Carbohydrate and Fiber Intake on Fasting Blood Glucose Levels in Patients with Type 2 Diabetes Mellitus Following Brown-Rice Diet Intervention

Chyntia Cahyawardani ¹*, Etik Sulistyowati ², Endang Widajati ²

¹¹ Undergraduate Program in Applied Nutrition and Dietetics, Department of Nutrition, Malang Health Polytechnic
²² Applied Nutrition and Dietetics Study Program, Department of Nutrition, Malang Health Polytechnic
*Correspondence Address: cinchyntia99@gmail.com

Accepted: August 2022 Reviewed: May 2023 Published: July 2023

ABSTRACT

Type 2 diabetes mellitus (T2DM) is a metabolic disorder characterized by hyperglycemia due to decreased insulin secretion by pancreatic beta cells and insulin resistance. Medical nutrition therapy is one of the pillars in the management of T2DM, in the form of a balanced diet. A good intake of carbohydrates and fiber can help regulate fasting blood glucose levels in diabetic patients. This study aims to determine the relationship between carbohydrate and fiber intake on fasting blood glucose levels in patients with T2DM following a brown-rice diet intervention. This study was pre-experimental without control variables and employed a non-random sample selection method. The research design was a one-shot case study, focusing on post-test results. The study included a sample size of 18 people aged 48–60 years. Data analysis involved the Shapiro-Wilk normality test and Spearman correlation test. The results showed that the majority of the respondents had normal carbohydrate intake (88.9%) and good fiber intake (100%). However, most respondents had uncontrolled fasting blood glucose levels (55.6%). There is no relationship between carbohydrate and fiber intake on fasting blood glucose levels following the intervention of a brown rice-based diet menu.

Keywords: T2DM, brown rice, carbohydrate intake, fiber intake, fasting blood glucose levels

INTRODUCTION

Diabetes mellitus is a chronic and progressive disease characterized by the body’s inability to metabolize carbohydrates, fats, and proteins, leading to hyperglycemia or high blood glucose levels (1). According to The Indonesian Basic Health Research in 2013 and 2018, the national prevalence of diabetes mellitus among individuals aged 15 and older has been increasing from 6.9% to 10.95%. The highest prevalence rates of diabetes mellitus were observed in the age range of 55-64 years, as much as 6.3%, followed by the age range of 65-74 years, as much as 6%. In addition, the occurrence

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01_1
of diabetes mellitus is more prevalent in women (1.8%) than in men (2).

Management of diabetes mellitus begins with adopting a healthy lifestyle, which includes medical nutrition therapy and physical activity, and pharmacological interventions involving oral and/or anti-hyperglycemic drug injections (3). The principle of dietary management in people with diabetes mellitus is known as the “3J Right Principles,” emphasizing the right amount (jumlah) of energy and nutrients, selecting the right type (jenis) of food and/or food, and adhering to the right meal schedule (jadwal). People with diabetes mellitus can still eat the same menu as their family members, as the amount of energy and nutrients is more significant than the type of food (4).

Brown rice is an alternative food, which has effective preventive and therapeutic effects for diabetes mellitus. Brown rice is untreated whole grain obtained by removing the outermost layers of seed called husk (5). Brown rice retains its germ and bran layers, which are rich in fiber. Thus, carbohydrates in brown rice are digested more slowly in the digestive tract, leading to a gradual increase in blood glucose levels. According to research results, consuming 50 grams of brown rice per day can potentially reduce the incidence of diabetes by 13% (6).

Rice serves as a source of carbohydrates, contributing to energy besides fat and protein. The amount of carbohydrates consumed from main meals and snacks can affect blood glucose levels and insulin secretion. Consequently, the amount of carbohydrates consumed holds greater importance than the carbohydrate (7). The results of a study conducted by Ngaisyah (2015) showed a relationship between a high-carbohydrate diet and an increased risk of type 2 diabetes mellitus (T2DM). However, regularly consuming high-fiber foods such as brown rice can help reduce the risk of T2DM (8).

The fiber and mineral content in brown rice (22.04 g) are higher compared to those in white rice (20.58 g) (9). Dietary fiber offers many benefits for the management of T2DM. Due to its slow processing in the body, fiber will cause a feeling of fullness. Water-insoluble dietary fiber enhances the rate of absorption of nutrients in the gastrointestinal tract so that it can reduce carbohydrate absorption and increase insulin sensitivity (10). According to research conducted by Amanda and Bening (2019), there is a relationship between fiber consumption and fasting blood glucose levels in people with T2DM. The higher-fiber intake is associated with lower fasting blood glucose level (11).

Consumption of high-fiber foods is related to lower insulin response, thereby reducing the incidence of insulin resistance. Fasting blood glucose level is one way to establish the diagnosis of T2DM. It can provide an overall picture of glucose homeostasis and can effectively predict HbA1C levels (7). According to research conducted by Lee et al (2018), fasting blood glucose levels are particularly sensitive for predicting the risk of developing T2DM, especially in individuals older than 40 years old (12).

The purpose of this study was to analyze the relationship between carbohydrate and fiber intake on fasting blood glucose levels in T2DM patients following a brown rice-based diet intervention.

**RESEARCH METHODS**

**Research Design**

The type of research used in this study was pre-experimental research without control variables, and the samples were not randomly selected (13). This study used a one-shot case study design, where the researcher only conducted a one-time treatment believed to have an effect and then conducted a post-test (14).
Data Source

All data collected were primary data. The data were in the form of respondent characteristics (gender, age, type of work, BMI, disease), carbohydrate intake, fiber intake, and fasting blood glucose levels.

Brown Rice Diet

This study used a diet menu intervention based on brown rice with a frequency of three main meals and three side dishes. The type of DM diet given was adjusted to the respondent’s daily energy needs, DM 1300, 1400, 1500, or 1600. The dietary intervention was given from Monday to Saturday for 12 weeks. The amount of brown rice consumed per day ranged from 200 to 270 grams, which contributes 86.2 to 116.4 grams of carbohydrates.

Research Target

The sampling method used in this study was purposive sampling, resulting in a total of 18 respondents who were outpatients with diabetes mellitus at Griya Bromo Malang Clinic. The inclusion criteria were female, aged between 48 and 60 years, nutritional status within the BMI range of 21.5–28.5 kg/m², Hb-A1c <8% with 1 or a combination of Anti-Diabetes Drugs (ADD), and were willing to be research respondents proven by signing the inform consent. The exclusion criteria were active smokers, having a history of gastrointestinal disorders requiring long-term medical therapy, having heart, kidney, and malignancy disorders.

Development of Data Collection Instruments and Techniques

Data on the characteristics of the respondents were taken using a questionnaire. Data on the nutritional status of patients were obtained from measuring height using a microtoa with an accuracy of 0.1 cm and body weight using Bioelectrical Impedance Analysis. The obtained data were then used to calculate the Body Mass Index (BMI). Then, BMI values were categorized into normal weight (18.5–22.9), overweight (23.0–24.9), or obesity I (25.0 – 29.9).

Food intake data during the intervention was collected using the method of food record three times a week for 12 weeks. The recording was done on two working days (Monday and Wednesday) and one day off (Saturday). Data on carbohydrate and fiber intake were obtained from brown rice-based food ingredients/diet menu consumed per day. Carbohydrate intake data were categorized into five levels: severe deficit (<70%), moderate deficit (70–79%), mild deficit (80–89%), normal (90–119%), and excess (>120%). Fiber intake is considered good when it is higher than 25 g per 1000 kcal and inadequate when below 25 g per 1000 kcal (4).

Data on fasting blood glucose (FBG) levels for each respondent were obtained from laboratory measurements one day after the dietary intervention was completed. FBG levels in respondents with T2DM can be categorized as controlled if below 126 mg/dL, and not controlled if higher or equal to 126 mg/dL (15).

Data Analysis Technique

The data obtained will be tested for the normality of the data using the Shapiro-Wilk test. The test was chosen because the sample size was less than 50. The results showed that the data on carbohydrate intake and fiber intake were not normally distributed at a significance level of α <0.05, while the fasting blood glucose data were normally distributed. Furthermore, a Spearman’s correlation test was carried out with a confidence level of 95% (α = 0.05) to determine the relationship between carbohydrate and fiber intake with fasting blood glucose levels.

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.1
This research has received ethical approval issued by the Health Research Ethics Committee, Faculty of Medicine, Universitas Brawijaya, with license number 143/EC/KEPK/07/2016.

RESEARCH RESULT
Overview of Respondents
All respondents in this study were female within the age range of 40-60 years. Table 1 shows that most of the respondents (50%) belong to the early elderly group or the age range of 46-55 years. Most of the respondents are housewives (61.1%). Most of the respondents were in the Obesity I category. The majority of respondents had a history of other diseases besides T2DM. Most of the respondents had a history of hypertension, hypercholesterolemia, and even both diseases.

<table>
<thead>
<tr>
<th>Tabel 1. Distribution of Respondents’ General Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Age (Years)</td>
</tr>
<tr>
<td>36 – 45</td>
</tr>
<tr>
<td>46 – 55</td>
</tr>
<tr>
<td>56 – 65</td>
</tr>
<tr>
<td>Profession</td>
</tr>
<tr>
<td>Housewife</td>
</tr>
<tr>
<td>Tailor</td>
</tr>
<tr>
<td>Notary officer</td>
</tr>
<tr>
<td>Teacher</td>
</tr>
<tr>
<td>Headmaster</td>
</tr>
<tr>
<td>Posyandu cadres</td>
</tr>
<tr>
<td>Church officer</td>
</tr>
<tr>
<td>BMI Category</td>
</tr>
<tr>
<td>Normal weight</td>
</tr>
<tr>
<td>Overweight</td>
</tr>
<tr>
<td>Obesity I</td>
</tr>
<tr>
<td>Disease History</td>
</tr>
<tr>
<td>Hypercholesterolemia</td>
</tr>
<tr>
<td>Hypertension</td>
</tr>
<tr>
<td>Hypercholesterolemia &amp; Hypertension</td>
</tr>
<tr>
<td>Hypercholesterolemia &amp; gout</td>
</tr>
<tr>
<td>Asthma &amp; gastritis</td>
</tr>
<tr>
<td>Spinal HNP</td>
</tr>
<tr>
<td>Nothing</td>
</tr>
</tbody>
</table>

DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.1
Description of Respondents’ Carbohydrate Intake

Table 2. Distribution of Respondents’ Carbohydrate Adequacy Levels

<table>
<thead>
<tr>
<th>Category</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal (90 – 119%)</td>
<td>16</td>
</tr>
<tr>
<td>Excess (&gt; 120%)</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
</tr>
</tbody>
</table>

The average respondent’s carbohydrate intake in this study ranged from 165 g to 320 g. Table 2 shows that most of the respondents had normal carbohydrate intake levels, 90-119%. As many as two people had carbohydrate intake that exceeded the recommended range (45-60%).

Description of Respondents’ Fiber Intake

The recommended daily fiber intake for people with T2DM is 25 g/1000 kcal (4). The respondents’ need for fiber in a day is equal to 31.5 g to 39.4 g. The fiber intake of all respondents (100%) was considered good as it exceeded the recommended needs.

Table 3 shows that most of the respondents (55.5%) had uncontrolled FBG levels, ≥126 mg/dL. The statistical test results using the Spearman correlation test obtained a p-value of 0.501, which is greater than α=0.05 (0.501 > 0.05). It indicated no relationship between carbohydrate intake and FBG levels in people with T2DM. Statistical test results on fiber intake and FBG levels value obtained a p-value of 0.368, which is greater than α=0.05 (0.276 > 0.05), suggesting that there is no relationship between fiber intake and FBG levels in patients with T2DM. The results of the relationship test are presented in Tables 4 and 5.

Table 4. Correlation Carbohydrate intake and FBG Levels

<table>
<thead>
<tr>
<th>Carbohydrate</th>
<th>FBG Levels</th>
<th>Total</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Controlled</td>
<td>Uncontrolled</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Normal</td>
<td>8</td>
<td>50</td>
<td>8</td>
</tr>
<tr>
<td>Excess</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>44.4</td>
<td>10</td>
</tr>
</tbody>
</table>

*Statistic test

Table 5. Correlation Fiber Intake and FBG Levels

<table>
<thead>
<tr>
<th>Fiber</th>
<th>FBG Levels</th>
<th>Total</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Controlled</td>
<td>Uncontrolled</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Bad</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Good</td>
<td>8</td>
<td>44.4</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>44.4</td>
<td>10</td>
</tr>
</tbody>
</table>

*Statistic test

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DISCUSSION
Overview of Respondents

All respondents in this study were female. Since there is a monthly cycle syndrome (premenstrual syndrome) and post-menopause in women, this factor may contribute to the accumulation of fat in the body. Additionally, women who have experienced menopause tend to have decreased sensitivity to the hormone insulin (16).

Most of the respondents were in the early elderly group or the age range of 46-55 years. According to research conducted by Lathifah (2017), the majority of T2DM sufferers are over 58 years old (52%). An individual aged 45 years and above has a higher risk of suffering from diabetes mellitus and glucose intolerance due to generative factors, such as decreased body function for glucose metabolism (17).

In this study, most of the respondents were housewives. According to Isnaini & Ratnasari (2018), working as a housewife involves engaging in light physical activities, such as washing, cooking, cleaning the house, and several other similar activities. Regular physical activity has been shown to increase insulin production so that blood glucose levels will decrease (18).

Obesity in adults has a four-fold increased risk of developing T2DM compared to people with normal nutritional status (19). Obesity can contribute to metabolic disorders and insulin resistance, as insulin cannot work optimally in muscle, fat, and liver cells (20). In this study, most of the respondents were in the category of Obesity 1. It is in line with research conducted by Dafriani (2017) that respondents who have diabetes mellitus are more likely to be obese (21).

Some respondents had a history of diseases other than T2DM, such as hypertension and hypercholesterolemia. Individuals who suffer from T2DM are at risk of experiencing chronic complications. As many as 60% of diabetic patients also have hypertension and 28% of diabetic patients also have dyslipidemia. Diabetic patients often have high LDL cholesterol and triglyceride levels and low HDL cholesterol levels, which can result in insulin resistance (22).

Analysis of Carbohydrate Intake and Respondents’ Fasting Blood Glucose Levels

T2DM sufferers need to be aware of the amount of carbohydrates consumed as most of the carbohydrates are converted into glucose in the body, mainly in the form of polysaccharides (4). The hormone insulin plays a crucial role in maintaining the balance of glucose levels in the blood (23). Statistical test results showed no relationship between carbohydrate intake and FBG levels in T2DM patients. These results are in line with a study conducted by Kurniasari (2014) that there was no relationship between carbohydrate intake and blood glucose levels in hospitalized T2DM patients, as the patients were given food containing carbohydrates according to their needs so that there is no excess carbohydrate intake (24). The result of Wati & Rodlah’s research (2019) stated that carbohydrate intake is not related to blood glucose levels since carbohydrate intake is not an influencing factor in controlling the patient’s blood glucose levels (25).

Another factor related to blood glucose levels is age, where most of the respondents in this study were over 40 years old. Physiological changes usually

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occur at the age of more than 40 years, one of which is the decreased ability of beta cells to produce insulin for glucose metabolism (17).

Table 4 shows eight people who had normal carbohydrate intake but had uncontrolled FBG levels. It could be caused by respondents’ BMI classification as overweight and obese. Research by Sa’pang et al. (2018) stated that a higher BMI is associated with higher fasting blood glucose levels in patients with T2DM. A person with a BMI above the normal range has an increase in insulin resistance, which results in increased blood glucose levels (26).

The results of this study indicate that two people who consumed excessive carbohydrates had uncontrolled FBG levels. Excessive carbohydrate intake can trigger insulin resistance since the carbohydrates consumed will be broken down into a simple form, glucose, absorbed in the intestines, and enter the blood circulation. This excess carbohydrate intake will increase blood glucose levels (27). Moreover, the results of research conducted by Wulandari and Kurnianingsih (2018) stated a relationship between a high-carbohydrate diet and blood glucose levels, as intake of foods rich in carbohydrates can interfere with the stimulation of pancreatic beta cells in producing insulin (23).

T2DM sufferers who consume carbohydrates more than their daily needs can experience elevated blood glucose levels. Insulin hormone levels in people with DM are not enough to convert glucose into glucagon. According to research conducted by Sandra and Isnawati (2015), carbohydrate intake has a significant relationship with blood glucose levels. Every gram of excess carbohydrates can increase blood glucose levels by 2,750 mg/dl (28). Furthermore, the study results conducted by Juwita et al. (2020) showed a significant relationship between carbohydrate intake and blood glucose levels (29).

Analysis of Respondents’ Fiber Intake and Fasting Blood Glucose Levels

Soluble dietary fiber can be fermented by bacteria in the large intestine, while only a small portion of insoluble fiber can be fermented. The content of soluble and insoluble dietary fiber in each food varies, thereby it is necessary to include a variety of foods that contain fiber in the diet plan (30).

However, the statistical test results in Table 5 show that there is no relationship between fiber intake and FBG levels in people with T2DM. A study conducted by Jenkins et al. (2002) involving 23 respondents who followed a high-fiber diet for 12 weeks found no significant relationship between a high-fiber diet and a decrease in fasting blood glucose levels. This dietary intervention used high-fiber cereals and broken wheat bread, resulting in an average daily fiber intake of 37.3 g a day per respondent. Studies using longer duration are needed to observe changes from high-fiber diets (31).

Furthermore, the results of a study conducted by Karimi et al. (2015) found no significant decrease in fasting blood glucose after being given a high-fiber diet for eight weeks (32). The results of McRae’s study (2018) stated that reducing fasting blood glucose levels could not reduce the incidence of T2DM in patients with adequate dietary fiber intake. Adequate fiber intake (25 grams per 1000 kcal) can reduce the occurrence of chronic microvascular and macrovascular complications in people with T2DM. However, long-term studies involving large populations are needed to analyze the relationship between fiber intake and blood glucose (33). According to Turner and Lupton (2011), there is no maximum limit to total fiber intake that the body can tolerate (34).

DOI: [https://doi.org/10.21776/ub.ijhn.2023.010.01.1](https://doi.org/10.21776/ub.ijhn.2023.010.01.1)
According to research conducted by Audina et al. (2018), lower fiber intake is associated with higher fasting blood glucose levels in T2DM sufferers (35). Fiber, especially soluble fiber, can help lower glucose levels by increasing food viscosity and slowing down the process of emptying and digestion in the stomach. This process results in decreased absorption of nutrients, including glucose, and creates a longer feeling of satiety so that food intake decreases. A decrease in glucose absorption and food intake lowers blood glucose levels. Undigested fiber will enter the large intestine and undergoes fermentation by bacteria. This process can increase insulin sensitivity and eventually lead to reduced blood glucose levels (36).

Research conducted by Audina et al. (2018) found a significant relationship between fiber intake and FBG levels of T2DM sufferers. Patients who consume fiber intake of more than 25 grams per day tend to experience reduced fasting blood glucose levels. Fiber intake can control fasting blood glucose levels and prevent complications (35). Furthermore, the results of a study conducted by Soviana and Maenasari (2019) showed a relationship between fiber intake and fasting blood glucose levels in T2DM patients at the Jasmine 2 Clinic in Surakarta. The average respondent’s fiber intake is 14.33 grams per day, which is classified in the low category (37).

CONCLUSION

In conclusion, this study indicates that the majority (88.9%) of respondents had normal carbohydrate intake. All respondents (100%) had good fiber intake. There were ten people (55.6%) who had uncontrolled FBG levels (≥126 mg/dL) and eight people (44.4%) who had controlled FBG levels (<126 mg/dL). There is no relationship between carbohydrate and fiber intake on fasting blood glucose levels in T2DM patients following the intervention of a brown rice-based diet menu.

ACKNOWLEDGMENTS

The authors would like to thank Prof. Dian Handayani, SKM, M.Kes, PhD who has provided the opportunity to join the research team. The authors also thank Dr. Etik Sulistyo wati, SST., S.Gz., M.Kes and Endang Widajati, SST., M.Kes., RD who have guided the completion of this research.

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DOI: https://doi.org/10.21776/ub.ijhn.2023.010.01.1


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