

POTENTIAL EFFECTS OF VEGAN DIET ON TYPE 2 DIABETES MELLITUS: A SYSTEMIC REVIEW

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ABSTRACT: A protective effect of vegan diets on health outcomes has been observed in previous studies, but its impact on diabetes is still debated. The aim of this review is to assess the relationship between vegan diets and the risk for type 2 diabetes (T2D) along with its effect on glycemic control and diabetes-related complications. In accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, Pubmed and Cochrane library databases were systematically searched for all relevant studies. We found that a vegan diet is associated with lower Type 2 Diabetes (T2D) prevalence or incidence and in T2D patients decreases high glucose values and improves glucose homeostasis, as reported from the majority of included studies. This approach seems to be comparable to other recommended healthful eating models, but as it may have potential adverse effects associated with the long-term exclusion of some nutrients, appropriate nutritional planning and surveillance are recommended, particularly in specific groups of diabetic patients such as frail elderly, adolescents, and pregnant or breastfeeding women.

KEYWORDS: potential, diabetes, vegan, homeostasis, glucose, risk, effects, mellitus, eating

I. INTRODUCTION

Type 2 diabetes is a global epidemic, with approximately 422 million cases worldwide and a rapidly rising prevalence in middle- and low-income countries.^[1] In the United States in 2011–2012, 12%–14% of adults had type 2 diabetes and 38% had prediabetes.^[2] Prediabetes is even more common among those aged ≥ 65 in the United States, with a prevalence of 50%.^[3] Diabetes accounts for \$176 billion of direct medical costs in the US, including annual per capita costs of \$7900, a number 2.3 times higher than costs for adults without diabetes.^[4] In 2015, type 2 diabetes was the 7th leading cause of death in the United States.^[5] Diabetes in older patients is associated with an increased risk of mortality, reduced functional status, and increased risk of institutionalization.^[6] Older patients also have the highest rates of macro- and micro-vascular complications from diabetes, including myocardial infarction, major lower extremity amputations, end stage renal disease, and visual impairment.^[3] Moreover, geriatric patients are at increased risk of medication-related complications, particularly hypoglycemia; the elderly have twice the number of emergency room visits for hypoglycemia than the general population with diabetes.^[6]

Dietary choices are a key driver of insulin resistance, especially in an aging, more sedentary population. Increases in consumption of calorie-dense foods, including fast foods, meats and other animal fats, highly refined grains, and sugar-sweetened beverages, are thought to play a critical role in the rising rates of type 2 diabetes worldwide.^[7] Lifestyle changes, particularly diet, can be highly effective in preventing, treating, and even reversing type 2 diabetes.^{[8]–[11]} Among the 20% of participants in the landmark Diabetes Prevention Program who were ages 60 and over, lifestyle changes conferred a 71% reduction in risk of type 2 diabetes, demonstrating that older adults reaped the greatest benefit⁹ from lifestyle interventions compared to other age groups.^[8] Lifestyle changes address the root causes of type 2 diabetes and can ameliorate comorbidities while reducing the risk of polypharmacy, particularly in the elderly. Plant-based diets (vegan diet)—i.e., eating patterns that emphasize legumes, whole grains, vegetables, fruits, nuts, and seeds and discourage most or all animal products—are especially potent in preventing type 2 diabetes and have been associated with much lower rates of obesity, hypertension, hyperlipidemia,¹⁰ cardiovascular mortality, and cancer.^[12] The vegan diet is completely free of meat, dairy, and animal-based products. Although it can be a nutritious

way of eating, it requires careful planning to make sure you're meeting all of your nutritional needs. For people with diabetes, following a vegan diet will require an extra layer of planning.¹¹ In general, people with diabetes need to keep their carb intake consistent throughout the day, as carbs affect blood sugar levels more significantly than protein and fat. Meals and snacks should also be balanced with carbs, protein, and healthy fat since including noncarb foods in your meal can help reduce the carbs' effects on your blood sugar. All of this can be done using exclusively plant-based foods, although it may be a bit challenging if you're new to the vegan diet. Here are some examples of carbs, proteins, and fats that you can use to build meals and snacks if you're following a vegan diet for diabetes:

- Carbs: whole grain flour (bread, pasta), rice, potatoes, oats, grits, quinoa, fruit (fresh, frozen, or unsweetened canned), corn
- Proteins: soybeans and soybean products (tofu, tempeh), beans, lentils, peas, peanuts, tree nuts, nut butters, seeds, plant-based meat alternatives
- Fats: olive oil, avocado oil, avocado, nuts and seeds, coconut, plant-based spreads¹³

Fortunately, many plant-based foods, such as beans and grains, contain a mixture of carbs, protein, and fat, so they can pull double or triple duty in your meal planning. Additionally, fiber — a type of indigestible carb — is found in most plant-based foods. Fiber helps make these foods more filling and may also help reduce their blood sugar impact. Based on the type of diabetes you have, your physical activity level, age, sex, and several other factors, your healthcare team — including a registered dietitian nutritionist (RDN) — can help you pinpoint the optimal amount of carbs you need with each meal.¹⁴

According to the Vegan Society, 'veganism is a way of living which seeks to exclude, as far as is possible and practicable, all forms of exploitation of, and cruelty to, animals for food, clothing or any other purpose. Vegans follow a plant-based diet avoiding all animal foods such as meat (including fish, shellfish and insects), dairy, eggs and honey – as well as products like leather and any tested on animals'. Vegan Life Magazine report that the vegan movement is growing fastest in the younger population: almost half (42%) of the 542,000 vegans in the UK are aged between 15–34, compared with just 15% who are over 65. People choose to follow a vegan lifestyle for different reasons such as concern about animal welfare and the planet. However, another contributing factor which may encourage people to follow a vegan diet is that it can provide some health benefits.¹⁵

It has also become considerably easier to 'go vegan' these days. Not so long ago, you'd have to make a special trip to a health food store for ingredients such as tofu or tempeh, but now you can find most of the produce needed for a healthy vegan diet in your regular supermarket. Additionally, more restaurants are now offering vegan options on their menus to cater for the growing numbers. Plant-based foods – which are a large part of a vegan diet – particularly fruit, vegetables, nuts, pulses and seeds, have been shown to help in the treatment of many chronic diseases and are often associated with lower levels of type 2 diabetes, less hypertension, lower cholesterol levels and reduced cancer rates. Some studies also show that vegans are less likely to be overweight and tend to have a lower percentage of body fat, which in turn will reduce the risk of many other diseases.^{16,17}

Even though most of the foods in a vegan diet are naturally good for you, it doesn't necessarily mean that all vegan diets are healthy. Ingredients such as salt, sugar and fat can still be added, making them less healthy. With the increased risk of cardiovascular disease (CVD) in people with diabetes, keeping your weight under control and reducing blood pressure and blood cholesterol are all essential and plant-based foods can help with this. General healthy eating advice – to choose wholegrain, low-GI carbs over refined options, to eat less salt, saturated fat and sugar and to watch your weight – still apply to people eating a vegan diet. A little more care and attention is needed when planning a vegan diet, particularly for children. When you first embark on a vegan diet, you must ensure that it will provide all the key nutrients that are necessary for good health. Speaking to a dietitian can be helpful to make sure your diet is balanced. Vegan diets tend to be lower in saturated fat, higher in fibre, fruit and vegetables and other protective substances like phytochemicals and antioxidants – as a result, they fit well with the current dietary guidelines for people with diabetes.¹⁸

Consuming enough protein is a concern for many new vegans. However, it may not be as big a problem as we anticipate. Most of us eat far more protein than our body requires, and there are plenty of vegan foods which are good sources of protein:

- nuts, seeds and most of their butters (e.g. cashew, tahini, peanut, almond and Brazil)
- beans and pulses (eg butterbeans, chickpeas and lentils)
- vegetable milks (eg soya, almond and hempseed)
- quinoa
- soya products (eg tofu, soya cheese and soya milk)
- vegan Quorn.¹⁹

There is generally more carbohydrate in plant-based protein sources, so it's possible that your carbohydrate intake may increase when you switch to a vegan diet. However, you can still watch your portions and always look for low glycaemic index (GI) options and pick foods that are high in fibre. The GI is a measure of how quickly carbohydrate is absorbed – the quicker it is, the higher the GI. The body needs vitamin B12 to maintain healthy blood and a healthy nervous system. We get vitamin B12 from food but it is only found naturally in animal products. However, many vegan foods are fortified with B12 to compensate for this. The Vegan Society recommend that you should eat a food fortified with B12 at each meal, or take a supplement that contains at least 10 micrograms of B12 each day in order to stay healthy. Fortified foods and/or supplements are the only reliable sources of B12 in a plant-based diet.²⁰

Vegan foods fortified with B12 include:

- some plant milks and yogurts
- some breakfast cereals
- some spreads
- yeast extract.

It's also important to ensure that a vegan diet contains enough calcium, which is important for strong bones. Calcium is needed throughout life, but particularly while bones are still growing until around the age of 25. you should choose dairy alternatives, such as plant-based milks and yogurts which are fortified with calcium.

Vegan foods that are sources of calcium include:

- almonds
- oranges
- kale
- red kidney beans
- chickpeas
- tahini
- some fortified foods (e.g. wholegrain breads).

You may have heard that spinach is a good source of calcium. Unfortunately, although it does contain calcium, it also contains chemicals which bind to the calcium and therefore make it difficult for the body to absorb. Don't let that stop you eating spinach though, as it still contains lots of other good stuff. Omega-3 fatty

acids are useful in the treatment and prevention of heart disease. As people with diabetes have an increased risk of heart disease they may benefit from including Omega-3 in their diet. It can, however, be more difficult when following a vegan diet.²¹

Vegan sources of Omega-3 include:

- flaxseed and rapeseed oil
- walnuts
- soya-based foods (eg soya milk, tofu and walnuts).

These sources are not as good as oily fish, so it's important to include them on a regular basis in order to get adequate amounts of Omega-3 fatty acids. You may want to consider taking a supplement, but make sure you choose one which is suitable for vegans.

There are good vegan sources of iron, including:

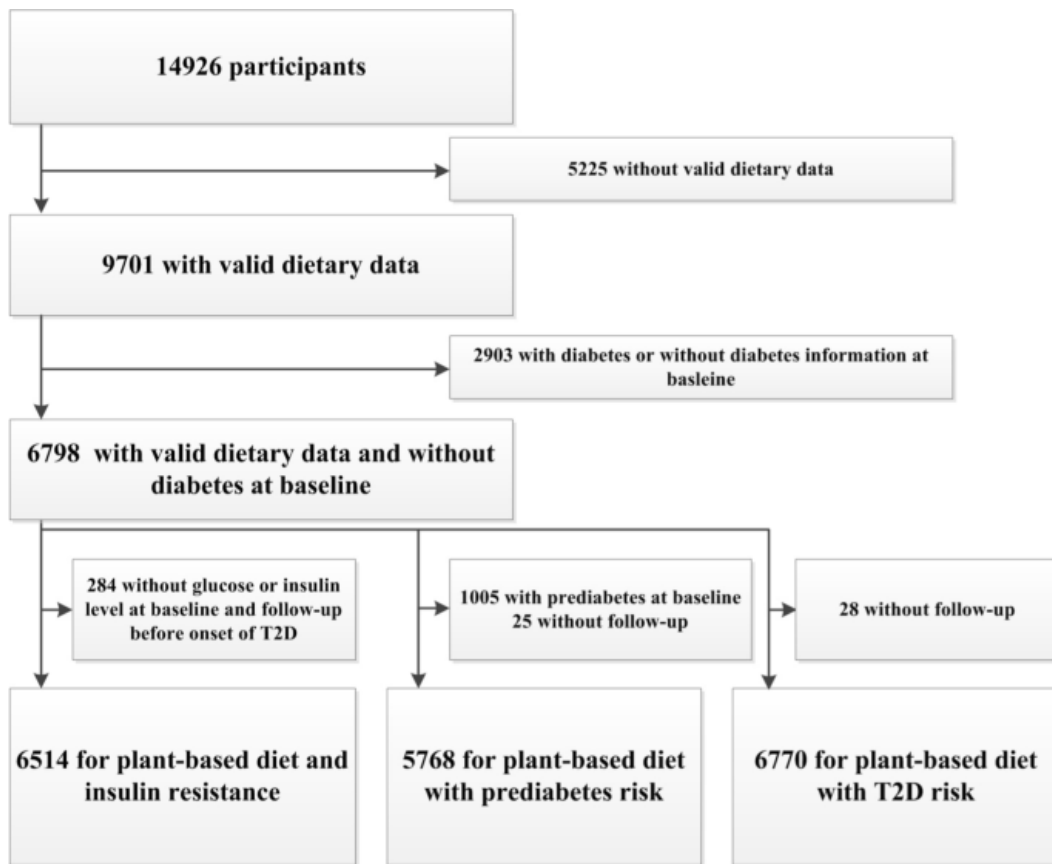
- bread
- breakfast cereals
- dark green vegetables
- nuts
- dried fruit
- beans and pulses.

Consuming more fruit and vegetables can also help as they are high in vitamin C which increases the amount of iron your body absorbs. Selenium is another essential nutrient, and is an important part of many enzymes (substances that speed up reactions in our bodies). Selenium tends to be high in Brazil nuts, so these can be a good source.²²

Although it's important not to eat too much selenium, you may want to consider a supplement as vegan sources can be hard to find. Speak to your healthcare team, a dietitian or pharmacist about suitable supplements. Thyroid hormones (which control how quickly your body cells work) are made with iodine. Plant based sources are not a reliable option and many plant-based milks currently are not fortified, so you may need to consider a supplement. Speak to your health care team. Zinc helps us to fight infection, along with other functions. You can get enough zinc by eating a varied vegan diet which includes beans and pulses, nuts and seeds tofu, grains and wholemeal bread. If you're considering a vegan diet – for health, lifestyle or other purposes – it's possible to ensure it's both healthy and balanced. As well as offering a number of potential health benefits, particularly for people with diabetes, the good news is that it's never been easier to begin.

II. DISCUSSION

Vegetarian and vegan diets offer significant benefits for diabetes management. In observational studies, individuals following vegetarian diets are about half as likely to develop diabetes, compared with non-vegetarians. In clinical trials in individuals with type 2 diabetes, low-fat vegan diets improve glycemic control to a greater extent than conventional diabetes diets. Although this effect is primarily attributable to greater weight loss, evidence also suggests that reduced intake of saturated fats and high-glycemic-index foods, increased intake of dietary fiber and vegetable protein, reduced intramyocellular lipid concentrations, and decreased iron stores mediate the influence of plant-based diets on glycemia. Vegetarian and vegan diets also improve plasma lipid concentrations and have been shown to reverse atherosclerosis progression. In clinical studies, the reported acceptability of vegetarian and vegan diets is comparable to other therapeutic regimens.²³



Several mechanisms behind the inverse associations could involve the intermediate conditions of T2D, such as obesity and inflammation, can offer explanations for the observed protection and T2D. On the one hand, a plant-based diet usually has more fiber, chlorogenic acids, certain amino acids, unsaturated fatty acids, and anti-oxidants. For example, vegetables and fruits are the main sources of fiber, anti-oxidants, and chlorogenic acids; nuts are rich in poly-unsaturated fatty acids; soy and beans are main sources of plant protein; whole grains are rich in fiber and plant protein; and coffee and tea are rich in anti-oxidants and phenol chlorogenic acid. These beneficial components may influence the development of T2D through impact on the potential intermediate conditions, such as obesity and inflammation. Fiber is known to lower gastric emptying and thereby glycemic responsiveness, and might improve inflammation and obesity. Chlorogenic acids can improve inflammation, glucose tolerance and glucose levels, and improve increasing insulin secretion. Soy protein contains high amounts of the amino acids arginine and glycine,²⁴ which have been associated with a decrease in cholesterol levels. High intake of unsaturated fatty acids has also been associated to lower inflammation and less obesity. Phenol chlorogenic acid was reported to reduce insulin resistance. On the other hand, a plant-based diet, usually has less animal protein, saturated fatty acids, and heme iron. Animal protein is rich in branched-chain amino acids and aromatic amino acids and may impair glucose metabolisms and increase T2D risk animal protein is also rich in heme iron, which has been suggested to increase risk of cardio-metabolic diseases. Higher saturated fatty acids have been suggested to be associated higher inflammation, higher risk of obesity, and T2D. Besides, other nutrients from processed red meat, such as sodium and nitrites, may increase risk of cardio-metabolic diseases. More research is needed to explore whether the mechanisms also involve an effect of plant foods on gut microbiome. Finally, these different mechanisms may influence each other because of inter-relations between different food components. This also highlights the relevance of examining overall diets in addition to isolated food items, as this enables capturing of the combined effects of the potential pathways.²⁵ This study has several strengths. First, to our knowledge, we are the first to investigate the associations between plant-based diets with longitudinal insulin resistance and prediabetes, for which we had longitudinal data from long follow-up available. Studying these early risk stages help minimize reverse causation, understand how plant-based diet influences the development of T2D. Second, we observed that the potential beneficial effect of a more plant-based diet was independent of less healthy plant foods, such as sweets, sugary beverages and refined grains, emphasizing the importance of considering the quality of plant-based foods consumed. We also observed associations of the plant-based dietary score independent of overall adherence to dietary guidelines, indicating that the plant-based diet score may reflect more than only a healthful dietary pattern as

reflected by current dietary guidelines. Other strengths also included the population-based nature of the study, the detailed and thorough data collected on the outcomes and the assessment of the extent to which diets were plant-based and animal based, based upon overall dietary intake patterns of the general population.²⁴

III. RESULTS

First, the assessment of a plant-based diet with this index has its limitations as several sometimes arbitrary decisions had to be made. A decision was, for example, to add up food items within categories based on the intake in grams per day. As a result, products that were high in water-content will have contributed less energy or nutrients compared to products containing less water in the same category. However, using grams per day reflects intake of foods as they are consumed and recommended^[19]. Also, decisions had to be made for the categorization of foods and the number of categories. We chose categories reflecting those used in the Dutch dietary guidelines, which are based on similarities of the food items in (botanical) origin, nutrient composition, and nutrient density^[18]; thereby reducing nutritional differences between food items within one category. Furthermore, in our main analyses, we treated all plant-based foods equally by giving all plant-based foods positive scores, and all animal-based foods equally by giving all animal-based foods reverse scores, irrespective of their nutrient-density or previous evidence for a role in T2D prevention and general health. For example, less healthy plant-based foods, such as sugary beverages and refined grains, were included as positive scores, although sugary beverages and refined grains have been linked to higher T2D risk; by contrast, healthy animal-based foods, such as dairy and fish, were included as reverse scores, although dairy and fish have been linked to lower T2D risk or mortality risk. That is because our study aimed to emphasize an overall plant-based diet including various increased plant-based foods consumption and decreased animal-based foods consumption, which would increase the potential for population-wide recommendation.¹¹ However, in our sensitivity analyses, excluding any one of alcoholic beverages, sugary beverages, sweets, potatoes, refined grains, fish, and dairy did not substantially change our estimates.

In addition to the choices we had to make in the construction of the index, this study has some other limitations. First, dietary data were derived from self-reported diet measured with FFQs, making measurement-errors likely. However, because we used relative scores (quintiles) of intake and the FFQs were shown in several validation studies to adequately rank subjects according to intake we do not expect these measurement-errors to have largely affected our results. Second, we did not have dietary data for many of the participants of the original cohort, which might have resulted in selection bias if associations of plant-based diets with T2D risk differed in those included and those not included in our current analyses. Third, we assumed stable diets over time. However, the estimates were similar after excluding the participants who were likely to change their diet during follow-up, such as participants with CHD, stroke, and cancers at baseline.¹⁵ Last, our results may be generalizable only to people of similar age and race.

IV. CONCLUSIONS

In this large population-based cohort, higher adherence to an overall plant-based diet is associated with lower longitudinal insulin resistance, and lower risk of prediabetes and T2D, indicating a protective role of diets high in plant-based foods and low in animal-based foods in the development to T2D beyond strict adherence to a vegetarian or vegan diet. These promising findings call for further exploration of overall plant-based dietary recommendations aimed at T2D prevention.²⁵

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