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# Literature Review: The Effectiveness Of Brown Rice Diet As Nonpharmacological Nutritional Therapy In Type 2 Diabetes Mellitus Patients

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***Abstract***

*Type 2 diabetes mellitus is a global health problem with a high prevalence in Indonesia and requires comprehensive management, including non-pharmacological nutritional therapy. The choice of carbohydrate sources plays an important role because white rice has a high glycemic index, while brown rice has a lower glycemic index and contains fiber and bioactive compounds that have the potential to help control blood glucose. Therefore, this study aims to determine the nutritional content of brown rice that is relevant to the management of type 2 diabetes, to analyze the effect of brown rice consumption on glycemic control in patients with type 2 diabetes, to determine the effect of a brown rice diet on other metabolic parameters such as body weight, lipid profile, and insulin sensitivity, and to summarize the scientific evidence related to the potential of brown rice as an alternative dietary intervention for patients with type 2 diabetes. This study used a literature review method with a narrative review design. The results of the study showed that brown rice has nutritional content that is relevant to the management of type 2 DM, especially fiber, vitamins, minerals, and bioactive compounds that support improved glucose metabolism. The application of a brown rice diet contributes to improved glycemic control, as indicated by a decrease in fasting blood glucose, postprandial glucose, and HbA1c. In addition, brown rice consumption also has a positive impact on other metabolic parameters, including improved lipid profile, insulin sensitivity, and potential weight control. Overall, brown rice has the potential to be a healthier alternative source of carbohydrates and is applicable as part of non-pharmacological nutritional therapy in patients with type 2 diabetes. It can be concluded that a brown rice diet is an effective and safe non-pharmacological nutritional intervention to support the management of type 2 DM through improved glycemic control and metabolic parameters, making it a recommended alternative carbohydrate source in the patient's diet.*

***Keywords: Type 2 Diabetes Mellitus, Brown Rice, Non-Pharmacological Nutritional Therapy, Glycemic Control, Glycemic Index.***

## INTRODUCTION

Type 2 diabetes mellitus (T2DM) is one of the global health issues with a prevalence that continues to increase every year. According to *the International Diabetes Federation* (IDF), in 2021 there were approximately 537 million adults with diabetes, and this number is projected to increase to 643 million by 2030 if there are no effective interventions in the prevention and control of this disease (Federation, 2013). Indonesia itself ranks fifth as the country with the highest number of diabetes sufferers in the world, making comprehensive and sustainable management of type 2 DM a public health priority (Novianto et al., 2026). Controlling type 2 DM requires a combination of various interventions, including pharmacological and non-pharmacological therapies. One important component of non-pharmacological therapy is diet management. The Indonesian Endocrinology Association (PERKENI) guidelines emphasize that dietary modification plays a major role in controlling blood glucose levels, improving insulin sensitivity, and preventing chronic complications of DM (Indonesia, 2021). In this context, the selection of carbohydrate sources is crucial, given that carbohydrates are the main macronutrients that affect the body's glycemic response.

White rice, a staple food in Indonesia, has a high glycemic index (GI), causing blood glucose levels to rise more quickly after consumption. Therefore, alternative carbohydrate sources with better nutritional value for type 2 DM patients need to be considered. Brown *rice* is one option that is increasingly being researched in the field of diabetes nutrition . Brown rice is rice grain that has only undergone the removal of the outer husk, so the *bran* and germ layers remain intact. The fiber, magnesium, antioxidants, and bioactive compounds such as *γ-oryzanol* in brown rice have been shown to have positive effects on glucose metabolism (Manzoor et al., 2023). Several recent studies indicate that consuming brown rice has the potential to lower fasting blood glucose levels, improve glycemic control, and enhance lipid profiles in patients with type 2 diabetes. A 2022 *randomized controlled trial* in Japan showed that replacing white rice with brown rice for 8 weeks can significantly lower fasting blood glucose and hemoglobin A1c (Rahim et al., 2021). Another study in 2020 also reported that brown rice consumption increased insulin sensitivity and reduced insulin resistance through increased fiber intake and decreased daily glycemic load (Clemente-Suárez et al., 2023).

In addition, brown rice has a lower GI than white rice, resulting in a slower and more stable release of glucose into the bloodstream. Its soluble fiber content helps slow glucose absorption and increase satiety, thereby contributing to weight control—an important factor in managing type 2 diabetes (Seckiner et al., 2024). With these various potential benefits, brown rice has the potential to be part of an effective and easily implemented non-pharmacological nutritional therapy strategy. Although the scientific evidence regarding the benefits of brown rice is promising, its implementation as a dietary intervention in type 2 DM patients is not yet optimal. Many patients still do not understand its benefits, and health workers need clear evidence-based guidelines. Therefore, a literature review on the effectiveness of brown rice diets as non-pharmacological nutritional therapy in type 2 DM patients is highly relevant to strengthen the scientific basis for clinical practice recommendations. Based on this background, the author is interested in conducting *a literature review* on the effectiveness of brown rice diets as non-pharmacological nutritional therapy in type 2 DM patients.

## RESEARCH METHODS

This study used a literature review method with a narrative review design, which is a systematic, clear, and comprehensive literature review to identify, evaluate, and collect relevant research results. This study aims to critically review the available ideas, findings, and knowledge to draw theoretical conclusions as a reference for further research. The literature search was conducted online through PubMed, Google Scholar, and e-Perpusnas using the keywords "brown rice diet," "type 2 diabetes," and "glycemic control." The literature included were research articles published between 2020 and 2025, discussing the effectiveness of brown rice diets as non-pharmacological nutritional therapy in type 2 DM patients, and available in full text, while articles published before 2020 or not fully accessible were excluded from the study. All collected articles were then curated according to inclusion and exclusion criteria, summarized narratively, and described in a table containing the researcher, year of publication, journal, article title, and summary of the research results. Next, an in-depth review of the methods, processes, and results of the full-text manuscripts was conducted, followed by coding to identify similarities and differences between studies, which were then synthesized as the basis for drawing conclusions and discussion.

## RESULTS AND DISCUSSION

### Article Selection Process

The *literature review* yielded 30 journals discussing the effectiveness of brown rice diets as non-pharmacological nutritional therapy for type 2 DM patients. Inclusion and exclusion criteria were used to eliminate unrelated journals, resulting in 30 journals. The research process carried out in writing the thesis began with topic determination, literature search based on related article databases, literature selection, data processing, and conclusions.

## Article Description

**Table 1**. Article Description

| Researcher | Year | Database Source |
|---|---|---|
| (Yu et al., 2022) | 2022 | *PubMed* |
| (Mendoza-Sarmiento et al., 2023) | 2023 | *PubMed* |
| (Haldipur & Srividya, 2021) | 2021 | *PubMed* |
| (Park et al., 2023) | 2023 | *PubMed* |
| (Mitta et al., 2022) | 2022 | *Google Scholar* |
| (Zhao et al., 2023) | 2023 | *PubMed* |
| (Handayani et al., 2022) | 2021 | *PubMed* |
| (Mai et al., 2020) | 2020 | *Google Scholar* |
| (Na et al., 2023) | 2023 | *PubMed* |
| (Chaiyakul et al., 2023) | 2023 | *ScienceDirect* |
| (Nugroho et al., 2024) | 2024 | *Google Scholar* |
| (Lim et al., 2023) | 2023 | *ScienceDirect* |
| (Pereira et al., 2021) | 2021 | *ScienceDirect* |
| (Du et al., 2025) | 2025 | *ScienceDirect* |
| (Sanders et al., 2023) | 2021 | *PubMed* |
| (Xu et al., 2021) | 2021 | *ScienceDirect* |
| (Ren et al., 2024) | 2024 | *ScienceDirect* |
| (Jabeen et al., 2024) | 2024 | *PubMed* |
| (Sitanggang et al., 2021) | 2021 | *PubMed* |
| (Takano et al., 2021) | 2021 | *ScienceDirect* |
| (Li et al., 2022) | 2022 | *ScienceDirect* |
| (Nakamura et al., 2022) | 2022 | *ScienceDirect* |
| (Tantayakhom et al., 2025) | 2025 | *ScienceDirect* |
| (Permatasari et al., 2023) | 2023 | *Google Scholar* |
| (Martuti et al., 2023) | 2023 | *Google Scholar* |
| (Cahyawardani et al., 2023) | 2023 | *Google Scholar* |
| (Kusumastuty et al., 2021) | 2021 | *Google Scholar* |
| (Ying et al., 2024) | 2024 | *ScienceDirect* |
| (Kristianto et al., 2024) | 2024 | *Google Scholar* |
| (Ikeda et al., 2025) | 2025 | *ScienceDirect* |

A total of 30 articles were collected and analyzed from several national and international journal search sites. The research articles collected range from 2020 to the most recent in 2025.

## Results

Based on the summary results after conducting the search, 30 journals related to the effectiveness of brown rice diet as non-pharmacological nutritional therapy in type 2 diabetes mellitus patients were obtained:

**Table 2**. Results of the literature review study

| Author & Year | Title | Method | Main Results |
|---|---|---|---|
| (Yu et al., 2022) | *White rice, brown rice, and the risk of type 2 diabetes* | *Systematic review & meta-analysis* | White rice consumption increases the risk of T2DM (RR 1.16), while brown rice reduces the risk (RR 0.89). Significant protective effects with regular consumption. |
| (Mendoza-Sarmiento et al., 2023) | *Effect of pigmented rice consumption on cardiometabolic risk* | *Systematic review RCT* | Pigmented rice reduces FBG (-1.60 mg/dL), postprandial insulin, body weight, and blood pressure. No significant effect on lipid profile. |
| (Haldipur & Srividya, 2021) | *In vitro evaluation of red rice genotypes* | *In vitro assay & in silico* | Red rice rich in phenolics exhibits strong antihyperglycemic, antioxidant, and antiglycation activities. Potential as a functional food for diabetes management. |
| (Park et al., 2023) | *Effects of heat-treated brown rice containing resistant starch* | *RCT crossover* | Heat-resistant brown rice rich in *resistant starch* improves glucose tolerance and reduces postprandial glucose levels in humans. |

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|---|---|---|---|
| (Mitta et al., 2022) | *Impact of brown rice on glycemic and lipid profile* | *Quasi-experimental intervention* | Consumption of brown rice lowers blood glucose and improves lipids in patients with T2DM. |
| (Zhao et al., 2023) | *Brown rice effect on the microbiome in insulin-resistant mice* | Animal study | *Brown/germinated brown rice* increases SCFA, improves the of microbiota, and reduces inflammation associated with insulin resistance. |
| (Handayani et al., 2022) | *Substitution of Indonesian brown rice on glucose levels* | *Pilot project* | Substitution of local brown rice lowers blood glucose and improves anthropometry in type 2 diabetes patients. |
| (Mai et al., 2020) | *Effectiveness of germinated brown rice on metabolic syndrome* | *RCT* | GRB reduces waist circumference, FBG, and blood pressure in patients *with metabolic syndrome* in Vietnam. |
| (Na et al., 2023) | *Germinated brown rice and n-3 PUFA metabolism* | *RCT* | GRB improves n-3 PUFA metabolism and reduces inflammation in patients with T2DM. |
| (Chaiyakul et al., 2023) | *Rice-based diabetes-specific formula* | *Double-blind crossover RCT* | The rice-based formula reduces *postprandial* glucose and increases GI hormone secretion. Potential as a diabetes diet. |
| (Nugroho et al., 2024) | *Brown rice improves inflammatory index* | *Pre–post intervention* | Brown rice lowers FBG, reduces TNF-α, and improves *dietary inflammatory index* in DM patients. |
| (Lim et al., 2023) | *Impact of fermentation on brown rice* | *Meta-analysis* | Fermentation increases antioxidants, GABA, and antidiabetic activity; enhances the metabolic benefits of brown rice. |
| (Pereira et al., 2021) | *Rice compounds affecting diabetes control* | *Review* | Bioactive compounds (γ-oryzanol, GABA, phenolics) play a role in lowering glucose and improving insulin sensitivity. |
| (Du et al., 2025) | *Whole grain vs white rice for starch digestibility* | *In vitro* | *Whole grain* mixtures slow starch digestion and increase microbiota fermentation compared to white rice. |
| (Sanders et al., 2023) | *Whole grain intake and glycemia* | *Systematic review and meta-analysis of RCTs* | *Whole grains* lower *postprandial* glucose and insulin levels, improving glycemic control compared to *refined grains.* |
| (Xu et al., 2021) | Whole grains for glycemic control | Meta-analysis | *Whole grains* lower HbA1c, FBG, and HOMA-IR in diabetic patients. |
| (Ren et al., 2024) | *Autoclave-treated germinated brown rice* | Clinical intervention | Autoclaved germinated brown rice (GRB) lowers blood lipids by modulating gut microbiota. |
| (Jabeen et al., 2024) | *Functional beverage from germinated brown rice* | Product development + nutritional analysis | GRB beverages increase GABA content, antioxidants, and have the potential to improve glucose control. |
| (Sitanggang et al., 2021) | *Increased GABA in germinated brown rice* | Food technology | Membrane reactor technology significantly increases GABA—a key component in glucose regulation and oxidative stress. |
| (Takano et al., 2021) | *Brown rice intake & cognition* | *Pilot trial* | Six months of brown rice consumption improves mild cognitive function in healthy elderly individuals. |
| (Li et al., 2022) | *Whole grain intake and glycemic control* | *Meta-analysis* | *Whole grains* lower FBG, postprandial glucose, and insulin compared to *refined grains.* |
| (Nakamura et al., 2022) | *Brown rice blends & diabetes/dementia* | *Preclinical/food science* | Three types of high-pressure brown rice have the potential to prevent diabetes and *dementia* through increased bioactive compounds. |
| (Tantayakhom et al., 2025) | *Rice bran supplementation & metabolic syndrome* | *Systematic review & meta-analysis* | Rice bran supplementation reduces total cholesterol, LDL, blood glucose, and improves insulin sensitivity. |

| | | | |
|---|---|---|---|
| (Permatasari et al., 2023) | *Brown rice intervention & BMI* | *Quasi-experimental* | A brown rice diet reduces BMI and waist circumference in patients with T2DM. |
| (Martuti et al., 2023) | Brown rice diet & blood glucose | Community intervention | Regular consumption of brown rice lowers blood glucose levels in villagers. |
| (Cahyawardani et al., 2023) | *Carbohydrate and fiber intake after brown rice diet* | Nutritional intervention | Fiber intake increased, and FBG decreased significantly after the brown rice intervention. |
| (Kusumastuty et al., 2021) | Brown rice diet compliance | Longitudinal | High adherence enhances FBG and body fat reduction; poor adherence yields no effect. |
| (Ying et al., 2024) | *Whole grains and glycemic control* | *Systematic review + dose-response meta-analysis* | *Whole grain* consumption shows a linear relationship with reduced risk of T2DM and improved FBG. |
| (Kristianto et al., 2024) | *Brown rice + oyster mushroom formulation* | Small RCT intervention | The combination of brown rice and oyster mushrooms lowers glucose and improves lipid profiles. |
| (Ikeda et al., 2025) | *Health and economic impacts of brown rice consumption* | *Simulation study* | Increased national brown rice consumption reduces T2DM incidence and saves Japan healthcare costs through 2029. |

Based on an analysis of 30 peer-reviewed journal articles, brown rice consumption shows consistent effectiveness in improving various metabolic indicators, particularly blood glucose levels and insulin sensitivity in individuals with type 2 diabetes mellitus and at-risk populations. Approximately 65% of articles indicate that brown rice intervention directly improves glycemic control, reflected in decreased fasting glucose, improved postprandial response, and decreased inflammatory indices. These effects were particularly noted in human intervention studies in Indonesia, Vietnam, China, and Korea, which generally reported significant improvements after consuming brown rice or sprouted rice for 2–12 weeks. Meanwhile, about 25% of studies report that enriched brown rice-based formulations (e.g., *germinated brown rice*, functional beverages, or special diabetes formulas) provide greater metabolic benefits than regular brown rice. These formulations are able to increase *γ-aminobutyric acid* (GABA) levels, improve gut microbiota composition, and increase the production of *short-chain fatty acids* (SCFA), which play a role in increasing insulin sensitivity. These studies show that post-processing modifications such as fermentation, germination, or *autoclaving* can increase antihyperlipidemic and anti-inflammatory activity.

Only about 10% of articles stated that brown rice consumption had no significant effect on key parameters such as blood glucose or lipid profile. Most of these non-significant results occurred in studies with very short intervention durations, small sample sizes, or populations with loose dietary control. In studies showing the strongest effects, the most effective brown rice consumption pattern was applied to individuals with type 2 diabetes and mild to moderate insulin resistance, who generally had high inflammation levels and a diet high in refined carbohydrates. This pattern showed optimal benefits thanks to the fiber, antioxidants, phenolics, and B vitamins in brown rice, which act as agents that reduce the glycemic load. Overall, the results of these 30 articles reinforce the understanding that brown rice is a strategic alternative in blood glucose control, while also supporting overall metabolic health. This intervention not only lowers blood glucose, but also improves lipid profiles, regulates PUFA metabolism, reduces systemic inflammation, and supports the balance of gut microbiota that plays a role in long-term metabolic homeostasis. Although some studies showed non-significant results, the overall trend still indicates that regular consumption of brown rice, especially in fermented or sprouted forms, offers more comprehensive metabolic benefits compared to white rice or *refined grains*.

## Discussion

### Definition and Epidemiology of Type 2 Diabetes Mellitus

Diabetes mellitus remains a global health challenge with an increasing prevalence. The *International Diabetes Federation* report estimates a significant increase in diabetes cases globally, including in developing countries such as Indonesia (Susanti et al., 2024). The country profile released by the WHO shows that Indonesia faces a heavy burden of diabetes with high prevalence and suboptimal glycemic control. This condition is emphasized by the PERKENI guidelines, which stress the importance of diet interventions based on local foods, including increased consumption of *whole grains* such as brown rice (Indonesia, 2021).

Rice and its by-products have significant health benefits. Rice bran, for example, is rich in nutrients and bioactive compounds that have the potential to improve metabolic profiles (Manzoor et al., 2023). A meta-analysis shows that a brown rice-based diet can improve glycemic control and metabolic parameters in prediabetes and type 2 diabetes mellitus (Rahim et al., 2021). Additionally, the Western diet is said to contribute to metabolic disorders and worsen the risk of chronic diseases, making the emphasis on whole grains increasingly relevant (Clemente-Suárez et al., 2023). Other research highlights that variations in glycemic index and carbohydrate concentration in the diet can affect glucose variability in type 1 diabetes (Seckiner et al., 2024). Another meta-analysis specifically compared white rice, brown rice, and the risk of type 2 diabetes; the results showed that brown rice consumption tended to reduce this risk (Yu et al., 2022). Meanwhile, consumption of *pigmented rice* with high anthocyanin content has also been reported to improve cardiometabolic risk factors (Mendoza-Sarmiento et al., 2023).

At the molecular level, various antihyperglycemic and antioxidant activities of brown rice, especially phenolic-rich varieties, have been demonstrated through *in vitro studies* (Haldipur & Srividya, 2021). Another study found that consumption of brown rice high in *resistant starch* improved glucose metabolism in healthy individuals (Park et al., 2023). Dietary intervention with brown rice in type 2 diabetes patients has also been clinically proven to lower glucose and improve lipids (Mitta et al., 2022). In animal studies, supplementation with brown rice or *germinated brown rice* (GBR) has been shown to increase short-chain fatty acids and improve insulin resistance (Zhao et al., 2023). In Indonesia, substituting local brown rice varieties in diabetic patients resulted in improved anthropometry and blood glucose (Handayani et al., 2022). Mai et al. (2020) in Vietnam conducted a controlled clinical trial on germinated brown rice, showing significant benefits for metabolic syndrome and in patients with type 2 diabetes. GBR increased n-3 PUFA metabolism, which is associated with increased insulin sensitivity (Na et al., 2023). A special diabetes rice diet formulation has also been shown to lower postprandial glucose and improve gastrointestinal hormones (Chaiyakul et al., 2023).

From an inflammatory perspective, a brown rice diet lowers *the dietary inflammatory index*, fasting glucose, and TNF-α levels in diabetic patients (Nugroho et al., 2024). Fermented brown rice even provides additional nutritional value and health benefits such as increased bioavailability (Lim et al., 2023). Another comprehensive review highlights various bioactive components of rice that contribute to glucose regulation and diabetes prevention (Pereira et al., 2021). Mechanistically, consuming *whole grains* compared to *refined grains* offers benefits in terms of starch digestibility and gut microbiota fermentation (Du et al., 2025). Meta-analyses also show that *whole grains* consistently improve postprandial glycemic response and insulin levels (Sanders et al., 2023).

Additionally, research (Xu et al., 2021) states that whole grain consumption has been proven to help glycemic control in diabetic patients, including the effect of GBR on hyperlipidemia through gut microbiota modulation (Ren et al., 2024). Research (Jabeen et al., 2024) states that the development of brown rice-based food products also continues to evolve, such as high-GABA *functional beverages* that have potential in metabolic regulation, or the production process of germinated brown rice with membrane reactors that increase GABA content (Sitanggang et al., 2021). Another protocol study by (Takano et al., 2021) even evaluated the use of brown rice in improving cognitive function in the elderly. The effectiveness of *whole grains* in glycemic control is also reinforced by a large meta-analysis showing a significant decrease in blood glucose levels (Li et al., 2022). High-pressure brown rice blends have also been evaluated for the prevention of diabetes and dementia (Nakamura et al., 2022).

Another meta-analysis discussed *the effects* of *rice bran* on metabolic syndrome parameters with promising results (Tantayakhom et al., 2025). In Indonesia, various clinical studies by (Permatasari et al., 2023), (Martuti et al., 2023), (Cahyawardani et al., 2023), and (Kusumastuty et al., 2021) showed that brown rice interventions can reduce BMI, waist circumference, blood glucose levels, and fasting glucose through increased fiber intake and a low glycemic index. Adherence to a brown rice-based diet ( ) was also found to reduce glucose and body fat. A 2024 study in *the Nutrition Journal* by (Ying et al., 2024) shows that whole grain consumption has a dose-response relationship with a reduced risk of glucose disorders, while brown rice and oyster mushroom-based food formulations can lower blood sugar and improve lipids in diabetic patients (Kristianto et al., 2024).

**Therapeutic Mechanism of Brown Rice Diet in Type 2 Diabetes**

**Mechanism of Action of Brown Rice as Nutritional Therapy**

Brown rice acts as a nutritional therapy through various complementary biological mechanisms that target the main pathophysiological components of type 2 diabetes mellitus (type 2 DM). As *a whole grain*, brown rice retains its bran and germ layers, which are rich in fiber, vitamins, minerals, and phytochemicals such as γ-oryzanol, tocopherols, tocotrienols, phenolics, and essential fatty acids. These components play a direct role in regulating glucose metabolism and improving insulin sensitivity. The soluble and insoluble fiber in brown rice works to slow gastric emptying, prolong intestinal transit time, and inhibit glucose absorption, resulting in a lower postprandial glycemic response compared to white rice. This mechanism is particularly relevant given that type 2 diabetes is characterized by insulin resistance and postprandial glucose spikes. A meta-analysis (Rahim et al., 2021) showed that consistent consumption of brown rice consistently lowers fasting blood glucose and HbA1c in prediabetic and type 2 diabetes patients. These effects are primarily due to the fiber content and lower glycemic index. Fiber helps slow glucose absorption, thereby preventing glycemic fluctuations that can worsen insulin resistance. In addition to fiber, various bioactive components in brown rice, particularly γ-oryzanol, have anti-inflammatory effects and improve insulin sensitivity through modification of cellular signaling pathways. (Nugroho et al., 2024) found that brown rice consumption reduced TNF-α levels and *Dietary Inflammatory Index* (DII) scores, indicating its role in reducing systemic inflammation, one of the factors that trigger insulin resistance. The phenolic compounds in brown rice also provide antioxidant effects that protect pancreatic β cells from oxidative stress damage. Therefore, brown rice not only serves as an alternative carbohydrate source but also as a nutritional therapy that significantly modulates metabolic pathways.

**The Role of Fiber and Glycemic Index in Glucose Control**

A lower glycemic index (GI) is one of the main advantages of brown rice compared to white rice. The intact bran layer causes the breakdown of starch by digestive enzymes to occur more slowly. This leads to a reduction in *postprandial* glucose spikes and helps improve long-term glycemic control. In the context of type 2 diabetes, reducing the postprandial glycemic response is crucial for maintaining blood glucose stability and reducing insulin requirements. Research (Park et al., 2023) shows that brown rice with high resistant starch produced through *heat treatment* can improve glucose metabolism in humans. *Resistant starch* acts as a prebiotic that is fermented by gut microbiota, producing SCFAs such as butyrate and propionate, which function to reduce hepatic glucose production and increase insulin sensitivity. These findings are reinforced by (Du et al., 2025), (Sanders et al., 2023), and (Xu et al., 2021), which report that consistent consumption of *whole grains* reduces starch digestion rate and *postprandial* glycemic response. These studies are consistent with a meta-analysis (Yu et al., 2022) concluding that brown rice consumption reduces the risk of type 2 diabetes through reduced postprandial glucose and improved insulin sensitivity.

**Mechanism of Gut Microbiota Modification**

Gut microbiota modification is another important mechanism of brown rice consumption. Its fiber, *resistant starch*, and phytochemical content can increase the growth of probiotic bacteria such as *Bifidobacteria* and *Lactobacillus*. Research (Zhao et al., 2023) proves that supplementation with brown rice or *germinated brown rice* increases SCFA production in insulin-resistant mice. SCFA plays an important role in metabolic signaling, improving insulin sensitivity and reducing systemic inflammation. In humans, (Ren et al., 2024), in similar literature, shows that consumption of germinated brown rice alters the composition of the gut microbiota and lowers blood lipid- . In type 2 DM, this change is very beneficial because it helps overcome dyslipidemia as one component of metabolic syndrome.

**Antioxidant, Anti-glycation, and β-Cell Protection Activities**

In addition to controlling blood glucose, brown rice provides a protective effect on pancreatic β cells through its antioxidant and antiglycation activities. (Haldipur & Srividya, 2021) found that phenolic-rich red rice varieties have strong antihyperglycemic and antioxidant activities. Phenolic compounds protect β cells from oxidative stress, while the antiglycation mechanism prevents the formation of AGEs, which play a role in tissue damage and worsen complications of type 2 diabetes. Additionally, the germination process increases the γ-aminobutyric acid (GABA) content in brown rice. GABA has been shown to increase insulin secretion and protect β cells through modification of the autonomic nervous system pathways that influence metabolism. (Sitanggang et al., 2021) and (Jabeen et al., 2024), although not listed in the citation list, have previously shown that germinated brown rice significantly improves insulin secretion. Studies by (Mitta et al., 2022) and (Handayani et al., 2022) also support that brown rice consumption can improve blood glucose and β-cell function in type 2 DM patients.

**Effects on Other Metabolic Parameters**

Brown rice has broader metabolic effects beyond blood glucose. Its high fiber content provides a longer feeling of fullness, helping to reduce calorie intake and improve body weight. A meta-analysis (Yu et al., 2022) shows that brown rice consumption reduces the risk of type 2 DM partly through obesity reduction. Additionally, consumption of pigmented rice, including brown, red, or black varieties, has been shown to lower blood pressure, total cholesterol, and inflammation. This is demonstrated by a meta-analysis (Mendoza-Sarmiento et al., 2023). These effects are highly relevant given that type 2 DM is often accompanied by dyslipidemia and hypertension. (Ren et al., 2024) and Guanqiong's research (Na et al., 2023) reinforce that germinated brown rice can improve n-3 PUFA fatty acid metabolism, reduce blood lipids, and improve the overall cardiometabolic profile.

**Integrating Mechanisms into Clinical Benefits**

The various mechanisms described, ranging from reduced glycemic response, gut microbiota modification, increased insulin sensitivity, to β-cell protection, collectively make brown rice an effective nutritional intervention in managing type 2 diabetes. Clinical studies, such as Handayani et al. (2021), (Mitta et al., 2022), and Guanqiong Na et al. (2023), show significant improvements in blood glucose, body weight, lipid profile, and inflammatory markers after substituting white rice with brown rice. These findings support the guidelines for managing type 2 diabetes from PERKENI (2021), WHO (2021), and IDF (2021), which emphasize the importance of *a whole grain-based* diet as a key component of non-pharmacological therapy for diabetes (1-3).

**The Effectiveness of the Brown Rice Diet**

The brown rice diet is increasingly used as a non-pharmacological nutritional therapy in patients with type 2 diabetes mellitus (T2DM), mainly due to its higher fiber, vitamin, mineral, and phenolic content, as well as its lower glycemic index (GI) compared to white rice. The aleurone structure and bran layer in brown rice play an important role in slowing glucose absorption, increasing insulin sensitivity, and improving the metabolic profile of T2DM patients. The mechanism of action of the brown rice diet, which relies on increased fiber and phytochemicals, makes this nutritional intervention superior in glycemic control compared to white rice consumption, which has lost most of its active components during the refining process. Several studies have demonstrated the significant effectiveness of brown rice consumption in managing T2DM. A meta-analysis by (Rahim et al., 2021) found that a brown rice diet can lower fasting blood glucose levels, HbA1c, and improve the lipid profile in prediabetic and T2DM patients.

This effect is due to the high content of soluble and insoluble fiber, which slows down *postprandial* glucose elevation and improves insulin function. Similar findings were also reported by Yu et al. (2022), showing that brown rice consumption is consistently associated with a reduced risk of T2DM. Brown rice is considered to have a lower glycemic load, resulting in a more stable glycemic response after meals compared to white rice consumption. Clinical studies on T2DM patients also recorded significant results. (Handayani et al., 2022) reported that substituting white rice with local Indonesian brown rice varieties for several weeks can lower fasting blood glucose levels and improve anthropometric parameters. This reduction occurs due to the combined effects of fiber, micronutrients, and bioactive components such as *γ-oryzanol* and tocopherol in brown rice, which simultaneously reduce metabolic inflammation and improve glucose regulation. Another study by (Mitta et al., 2022) reinforced these findings by showing a significant reduction in blood glucose and lipid levels after brown rice consumption in T2DM patients.

In addition to regular brown rice, *germinated brown rice* (GBR) also shows higher effectiveness. The germination process increases the levels of *γ-aminobutyric acid* (GABA), essential amino acids, phenolics, and antioxidants that play a role in reducing insulin resistance. (Mai et al., 2020) and (Na et al., 2023) show that GBR consumption not only improves glycemia but also increases n-3 fatty acid metabolism, improves lipid profiles, and lowers blood pressure in T2DM patients. The mechanism of GABA increase also plays a role in suppressing oxidative stress, which is one of the key factors in the progression of T2DM. The benefits of brown rice can also be seen in its ability to modulate the gut microbiota. Zhao et al. (2023) found that supplementation with brown rice and sprouted brown rice increases the production of *short-chain fatty acids* (SCFAs) such as butyrate, which plays a role in increasing insulin sensitivity and controlling systemic inflammation. SCFAs are known to have an important effect in maintaining metabolic homeostasis, so increasing their production is very beneficial for T2DM patients.

The effectiveness of the brown rice diet is also supported by modern nutritional research related to *whole grain* consumption. (Sanders et al., 2023) and (Xu et al., 2021) show that *whole grain* consumption significantly reduces postprandial glucose and insulinemic response. As one of the most widely consumed sources of whole grains in Asia, brown rice is a realistic and easily implementable choice in the diet of T2DM patients. These findings are reinforced by

(Du et al., 2025), which compared starch digestion between whole grain blends and white rice, showing that the starch structure and fiber in whole grains result in a lower glycemic response and more beneficial microbiota fermentation. Several interventions utilizing brown rice-based innovations have also yielded promising results. (Chaiyakul et al., 2023) developed a diabetes-specific rice-based diet formula that demonstrated a significant reduction in postprandial glucose levels. The formula showed increased secretion of gastrointestinal hormones involved in glucose regulation, such as GLP-1, which is a primary target of modern T2DM therapy. From a physiological perspective, the success of brown rice diets in controlling T2DM is influenced by three main mechanisms: (1) reduced glucose absorption rate, (2) reduced metabolic inflammation, and (3) improved hormonal and gut microbiota function. The combination of bioactive components such as phenolics, flavonoids, GABA, γ-oryzanol, and high fiber provides synergistic effects in improving insulin sensitivity and glycemic control.

The effectiveness of the brown rice diet as a non-pharmacological intervention also has important implications in the context of Indonesian public health. The increasing prevalence of T2DM, as reported by the IDF (2021), WHO (2021), and PERKENI (2021), demands food-based interventions that are easily accessible, affordable, and adoptable in the long term. Brown rice offers a solution that fits with the rice-based consumption culture of Indonesians, without requiring drastic changes in diet. However, the success of this diet is greatly influenced by consumption compliance and education regarding the processing of brown rice, which tends to be harder and requires longer cooking times than white rice. Education on processing variations, soaking methods, or the use of pre-cooked brown rice needs to be part of nutritional interventions to ensure sustainable consumption. With a comprehensive approach and food policy support, the brown rice diet has the potential to become an integral part of T2DM management, reducing the burden of disease and improving patients' quality of life. Blood glucose control in people with type 2 diabetes mellitus is greatly influenced by the type of carbohydrate source consumed, especially in terms of its glycemic index. Brown rice is known to have a lower glycemic index than white rice because it retains its bran layer, which is rich in fiber and bioactive compounds. This causes slower digestion and absorption of glucose, resulting in more controlled postprandial glucose response. This finding is consistent with the results of a meta-analysis (Yu et al., 2022) showing that brown rice consumption is associated with improved glycemic control and a reduced risk of type 2 diabetes mellitus compared to white rice consumption.

In terms of consumption quantity, intervention studies generally do not strictly specify the dose of brown rice in grams but instead use a substitution approach, replacing white rice with brown rice as the daily staple food. (Handayani et al., 2022) reported that replacing white rice with local Indonesian brown rice as the main source of carbohydrates for 12 weeks resulted in significant improvements in fasting blood glucose levels and anthropometric parameters in patients with type 2 diabetes mellitus. This indicates that the effectiveness of brown rice is more determined by the consistency of rice type substitution than by the absolute amount measured in grams. Regarding the onset of effects, brown rice consumption does not cause an immediate decrease in blood glucose. An intervention study by Nakayama et al. (2017) showed that consuming brown rice twice a day as a staple food for eight weeks resulted in a significant reduction in HbA1c levels, glycoalbumin, and postprandial glucose response in patients with diabetes mellitus. These findings indicate that improvements in glycemic control begin to appear after dietary intervention is carried out continuously over a certain period, specifically a minimum of eight weeks.

In terms of consumption duration, the effectiveness of brown rice in lowering HbA1c levels tends to be more evident in medium to long-term interventions. A meta-analysis by Nathasya (2025) shows that a brown rice-based diet has a significant effect on lowering HbA1c levels in people with diabetes mellitus, especially when applied consistently. This can be explained because HbA1c reflects the average blood glucose level over a period of about two to three months, so changes in carbohydrate consumption patterns require sufficient duration to be reflected in this parameter. The effectiveness of brown rice consumption in controlling blood glucose is influenced by a combination of a lower glycemic index, the substitution of white rice with brown rice as a staple food, and adequate consumption duration, namely a minimum of eight to twelve weeks. Therefore, brown rice is more appropriately positioned as part of a long-term nutritional therapy strategy in the management of type 2 diabetes mellitus, rather than as a short-term dietary intervention.

**Comparison of Advantages and Disadvantages**

The brown rice diet is increasingly recognized as a potential non-pharmacological nutritional strategy in the management of type 2 diabetes mellitus (T2DM), mainly due to its fiber, vitamin, mineral, and bioactive component content, such as phenolics and *γ-aminobutyric acid* (GABA). Various studies show that brown rice consumption has a positive impact on glycemic control and metabolic profile, but there are still limitations that need to be considered in its application. One of the main advantages of the brown rice diet is its ability to improve glycemic control through the mechanism of reducing postprandial glucose response and increasing insulin sensitivity.

A meta-analysis (Rahim et al., 2021) reported that brown rice consumption significantly reduced fasting glucose and HbA1c levels in prediabetic and T2DM patients compared to white rice. These results are in line with the findings (Yu et al., 2022) showing that replacing white rice with brown rice can reduce the risk of T2DM due to its lower glycemic index and high fiber and magnesium content, which play a role in glucose metabolism regulation. Another advantage comes from its bioactive components, such as phenolics and antioxidants, which have been proven to have antihyperglycemic, antiglycation, and anti-inflammatory effects. The high GABA content in brown rice sprouts has also been shown to improve blood sugar regulation and lipid metabolism, as demonstrated by studies (Mai et al., 2020) and (Chaiyakul et al., 2023).

An additional advantage of a brown rice diet is its role in improving other metabolic parameters beyond blood glucose. Various clinical trials have shown that brown rice consumption can improve lipid profiles, lower inflammatory indices, and improve gut microbiota composition, mechanisms that contribute to increased insulin sensitivity and decreased insulin resistance. Additionally, a study by (Handayani et al., 2022) on T2DM patients in Indonesia showed that substituting white rice with local brown rice varieties could lower blood glucose while improving patient anthropometry, thereby reinforcing the relevance of this diet in the local population context. However, the brown rice diet also has limitations. One of the most commonly reported drawbacks is lower consumer acceptance due to its harder texture, *nuttier* taste, and longer cooking time compared to white rice.

This factor can reduce patient compliance with long-term diets, especially among the elderly or patients with dental and digestive problems. (Clemente-Suárez et al., 2023) also emphasized that individuals accustomed to modern diets or diets high in processed foods tend to have difficulty adapting to whole foods such as brown rice. In addition, not all types of brown rice have the same effects. Variations in phenolic content, GABA, fiber, and resistant starch can differ between varieties, processing techniques, and cooking methods. A study (Park et al., 2023) shows that brown rice that has been processed to be high in resistant starch has a more significant impact on improving glycemic parameters than regular brown rice. This indicates that *the quality* of brown rice is an important factor in determining clinical effectiveness, not just the type of rice.

Several studies by Pereira et al. (2021) and Sanders et al. (2023) also note that in some patients with gastrointestinal disorders or irritable bowel syndrome, the high fiber content of brown rice can cause bloating or discomfort, requiring gradual adjustments to the diet. Furthermore, despite its many benefits, a brown rice diet cannot replace pharmacological therapy in patients with severe hyperglycemia, but rather serves as a supportive strategy that must be integrated with standard treatment according to clinical guidelines. From a long-term metabolic perspective, brown rice consumption also requires high consistency to achieve optimal benefits. Longitudinal studies show that significant changes in glycemic parameters only become apparent after a minimum of 8–12 weeks of intervention. This poses a particular challenge for patients who lack discipline in modifying their diet. Overall, the brown rice diet has a number of strong advantages, particularly in lowering blood glucose, improving lipid profiles, reducing inflammation, and improving gut health thanks to its high fiber and phytonutrient content. However, its drawbacks, such as low palatability, quality variations between varieties, long adaptation time, and limitations in certain patients, remain considerations in its implementation. Therefore, the selection of a brown rice diet as a non-pharmacological therapy must take into account the patient's condition, food preferences, cultural habits, and ability to maintain the diet in the long term. In clinical practice, brown rice is ideally used as a key component of a healthy whole-grain-based diet, but it is not the sole strategy; rather, it is part of a holistic approach that includes education, calorie management, physical activity, and pharmacological therapy in accordance with current diabetes guidelines.

## CONCLUSION

This study shows that the implementation of a brown rice diet is an effective non-pharmacological nutritional strategy in helping to manage type 2 diabetes mellitus. Brown rice, as a source of *whole grain* carbohydrates, has nutritional advantages in the form of fiber, vitamins, minerals, and bioactive compounds such as *γ-oryzanol* and phenolics, which have been shown to play a role in lowering blood glucose levels, improving insulin sensitivity, and suppressing chronic inflammatory processes associated with diabetes. Recent studies confirm that substituting white rice with brown rice can significantly improve glycemic control, including lowering fasting blood glucose levels, postprandial glucose levels, and improving HbA1c values in patients with type 2 diabetes. This effectiveness is even stronger when brown rice is consumed in the form of *germinated brown rice* or using *pigmented rice* varieties that have higher antioxidant content [9,16]. In addition, brown rice-based dietary interventions also contribute to improvements in other metabolic profiles, including blood lipid levels and systemic inflammatory responses, thus providing broader cardiometabolic benefits.

The findings also show that a brown rice diet can be practically and affordably implemented in everyday life, especially in countries with high rice consumption patterns such as Indonesia. The implementation of this diet is in line with nutritional therapy recommendations for type 2 diabetes patients, as stated in the national diabetes management guidelines, which emphasize the importance of consuming high-fiber and low-glycemic index foods to achieve optimal glycemic control. Additionally, this dietary change also affects the composition of gut microbiota, which in turn contributes to improved insulin sensitivity and glucose metabolism modulation. Overall, the brown rice diet can be positioned as a safe, effective, and evidence-based non-pharmacological nutritional intervention for the management of type 2 DM. Although it does not replace pharmacological therapy, this strategy can be an important component of a comprehensive therapeutic approach to improve glycemic control, improve metabolic parameters, and reduce the risk of long-term complications in diabetic patients. With proper implementation, including nutrition education and consistent clinical monitoring, the brown rice diet intervention has the potential to significantly improve the quality of life for diabetes patients and reduce the disease burden in the population.

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