix G2.[3]

[b] Consumption of specific amounts of cooked dry beans are recommended as a vegetable subgroup. Therefore, for the purpose of calculating nutrient profiles, dry beans are included as a subgroup of vegetables rather than with the MPFEN group.

[c] Based on food intake from the NHANES 1999-2000 survey. See accompanying article for more information.[2]

[d] Assuming that intakes of these foods are in the proportions eaten on average by the population as reported in NHANES 1999-2000.

[e] Amounts that count as 1 once equivalent are 1 ounce of cooked meat, poultry, or fish; 1 egg; and ½ ounce of nuts and seeds.

beans were included as a subgroup of vegetables rather than with the MPFEN group. To determine the adequacy of the food patterns including only vegetarian choices, dry beans were included in the nutrient profile for the MPFEN group, as well.

This analysis served 2 purposes: to determine if lacto-ovo-vegetarians could use the food intake patterns to select an adequate diet and to identify appropriate ratios of dry beans, nuts, and eggs that would meet nutrient recommendations for various age–gender groups.

**Approach.** We conducted the analysis by modifying the composition of the MPFEN nutrient profile to include only eggs, nuts, and dry beans and determined the changes in nutrient and calorie levels with varying proportions of these foods in the new profile. The modified profile included the nutrient profile developed for dry beans as a vegetable subgroup along with nutrient profiles for eggs and nuts.[2] Then we used the new nutrient profile in the food intake patterns and compared the nutrient content of each pattern to the nutritional goals that had been established for it.[1]

No attempt was made to base proportions of eggs, nuts, and dry beans on actual intakes by vegetarians, because at the time there were not sufficient data available from national food consumption surveys for individuals choosing a vegetarian diet to do such an analysis. We did, however, make a qualitative assessment of the "reasonableness" of the proportions tested by identifying how the amounts might fit into possible vegetarian meals. After analyzing the adequacy of the resulting food patterns, we adjusted proportions and amounts of eggs, nuts, and dry beans in the nutrient profiles iteratively to meet nutrient needs within calorie limits. Using the adjusted nutrient profiles for a vegetarian egg, nuts, and dry beans group, we calculated recommended intakes for each food category in food patterns that contained 5-, 6-, and 7-ounce equivalent daily intakes from this food group.

**Findings.** We identified intake levels of eggs, nuts, and dry beans for a lacto-ovo-vegetarian food intake pattern (Table 3) that met nutritional goals.[1] All nutrient goals were met, with the exception of vitamin E, potassium in lower-calorie patterns, and sodium in higher-calorie patterns. These shortcomings also were present in the final intake patterns that used the full MPFEN nutrient profile.[1] There were no differences in the goals met between vegetarian patterns and MPFEN patterns.

We also considered the adequacy of iron intakes with this pattern, assuming lower absorption without consumption of heme iron. When differences in absorption were considered, using percent absorption factors from an IOM Dietary Reference Intake report,[8] amounts of iron in the patterns were marginal for females from 19 to 50 years old. However, the lacto-ovo-vegetarian patterns met more than 90% of calculated absorbed iron needs for this age/gender group, which has the highest iron requirements.

In addition, we analyzed the lacto-ovo-vegetarian patterns for amino acid adequacy, considering the amino acids available in both animal (eggs and milk) and plant (nuts, dry beans, and grains) protein sources in the patterns. Lysine, identified by the IOM as likely to be the most limiting essential amino acid in vegetarian diets,[9] met or exceeded the Recommended Dietary Allowances (RDAs) for all age/gender groups at targeted energy levels. Based on our analysis of lysine content, we concluded that it was unlikely that any of the other eight essential amino acids would be less than the RDA in these food patterns.

**Implications.** The original amounts of nuts and dry beans considered equivalent to 1 ounce of meat, poultry, or fish were 1-1/2 ounces for nuts and 1/2 cup for dry beans. However, findings from the analyses showed that the total number of ounce equivalents (oz eq) of eggs, nuts, and dry beans needed to meet nutritional goals and stay within target calorie levels was substantially less than the amounts these equivalencies would suggest. For example, in a 2000-calorie pattern, 5 oz eq of MPFEN are recommended. To meet nutrient recommendations and stay within calorie limits, using the original equivalencies, only about 2.7 oz eq of eggs, nuts, and dry beans were needed. This finding from the analysis was a primary reason for modifying the ounce equivalencies for dry beans and nuts within the MPFEN

**Table 3.** Approximate Daily and Weekly Intakes of Eggs, Nuts, and Dry Beans for Lacto-ovo-vegetarian Food Intake Patterns at Selected Energy Levels to Meet Nutritional Goals[a]

| | 1800 kcal Pattern 5 oz eq per Day | | 2200 kcal Pattern 6 oz eq per Day | | 2800 kcal Pattern 7 oz eq per Day | |
|---|---|---|---|---|---|---|
| **Food** | **Daily** | **Weekly** | **Daily** | **Weekly** | **Daily** | **Weekly** |
| Eggs | ~¾ egg | ~5 eggs | ~1 egg | ~6 eggs | ~1 egg | ~7 eggs |
| Nuts | ~1 ¼ ounces | ~7 ounces | ~1 ½ ounces | ~10 ounces | ~1 ¾ ounces | ~12 ounces |
| Dry beans[b] | ~1 cup total | ~7 cups total | ~1 ⅛ cups total | ~8 cups total | ~1 ⅓ cups total | ~9 cups total |

[a] Table adapted from DGAC report, appendix G2.[3]

[b] Totals for cooked dry beans include a weekly intake of 4 cups, 5 cups, and 5½ cups, respectively, at the 1800, 2200, and 2800 calorie levels for the meat & beans group, plus 3 to 3½ cups per week to meet the recommended intake of dry beans as a vegetable subgroup.

group before release of the final food intake patterns. The new ounce equivalents, shown in Table 4, provide a more balanced approach to the nutrient content of various foods within the group, and they allow substitution by ounce equivalent without exceeding the caloric limits of each pattern. Final nutrient profiles for the food intake patterns[2] incorporate these equivalents into calculations of the expected nutrients from each food group. The suggested daily intake amounts for eggs, nuts, and dry beans calculated through this analysis (Table 3) now approximate the number of ounce equivalents recommended in the food intake patterns. Therefore, the final patterns and revised ounce equivalencies can be used as the basis for selecting a lacto-ovo-vegetarian pattern without modification.

## Varying Amounts of Fat in Food Intake Patterns

The IOM Dietary Reference Intakes Report on macronutrients suggested a possible range of fat intake from 20% to 35% of calories.[9] The final food intake patterns contain about 29% to 31% of calories from fat.[1] The DGAC requested a food pattern modeling analysis to determine the impact on meeting established goals for nutrient adequacy and moderation if the food intake patterns were modified to result in a differing percentage of calories from fat within the range recommended by the IOM.

Within each food group and subgroup, food items in low-fat or fat-free forms are used in determining the nutrient profile of the group.[2] However, some fat is contained in these foods and is considered the minimum "intrinsic" amount of fat in each pattern. For example, in the 2000-calorie pattern, 23.8 grams of total fat comes from recommended amounts of low-fat or fat-free forms of meats and beans (14.5 g of fat), grain (6.5 g), milk (0.6 g), vegetables (1.6 g), and fruits (0.6 g).[2] To bring the amounts of essential fatty acids to recommended levels, to help account for additional calories needed to meet energy needs, and to provide for flexibility in food choices by allowing some higher-fat selections, we had originally added a specific amount of additional solid fats and oils, termed "discretionary" fats, to each food intake pattern. (Solid fats include animal fats such as beef, pork, chicken, and dairy fats, as well as hydrogenated vegetable fats such as shortening and stick margarine.) In determining amounts to add, we decreased the ratio of solid fats to oils from the 58% solid to 42% oils ratio that is typically consumed[10,11] to 40% solid and 60% oils in the patterns.

**Table 4.** Amounts that Count as 1 Ounce Equivalent in the Meat, Poultry, Fish, Dry Beans, Eggs, and Nuts (MPFEN) Group

| Food | Amount to Equal 1 Ounce-equivalent of MPFEN |
|---|---|
| Meat, poultry, fish | 1 ounce cooked |
| Eggs | 1 egg |
| Nuts and seeds | ½ ounce, or 1 Tbsp. peanut butter |
| Dry beans and peas | ¼ cup cooked |

**Approach.** To change the overall percentage of calories from fat in the patterns, we altered the amounts of "discretionary" fat in the food patterns at all calorie levels. For each level of fat modeled (20%, 25%, 30%, and 35% of calories), we determined the total grams of fat that would be needed to reach the appropriate percentage of calories. Then, we subtracted the intrinsic fat already present within each food group from the total to determine the amount of discretionary fat allowed in each food intake pattern at each percentage of calories from fat. The discretionary fat was divided into solid fat and oil in a ratio of 40% solid to 60% oil. These amounts of fats and oils were inserted into the food patterns. At the level of 20% of calories from fat, we also created patterns containing only oil and no solid fat to determine if this modification would help lower-fat patterns meet the nutritional goals. For all patterns, after the appropriate levels of fat were included, the caloric deficit was calculated, and sufficient amounts of added sugars were inserted to bring the total calories up to the target levels. We calculated the amount of all nutrients in each pattern and the percentage of goal for each nutrient at each level of fat, from 20% to 35% of calories.

**Findings.** In addition to the nutrients that are fat components (essential fatty acids), solid fats and oils contain small amounts of many nutrients. However, levels of most nutrients in the patterns were not substantively affected by changing the amounts of fat. Only vitamin E, linoleic acid, alpha-linolenic acid, and cholesterol were changed substantially by manipulating the fat content of the food intake patterns.

Few of the food patterns at any level of fat, from 20% to 35% of calories, met 100% of the RDA for vitamin E. Only the highest calorie patterns (3000 and 3200 calories) at higher percentage of calories from fat met the RDA. As would be expected, the percentage of the RDA for vitamin E in an intake pattern increased consistently with additional discretionary fat in the pattern, as well as with additional calories in the pattern. In the pattern with 20% of calories from fat, using oils for all of the discretionary fats increased the amount of vitamin E in the pattern by about 5% to 10% of the RDA, but overall levels of E were still very low.

Levels of linoleic acid and alpha-linolenic acid (ALA) were highly sensitive to the overall fat content of the pattern. At 20% of calories from fat, only patterns at the highest calorie levels met the Adequate Intakes (AI) or were within the Acceptable Macronutrient Distribution Ranges (AMDR) for these fatty acids. When the patterns with 20% of calories from fat were modified to contain only oils (no solid fats), the amounts of linoleic acid and ALA were higher, but they still did not meet the goals at many calorie levels. At 25% calories from fat, most patterns met the AIs, and all patterns were within the AMDRs for linoleic acid and ALA. The patterns at 30% and 35% calories from fat all met the AI and AMDR recommendations. However, in the highest calorie patterns (2800, 3000, and 3200) at 35% calories from fat, levels of cholesterol exceeded the recommended limit. The amounts of added sugars that could be accommodated in the patterns with 35% calories from fat were also quite restricted, and at some calorie levels they were zero.

**Implications.** This analysis was completed before the DGAC developed the concept of discretionary calories.[1,3] The calories in each pattern that had been allocated to solid fats as well as added sugars are now assigned to the new category of discretionary calories, as shown in the *Dietary Guidelines* Appendices A-2 and A-3.[6] Oils, including *trans* fat-free soft margarines, were retained as a separate category because they are the major source of essential fatty acids and vitamin E in the patterns. This modeling exercise helped to document the importance of oils in supplying vitamin E and provided justification for including a recommendation for oils separate from the discretionary calorie allowance. Even without a specific category for solid fats in the final food intake patterns, the findings from this analysis remain valid and can provide guidance on appropriate uses of the discretionary calorie allowance. The allowance for discretionary calories in the final food intake patterns provides consumers with the flexibility to make choices that could result in more varied solid fat levels in their diets.

The analysis also suggested that the inclusion of vitamin E-rich food sources is an effective strategy for significantly increasing dietary vitamin E for a food pattern at any level of fat (from 20% to 35% of calories). Selecting oils such as sunflower, cottonseed, and safflower oils that contain higher amounts of vitamin E compared with soybean oil, the most widely consumed vegetable oil, would increase dietary vitamin E. Likewise, selecting nuts such as almonds, hazelnuts, and walnuts that are relatively rich in vitamin E compared to the more commonly consumed peanuts and peanut butter, also would increase dietary vitamin E.

## High Omega-3 Fish Analysis

In developing the food intake patterns, fish were grouped with meats, poultry, eggs, nuts, and seeds into a single food group. The nutrient profile of this group was calculated by assuming a proportionate intake of each category of food equal to the proportion consumed by the population, as shown in Table 2. The DGAC requested an analysis of the impact on the patterns' nutrient adequacy if recommendations for all fish and/or high omega-3 fish consumption were increased to 8 ounces per week. This amount would represent about 2 servings of fish per week based on the typical portion of fish consumed in the United States.

**Approach.** We created 2 separate subgroups for fish, based on the level of omega-3 fatty acids in each fish type. To create these subgroups, we identified new item clusters including more types of fish, so that fish could be categorized and placed into these new subgroups. The process is described in an accompanying article.[2]

The new nutrient profiles for the fish subgroups were used to calculate 2 new overall nutrient profiles for the MPFEN group that included 8 ounces per week of all fish or of fish high in omega-3 fatty acids (HI$\omega$3) in food patterns containing 5 ounce equivalents per day from the group. The percentage of total MPFEN group consumption assigned to each food category (meat, poultry, etc.) was adjusted to accommodate intake of 8 ounces of fish per week and then 8 ounces of HI$\omega$3 fish per week. For this analysis, meat and poultry intakes were decreased, whereas egg and nut intakes were held constant. For the 8 ounces of all fish per week scenario, the ratio between fish low in omega-3 fatty acids (LO$\omega$3) and HI$\omega$3 fish was maintained at current intake proportions of about 20% HI$\omega$3 fish and about 80% LO$\omega$3 fish. For the 8 ounces of HI$\omega$3 fish per week, all fish intake was assumed to be HI$\omega$3 fish, and LO$\omega$3 fish intake was set to zero.

These new nutrient profiles for the MPFEN group were used in the food intake pattern to assess nutrient outcomes, including eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) intakes. For this analysis, EPA and DHA intakes from foods other than fish were assumed to be zero. Data are not readily available for many foods, and amounts of these fatty acids were assumed to be negligible for other foods included in the food intake pattern.

**Findings.** Based on National Health and Nutrition Examination Survey (NHANES) 1999-2000 data, current fish consumption is about 8% of all MPFEN consumption, and only about 20% of the fish consumed is from species high in omega-3 fatty acids.[2] These data translate to a presumed intake of about 0.4 ounces per day of all fish in a food pattern that contains 5 ounce equivalents from the MPFEN group (Table 5). Including either 8 ounces of all fish or 8 ounces of HI$\omega$3 fish per week in the food intake patterns would result in an average intake of approximately 1.1 ounces of fish per day (Table 5), almost triple current fish consumption, or more than 10 times current HI$\omega$3 fish consumption.

Combined amounts of EPA and DHA in the fish subgroups were 0.4 grams per ounce in the HI$\omega$3 fish subgroup, and 0.1 gram per ounce in the LO$\omega$3 fish subgroup, based on weighted averages of the EPA and DHA content of each fish in the group. The total amounts of DHA and EPA in food intake patterns containing 5 ounce equivalents of MPFEN per day were 0.2 grams (with 8 ounces of all fish per week) and 0.5 grams (with 8 ounces of HI$\omega$3 fish per week). Two servings of HI$\omega$3 fish per week would provide approximately 0.5 grams per day of EPA and DHA, in total. Two servings of all fish per week in proportions currently eaten

**Table 5.** Proportional Intakes of Foods in the MPFEN Group if Including 8 Ounces of All Fish or 8 Ounces of Fish High in Omega-3 Fatty Acids (HIω3 fish) per Week[a]

| | **Percentage of Total Food Group Consumption[b]** | | | **Assumed Intake (oz eq per day) in Pattern Containing 5 oz eq of MPFEN** | | |
|---|---|---|---|---|---|---|
| **MPFEN Subgroups** | **Original** | **With 8 oz. Total Fish per Week** | **With 8 oz. HIω3 Fish per Week** | **Original** | **With 8 oz. Total Fish per Week** | **With 8 oz. HIω3 Fish per Week** |
| Meats | 53.0% | 42.9% | 42.9% | 2.6 oz | 2.1 oz | 2.1 oz |
| Poultry | 23.2% | 18.9% | 18.9% | 1.2 oz | 0.9 oz | 0.9 oz |
| Fish–total | 8.0% | 22.9% | 22.9% | 0.4 oz | 1.1 oz | 1.1 oz |
| HIω3 fish | 1.6% | 4.6% | 22.9% | 0.1 oz | 0.2 oz | 1.1 oz |
| LOω3 fish | 6.4% | 18.3% | 0.0% | 0.3 oz | 0.9 oz | 0.0 oz |
| Eggs | 7.4% | 7.4% | 7.4% | 0.4 eggs | 0.4 eggs | 0.4 eggs |
| Nuts and seeds | 8.3% | 8.3% | 8.3% | 0.2 oz (0.4 oz eq) | 0.2 oz (0.4 oz eq) | 0.2 oz (0.4 oz eq) |

[a] Table adapted from DGAC report, appendix G2.[3]

[b] Amounts of meats and poultry decreased to accommodate increased intake of fish. Recalculated from original analysis to include new oz eq for nuts and seeds.

by Americans would provide approximately 0.2 grams per day of EPA and DHA in total.

The impact on other nutrients of substituting more fish or HIω3 fish for some meat and poultry was quite small. For most nutrients, no change was evident when expressed as a percentage of the RDA or AI. For iron, a decrease of 2% to 4% was seen in the pattern with 8 ounces of HIω3 fish, but not in the pattern with 8 ounces of all fish. This difference is a result of the inclusion of shellfish in the all-fish pattern, as most shellfish are richer sources of iron than finfish. For several nutrients, a change of 1% to 2% of the RDA or AI was noted, but this change did not affect the adequacy of the pattern.

**Implications.** The more detailed nutrient profiles for fish that were developed for this analysis were used in developing the final food intake patterns. The fish and nutrients in this profile are listed in an accompanying article on the development of nutrient profiles.[2] The final patterns do not include a specific quantitative recommendation for fish intake because one was not included for the general population in the *2005 Dietary Guidelines*. However, the Guidelines did recommend that a variety of foods be selected within several food groups and highlighted fish as an example.[6]

*"Selecting a variety of foods within the grain, vegetable, fruit, and meat groups may help to ensure that an adequate amount of nutrients and other potentially beneficial substances are consumed. For example, fish contains varying amounts of fatty acids that may be beneficial in reducing cardiovascular disease risk." (p. 7)*

## Fruit and Fruit Juices Analysis

The American Academy of Pediatrics has recommended limiting fruit juice intake to no more than 4 to 6 ounces per day for children ages 1 to 6 years, and to no more than 8 to 12 ounces per day for children ages 7 to 18 years.[12] Based in part on this recommendation, the DGAC requested an analysis of the appropriate partitioning of the Fruit group intake into whole fruit and 100% fruit juices. (The term "whole fruit" refers to fresh, frozen, dried, and canned fruit that is whole or has been cut up. The term "fruit juice" in this analysis refers to 100% fruit juice; fruit drinks and fruitades are not included.) The analysis was designed to examine if fruit juices could be removed from the food intake patterns without compromising nutrient adequacy, and how the proportion of the fruit group intake supplied by fruit juice affects the nutritional adequacy of the patterns.

**Approach.** For this analysis, we developed separate subgroups for 4 categories within the Fruit group by classifying each item cluster in the Fruit group as one of the following: citrus fruit, melons, and berries; citrus juices (orange and grapefruit); other fruit (bananas, apples, grapes, peaches, pears, etc.); and other juices (apple and grape).

We then created a nutrient profile for each subgroup, as well as a "fruit only" nutrient profile that eliminated all juices. The adequacy of the resulting food patterns was assessed with no juice and the amount of whole fruit held to current recommendation levels, then with the amounts of whole fruit adjusted to compensate for the amount of juice removed. Citrus, melons, and berries were increased to compensate for amounts of citrus juices removed from the patterns for the modeling exercise, and other fruit was increased to compensate for amounts of other juices removed.

**Findings.** The nutrient profile for whole fruit only without 100% fruit juice was substantially lower in vitamin C, folate, potassium, and calories than the fruit plus juice nutrient profile. It was notably higher in fiber and vitamin A. With fruit juices removed from the intake patterns, levels of vitamin C and potassium were the most affected. For example, amounts of vitamin C fell from 141% to 92% of the RDA for females 31-50, and amounts of potassium fell from 66% to 61% of the RDA[3] (Appendix G-2, p. 303). When additional amounts of whole fruit were added to the patterns to compensate for the removal of juices, these changes were lessened but not eliminated.

When this analysis was undertaken, 3/4 cup of fruit juice was counted as 1 serving, or the equivalent of 1/2 cup of fruit. Using these equivalencies and NHANES 1999-2000 consumption data, total fruit juice intake was about 37% of all fruit servings, across all ages 2 and over. The lower levels of calories, vitamin C, potassium, and folate in whole fruit in comparison to juices was due, in large part, to 3/4 cup of juice being considered equal to 1/2 cup of fruit.

**Implications.** The results from this analysis helped to drive a decision to change the equivalency for fruit juices so that 1/2 cup of 100% fruit juice is considered equivalent to 1/2 cup of whole fruit in the final intake patterns. This change makes the nutrition contribution of juices more equivalent to that of fruit, with the exception of dietary fiber. With this new equivalency, fruit juice represents about 47% of all fruit intake in cup equivalents.[2] To increase fiber intake, the Dietary Guidelines recommend that the majority of fruit intake be whole fruit (fresh, frozen, canned, or dried) rather than juice.

In addition, this analysis helped to identify the variation in potassium content among different types of fruit. Since potassium is low in almost all food patterns, suggestions for selecting at least some fruit or juice rich in potassium could help to increase overall intakes. Of the subcategories created for this analysis of juice and fruit intake, citrus juices and other fruit have the highest level of potassium. A table of rich sources of potassium was included in the *2005 Dietary Guidelines*.[6]

## Flexibility Analyses

Several analyses were requested by the DGAC to explore how much flexibility was feasible in the food intake patterns. DGAC members were interested in identifying whether alternative sources of the same nutrients provided by some food categories were available within foods typically consumed by Americans. The nutrient contributions of enriched grains, dry beans, and milk to overall intake were identified, and potential alternative sources for these nutrients were investigated. Appendix G-2 of the DGAC report provides a detailed description of each analysis.[3] The following paragraphs give a general picture of the flexibility analyses undertaken and their results.

In the Grain group, a mix of half whole grains and half enriched grains was proposed in the food intake patterns. The DGAC asked for an analysis of the nutrient shortfalls if no enriched grains were consumed, and what other foods could provide these nutrients. For enriched grains, the nutrients provided included folate, iron, copper, dietary fiber, calcium, and magnesium. We found that shortfalls of these nutrients if enriched grains were not eaten could be entirely compensated for by substituting whole grains for enriched grains. Since some commonly eaten whole-grain, ready-to-eat breakfast cereals are fortified with folate, folate intake was not compromised if a variety of whole grains, including folate-fortified products, were substituted for enriched grains. Based in part on this analysis, the DGAC and the food intake patterns recommended that *at least* half of all grains be whole grains, with the implication that more than half whole grains was acceptable.

Regular intake of dry beans and peas is suggested by the food intake patterns. The DGAC requested an analysis of what other combinations of foods could provide the same nutrients for individuals who do not consume dry beans. The nutrient shortfalls if dry beans were not consumed included dietary fiber, magnesium, calcium, and iron. We found that these nutrients could be provided by additional amounts of whole grains, dark-green vegetables, and other vegetables. However, the amounts needed were large. For example, about 1-1/2 cups of dark-green vegetables or 3 cups of other vegetables would be needed to substitute for 1/2 cup of dry beans. These amounts would be in addition to the amounts for dark-green vegetables or other vegetables in the food pattern.

Although milk and milk products contribute the vast majority of calcium, as well as a substantial amount of other nutrients, in American diets, questions often arise about substitutions for milk products. The DGAC requested an analysis of the nutrient shortfalls if milk or milk products were not consumed and not replaced by another food product. We found that calcium and potassium intakes were severely compromised without milk products in the food patterns, but magnesium and vitamin A also became shortfalls for some groups. Since about 60% to 70% of the calcium in the food intake patterns comes from the Milk group, no scenarios for replacement of milk products with other foods were developed, as this would have necessitated substantial deviations from typical food choices for most of the population. The DGAC concluded that the most viable alternatives for many individuals may be lactose-reduced or low-lactose foods within the Milk group for many individuals who avoid milk because of its lactose content. The committee also identified other options for those who do not consume any dairy products, including fortified foods such as calcium-fortified orange juice or calcium-fortified soy products. A table of nondairy calcium sources was included in the DGAC report and in the *2005 Dietary Guidelines*.[3,6]

## DISCUSSION

The food pattern modeling analyses undertaken by CNPP provided a valuable tool for the DGAC in determining how a food pattern could be developed to meet science-based criteria for a healthful diet.[3] Data on the effects of whole diets on body mass index, cardiovascular disease, and other health conditions are limited. The majority of research on diet and disease relationships examines the effect of specific nutrients, food components, single categories of food, or individual food groups. Food pattern modeling allowed the DGAC to assess the impact of converting a full set of nutrient recommendations based on that body of research into food-based recommendations. The findings from each analysis provided information that was useful in developing the DGAC's conclusive statements and recommendations for the *2005 Dietary Guidelines for Americans*. Advantages of using the food intake patterns were noted by the DGAC. These advantages included the continuity of the food intake patterns with previous food guidance, which allows consumers to build new nutrition knowledge on the base of what they already know. In addition, the DGAC noted that the patterns provide an educational tool that integrates the gamut of IOM nutrient recommendations into food-based recommendations. The modeling analyses showed that food patterns can be developed to meet all of the current dietary recommendations.

The modeling also demonstrated that very careful food selections are needed in order to meet all food group and nutrient recommendations. Additional advice may be helpful to consumers in applying these dietary patterns to ensure they are implemented appropriately. For example, the nutrient profiles for each food group reflect low-fat and no-added-sugars choices, which are not the typical choices of many Americans. Therefore, consumers who select foods with higher fat levels and/or added sugars need to account for them as discretionary calories. Guidance may help consumers recognize and account for discretionary calories from the fat contained in milk products or meats, and the fats and added sugars that are a part of processed foods, as well as those added when preparing or serving food.

The findings from these modeling exercises were also of use to CNPP in finalizing the intake patterns for MyPyramid. For example, results from the vegetarian analysis identified that modifications were needed in the amounts of nuts, seeds, and dry beans that were considered equivalent to other foods in the meat and beans group. (The modified equivalencies are shown in Table 4.) This adjustment will make it easier to promote intake of these foods to increase variety within the group. The results from other analyses also helped to shape final decisions about the food intake patterns, such as establishing the equivalency for fruit and vegetable juices at 1 cup equal to 1 cup of fruits or vegetables.

Limitations in using the food intake pattern modeling were noted by the DGAC.[3] Since the nutrient profiles for each food group are developed from Americans' current consumption of foods within that group, the profiles may be low in a nutrient if typical diets do not include rich sources of it. For example, the nuts that Americans tend to eat are not especially rich in vitamin E, and they eat relatively few nuts in comparison to meat and poultry. In addition, relatively few individuals use oils that are especially rich in vitamin E. Therefore, the nutrient profile for the meat and beans group and the oils group are relatively low in vitamin E. Using these nutrient profiles, it is difficult to develop a food intake pattern that meets the RDA for vitamin E. Sources of vitamin E for consumers choosing a diet at the lower range of fat recommendations include fortified breakfast cereals and other fortified foods, oils high in vitamin E (e.g., sunflower and safflower), and nuts high in vitamin E (e.g., almonds and hazelnuts).

With adequate data on food consumption patterns of various population groups and on the nutrient content of the foods eaten, food pattern modeling can be applied to diverse population groups whose food choices differ from those typical in the general U.S. population. The modeling process can also be used to focus on subpopulation groups with specific needs, such as children, pregnant and lactating women, and older adults. In addition, improvements in the data available on food content of some nutrients, such as DHA and EPA, will allow analysis of how the food patterns can meet additional nutritional needs.

## IMPLICATIONS FOR RESEARCH AND PRACTICE

Food intake pattern modeling can be a useful tool for researchers to assess possible impacts of recommended changes in food selection for various groups of people. Modeling exercises can show the overall impact on nutrient adequacy and energy intake of proposed food intakes. Scenarios for potential new nutrient recommendations can be modeled to determine what other compensating changes are needed in overall dietary recommendations. Through careful planning that considers the relative nutrient content of different foods, professionals can adapt food intake patterns for different cultural food choices or population groups and continue to meet recommended nutrient intakes. There is room for flexibility within the food groups, but elimination of entire food categories such as dry beans or milk products can greatly reduce the ability to meet recommended nutrient intakes if nutritionally similar products are not consumed. This work shows that food patterns can be implemented to achieve current dietary recommendations. Professionals can help individuals implement the food-based recommendations within calorie needs by using or adapting the food intake patterns for personal needs and preferences.

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