

# AN ASSESSMENT OF DIFFERENT DIETARY APPROACHES FOR THE MANAGEMENT OF DIABETES

## Abstract

Diabetes is a prevalent chronic condition necessitating effective dietary interventions for management. This chapter explores the efficacy of different dietary approaches, with a specific focus on low-carbohydrate and plant-based diets, in managing diabetes. Research indicates that both dietary approaches contribute to improved glycemic control and overall health outcomes in individuals with diabetes. Low-carbohydrate diets exhibit particular effectiveness in reducing blood sugar levels, while plant-based diets demonstrate the potential to enhance insulin sensitivity and reduce cardiovascular disease risk. Nevertheless, potential drawbacks include nutrient deficiencies in plant-based diets and high saturated fat intake in low-carbohydrate diets. Further research is essential to determine the optimal dietary strategies for diabetes management and to develop effective strategies to promote long-term adherence to healthy dietary habits among individuals with diabetes.

**Keywords:** Diabetes; Dietary approaches; Low-carbohydrate diet; Plant-based diet; Blood sugar control; Insulin sensitivity; Nutrient deficiencies.

## Authors

### Dr. Asghar Ali

School of Chemical and Life Sciences  
Jamia Hamdard  
New Delhi, India.  
asgharali@jamiahamdard.ac.in

### Manika Garg

School of Chemical and Life Sciences  
Jamia Hamdard  
New Delhi, India.

### Riya Sharma

School of Chemical and Life Sciences  
Jamia Hamdard  
New Delhi, India.

### Sarita

Department of Fruit Science  
College of Horticulture  
Dr. Y.S. Parmar University of Horticulture  
and Forestry  
Nauni-Solan, Himachal Pradesh, India.

### Ruhi Firdaus

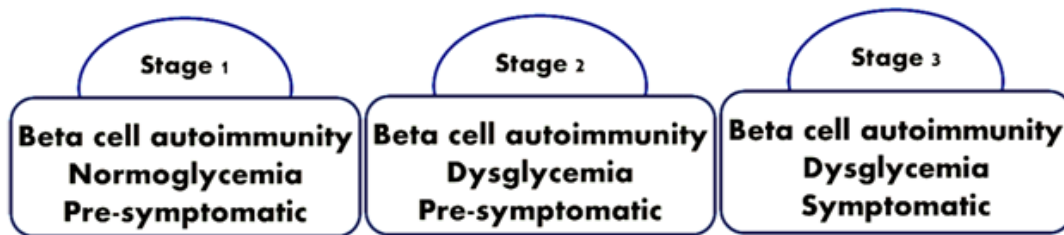
School of Unani Medicine and Surgery  
Jamia Hamdard  
New Delhi, India

### Dr. Md Salik Noorani

School of Chemical and Life Sciences  
Jamia Hamdard  
New Delhi, India.  
saliknoorani@jamiahamdard.ac.in

## I. INTRODUCTION

The body's main energy source is derived from blood glucose obtained through food consumption. Diabetes, a metabolic disorder, is marked by high blood sugar and compromised pancreatic insulin production, leading to lasting damage to the heart, blood vessels, eyes, nerves, and kidneys, including nephropathy, retinopathy, and cardiovascular complications. The main types are Type 1 diabetes (T1D) and Type 2 diabetes. T1D is an autoimmune disorder characterized by the destruction of pancreatic beta cells, influenced by genetic factors and environmental triggers, typically occurring during adolescence. It accounts for approximately 5-10% of all diabetes cases, and is entirely dependent on insulin injections or insulin pump therapy to regulate their blood sugar levels. Unlike type 2, It is not directly associated with body weight or obesity. The destruction of beta cells results in little to no insulin production in the body. Family history of Type 1 diabetes, genetic predisposition, and certain viral infections are considered risk factors. Prediction models based on genetic factors have been developed to identify individuals at risk of developing T1D, enabling proactive monitoring and interventions. However, genetic factors alone do not fully explain the development of the disease. The Eisenbarth model, proposed in recent years, delineates three key stages in the natural history of T1D (Primavera et al., 2020). Stage 1, known as the "asymptomatic phase," is characterized by the presence of autoantibodies (at least two islet autoantibodies), normal blood sugar levels, and absence of symptoms.



**Figure 1:** Development of Type 1 Diabetes

Stage 2 involves the presence of multiple autoantibodies and abnormal glucose metabolism without diabetes. Finally, Stage 3, referred to as "clinical diabetes," is marked by the manifestation of diabetes-related symptoms (Figure 1). The optimal management for type 1 diabetes involves insulin therapy, regular blood sugar monitoring, healthy eating, physical activity, and careful carbohydrate management. The duration and progression between stages remain uncertain. Forecasting and preventing T1D pose significant challenges for medical professionals and researchers, necessitating a thorough understanding of each phase of this complex condition.

Type 2 diabetes, which is more common than type 1, is characterized by elevated blood sugar levels brought on by insulin resistance and decreased insulin production. Despite being able to happen at any age, it often begins to manifest in maturity. The primary cause is a combination of genetic and lifestyle factors, with obesity, physical inactivity, and unhealthy eating habits playing significant roles. Excess body weight, particularly central obesity, increases the risk of developing type 2 diabetes. Management of type 2 diabetes involves lifestyle modifications, including adopting a healthy eating pattern, engaging in regular physical activity, and managing body weight. Medications may be prescribed to improve

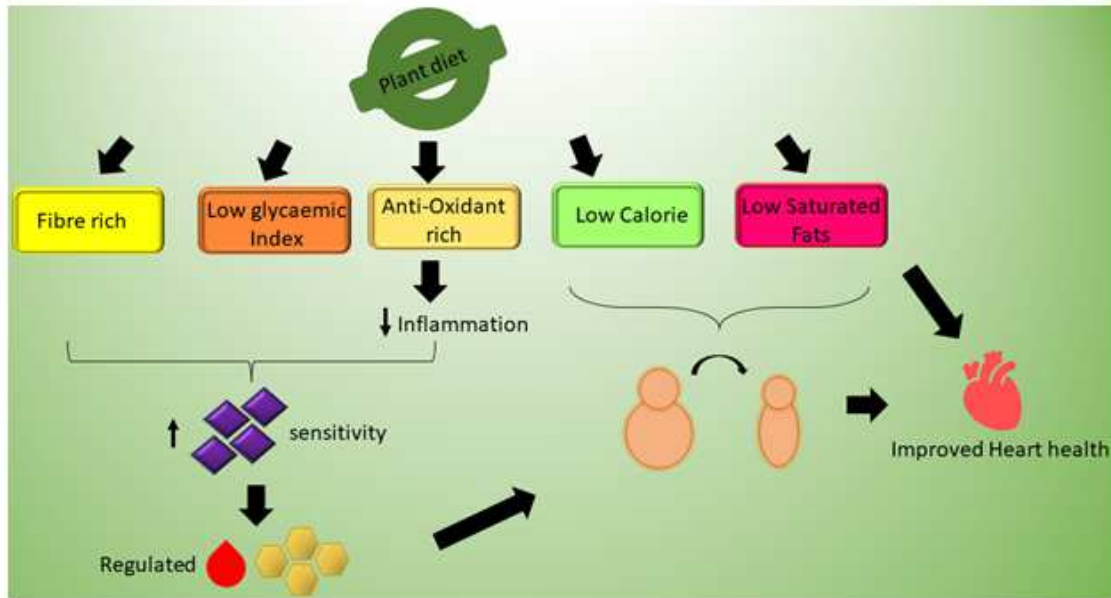
insulin sensitivity, stimulate insulin secretion, or regulate blood sugar levels. In some cases, insulin therapy may be necessary. Regular monitoring of blood sugar, blood pressure, and cholesterol levels is crucial for effectively managing and preventing complications. Patient education, support, and self-care practices are essential for long-term management. For effective control and complication prevention, continuous management is essential in type 2 diabetes, necessitating close collaboration between individuals and their healthcare providers to tailor a personalized management plan aligned with their specific needs and circumstances. Type 2 diabetes arises from pancreatic beta cell impairment, hindering insulin utilization. Microvascular and macrovascular complications, like retinopathy, nephropathy, neuropathy, and cardiovascular comorbidities, frequently occur in T2D individuals. Genetic and environmental factors contribute to the pathophysiological abnormalities causing disrupted glucose homeostasis. Primary treatment aims to maintain normal blood glucose levels. Options include exercise, dietary adjustments, insulin therapy, and psychological counseling (Chung et al., 2020). Despite the requirement for medicine and insulin therapy, patient-centered initiatives to educate themselves about nutrition and exercise to reduce complications have also grown in importance. The importance of dietary education necessitates training, counselling, and diet management (Silva et al., 2013). A significant decrease in body mass index (BMI), glycated haemoglobin (HbA1c), and fasting blood sugar levels can all be attributed to dietary education interventions, according to earlier research. These interventions have also been shown to significantly lower the risk of microvascular complications and cardiovascular disease.

In managing T2D, blood glucose levels can be managed with diet alone or in conjunction with hypoglycemic medications. Different diets with different food compositions cause changes in the gut microbiome and metabolites, which are in charge of the body's overall glucose metabolism. For instance, different diets with varying amounts of amino acids can change plasma concentrations of branched-chain amino acids (BCAAs), associated with a higher risk of T2D. An increase in fibre and protein in the diet reduced the participant's fasting glucose levels and altered the quantity of *Akkermansia muciniphila* (Guo et al., 2020). The usefulness of various dietary regimens in controlling diabetes is examined in this review, with a special emphasis on low-carbohydrate and plant-based diets.

## II. LOW-CARBOHYDRATE DIETS

Low-carbohydrate (low-carb) diets have been used as a weight loss approach since 1860 and more recently in 1972. This approach continues to be popular in contemporary times. Although all forms of low-carb diets aim to reduce overall carbohydrate intake, there is a lack of consensus regarding a standardized definition for what constitutes a low-carb diet. Within the context of diet composition, the three primary macronutrients include protein (providing 4 kcal/g), fat (providing 9 kcal/g), and carbohydrates (providing 4 kcal/g). Consequently, the term 'low carbohydrate' has been defined diversely across research studies. It may refer to either the total daily carbohydrate quantity or as a proportion of the daily macronutrient intake. Distinguishing from very low-carb diets, often characterized by an absolute carbohydrate amount, typically less than 70 grams per day, other gradations of dietary carbohydrate are typically established based on the proportion of total energy consumption. With a reduction in total caloric intake, the relative energy derived from carbohydrates escalates (Fig. 2). For instance, a carbohydrate intake of 200 grams could be

categorized as moderate for an energy intake of 1,500 calories, high for 1,200 calories, and moderately low for 2,000 calories.

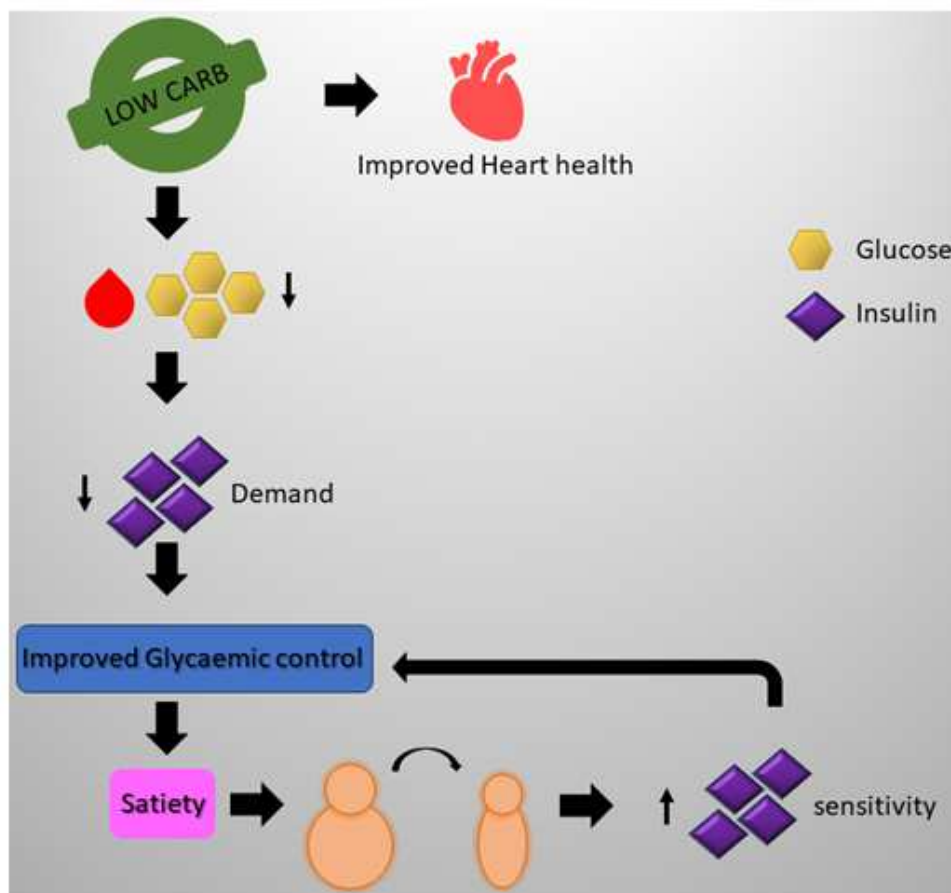


**Figure 2:** Role of Plant Diet in Improving Health of the Heart

1. **Mechanisms of Action in Managing Diabetes:** Carbohydrate restriction has historically played a pivotal role in glycemic control for both type 1 and type 2 diabetes, predating pharmaceutical interventions. Minimizing dietary carbohydrates can effectively aid in glycemic control by reducing insulin demands (Feinman et al., 2015). Recent research has demonstrated that adopting ketogenic strategies significantly reduces reliance on insulin and oral medications, resulting in lowered haemoglobin A1c levels and sustained intervention adherence over 12 months (Chen et al., 2019; McKenzie et al., 2017). Furthermore, favorable changes in cardiometabolic risk factors have been observed (Bhanpuri et al., 2018). A comprehensive study and meta-analysis have provided low-quality evidence supporting the effectiveness of low-carb approaches in enhancing type 2 diabetes remission, while maintaining safety (Goldenberg et al., 2021a). Recent recommendations have suggested low carb as a possible strategy to nutritional lifestyle and diabetes (medical nutrition treatment) (Davies et al., 2018; Evert et al., 2019). Recent prospective and randomized controlled trials have repeatedly shown benefits from a very low carb diet (less than 14% of energy from carbohydrates) for glycemic control, weight loss, and persistent medication reduction.
  
2. **Evidence for the Effectiveness of Low-Carbohydrate Diets in Managing Diabetes:** Despite a growing body of research supporting the efficacy of low-carbohydrate diets (LoCHO) and their increasing acceptance, clinicians remain reluctant to recommend them, particularly for high-risk populations who have not benefited from traditional low-fat diets. This hesitation partly arises from the association of carbohydrate restriction with the controversial Atkins diet, criticized for advocating unlimited fat consumption. Health organizations have been slow to endorse carbohydrate-restricted diets, despite evidence linking excessive carbohydrate intake to metabolic irregularities in diabetes and insulin resistance. Some researchers, in line with prior discussions, tend to downplay the

advantages of LoCHO diets (Vernon et al., 2004). The perception of rapid weight loss in LoCHO diets has often been linked to changes in body water content rather than fat loss (Fig 3). However, various studies indicate that this transient water shift normalizes within two to three weeks, leading to actual fat mass reduction (Brehm et al., 2003; Freedman et al., 2001; Volek et al., 2004). Recent research revealed that adopting a low-carb diet led to a daily energy deficit of 1027 kcal and a reduction in average daily caloric intake from 3111 to 2164 kcal. Weight loss was proportional to the calorie deficit and attributed to fat mass reduction rather than water loss.

Claims of unrestricted fat consumption causing long-term weight gain and obesity in low-carb diets lack substantiation (Franz et al., n.d.). It's essential to recognize that the type of fat consumed carries greater significance than overall fat intake. Saturated fats correlate with increased cardiovascular risk, while monounsaturated and polyunsaturated fats exhibit opposite associations.



**Figure 3:** Role of Low Carbohydrate Diets in Blood Glucose Level

- 3. Reduction in Blood Sugar Levels:** Dietary carbohydrate restriction correlates with diminished glycemic control and related factors like body mass and lipid profile. To ascertain a diet's impact on glycemic control, it's crucial to differentiate between the effects of carbohydrate reduction and weight loss, thus determining whether the diet benefits glycemic control independently of weight changes. This distinction was

exemplified in a short-term study involving weight-stable individuals with diabetes. Carbohydrate restriction significantly decreased glycosylated hemoglobin (HbA1c) compared to a high-carbohydrate control diet (8.1% to 7.3%,  $p < 0.05$ ), demonstrating its favorable influence on glycemic control even without substantial weight loss (Sheard et al., 2004). In a subsequent study conducted by the same researchers, a low-carbohydrate intervention (20% carbohydrates, 30% protein, 50% fat) demonstrated even more favorable effects on glycemic control compared to the control diet (55% carbohydrates, 15% protein, 30% fat) (Gannon et al., 2003) among 8 diabetic men in a randomized 5-week crossover design with a 5-week washout period. Despite equal weight loss between the two diets, the low-carb diet exhibited lower HbA1c levels ( $7.6\% \pm 0.3$ ), glucose levels, and insulin levels compared to the high-carb group (HbA1c  $9.8\% \pm 0.5$ ). These results demonstrate that the benefits of a low-carb diet for glycemic control are mostly due to carbohydrate restriction as opposed to weight loss, which is independent of weight loss.

A low-carbohydrate (LoCHO) diet with 20% carbohydrates demonstrated a notable reduction in body weight, BMI, fasting blood glucose, and HbA1C at 6 months compared to the high-carbohydrate group with 60% carbohydrates in a recent trial of obese diabetic people. The low-carb diet group also exhibited a significant decrease in insulin demand and hypoglycemic medication usage. The study by Samaha et al. (Foster et al., 2003a) further demonstrated that diabetic participants following a low-carb diet had lower mean fasting plasma glucose (FPG) levels than those on a low-fat diet. To summarize, the advantageous impact of the LoCHO diet on glycemic control proved consistently significant, regardless of weight loss, particularly in studies maintaining sufficient carbohydrate restriction (Foster et al., 2003a). Moreover, other research indicated that weight loss alone marginally enhanced glycemic control, comparable to the outcomes of a low-fat diet. Ultimately, a low-carbohydrate diet exhibits potential in notably ameliorating glycemic control, leading to a notable decrease in the requirement for exogenous insulin or oral hypoglycemic medications.

#### 4. Improvement in Other Health Outcomes:

- **Weight Loss:** Low-carbohydrate diets have been associated with significant weight loss in individuals with diabetes (Merrill JD, et al 2020, Arora SK, et al 2005, Eleni et al 2023). By restricting carbohydrate intake and focusing on higher protein and fat consumption, these diets can lead to reduced calorie intake and improved satiety, which can contribute to weight loss. Plant-based diets, particularly those that emphasize whole foods and limit processed foods, can also contribute to weight loss in individuals with diabetes (Jardine et al., 2021a; McMacken & Shah, 2017). Plant-based diets tend to be high in fiber and low in saturated fat, promoting feelings of fullness and supporting weight management (Kahleova et al., 2011; Najjar & Feresin, 2019).
- **Blood lipid levels:** Low-carbohydrate diets have been shown to favor blood lipid profiles in individuals with diabetes (Arora & McFarlane, 2005; Pavlidou et al., 2023). They can lead to reductions in triglycerides, an increase in high-density lipoprotein (HDL) cholesterol (the “good cholesterol”), and improvements in the ratio of total

cholesterol to HDL cholesterol, which are all markers of improved cardiovascular health (Eric C Westman et al 2008). Plant-based diets, especially those that prioritize the consumption of healthy fats, such as monounsaturated and polyunsaturated fats found in nuts, seeds, and avocados, can also positively impact blood lipid levels (Satija et al., 2016). These diets tend to be low in saturated fat and cholesterol, which can help reduce low-density lipoprotein (LDL) cholesterol (the “bad” cholesterol) and promote a healthier lipid profile. It is important to note that the specific effects on weight loss and blood lipid levels may vary among individuals, and the success of any dietary approach in achieving these outcomes depends on various factors such as adherence, individual metabolic response, and overall dietary quality. Additionally, it is crucial to consider the overall dietary pattern rather than solely focusing on isolated nutrients or macronutrients when assessing the impact on health outcomes. Further research is needed to understand better the long-term effects of low-carbohydrate and plant-based diets on weight management and lipid profiles in individuals with diabetes. Additionally, it is essential to consider the individual’s medical history, preferences, and cultural factors when recommending and implementing dietary approaches for diabetes management. Regular monitoring and guidance from healthcare professionals are vital to ensure optimal results and overall health.

- 5. Potential Drawbacks of Low-Carbohydrate Diets:** For any dietary modification to be effective long-term, it must align with the individual's preferences and practicality. Acceptance is influenced by the diet's feasibility and, crucially, the satisfaction it offers upon adoption. Regrettably, the pleasurable hedonic outcomes of eating are predominantly attributed to the consumption of carbohydrates, particularly in combination with fats. Sweet foods are inherently appealing, posing a challenge for a low-carbohydrate diet (LCD) as it might render low-carb options less flavorful. Consequently, reduced enjoyment of eating could hinder sustained adherence to the LCD. Moreover, the successful adoption of the LCD often entails limiting food diversity, elevating the risk of nutritional deficiencies, and hampering consistent adherence. Another potential limitation lies in the LCD's potential to compromise athletic performance. A study involving elite endurance athletes demonstrated that training with an LCD, accompanied by a high-fat diet (HFD), diminished performance despite an increase in peak aerobic capacity (Burke et al., 2017). This contrasted with diets offering ample carbohydrate availability. Nevertheless, the literature has limited evidence to suggest notable effects of the LCD on physical endurance and performance for most adherents.
- **Risk of Nutrient Deficiencies:** Adopting a low-carbohydrate diet (LCD) may heighten the risk of severe hypoglycemia in individuals with Type 1 Diabetes Mellitus, as glucagon's effectiveness is compromised by depleted glycogen stores in such cases (Turton et al., 2018). The LCD's dietary restrictions, often combined with caloric restriction for weight loss, could lead to nutritional deficiencies, including minerals, vitamins, and trace elements, as well as bone health issues, kidney stones, and potential growth problems, typically evident after three months of usage (Sampaio, 2016). Moreover, the limited dietary fiber intake in the LCD, primarily due to the emphasis on high-fat and high-protein animal-based foods, may lead to constipation and other health complications. Imbalances in macronutrient intake may

result in adverse long-term effects, including dyslipidemia and reduced glomerular filtration rate, especially in those with mild renal impairment. Additionally, low- and high-carbohydrate diets are associated with higher mortality rates, while a plant-based diet with 50-55% of daily calories from carbohydrates presents the lowest mortality risk. The LCD's insufficiency in plant-based foods, like vegetables and legumes, might elevate mortality risk due to reduced essential micronutrients, such as polyunsaturated fatty acids (PUFA).

- **High Saturated Fat Intake:** Extensive research conducted on laboratory animals strongly corroborates the hypothesis linking high-fat diets to reduced insulin activity, with saturated fats demonstrating the most adverse effects. In light of these findings, along with the recognized cardiovascular disease risks associated with excessive saturated fat consumption, professional organizations like the American Diabetes Association, American Heart Association, and U.S. Department of Agriculture have advocated for maintaining total fat intake at or below 30% of caloric intake while prioritizing foods low in saturated fat. Nonetheless, certain authors (Taubes, 2001) have challenged the validity of the evidence supporting these public health recommendations, suggesting that the proportion of total energy from total fat might not be paramount for type 2 diabetes prevention (Hu et al., n.d.).

The latest study strengthens the conventional advice to limit saturation and total fat. According to biological theory, high-fat diets encourage weight growth, which in turn encourages insulin resistance. This viewpoint is backed up by much evidence. This implies that any dietary element that encourages weight gain will probably encourage the onset of diabetes.

### III. PLANT-BASED DIETS

Diet plays a significant role in insulin resistance, particularly in an aging and less active demographic. The global surge in type 2 diabetes cases is partly attributed to the escalated consumption of energy-dense foods, such as fast food, animal fats, refined carbohydrates, and sugary beverages (Ley et al., 2014a). Lifestyle modifications, particularly dietary adjustments, can effectively prevent, alleviate, and even reverse type 2 diabetes. Among participants aged 60 years and older in the Diabetes Prevention Program, there was a remarkable 71% reduction in type 2 diabetes risk due to lifestyle changes, suggesting that older individuals benefit significantly from such shifts (Knowler et al., 2002).

Lifestyle adjustments, especially in the elderly, hold the potential to alleviate comorbidities, reduce reliance on multiple medications, and address the root causes of type 2 diabetes. A plant-based diet prioritizing legumes, whole grains, vegetables, fruits, nuts, and seeds, while minimizing or eliminating animal products, emerges as particularly effective in type 2 diabetes prevention. This dietary approach has also been correlated with markedly reduced incidences of cancer, cardiovascular mortality, hypertension, hyperlipidemia, and obesity. This discussion will delve into the mechanisms through which plant-based diets can prevent, manage, and mitigate complications of type 2 diabetes. An exploration of their mechanisms for reducing insulin resistance will also be undertaken.



**1. Mechanisms of Action in Treating Insulin Resistance:** Achieving glycemic control and mitigating insulin resistance can be effectively facilitated by consuming minimally processed, nutrient-dense plant-based meals, which act through various hypothesized mechanisms. Plant-based diets, abundant in fiber, antioxidants, and magnesium, exhibit the capacity to enhance insulin sensitivity (Ley et al., 2014b; Satija et al., 2016b). Antioxidant-rich polyphenols, found in these diets, are believed to enhance insulin secretion, glucose uptake, and hepatic glucose production reduction, thereby affecting glucose absorption (Kim et al., 2016). Fiber, exclusively present in plant-based diets, significantly regulates postprandial glucose response. Its fermentation by gut microbiota yields short-chain fatty acids that enhance insulin signaling, insulin sensitivity, and glucose response (Bach Knudsen, 2015; Baothman et al., 2016; Lattimer & Haub, 2010; Li et al., 2015). By reducing meal energy density and increasing satiety, fiber contributes to weight loss and decreased insulin resistance (Lattimer & Haub, 2010). Furthermore, an augmented dietary fiber intake correlates with lowered inflammatory biomarker levels, potentially influencing insulin resistance (Satija et al., 2016). Lastly, a diet rich in plant-based foods and low in animal products can modulate gut microbiota composition and reduce trimethylamine N-oxide production, associated with insulin resistance (Li et al., 2015; Satija et al., 2016b).

In epidemiological and metabolic research, dietary elements that are often lower in plant-based diets and linked to insulin resistance include saturated fat, advanced glycation end products, nitrosamines, and heme iron. Saturated fat, abundant in animal-based meals, contributes to lipotoxicity, characterized by harmful fat metabolite accumulation in liver and muscle cells, disrupting insulin signaling and reducing glucose uptake (Estadella et al., 2013; Kitessa & Abeywardena, 2016; Nolan & Larter, 2009). Additionally, saturated fat is connected to oxidative stress, mitochondrial dysfunction, insulin resistance, and inflammation. Saturated fat-rich diets are associated with Gram-negative, lipopolysaccharide-rich patterns in the gut microbiota that worsen insulin resistance. In individuals with type 2 diabetes, plant-based diets have shown superior visceral fat and oxidative stress reductions compared to traditional diets (Kahleova et al., 2011). In contrast to plant-based diets high in fruits, vegetables, legumes, and whole grains, as well as dishes prepared by grilling, broiling, roasting, searing, or frying, meat-rich diets are more likely to contain advanced glycation end products, or oxidant chemicals (Uribarri et al., 2010). Reduced consumption of these components has been found to decrease insulin resistance in individuals with type 2 diabetes. Advanced glycation end products are associated with the pathogenesis of type 2 diabetes (Uribarri et al., 2011). Nitrosamines, formed when nitrite and nitrate preservatives in processed meats react with amino compounds, accelerate DNA damage, pro-inflammatory cytokine production, and reactive oxygen species formation, resulting in oxidative stress and insulin resistance. Mechanisms promoting insulin resistance include pro-oxidant iron from heme (animal) sources, intensifying oxidative stress, disrupting insulin signaling, damaging pancreatic beta cells, hindering glucose transporter type 4 channel translocation to cell membranes, and increasing hepatic glucose output. Several meta-analyses have established links between serum ferritin or dietary heme iron and the risk of type 2 diabetes (Bao et al., 2012; Zhao et al., 2012).

Last but not least, plant-based diets frequently encourage weight loss and reduce adiposity (Huang et al., 2016; Tonstad et al., 2009), two aspects that are very

effective at preventing insulin resistance. On the other hand, meat consumption—including that of poultry—is a strong indicator of obesity and long-term weight increase. Consequently, meat elevates the risk of type 2 diabetes through mechanisms not solely related to weight increase, as previously mentioned, thus decoupling the impact from body mass index. Moreover, the elevated protein content in a calorie-deficient high-protein diet might counteract significant metabolic benefits derived from weight reduction. Notably, a low-calorie, high-protein diet has been observed to hinder the beneficial effects of weight loss on insulin sensitivity in skeletal muscles among obese postmenopausal women (Smith et al., 2016). This is most likely because the high-protein diet worsened oxidative stress and caused changes in the structure and organization of muscle cells. Additionally linked to weight gain and insulin resistance are refined carbohydrates and added sweets (AlEssa et al., 2015; Bhupathiraju et al., 2014; Malik & Hu, 2015). A whole-food, plant-based diet, which excludes animal products, refined grains, and added sugars, fosters insulin sensitivity by facilitating weight loss and maintaining a healthy body weight. Importantly, research has also indicated that plant-based diets can enhance insulin sensitivity independently of weight loss or when accounting for body weight statistically.

- 2. Reduction in the Risk of Cardiovascular Disease:** Numerous studies have shown the advantages of plant-based diets in preventing and treating cardiovascular disease, which is the main cause of premature mortality in the diabetic population. In comparison to omnivorous diets, vegetarian diets have been linked to incidence and mortality rates of ischemic heart disease that are reduced by 24% to 32% in large cohort studies. Coronary artery disease has been shown to reverse clinically and by angiography in intervention trials of plant-based diets. In a study conducted by Ornish et al., patients diagnosed with cardiovascular disease were randomized into two groups: standard medical therapy or a lifestyle intervention comprising a low-fat vegetarian diet, moderate exercise, stress management, and smoking cessation. Over a 5-year period, the group undergoing lifestyle interventions witnessed a 20% reduction in LDL levels from baseline, achieved without lipid-lowering medications. This reduction paralleled the levels seen in the usual care group, where 60% of patients were on lipid-lowering medications. In contrast to a worsening of 27.7% in the conventional treatment group, there had been a 7.9% relative improvement in the average degree of coronary artery stenosis in the lifestyle group by year 5. When compared to the group receiving conventional treatment, the lifestyle group experienced a 60% decrease in cardiac events. As a result of additional research showing the enormous cardiovascular advantages of adopting this plant-based lifestyle strategy, Medicare started to pay for the Ornish lifestyle intervention as part of a comprehensive cardiac rehabilitation programme in 2010 (Jacques et al., 2010).

In response to dietary changes alone, cardiovascular disease patients demonstrated notable effects. Following a five-year adherence to a low-fat plant-based diet, 73% (eight out of 11) of patients with severe coronary artery disease exhibited a reversal of coronary artery disease, as confirmed by repeat angiography. An additional analysis presented outcomes from 198 consecutive cardiovascular disease patients who voluntarily participated in the Esselstyn program. 89% of respondents strictly adhered to the diet, consuming only unprocessed, plant-based meals (including fish and poultry) and no additional dairy products, oils, or meat. Cardiovascular events were extremely rare, occurring in 0.6% of adherent patients versus 62% of non-adherent individuals. A

multitude of studies substantiate the effectiveness of plant-based diets in mitigating cardiovascular risk factors. Several investigations (Orlich & Fraser, 2014; Pettersen et al., 2012) have found that individuals adhering to plant-based diets exhibit significantly lower prevalence and incidence of hypertension compared to omnivores. Notably, participants following a vegan diet within the Adventist Health Study 2 cohort displayed a 50% lower risk of hypertension compared to omnivores, a distinction that remained after accounting for body mass index (Pettersen et al., 2012). While animal protein has consistently shown in prospective trials to elevate hypertension risk, plant protein often exerts a blood pressure-lowering effect, particularly among older adults (Borgia et al., 2015; Miura et al., 2004; Steffen et al., 2005). Interventional trials further confirm that vegetarian diets yield lower blood pressure outcomes compared to omnivorous control diets.

### 3. Potential Drawbacks of Plant-Based Diets:

- **Vitamins and Minerals:** B12 levels in water are being reduced by current standards of filtration, and fruit and vegetables are routinely cleaned to remove any dirt or soil remains before ingestion. Animals naturally consume B12 with their food, which is frequently taken directly from the ground, and via their water source, which is frequently an unpurified reservoir. As a result, someone who relies on an animal-based diet obtains B12 by consuming animal proteins (Adair & Bowden, 2020)
- **Calorie Consumption:** To attain energy balance, it is crucial to consume a range of plant-based meals, such as starchy vegetables and fruits, as it is very challenging to obtain sufficient amounts of energy from low-calorie foods (such as leafy greens). Rapid introduction of high fibre consumption has the potential to make people feel bloated and uncomfortable, which may further discourage them from consuming enough calories. (Adair & Bowden, 2020)

**4. Risk of Nutrient Deficiencies:** Contrarily, plant-based diets showed significant associations with improvements in emotional well-being, physical well-being, depression, quality of life, general health, HbA1c levels (a gauge of long-term blood glucose levels), weight, and both total and LDL cholesterol levels, as compared to control diets, which frequently align with those recommended by various diabetes associations (Toumpanakis et al., 2018). In a previous systematic review and meta-analysis of six studies, vegetarian dietary patterns were correlated with significantly lower HbA1c levels compared to control diets (Yokoyama et al., 2014). Similarly, various dietary approaches, including vegetarian, vegan, Mediterranean, and Dietary Approaches to Stop Hypertension (DASH) diets, have shown the capacity to decrease HbA1c levels compared to control or conventional diets.

Multiple factors contribute to the favorable effects of plant-based diets on diabetes management and prevention. In contrast to Western diets, vegetarian and vegan diets exhibit elevated dietary fiber levels, often featuring whole grains, legumes, and nuts, which are connected to lowered T2D risk. Reduced red meat consumption and animal protein absence may also play a role. Approximately 25 studies have explored meat consumption's relationship with T2D risk, mostly showing a positive link between red/processed meat and T2D risk. A 2013 meta-analysis confirmed that higher

red/processed meat intake in diets correlated with heightened T2D risk. The robust evidence linking dietary heme iron, especially from red meat to this risk is particularly noteworthy. Increased serum ferritin levels are tied to insulin resistance and T2D risk. A 2019 meta-analysis of prospective cohort studies revealed that higher total/animal protein intake was associated with elevated T2D risk, while moderate plant protein intake was connected to reduced risk.

- 5. Need for Careful Planning to Ensure Adequate Protein Intake:** Protein plays a crucial role in various aspects of health, including muscle growth and repair, immune function, and hormone synthesis. Adequate protein intake is particularly important for individuals with diabetes, as it can help support stable blood sugar levels, preserve lean muscle mass, and promote satiety (Franz et al., 2010). There are some challenges of protein intake in low-carbohydrate diets. Low-carbohydrate diets often prioritize high-fat and moderate protein intake. While these diets can effectively control blood sugar, it is important to carefully plan protein sources to avoid excessive saturated fat intake. Choosing lean protein sources, such as skinless poultry, fish, legumes, and low-fat dairy products, can help balance protein intake and saturated fat content. Some challenges of protein intake in plant-based diets are mentioned. Plant-based diets can provide adequate protein, but it may require careful planning to ensure all essential amino acids are obtained. Combining plant protein sources, such as legumes, grains, nuts, and seeds, can help create a complete protein profile containing all essential amino acids. Including a variety of plant-based protein sources throughout the day can also enhance protein quality and bioavailability (Mariotti & Gardner, 2019).

#### IV. COMPARISON OF LOW-CARBOHYDRATE AND PLANT-BASED DIETS

- 1. Similarities and Differences Between Low-Carbohydrate and Plant-Based Diets:** In 1-y comparisons, Low-carb diets don't work much better at shedding pounds than plant-based diets or other dietary plans, although they do help obese people lose weight. In a metabolic-ward study conducted in 2021, the conventional wisdom that low-carb diets lower appetite was refuted. A low-fat, vegan diet (10% fat, 75% carbs) or a low-carbohydrate diet (76% fat, 10% carbs) were given to twenty young, overweight people for two weeks before switching to the other diet for a further two weeks. When compared to the low-carb phase, energy intake was 689 (73) kcal/d lower during the vegan phase (P 0.0001). The vegan diet caused a substantially higher decrease in calorie intake (Jardine et al., 2021b). Low-carbohydrate diets may initially lower blood glucose levels in diabetics, but these advantages frequently disappear by 12 months (Goldenberg et al., 2021b). The safety of a low-carbohydrate diet may be questioned. They frequently increase plasma LDL cholesterol levels, with wildly different effects amongst people (Foster et al., 2003b). Low-carb diets raise concerns about the potential long-term risks of conditions such as cancer and Alzheimer's disease due to their restriction or exclusion of nutrient-rich foods like fruits, whole grains, and legumes. They are also usually rich in saturated fats. Long-term low-carb diet intake is associated with an increase in all-cause mortality (Noto et al., 2013).

Plant-based diets reduce diabetes risk without any negative side effects. This also applies to controlling diabetes while taking steps to avoid hypoglycemia. 43% of the participants in the low-fat vegan group in the trial by Barnard et al. had to cut back on or stop using

their diabetes medications because of hypoglycemia (Barnard et al., 2006). Regular monitoring of blood glucose levels, patient education, and medication adjustments, when needed, can help prevent episodes of low blood glucose levels. Research has shown that diets predominantly composed of plant-based foods offer sufficient nutrients and high dietary quality. The Academy of Nutrition and Dietetics (AND) affirms that vegetarian diets, including vegan diets, are both safe and nutritionally adequate.

- 2. Comparing the Effectiveness of Low-Carbohydrate and Plant-Based Diets in Diabetes Management:** While low- and very-low-carbohydrate diets may positively impact energy intake and expenditure, their extended effects on weight loss might not be as prominent as those achieved through conventional approaches. According to the 2013 American Heart Association/American Cardiology/The Obesity Society (AHA/ACC/TOS) Guideline for the Management of Overweight and Obesity in Adults, research indicates that very low-carbohydrate diets do not yield additional weight loss advantages at the 6-month mark when compared to calorie-restricted, low-fat diets. Recent systematic reviews and meta-analyses of randomized controlled trials have assessed the comparative effectiveness of low-carbohydrate, high-fat (LCHF) and high-carbohydrate, low-fat (HCLF) diets for weight loss among individuals with overweight or obesity over time spans of 3 to 6 months and 1 to 2 years. LCHF diets are defined as those with >30% of total daily energy intake originating from fat.

## V. PRACTICAL CONSIDERATIONS FOR ADOPTING A PLANT-BASED DIET

Educating and motivating individuals with diabetes or those prone to it regarding the advantages of adopting a plant-based diet holds significance. When provided with personalized nutritional guidance and aware of the associated benefits, patients often show eagerness to explore a plant-based dietary approach (Lee et al., 2015). The lack of calorie, carb, or portion limits on a plant-based diet is alluring, and most patients do not find it to be any more difficult to adhere to than other therapeutic diets. Moreover, randomized trials involving diabetic patients revealed that the adoption of a low-fat plant-based diet yielded comparable outcomes to alternative therapeutic dietary patterns. People are frequently persuaded to switch to a plant-based diet by its advantages, which include increased quality of life, glycemic control, and weight loss (Jardine et al., 2021b)

- 1. Strategies for Overcoming Common Challenges (e.g., Meal Planning, Social Situations):** Protein requirements can differ depending on variables such as age, gender, physical activity level, and overall health status. Working with a registered dietitian or healthcare provider experienced in diabetes management is crucial to develop an individualized meal plan that meets protein needs while considering personal preferences, cultural factors, and dietary restrictions. Regular monitoring and adjustment of the dietary plan may be necessary to ensure adequate protein intake and optimize diabetes management. It is important to note that protein intake should be part of a well-balanced diet that includes adequate intake of carbohydrates, fats, fiber, vitamins, and minerals. Striking a balance between macronutrients and considering the overall quality of the diet is essential for long-term health and diabetes management. Individualized guidance and professional support can help individuals with diabetes navigate the challenges of protein intake and ensure a well-rounded dietary approach (Johnson et al., 2021)

- 2. Advice for Working with a Healthcare Provider to Develop an Appropriate Dietary Plan:** The objectives of these recommendations encompass encouraging prudent dietary selections, mitigating the susceptibility to Type 2 diabetes and associated diabetic complications, attaining optimal glycemic management, and elevating the quality of life for healthcare practitioners, individuals at diabetes risk, and those already diagnosed. Notably, these directives do not pertain to children and adolescents as Diabetes UK has embraced the ISPAD (International Society of Paediatric and Adolescent Diabetes) guidelines for this demographic (Smart et al., 2009).

All multidisciplinary team members should be able to provide and apply evidence-based nutritional guidance. It is recommended that a licensed dietitian with specialized training spearheads nutritional care. A coordinated approach is essential, placing individuals with diabetes at the core of decision-making. Each advice must stem from empirical research and be tailored to personal preferences, beliefs, lifestyle, and readiness for change, considering both personal and cultural contexts. These recommendations are designed to promote self-management, mitigate Type 2 diabetes risk and associated comorbidities, endorse healthy lifestyles, ensure adaptability, and cater to diverse needs, especially in cases of coexisting conditions like coeliac disease and cystic fibrosis.

- 3. Discussion of Ongoing Support and Resources for Maintaining a Healthy Dietary Pattern:** The poor and high-resource groups interact on a variety of levels, including economic resources, considerable social participation, commitment to health, and health management and capability. Health of those in low resource groups: A lack of resources reduces opportunities for fulfilling social interaction, lowers motivation to maintain health, and weakens health capacity. The consequences of this include additional depletion of financial resources, a decline in social involvement, health capacity, and nutritional control, as well as decisions and activities that worsen existing health issues and raise risk of developing new ones. Health within the high-resource group (establishing a "virtuous cycle"): Increased financial resources enhance individuals' opportunities for meaningful social interactions, motivate healthier lifestyles, and augment their health capacity. This leads to decisions and behaviors that enhance management, reduce the susceptibility and severity of concurrent conditions, ultimately nurturing their health capacity and well-being over time. Their discoveries underscore the significance of social resources in dietary management, functioning in two main ways: firstly, by cultivating a health-promoting eating environment at home, and secondly, more subtly, by facilitating gratifying social exchanges that foster and encourage good health practices(Weaver et al., 2014).

## VI. CONCLUSION

Dietary interventions are an important component of managing diabetes, and both low-carbohydrate and plant-based diets have been shown to have beneficial effects on blood sugar control and other health outcomes. While low-carbohydrate diets are particularly effective in reducing blood sugar levels, plant-based diets may offer additional benefits for insulin sensitivity and reducing the risk of cardiovascular disease. However, both types of diets have potential drawbacks and require careful planning to ensure adequate nutrient intake. Further research is needed to understand better the optimal dietary approaches for

managing diabetes and to develop effective strategies for supporting individuals with diabetes in adopting and maintaining healthy dietary habits.

## REFERENCE

- [1] Adair, K. E., & Bowden, R. G. (2020). Ameliorating chronic kidney disease using a whole food plant-based diet. In *Nutrients* (Vol. 12, Issue 4). MDPI AG. <https://doi.org/10.3390/nu12041007>
- [2] AlEsa, H. B., Bhupathiraju, S. N., Malik, V. S., Wedick, N. M., Campos, H., Rosner, B., Willett, W. C., & Hu, F. B. (2015). Carbohydrate quality and quantity and risk of type 2 diabetes in US women. *American Journal of Clinical Nutrition*, *102*(6), 1543–1553. <https://doi.org/10.3945/ajcn.115.116558>
- [3] Arora, S. K., & McFarlane, S. I. (2005). The case for low carbohydrate diets in diabetes management. In *Nutrition and Metabolism* (Vol. 2). <https://doi.org/10.1186/1743-7075-2-16>
- [4] Bach Knudsen, K. E. (2015). Microbial degradation of whole-grain complex carbohydrates and impact on short-chain fatty acids and health. *Advances in Nutrition*, *6*(2), 206–213. <https://doi.org/10.3945/an.114.007450>
- [5] Bao, W., Rong, Y., Rong, S., & Liu, L. (2012). Dietary iron intake, body iron stores, and the risk of type 2 diabetes: A systematic review and meta-analysis. *BMC Medicine*, *10*. <https://doi.org/10.1186/1741-7015-10-119>
- [6] Baothman, O. A., Zamzami, M. A., Taher, I., Abubaker, J., & Abu-Farha, M. (2016). The role of Gut Microbiota in the development of obesity and Diabetes. In *Lipids in Health and Disease* (Vol. 15, Issue 1). BioMed Central Ltd. <https://doi.org/10.1186/s12944-016-0278-4>
- [7] Barnard, N. D., Cohen, J., Jenkins, D. J. A., Turner-McGrievy, G., Gloede, L., Jaster, B., Seidl, K., Green, A. A., & Talpers, S. (2006). A low-fat vegan diet improves glycemic control and cardiovascular risk factors in a randomized clinical trial in individuals with type 2 diabetes. *Diabetes Care*, *29*(8), 1777–1783. <https://doi.org/10.2337/dc06-0606>
- [8] Bhanpuri, N. H., Hallberg, S. J., Williams, P. T., McKenzie, A. L., Ballard, K. D., Campbell, W. W., McCarter, J. P., Phinney, S. D., & Volek, J. S. (2018). Cardiovascular disease risk factor responses to a type 2 diabetes care model including nutritional ketosis induced by sustained carbohydrate restriction at 1 year: An open label, non-randomized, controlled study. *Cardiovascular Diabetology*, *17*(1). <https://doi.org/10.1186/s12933-018-0698-8>
- [9] Bhupathiraju, S. N., Tobias, D. K., Malik, V. S., Pan, A., Hruby, A., Manson, J. E., Willett, W. C., & Hu, F. B. (2014). Glycemic index, glycemic load, and risk of type 2 diabetes: Results from 3 large US cohorts and an updated meta-analysis. *American Journal of Clinical Nutrition*, *100*(1), 218–232. <https://doi.org/10.3945/ajcn.113.079533>
- [10] Borgia, L., Curhan, G. C., Willett, W. C., Hu, F. B., Satijad, A., & Forman, J. P. (2015). Long-term intake of animal flesh and risk of developing hypertension in three prospective cohort studies. *Journal of Hypertension*, *33*(11), 2231–2238. <https://doi.org/10.1097/HJH.0000000000000722>
- [11] Brehm, B. J., Seeley, R. J., Daniels, S. R., & D'Alessio, D. A. (2003). A randomized trial comparing a very low carbohydrate diet and a calorie-restricted low fat diet on body weight and cardiovascular risk factors in healthy women. *Journal of Clinical Endocrinology and Metabolism*, *88*(4), 1617–1623. <https://doi.org/10.1210/jc.2002-021480>
- [12] Burke, L. M., Ross, M. L., Garvican-Lewis, L. A., Welvaert, M., Heikura, I. A., Forbes, S. G., Mirtschin, J. G., Cato, L. E., Strobel, N., Sharma, A. P., & Hawley, J. A. (2017). Low carbohydrate, high fat diet impairs exercise economy and negates the performance benefit from intensified training in elite race walkers. *Journal of Physiology*, *595*(9), 2785–2807. <https://doi.org/10.1113/JP273230>
- [13] Chen, G., Li, J., Lv, H., Wang, S., Zuo, J., & Zhu, L. (2019). Mesoporous coxsni(1 - x)o2 as an efficient oxygen evolution catalyst support for spe water electrolyzer. *Royal Society Open Science*, *6*(4). <https://doi.org/10.6084/m9.figshare>
- [14] Chung, S. M., Lee, Y. Y., Ha, E., Yoon, J. S., Won, K. C., Lee, H. W., Hur, J., Hong, K. S., Jang, J. G., Jin, H. J., Choi, E. Y., Shin, K. C., Chung, J. H., Lee, K. H., Ahn, J. H., & Moon, J. S. (2020). The risk of diabetes on clinical outcomes in patients with coronavirus disease 2019: A retrospective cohort study. *Diabetes and Metabolism Journal*, *44*. <https://doi.org/10.4093/dmj.2020.0105>
- [15] Davies, M. J., D'Alessio, D. A., Fradkin, J., Kernan, W. N., Mathieu, C., Mingrone, G., Rossing, P., Tsapas, A., Wexler, D. J., & Buse, J. B. (2018). Management of hyperglycemia in type 2 diabetes, 2018. A consensus report by the American Diabetes Association (ADA) and the european association for the study

- of diabetes (EASD). In *Diabetes Care* (Vol. 41, Issue 12, pp. 2669–2701). American Diabetes Association Inc. <https://doi.org/10.2337/dci18-0033>
- [16] Estadella, D., Da Penha Oller Do Nascimento, C. M., Oyama, L. M., Ribeiro, E. B., Dâmaso, A. R., & De Piano, A. (2013). Lipotoxicity: Effects of dietary saturated and trans fatty acids. In *Mediators of Inflammation* (Vol. 2013). <https://doi.org/10.1155/2013/137579>
- [17] Evert, A. B., Dennison, M., Gardner, C. D., Timothy Garvey, W., Karen Lau, K. H., MacLeod, J., Mitri, J., Pereira, R. F., Rawlings, K., Robinson, S., Saslow, L., Uelmen, S., Urbanski, P. B., & Yancy, W. S. (2019). Nutrition therapy for adults with diabetes or prediabetes: A consensus report. In *Diabetes Care* (Vol. 42, Issue 5, pp. 731–754). American Diabetes Association Inc. <https://doi.org/10.2337/dci19-0014>
- [18] Feinman, R. D., Pogozelski, W. K., Astrup, A., Bernstein, R. K., Fine, E. J., Westman, E. C., Accurso, A., Frassetto, L., Gower, B. A., McFarlane, S. I., Nielsen, J. V., Krarup, T., Saslow, L., Roth, K. S., Vernon, M. C., Volek, J. S., Wilshire, G. B., Dahlqvist, A., Sundberg, R., ... Worm, N. (2015). Dietary carbohydrate restriction as the first approach in diabetes management: Critical review and evidence base. In *Nutrition* (Vol. 31, Issue 1, pp. 1–13). Elsevier Inc. <https://doi.org/10.1016/j.nut.2014.06.011>
- [19] Foster, G. D., Wyatt, H. R., Hill, J. O., McGuckin, B. G., Brill, C., Selma Mohammed, B., Szapary, P. O., Rader, D. J., Edman, J. S., & Klein, S. (2003a). A Randomized Trial of a Low-Carbohydrate Diet for Obesity. In *N Engl J Med* (Vol. 21, Issue 22). <http://www.nejm.org> Foster, G. D., Wyatt, H. R., Hill, J. O., McGuckin, B. G., Brill, C., Selma Mohammed, B., Szapary, P. O., Rader, D. J., Edman, J. S., & Klein, S. (2003b). A Randomized Trial of a Low-Carbohydrate Diet for Obesity. In *N Engl J Med* (Vol. 21, Issue 22). <http://www.nejm.org>
- [20] Franz, M. J., Bantle, J. P., Beebe, C. A., Brunzell, J. D., Chiasson, J., Garg, A., Ann Holzmeister, L., Hoogwerf, B., Mayer-davis, E., Mooradian, A. D., Purnell, J. Q., & Wheeler, M. (n.d.). *Evidence-Based Nutrition Principles and Recommendations for the Treatment and Prevention of Diabetes and Related Complications*. <http://diabetesjournals.org/care/article-pdf/25/1/148/649694/dc0102000148.pdf>
- [21] Franz, M. J., Powers, M. A., Leontos, C., Holzmeister, L. A., Kulkarni, K., Monk, A., Wedel, N., & Gradwell, E. (2010). The evidence for medical nutrition therapy for type 1 and type 2 diabetes in adults. *Journal of the American Dietetic Association*, 110(12), 1852–1889. <https://doi.org/10.1016/j.jada.2010.09.014>
- [22] Freedman, M. R., King, J., & Kennedy, E. (2001). Executive Summary. *Obesity Research*, 9(S3), 1S-5S. <https://doi.org/10.1038/oby.2001.113>
- [23] Gannon, M. C., Nuttall, F. Q., Saeed, A., Jordan, K., & Hoover, H. (2003). An increase in dietary protein improves the blood glucose response in persons with type 2 diabetes 1-3. In *Am J Clin Nutr* (Vol. 78). <https://academic.oup.com/ajcn/article/78/4/734/4690022>
- [24] Goldenberg, J. Z., Day, A., Brinkworth, G. D., Sato, J., Yamada, S., Jönsson, T., Beardsley, J., Johnson, J. A., Thabane, L., & Johnston, B. C. (2021a). Efficacy and safety of low and very low carbohydrate diets for type 2 diabetes remission: systematic review and meta-analysis of published and unpublished randomized trial data. *BMJ*, 372. <https://doi.org/10.1136/bmj.m4743>
- [25] Goldenberg, J. Z., Day, A., Brinkworth, G. D., Sato, J., Yamada, S., Jönsson, T., Beardsley, J., Johnson, J. A., Thabane, L., & Johnston, B. C. (2021b). Efficacy and safety of low and very low carbohydrate diets for type 2 diabetes remission: systematic review and meta-analysis of published and unpublished randomized trial data. *BMJ*, 372. <https://doi.org/10.1136/bmj.m4743>
- [26] Guo, Y., Huang, Z., Sang, D., Gao, Q., & Li, Q. (2020). The Role of Nutrition in the Prevention and Intervention of Type 2 Diabetes. In *Frontiers in Bioengineering and Biotechnology* (Vol. 8). Frontiers Media S.A. <https://doi.org/10.3389/fbioe.2020.575442>
- [27] Hu, F. B., Van Dam, R. M., & Liu, S. (n.d.). *The prevalence of Type II (non-insulin-dependent) diabetes mellitus is increasing rapidly in the Diet and risk of Type II diabetes: the role of types of fat and carbohydrate*. Huang, R. Y., Huang, C. C., Hu, F. B., & Chavarro, J. E. (2016). Vegetarian Diets and Weight Reduction: a Meta-Analysis of Randomized Controlled Trials. *Journal of General Internal Medicine*, 31(1), 109–116. <https://doi.org/10.1007/s11606-015-3390-7>
- [28] Jacques, L. B., Jensen, T. S., Salive, M. E., McClain, S., & Chin, J. (2010). *NCA - Intensive Cardiac Rehabilitation (ICR) Program - Dr. Ornish's Program for Reversing Heart Disease (CAG-00419N) - Decision Memo*. <http://www.cms.gov/Medicare/Medicare-General->
- [29] Jardine, M. A., Kahleova, H., Levin, S. M., Ali, Z., Trapp, C. B., & Barnard, N. D. (2021a). Perspective: Plant-Based Eating Pattern for Type 2 Diabetes Prevention and Treatment: Efficacy, Mechanisms, and Practical Considerations. *Advances in Nutrition*, 12(6), 2045–2055. <https://doi.org/10.1093/advances/nmab063>



- [30] Jardine, M. A., Kahleova, H., Levin, S. M., Ali, Z., Trapp, C. B., & Barnard, N. D. (2021b). Perspective: Plant-Based Eating Pattern for Type 2 Diabetes Prevention and Treatment: Efficacy, Mechanisms, and Practical Considerations. *Advances in Nutrition*, 12(6), 2045–2055. <https://doi.org/10.1093/advances/nmab063>
- [31] Johnson, E. L., Feldman, H., Butts, A., Chamberlain, J., Collins, B., Doyle-Delgado, K., Dugan-Moverley, J., Freeman, R. S., Leal, S., Saini, P., Shubrook, J. H., Trujillo, J., Draznin, B., Aroda, V. R., Bakris, G., Benson, G., Brown, F. M., Green, J., Huang, E., ... Gabbay, R. A. (2021). Standards of medical care in diabetes - 2021 abridged for primary care providers. In *Clinical Diabetes* (Vol. 39, Issue 1, pp. 14–43). American Diabetes Association Inc. <https://doi.org/10.2337/cd21-as01>
- [32] Kahleova, H., Matoulek, M., Malinska, H., Oliyarnik, O., Kazdova, L., Neskudla, T., Skoch, A., Hajek, M., Hill, M., Kahle, M., & Pelikanova, T. (2011). Vegetarian diet improves insulin resistance and oxidative stress markers more than conventional diet in subjects with Type2 diabetes. *Diabetic Medicine*, 28(5), 549–559. <https://doi.org/10.1111/j.1464-5491.2010.03209.x>
- [33] Kim, Y. A., Keogh, J. B., & Clifton, P. M. (2016). Polyphenols and glycémic control. In *Nutrients* (Vol. 8, Issue 1). MDPI AG. <https://doi.org/10.3390/nu8010017>
- [34] Kiteessa, S. M., & Abeywardena, M. Y. (2016). Lipid-induced insulin resistance in skeletal muscle: The chase for the culprit goes from total intramuscular fat to lipid intermediates, and finally to species of lipid intermediates. In *Nutrients* (Vol. 8, Issue 8). MDPI AG. <https://doi.org/10.3390/nu8080466>
- [35] Knowler, W. C., Barrett-Connor, E., Fowler, S. E., Hamman, R. F., Lachin, J. M., Walker, E. A., Nathan, D. M., & Diabetes Prevention Program Research Group. (2002). Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *The New England Journal of Medicine*, 346(6), 393–403. <https://doi.org/10.1056/NEJMoa012512>
- [36] Lattimer, J. M., & Haub, M. D. (2010). Effects of dietary fiber and its components on metabolic health. In *Nutrients* (Vol. 2, Issue 12, pp. 1266–1289). MDPI AG. <https://doi.org/10.3390/nu2121266>
- [37] Lee, V., Mckay, T., & Ardern, C. I. (2015). Awareness and perception of plant-based diets for the treatment and management of type 2 diabetes in a community education clinic: A pilot study. *Journal of Nutrition and Metabolism*, 2015. <https://doi.org/10.1155/2015/236234>
- [38] Ley, S. H., Hamdy, O., Mohan, V., & Hu, F. B. (2014a). Prevention and management of type 2 diabetes: Dietary components and nutritional strategies. In *The Lancet* (Vol. 383, Issue 9933, pp. 1999–2007). Elsevier B.V. [https://doi.org/10.1016/S0140-6736\(14\)60613-9](https://doi.org/10.1016/S0140-6736(14)60613-9)
- [39] Ley, S. H., Hamdy, O., Mohan, V., & Hu, F. B. (2014b). Prevention and management of type 2 diabetes: Dietary components and nutritional strategies. In *The Lancet* (Vol. 383, Issue 9933, pp. 1999–2007). Elsevier B.V. [https://doi.org/10.1016/S0140-6736\(14\)60613-9](https://doi.org/10.1016/S0140-6736(14)60613-9)
- [40] Li, D., Kirsop, J., & Tang, W. H. W. (2015). Listening to Our Gut: Contribution of Gut Microbiota and Cardiovascular Risk in Diabetes Pathogenesis. In *Current Diabetes Reports* (Vol. 15, Issue 9). Current Medicine Group LLC 1. <https://doi.org/10.1007/s11892-015-0634-1>
- [41] Malik, V. S., & Hu, F. B. (2015). Fructose and Cardiometabolic Health What the Evidence from Sugar-Sweetened Beverages Tells Us. In *Journal of the American College of Cardiology* (Vol. 66, Issue 14, pp. 1615–1624). Elsevier USA. <https://doi.org/10.1016/j.jacc.2015.08.025>
- [42] Mariotti, F., & Gardner, C. D. (2019). Dietary protein and amino acids in vegetarian diets—A review. In *Nutrients* (Vol. 11, Issue 11). MDPI AG. <https://doi.org/10.3390/nu11112661>
- [43] McKenzie, A. L., Hallberg, S. J., Creighton, B. C., Volk, B. M., Link, T. M., Abner, M. K., Glon, R. M., McCarter, J. P., Volek, J. S., & Phinney, S. D. (2017). A novel intervention including individualized nutritional recommendations reduces hemoglobin A1c level, medication use, and weight in type 2 diabetes. *JMIR Diabetes*, 2(1). <https://doi.org/10.2196/diabetes.6981>
- [44] McMacken, M., & Shah, S. (2017). A plant-based diet for the prevention and treatment of type 2 diabetes. In *Journal of Geriatric Cardiology* (Vol. 14, Issue 5, pp. 342–354). Science Press. <https://doi.org/10.11909/j.issn.1671-5411.2017.05.009>
- [45] Miura, K., Greenland, P., Stamler, J., Liu, K., Daviglius, M. L., & Nakagawa, H. (2004). Relation of Vegetable, Fruit, and Meat Intake to 7-Year Blood Pressure Change in Middle-aged Men: The Chicago Western Electric Study. *American Journal of Epidemiology*, 159(6), 572–580. <https://doi.org/10.1093/aje/kwh085>
- [46] Najjar, R. S., & Feresin, R. G. (2019). Plant-based diets in the reduction of body fat: Physiological effects and biochemical insights. In *Nutrients* (Vol. 11, Issue 11). MDPI AG. <https://doi.org/10.3390/nu11112712>
- [47] Nolan, C. J., & Larter, C. Z. (2009). Lipotoxicity: Why do saturated fatty acids cause and monounsaturates protect against it? In *Journal of Gastroenterology and Hepatology (Australia)* (Vol. 24, Issue 5, pp. 703–706). Blackwell Publishing. <https://doi.org/10.1111/j.1440-1746.2009.05823.x>

- [48] Noto, H., Goto, A., Tsujimoto, T., & Noda, M. (2013). Low-Carbohydrate Diets and All-Cause Mortality: A Systematic Review and Meta-Analysis of Observational Studies. In *PLoS ONE* (Vol. 8, Issue 1). Public Library of Science. <https://doi.org/10.1371/journal.pone.0055030>
- [49] Orlich, M. J., & Fraser, G. E. (2014). Vegetarian diets in the Adventist Health Study 2: A review of initial published findings. *American Journal of Clinical Nutrition*, 100(SUPPL. 1). <https://doi.org/10.3945/ajcn.113.071233>
- [50] Pavlidou, E., Papadopoulou, S. K., Fasoulas, A., Mantzourou, M., & Giaginis, C. (2023). Clinical Evidence of Low-Carbohydrate Diets against Obesity and Diabetes Mellitus. In *Metabolites* (Vol. 13, Issue 2). MDPI. <https://doi.org/10.3390/metabo13020240>
- [51] Pettersen, B. J., Anousheh, R., Fan, J., Jaceldo-Siegl, K., & Fraser, G. E. (2012). Vegetarian diets and blood pressure among white subjects: Results from the Adventist Health Study-2 (AHS-2). *Public Health Nutrition*, 15(10), 1909–1916. <https://doi.org/10.1017/S1368980011003454>
- [52] Primavera, M., Giannini, C., & Chiarelli, F. (2020). Prediction and Prevention of Type 1 Diabetes. In *Frontiers in Endocrinology* (Vol. 11). Frontiers Media S.A. <https://doi.org/10.3389/fendo.2020.00248>
- [53] Sampaio, L. P. de B. (2016). Ketogenic diet for epilepsy treatment. In *Arquivos de Neuro-Psiquiatria* (Vol. 74, Issue 10, pp. 842–848). Associacao Arquivos de Neuro-Psiquiatria. <https://doi.org/10.1590/0004-282X20160116>
- [54] Satija, A., Bhupathiraju, S. N., Rimm, E. B., Spiegelman, D., Chiuve, S. E., Borgi, L., Willett, W. C., Manson, J. A. E., Sun, Q., & Hu, F. B. (2016a). Plant-Based Dietary Patterns and Incidence of Type 2 Diabetes in US Men and Women: Results from Three Prospective Cohort Studies. *PLoS Medicine*, 13(6). <https://doi.org/10.1371/journal.pmed.1002039>
- [55] Satija, A., Bhupathiraju, S. N., Rimm, E. B., Spiegelman, D., Chiuve, S. E., Borgi, L., Willett, W. C., Manson, J. A. E., Sun, Q., & Hu, F. B. (2016b). Plant-Based Dietary Patterns and Incidence of Type 2 Diabetes in US Men and Women: Results from Three Prospective Cohort Studies. *PLoS Medicine*, 13(6). <https://doi.org/10.1371/journal.pmed.1002039>
- [56] Sheard, N. F., Clark, N. G., Brand-miller, J. C., Franz, M. J., Xavier Pi-sunyer, F., Mayer-davis, E., Kulkarni, K., & Geil, P. (2004). *Dietary Carbohydrate (Amount and Type) in the Prevention and Management of Diabetes A statement by the American Diabetes Association*. <http://diabetesjournals.org/care/article-pdf/27/9/2266/563960/zdc00904002266.pdf>
- [57] Silva, F. M., Kramer, C. K., de Almeida, J. C., Steemburgo, T., Gross, J. L., & Azevedo, M. J. (2013). Fiber intake and glycemic control in patients with type 2 diabetes mellitus: A systematic review with meta-analysis of randomized controlled trials. *Nutrition Reviews*, 71(12), 790–801. <https://doi.org/10.1111/nure.12076>
- [58] Smart, C., Aslander-van Vliet, E., & Waldron, S. (2009). Nutritional management in children and adolescents with diabetes. *Pediatric Diabetes*, 10(SUPPL. 12), 100–117. <https://doi.org/10.1111/j.1399-5448.2009.00572.x>
- [59] Smith, G. I., Yoshino, J., Kelly, S. C., Reeds, D. N., Okunade, A., Patterson, B. W., Klein, S., & Mittendorfer, B. (2016). High-Protein Intake during Weight Loss Therapy Eliminates the Weight-Loss-Induced Improvement in Insulin Action in Obese Postmenopausal Women. *Cell Reports*, 17(3), 849–861. <https://doi.org/10.1016/j.celrep.2016.09.047>
- [60] Steffen, L. M., Kroenke, C. H., Yu, X., Pereira, M. A., Slattery, M. L., Van Horn, L., Gross, M. D., & Jacobs, D. R. (2005). *See corresponding CME exam on page 1363*. Taubes, G. (2001). The Soft Science of Dietary Fat. In *Source: Science, New Series* (Vol. 291, Issue 5513). Tonstad, S., Butler, T., Yan, R., & Fraser, G. E. (2009). Type of vegetarian diet, body weight, and prevalence of type 2 diabetes. *Diabetes Care*, 32(5), 791–796. <https://doi.org/10.2337/dc08-1886>
- [61] Toumpanakis, A., Turnbull, T., & Alba-Barba, I. (2018). Effectiveness of plant-based diets in promoting well-being in the management of type 2 diabetes: A systematic review. In *BMJ Open Diabetes Research and Care* (Vol. 6, Issue 1). BMJ Publishing Group. <https://doi.org/10.1136/bmjdr-2018-000534>
- [62] Turton, J. L., Raab, R., & Rooney, K. B. (2018). Low-carbohydrate diets for type 1 diabetes mellitus: A systematic review. In *PLoS ONE* (Vol. 13, Issue 3). Public Library of Science. <https://doi.org/10.1371/journal.pone.0194987>
- [63] Uribarri, J., Cai, W., Ramdas, M., Goodman, S., Pyzik, R., Xue, C., Li, Z., Striker, G. E., & Vlassara, H. (2011). Restriction of advanced glycation end products improves insulin resistance in human type 2 diabetes: Potential role of AGER1 and SIRT1. *Diabetes Care*, 34(7), 1610–1616. <https://doi.org/10.2337/dc11-0091>
- [64] Uribarri, J., Woodruff, S., Goodman, S., Cai, W., Chen, X., Pyzik, R., Yong, A., Striker, G. E., & Vlassara, H. (2010). Advanced Glycation End Products in Foods and a Practical Guide to Their Reduction

- in the Diet. *Journal of the American Dietetic Association*, 110(6).  
<https://doi.org/10.1016/j.jada.2010.03.018>
- [65] Vernon, M. C., Eberstein, J. A., Arora, S., & Mcfarlane, S. I. (2004). *Book review Review on “Atkins Diabetes Revolution: The Groundbreaking Approach to Preventing and Controlling Type 2 Diabetes” Book details.* <https://doi.org/10.1186/1743-7075-1-14>
- [66] Volek, J. S., Sharman, M. J., Gómez, A. L., Judelson, D. A., Rubin, M. R., Watson, G., Sokmen, B., Silvestre, R., French, D. N., & Kraemer, W. J. (2004). Comparison of energy-restricted very low-carbohydrate and low-fat diets on weight loss and body composition in overweight men and women. *Nutrition and Metabolism*, 1. <https://doi.org/10.1186/1743-7075-1-13>
- [67] Weaver, R. R., Lemonde, M., Payman, N., & Goodman, W. M. (2014). Health capabilities and diabetes self-management: The impact of economic, social, and cultural resources. *Social Science and Medicine*, 102, 58–68. <https://doi.org/10.1016/j.socscimed.2013.11.033>
- [68] Wylie-Rosett, J., Aebersold, K., Conlon, B., Isasi, C. R., & Ostrovsky, N. W. (2013). Health effects of low-carbohydrate diets: Where should new research go? *Current Diabetes Reports*, 13(2), 271–278. <https://doi.org/10.1007/s11892-012-0357-5>
- [69] Yokoyama, Y., Barnard, N. D., Levin, S. M., & Watanabe, M. (2014). Vegetarian diets and glycemic control in diabetes: a systematic review and meta-analysis. *Cardiovascular Diagnosis and Therapy*, 4(5), 373–382. <https://doi.org/10.3978/j.issn.2223-3652.2014.10.04>
- [70] Zhao, Z., Li, S., Liu, G., Yan, F., Ma, X., Huang, Z., & Tian, H. (2012). Body iron stores and heme-iron intake in relation to risk of type 2 diabetes: A systematic review and meta-analysis. *PLoS ONE*, 7(7). <https://doi.org/10.1371/journal.pone.0041641>