Review Article

# The role of high fiber diet in the management of Type 2 diabetes: A review on dietetic perspective

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**ABSTRACT**

Dietary fiber is now recognized to have a profound influence on human nutrition, because of its therapeutic and beneficial effects on various states of health and diseases. Consumption of high fiber reduces the likelihood of developing cardiovascular disease, stroke, hypertension, obesity, and some gastrointestinal conditions. This review article delivers information about the role of fiber-rich foods in the management of Type 2 diabetes (T2DM). Indian Council of Medical Research (ICMR) emphasizes the importance of Medical Nutrition Therapy (MNT) in T2DM clinical practice recommendations. The benefits of a high-fiber diet, known as Fiber-rich diabetes nutrition (FDN) are improved glycaemic control, lesser glucose spikes, reduced hyperinsulinemia, better plasma lipid concentrations, and weight loss in type 2 diabetes patients. Comparing the two types of fiber (soluble and insoluble), it has been found that soluble fiber is better at lowering blood sugar, insulin, and serum lipid levels than insoluble fiber. The possible ways are slowing down glucose absorption, taking longer for hepatic insulin extraction, and improving insulin sensitivity. Skeletal muscle expression of the insulin-responsive glucose transporter type 4 (GLUT-4) can be influenced by diet and hence affect the body's ability to take in glucose. This increases skeletal muscle uptake, improves insulin sensitivity, and normalizes blood sugar. Over 25 grams of fiber per day is recommended for women with type 2 diabetes, and 35 grams is recommended for males. For preventing and treating Type 2 Diabetes, it's essential to give appropriate dietary instructions for the adequate intake of dietary fiber.

**Keywords:** Dietary Fiber, Type 2 diabetes, Fiber-rich diabetes nutrition, glycaemic control

## INTRODUCTION

Dietary fiber (DF) is a class of carbohydrate polymers that are observed in plant-based foods, such as cereals, nuts, fruits, and vegetables, and are composed of cellulose, hemicellulose, pectins, gums, mucilage, lignin, cutin, and silica (Archana Singh *et al*., 2015). DFs were first described by Trowell as the skeletal remains of plant cells that are resistant to hydrolysis by human gastrointestinal enzymes. Epidemiological, clinical, and experimental studies established the relationship between a high intake of dietary fiber (DF) and with significantly lower risk of developing coronary heart disease, stroke, hypertension, diabetes, obesity, and certain gastrointestinal diseases. DF plays a vital role in preventing and controlling these diseases and has become an important nutrient for human health and diseases. Increased DF consumption improves serum lipid concentrations, lowers blood pressure; controls blood glucose levels, and weight loss, and boosts immune function (James *et al*., 2009). DF affects the rate and route of absorption of fats, carbohydrates, proteins, and vitamins and alters sterol metabolism and mineral balance. The physic-chemical properties of dietary fiber

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are responsible for most of its physiological effects. The significant properties are water-holding capacity, ion exchange, adsorption of organic and inorganic substances, gelling capacity, solubility, and particle size. Viscosity is related to the physiological effects of fiber such as gastric emptying, increased satiety, or reduced hunger (Devinder Dhingra *et al*., 2012). Based on solubility DF is categorized as soluble fibers, which are fermented in the colon, and insoluble fibers, which have bulking effects, but may only be fermented to a small extent in the colon (Table 1).

Diabetes mellitus (DM), more often referred to as diabetes, is a set of metabolic illnesses defined by high blood sugar levels for an extended period of time. It is a dangerous epidemic health problem that is quickly distributed throughout low- and middle-income nations. India, which has the second-highest diabetes prevalence globally, contributes significantly to the worldwide diabetes epidemic. By 2045, the prevalence is predicted to rise from 425 million to 629 million. Pre-diabetes increasing incidence is assessed by a similar trend (Banshi *et al*., 2022). Type 1 diabetes was once known as juvenile diabetes or insulin-dependent diabetes mellitus (IDDM). An unknown autoimmune response is responsible for the destruction of beta cells. Condition in which cells fail to respond normally to insulin, over time, may lead to insulin insufficiency. Type 2 diabetes begins with insulin resistance, a condition where cells fail to properly respond to insulin. As the disease progresses, a lack of insulin may develop. This form was previously known as "adult-onset diabetes" or "non-insulin-dependent diabetes mellitus" (NIDDM). The third most prevalent form of diabetes, gestational diabetes occurs when a woman who does not normally have high blood sugar when pregnant experiences such symptoms. High blood glucose (sugar) levels can cause symptoms such as increased hunger, thirst, and frequent urination (WHO., 2013). Acute complications of diabetes include diabetic ketoacidosis, hyperosmolar hyperglycemia, and even fatality. Long-term health issues include kidney damage, foot ulcers, chronic kidney diseases, ulceration on the feet, eye damage, heart disease, and stroke. This is mainly caused by dietary changes and decreased physical activity levels, which alter the physiological environment and promotes overweight, obesity, and diabetes (Chinaza *et al*., 2020). It is necessary to take health care for the management of Diabetes mellitus.

The risk of developing cardiovascular disease is increased twofold in people with diabetes, and coronary artery disease is responsible for about 75% of diabetic deaths (O'Gara *et al.,* 2013). Stroke and peripheral artery disease are two more examples of macro-vascular illnesses. According to estimates, 10% of the global population will have diabetes mellitus (DM) by 2030. The effects of type 2 diabetes are so severe that early dietary training is crucial for delaying or preventing the onset of illness; one practical approach is to increase fiber intake.

Coordination between all levels of the health care system is necessary for diabetes care. The patient's knowledge, attitudes, and views of awareness, treatment, and adherence to the recommendations are most important. Regular physical exercise, a healthy diet, and keeping a normal body weight can usually prevent or delay type 2 diabetes, which makes up 85 to 90% of all cases globally. Diabetes risk is decreased by 28% with more physical exercise (above 90 minutes per day) (Kyu *et al.,* 2013). Maintaining a diet high in fiber and whole grains, as well as selecting healthy fats such as the polyunsaturated fats found in vegetable oils, nuts, and fish, are effective dietary adjustments known to avoid diabetes [Harvard School of Public Health., 2012). Diets and nutrition for the prevention of Diabetes include adhering to a healthy diet, such as one that is low in fat and calories, and carbohydrates. Intensive changes in lifestyle are both the foundation for preventing diabetes and for treating diabetes. Preliminary research, such as that conducted by the Indian Diabetes Prevention Program (Ramachandran *et al*., 2006; Weber *et al*., 2016) and

**Table 1:** Main sources of dietary fiber

| Types | Examples | Sources |
|---|---|---|
| Soluble dietary fiber | Pectins, inulin, gums, mucliages, glucomannans, βglycans. | Fruits, berries, vegetables (i.e., pectins from oranges, apples, guava, carrots, beans, lentils; nuts); germ fraction from oat and barley products; guar; psyllium. |
| Insoluble dietary fiber | Cellulose and hemicelluloses; are some types of resistant starch. | Whole-grain and bran products, skins of fruit; cucumbers, tomatoes; the hull of grains; brown rice; legumes; nuts, almonds legumes, sugar beet and potato. |

the Look Ahead trial (Look AHEAD Research Group., 2010), have demonstrated that lifestyle modification measures, including altering eating habits and boosting physical activity, can delay the development of diabetes (Edwardson *et al*., 2014). Current type 2 diabetes mellitus (T2DM) clinical practice guidelines from the Indian Council of Medical Research (ICMR), Research Society for the Study of Diabetes in India (RSSDI), and American Diabetic Association (ADA) focussing the importance of using medical nutrition therapy (MNT) as first-line therapy and offering consistent nutritional recommendations for daily dietary needs (ICMR., 2018; Chawla *et al*., 2020).

## Fiber-rich Diabetes Nutrition

According to the studies of the World Health Organisation (WHO., 2013) improved glycaemic control, decreased glucose spikes, decreased hyperinsulinemia, improved plasma lipid concentrations, and weight management is just some of the many benefits of fiber-rich diabetes nutrition (FDN) in type 2 diabetes patients. This larger bulk of food requires more time to consume, and its presence in the stomach may prompt a sense of fullness sooner, even though this sensation of fullness is just temporary (Rolls *et al.*,1999). Humans have always had a fundamental need to acquire and consume "natural foods" (Chawla *et al*., 2010). Fiber is measured as crude fiber and is referred to as roughage, bulk, or ballast. Nuts, whole-grain cereal, fruits, and vegetables are among the fiber-rich foods that are now known to improve laxative properties, lower levels of low-density lipoprotein (LDL cholesterol, increase insulin sensitivity, increase stool bulk, soften fecal contents, as well as regulate weight (Gordon., 1989; Bertolami *et al*., 1999; Park *et al*., 2005). Humans may consume a certain amount of food; therefore, a fixed amount of lower-energy food (i.e., high-fiber) may encourage weight loss (Rolls *et al*., 2000). The bulking and viscosity properties of DF have a major impact on satiety and stomach fullness. Fiber-rich foods typically require more work and/or time to chew, resulting in greater satiety by slowing down the absorption rate. Additionally, it slows the assimilation of nutrients and energy, which lowers postprandial glucose and cholesterol levels (Howarth *et al*., 2001).

Soluble DF (SDF) is present mainly in the pulp of fruits, legumes, vegetables, and other foods (Sharma *et al*., 2011). SDF has two benefits (1) Lowers total and LDL cholesterol (bad cholesterol) which reduces the risk of heart disease: and (2) Controls blood sugar levels in people with diabetes. Managing blood sugar levels is much easier when there is a high consumption of DF, especially the soluble kind (Lattimer *et al*., 2010). Soluble DF can make digesta more viscous depending on its chemical nature and molecular weight. This, in turn, can lead to a reduced glycaemic response, by delaying gastric emptying and nutrient release as well as by inhibiting the action of α-amylase. Consequently, blood sugar is regulated, a crucial mechanism related to the emergence of insulin resistance and later Type 2 diabetes (Barbara *et al*., 2017). Insoluble DF (IDF) are structural constituents of plant foods cell walls. DF adds bulk to the stool so that it becomes softer and takes a longer time to pass through the intestines. Certain minerals, including calcium, magnesium, phosphorus, and iron, are bound by certain insoluble fibers. The benefits of IDF include: (1) encouraging regular bowel movements and preventing constipation, (2) eliminating hazardous waste from the body, and (3) preventing the stagnation of bacteria that could otherwise produce carcinogens. Both soluble and insoluble dietary fiber makes the feeling of stomach fullness, which helps with weight management and preventing obesity including cellulose, gums, mucilages, hemicellulose, and lignins (Gutkowski *et al*., 2000).

Meals high in fiber contain complex carbohydrates that are difficult to break down, hence decreasing glucose absorption and insulin secretion are helpful for people with T2DM (Desmedt *et al*., 2001). Excessive DF consumption will help to reduce the risk of developing diabetes (Chandalia., 2000; Lindstrom *et al*., 2006). Researchers have found that those who consume more DF have lower levels of insulin resistance (Mohan *et al*., 2010). For individuals with diabetes, eating foods high in fiber can be used in combination with other medications to lessen the effects of prandial hyperglycaemic changes, and it may also help to control their blood sugar levels more evenly between meals. Further studies have shown that even in patients without diabetes, an increase in fiber consumption from food or supplements may lead to a notable decrease in fasting plasma glucose and insulin levels and an increase in insulin sensitivity (Reynolds et *al*., 2020). The functions and benefits of dietary fiber for human health are shown in Table 2.

Grain consumption varies across India, with distinct regional options for rice, wheat, jawar, bajra, and corn (Archana Singh *et al*., 2013). In 2014, researchers found that when obese people switched from eating white

**Table 2:** Functions and benefits of dietary fiber for human health

| Functions | Benefits to human health |
|---|---|
| Increases satiety by adding bulk to the meal, attracting water, and transforming into a gel during digestion. | May reduce hunger, reduces blood sugar levels, and delays glucose absorption. |
| Lowers total and LDL cholesterol | Reduces risk of heart disease |
| Adds bulk to the diet | Making the feeling of fullness faster |
| Attracts water and transforms into a gel | May reduce appetite |
| Regulates blood pressure | Reduces risk of heart disease |
| Speeds the passage of foods through the digestive system | Facilitates regularity |
| Stabilizes intestinal pH and increases the formation of short-chain fatty acids through intestinal fermentation. | May reduce the risk of colorectal cancers. |
| Adds bulk to stool | Alleviates constipation |

rice to brown rice, their glucose and insulin responses improved over the course in South and Southeast Asian Indians (Mohan *et al*., 2014). Pearl millet (bajra), sorghum (jowar), finger millet (ragi or nachni), foxtail millet (kaon), Kodo millet (kodra), tiny millet (gajrao), barnyard millet (konidhan), proso millet (chena), quinoa, and barley are all examples of millets that are rich in fiber and numerous micronutrients (Thakur and Tiwari, 2019). Consuming at least four to five servings of fiber-rich vegetables and fruits daily plus a handful of whole grains daily can help to obtain all the essential micronutrients (Misra *et al*., 2001). Plant foods are a great place to find the daily dose of fiber. Nutrient profiles varied evidently among dietary patterns that were defined by meat and dairy intakes. These differences are of interest in the etiology of obesity and chronic diseases (Rizo *et al.,* 2013).

**Table 3:** Dietary fibre content of various food sources

| Source | Dietary fibre (g/100 g edible portion) | | |
|---|---|---|---|
| | Total | Insoluble | Soluble |
| **Grains** | | | |
| Barley | 17.3 | — | — |
| Corn | 13.4 | — | — |
| Oats | 10.3 | 6.5 | 3.8 |
| Rice (cooked) | 0.7 | 0.7 | 0.0 |
| Wheat (whole grain) | 12.6 | 10.2 | 2.3 |
| Wheat germ | 14.0 | 12.9 | 1.1 |
| **Legumes & pulses** | | | |
| Green beans | 1.90 | 1.40 | 0.50 |
| Soy | 15.0 | — | — |
| Peas, green frozen | 3.5 | 3.2 | 0.3 |
| Kidney beans, canned | 6.3 | 4.7 | 1.6 |
| White beans, raw | 17.7 | 13.4 | 4.3 |
| **Vegetables** | | | |
| Potato, no skin | 1.30 | 1.0 | 0.30 |
| Bitter gourd | 16.6 | 13.5 | 3.1 |
| Beetroot | 7.8 | 5.4 | 2.4 |
| Ladyfinger | 4.3 | 3.0 | 1.3 |
| Spinach, raw | 2.6 | 2.1 | 0.5 |
| Turnips | 2.0 | 1.5 | 0.5 |
| Eggplant | 6.6 | 5.3 | 1.3 |
| Celery, raw | 1.5 | 1.0 | 0.5 |
| Carrot, raw | 2.5 | 2.30 | 0.20 |
| **Fruits** | | | |
| Apple, unpeeled | 2.0 | 1.8 | 0.2 |
| Kiwi | 3.39 | 2.61 | 0.80 |
| Mango | 1.80 | 1.06 | 0.74 |
| Pineapple | 1.20 | 1.10 | 0.10 |
| Pomegranate | 0.60 | 0.49 | 0.11 |
| Watermelon | 0.50 | 0.30 | 0.20 |
| Grapes | 1.2 | 0.7 | 0.5 |
| Oranges | 1.8 | 0.7 | 1.1 |
| Pear | 3.0 | 2.0 | 1.0 |
| **Nuts and seeds** | | | |
| Almonds | 11.20 | 10.10 | 1.10 |
| Coconut, raw | 9.0 | 8.5 | 0.5 |
| Peanut, dry roasted | 8.0 | 7.5 | 0.5 |
| Cashew, oil roasted | 6.0 | — | — |
| Seasame seed | 7.79 | 5.89 | 1.90 |
| Flaxseed | 22.33 | 10.15 | 12.18 |

***Source:*** *Dhingra et al. 2012.*

## Recommended daily intake of dietary fiber

Cereals, fruits, vegetables, and nuts are natural sources of dietary fiber. Common food sources with their dietary fiber content are presented in Table 3 (Dhingra *et al*, 2012). Fiber content and type can vary greatly across

various foods (Desmed *et al*., 2001). A high-fiber diet has a lower energy density, a greater volume, typically a lower fat content, and a greater concentration of micronutrients. This larger bulk of food takes longer to consume, and its presence in the stomach may induce satiety more quickly, albeit for a brief period of time (Papathanasopoulos and Camilleri ,2010).

The most popular DF supplements are soluble-fiber forms, such as guar gum, glucomannan, xanthan gum, psyllium, pectin, alginate, and -glucan concentrates as numerous other fiber combinations. As a replacement for insoluble fiber, soluble fiber was credited with beneficial effects on glucose (Evert *et al*., 2014) and lipid abnormalities (NCHS., 1998). Partially hydrolyzed guar gum (PHGG) is a water-soluble dietary fiber derived from the partial enzymatic hydrolysis of guar gum (GG) that is flavorless and easily incorporated into the diet (Yoon *et al*., 2008; Slavin and Greenberg, 2003). Dietary choices are a significant driver of insulin resistance, particularly in aging and sedentary populations. The prevention of diabetes is defined as managing blood glucose and insulin levels and preserving the function of insulin receptors and pancreatic cells. This is feasible through the application of early and lasting lifestyle interventions, such as the modification of dietary habits and physical activity, which leads to greater weight control or modest weight loss, a preferred method of pharmacological treatment (Weisman *et al.,* 2018). Adults in good health are advised to consume between 20 and 35 grams of dietary fiber daily. Several non-starch meals have up to 20–35 g of fiber per 100 g of dry weight, while starch-containing foods include about 10 g per 100 g of dry weight, and fruits and vegetables provide 1.5–2.5 g per 100 g of dry weight (Selvendran and Robertson, 1994). About half of the dietary fiber consumed in Western countries comes from cereals, with 30–40% coming from vegetables, 16 % from fruits, and the other 3–5% from other small sources. The National Academy of Sciences' Institute of Medicine recommends an uptake of 25-35 g of fiber for adults up to age 50 and 20-30 g for adults older than age 50. Select foods like dried beans and peas, raw or cooked veggies, and whole grains. Fruit juice, white bread and pasta, and non-whole-grain cereals are examples of refined or processed meals that are lower in fiber. Removing the bran during grain processing reduces the grain's fiber content (Lambo *et al*., 2005).

## Consumption of whole grain foods for the management of type 2 Diabetes

Intact, flaked, or damaged grain kernels, coarsely crushed kernels, or flour prepared from complete grains are all examples of what we mean by "whole grain" (entire-meal flour). American Diabetes Association, (2002) has established the fact that high-fiber diets (about 30 grams per day) can improve metabolic health, mitigate the effects of type 2 diabetes, and lessen the incidence of cardiovascular disease risk factors. Studies of Jenkins *et al*. (1976) have shown that soluble dietary fibers (DF) have physiological effects on the stomach and small intestine that influence postprandial glycaemic responses, slowing down the movement of the small intestine via controlling myoelectrical activity in the gut, reducing glucose transport through the undisturbed water layer and reduces amylase accessibility to its substrates due to the increased viscosity of gastrointestinal contents (Leclère *et al*., 1994). Although soluble fiber's glycemic impact is mainly attributable to its increased viscosity and gel-forming properties, experimental clamp studies have shown that soluble DF can also influence mechanisms of peripheral glucose uptake (Cameron-Smith *et al*., 1997), such as increasing expression of the insulin-responsive glucose transporter kind four (GLUT-4) in skeletal muscle, which boosts skeletal muscle uptake, increases insulin sensitivity, and normalizes blood glucose (Song *et al*., 2000). Therefore, rather than relying on fiber supplements, diabetic diets should emphasize increasing dietary fiber intake through the consumption of naturally occurring foods. Eat more seasonal, locally grown produce, healthful grains, legumes, nuts, and seeds. Instead of eating foods made with refined flour and starches, we should eat foods made with whole grains.

## CONCLUSION

A high-fiber diet has health-protective and disease-reversing advantages. By limiting or delaying the absorption of carbohydrates, dietary fiber improves glycaemic control. People who consume beneficial levels of DF have a lower risk of acquiring chronic diseases such as heart disease, stroke, high blood pressure, diabetes, obesity, and several gastrointestinal diseases than those with modest amounts. An increase in the consumption of high-fiber meals or fiber supplements has been shown to enhance blood glucose management in

people with diabetes, assist in weight loss, and promote regularity. It was shown that a wide variety of processed and ready-to-eat meals have significant DF content. As a result of its unique physiological effects, it has been proposed as a useful source in the control of Type 2 Diabetes Mellitus. The incidence of Type 2 diabetes can be addressed by promoting the role of dietary fiber through various types of health awareness activities.

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