EFFECTIVENESS OF PLANT-BASED DIET ON REDUCING THE RISK OF TYPE 2 DIABETES MELLITUS: A LITERATURE REVIEW

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ABSTRACT

Prevalence of Type 2 Diabetes Mellitus (T2DM) disease in Indonesia is still classified as high. Dietary pattern is a factor that affects the occurrence of T2DM, hence patients' dietary pattern must be monitored to avoid further health complications. One of the interventions that can be applied is a plant-based diet, with a consumption pattern of plant-food such as fruit, vegetable, nut, and seed. The aim of this literature study is to identify the effectiveness of plant-based diet in patients with T2DM. This study was conducted using literature review method that resulted in six relevant journals within the last ten years from *Google Scholar, PubMed/Medline, Science Direct,* and *Wiley Online Library*. The results of this study show that a plant-based diet affects weight loss, body mass index, blood glucose (HbA1C, fructosamine, fasting plasma glucose), and hormones (insulin, GLP-1, PYY, PP, amylin). It proves that plant-based diets have a positive impact on people with T2DM patients.

Keywords: dietary pattern, type 2 diabetes mellitus, plant-based diet

INTRODUCTION

Diabetes Mellitus (DM) is a metabolic disease marked by high sugar level in the blood called hyperglycemia due to abnormalities in insulin action, insulin secretion, or both. Indonesia is a country that has a high prevalence of Diabetes Mellitus. In 2018, the prevalence in Indonesia increased by 1.6% from 2013 which was from 6.9% to 8.5% (Saputri, 2020). Based on data from Indonesia Basic Health Research (2018), the prevalence of Diabetes Mellitus in women is greater (1.7%) than men (1.4%). In addition, Diabetes Mellitus diagnosed in urban communities is also greater than in rural areas, 2.0% and 1.0%, respectively (Saputri, 2020).

There are two types of Diabetes Mellitus, namely type 1 Diabetes Mellitus (T1DM) and type 2 Diabetes Mellitus (T2DM). T1DM or Insulin-Dependent Diabetes Mellitus caused by insufficient insulin production, while T2DM or Non-Insulin-Dependent Diabetes Mellitus is caused by the ineffective use of insulin (Mahfudzoh et al., 2019). T2DM dominates 90% of all Diabetes Mellitus cases in Indonesia. T2DM usually occurs in individuals aged >45 years. Some of the risk factors for T2DM include dyslipidemia, lack of physical activity, obesity, hypertension, and an unhealthy diet (Mahfudzoh et al., 2019).

Diet is highly influential on the occurrence of Diabetes Mellitus. To prevent its complications or severity, the diet for people with Diabetes Mellitus must be considered. Blood sugar content in Diabetes Mellitus patients tends to be uncontrolled. It rises dramatically when a person with Diabetes Mellitus eats meals high in carbohydrates and/or glucose, hence diet must be closely monitored to keep blood sugar levels under control (Mahfudzoh et al., 2019). The type of diet that can be given to T2DM patients is by increasing fiber intake to improve glycemic control (Yosmar et al., 2018).

Plant-based diet has existed for a long time, but there has been an increase in demand as a result of awareness increment. The popularity of this diet is motivated by the concern of animal prosperity as well as the health benefits delivered by the diet, such as weight loss. Plant-based diet trend is also influenced by environmental, economic, and religious factors, as a result of rising concern about the impact of animal food production on greenhouse gas emission (Tran et al., 2020). The aim of a plant-based diet is to eat as many nutrient-dense plant foods as possible while reducing processed food,

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animal food, and oil. Whole plant foods, including nut, fruit and vegetable, and seed, are emphasized in plant-based diet (Tuso et al., 2013). This food is both nutrient-dense and low in calories. Fiber, flavonoid, vitamin C, vitamin B1, potassium, magnesium, and folic acid all can be found in plant-based diet. Furthermore, it has low saturated fat and cholesterol level (Bowman, 2020).

Plant-based diet is related to a better weight control and blood lipid profile, and it is frequently recommended for chronic disease prevention. It has been proven that a plant-based diet could lower the risk of heart disease, hypertension, Diabetes Mellitus, and certain cancers (Tran et al., 2020). The benefit for diabetic patients is that a lower-fat diet with little or without meat can help to avoid and manage diabetes by increasing the insulin sensitivity and reducing the insulin resistance. In addition to its effect on Diabetes Mellitus, switching from an omnivorous diet to a plant-based diet resulted in weight loss in the majority of people (Tran et al., 2020). This is due to a high fiber and low fat diet, which leads to the reduction of energy intake, an improvement in the thermic effect of food, and weight loss. Plant-based diet is commonly related with a higher risk of malnutrition than omnivore diet. However, this may be overcome with a well-balanced diet, careful planning, practice of reading food labels, and self-discipline (Tuso et al., 2013).

Many studies on the development of plant-based food have been performed in Indonesia. According to Avianty and Ayustaningwarno (2014), black soybean sweet potato snack bar has a low glycemic index and glycemic load, making it suitable as a diabetic snack. Complex carbohydrate in the black soybean sweet potato snack bar helps to manage blood sugar increment, while isoflavone and anthocyanin act as antioxidant. Winarsi et al. (2021) published another study that can be applied to enhance people's transition to plant-based diet. The latest results are vegetable yogurt product derived from mung bean containing 525.96±48.9 mg GAE/L phenolic antioxidant and 43.18±1.87% soluble protein. Also, this mung bean milk yogurt product contains 3.50% dietary fiber. People with degenerative disorders, such as Diabetes Mellitus, certainly take benefit from the presence of phenolic antioxidants. These studies show that a plant-based diet is beneficial to health, especially for diabetic people.

The aim of this literature review is to identify the efficacy of plant-based diet in patients with T2DM. Additionally, to raise awareness about the effect of plant-based diet on patients with T2DM.

METHODS

The literature review is used as the design method in this study. To conduct this literature review, researchers compiled research publications from the last ten years with cross-sectional, cohort, case-control, crossover randomized and prospective study design (2011–2021). The electronic databases used to obtain the research paper include *Google Scholar, PubMed/Medline, Science Direct* and *Wiley Online Library*. Plant-based diet; Type 2 Diabetes Mellitus; glycemic index; non-insulin dependent were the keywords selected in this literature review, which were found in English-language international journals and could be read in full text using the AND search approach. People with Type 2 Diabetes Mellitus who adopted a plant-based diet and saw improvements to their health were included as the selected paper. At-risk groups, those with pre-diabetes, people with type 1 Diabetes Mellitus and utilized diets other than plant-based diet were not included in the study.

This literature review was conducted following PRISMA guidelines which consists of a four-phase flow chart (Figure 1). In the first phase, there were 2838 journals obtained, then several journals were eliminated because the same journal appeared more than once and for other reasons, such as not English-language journals, the year published before 2011 or after 2021, and not research articles so that in the second phase there were 791 journals. Several journals were eliminated because the title/abstract was irrelevant to the research question:184 journals were eliminated and 607 journals were left in the third phase.

Several research articles were excluded because they were not fully accessed, leaving 28 journals in the fourth phase. After reviewing 28 journals, in the fourth phase some research articles were excluded for several reasons including the sample in the study was not type 2 diabetes patients, the study design was wrong, and the study

did not explain the plant-based diet intervention. After going through the screening, six relevant journals were obtained.

RESULTS AND DISCUSSION

In total, six research articles were included in this review after selecting the inclusion and exclusion criteria according to Table.1. Those six research articles are analyzed regarding the impact of the plant-based diet in people with T2DM. There are relations between the plant-based diet and T2DM. The consumption of a plant-based diet by patients can decrease weight and body mass index, blood glucose rate, in addition to influence hormones like insulin, intestinal hormone, etc.

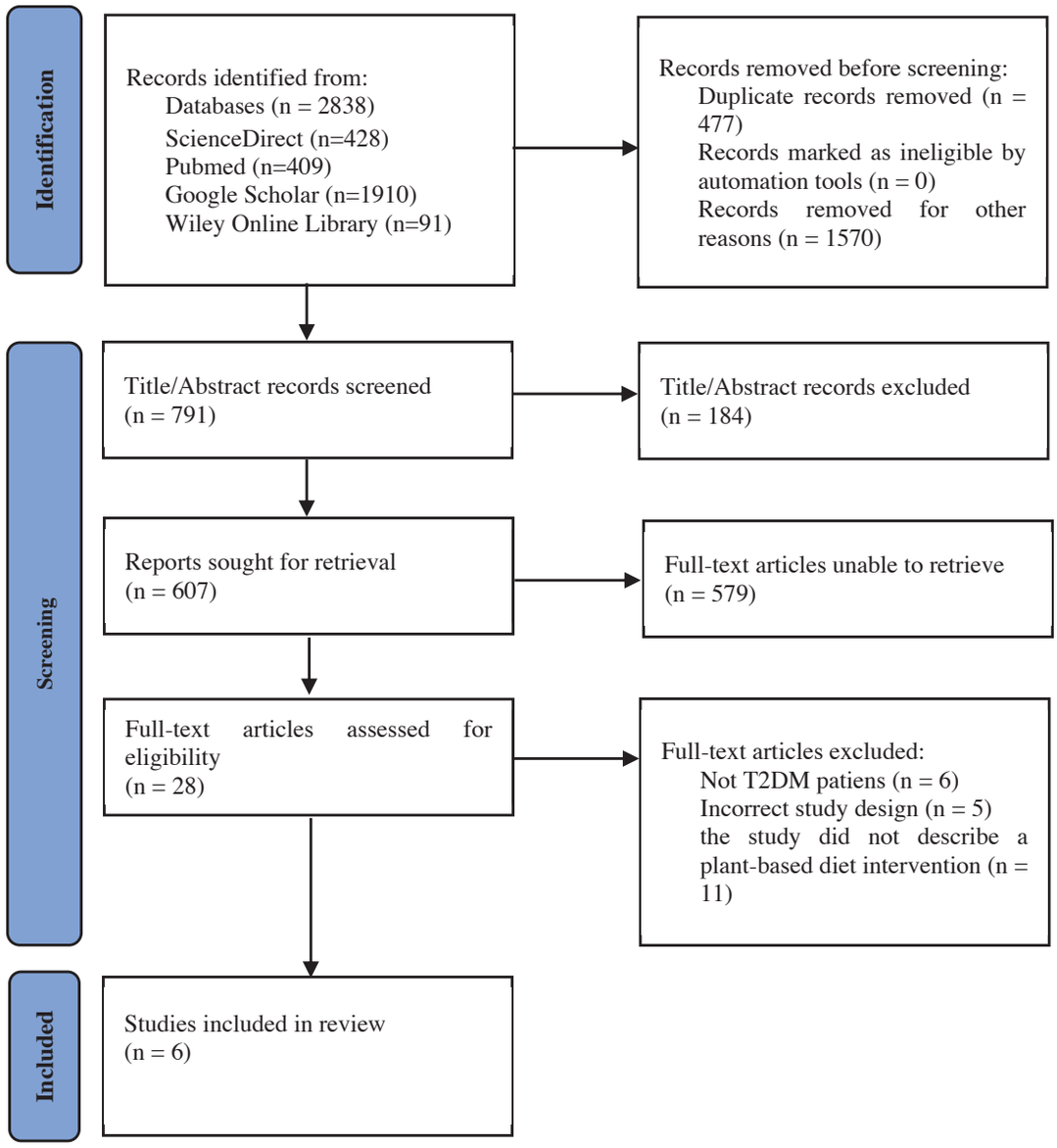

Figure 1. PRISMA flow chart of the literature review

Weight Loss

Patients with T2DM are mostly overweight or obese, which can lead to an increase in the incidence of hypertension, dyslipidemia, and unable to control glycemic level, so a high-intensity diet, physical activity, and behavioral change strategies to lose weight are recommended (Bangalore et al., 2018). Change in the dietary pattern or commitment to a specific diet program is prevailing in people who want to lose weight. The low carb and fat diet for six months can be one of the other interventions for losing weight (Johnston et al., 2014). Wright et al. (2017) suggested a whole food plant-based diet to change the dietary in patients with T2DM. A whole plant-based diet is based on cereals, nuts, vegetables, and fruits (around 7–15% energy total from fat). In consumption of food without limiting it until replete, a patient that commits to a whole food plant-based diet in twelve month s was proven effective and safe to lose weight and decrease a little bit of blood glucose rate without doing rigorous physical exercise.

Body Mass Index

Body Mass Index (BMI) is a calculation usually used to define characteristics of height/weight and categorize people as underweight, regular, or overweight (Nuttal, 2015). The way to calculate BMI is to divide the weight (kilograms) by the height squared (meters) (Alsulami et al., 2021). Enhancement of BMI is usually related to several diseases, such as T2DM disease. BMI is discovered to be an independent variable that is significant for diabetes in multivariate regression research models (Alqurashi et al., 2011). Therefore, the BMI number can be lowered by doing a diet program for people with T2DM. One of those diets is a plant-based diet, which is known to lower BMI. Research by Wright et al. (2017) indicates that the body mass index group of patients with a plant-based diet intervention had a higher average than patients with standard interventions. A plant-based diet has lower fat, higher water, and fiber and there was a reduction in energy density from food consumed by patients. The group with a plant-based diet as an intervention also stated feeling less hungry.

Blood Glucose

Fiber, both soluble and insoluble, can prevent an increase in blood glucose level. This is because fiber serves to bind excess blood glucose in the blood along with feces. In addition, it will be beneficial for carbohydrate metabolism so that it can lower blood glucose level (Made et al., 2017). As mentioned in a study conducted by Abubakari et al. (2014) in Ghana the average capillary glucose result dropped to near normal after 21 days of being given the Ma-Pi macrobiotic dietary intervention in T2DM patients. It also showed that fructosamine level dropped significantly. In the study conducted by Yang et al. (2021), they stated that they believed a plant-based diet would overcome to some extent inflammation and insulin secretion and improve blood glucose control. This can reduce the risk of T2DM. Research by Alsulami et al. (2021) also showed that increasing plant protein intake is an effective way to manage the level of blood glucose, especially in India, Asia, in individuals with high genetic susceptibility to T2DM.

Study by Wright et al. (2017) showed there was a difference in HbA1C in the intervention group, with a 5 mmol decrease in six months. In the group that received the intervention, two individuals were no longer included in the diagnostic criteria at six and 12 months of intervention.

HbA1C reduction supported the intervention and all diabetes patients who adhered to the intervention experienced improvement, two of whom had improved condition based on HbA1C. Research conducted by Alsulami et al. (2021), stated that among individuals with a lower plant-based diet, individuals with risk allele >1 had higher-

Table 1. Result of Literature Review on the Association between Plant-Based Diet with Type 2 Diabetes Mellitus

Research Title	Author	Year	Method	Instrument	Sample	Outcomes	Results
Ma-Pi 2 Macrobiotic Diet Intervention During 21 Days in Adults with Type 2 Diabetes Mellitus, Ghana 2011.	Braimah Baba Abubakari et al.	2014	Prospective 21 days dietary intervention study	Assessment of blood pressure, anthropometry, blood biochemical tests, and urine tests.	23 patients aged 25-70 years old with T2DM were given the Ma-Pi 2 macrobiotic dietary intervention for 21 days.	Blood sugar, fructosemine, and insulin.	The Ma-Pi 2 macrobiotic diet affects the treatment of T2DM as evidenced by a rapid decrease in hyperglycemic and fructosemic values, marked by a decrease in blood glucose (47%) and fructosamine (27%). In addition, there was a decrease in insulin consumption by 44%
The BROAD Study: A Randomized Controlled Trial Using A Whole Food Plant-Based Diet in the Community for Obesity, Ischemic Heart Disease or Diabetes.	Wright et al.	2017	Randomized Controlled Trial	Stadiometer, calibrated medical scale, and T-Lab Gisborne.	65 subjects were randomized (control n = 32 i.e. group given standard media care, intervention n = 33 i.e. group given standard medical care and added diet change program), 75.4% (49 subjects) completed the study up to 6 months and 70% (23 subjects) intervention participants were followed up at 12 months.	Body weight, cholesterol and HbA1C.	Within one month, the reduction in BMI was higher on the WFPB diet compared to the normal treatment. The average reduction in cholesterol was higher with the WFPB diet compared to normal treatment, but these two groups had no significant difference. In patients diagnosed with diabetes within 6 months of intervention, there was a reduction in the value of HbA1C and an improvement in quality of life.
A Plant-Based Meal Increases Gastrointestinal Hormones and Satiety More Than an Energy- and Macronutrient-Matched Processed-Meat Meal in T2D, Obese, and Healthy Men: A Three-Group Randomized Crossover Study	Klementova et al.	2019	Randomized crossover study	Measuring anthropometry and blood pressure, also gastrointestinal and appetite hormones.	It consisted of 60 men divided into 20 men diagnosed with T2DM aged 30-65 years old with a BMI between 25-45 kg/m2 and taking diabetes medication, 20 obese men with BMI and men of the same age as diagnosed T2DM (obesity), and 20 control of the same age (healthy) given two interventions namely fasting for 10-12 hours for all men, whereas men with T2DM were ordered to skip their diabetes medication in the evening and the morning before assessment. Then, they were given a meal consisted of processed meat and cheeseburger (M-meal), or a vegetable tofu burger (V-meal).	Gastrointestinal and appetite hormones.	There was an increase in satiety and gut hormones, after consuming a plant-based meal with tofu when compared to a processed meat and cheese meal that was appropriate for energy and macronutrients fulfillment and 16-week plant-based diet intervention in T2DM patients could increase postprandial GLP-1 concentration especially in participant with T2DM.

Continued Table 1. Result of Literature Review on the Association between Plant-Based Diet with Type 2 Diabetes Mellitus

Research Title	Author	Year	Method	Instrument	Sample	Outcomes	Results
A Plant-Based Meal Stimulates Incretin and Insulin Secretion More Than an Energy- and Macronutrient-Matched Standard Meal in Type 2 Diabetes: A Randomized Crossover Study	Kahleova et al.	2019	Randomized crossover study	Assessment of anthropometry and blood pressure, beta-cell hormone function, plasma glucose, gastrointestinal insulin resistance and appetite.	T2DM men aged between 30 and 65 years old, BMI 25 & 45 kg/m2, using oral hypoglycemic agent for at least one year such as metformin and/or sulfonylurea or treated with lifestyle modification alone, had an HbA1C of 42 to 105 mmol/mol (≥6 0.0 to 11.8%), at least had three symptoms of metabolic syndrome, and treated overnight fasting for at least 10-12 hours and the night or morning before assessment, and were not taking any diabetes medication. Then subjects were given a meal which consisted of processed meat burgers (M-meal), or vegetable tofu burgers (V-meal).	Postprandial incretin, insulin secretion of T2DM patients, and pancreas beta-cell	An increase of insulin secretion and postprandial incretin in individuals with T2DM after consuming V-meal suggests the therapeutic potential of plant foods to repair beta-cell function in T2DM.
Lower Dietary Intake of Plant Protein Is Associated with Genetic Risk of Diabetes-Related Traits in Urban Asian Indian Adults	Alsulami et al.	2021	Cross-sectional epidemiological study	Weight scale, height measure, Hitachi-oqw Auto Analyzer, high-performance liquid chromatography on a Variant machine (Hercules, USA, CA, Bio-Rad), glucose oxidase-peroxidase, FFQ form, Phenol chloroform technique, SPSS application.	1062 individuals (496 individuals with NGT and 566 individuals with T2DM).	HbA1C, Fasting Plasma Glucose (FPG), and reduced risk of T2DM in individuals consuming plant protein.	Vegetable protein intake is an effective way to regulate the level of blood sugar in individuals with higher genetic susceptibility to T2DM in India.
Association of Plant Based Diet and Type 2 Diabetes Mellitus in Chinese Rural Adults: The Henan Rural Cohort Study	Yang et al.	2021	Cohort study	Sociodemographic related information, medical history was collected using a questionnaire, and lifestyle factors.	37,985 of 39,259 women and men aged 18-79 years. Excluding participants who had too low or too high energy intake.	Blood glucose, plant based-diet index, and insulin secretion.	In comparison to participants who had a lower plant-based diet index, participants who had a high plant-based diet index had a lower risk of T2DM.

—HbA1C and FPG levels rather than individuals with risk allele ≤1. HbA1C is glucose attached to red blood cells, where HbA1C levels in the blood will describe the average blood glucose level from the last three months (Fauzi, 2013).

Hormone

Lifestyle intervention in patients with T2DM, especially regarding dietary patterns, has more effectiveness than insulin treatment. This is evidenced by a study conducted by Abubakari et al. (2014) which stated that diet is important in the therapy of Diabetes Mellitus. This study uses a dietary intervention that contains plant-based ingredients so this diet has high fiber content, adequate protein, low fat, and high complex carbohydrate. This diet provides a longer feeling of fullness. In addition, this diet also normalizes the function of beta cells and improves insulin sensitivity by limiting energy intake. This statement is supported by study conducted by Kahleova et al. (2019). Diet that contains plant-based foods can increase post-prandial insulin secretion, so it affects the treatment of diabetic people. Lifestyle intervention, especially in diet, needs to be used as the first choice of treatment. In addition to having a healthy effect, dietary changes are considered cheaper than the use of drugs and bariatric surgery.

Plant-based foods, especially those containing complex carbohydrates and low in fat can slow the absorption of glucose in the intestine. The fiber in food is useful to improve glycemic control that reduces insulin needs. So that insulin sensitivity increases (Abubakari et al., 2014). In addition to being high in fiber, plant-based foods also contain antioxidants, like polyphenol, which can trigger insulin secretion by inhibiting the absorption of glucose in the intestine. It causes decreased postprandial glycemic response and increased insulin sensitivity (Yang et al., 2021).

Food that enters the body gives a signal to the digestive tract to secrete the incretin hormone. This hormone consists of Glucagon-like Peptide-1 (GLP-1) or also known as the hormone that causes a feeling of satiety and Gastric Inhibitory Peptide (GIP). These two hormones help in the secretion of insulin and maintain glucose homeostasis in the body. Besides GLP-1, other satiety hormones are Pancreatic Polypeptide (PP), Peptide YY (PYY), and amylin which serve to regulate appetite and energy homeostasis. The secretion of this hormone depends on diet composition and body condition disorder. The effect given by the incretin hormone in patients with T2DM will be lower due to a decrease in beta-cell sensitivity. This condition can be detrimental to the body because the incretin hormone contributes to 50-70% of the total postprandial insulin secretion. Study by Klementova et al. (2019) found that high levels of GLP-1 were found in respondents who had T2DM who intervened using plant-based tofu burgers. High levels of PYY were also found in respondents with T2DM. The increase in this hormone indicates the regulation of satiety in individuals with insulin resistance. However, the increase in this hormone also has a relationship with the presence of free fatty acids (FFA) and other nutrients in the intestine. Amylin level is known to regulate glucose homeostasis and provide a feeling of satiety to reduce eating (Klementova et al., 2019).

Plant-based foods can provide a higher feeling of fullness than animal-based foods. This is due to the presence of fiber and bioactive compounds, like polyphenol. Fiber can increase the secretion of PYY, causing a feeling of fullness, while polyphenol plays a role in increasing GLP-1 secretion, then increasing the half-life by increasing insulin secretion and inhibiting dipeptidyl peptidase-4. Animal-based foods can cause postprandial hyperlipidemia, postprandial hyperinsulinemia, increased lipoperoxide, and lower GLP-1 hormone secretion.

Negative Impact of Plant-Based Diet

A plant-based diet rich in refined carbohydrates, sugar, sweet beverages, and salty vegetables is an unhealthy sort of plant-based diet. This sort of diet has been linked to metabolic syndrome such as obesity, hypertriglyceridemia, low HDL level in the blood, and high blood pressure, all of which lead to non-communicable diseases. These findings are supported by research from the Nurses' Health Study (NHS) in the United States, which found a link between unhealthy

plant-based diet and excess weight gain as well as a high risk of T2DM. Research by Wright et al. (2017) reported there were no major side effects from the intervention, but one participant experienced hypoglycemia during the first week of the plant-based diet intervention, and two others showed a decrease in serum vitamin B12 level so they had to be given supplements.

The limitations of the research articles that we used are a small sample and not taken at random from several papers, as well as the presence of a sample who decided to leave in the middle of the study, measurement bias in the assessment of eating history, ethnic and economic differences that may not apply to other ethnic populations, the short intervention period and does not really describe the sample's eating pattern. In addition, several papers did not examine the bioavailability of micronutrients from the food that is given at the time of the intervention. The limitation of this literature study is there are many types of plant-based diet so that the discussion in this literature is less specific.

CONCLUSION

Food intake has a major impact on T2DM. Plant-based diet is effective to decrease the risk of T2DM in patients. It can decrease the body weight and body mass index (BMI) because this diet is low in carbohydrate and fat, and also high in fiber. The high amount of fiber in the plant-based diet can decrease the blood glucose rate which is marked by the reduction of fructosamine and HbA1C, it can endure hunger and increases the secretion of insulin and incretin.

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