Nutritional adequacy of plant-based diets for weight management: observations from the NHANES[1–3]

Bonnie Farmer

ABSTRACT

Observational studies have shown that body mass indexes of vegetarians are lower than those of nonvegetarians and that caloric intake of vegetarians is typically lower than that of nonvegetarians, suggesting that a vegetarian diet could be an approach for weight management. However, vegetarians may be at risk of inadequate intakes of certain vitamins and minerals. Population-based studies indicate that vegetarians have lower mean intakes of vitamin B-12 and zinc and higher intakes of fiber, magnesium, and vitamins A, C, and E than do nonvegetarians. Usual intake data suggest a similar prevalence of inadequacy between vegetarians and nonvegetarians for magnesium and vitamins A, C, and E, with both groups at high risk of inadequate intakes of these nutrients. These same data report that vegetarians have a higher prevalence of inadequacy for iron, vitamin B-12, protein, and zinc than do nonvegetarians. Although mean intake data suggest that a vegetarian diet may be a useful approach for weight management, combined with energy restriction it may have a detrimental effect on diet quality. Mean intakes of fiber, vitamins A and C, magnesium, and iron were significantly lower for vegetarians with energy intakes ≥500 kcal below Estimated Energy Requirements than for vegetarians who did not restrict energy. Vegetarian diets should be recommended for weight management; however, care should be taken to optimize food intake to provide adequate intakes of nutrients of concern when energy restriction is used in conjunction with a vegetarian dietary pattern. At any caloric amount, vegetarians should optimize intakes of vitamin B-12, zinc, and protein; and both vegetarians and nonvegetarians need to increase intakes of calcium, magnesium, fiber, and vitamins A, C, and E. *Am J Clin Nutr* 2014;100 (suppl):365S–8S.

INTRODUCTION

Observational studies have shown that BMIs of vegetarians are lower than those of nonvegetarians (1–4). In the European Prospective Investigation into Cancer and Nutrition (EPIC)–Oxford cohort, Spencer et al (4) observed a wide range of BMIs, but the differences between vegetarians and nonvegetarians remained significant even after lifestyle and dietary factors were adjusted for. In addition, ANOVA showed that lower protein and higher fiber intakes, characteristic of vegetarian diets, were the most important determinants of BMI. Likewise, Newby et al (2), after adjustment for energy and total fat intake, also observed a lower risk of overweight for vegetarians in the Swedish Mammography Study. Last, Haddad and Tanzman (5) reported that self-defined vegetarians who ate meat had higher mean BMIs than those who did not, and both groups had significantly lower BMIs than did nonvegetarians.

Dietary data show that caloric intake of vegetarians is typically lower than that of nonvegetarians, with a difference of as much as 424 calories/d (1, 2, 6). The Academy of Nutrition and Dietetics (7) and the NIH National Heart, Lung, and Blood Institute (8) recommend a reduction of 500–1000 kcal/d for weight loss, with most experts recommending 500 kcal. This, taken with the observed BMI differences, suggests that a vegetarian diet could be considered as an effective approach for weight management. However, weight management ideally requires long-term adherence to dietary changes; therefore, it is important to consider the nutritional adequacy of the diet pattern chosen, whether it is a vegetarian or low-calorie nonvegetarian dietary pattern. Observational studies have documented nutrient intakes for individuals who follow vegetarian dietary patterns and reported that these subjects consume diets that are generally consistent with current dietary guidelines (9), particularly with lower intakes of fat, saturated fat, and cholesterol and higher intakes of vitamin C, fiber, magnesium, and β-carotene (10–16). Despite these advantages, concerns have been raised as to the nutritional adequacy of vegetarian diets, particularly if calories are restricted for weight loss (12, 16).

In many population-based studies, mean nutrient intake data are used to characterize nutrient intakes of vegetarians and to evaluate differences between vegetarians and nonvegetarians; however, the nutritional adequacy of the dietary patterns must be assessed by comparing usual intakes to Estimated Average Requirements (EARs) (17). Mean nutrient intakes are reflective of a point in time and cannot be used to provide information on nutritional adequacy, whereas usual intake, estimated from 2 nonconsecutive days, indicates average nutrient intake over time, thus can characterize the nutrient adequacy of a dietary pattern. Usual intake data may be used to describe the prevalence, or risk, of inadequate intake and is presented as the percentage of the population with usual nutrient intakes below the EAR. High prevalence of inadequacy is defined as more than one-third of the population having intakes below the EAR (18). To understand whether concerns with regard to nutrient adequacy of vegetarian

[1] From PlantWise Nutrition Consulting LLC, Plainwell, MI.

[2] Presented at the symposium "Sixth International Congress on Vegetarian Nutrition" held in Loma Linda, CA, 24–26 February 2013.

[3] Address correspondence to B Farmer, 501 3rd Street, Plainwell, MI 49080. E-mail: plantwisenutrition@yahoo.com.

First published online May 28, 2014; doi: 10.3945/ajcn.113.071308.

TABLE 1
Adjusted mean intakes of selected nutrients for vegetarians and nonvegetarians aged ≥19 y, NHANES 1999–2004[1]

Nutrient[2]	Vegetarians (n = 851)	Nonvegetarians (n = 12,441)
Energy (kcal)	1877 ± 42	2241 ± 11*
Protein (g)	63.4 ± 0.7	83.6 ± 0.4*
Fiber (g)	20.3 ± 0.6	15.4 ± 0.2*
Vitamin A (μg RAE)	718 ± 28	603 ± 10*
Vitamin C (mg)	112 ± 6.5	91 ± 1.6*
Vitamin E (mg AT)	8.3 ± 0.3	7.0 ± 0.1*
Vitamin B-12 (μg)	3.8 ± 0.2	5.3 ± 0.1*
Magnesium (mg)	322 ± 5	281 ± 2*
Iron (mg)	16.9 ± 0.4	15.5 ± 0.1*
Zinc (mg)	10.1 ± 0.2	12.1 ± 0.1*

[1] All values are means ± SEMs. Modified from reference 16. *$P < 0.01$ (ANOVA). AT, α-tocopherol; RAE, retinol activity equivalents.
[2] Energy intake adjusted for sex and ethnicity; all other nutrients adjusted for energy, sex, and ethnicity.

diets are warranted, particularly in the context of low-calorie intake, the purpose of this review is to present recent data describing nutrient intakes and nutritional adequacy of vegetarian diets, examining studies with both mean and usual intake data.

NUTRITIONAL ADEQUACY OF VEGETARIAN DIETS

In a report from the USDA, Agricultural Research Service, usual intake data from the NHANES 2001–2002 were compared with Dietary Reference Intakes (DRIs) to identify nutrients with a high prevalence of inadequate intake (18). According to that analysis, the nutrients of concern for the general population included fiber, calcium, magnesium, and vitamins A, C, and E. With few exceptions, vegetarians have higher mean intakes of these nutrients than do nonvegetarians.

Mean nutrient intakes

Davey et al (15) showed that, whereas vegetarians had lower mean intakes of vitamin B-12, vitamin D, and zinc than did nonvegetarians, they had higher intakes of vitamins C and E and magnesium and similar intakes of iron. Similar results reported by Haddad and Tanzman (5) showed that, after calories were adjusted for, self-defined vegetarians had higher intakes of magnesium, fiber, and vitamins A, E, and C than did nonvegetarians. Iron intake was similar between the groups; however, vegetarians again had lower intakes of vitamin B-12 and zinc.

In an analysis of 1-d nutrient intakes from NHANES 1999–2004 (16), diet quality for vegetarians was compared with that of nonvegetarians. Vegetarians were defined as participants who did not report eating meat, poultry, or fish on the day of the survey. As with the previous studies, fiber, magnesium, and vitamins A, C, and E intakes were higher for vegetarians than for nonvegetarians, but iron intake was also found to be higher in the vegetarian diet pattern (**Table 1**). Results from this analysis and others (5, 14, 15) suggest that a vegetarian dietary pattern is nutrient-dense and consistent with current dietary guidelines.

The lower calorie intake typically seen with vegetarian diet patterns suggests that a vegetarian diet could be considered an option for weight loss. However, individuals who follow recommendations to decrease caloric intake by 500 kcal/d may experience detrimental effects on diet quality. In the analysis of NHANES 1999–2004 data by Farmer et al (16), vegetarian and nonvegetarian groups were stratified by caloric intake to represent dieters and nondieters. Dieters were defined as respondents with dietary intakes of ≥500 kcal less than Estimated Energy Requirements (EERs). Pairwise comparisons of mean nutrient intakes (**Table 2**) suggest a detrimental effect on diet quality when energy intake is ≥500 kcal below EERs. Mean intakes of fiber, vitamins A and C, magnesium, and iron, which are generally higher in vegetarians, were significantly lower for the dieting vegetarians compared with the nondieting vegetarians and were similar to intakes of nondieting nonvegetarians.

Usual nutrient intakes

In a sample of British Columbia adults (14), the prevalence of inadequate intakes of some nutrients was determined on the basis of usual intakes from both food and supplements. There were no differences between vegetarians and nonvegetarians for intakes of vitamin B-12 and zinc, but even with vitamin and mineral supplementation, the prevalence of inadequate intakes of

TABLE 2
Adjusted mean intakes of selected nutrients for dieting and nondieting vegetarians and nonvegetarians aged ≥19 y, NHANES 1999–2004[1]

Nutrient[2]	Nondieting vegetarians (n = 432)	Nondieting nonvegetarians (n = 8225)	Dieting vegetarians[3] (n = 419)	Dieting nonvegetarians[4] (n = 4216)
Energy (kcal)	2440 ± 36^{c}	2623 ± 11^{d}	1179 ± 29^{a}	1396 ± 10^{b}
Protein (g)	62.5 ± 1.3^{a}	83.9 ± 0.6^{b}	64.4 ± 0.9^{a}	83.1 ± 0.7^{b}
Fiber (g)	23.4 ± 0.8^{c}	15.8 ± 0.2^{b}	16.0 ± 0.6^{b}	14.3 ± 0.3^{a}
Vitamin A (μg RAE)	801 ± 33^{b}	619 ± 11^{a}	600 ± 44^{a}	570 ± 19^{a}
Vitamin C (mg)	127 ± 7.9^{c}	96 ± 1.7^{b}	91 ± 6.1^{a,b}	81 ± 2.6^{a}
Vitamin E (mg AT)	8.8 ± 0.3^{c}	7.2 ± 0.1^{b}	7.5 ± 0.5^{a,b,c}	6.6 ± 0.2^{a}
Vitamin B-12 (μg)	3.8 ± 0.3^{a}	5.3 ± 0.1^{b}	3.9 ± 0.2^{a}	5.2 ± 0.2^{b}
Magnesium (mg)	349 ± 6^{a}	286 ± 2^{c}	283 ± 7^{b,c}	268 ± 3^{b}
Iron (mg)	17.9 ± 0.5^{a}	15.9 ± 0.1^{c}	15.4 ± 0.6^{b,c}	14.8 ± 0.2^{b}
Zinc (mg)	10.2 ± 0.3^{a}	12.3 ± 0.1^{b}	9.9 ± 0.3^{a}	11.8 ± 0.2^{b}

[1] All values are means ± SEMs. Modified from reference 16. Values in the same row with different superscript letters are significantly different, $P < 0.01$ (ANOVA). AT, α-tocopherol; RAE, retinol activity equivalents.
[2] Energy intake adjusted for sex and ethnicity; all other nutrients adjusted for energy, sex, and ethnicity.
[3] Vegetarians with energy intakes ≥500 kcal below Estimated Energy Requirements.
[4] Nonvegetarians with energy intakes ≥500 kcal below Estimated Energy Requirements.

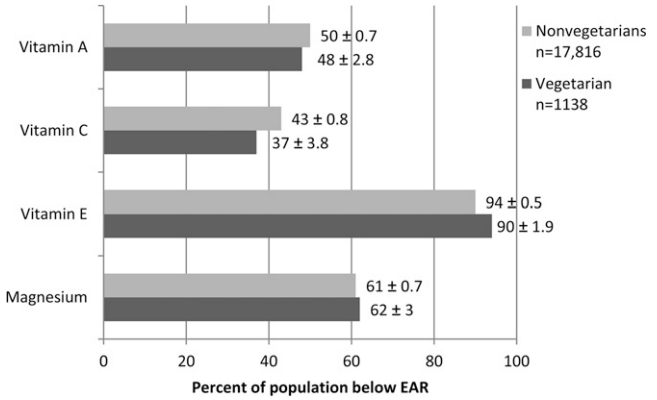

FIGURE 1. Percentages (±SEs) of vegetarians and nonvegetarians with inadequate intakes of selected nutrients based on EARs, NHANES 2001–2008. There were no differences between groups for any of the variables (ANOVA, $P < 0.01$). Adapted from reference 19. EAR, Estimated Average Requirement.

magnesium, vitamin C, vitamin B-6, and folate was higher for nonvegetarians.

In a recent study, usual nutrient intakes for vegetarians and nonvegetarians in the United States were estimated from NHANES 2001–2008 data, and the results were compared with EARs (19). The prevalence of inadequacy was similar between vegetarians and nonvegetarians for magnesium and vitamins A, C, and E, with both groups at high risk of inadequate intakes of these nutrients (**Figure 1**). Vegetarians had a higher prevalence of inadequacy for iron, vitamin B-12, protein, and zinc than did nonvegetarians (**Figure 2**), although the risk of inadequate intake of iron was not considered high at 16.8% and for vitamin B-12 it was just below the one-third threshold, which is considered high risk. In addition, the prevalence of inadequacy was high in the vegetarian group for both calcium and zinc; however, vegetarians and nonvegetarians had a similar risk of inadequate calcium intake.

LIMITATIONS OF CURRENTLY AVAILABLE LITERATURE

Among the limitations that should be addressed in analyses of NHANES or other population data sets include the definition of vegetarians. Before 2009–2010, vegetarians were defined by the absence of meat, poultry, or fish on the day of the survey for both NHANES and by Kennedy et al (1) in an analysis of the Continuing Survey of Food Intake by Individuals (CSFII) 1994–1996 data. However, some participants who were defined as vegetarians may have avoided eating meat on the day of the survey for reasons other than vegetarianism. In another analysis of CSFII 1994–1996, Haddad and Tanzman (5) used the survey question "Do you consider yourself to be a vegetarian," and on finding that self-defined vegetarians consumed some meat, poultry, or fish, further classified the respondents on the basis of a cutoff of 10 g meat/d. For the EPIC-Oxford study, Davey et al (15) classified vegetarians by responses to 4 questions characterizing their intakes of meat, poultry, fish, dairy, and eggs. A consistent and characterizing definition of vegetarian dietary patterns should be developed for use within the collection and analysis of population data sets.

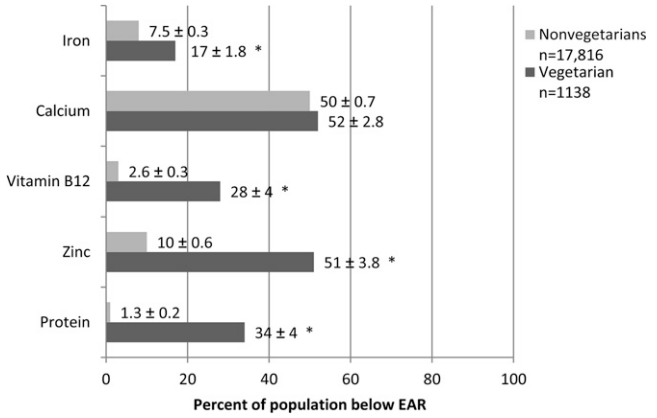

FIGURE 2. Percentages (±SEs) of vegetarians and nonvegetarians with inadequate intakes of vegetarian nutrients of concern based on EARs, NHANES 2001–2008. *$P < 0.01$ (ANOVA). Adapted from reference 19. EAR, Estimated Average Requirement.

CONCLUSIONS

Vegetarian eating patterns can and should be recommended without energy restriction for safe and nutritious weight loss and weight management. With the addition of calorie restriction, dietary counseling is needed to maintain the nutrient density of the vegetarian as well as the nonvegetarian dietary pattern. At any caloric amount, vegetarians should optimize intakes of vitamin B-12, zinc, and protein, whereas both vegetarians and nonvegetarians should consume foods to maximize intakes of calcium, magnesium, fiber, and vitamins A, C, and E.

The sole author had responsibility for all parts of the manuscript. The author had no conflicts of interests.

REFERENCES

1. Kennedy ET, Bowman SA, Spence JT, Freedman M, King J. Popular diets: correlation to health, nutrition, and obesity. J Am Diet Assoc 2001;101:411–20.
2. Newby PK, Tucker KL, Wolk A. Risk of overweight and obesity among semivegetarian, lactovegetarian, and vegan women. Am J Clin Nutr 2005;81:1267–74.
3. Fraser GE. Associations between diet and cancer, ischemic heart disease, and all-cause mortality in non-Hispanic white California Seventh-day Adventists. Am J Clin Nutr 1999;70:532S–8S.
4. Spencer EA, Appleby PN, Davey GK, Key TJ. Diet and body mass index in 38,000 EPIC-Oxford meat-eaters, fish-eaters, vegetarians and vegans. Int J Obes 2003;27:728–34.
5. Haddad EH, Tanzman JS. What do vegetarians in the United States eat? Am J Clin Nutr 2003;78(suppl):626S–32S.
6. Barr SI, Chapman GE. Perceptions and practices of self-defined current vegetarian, former vegetarian, and nonvegetarian women. J Am Diet Assoc 2002;102:354–60.
7. Seagle HM, Strain GW, Makris A, Reeves RS; American Dietetic Association. Position of the American Dietetic Association: weight management. J Am Diet Assoc 2009;109:330–46.
8. NIH, National Heart, Lung, and Blood Institute. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults. Available from: http://www.nhlbi.nih.gov/guidelines/obesity/ob_home.htm (cited 15 February 2013).
9. USDA, US Department of Health and Human Services. Dietary guidelines for Americans, 2010. 7th ed. Washington, DC: US Government Printing Office, 2010.
10. Janelle KC, Barr SI. Nutrient intakes and eating behavior scores of vegetarian and nonvegetarian women. J Am Diet Assoc 1995;95:180–6, 189.
11. Haddad EH, Berk LS, Kettering JD, Hubbard RW, Peters WR. Dietary intake and biochemical, hematologic, and immune status of vegans compared with nonvegetarians. Am J Clin Nutr 1999;70:586S–93S.

12. Barr SI, Broughton TM. Relative weight, weight loss efforts and nutrient intakes among health-conscious vegetarian, past vegetarian and nonvegetarian women ages 18-50. J Am Coll Nutr 2000;19:781–8.
13. Millet P, Guilland JC, Fuchs F, Klepping J. Nutrient intake and vitamin status of healthy French vegetarians and nonvegetarians. Am J Clin Nutr 1989;50:718–27.
14. Bedford JL, Barr SI. Diets and selected lifestyle practices of self-defined adult vegetarians from a population-based sample suggest they are more health-conscious. Int J Behav Nutr Phys Activ [serial online] 2005. Available from: http://www.ijbnpa.org/content/2/1/4 (cited 27 December 2007).
15. Davey GK, Spencer EA, Appleby PN, Allen NE, Knox KH, Key TJ. EPIC-Oxford: lifestyle characteristics and nutrient intakes in a cohort of 33,883 meat-eaters and 31,546 non meat-eaters in the UK. Public Health Nutr 2003;6:259–69.
16. Farmer B, Larson BT, Fulgoni VL, Rainville AJ, Liepa GU. A vegetarian dietary pattern as a nutrient-dense approach to weight management: an analysis of the National Health and Nutrition Examination Survey 1999-2004. J Am Diet Assoc 2011;111:819–27.
17. Food and Nutrition Board, Institute of Medicine. Dietary Reference Intakes: applications in dietary assessments. Washington, DC: National Academies Press, 2000.
18. Moshfegh A, Goldman J, Cleveland L. What we eat in America, NHANES 2001-2002: usual nutrient intakes from food compared to dietary reference intakes. Washington, DC: USDA, Agricultural Research Service, 2005.
19. Farmer B, Larson B, Keast DR, Fulgoni VL. Vegetarians have higher risk for inadequate intake of iron, zinc, and vitamin B12 compared to non-vegetarians even when considering use of dietary supplements. FASEB J 2012;26:635.3 (abstr).