

Position of the American Dietetic Association: Vegetarian Diets

ABSTRACT

It is the position of the American Dietetic Association that appropriately planned vegetarian diets, including total vegetarian or vegan diets, are healthful, nutritionally adequate, and may provide health benefits in the prevention and treatment of certain diseases. Well-planned vegetarian diets are appropriate for individuals during all stages of the life cycle, including pregnancy, lactation, infancy, childhood, and adolescence, and for athletes. A vegetarian diet is defined as one that does not include meat (including fowl) or seafood, or products containing those foods. This article reviews the current data related to key nutrients for vegetarians including protein, n-3 fatty acids, iron, zinc, iodine, calcium, and vitamins D and B-12. A vegetarian diet can meet current recommendations for all of these nutrients. In some cases, supplements or fortified foods can provide useful amounts of important nutrients. An evidence-based review showed that vegetarian diets can be nutritionally adequate in pregnancy and result in positive maternal and infant health outcomes. The results of an evidence-based review showed that a vegetarian diet is associated with a lower risk of death from ischemic heart disease. Vegetarians also appear to have lower low-density lipoprotein cholesterol levels, lower blood pressure, and lower rates of hypertension and type 2 diabetes than nonvegetarians. Furthermore, vegetarians tend to have a lower body mass index and lower overall cancer rates. Features of a vegetarian diet that may reduce risk of chronic disease include lower intakes of saturated fat and cholesterol and higher intakes of fruits, vegetables, whole grains, nuts, soy products, fiber, and phytochemi-

This American Dietetic Association (ADA) position paper includes the authors' independent review of the literature in addition to systematic review conducted using the ADA's Evidence Analysis Process and information from the Evidence Analysis Library. Topics from the Evidence Analysis Library are clearly delineated. The use of an evidence-based approach provides important added benefits to earlier review methods. The major advantage of the approach is the more rigorous standardization of review criteria, which minimizes the likelihood of reviewer bias and increases the ease with which disparate articles may be compared. For a detailed description of the methods used in the evidence analysis process, access ADA's Evidence Analysis Process at <http://adaeal.com/eaprocess/>.

Conclusion Statements are assigned a grade by an expert work group based on the systematic analysis and evaluation of the supporting research evidence. Grade I=Good; Grade II=Fair; Grade III=Limited; Grade IV=Expert Opinion Only; and Grade V=Not Assignable (because there is no evidence to support or refute the conclusion).

Evidence-based information for this and other topics can be found at <https://www.adaevidencelibrary.com> and subscriptions for nonmembers are available for purchase at <https://www.adaevidencelibrary.com/store.cfm>.

icals. The variability of dietary practices among vegetarians makes individual assessment of dietary adequacy essential. In addition to assessing dietary adequacy, food and nutrition professionals can also play key roles in educating vegetarians about sources of specific nutrients, food purchase and preparation, and dietary modifications to meet their needs.

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POSITION STATEMENT

It is the position of the American Dietetic Association that appropriately planned vegetarian diets, including total vegetarian or vegan diets, are healthful, nutritionally adequate, and may provide health benefits in the prevention and treatment of certain diseases. Well-planned vegetarian diets are appropriate for individuals during all stages of the lifecycle, including pregnancy, lactation, infancy, childhood, and adolescence, and for athletes.

VEGETARIAN DIETS IN PERSPECTIVE

A vegetarian is a person who does not eat meat (including fowl) or seafood,

or products containing these foods. The eating patterns of vegetarians may vary considerably. The lacto-ovo-vegetarian eating pattern is based on grains, vegetables, fruits, legumes, seeds, nuts, dairy products, and eggs. The lacto-vegetarian excludes eggs as well as meat, fish, and fowl. The vegan, or total vegetarian, eating pattern excludes eggs, dairy, and other animal products. Even within these patterns, considerable variation may exist in the extent to which animal products are excluded.

Evidence-based analysis was used to evaluate existing research on types of vegetarian diets (1). One question for evidence-analysis was identified: What types of vegetarian diets are examined in the research? The complete results of this evidence-based analysis can be found on the American Dietetic Association's Evidence Analysis Library (EAL) Web site (www.adaevidencelibrary.com) and are summarized below.

EAL Conclusion Statement: The two most common ways of defining vegetarian diets in the research are vegan diets: Diets devoid of all flesh foods;

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and vegetarian diets: Diets devoid of all flesh foods, but also include egg (ovo) and/or dairy (lacto) products.

However, these very broad categories mask important variations within vegetarian diets and dietary practices. These variations within vegetarian diets make absolute categorization of vegetarian dietary practices difficult and may be one of the sources of unclear relationships between vegetarian diets and other factors. **Grade II=Fair.**

In this article, the term *vegetarian* will be used to refer to people choosing a lacto-ovo-, lacto-, or vegan vegetarian diet unless otherwise specified.

Whereas lacto-ovo-, lacto-, and vegan-vegetarian diets are those most commonly studied, practitioners may encounter other types of vegetarian or near-vegetarian diets. For example, people choosing macrobiotic diets typically describe their diet as vegetarian. The macrobiotic diet is based largely on grains, legumes, and vegetables. Fruits, nuts, and seeds are used to a lesser extent. Some people following a macrobiotic diet are not truly vegetarian because they eat limited amounts of fish. The traditional Asian-Indian diet is predominantly plant based and is frequently lacto-vegetarian although changes often occur with acculturation, including greater consumption of cheese and a movement away from a vegetarian diet. A raw foods diet may be a vegan diet, consisting mainly or exclusively of uncooked and unprocessed foods. Foods used include fruits, vegetables, nuts, seeds, and sprouted grains and beans; in rare instances unpasteurized dairy products and even raw meat and fish may be used. Fruitarian diets are vegan diets based on fruits, nuts, and seeds. Vegetables that are classified botanically as fruits like avocado and tomatoes are commonly included in fruitarian diets; other vegetables, grains, beans, and animal products are excluded.

Some people will describe themselves as vegetarian but will eat fish, chicken, or even meat. These self-described vegetarians may be identified in research studies as semivegetarians. Individual assessment is required to accurately evaluate the nutritional quality of the diet of a vegetarian or a self-described vegetarian.

Common reasons for choosing a vegetarian diet include health consid-

erations, concern for the environment, and animal welfare factors. Vegetarians also cite economic reasons, ethical considerations, world hunger issues, and religious beliefs as their reasons for following their chosen eating pattern.

Consumer Trends

In 2006, based on a nationwide poll, approximately 2.3% of the US adult population (4.9 million people) consistently followed a vegetarian diet, stating that they never ate meat, fish, or poultry (2). About 1.4% of the US adult population was vegan (2). In 2005, according to a nationwide poll, 3% of 8- to 18-year-old children and adolescents were vegetarian; close to 1% were vegan (3).

Many consumers report an interest in vegetarian diets (4) and 22% report regular consumption of meatless substitutes for meat products (5). Additional evidence for the increasing interest in vegetarian diets includes the emergence of college courses on vegetarian nutrition and on animal rights; the proliferation of Web sites, periodicals, and cookbooks with a vegetarian theme; and the public's attitude toward ordering a vegetarian meal when eating away from home.

Restaurants have responded to this interest in vegetarian diets. A survey of chefs found that vegetarian dishes were considered "hot" or "a perennial favorite" by 71%; vegan dishes by 63% (6). Fast-food restaurants are beginning to offer salads, veggie burgers, and other meatless options. Most university foodservices offer vegetarian options.

New Product Availability

The US market for processed vegetarian foods (foods like meat analogs, nondairy milks, and vegetarian entrees that directly replace meat or other animal products) was estimated to be \$1.17 billion in 2006 (7). This market is forecast to grow to \$1.6 billion by 2011 (7).

The availability of new products, including fortified foods and convenience foods, would be expected to have an impact on the nutrient intake of vegetarians who choose to eat these foods. Fortified foods such as soy milks, meat analogs, juices, and breakfast cereals are continually being added to the mar-

ketplace with new levels of fortification. These products and dietary supplements, which are widely available in supermarkets and natural foods stores, can add substantially to vegetarians' intakes of key nutrients such as calcium, iron, zinc, vitamin B-12, vitamin D, riboflavin, and long-chain n-3 fatty acids. With so many fortified products available today, the nutritional status of the typical vegetarian today would be expected to be greatly improved from that of a vegetarian 1 to 2 decades ago. This improvement would be enhanced by the greater awareness among the vegetarian population of what constitutes a balanced vegetarian diet. Consequently older research data may not represent the nutritional status of present-day vegetarians.

Health Implications of Vegetarian Diets

Vegetarian diets are often associated with a number of health advantages, including lower blood cholesterol levels, lower risk of heart disease, lower blood pressure levels, and lower risk of hypertension and type 2 diabetes. Vegetarians tend to have a lower body mass index (BMI) and lower overall cancer rates. Vegetarian diets tend to be lower in saturated fat and cholesterol, and have higher levels of dietary fiber, magnesium and potassium, vitamins C and E, folate, carotenoids, flavonoids, and other phytochemicals. These nutritional differences may explain some of the health advantages of those following a varied, balanced vegetarian diet. However, vegans and some other vegetarians may have lower intakes of vitamin B-12, calcium, vitamin D, zinc, and long-chain n-3 fatty acids.

Recently, outbreaks of food-borne illness associated with the consumption of domestically grown and imported fresh fruits, sprouts, and vegetables that have been contaminated by *Salmonella*, *Escherichia coli*, and other micro-organisms have been seen. Health advocacy groups are calling for stricter inspection and reporting procedures and better food-handling practices.

NUTRITION CONSIDERATIONS FOR VEGETARIANS

Protein

Plant protein can meet protein requirements when a variety of plant foods is consumed and energy needs

are met. Research indicates that an assortment of plant foods eaten over the course of a day can provide all essential amino acids and ensure adequate nitrogen retention and use in healthy adults; thus, complementary proteins do not need to be consumed at the same meal (8).

A meta-analysis of nitrogen balance studies found no significant difference in protein needs due to the source of dietary protein (9). Based on the protein digestibility-corrected amino acid score, which is the standard method for determining protein quality, other studies have found that although isolated soy protein can meet protein needs as effectively as animal protein, wheat protein eaten alone, for example, may result in a reduced efficiency of nitrogen utilization (10). Thus, estimates of protein requirements of vegans may vary, depending to some degree on dietary choices. Food and nutrition professionals should be aware that protein needs might be somewhat higher than the Recommended Dietary Allowance in those vegetarians whose dietary protein sources are mainly those that are less well digested, such as some cereals and legumes (11).

Cereals tend to be low in lysine, an essential amino acid (8). This may be relevant when evaluating diets of individuals who do not consume animal protein sources and when diets are relatively low in protein. Dietary adjustments such as the use of more beans and soy products in place of other protein sources that are lower in lysine or an increase in dietary protein from all sources can ensure an adequate intake of lysine.

Although some vegan women have protein intakes that are marginal, typical protein intakes of lacto-ovo-vegetarians and of vegans appear to meet and exceed requirements (12). Athletes can also meet their protein needs on plant-based diets (13).

n-3 Fatty Acids

Whereas vegetarian diets are generally rich in n-6 fatty acids, they may be marginal in n-3 fatty acids. Diets that do not include fish, eggs, or generous amounts of algae generally are low in eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), fatty acids important for cardiovascular health as well as eye and brain

development. The bioconversion of α -linolenic acid (ALA), a plant-based n-3 fatty acid, to EPA is generally less than 10% in humans; conversion of ALA to DHA is substantially less (14). Vegetarians, and particularly vegans, tend to have lower blood levels of EPA and DHA than nonvegetarians (15). DHA supplements derived from microalgae are well absorbed and positively influence blood levels of DHA, and also EPA through retroconversion (16). Soy milk and breakfast bars, fortified with DHA, are now available in the marketplace.

The Dietary Reference Intakes recommend intakes of 1.6 and 1.1 g ALA per day, for men and women, respectively (17). These recommendations may not be optimal for vegetarians who consume little if any DHA and EPA (17) and thus may need additional ALA for conversion to DHA and EPA. Conversion rates for ALA tend to improve when dietary n-6 levels are not high or excessive (14). Vegetarians should include good sources of ALA in their diet, such as flaxseed, walnuts, canola oil, and soy. Those with increased requirements of n-3 fatty acids, such as pregnant and lactating women, may benefit from DHA-rich microalgae (18).

Iron

The iron in plant foods is nonheme iron, which is sensitive to both inhibitors and enhancers of iron absorption. Inhibitors of iron absorption include phytates, calcium, and the polyphenolics in tea, coffee, herb teas, and cocoa. Fiber only slightly inhibits iron absorption (19). Some food preparation techniques such as soaking and sprouting beans, grains, and seeds, and the leavening of bread, can diminish phytate levels (20) and thereby enhance iron absorption (21,22). Other fermentation processes, such as those used to make miso and tempeh, may also improve iron bioavailability (23).

Vitamin C and other organic acids found in fruits and vegetables can substantially enhance iron absorption and reduce the inhibitory effects of phytate and thereby improve iron status (24,25). Because of lower bioavailability of iron from a vegetarian diet, the recommended iron intakes for vegetarians are 1.8 times those of nonvegetarians (26).

Whereas many studies of iron ab-

sorption have been short term, there is evidence that adaptation to low intakes takes place over the long term, and involves both increased absorption and decreased losses (27,28). Incidence of iron-deficiency anemia among vegetarians is similar to that of nonvegetarians (12,29). Although vegetarian adults have lower iron stores than nonvegetarians, their serum ferritin levels are usually within the normal range (29,30).

Zinc

The bioavailability of zinc from vegetarian diets is lower than from nonvegetarian diets, mainly due to the higher phytic acid content of vegetarian diets (31). Thus, zinc requirements for some vegetarians whose diets consist mainly of phytate-rich unrefined grains and legumes may exceed the Recommended Dietary Allowance (26). Zinc intakes of vegetarians vary with some research showing zinc intakes near recommendations (32) and other research finding zinc intakes of vegetarians significantly below recommendations (29,33). Overt zinc deficiency is not evident in Western vegetarians. Due to the difficulty in evaluating marginal zinc status, it is not possible to determine the possible effect of lower zinc absorption from vegetarian diets (31). Zinc sources include soy products, legumes, grains, cheese, and nuts. Food preparation techniques, such as soaking and sprouting beans, grains, and seeds as well as leavening bread, can reduce binding of zinc by phytic acid and increase zinc bioavailability (34). Organic acids, such as citric acid, can also enhance zinc absorption to some extent (34).

Iodine

Some studies suggest that vegans who do not consume key sources of iodine, such as iodized salt or sea vegetables, may be at risk for iodine deficiency, because plant-based diets are typically low in iodine (12,35). Sea salt and kosher salt are generally not iodized nor are salty seasonings such as tamari. Iodine intake from sea vegetables should be monitored because the iodine content of sea vegetables varies widely and some contain substantial amounts of iodine (36).

Foods such as soybeans, cruciferous vegetables, and sweet potatoes con-

tain natural goitrogens. These foods have not been associated with thyroid insufficiency in healthy people provided iodine intake is adequate (37).

Calcium

Calcium intakes of lacto-ovo-vegetarians are similar to, or higher than, those of nonvegetarians (12), whereas intakes of vegans tend to be lower than both groups and may fall below recommended intakes (12). In the Oxford component of the European Prospective Investigation into Cancer and Nutrition (EPIC-Oxford) study, the risk of bone fracture was similar for lacto-ovo-vegetarians and meat eaters, whereas vegans had a 30% higher risk of fracture possibly due to their considerably lower mean calcium intake (38). Diets rich in meat, fish, dairy products, nuts, and grains produce a high renal acid load, mainly due to sulfate and phosphate residues. Calcium resorption from bone helps to buffer this acid load, resulting in increased urinary losses of calcium. A high sodium intake can also promote urinary calcium losses. On the other hand, fruits and vegetables rich in potassium and magnesium produce a high renal alkaline load which slows bone calcium resorption, and decreases calcium losses in the urine. In addition, some studies show that the ratio of dietary calcium to protein is a better predictor of bone health than calcium intake alone. Typically, this ratio is high in lacto-ovo-vegetarian diets and favors bone health, whereas vegans have a ratio of calcium to protein that is similar to or lower than that of nonvegetarians (39). Many vegans may find it is easier to meet their calcium needs if calcium-fortified foods or dietary supplements are utilized (39).

Low-oxalate greens (eg, bok choy, broccoli, Chinese cabbage, collards, and kale) and fruit juices fortified with calcium citrate malate are good sources of highly bioavailable calcium (50% to 60% and 40% to 50%, respectively), while calcium-set tofu, and cow's milk have good bioavailability of calcium (about 30% to 35%), and sesame seeds, almonds, and dried beans have a lower bioavailability (21% to 27%) (39). The bioavailability of calcium from soy milk fortified with calcium carbonate is equivalent to cow's milk although limited research

has shown that calcium availability is substantially less when tricalcium phosphate is used to fortify the soy beverage (40). Fortified foods such as fruit juices, soy milk, and rice milk, and breakfast cereals can contribute significant amounts of dietary calcium for the vegan (41). Oxalates in some foods, such as spinach and Swiss chard, greatly reduce calcium absorption, making these vegetables a poor source of usable calcium. Foods rich in phytate may also inhibit calcium absorption

Vitamin D

Vitamin D has long been known to play a role in bone health. Vitamin D status depends on sunlight exposure and intake of vitamin D-fortified foods or supplements. The extent of cutaneous vitamin D production following sunlight exposure is highly variable and is dependent on a number of factors, including the time of day, season, latitude, skin pigmentation, sunscreen use, and age. Low vitamin D intakes (42), low serum 25-hydroxyvitamin D levels (12), and reduced bone mass (43) have been reported in some vegan and macrobiotic groups who did not use vitamin D supplements or fortified foods.

Foods that are fortified with vitamin D include cow's milk, some brands of soy milk, rice milk, and orange juice, and some breakfast cereals and margarines. Both vitamin D-2 and vitamin D-3 are used in supplements and to fortify foods. Vitamin D-3 (cholecalciferol) is of animal origin and is obtained through the ultraviolet irradiation of 7-dehydrocholesterol from lanolin. Vitamin D-2 (ergocalciferol) is produced from the ultraviolet irradiation of ergosterol from yeast and is acceptable to vegans. Although some research suggests that vitamin D-2 is less effective than vitamin D-3 in maintaining serum 25-hydroxyvitamin D levels (44) other studies find that vitamin D-2 and vitamin D-3 are equally effective (45). If sun exposure and intake of fortified foods are insufficient to meet needs, vitamin D supplements are recommended.

Vitamin B-12

The vitamin B-12 status of some vegetarians is less than adequate due to

not regularly consuming reliable sources of vitamin B-12 (12,46,47). Lacto-ovo-vegetarians can obtain adequate vitamin B-12 from dairy foods, eggs, or other reliable vitamin B-12 sources (fortified foods and supplements), if regularly consumed. For vegans, vitamin B-12 must be obtained from regular use of vitamin B-12-fortified foods, such as fortified soy and rice beverages, some breakfast cereals and meat analogs, or Red Star Vegetarian Support Formula nutritional yeast; otherwise a daily vitamin B-12 supplement is needed. No unfortified plant food contains any significant amount of active vitamin B-12. Fermented soy products cannot be considered a reliable source of active B-12 (12,46).

Vegetarian diets are typically rich in folacin, which may mask the hematological symptoms of vitamin B-12 deficiency, so that vitamin B-12 deficiency may go undetected until after neurological signs and symptoms may be manifest (47). Vitamin B-12 status is best determined by measuring serum levels of homocysteine, methylmalonic acid, or holotranscobalamin II (48).

VEGETARIAN DIETS THROUGHOUT THE LIFE CYCLE

Well-planned vegan, lacto-vegetarian, and lacto-ovo-vegetarian diets are appropriate for all stages of the life cycle, including pregnancy and lactation. Appropriately planned vegan, lacto-vegetarian, and lacto-ovo-vegetarian diets satisfy nutrient needs of infants, children, and adolescents and promote normal growth (49-51). Figure 1 provides specific suggestions for meal planning for vegetarian diets. Lifelong vegetarians have adult height, weight, and BMIs that are similar to those who became vegetarian later in life, suggesting that well-planned vegetarian diets in infancy and childhood do not affect final adult height or weight (53). Vegetarian diets in childhood and adolescence can aid in the establishment of lifelong healthful eating patterns and can offer some important nutritional advantages. Vegetarian children and adolescents have lower intakes of cholesterol, saturated fat, and total fat and higher intakes of fruits, vegetables, and fiber than nonvegetarians (54,55). Vegetarian children have also been re-

A variety of menu planning approaches can provide adequate nutrition for vegetarians. The Dietary Reference Intakes are a valuable resource for food and nutrition professionals. Various food guides (41,52) can be used when working with vegetarian clients. In addition, the following guidelines can help vegetarians plan healthful diets:

- Choose a variety of foods, including whole grains, vegetables, fruits, legumes, nuts, seeds, and, if desired, dairy products, and eggs.
- Minimize intake of foods that are highly sweetened, high in sodium, and high in fat, especially saturated fat and *trans*-fatty acids.
- Choose a variety of fruits and vegetables.
- If animal foods such as dairy products and eggs are used, choose lower-fat dairy products and use both eggs and dairy products in moderation.
- Use a regular source of vitamin B-12 and, if sunlight exposure is limited, of vitamin D.

Figure 1. Suggestions for planning vegetarian meals.

ported to be leaner and to have lower serum cholesterol levels (50,56).

Pregnant and Lactating Women

The nutrient and energy needs of pregnant and lactating vegetarian women do not differ from those of nonvegetarian women with the exception of higher iron recommendations for vegetarians. Vegetarian diets can be planned to meet the nutrient needs of pregnant and lactating women. Evidence-based analysis of the research literature was used to evaluate existing research on vegetarian pregnancy (57). Seven questions for evidence-analysis were identified:

- How do macronutrient and energy intake in pregnant vegetarians differ from intakes in pregnant omnivores?
- Are birth outcomes different for mothers who maintain a vegetarian vs an omnivorous diet during pregnancy?
- How do macronutrient and energy intake in pregnant vegans differ from intakes in pregnant omnivores?
- Are birth outcomes different for mothers who maintain a vegan vs an omnivorous diet during pregnancy?
- What are patterns of micronutrient intake among pregnant vegetarians?
- What is the bioavailability of different micronutrients in pregnant vegetarians?
- What are birth outcomes associated with the micronutrient intake of maternal vegetarian diets?

The complete results of this evidence-based analysis can be found on the EAL Web site (www.adaevidencelibrary.com) and are summarized below.

Macronutrient and Energy Intake. Four primary research studies were identified that examined maternal macronutrient intake during lacto-ovo- or lacto-vegetarian pregnancy (58-61). None focused on pregnant vegans.

EAL Conclusion Statement: Limited research on non-US populations indicates that the macronutrient intake of pregnant vegetarians is similar to that of nonvegetarians with the following exceptions (as percentages of energy intake):

- pregnant vegetarians receive statistically lower levels of protein than pregnant nonvegetarians; and
- pregnant vegetarians receive statistically higher levels of carbohydrates than pregnant nonvegetarians.

It is important to note, however, that none of the studies report a clinically significant difference in macronutrient intake. In other words, none of the studies report a protein deficiency in pregnant vegetarians. **Grade III=Limited.**

EAL Conclusion Statement: No research was identified that focused on macronutrient intakes among pregnant vegans. **Grade V=Not Assignable.**

Birth Outcomes. Four cohort studies were identified that examined the relationship between maternal macronutrient intake during pregnancy and birth outcomes such as birth weight and length (59-62). None of the studies focused on pregnant vegans.

EAL Conclusion Statement: Limited research on non-US populations indicates that there are no significant health differences in babies born to nonvegan vegetarian mothers vs non-vegetarians. **Grade III=Limited.**

EAL Conclusion Statement: No research was identified that focused on the birth outcomes of vegan vs omnivorous mothers. **Grade V=Not Assignable.**

Micronutrient Intake. Based on 10 studies (58-60,63-69), two of which were conducted in the United States (64,65), only the following micronutrients had lower intake among vegetarians than nonvegetarians:

- vitamin B-12;
- vitamin C;
- calcium; and
- zinc.

Vegetarians did not meet dietary standard (in at least one country) for:

- vitamin B-12 (in the United Kingdom);
- iron (in the United States, for both vegetarians and omnivores);
- folate (in Germany, though lower rate of deficiency than among omnivores); and
- zinc (in the United Kingdom).

EAL Conclusion Statement: Grade III=Limited.

Micronutrient Bioavailability. Six studies (five non-US, one with combined US and non-US samples; all but one of positive quality) were identified that examined the bioavailability of different micronutrients in vegetarian vs non-vegetarian pregnant women (58,63,64,66,67,69). Of the micronutrients examined in the research, only serum B-12 levels were significantly lower in non-vegan-vegetarians than nonvegetarians. In addition, one study reported that lower B-12 levels are more likely to be associated with high serum total homocysteine in lacto-ovo-vegetarians than low meat eaters or omnivores. Whereas zinc levels were not significantly different between nonvegan-vegetarians and nonvegetarians, vegetarians who have a high intake of calcium may be at risk for zinc deficiency (because of the interaction between phytate, calcium, and zinc). Based on limited evidence, plasma folate levels may actually be higher among some vegetarian groups than nonvegetarians.

EAL Conclusion Statement: Grade III=Limited.

Micronutrients and Birth Outcome EAL Conclusion Statement: Limited evidence from seven studies (all outside the

United States) indicated that the micronutrient content of a balanced maternal vegetarian diet does not have detrimental outcomes for the health of the child at birth (58-63,69). There may be, however, a risk for a false positive diagnosis of Down syndrome in the fetus when maternal serum free beta-human chorionic gonadotropin and alpha fetoprotein levels are used as markers in vegetarian mothers. **Grade III=Limited.**

Nutrition Considerations. Results of evidence-based analysis suggest that vegetarian diets can be nutritionally adequate in pregnancy and can lead to a positive birth outcome (57).

Key nutrients in pregnancy include vitamin B-12, vitamin D, iron, and folate whereas key nutrients in lactation include vitamin B-12, vitamin D, calcium, and zinc. Diets of pregnant and lactating vegetarians should contain reliable sources of vitamin B-12 daily. Based on recommendations for pregnancy and lactation, if there is concern about vitamin D synthesis because of limited sunlight exposure, skin tone, season, or sunscreen use, pregnant and lactating women should use vitamin D supplements or vitamin D-fortified foods. No studies included in the evidence-analysis examined vitamin D status during vegetarian pregnancy. Iron supplements may be needed to prevent or treat iron-deficiency anemia, which is common in pregnancy. Women capable of becoming pregnant as well as women in the periconceptional period are advised to consume 400 μg folate daily from supplements, fortified foods, or both. Zinc and calcium needs can be met through food or supplement sources as identified in earlier sections on these nutrients.

DHA also plays a role in pregnancy and lactation. Infants of vegetarian mothers appear to have lower cord and plasma DHA than do infants of nonvegetarians (70). Breast milk DHA is lower in vegans and lacto-ovo-vegetarians than in nonvegetarians (71). Because of DHA's beneficial effects on gestational length, infant visual function, and neurodevelopment, pregnant and lactating vegetarians and vegans should choose food sources of DHA (fortified foods or eggs from hens fed DHA-rich microalgae) or use a microalgae-derived DHA supplement (72,73). Supplementation

with ALA, a DHA precursor, in pregnancy and lactation has not been shown to be effective in increasing infant DHA levels or breast milk DHA concentration (74,75).

Infants

Growth of young vegetarian infants receiving adequate amounts of breast milk or commercial infant formula is normal. When solid foods are introduced, provision of good sources of energy and nutrients can ensure normal growth. The safety of extremely restrictive diets such as fruitarian and raw foods diets has not been studied in children. These diets can be very low in energy, protein, some vitamins, and some minerals and cannot be recommended for infants and children.

Breastfeeding is common in vegetarian women, and this practice should be supported. The breast milk of vegetarian women is similar in composition to that of nonvegetarians and is nutritionally adequate. Commercial infant formulas should be used if infants are not breastfed or are weaned before 1 year of age. Soy formula is the only option for non-breastfed vegan infants. Other preparations including soymilk, rice milk, and homemade formulas should not be used to replace breast milk or commercial infant formula.

Solid foods should be introduced in the same progression as for nonvegetarian infants, replacing strained meat with mashed or pureed tofu, legumes (pureed and strained if necessary), soy or dairy yogurt, cooked egg yolk, and cottage cheese. Later, around 7 to 10 months, foods such as cubed tofu, cheese, or soy cheese and bite-size pieces of veggie burgers can be started. Commercial, full-fat, fortified soy milk or pasteurized cow's milk can be used as a primary beverage starting at age 1 year or older for a child who is growing normally and eating a variety of foods (51). Foods that are rich in energy and nutrients such as legume spreads, tofu, and mashed avocado should be used when the infant is being weaned. Dietary fat should not be restricted in children younger than 2 years.

Guidelines for dietary supplements generally follow those for nonvegetarian infants. Breastfed infants whose mothers do not have an adequate in-

take of vitamin B-12 should receive a vitamin B-12 supplement (51). Zinc intake should be assessed and zinc supplements or zinc-fortified foods used when complementary foods are introduced if the diet is low in zinc or mainly consists of foods with low zinc bioavailability (76).

Children

Growth of lacto-ovo-vegetarian children is similar to that of their nonvegetarian peers (50). Little information about the growth of nonmacrobiotic vegan children has been published. Some studies suggest that vegan children tend to be slightly smaller but within the normal ranges of the standards for weight and height (58). Poor growth in children has primarily been seen in those on very restricted diets (77).

Frequent meals and snacks and the use of some refined foods (such as fortified breakfast cereals, breads, and pasta) and foods higher in unsaturated fats can help vegetarian children meet energy and nutrient needs. Average protein intakes of vegetarian children (lacto-ovo, vegan, and macrobiotic) generally meet or exceed recommendations (12). Vegan children may have slightly higher protein needs because of differences in protein digestibility and amino acid composition (49,78) but these protein needs are generally met when diets contain adequate energy and a variety of plant foods.

Food guides for vegetarian children have been published elsewhere (12).

Adolescents

Growth of lacto-ovo-vegetarian and nonvegetarian adolescents is similar (50). Earlier studies suggest that vegetarian girls reach menarche slightly later than nonvegetarians (79); more recent studies find no difference in age at menarche (53,80).

Vegetarian diets appear to offer some nutritional advantages for adolescents. Vegetarian adolescents are reported to consume more fiber, iron, folate, vitamin A, and vitamin C than nonvegetarians (54,81). Vegetarian adolescents also consume more fruits and vegetables, and fewer sweets, fast foods, and salty snacks compared to nonvegetarian adolescents (54,55). Key nutrients of concern for adoles-

cent vegetarians include calcium, vitamin D, iron, zinc, and vitamin B-12.

Being vegetarian does not cause disordered eating as some have suggested although a vegetarian diet may be selected to camouflage an existing eating disorder (82). Because of this, vegetarian diets are somewhat more common among adolescents with eating disorders than in the general adolescent population (83). Food and nutrition professionals should be aware of young clients who greatly limit food choices and who exhibit symptoms of eating disorders.

With guidance in meal planning, vegetarian diets can be appropriate and healthful choices for adolescents.

Older Adults

With aging, energy needs decrease but recommendations for several nutrients, including calcium, vitamin D, and vitamin B-6 are higher. Intakes of micronutrients, especially calcium, zinc, iron, and vitamin B-12, decline in older adults (84). Studies indicate that older vegetarians have dietary intakes that are similar to nonvegetarians (85,86).

Older adults may have difficulty with vitamin B-12 absorption from food, frequently due to atrophic gastritis, so vitamin B-12-fortified foods or supplements should be used because the vitamin B-12 in fortified foods and supplements is usually well-absorbed (87). Cutaneous vitamin D production decreases with aging so that dietary or supplemental sources of vitamin D are especially important (88). Although current recommendations for protein for healthy older adults are the same as those for younger adults on a body weight basis (17), this is a controversial area (89). Certainly older adults who have low energy requirements will need to consume concentrated sources of protein. Older adults can meet protein needs on a vegetarian diet if a variety of protein-rich plant foods, including legumes and soy products, are eaten daily.

Athletes

Vegetarian diets can also meet the needs of competitive athletes. Nutrition recommendations for vegetarian athletes should be formulated with consideration of the effects of both vegetar-

ian diets and exercise. The position of American Dietetic Association and Dietitians of Canada on nutrition and athletic performance provides additional information specific to vegetarian athletes (90). Research is needed on the relation between vegetarian diet and performance. Vegetarian diets that meet energy needs and contain a variety of plant-based protein foods, such as soy products, other legumes, grains, nuts, and seeds, can provide adequate protein without the use of special foods or supplements (91). Vegetarian athletes may have lower muscle creatine concentration due to low dietary creatine levels (92,93). Vegetarian athletes participating in short-term, high-intensity exercise and resistance training may benefit from creatine supplementation (91). Some, but not all research suggests that amenorrhea may be more common among vegetarian than nonvegetarian athletes (94,95). Female vegetarian athletes may benefit from diets that include adequate energy, higher levels of fat, and generous amounts of calcium and iron.

VEGETARIAN DIETS AND CHRONIC DISEASE

Cardiovascular Disease (CVD)

Evidence-based analysis of the research literature is being used to evaluate existing research on the relationship between vegetarian dietary patterns and CVD risk factors (96). Two evidence analysis questions have been completed:

- What is the relationship between a vegetarian diet and ischemic heart disease?
- How is micronutrient intake in a vegetarian diet associated with CVD risk factors?

Ischemic Heart Disease. Two large cohort studies (97,98) and one meta-analysis (99) found that vegetarians were at lower risk of death from ischemic heart disease than nonvegetarians. The lower risk of death was seen in both lacto-ovo-vegetarians and vegans (99). The difference in risk persisted after adjustment for BMI, smoking habits, and social class (97). This is especially significant because the lower BMI commonly seen in vegetarians (99) is one factor that may help to explain the lower risk of heart disease in vegetarians. If this differ-

ence in risk persists even after adjustment for BMI, other aspects of a vegetarian diet may be responsible for the risk reduction, above and beyond that which would be expected due to lower BMI.

EAL Conclusion Statement: A vegetarian diet is associated with a lower risk of death from ischemic heart disease. **Grade I=Good.**

Blood Lipid Levels. The lower risk of death from ischemic heart disease seen in vegetarians could be explained in part by differences in blood lipid levels. Based on blood lipid levels in one large cohort study, the incidence of ischemic heart disease was estimated to be 24% lower in lifelong vegetarians and 57% lower in lifelong vegans compared to meat eaters (97). Typically, studies find lower total cholesterol and low-density lipoprotein (LDL) cholesterol levels in vegetarians (100, for example). Intervention studies have demonstrated a reduction in total and LDL-cholesterol levels when subjects switched from their usual diet to a vegetarian diet (101, for example). Although evidence is limited that a vegetarian diet is associated with higher high-density lipoprotein cholesterol levels or with higher or lower triglyceride levels, a vegetarian diet is consistently associated with lower LDL cholesterol levels. Other factors such as variations in BMI and foods eaten or avoided within the context of a vegetarian diet or lifestyle differences could partially explain the inconsistent results with regard to blood lipid levels.

Factors in a vegetarian diet that could have a beneficial effect on blood lipid levels include the higher amounts of fiber, nuts, soy, and plant sterols and lower levels of saturated fat. Vegetarians consume between 50% and 100% more fiber than nonvegetarians and vegans have higher intakes than lacto-ovo-vegetarians (12). Soluble fiber has been repeatedly shown to lower total and LDL cholesterol levels and to reduce risk of coronary heart disease (17). A diet high in nuts significantly lowers total and LDL cholesterol levels (102). Soy isoflavones may play a role in reducing LDL cholesterol levels and in reducing the susceptibility of LDL to oxidation (103). Plant sterols, found in legumes, nuts and seeds, whole grains, vegetable oils, and other plant-based

foods reduce cholesterol absorption and lower LDL cholesterol levels (104).

Factors Associated with Vegetarian Diets that May Affect Risk of CVD. Other factors in vegetarian diets may impact CVD risk independent of effects on cholesterol levels. Foods that feature prominently in a vegetarian diet that may offer protection from CVD include soy protein (105), fruits and vegetables, whole grains, and nuts (106,107). Vegetarians appear to consume more phytochemicals than do nonvegetarians because a greater percentage of their energy intake comes from plant foods. Flavonoids and other phytochemicals appear to have protective effects as antioxidants, in reducing platelet aggregation and blood clotting, as anti-inflammatory agents, and in improving endothelial function (108,109). Lacto-ovo-vegetarians have been shown to have significantly better vasodilation responses, suggesting a beneficial effect of vegetarian diet on vascular endothelial function (110).

Evidence analysis was conducted to examine how the micronutrient makeup of vegetarian diets might be related to CVD risk factors.

EAL Conclusion Statement: No research meeting inclusion criteria were identified that examined the micronutrient intake of a vegetarian diet and CVD risk factors. **Grade V=Not Assignable.**

Not all aspects of vegetarian diets are associated with reduced risk for heart disease. The higher serum homocysteine levels that have been reported in some vegetarians, apparently due to inadequate vitamin B-12 intake, may increase risk of CVD (111,112) although not all studies support this (113).

Vegetarian diets have been successfully used in treatment of CVD. A regimen that used a very low-fat ($\leq 10\%$ of energy) near vegan (limited nonfat dairy and egg whites allowed) diet along with exercise, smoking cessation, and stress management, was shown to reduce blood lipid levels, blood pressure, and weight, and improve exercise capacity (114). A near-vegan diet high in phytosterols, viscous fiber, nuts, and soy protein has been shown to be as effective as a low-saturated fat diet and a statin for lowering serum LDL-cholesterol levels (115).

Hypertension

A cross-sectional study and a cohort study found that there was a lower rate of hypertension among vegetarians than nonvegetarians (97,98). Similar findings were reported in Seventh-day Adventists (Adventists) in Barbados (116) and in preliminary results from the Adventist Health Study-2 cohort (117). Vegans appear to have a lower rate of hypertension than do other vegetarians (97,117).

Several studies have reported lower blood pressure in vegetarians compared to nonvegetarians (97,118) although other studies reported little difference in blood pressure between vegetarians and nonvegetarians (100,119,120). At least one of the studies reporting lower blood pressure in vegetarians found that BMI rather than diet accounted for much of the age-adjusted variation in blood pressure (97). Vegetarians tend to have a lower BMI than nonvegetarians (99); thus, vegetarian diets' influence on BMI may partially account for reported differences in blood pressure between vegetarians and nonvegetarians. Variations in dietary intake and lifestyle within groups of vegetarians may limit the strength of conclusions with regard to the relationship between vegetarian diets and blood pressure.

Possible factors in vegetarian diets that could result in lower blood pressure include the collective effect of various beneficial compounds found in plant foods such as potassium, magnesium, antioxidants, dietary fat, and fiber (118,121). Results from the Dietary Approaches to Stop Hypertension study, in which subjects consumed a low-fat diet rich in fruits, vegetables and dairy, suggest that substantial dietary levels of potassium, magnesium, and calcium play an important role in reducing blood pressure levels (122). Fruit and vegetable intake was responsible for about one-half of the blood pressure reduction of the Dietary Approaches to Stop Hypertension diet (123). In addition, nine studies report that consumption of five to 10 servings of fruit and vegetables significantly lowers blood pressure (124).

Diabetes

Adventist vegetarians are reported to have lower rates of diabetes than Ad-

ventist nonvegetarians (125). In the Adventist Health Study, age-adjusted risk for developing diabetes was two-fold greater in nonvegetarians, compared with their vegetarian counterparts (98). Although obesity increases the risk of type 2 diabetes, meat and processed meat intake was found to be an important risk factor for diabetes even after adjustment for BMI (126). In the Women's Health Study, the authors also observed positive associations between intakes of red meat and processed meat and risk of diabetes after adjusting for BMI, total energy intake, and exercise (127). A significantly increased risk of diabetes was most pronounced for frequent consumption of processed meats such as bacon and hot dogs. Results remained significant even after further adjustment for dietary fiber, magnesium, fat, and glycemic load (128). In a large cohort study, the relative risk for type 2 diabetes in women for every one-serving increase in intake was 1.26 for red meat and 1.38 to 1.73 for processed meats (128).

In addition, higher intakes of vegetables, whole-grain foods, legumes, and nuts have all been associated with a substantially lower risk of insulin resistance and type 2 diabetes, and improved glycemic control in either normal or insulin-resistant individuals (129-132). Observational studies have found that diets rich in whole-grain foods are associated with improved insulin sensitivity. This effect may be partly mediated by significant levels of magnesium and cereal fiber in the whole-grain foods (133). Persons with elevated blood glucose may experience an improvement in insulin resistance and lower fasting blood glucose levels after they have consumed whole grains (134). People consuming about three servings per day of whole-grain foods are 20% to 30% less likely to develop type 2 diabetes than low consumers (< 3 servings per week) (135).

In the Nurses' Health Study, nut consumption was inversely associated with risk of type 2 diabetes after adjustment for BMI, physical activity, and many other factors. The risk of diabetes for those consuming nuts five or more times a week was 27% lower than those almost never eating nuts, whereas the risk of diabetes for those consuming peanut butter at least five times a week (equivalent to

5 oz peanuts/week) was 21% lower than those who almost never ate peanut butter (129).

Because legumes contain slowly digested carbohydrate and have a high fiber content, they are expected to improve glycemic control and reduce incident diabetes. In a large prospective study, an inverse association was seen between the intake of total legumes, peanuts, soybeans, and other legumes by Chinese women, and the incidence of type 2 diabetes mellitus, after adjustment for BMI and other factors. The risk of type 2 diabetes was 38% and 47% lower, for those consuming a high intake of total legumes and soybeans, respectively, compared to a low intake (132).

In a prospective study, the risk of type 2 diabetes was 28% lower for women in the upper quintile of vegetable, but not fruit intake, compared to the lower quintile of vegetable intake. Individual vegetable groups were all inversely and significantly associated with the risk of type 2 diabetes (131). In another study, consumption of green leafy vegetables and fruit, but not fruit juice, was associated with a lower risk of diabetes (136).

Fiber-rich vegan diets are characterized by a low glycemic index and a low to moderate glycemic load (137). In a 5-month randomized clinical trial, a low-fat vegan diet was shown to considerably improve glycemic control in persons with type 2 diabetes, with 43% of subjects reducing diabetes medication (138). Results were superior to those obtained from following a diet based on American Diabetes Association guidelines (individualized based on body weight and lipid concentrations; 15%-20% protein; <7% saturated fat; 60% to 70% carbohydrate and monounsaturated fat; \leq 200 mg cholesterol).

Obesity

Among Adventists, about 30% of whom follow a meatless diet, vegetarian eating patterns have been associated with lower BMI, and BMI increased as the frequency of meat consumption increased in both men and women (98). In the Oxford Vegetarian Study, BMI values were higher in nonvegetarians compared with vegetarians in all age groups for both men and women (139). In a cross-sectional

study of 37,875 adults, meat-eaters had the highest age-adjusted mean BMI and vegans the lowest, with other vegetarians having intermediate values (140). In the EPIC-Oxford Study, weight gain over a 5-year period, among a health-conscious cohort, was lowest among those who moved to a diet containing fewer animal foods (141). In a large cross-sectional British study, it was observed that those people who became vegetarian as adults did not differ in BMI or body weight compared to those who were life-long vegetarians (53). However, those who have been following a vegetarian diet for at least 5 years typically have a lower BMI. Among Adventists in Barbados, the number of obese vegetarians, who had followed the diet for more than 5 years, was 70% less than the number of obese omnivores whereas recent vegetarians (following the diet <5 years) had body weights similar to omnivores (116). A low-fat vegetarian diet has been shown to be more effective in long-term weight loss for postmenopausal women than a more conventional National Cholesterol Education Program diet (142). Vegetarians may have a lower BMI due to their higher consumption of fiber-rich, low-energy foods, such as fruit and vegetables.

Cancer

Vegetarians tend to have an overall cancer rate lower than that of the general population, and this is not confined to smoking-related cancers. Data from the Adventist Health Study revealed that nonvegetarians had a substantially increased risk for both colorectal and prostate cancer compared with vegetarians, but there were no significant differences in risk of lung, breast, uterine, or stomach cancer between the groups after controlling for age, sex, and smoking (98). Obesity is a significant factor increasing the risk of cancer at a number of sites (143). Because the BMI of vegetarians tends to be lower than that of nonvegetarians, the lighter body weight of the vegetarians may be an important factor.

A vegetarian diet provides a variety of cancer-protective dietary factors (144). Epidemiologic studies have consistently shown that a regular consumption of fruit and vegetables is

strongly associated with a reduced risk of some cancers (108,145,146). In contrast, among survivors of early stage breast cancer in the Women's Healthy Eating and Living trial, the adoption of a diet enhanced by additional daily fruit and vegetable servings did not reduce additional breast cancer events or mortality over a 7-year period (147).

Fruit and vegetables contain a complex mixture of phytochemicals, possessing potent antioxidant, antiproliferative, and cancer-protective activity. The phytochemicals can display additive and synergistic effects, and are best consumed in whole foods (148-150). These phytochemicals interfere with several cellular processes involved in the progression of cancer. These mechanisms include the inhibition of cell proliferation, inhibition of DNA adduct formation, inhibition of phase 1 enzymes, inhibition of signal transduction pathways and oncogene expression, induction of cell cycle arrest and apoptosis, induction of phase 2 enzymes, blocking the activation of nuclear factor-kappaB, and inhibiting angiogenesis (149).

According to the recent World Cancer Research Fund report (143), fruit and vegetables are protective against cancer of the lung, mouth, esophagus, and stomach, and to a lesser degree some other sites. The regular use of legumes also provides a measure of protection against stomach and prostate cancer (143). Fiber, vitamin C, carotenoids, flavonoids, and other phytochemicals in the diet are reported to exhibit protection against various cancers. Allium vegetables may protect against stomach cancer and garlic protects against colorectal cancer. Fruits rich in the red pigment lycopene are reported to protect against prostate cancer (143). Recently, cohort studies have suggested that a high intake of whole grains provided substantial protection against various cancers (151). Regular physical activity provides significant protection against most of the major cancers (143).

Although there is such a variety of potent phytochemicals in fruit and vegetables, human population studies have not shown large differences in cancer incidence or mortality rates between vegetarians and nonvegetarians (99,152). Perhaps more detailed food consumption data are needed because the bioavailability and potency

of phytochemicals depends on food preparation, such as whether the vegetables are cooked or raw. In the case of prostate cancer, a high dairy intake may lessen the chemoprotective effect of a vegetarian diet. Use of dairy and other calcium-rich foods have been associated with an increased risk of prostate cancer (143,153,154), although not all studies support this finding (155).

Red meat and processed meat consumption is consistently associated with an increase in the risk of colorectal cancer (143). On the other hand, the intake of legumes was negatively associated with risk of colon cancer in nonvegetarians (98). In a pooled analysis of 14 cohort studies, the adjusted risk of colon cancer was substantially reduced by a high intake of fruit and vegetable vs a low intake. Fruit and vegetable intakes were associated with a lower risk of distal colon cancer, but not with proximal colon cancer (156). Vegetarians have a substantially greater intake of fiber than nonvegetarians. A high fiber intake is thought to protect against colon cancer, although not all research supports this. The EPIC study involving 10 European countries reported a 25% reduction in risk of colorectal cancer in the highest quartile of dietary fiber intake compared to the lowest. Based upon these findings, Bingham and colleagues (157) concluded that in populations with a low fiber intake, doubling the fiber intake could reduce the colorectal cancer by 40%. On the other hand, a pooled analysis of 13 prospective cohort studies reported a high dietary fiber intake was not associated with a decreased risk of colorectal cancer after accounting for multiple risk factors (158).

Soy isoflavones and soy foods have been shown to possess anti-cancer properties. Meta-analysis of eight studies (one cohort, and seven case control) conducted in high-soy-consuming Asians showed a significant trend of decreasing risk of breast cancer with increasing soy food intake. In contrast, soy intake was unrelated to breast cancer risk in studies conducted in 11 low-soy-consuming Western populations (159). However, controversy remains regarding the value of soy as a cancer-protective agent, because not all research supports the protective value of soy to

wards breast cancer (160). On the other hand, meat consumption has been linked in some, but not all, studies with an increased risk of breast cancer (161). In one study, breast cancer risk increased by 50% to 60% for each additional 100 g/day of meat consumed (162).

Osteoporosis

Dairy products, green leafy vegetables, and calcium-fortified plant foods (including some brands of ready-to-eat cereals, soy and rice beverages, and juices) can provide ample calcium for vegetarians. Cross-sectional and longitudinal population-based studies published during the past 2 decades suggest no differences in bone mineral density (BMD), for both trabecular and cortical bone, between omnivores and lacto-ovo-vegetarians (163).

Although very little data exist on the bone health of vegans, some studies suggest that bone density is lower among vegans compared with non-vegetarians (164,165). The Asian vegan women in these studies had very low intakes of protein and calcium. An inadequate protein and low calcium intake has been shown to be associated with bone loss and fractures at the hip and spine in elderly adults (166,167). In addition, vitamin D status is compromised in some vegans (168).

Results from the EPIC-Oxford study provide evidence that the risk of bone fractures for vegetarians is similar to that of omnivores (38). The higher risk of bone fracture in vegans appeared to be a consequence of a lower calcium intake. However, the fracture rates of the vegans who consumed over 525 mg calcium/day were not different from the fracture rates in omnivores (38). Other factors associated with a vegetarian diet, such as fruit and vegetable consumption, soy intake, and intake of vitamin K-rich leafy greens must be considered when examining bone health.

Bone has a protective role in maintaining systemic pH. Acidosis is seen to suppress osteoblastic activity, with the gene expression of specific matrix proteins and alkaline phosphatase activity diminished. Prostaglandin production by the osteoblasts increases synthesis of the osteoblastic receptor activator of nuclear factor kappaB ligand. The acid induction of receptor activator of nuclear factor kappaB li-

gand stimulates osteoclastic activity and recruitment of new osteoclasts to promote bone resorption and buffering of the proton load (169).

An increased fruit and vegetable consumption has a positive effect on the calcium economy and markers of bone metabolism (170). The high potassium and magnesium content of fruits, berries, and vegetables, with their alkaline ash, makes these foods useful dietary agents for inhibiting bone resorption (171). Femoral neck and lumbar spine BMD of premenopausal women was about 15% to 20% higher for women in the highest quartile of potassium intake compared with those in the lowest quartile (172).

Dietary potassium, an indicator of net endogenous acid production and fruit and vegetable intake, was shown to exert a modest influence on markers of bone health, which over a lifetime may contribute to a decreased risk of osteoporosis (173).

High protein intake, especially animal protein, can produce increased calciuria (167,174). Postmenopausal women with diets high in animal protein and low in plant protein revealed a high rate of bone loss and a greatly increased risk of hip fracture (175). Although excessive protein intake may compromise bone health, evidence exists that low protein intakes may increase the risk of low bone integrity (176).

Blood levels of undercarboxylated osteocalcin, a sensitive marker of vitamin K status, are used to indicate risk of hip fracture (177), and predict BMD (178). Results from two large, prospective cohort studies suggest an inverse relationship between vitamin K (and green, leafy vegetable) intake and risk of hip fracture (179,180).

Short-term clinical studies suggest that soy protein rich in isoflavones decreases spinal bone loss in postmenopausal women (181). In a meta-analysis of 10 randomized controlled trials, soy isoflavones demonstrated a significant benefit on spine BMD (182). In a randomized controlled trial, postmenopausal women receiving genistein experienced significant decreases in urinary excretion of deoxypyridinoline (a marker of bone resorption), and increased levels of serum bone-specific alkaline phosphatase (a marker of bone formation) (183). In another meta-analysis of nine randomized controlled tri-

als on menopausal women, soy isoflavones significantly inhibited bone resorption and stimulated bone formation compared to placebo (184).

To promote bone health, vegetarians should be encouraged to consume foods that provide adequate intakes of calcium, vitamin D, vitamin K, potassium, and magnesium; adequate, but not excessive protein; and to include generous amounts of fruits and vegetables and soy products, with minimal amounts of sodium.

Renal Disease

Long-term high intakes of dietary protein (above 0.6 g/kg/day for a person with kidney disease not undergoing dialysis or above the Dietary Reference Intake for protein of 0.8 g/kg/day for people with normal kidney function) from either animal or vegetable sources, may worsen existing chronic kidney disease or cause renal injury in those with normal renal function (185). This may be due to the higher glomerular filtration rate associated with a higher protein intake. Soy-based vegan diets appear to be nutritionally adequate for people with chronic kidney disease and may slow progression of kidney disease (185).

Dementia

One study suggests that vegetarians are at lower risk of developing dementia than nonvegetarians (186). This reduced risk may be due to the lower blood pressure seen in vegetarians or to the higher antioxidant intake of vegetarians (187). Other possible factors reducing risk could include a lower incidence of cerebrovascular disease and possible reduced use of postmenopausal hormones. Vegetarians can, however, have risk factors for dementia. For example, poor vitamin B-12 status has been linked to an increased risk of dementia apparently due to the hyperhomocysteinemia that is seen with vitamin B-12 deficiency (188).

Other Health Effects of Vegetarian Diets

In a cohort study, middle-aged vegetarians were found to be 50% less likely to have diverticulitis compared with nonvegetarians (189). Fiber was considered to be the most important

protective factor, whereas meat intake may increase the risk of diverticulitis (190). In a cohort study of 800 women aged 40 to 69 years, nonvegetarians were more than twice as likely as vegetarians to suffer from gallstones (191), even after controlling for obesity, sex, and aging. Several studies from a research group in Finland suggest that fasting, followed by a vegan diet, may be useful in the treatment of rheumatoid arthritis (192).

PROGRAMS AND AUDIENCES AFFECTED

Special Supplemental Nutrition Program for Women, Infants, and Children

The Special Supplemental Nutrition Program for Women, Infants, and Children is a federal grant program that serves pregnant, postpartum, and breastfeeding women; infants; and children up to age 5 years who are documented as being at nutritional risk with family income below federal standards. This program provides vouchers to purchase some foods suitable for vegetarians including infant formula, iron-fortified infant cereal, vitamin C-rich fruit or vegetable juice, carrots, cow's milk, cheese, eggs, iron-fortified ready-to-eat cereal, dried beans or peas, and peanut butter. Recent changes to this program promote the purchase of whole-grain breads and cereals, allow the substitution of canned beans for dried beans, and provide vouchers for purchasing fruits and vegetables (193). Soy-based beverages and calcium-set tofu that meet specifications can be substituted for cow's milk for women and for children with medical documentation (193).

Child Nutrition Programs

The National School Lunch Program allows nonmeat protein products including certain soy products, cheese, eggs, cooked dried beans or peas, yogurt, peanut butter, other nut or seed butters, peanuts, tree nuts, and seeds to be used (194). Meals served must meet the 2005 Dietary Guidelines for Americans and provide at least one third of the Recommended Dietary Allowance for protein, vitamins A and C, iron, calcium, and energy. Schools are not required to make modifications to meals based on food choices of a family or a child although they are

permitted to provide substitute foods for children who are medically certified as having a special dietary need (195). Some public schools regularly feature vegetarian choices, including vegan, menu items and this seems to be more common than in the past although many school food programs still have limited options for vegetarians (196). Public schools are allowed to offer soy milk to children who bring a written statement from a parent or guardian identifying the student's special dietary need. Soy milks must meet specified standards to be approved as substitutes and schools must pay for expenses that exceed federal reimbursements (197).

Feeding Programs for Elderly Adults

The federal Elderly Nutrition Program distributes funds to states, territories, and tribal organizations for a national network of programs that provide congregate and home-delivered meals (often known as Meals on Wheels) for older Americans. Meals are often provided by local Meals on Wheels agencies. A 4-week set of vegetarian menus has been developed for use by the National Meals on Wheels Foundation (198). Similar menus have been adapted by individual programs including New York City's Department for the Aging which has preapproved a 4-week set of vegetarian menus (199).

Corrections Facilities

Court rulings in the United States have granted prison inmates the right to have vegetarian meals for certain religious and medical reasons (200). In the federal prison system, vegetarian diets are only provided for inmates who document that their diet is a part of an established religious practice (201). Following review and approval by the chaplaincy team, the inmate can participate in the Alternative Diet Program either through self-selection from the main line that includes a nonflesh option and access to the salad/hot bar or through provision of nationally recognized, religiously certified processed foods (202). If meals are served in prepared trays, local procedures are developed for the provision of nonflesh foods (201). In other prisons, the process for obtaining vegetarian meals and the type of

meal available varies depending on where the prison is located and the type of prison (201). Although some prison systems provide meatless alternatives, others simply leave meat off the inmate's tray.

Military/Armed Forces

The US Army's Combat Feeding Program, which oversees all food regulations, provides a choice of vegetarian menus including vegetarian Meals, Ready-to-Eat (203,204).

Other Institutions and Quantity Food Service Organizations

Other institutions, including colleges, universities, hospitals, restaurants, and publicly funded museums and parks, offer varying amounts and types of vegetarian selections. Resources are available for vegetarian quantity food preparation.

ROLES AND RESPONSIBILITIES OF FOOD AND NUTRITION PROFESSIONALS

Nutrition counseling can be highly beneficial for vegetarian clients who manifest specific health problems related to poor dietary choices and for vegetarians with existing clinical conditions that require additional dietary modifications (eg, diabetes, hyperlipidemia, and kidney disease). Depending on the client's knowledge level, nutrition counseling may be useful for new vegetarians and for individuals at various stages of the life cycle including pregnancy, infancy, childhood, adolescence, and for the elderly. Food and nutrition professionals have an important role in providing assistance in the planning of healthful vegetarian diets for those who express an interest in adopting vegetarian diets or who already eat a vegetarian diet, and they should be able to give current accurate information about vegetarian nutrition. Information should be individualized depending on type of vegetarian diet, age of the client, food preparation skills, and activity level. It is important to listen to the client's own description of his or her diet to ascertain which foods can play a role in meal planning. Figure 1 provides meal planning suggestions. Figure 2 provides a list of Web resources on vegetarian diets.

Vegetarian Nutrition Dietetic Practice Group

<http://vegetariannutrition.net>

Andrews University Nutrition Department

<http://www.vegetarian-nutrition.info>

Center for Nutrition Policy and Promotion

http://www.mypyramid.gov/tips_resources/vegetarian_diets.html

Food and Nutrition Information Center

<http://www.nal.usda.gov/fnic/pubs/bibs/gen/vegetarian.pdf>

Mayo Clinic

<http://www.mayoclinic.com/health/vegetarian-diet/HQ01596>

Medline Plus, Vegetarian Diet

<http://www.nlm.nih.gov/medlineplus/vegetariandiet.html>

Seventh-day Adventist Dietetic Association

<http://www.sdada.org/plant.htm>

The Vegan Society (vitamin B-12)

<http://www.vegansociety.com/food/nutrition/b12/>

The Vegetarian Resource Group

<http://www.vrg.org>

The Vegetarian Society of the United Kingdom

<http://www.vegsoc.org/health>

Figure 2. Useful Web sites concerning vegetarian diets.

Qualified food and nutrition professionals can help vegetarian clients in the following ways:

- Provide information about meeting requirements for vitamin B-12, calcium, vitamin D, zinc, iron, and n-3 fatty acids because poorly planned vegetarian diets may sometimes fall short of these nutrients.
- Give specific guidelines for planning balanced lacto-ovo-vegetarian or vegan meals for all stages of the life cycle.
- Supply information about general measures for health promotion and disease prevention.
- Adapt guidelines for planning balanced lacto-ovo-vegetarian or vegan meals for clients with special dietary needs due to allergies or chronic disease or other restrictions.
- Be familiar with vegetarian options at local restaurants.
- Provide ideas for planning optimal vegetarian meals while traveling.

- Instruct clients about the preparation and use of foods that frequently are part of vegetarian diets. The growing selection of products aimed at vegetarians may make it impossible to be knowledgeable about all such products. However, practitioners working with vegetarian clients should have a basic knowledge of preparation, use, and nutrient content of a variety of grains, beans, soy products, meat analogs, and fortified foods.
- Be familiar with local sources for purchase of vegetarian foods. In some communities, mail order sources may be necessary.
- Work with family members, particularly the parents of vegetarian children, to help provide the best possible environment for meeting nutrient needs on a vegetarian diet.
- If a practitioner is unfamiliar with vegetarian nutrition, he/she should assist the individual in finding someone who is qualified to advise the client or should direct the client to reliable resources.

Qualified food and nutrition professionals can also play key roles in ensuring that the needs of vegetarians are met in foodservice operations, including child nutrition programs, feeding programs for the elderly, corrections facilities, the military, colleges, universities, and hospitals. This can be accomplished through development of guidelines specifically addressing the needs of vegetarians, creation and implementation of menus acceptable to vegetarians, and the evaluation of whether or not a program meets the needs of its vegetarian participants.

CONCLUSIONS

Appropriately planned vegetarian diets have been shown to be healthful, nutritionally adequate, and may be beneficial in the prevention and treatment of certain diseases. Vegetarian diets are appropriate for all stages of the life cycle. There are many reasons for the rising interest in vegetarian diets. The number of vegetarians in the United States is expected to increase during the next decade. Food and nutrition professionals can assist vegetarian clients by providing current, accurate information about vegetarian nutrition, foods, and resources.

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