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Usefulness of Vegetarian and Vegan Diets for Treating Type 2 Diabetes

Caroline B. Trapp · Neal D. Barnard

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Abstract Significant benefits for diabetes prevention and management have been observed with vegetarian and especially vegan diets. This article reviews observational studies and intervention trials on such diets, and discusses their efficacy, nutritional adequacy, acceptability, and sustainability. Research to date has demonstrated that a low-fat, plant-based nutritional approach improves control of weight, glycemia, and cardiovascular risk. These studies have also shown that carefully planned vegan diets can be more nutritious than diets based on more conventional diet guidelines, with an acceptability that is comparable with that of other therapeutic regimens. Current intervention guidelines from professional organizations offer support for this approach. Vegetarian and vegan diets present potential advantages in managing type 2 diabetes that merit the attention of individuals with diabetes and their caregivers.

Keywords Vegetarian diet · Vegan diet · Type 2 diabetes

Introduction

Type 2 diabetes is a rapidly growing international epidemic, accounting for more than 90% of the 171 million diabetes cases diagnosed worldwide—a number expected to more than double by 2030 [1]. Increased consumption of energy-dense foods contributes to the risk of developing obesity and diabetes, and therefore is a primary target for diabetes prevention and management [2]. Vegetarian and vegan diets have long been used for weight loss [3, 4], increasing insulin sensitivity [5•], and reducing cardiac risk factors [6, 7], and are therefore of interest to researchers and clinicians for their use in diabetes prevention and treatment.

C. B. Trapp (✉) · N. D. Barnard
Physicians Committee for Responsible Medicine,
5100 Wisconsin Avenue NW, Suite 400,
Washington, DC 20016, USA
e-mail: ctrapp@pcrm.org

N. D. Barnard
e-mail: nbarnard@pcrm.org

Emerging Nutrition Lessons From the Global Diabetes Epidemic

In countries where the Western dietary habits have taken hold, obesity and type 2 diabetes have followed. In international comparisons, Western-style diets are associated with higher diabetes prevalence, and in population groups that change from lower to higher fat intakes, or from plant-based to more animal-based eating styles, diabetes prevalence rises. Often due to migration or changes in local culture, this phenomenon has been observed in studies with populations groups in India [8], in Pacific Islanders [9], in Mexican Americans [10], in Puerto Rican Americans [10], in Japanese [11], in Native Americans [12], in Chinese [13], and in Africans [14].

A Western dietary pattern typically includes animal products at two or three meals a day, and is relatively high in fat and animal protein. Meat or other products from animals are usually the meal's centerpiece. This is in contrast to plant-based diets, which may be largely drawn from grains, fruits, vegetables, legumes, nuts and seeds. Unprocessed or minimally processed starches are typically the centerpiece of non-Western diets: rice in Asia, potatoes in Peru, and beans and grains in Africa and South America. Animal products, if included, often function as condiments and are a small part of the total caloric intake.

In the publications reviewed for this article, terms describing those who consume animal meat and animal products include "nonvegetarian" and "omnivore"; and those who avoid all meat and dairy products are "vegan" or follow a "vegan diet" or a completely "plant-based" diet. In between are "lacto-ovo-vegetarians," who include eggs, milk, and milk products, and "pesco-vegetarians," who include eggs, milk, milk products, and fish.

The Role of Diet in Preventing Type 2 Diabetes

In the United States, diabetes prevalence is lower among vegetarians, compared with omnivores [15–17]. This phenomenon has been extensively documented through studies of Seventh-day Adventists, a population group that generally avoids tobacco, alcohol, and caffeine, while roughly half are omnivores and half are vegetarians. In two large Adventist cohort studies (n=25,698 [15]; and n= 22,434 men and 38,469 women [18••]), the prevalence of diagnosed diabetes was 1.6 to two times higher among nonvegetarians compared with vegetarians or vegans. This difference is reduced only slightly when adjusted for body weight. Tonstad et al. [18••] found that among a range of diets, from vegan to nonvegetarian, as consumption of meat and animal products increase, there was a corresponding increase in diabetes prevalence (Fig. 1).

A recent systematic review of 12 cohort studies published in *Diabetologia* adds more evidence linking meat consumption to diabetes risk [19]. This review, which included data from Harvard's Women's Health Study, the Nurses' Health Study, the Health Professionals' Follow-Up Study, and others, found that men and women who ate the most meat had the highest risk of type 2 diabetes. Specifically, intakes of red meat and processed meat were associated with 21% and 41% increased risk for type 2 diabetes, respectively.

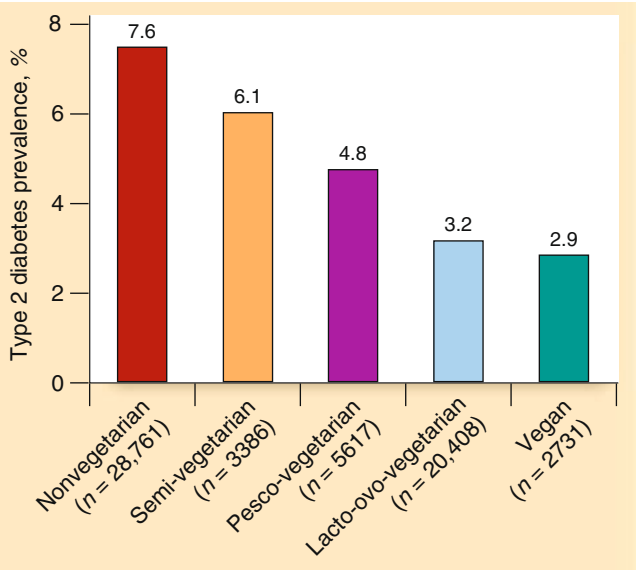

Fig. 1 The Adventist Health Study-2, with 60,903 participants, ≥30 years of age, enrolled from 2002 to 2006. (*Adapted from* Tonstad et al. [18••].)

Vegetarian and Vegan Diets for Treating Type 2 Diabetes

Intervention trials using near-vegetarian diets for treating type 2 diabetes demonstrated reduced glycemia; however, they included exercise as an intervention [20, 21], making it difficult to isolate the effect of diet. More recently, in a 22-week randomized trial in which exercise was held constant, 99 individuals with type 2 diabetes were assigned to a low-fat, low glycemic index, vegan diet (n=49) (Tables 1 and 2), or a portion-controlled omnivorous diet (n=50) following the 2003 American Diabetes Association (ADA) guidelines [22]. In medication-stable patients, hemoglobin A_{1c} fell 1.23 points in the vegan group, compared with 0.38 points in the ADA group (P=0.01). Participants in the vegan group lost an average of 14.3 lb of body weight, whereas the ADA group lost an average of 6.8 lb (P<0.001). Medication-stable participants lowered low-density lipoprotein (LDL) cholesterol by an average of 22.6 mg/dL (21.2%), compared with an average reduction of 10.7 mg/dL (9.3%) in the ADA group (P=0.02). Although medication changes were not a goal of the study, requirements for medication also dropped: 43% (21/49) of those following the vegan diet reduced their diabetes medications compared with 26% (13/50) in the ADA group. Following the same patients for a total of 74 weeks showed that improvements in glycemia and plasma lipid concentrations remained greater in the vegan study group [5•].

Diabetes Complications

Cardiovascular Disease

Heart disease has been noted on 68% of diabetes-related death certificates among people 65 years of age or older [23], showing the importance of managing cardiovascular risk in this population. Plant-based diets have been studied in those with known heart disease or risk of heart disease, and have shown great efficacy in improving cardiovascular risk factors and reducing cardiovascular events. Appleby et al. [24] showed improvements in blood pressure across a spectrum of diets, with vegetarians doing better than omnivores and vegan diets achieving the most significant reductions. Ferdowsian and Barnard [25] recently published

Table 1 Components of a low-fat, plant-based diet

Ad libitum[a] foods from four food groups: whole grains, legumes (beans, peas, and lentils), vegetables, and fruits
Limit or avoid added vegetable oils and other high-fat foods for weight and glycemic control. Use nuts and seeds sparingly (to top a salad or oatmeal; not as a snack)
Unprocessed and minimally processed foods are best
Choosing low glycemic index foods (eg, old-fashioned oatmeal, sweet potatoes, pasta, grains, most fruits and vegetables) may have an additional benefit
≥40 g of fiber from whole foods per day is recommended
Avoid all animal products
B12 supplementation of 5 μg/d (eg, a common multivitamin) is recommended for anyone avoiding animal products and all people over 50 years of age
A macronutrient profile of ~75% to 80% of energy from carbohydrate, 10% to 15% from protein, and 10% from fat is recommended

[a] Those individuals who adjust insulin based on carbohydrate intake will still need to count carbohydrates; Insulin requirements may change, requiring dose adjustment

a review of studies of vegetarian and vegan diets, which concluded that a plant-based diet combined with nuts, soy, and/or soluble fiber can reduce LDL cholesterol by 25% to 30%, a figure comparable to what can be achieved with statin drugs [26]. Esselstyn [27] demonstrated reversal of heart disease in a 12-year study of 17 participants with severe coronary artery disease, with a diet that included no meat, animal products, or added fats. Ornish et al. [28] effectively used a low-fat (10%), plant-based dietary approach in a 5-year landmark MLDP (Multicenter Lifestyle Demonstration Project) clinical trial demonstrating reversal of heart disease. A substudy (n=55 men and 36 women) of the MLDP specifically looked at people with diabetes, and showed that patients with coronary artery disease and diabetes showed the same improvements in cardiovascular risk factors as those who did not have diabetes [29].

Renal Function

Diabetes is the leading cause of kidney failure [23], with 40% of individuals with diabetes having mild renal insufficiency [30]. Loss of renal function may be slowed by changing the amount and type of protein in the diet. In the Nurses' Health Study, progressive worsening renal function was associated with animal protein intake in individuals who had some degree of renal impairment at baseline [31]. In 2006, de Mello et al. [32] demonstrated in a study of type 2 diabetes patients with macroalbuminuria that reducing red meat consumption reduced albuminuria. In the 22-week study described above, Barnard et al. [22] found that urinary albumin decreased by −15.9 mg per 24 h in the vegan group versus by −10.9 mg per 24 h in the ADA group (P=0.013).

Nerve Function

Approximately 60% to 70% of people with diabetes have some degree of neuropathy [23]. Severe pain in the legs from diabetic neuropathy was found to respond favorably to a pilot trial using a 2-week inpatient program that included a low-fat vegan diet and a 30-minute walk per day, with 17 of 21 participants becoming pain free, and the remaining four experiencing partial improvement [33]. Anecdotal reports have suggested that dietary changes have improved erectile function in men with erectile dysfunction [34] and specifically in diabetic men [35], although clinical trials involving men with diabetes are lacking.

Table 2 Example of a 1-day menu for a low-fat, vegan diet

Breakfast:
Old-fashioned oatmeal with 1/2 tsp cinnamon, cooked, no added fat (1 cup)
Sliced banana (1 whole)
Pumpernickel toast (1 slice)
Jam (1 tbsp)
Lunch:
Bean burrito (1, made with fat-free vegetarian beans and whole-wheat tortillas) with salsa
Cucumber, mango and spinach salad (1 cup, dressed with seasoned rice vinegar, lime juice, fresh basil and pepper)
Raspberries (1 cup)
Snack:
Hummus (1/4 cup made with chickpeas and tahini, no added oil) with tomato slices (2) on rye toast (1 slice)
Dinner:
Lentil-spinach soup (1 cup)
Italian pasta marinara (1 cup tomato-mushroom sauce over 2 oz [uncooked] pasta)
Broccoli with vinaigrette (1 cup raw broccoli seasoned with oil-free dressing)
Strawberries (1 cup)
Nutrient analysis:
Calories: 1479
Fat: 16.3 g (9.92%)
Saturated fat: 2.4 g
Cholesterol: 0.00
Protein: 57.6 g
Carbohydrates: 284.4 g
Fiber: 53.9 g
Beta-carotene: 6291.00 μg

Quantities provided are only for nutritional analysis; recipes and nutrition analysis can be found at http://www.NutritionMD.org

Nutritional Adequacy of Vegetarian and Vegan Diets

The effect of a low-fat vegan diet on overall nutrition was examined by Turner-McGrievy et al. [36•]. Nutrient intake was examined using 3-day dietary records, and was also evaluated using the Alternative Healthy Eating Index (AHEI)—an index used to score diets based on servings per day of vegetables, fruit, nuts, and soy protein; ratio in grams of white to red meat; grams of cereal fiber; percent of energy from trans fat; and ratio in grams of polyunsaturated to saturated fatty acids. The AHEI has been shown to be a reliable predictor of risk of cardiovascular disease and other major chronic diseases [37]. The study concluded that a vegan diet and a more conventional diet for diabetes led to significant improvements in energy, total fat, trans fat, and cholesterol. However, the vegan group had a higher fiber intake, which helps to promote insulin sensitivity and reduced insulin resistance, and does not interfere significantly with mineral absorption [38••]. The vegan group also had significant improvements in several vitamins and minerals and an improved AHEI score. The ADA group saw no improvement in AHEI score from baseline. This study suggests that, if followed for the long term, a low-fat vegan diet may reduce risk of major chronic diseases, particularly cardiovascular disease.

Professional Organization Guidelines

Two prominent professional organizations have addressed plant-based nutrition in practice recommendations or position papers. The American Dietetic Association in its 2009 Position Paper on Vegetarian Diets [38••] states that "appropriately planned vegetarian diets, including total vegetarian or vegan diets, are healthful…, and may provide health benefits in the prevention and treatment of certain diseases," including diabetes. Furthermore, these diets are "appropriate for individuals during all stages of the life cycle, including pregnancy, lactation, infancy, childhood and adolescence, and for athletes." The ADA updated its 2010 Clinical Practice Guidelines to state that plant-based diets have been shown to improve metabolic control in persons with diabetes [39].

Acceptability

Clinical studies have demonstrated the acceptability of a vegan diet in several nondiabetic populations: individuals with cardiac disease [40], in overweight postmenopausal women [41], and in women with dysmenorrhea [42]. Two studies published in 2009 offer reassurance to clinicians who are uncertain about their patients' ability to adhere to a plant-based diet. In the first, acceptability of a low-fat vegan diet was compared with that of a diet based on more conventional diabetes diet recommendations using several measures, including adherence, attrition, and nutritional changes, and using instruments to quantify eating behavior, diet acceptability, and cravings. The vegan diet was shown to be as acceptable as a more conventional diet and led to no increases in dietary restraint, disinhibition, or reported hunger [43]. Although the study showed that a low-fat vegan diet requires somewhat greater effort initially, as participants learn about new foods and cooking techniques, for some it may be simpler, because it dispenses with restrictions on calories, carbohydrates, and portion sizes.

The second article challenges the notion that asking patients to take small steps is preferable to recommending major diet changes. Young et al. [44] evaluated goal attainment of 810 individuals with hypertension. Participants were randomly assigned to one of three levels of lifestyle change advice. Those randomized to a treatment group asked to make the highest levels of lifestyle change were asked to make multiple specific dietary changes. Goals included ≤2400 mg of salt, increased fruits and vegetables to 9–12 servings/day, total dietary fat ≤25% of kcal, and total saturated fat ≤7% of kcal. At 6-month and 18-month evaluations, it was demonstrated that rather than being overwhelmed by the request to change so many behaviors at once, those with the most behavior-change goals reached the most goals. The old adage, "Shoot for the moon. If you fail, you will land among the stars" seems to apply, and may be more effective than limiting patients to small steps that sound more manageable but are not sufficient to prevent disease progression.

Sustainability

Long-term adherence is required to maintain clinical improvements. In the 22-week study of a low-fat vegan diet compared with a diet based on the 2003 ADA recommendations described above, nutrient intake changes such as reduction in fat (P=0.0001), saturated fat (P=0.0001), and cholesterol intake (P=0.0001) and greater increase in fiber (P=0.0001) and complex carbohydrate intake (P=0.0001) were largely maintained at follow-up 1 year later [43]. Changes in body weight were significant within each group (vegan and ADA) at 1-year follow-up, but not significantly different between groups. Although other intervention trials of this duration with people with diabetes have not yet been done, studies of people who did not have diabetes have demonstrated the sustainability of vegan diets. For example, at the end of a 2-year study of weight loss in postmenopausal women comparing a vegan diet to a more moderate low-fat diet, 61% (19/31) of

participants reported consuming ≤3 oz of meat per week, ≤1 serving of dairy per week, ≤1 egg per week, and ≤2 servings of high-fat items (eg, nuts, salad dressings) per day, and body weight remained below baseline [45]. In a study looking at long-term adherence to an lacto-ovo-vegetarian diet compared with a conventional reduced-calorie "weight-loss" diet [46], adherence was greater than 1 year for 62% of the vegetarian group, whereas 61% of participants in the weight-loss group maintained their diet for only 1–3 months. The most common reason cited for discontinuing the weight-loss diet was boredom.

Discussion

Our review demonstrates that individuals following plant-based diets experience improved reductions in glycemia, body weight, and cardiovascular risk, compared with those following diets that included animal products. In observational studies, diabetes prevalence is lower in vegans and vegetarians compared with omnivores, with increased prevalence as consumption of animal products increases [15–17, 18••, 19].

A number of biological changes may be responsible for the improved glycemic control seen with a plant-based diet. Diets that cause weight loss are associated with hemoglobin A_{1c} reduction, and low-fat vegan diets promote weight loss [22]. Because foods from animal sources are proscribed in such diets, a significant source of total and saturated fat is removed from the diet. This reduction in dietary fat promotes weight loss, but independent of changes in body weight, a lower saturated fat intake has been shown to improve insulin sensitivity [47]. Lowering saturated fat intake may also contribute to a decreased concentration of intramyocellular lipid, which is strongly associated with improved insulin sensitivity [48]. Favoring low glycemic index food choices may also contribute to improved glycemia [2]. Finally, iron intake may play a role. Excess stores of iron have been shown to promote insulin resistance [49]. The non-heme iron in plant foods is less bioavailable and may reduce iron stores to more beneficial levels [50].

The favorable results of nutritional adequacy analyses [36•] should provide comfort to clinicians and their patients. Plant sources of protein meet daily requirements; high-fiber diets are well tolerated; the absence of fish or olive oil is safe and perhaps even beneficial; and perhaps most significantly, blood glucose improves when low glycemic index carbohydrate intake goes up and total and saturated fat intake are reduced. Diets drawing their nutrition from plant sources without added fats typically derive about 10% of energy from fat, 10% to 15% from protein, and 75% to 80% from carbohydrates (Table 2). Patient education will be important to ensure adequate intake of vitamin B_{12} (from supplements or fortified foods) and calcium (from beans, greens, and fortified juices).

Patients diagnosed with hypercholesterolemia are usually advised to lower their intake of fat and cholesterol. Ornish [26] states that these moderate changes in diet usually result in only modest reductions in LDL cholesterol levels. Similarly, asking people with diabetes to make moderate changes in nutritional intake (eg, "eat fewer carbs"; "remove the skin from chicken"; "get more exercise") often achieves equally moderate results, which is one possible reason why 84% of those with type 2 diabetes require oral medications, insulin, or both [23].

For many people, a low-fat, plant-based diet requires a number of behavioral changes: forgoing meat, dairy, eggs, and high-fat foods, while learning new ways to prepare whole grains, beans, vegetables, and fruits. As Young et al. [44] demonstrated in people with hypertension, requesting multiple changes simultaneously, with clear instructions and ongoing support, achieves significant clinical changes. When the rules are clear, the dietary changes requested are significant, and clinical support is provided, people can reap the benefits of a therapeutic diet [5•, 22, 36•, 43]. Significant changes beget significant results, which may provide the necessary motivation to continue.

Two additional factors may contribute to the acceptability of a vegan diet. One is the higher-fiber content, which boosts satiety [51]. In the study by Turner-McGrievy et al. [36•], ADA participants averaged 18.3±7.7 g of fiber per day, whereas the vegan arm averaged 35.4±14.4 g of fiber per day. To promote a smooth transition to a high-fiber diet, participants were instructed to improve the digestibility of beans by cooking thoroughly, starting with small portions, and choosing lentils or split peas, which are more easily digested. Second, the diet has the advantage of simplicity, as caloric restriction, carbohydrate counting, and portion limits are not required. A decrease in total daily energy intake occurs naturally, presumably as a result of reduced energy-density of the diet caused by its low-fat content and high-fiber content. Participants are instructed in using four food groups (whole grains, vegetables, legumes, and fruits), taught to keep oils low (≤2 tsp per recipe or ≤3 g per serving and are instructed in oil-free cooking techniques), and are encouraged to favor low glycemic index foods. Effective in the research setting, these simple instructions may prove to be especially useful in the clinical setting.

For some, health or improved appearance (eg, weight loss) is a motivator for maintaining long-term dietary adherence. In addition, patients' personal values (eg, concerns about climate change [52] or animal welfare) may also play a role in long-term adherence.

Useful Resources

Clinicians may find they have success by referring patients to nutrition professionals with expertise in plant-based nutrition, providing or recommending written and web-based resources, and encouraging a 3-week diet trial, which is a manageable time frame that provides sufficient opportunity to change old habits and see initial results.

Clinicians seeking continuing education on the topic of nutrition and diabetes, as well as other chronic diseases, may wish to visit NutritionCME (http://www.NutritionCME.org). Patient education resources, including recipes, weekly webcasts, and a message board are available at NutritionMD (http://www.NutritionMD.org) and the Physicians Committee for Responsible Medicine (http://www.pcrm.org/diabetes), respectively.

Conclusions

Low-fat vegetarian and vegan diets are effective for lowering glycemia, weight control, and reducing cardiovascular risk. They offer additional benefits for the comorbidities of cardiovascular disease, kidney disease, and neuropathy. Carefully planned low-fat vegan diets are nutritionally adequate and may have a higher diet quality, compared with more conventional diet recommendations. Vegetarian and vegan diets have been found to be as acceptable to patients as other therapeutic diets and may have additional advantages in terms of promoting satiety. Improved clinical outcomes are achieved without carbohydrate calculations or portion size control, making the approach easier for some patients.

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- • Of importance
- •• Of major importance

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