

Modified Food Guide Pyramid for Lactovegetarians and Vegans

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Health benefits of vegetarian diets include reduced risk of hypertension, type 2 diabetes and certain cancers (1,2), reduced body mass index (3) and lower mortality due to ischemic heart disease (4,5). Although nutrient bioavailability is compromised when meatless diets are consumed (6–8), and nutrient deficiencies have been noted in long-term Western vegetarians (9,10), vegetarian diets can be nutritionally adequate if properly planned.

A food guide provides a conceptual framework for diet planning. Food guides translate recommendations on nutrient intakes to types and amounts of foods, which together provide a nutritionally satisfactory diet (11). The nutritional goals utilized in the development of the USDA Food Guide Pyramid were based on the 10th edition of the Recommended Dietary Allowances (RDA) and the 1990 Dietary Guidelines for Americans (11). The USDA Food Guide Pyramid is often adapted for use by vegetarians by substituting 2–3 servings of legumes, nuts, seeds or meat alternatives for 2–3 servings of meat, poultry or fish (12–14). However, there are nutrients present in animal products that are not present in certain meat alternatives or plant products, and many of the nutrients present in plant products (e.g., calcium and some trace minerals) are not as bioavailable from vegetarian meals as from meat-containing meals.

Furthermore, the nutrient intake recommendations used in the development of the USDA Food Guide Pyramid may not be appropriate for vegetarian diet planning. By definition, the RDA are “amounts intended to be consumed as part of a normal diet,” and can typically be met by “diets that are based on the consumption of a variety of foods from diverse food groups that contain adequate energy” (15). Vegetarian diets omit some or all animal products, and this deviation from the “normal” American diet necessitates careful reconsideration of the organization of a food guide for vegetarians, and specific foods, fortified foods or food groups rich in the less bioavailable or missing nutrients must be emphasized.

Haddad et al. (16) provided a conceptual framework for the development of a new and unique food guide for vegetarians based on the input from an international panel of experts in vegetarian nutrition. These experts concurred that the guide should be applicable to diverse vegetarian practices, help reduce risk of chronic disease, meet nutrient recommendations and help persons who want to become vegetarians (16). Also, epidemiologic data should be considered; whole foods should be emphasized; food groups should be utilized, as opposed to a

point system, and the graphic format should be the pyramid. We have used this framework to develop a modified food guide pyramid for vegetarians, encompassing both lactovegetarians and vegans (Fig. 1).

Nutritional goals for vegetarians

Surveys of vegetarian populations indicate that vegetarians, particularly vegans, are at an increased risk for dietary deficiencies of protein, vitamin B-12 and vitamin D (10,17,18). These dietary deficiencies are verified by biochemical indices showing significant reductions in serum B-12 and serum 25-hydroxyvitamin D in vegetarians vs. omnivore controls. Although dietary intakes of calcium, zinc and iron are often similar among vegetarians and omnivores, bioavailability of these minerals is reduced when vegetarian diets are consumed, and the actual degree of risk may be underestimated. Biochemical indices indicative of calcium, zinc and iron status are generally reduced in vegetarians (19–21).

Protein. The 10th edition RDA for protein [0.8 g/(kg · d), or 63 and 50 g for the reference adult man and woman, respectively] was formulated for diets containing highly digestible, high quality protein (i.e., egg, meat, milk or fish) (15). If dairy products, whole grains, beans, nuts and seeds are the primary protein sources in the diet, as for lactovegetarians, recalculation of the protein allowance indicates that the protein digestibility score is only ~90%, relative to diets composed of highly digestible protein [see (15) for calculation example]. For vegan diets, the protein digestibility falls to 76% of the reference value due to the absence of dairy products. Hence, the recommendation for dietary protein should increase ~20% for vegetarians, 1.0 g/(kg · d), or 75 and 60 g for the reference adult man and woman, respectively.

Vitamin B-12. Tuna fish, beef and milk products are rich sources of vitamin B-12, averaging 2.5, 2.0 and 0.3 µg per serving, respectively. Vitamin B-12 is not a normal constituent of plant foods, but fortified breakfast cereals (containing up to 10 µg per serving) contribute to vitamin B-12 intakes in the United States. The current RDA for vitamin B-12 (2.4 µg/d) is easily achieved by consuming mixed diets, and Americans typically consume 4.0–6.2 µg daily (22). Both vegans and lactovegetarians have low intakes of vitamin B-12 (0.16 and 1.68 µg/d, respectively) (23,24). In a recent report, serum vitamin B-12 deficiency was noted in 78% of vegans, 26% of lactovegetarians and 0% of omnivores (25). Hyperhomocysteinemia was detected in 53% of the vegans, 29% of the lactovegetarians and 5% of the omnivores (25). Mann et al. (18) noted an inverse association between plasma homocysteine concentration and degree of animal product consump-

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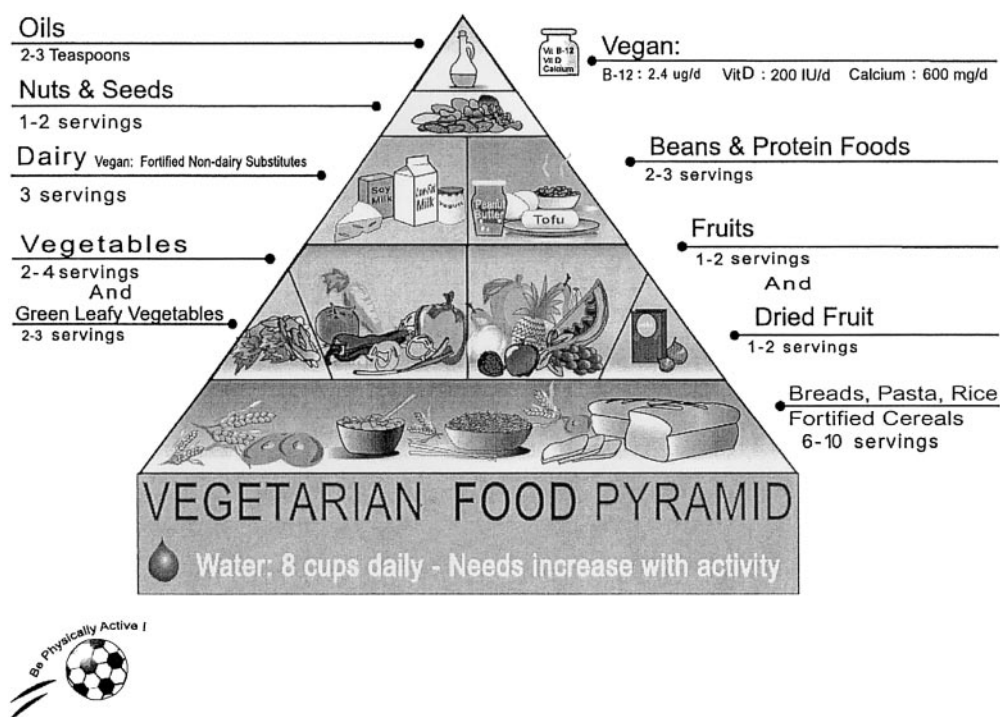


FIGURE 1 Modified food guide pyramid for lactovegetarians and vegans.

tion. Lactovegetarians have to consume 3 servings of dairy products daily, as well as fortified breakfast cereals, to provide adequate amounts of vitamin B-12 (~3 µg); vegan vegetarians would be advised to choose vitamin B-12–fortified nondairy soy foods and breakfast cereals or to consume a vitamin B-12 supplement daily (2.4 µg/d).

Vitamin D. Only a few foods are naturally good sources of vitamin D, i.e., fish liver oils, fatty fish and egg yolks, yet the vitamin D content of these foods varies greatly by time of year. Thus, Americans rely on vitamin D–fortified milk (~100 IU per cup or 250 mL) and breakfast cereals (30–70 IU per cup or 225 g) for dietary vitamin D. The recommended adequate intake (AI) for vitamin D (200 and 400 IU/d for adults 19–50 and 51–70 y, respectively) assumes that no vitamin D is available from sun-mediated cutaneous synthesis (26). This level of intake maintains serum 25-hydroxyvitamin D at adequate levels (>30 nmol/L). Vegan vegetarians have lower average intakes of vitamin D than lactovegetarians and omnivores, 3.6, 28 and 160 IU/d, respectively, and average serum levels of 25-hydroxyvitamin D in winter are reduced in vegans (25 nmol/L) and lactovegetarians (28 nmol/L) vs. omnivores (50 nmol/L) (17). Moreover, serum intact parathyroid hormone correlated negatively with serum 25-hydroxyvitamin D, and bone mineral density was directly related to serum 25-hydroxyvitamin D, in vegetarian and omnivore subjects (17,27). Adult lactovegetarians consuming 2 servings of milk daily (2 cups or 500 mL) receive adequate dietary vitamin D; however, older adult lactovegetarians should regularly consume vitamin D–fortified breakfast cereals in addition to milk, and vegans, particularly if exposure to sunlight is limited, should choose vitamin D–fortified breakfast cereals and soymilks daily or ingest a daily vitamin D supplement (200 IU/d).

Calcium. Calcium intakes in lactovegetarians are similar to those reported for omnivores (17,24), but calcium intakes of vegans are often lower than reported values for both lactovege-

etarians and omnivores (10,28). The AI for calcium, 1000 and 1200 mg for adults 19–50 and 51+ y, respectively (26), assumes a 30% absorption rate from food sources. Absorption of dietary calcium, however, is reduced as much as 20–30% when low meat (<2 oz/d or 50 g/d) and lactovegetarian diets are consumed (17,29), yet in vegans, calcium absorption is elevated, perhaps as high as 40%, concomitant with a rise in serum parathyroid hormone due to a negative calcium balance (17). Recent reports suggest that bone mineral densities average 3–5% lower in lactovegetarians than in omnivores (17,28,30), and long-term vegan vegetarians may have lower bone mineral densities than lactovegetarians (20). Body weight and lean mass are strong predictors of bone mineral density, and dietary protein, calcium, and phosphorus are directly correlated with bone mineral density when lean mass is controlled (31). Thus, vegetarians should be encouraged to consume ~20% more calcium than that recommended for omnivores, 1200–1500 mg calcium daily, depending on age. Dairy products average 300 mg calcium per serving, and fortified, nondairy milks, yogurts and cheeses average ~240 mg calcium per serving.

Zinc and iron. The reported zinc contents of vegetarian and omnivore diets are similar (10,24), and intakes are adequate compared with the recommended intake, 8 and 11 mg/d for adult women and men, respectively (32). However, plasma and tissue zinc concentrations are significantly lower in vegetarians than in omnivores (7,19,33,34). Zinc bioavailability from a meatless diet is reduced ~20% (7), and if the vegetarian diet contains particularly high levels of phytates from grains and legumes, zinc bioavailability may fall by as much as 50% (32). Because the RDA for zinc assumes an absorption rate near 45% (32), vegetarian women and men would be advised to consume at least 10 and 14 mg zinc/d, respectively.

In comparison, the absorption of nonheme iron (the form of iron in plant foods) is reduced by as much as 70% when meat is removed from the diet (35). Biomarkers of iron status,

serum ferritin and transferrin saturation, are often reduced in vegetarians (10,36,37). Yet, because the percentage of iron absorbed is inversely proportional to the serum ferritin concentration, and absorption may increase as much as 300–400% when iron status is low (35,38), the prevalence of iron deficiency (serum ferritin < 12 µg/L) is not necessarily higher among vegetarians compared with omnivores (10,39). The RDA for vegetarian adult men and premenopausal women were recently set at 14 and 33 mg/d, respectively by the Food and Nutrition Board (32), nearly twice that recommended for omnivore men and women, 8 and 18 mg/d, respectively.

Food groups for vegetarians

The food groups chosen for the vegetarian food guide are similar to those of the USDA Food Guide Pyramid, but four groups, or subgroups of foods have been added to the guide to encourage the consumption of foods that particularly address nutritional concerns of vegetarians. We calculated serving sizes as defined by the USDA Food Guide Pyramid (40), and the number of servings from each food group was adjusted so that collectively, the food guide meets the protein, vitamin and mineral needs specific to vegetarians.

Food groups (Table 1). A food subgroup was added to both the vegetable group and the fruit group, green leafy vegetables and dried fruit, respectively. Green leafy vegetables are emphasized because they are particularly rich plant sources of calcium, averaging 77 mg/serving compared with 17 mg/serving for vegetables in general. Dried fruits contain about sixfold the amount of iron contained in typical fruits [1.3 mg/0.25 cup (62.5 g) vs. 0.2 mg for a serving of fruit].

A nuts and seeds group was to the food guide to provide an added source of protein (5.2 g/serving), iron (1.5 mg/serving), zinc (1.3 mg/serving), and essential fatty acids [0.24 g (n-3) α-linolenic acid and 5 g (n-6) linoleic acid/serving]. Addition-

ally, an oils group is included on the food guide to encourage the use of oils rich in the monounsaturated fats and (n-3) essential fatty acids. The nuts/seed and oils groups replaced the fats/oils/sweets group of the USDA Food Guide Pyramid, a group that was eliminated because these foods were not intended to be consumed regularly and were often rich in nutrients implicated in chronic disease and obesity, i.e., saturated fatty acids, *trans* fatty acids and simple sugars.

We replaced the meat group (encompassing meats, poultry, fish, dry beans, eggs and nuts) with the beans and protein foods group. A serving of these foods provides 8 g protein, 2.4 mg iron, 1.1 mg zinc and 40 mg calcium. Fortified soy milks were included in the dairy food group for use by vegan vegetarians.

Fortified foods and supplements. The vegetarian food guide places special emphasis on fortified foods that are commonly available, i.e., fortified breakfast cereals and nondairy soy milks. With careful selection, these foods are good sources of vitamins B-12 and D, and calcium. Alternatively, daily supplementation would be advocated for vegans to ensure adequate intakes of these micronutrients: 2.4 µg, 200 IU, and 600 mg daily for vitamin B-12, vitamin D and calcium, respectively.

Number of servings (Table 2). Utilizing the same framework used in the development of the USDA Food Guide Pyramid, we analyzed the nutrient adequacy of three dietary patterns by number of food group servings, lowest (~1600 kcal or 6700 kJ), midrange (~2000 kcal or 8400 kJ) and highest (~2500 kcal or 10,500 kJ). Our diet plans meet or exceed the recommended, or proposed, nutrient needs of individuals following lactovegetarian or vegan diets. The percentages of total energy from fat:protein:carbohydrate are close to 27:18:55 for each dietary pattern, and <10% of total energy is from saturated fatty acids. Daily cholesterol values range from 0 mg in vegan diets to 220–260 mg/d in lactovegetarian diets. Sodium

TABLE 1

Nutrient profiles of food groups based on averages compiled from single servings of representative foods¹

Food group	Energy ²	Protein	Total fat	Saturated fat	(n-6)/(n-3) ratio	Fiber	Vitamin	Vitamin D	Calcium	Iron	Zinc
	kcal						B-12				
		g				g			mg		
Grains	89	2.6	1.2	0.24	14.0	1.5	0.33	5.2	27	2.2	1.1
Vegetables	37	1.5	0.2	0.04	2.0	1.7	0	0	17	0.6	0.2
Green leafy vegetables	17	1.6	0	0	0.7	1.8	0	0	77	0.9	0.2
Fruits	53	0.6	0.3	0.04	2.0	1.6	0	0	13	0.2	0.1
Dried fruits	76	0.7	0.2	0.02	0	1.9	0	0	19	1.3	0.1
Beans and protein foods	122	8.1	1.2	0.22	4.9	6.1	0	0	40	2.4	1.1
Dairy (lactovegetarian)	119	10.2	5.5	3.47	1.5	0	0.4	66.7 ³	305	0.1	0.9
or											
Nondairy (vegan)	111	7.8	3.5	0.47	0	0.6	0.8 ³	66.7 ³	237 ³	1.4	0.7
Nuts/seeds	171	5.2	15.0	2.00	20.8	2.3	0	0	28	1.5	1.3
Oils	40	0	4.5	0.44	1.2	0	0	0	0	0	0

¹ Serving sizes defined by the USDA Food Guide Pyramid. Grains: fortified breakfast cereals, muffins, rice, tortilla, couscous, crackers, oatmeal, pita, bagel, breads, pasta (an equal contribution of whole grain and refined products); vegetables: broccoli, Brussels sprouts, carrots, cauliflower, green pepper, green peas, lettuce, potato, peppers, green beans, squash, tomato, onion, corn; green leafy vegetables: bok choy, Chinese cabbage, collard greens, dandelion greens, kale, mustard greens, red cabbage, spinach, turnip greens; fruits: apple, apricots, banana, blueberries, melons, fruit cocktail, grapes, kiwi, lemon, mango, orange, juice, pineapple, grapefruit, raspberries, strawberries; dried fruit: apricot, figs, mixed fruit, mango, peaches, prunes, raisins; beans and protein foods: adzuki, black, garbanzo, great northern, kidney, lentils, lima, navy, pinto, refried, soybean, split peas, egg, egg beaters, meatless burger/chicken, miso, tempeh, tofu, peanut butter; dairy (lactovegetarian): nonfat skim milk, low fat yogurt, mozzarella cheese; fortified nondairy (vegan): fortified soy milk, soy yogurt, NuTaste nondairy low fat milk, soy cheese; nuts and seeds: almonds, walnuts, brazil nuts, cashews, chestnuts, hazelnuts, macadamia nuts, peanuts, pecans, pine nuts, pistachios, pumpkin kernels, sesame seeds, sunflower seeds, tahini; oils: olive, flax seed, canola walnut.

² 1 kcal = 4.2 kJ.

³ Averages assume use of fortified products.

TABLE 2

Food guide sample patterns at three energy levels for lactovegetarians (using dairy foods) or vegans (using fortified non-dairy foods)¹

Food group	Energy ²	Protein	Total fat	Saturated fat	(n-6)/(n-3) ratio	Fiber	Vitamin B-12 ³	Vitamin D ³	Calcium ³	Iron	Zinc
	<i>kcal</i>	<i>g</i>				<i>g</i>	<i>μg</i>	<i>IU</i>	<i>mg</i>		
Pattern A											
Lactovegetarian	1600	76	51	14	6.4	34	3.0	231	1402	24	14
Vegan	1600	68	45	5	6.2	36	4.2	231	1198	28	13
Pattern B											
Lactovegetarian	2000	89	64	17	5.5	46	3.6	242	1565	32	18
Vegan	2000	82	58	8	5.4	48	4.8	242	1361	36	18
Pattern C											
Lactovegetarian	2500	104	77	19	6.8	57	4.2	252	1723	39	21
Vegan	2500	96	71	10	6.7	59	5.4	252	1519	43	21

¹ Serving sizes defined by the USDA Food Guide Pyramid. Pattern A: 6 grains, 2 vegetables, 2 green leafy vegetables, 1 fruit, 1 dried fruit, 2 beans and protein foods, 3 dairy or fortified nondairy, 1 nuts and seeds, 2 oils; Pattern B: 8 grains, 3 vegetables, 2.5 green leafy vegetables, 1.5 fruit, 1.5 dried fruit, 2.5 beans and protein foods, 3 dairy or fortified nondairy, 1.5 nuts and seeds, 2.5 oils; Pattern C: 10 grains, 4 vegetables, 3 green leafy vegetables, 2 fruit, 2 dried fruit, 3 beans and protein foods, 3 dairy or fortified nondairy, 2 nuts and seeds, 3 oils.

² 1 kcal = 4.2 kJ.

³ Values assume use of fortified products.

levels range from 1650 to 2050 mg daily, and the fiber content of these diet plans ranges from ~35 to 60 g/d. Finally, a variety of foods are promoted by this food plan, and water consumption as well as an active lifestyle are encouraged.

In conclusion, we have designed a food guide pyramid specifically addressing the nutrient inadequacies and reduced mineral bioavailability of lactovegetarian and vegan diets. Three new food groups, green leafy vegetables, dried fruit, and nuts and seeds, have been added to the traditional food groups, increasing the protein, calcium, iron, and zinc contents of the meal plans by 15–20%. The inclusion of fortified breakfast cereals and nondairy soy milks provides the recommended amounts of the vitamin B-12, vitamin D and calcium. If fortified foods are absent from the diet, the use of specific supplements for these micronutrients is encouraged. The addition of an oils group promotes the consumption of dietary fats in the form of the EFA and the monounsaturated fats while keeping the saturated fat level at <10% total dietary energy.

Increasing the number of food groups from 5 to 9 encourages the consumption of a variety of foods daily. Fruit and vegetable consumption is particularly promoted, 6–11 servings daily, which along with legumes, soy products and whole grain products, provides a diet rich in antioxidants, phytochemicals and fiber to reduce risk for chronic disease. Food items composed mainly of refined sugars and/or processed fats (e.g., sodas, candies, bakery items, savory snacks, gravies or desserts) are not represented in this food guide and should be consumed sparingly.

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