A novel konjac rice formula with glucomannan and tapioca starch improve postprandial glycemic response – a randomized single-blind clinical trial

by Sumi Wijaya

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A novel konjac rice formula with glucomannan and tapioca starch improve postprandial glycemic response – a randomized single-blind clinical trial

Single-blind clinical trial

Yufita Ratnasari Wilianto, Yudy Tjahjono, Kuncoro Foe, Sumi Wijaya, Martha Ervina and Diga Albrian Setiadi
Biomedical Laboratory, Faculty of Pharmacy, Widya Mandala Catholic University Surabaya, Surabaya, Indonesia

Hevi Wihadmadyatami
Department of Anatomy, Faculty of Veterinary Medicine, Gadjah Mada University, Yogyakarta, Indonesia

Bernadette Dian Novita Dewi
Department of Pharmacology, Medical Faculty, Widya Mandala Catholic University Surabaya, Surabaya, Indonesia, and

Hendy Wijaya
Biomedical Laboratory, Faculty of Pharmacy, Widya Mandala Catholic University Surabaya, Surabaya, Indonesia

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Abstract

Purpose – Due to white rice's association with diabetes and other chronic diseases in many Asian countries, many industries are working to develop high-fiber rice substitutes with similar organoleptic characteristics. Konjac rice (KR) is a promising option, but maintaining its optimal fiber content for health benefits while preserving its ideal sensory profile remains a challenge. This study aims to investigate whether a KR formula, combining tapioca flour and glucomannan gel, possesses similar organoleptic attributes to white rice while preventing glycemic response elevation.

Design/methodology/approach – In a six-week randomized single-blind clinical trial, 13 normoweight nondiabetic subjects received varying konjac-based rice and white rice ratios. Blood glucose levels were measured at intervals, and glycemic response was assessed using incremental area under the curve (iAUC). Visual analog scale gauged satiety, and organoleptic properties were evaluated.

Findings – Substituting white rice with pure and partial konjac-based rice significantly lowered postprandial blood sugar levels and glycemic response ($p = 0.002$). iAUC for pure KR and KR 1:1 was notably lower than white rice ($p = 0.002$). Subjects reported a sense of fullness comparable to white rice, with no significant organoleptic score differences ($p = 0.260$).

Research limitations/implications – The study's generalizability is compromised due to the limited number of participants, impacting external validity. The examined parameters offer a rough understanding of konjac grain's impact on postprandial glycemic responses but do not elucidate underlying mechanisms or the duration of its inhibitory effect on glucose absorption. Long-term effects on metabolic, hormonal parameters and the colon's microbial flora composition and function remain unexplored, constraining comprehensive insights into konjac grain's extended implications.

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Practical implications – This study introduces a novel KR formula to address the escalating diabetes risks associated with white rice consumption. Substituting white rice with KR significantly reduces postprandial blood sugar levels, highlighting its potential in preventing type 2 diabetes (T2D). Tapioca flour enhances palatability, making KR a viable option. While promising, long-term effectiveness and safety require further research, emphasizing comprehensive lifestyle interventions. The study contributes valuable insights to innovative dietary strategies for prevalent health conditions, emphasizing the need for ongoing efforts in public health.

Social implications – White rice, a staple in Asian societies, is linked to a heightened risk of T2D due to increased production and inadequate dietary fiber. This connection contributes to the economic burden on governments through health insurance and lost productivity. Encouraging alternatives rich in fiber can mitigate this burden, offering a socioeconomically beneficial solution to preventable chronic diseases.

Originality/value – This trial demonstrates konjac-based rice's potential in curbing glycemic responses, hinting at its role in preventing T2D. Glucomannan's viscosity, satiety induction and potential gut health impact are highlighted. Further research is warranted for long-term effectiveness and safety. These findings contribute to the growing evidence supporting glucomannan as a valuable tool in addressing prevalent health conditions.

Keywords Rice, Glycemic index, Glucomannan, Konjac, Tapioca

Paper type Research paper

Introduction

The escalating global prevalence of diabetes mellitus, a chronic disease with substantial implications for morbidity and mortality, underscores an urgent need for effective preventive measures. In 2019, almost half a billion people, approximately 9.3% of the population aged 20–79, were afflicted with diabetes mellitus, marking a 62% increase over the past decade. Without robust interventions, projections estimate a rise to 578 million people by 2030 and a staggering 700 million by 2045 (Saeedi *et al.*, 2019). Notably, Southeast Asia and the Western Pacific regions bear the highest concentrations, with 163 million and 88 million affected individuals, respectively (Saeedi *et al.*, 2019). The primary types of diabetes mellitus – type 1, type 2 and gestational – present multifaceted challenges, with type 2 diabetes (T2D) being the most prevalent, accounting for over 90% of cases. T2D's close association with weight issues and lifestyle factors emphasizes the critical role of diet, physical activity and other lifestyle choices in diabetes prevention (Liu *et al.*, 2020; Zhao *et al.*, 2017; Joseph *et al.*, 2016).

Weight-related concerns extend beyond those classified as overweight, as even an increase in body mass index (BMI) alone elevates the risk of prediabetes and T2D (Gupta and Bansal, 2020; Karin *et al.*, 2022). Sedentary lifestyles further compound this risk, with those engaging in regular physical activity benefiting from a significant risk reduction (Joseph *et al.*, 2016). In addition, recent research underscores the importance of dietary factors, such as low fiber intake and the consumption of refined carbohydrates, in influencing T2D risk irrespective of body weight (Fung *et al.*, 2004; Neuenschwander *et al.*, 2019; Global Dietary Database, 2023). Rice holds immense cultural significance in many Asian countries, playing a central role in traditional diets and culinary practices. Its cultivation dates back thousands of years, and it has become deeply intertwined with the cultural identities of these regions. In many Asian cultures, rice is not just a staple food but also a symbol of prosperity, fertility and even religious significance. It is often at the heart of traditional ceremonies, festivals and daily meals. The way rice is prepared and consumed varies widely across different Asian cultures, with each region having its own unique methods and dishes. For example, in Japan, rice is the foundation of the traditional diet, often served alongside various side dishes such as fish, vegetables and pickles. In India, rice is a staple in many regional cuisines, with dishes like biryani, pulao and dosa showcasing the diversity of rice-based dishes. In Indonesia, rice is more than just a staple food – it is a fundamental part of the country's cultural identity, reflecting its history, traditions and way of life. Rice plays a central role in Indonesian cuisine, with many traditional dishes revolving around this versatile grain. From savory dishes like nasi goreng (fried rice) and nasi padang (steamed rice with various side dishes) to sweet treats like sticky rice desserts, rice is featured prominently in Indonesian culinary traditions. However, the increasing prevalence of diabetes and other diet-related health issues in Asian countries has highlighted the need to find culturally acceptable alternatives to rice. While rice is a nutritious grain, it is also high in carbohydrates, which can impact blood sugar levels. Finding culturally acceptable alternatives involves not just identifying suitable substitutes but also ensuring that these alternatives fit into the cultural and culinary traditions of the region. This could include promoting the consumption of other whole grains like millet, quinoa or barley, which offer similar nutritional benefits but with lower glycemic indexes (GI) (Gross *et al.*, 2004; Schmidhuber *et al.*, 2018; INTERMAP Research Group, 2003). These observations create a pressing need to explore alternatives that can mitigate the adverse metabolic effects linked to white rice consumption.

The historical shift from less refined, manually pounded rice varieties to the prevalent consumption of fully milled white rice in Asian countries further complicates the diabetes landscape. Traditional undermilled rice varieties, characterized by higher antioxidant levels, dietary fiber and essential minerals, have given way to a dietary norm dominated by white rice (Finocchiaro *et al.*, 2007; Liu *et al.*, 2022a; Ma *et al.*, 2020). The excessive consumption of white rice, characterized by its high GI and associated postprandial spikes in blood glucose levels, heightens the risk of insulin resistance and T2D (Hu *et al.*, 2012).

Based on the aforementioned facts regarding the positive effects of dietary fiber, in recent times, numerous health food producers in Asia have initiated the production of rice substitutes rich in dietary fiber. These rice substitute products make use of dietary fiber from the konjac corm (*Amorphophallus muelleri* Bl), specifically glucomannan. Konjac glucomannan (KGM), a soluble dietary fiber abundant in the konjac plant, has garnered attention for its potential to address the glycemic impact of white rice consumption. This dietary component possesses a unique and advantageous property, it forms a viscous gel when exposed to water (Sudha *et al.*, 2013). Many studies indicate that KGM-based rice can slow carbohydrate absorption, thereby attenuating glycemic excursions, holds the potential to enhance insulin sensitivity and reduce the risk of insulin resistance (Fang *et al.*, 2023). Moreover, the viscous gel formed by KGM may act as a physical barrier, preventing rapid glucose release into the bloodstream. Furthermore, prior research has demonstrated that increasing the viscosity of food and fluids within the gastrointestinal tract through the administration of KGM can induce a sense of satiety (Fang *et al.*, 2023,Shang *et al.*, 2020). These combined effects position it as an appealing option for individuals seeking to maintain blood glucose homeostasis.

The acceptance of alternative food sources with high fiber content as a substitute for white rice in several Asian countries remains significantly low (Gyawali *et al.*, 2022; Sudha *et al.*, 2013; Helmyati *et al.*, 2020). Konjac-based rice with pure glucomannan has been introduced as a beneficial diet to improve health parameters, particularly glycemic response (Ueno *et al.*, 2023; Au-Yeung *et al.*, 2018). However, the undoubtedly beneficial aspect of konjac-based glucomannan has been severely neglected due to its less palatability and high market price compared to rice grains, especially in middle-low- and lower-income countries. To address this issue, many factories have introduced konjac rice (KR) formulas by mixing glucomannan powder with other flour, which could reduce production costs and improve palatability but may have a deleterious impact on glucomannan's health benefits.

Furthermore, the cultivation of konjac as a substitute for white rice has the potential to offer environmental benefits compared to traditional rice production. Konjac plants require less water and fertilizer than rice, and they can thrive in a variety of soil conditions. In addition, konjac plants have a high yield per acre compared to rice, which means that less land may be needed to produce an equivalent amount of food. Furthermore, konjac plants are perennial, which means that they do not need to be replanted every year, reducing the environmental impact associated with annual tilling and planting (Chua *et al.*, 2010). Overall, the cultivation of konjac as a substitute for white rice may help reduce water usage, fertilizer runoff and land degradation, making it a more sustainable option for food production.

In Southeast Asia, tapioca, also known as tapioca starch from *Manihot esculenta Crantz* (cassava), is abundantly used as a daily dietary source (Pokharel *et al.*, 2023) and offers numerous advantages over rice flour (Liu *et al.*, 2022b). Tapioca is a versatile and gluten-free ingredient suitable for individuals with celiac disease or gluten sensitivity (El Khoury *et al.*, 2018). Tapioca flour has more dietary fiber, is rich in vitamins and has a lower GI than rice flour (Liu *et al.*, 2022b; El Khoury *et al.*, 2018; Jeanes *et al.*, 2022). Its neutral flavor allows it to complement a wide range of both sweet and savory culinary applications with optimal palatability. Therefore, in this case study, we introduce a new KR formula, a novel form of white rice substituent using the KGM and tapioca flour to maximize the beneficial impact of glucomannan based rice. However, the palatable rice-like organoleptic properties of KR as a white rice substitute, and its potential to decrease postprandial blood sugar levels and glycemic response for the prevention of type 2 diabetes mellitus (T2DM), remain unknown. In this randomized single-blind clinical trial report involving normoweight nondiabetic subjects, we successfully demonstrated that KR can induce satiety and exhibits organoleptic properties equivalent to white rice. Furthermore, KR could prevent the increase in post-meal blood sugar levels and glycemic response, suggesting a potential capability of this product to enhance public health quality through T2DM prevention.

Materials and methods

Materials

KR is made by combining glucomannan with tapioca flour and is available on the market as "Konnyaku Grain" from PT.Ambico (Surabaya, Indonesia). The production of KGM powder initiates with cultivating and harvesting konjac tubers, the subterranean corms of the konjac plant (*Amorphophallus muelleri* Bl). The harvested tubers undergo a meticulous cleaning and peeling process to eliminate impurities, soil and outer layers. Following washing, peeling and slicing, the konjac chips are combined with SO_2 and hot air in a specialized device. Subsequently, the konjac chips undergo drying and pulverization into powder using both a hammer grinder and fine grinder. Finally, using a grinding and sorting machine along with a bag dust collector, finer airborne particles like starch and cellulose are eliminated, leaving only the retained KGM. These ingredients are blended with tapioca flour (PT Ambico, Surabaya, Indonesia), water and alkali compounds contain calcium hydroxide, to create a basic solution. The mixture is heated and homogenized, and a calcium salt is introduced to initiate the gelation of the konjac solution. The resulting gel is dried in an oven and formed into grains which will be termed as KR. The purity and stability were assessed using thin layer chromatography and infrared spectroscopy, in accordance with the

Guidance for Industry Q1E Evaluation of Stability Data from U.S. Department of Health and Human Services Food and Drug Administration, version June 2004.

Subjects

Thirteen ($n = 13$) healthy subjects were voluntarily recruited. Inclusion criteria encompassed a normal BMI, absence of ongoing diet programs, nonpregnant status, absence of specific medical treatments, absence of chronic illnesses such as diabetes, prediabetes, hypertension, congenital heart disease, fatty liver or any acute illness, and not currently in a recovery phase from illness. This study was approved by the Health Research Ethics Committee of Widya Mandala Catholic University Surabaya (No. 0015/WM12/KEPK/DOSEN/T/2023).

Trial design, intervention and material preparation

In this experiment, a single-arm trial analysis was employed. During the initial week, we assessed the glycemic response to the meal in the absence of any intervention, and these results served as our baseline. Three days prior to the intervention, all subjects were instructed to maintain their regular diet, engage in their usual physical activities, ensure sufficient sleep (6–8 h per day), and fast for 10–12 h before the intervention. Before the intervention, participants completed detailed dietary recall questionnaires to provide information on their typical dietary habits. This included the frequency and portion sizes of foods consumed, including rice, vegetables, fruits, protein sources and other carbohydrates. During the intervention period, participants were provided with specific dietary guidelines and meal plans to follow. They were also asked to keep food diaries to record everything they ate and drank throughout the study. In addition, participants were instructed to refrain from making any significant changes to their diet or lifestyle during the study period. Compliance with the dietary guidelines was monitored through regular check-ins and discussions with the participants. In the first week, the subject group received Fiesta Ready Meals (Charoen Pokphand, Jakarta, Indonesia) with white rice. The blood glucose measurements during this first week served as the negative control data. During the second, third, and fourth weeks, the subjects received KR, which is available on the market as "Konnyaku Grain" (Ambico, Inc. in Surabaya, Indonesia), as a component of their ready-made meals. The nutrition composition of KR is presented in Table 1. The ratio of konjac-based rice to regular white rice increased progressively each week, starting at 1:2 and then transitioning to 1:1 until they consumed pure KR. In the fifth week, the subjects substituted their regular white rice with other pure konjac-based rice options currently available on the market (KO). The KR was cooked together with rice. The ratio mentioned above represents the weight ratio of rice to KR before cooking.

Nutrients composition	Average quantity
Total fat	0
Protein	0
Total carbohydrate	91 g
Dietary fiber	11 g
Sugar	1 g
Sugar alcohol	0
Sodium	170 mg
Calcium	250 mg
Iron	160 mcg

Source: Authors' own creation

Table 1. The nutritional composition of konjac-based rice (per 100 g)

Both were cooked with a KR to water volume ratio of 2:1. Their combined weight after cooking was 160 g. The composition of KR can be observed in Table 1. In the sixth week, subjects received a regular ready-made meal with white rice, but before the meal, they were given 100 mg of Acarbose to chew immediately before eating. The measurement data from this last week served as the positive control data. Confidentiality of participant information was ensured by assigning unique identifiers to each participant. Personal identifying information was stored separately from study data and was accessible only to authorized personnel.

Blood sampling, blood glucose and glycemic response (iAUC)

Peripheral vein whole blood samples were collected to assess glucose concentration, using the FreeStyle Optium glucose monitoring system from Abbott Laboratories, Chicago, IL, USA. Blood glucose levels were monitored at 0, 30, 60, 90 and 120 min following the intervention and meal. The initial measurement at 0 min served as the baseline fasting plasma glucose. The postprandial glucose response was quantified as the incremental area under the curve (iAUC) of blood glucose using a linear trapezoidal method, following the methodology outlined in existing literature (Sasaki *et al.*, 2007).

Visual analog scale score

Subjective satiety was assessed using a visual analog scale (VAS). Prior to any food or beverage consumption, subjects were presented with a VAS questionnaire consisting of a 100 mm horizontal line anchored at one end with "Not at all full" or "0" and at the other end with "Completely full" or "10." Detailed instructions were provided to ensure subjects' understanding of the scale's purpose. Each subject was asked to pinpoint their baseline satiety level on the VAS before the commencement of the meal. Subsequently, 30 and 120 min after consuming the provided meal, they were instructed to mark their postprandial satiety level on the same VAS scale. All measurements were recorded meticulously, and statistical analyses were applied to interpret the data.

Organoleptic and hedonic test score

The organoleptic properties of KR were measured using a questionnaire-based approach. This evaluation using a trained panel consisting of eight women and four men, who were recruited via voluntary enrollment. The panelists were trained to evaluate various sensory attributes including appearance, texture, flavor and overall acceptability. A five-point hedonic scale, ranging from 1 (dislike extremely) to 5 (like extremely), was employed to quantify the sensory responses. Standardized samples, which was white rice, will be prepared and served anonymously to the panelists to ensure unbiased evaluations. Questions focused on the attributes and overall preference will guide the assessment, providing insights into the sensory characteristics and consumer preference for KR compared to white rice.

Statistical analysis

Statistical analysis was conducted using the paired-samples *t*-test method. The results were graphically represented as the mean ± standard error (SE) using Graphpad Prism™ 5.0 (San Diego, USA). A significance level of $p < 0.05$ was used for interpreting all findings.

Results

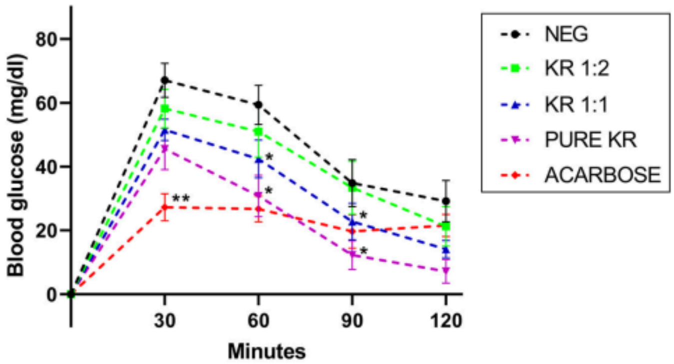
All subjects successfully concluded the trial, and their respective characteristics are presented in Table 2. Substituting rice with pure and partial KR can assist in lowering

Characteristics	Value ± SD
Age (years old)	19.9 ± 0.7
Sex	
Male	4
Female	9
Weight (kg)	55.9 ± 8.8
Height (cm)	162.9 ± 7.8
BMI (kg/m^2)[b]	21.0 ± 1.9
EER (kcal)[c]	1,745 ± 179

Notes: [a]Results are presented as means ± standard deviation (SD); BMI = body mass index; [c]EER = estimated energy requirements: calculated based on the Harris–Benedict formula, with the physical activity level 1.0 (sedentary activity)
Source: Authors' own creation

Table 2. Baseline characteristics of trial subjects[a]

the glycemic response of experimental subjects from minute 30 to minute 120 (Figure 1). The total iAUC for pure KR and KR 1:1 is 92.1 ± 42.9 and 124 ± 48.9 mg/dL, respectively (Table 3). Both values demonstrate a significantly lower iAUC compared to the iAUC of the negative control or white rice alone (both $p = 0.002$). The results of our study demonstrate that substituting white rice with KR can significantly reduce iAUC by 40.4 ± 30.5 mg/dL ($p = 0.000$) (Table 3). Similarly, when substituting KR in a 1:1 ratio, there was a significant reduction in iAUC by 24.7 ± 30.2 mg/dL ($p = 0.012$) (Table 3). A significant reduction in iAUC was not observed in the 1:2 KR substitution group.



Notes: The above graph illustrates the glycemic response of subjects to mixtures of konjac rice (KR) and white rice in different proportions (KR to rice 1:2, KR to rice 1:1, pure KR), compared to white rice alone (negative control, NEG), and a positive control (white rice and 50 mg of acarbose, ACARBOSE). From the data above, pure KR and KR 1:1 were able to suppress the increase in blood glucose levels at 60 and 90 min after meal. Statistical analysis was performed using a paired t-test. Data presented as mean values with standard deviation (SD). $^*p < 0.05$ compared to negative control; $^{**}p < 0.00$
Source: Authors' own creation

Figure 1. Plasma glucose from minute 0 to minute 120 between different interventions

Furthermore, substituting rice with pure KR has been shown to induce a sense of fullness immediately after consumption, which is relatively similar to white rice (Table 4). The VAS values at the first 30 min after consuming pure KR showed no statistically significant difference compared to VAS values after consuming white rice ($p = 0.06$). The VAS values for KR remain relatively consistent with white rice up to 120 min after consumption ($p = 0.158$). There were no significant differences in the overall organoleptic scores between KR and white rice, indicating no preference variations among the subjects between pure KR and white rice (Figure 2, $p = 0.260$).

Discussion

Substitution of white rice with KR has the potential to inhibit the elevation of postprandial blood sugar levels and glycemic response, as evidenced by the reduced postprandial blood glucose levels (Figure 1) and glycemic response (Table 3), confirming this hypothesis. In addition, this study demonstrates that KR has a satiety-inducing effect and organoleptic properties that are relatively comparable to white rice, even though it can significantly reduce glycemic response (Table 4 and Figure 2). The findings of this study shed light on the potential effectiveness of KR in reducing glycemic response, thereby contributing to the prevention of T2D, obesity and metabolic diseases. In this discussion, we will delve into the implications of these results, the underlying mechanisms and the broader implications for public health.

The reduction in postprandial blood glucose levels observed in our study aligns with previous research highlighting glucomannan's potential in glycemic control. Previous

Table 3. Total incremental area under the curve (iAUC) and iAUC reduction compared to negative control between different intervention[a]

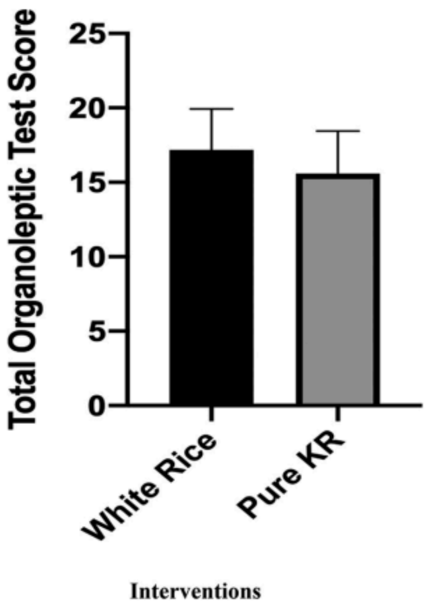
Intervention group	Total iAUC[b] ± SD (mg/dL)	iAUC[b] reduction ± SD (mg/dL)
Negative control	176 ± 67	–
Positive control	84.4 ± 45.3*	49.5 ± 22.9**
Pure KR	92.1 ± 42.9*	40.4 ± 30.5**
KR 1:1	124 ± 48.9*	24.7 ± 30.2**
KR 1:2	153 ± 72.2	12.1 ± 23.4

Notes: [a]Results are presented as means ± standard deviation (SD); iAUC stands for incremental area under the curve. Total iAUC represents the total blood glucose exposure within a given time. *$p < 0.05$ compared to total iAUC in negative control group; **$p < 0.05$ compared to iAUC reduction in negative control group
Source: Authors' own creation

Table 4. VAS score changes at 30 and 120 min after meal between different intervention[a]

Intervention group	Initial VAS[b] ± SD	VAS[b] at 30 min ± SD	VAS[b] at 120 min ± SD
Negative control	3.0 ± 1.3	9.2 ± 0.9	6.6 ± 2.4
Positive control	1.2 ± 0.4	8.6 ± 1.0*	6.2 ± 1.1
Pure KR	1.8 ± 1.1	7.2 ± 1.3	4.2 ± 1.5
KR 1:1	2.4 ± 0.9	7.3 ± 0.9	6.1 ± 0.9
KR 1:2	3.2 ± 1.7	7.5 ± 1.4	5.7 ± 1.5

Notes: [a]Results are presented as means ± standard deviation (SD); VAS stands for visual analog scale which is measured using five-point hedonic scale at 30 min and 120 min after meal. *$p < 0.05$ compared to negative control within the same measurement time
Source: Authors' own creation



Notes: The above graph illustrates the results of a organoleptic or hedonic test comparing white rice to pure konjac rice (KR) among 12 panelists (8 males and 4 females). The test result indicates no significant difference in organoleptic scores between white rice and KR ($p = 0.260$). This finding suggests that there is no preference variations among the panelists between pure KR and white rice. Data are presented as mean values with standard deviation (SD)
Source: Authors' own creation

Figure 2. Total hedonic test score between pure KR and white rice

studies indicated that KGM can maintain it high performance in acidic conditions but becomes unstable in alkaline environments. For instance, these gels retain their strength even after multiple heatings at 100°C. One potential reason for this phenomenon is the loss of the acetyl group of KGM in alkaline conditions, leading to the aggregation and entanglement of split self-body substrates, ultimately forming a localized, continuous gel reticular structure. These characteristics could also account for the decreased diffusion of glucose in the intestines, thereby hindering the absorption of glucose from the small intestine into the bloodstream (Fang *et al.*, 2023). Furthermore, the mechanism by which KGM improves metabolic control may be related to its rheological properties, such as increasing the viscosity of digestive juices (Fang *et al.*, 2023; Guo *et al.*, 2022; Devaraj *et al.*, 2019). By slowing the rate at which carbohydrates are digested and absorbed, glucomannan mitigates postprandial spikes in blood sugar levels. This is particularly beneficial for individuals with impaired glucose tolerance or insulin resistance, as it helps maintain more stable blood sugar levels throughout the day.

Beyond its direct impact on glycemic control, glucomannan may also influence satiety and weight management (Fang *et al.*, 2023; Xu *et al.*, 2023). Our study hinted at increased feelings of fullness among subjects taking glucomannan, which can potentially discourage overeating and promote weight management. This is evidenced by our research findings that, although subjects consuming KR have significantly lower postprandial blood sugar levels and iAUC than when they consume white rice, they experience a relatively similar sense of satiety both immediately after eating and 120 min thereafter (Table 4). Previous studies indicated that KGM has the ability to create a highly viscous solution due to its high molecular weight, strong affinity for water, and electrical neutrality. A 1% (w/w) solution of KGM exhibits an apparent viscosity of approximately 30,000 cps, rendering it the most viscous natural polysaccharide (Fang *et al.*, 2023). This exceptional viscosity can play a crucial role in managing hunger and body weight. By moderately increasing dietary viscosity through KGM, individuals can better manage hunger, aiding in weight management. Appetite suppression is one of the crucial strategies in regulating food or calorie intake, thereby preventing obesity and aiding weight loss in individuals with overweight. Given the strong link between obesity and the development of T2D and metabolic diseases, strategies that support weight control are of paramount importance in prevention efforts (Narayan *et al.*, 2007).

Emerging research suggests that glucomannan, along with certain other dietary fibers, may have a beneficial impact on gut health. These fibers serve as prebiotics, nourishing beneficial gut bacteria. Glucomannan in the form of konjac flour has been shown to notably increase the presence of beneficial microorganisms associated with obesity in patients, including *Lachnospiraceae, Roseburia, Solobacterium, R. inulinivorans, Clostridium perfringens* and *Intestinimonas butyriciproducens*. Conversely, it reduces the prevalence of detrimental microorganisms such as *Lactococcus, Bacteroides fragilis, Lactococcus garvieae, B. coprophilus, B. ovatus* and *B. thetaiotaomicron* (Li *et al.*, 2022). A healthier gut microbiome, which produce short-chain fatty acids such as acetate, propionate and butyrate, is associated with improved glucose metabolism and reduced inflammation, both of which are critical factors in preventing T2D and metabolic diseases (Bielka *et al.*, 2022). While our study did not directly assess gut microbiota changes, this area warrants further exploration in future research.

The implications of our findings extend to the realm of public health. In an era marked by escalating rates of T2D, obesity and metabolic diseases, identifying safe and effective preventive measures is a global imperative. Glucomannan, as a natural dietary fiber, in the form of KR which can be used as a rice substitute with organoleptic properties comparable to white rice, offers a potentially accessible and practical strategy for individuals at risk. However, it is crucial to address the impact and safety of long-term consumption. Specifically, attention must be given to potential effects on gastrointestinal health, nutrient absorption, and any possible adverse effects associated with prolonged use of KR. Further research focusing on these aspects is necessary to fully understand the implications of incorporating KR into the diet over an extended period. In addition, comprehensive lifestyle interventions, including a balanced diet and regular physical activity, remain fundamental in reducing the risk of T2D, obesity and other metabolic diseases.

In conclusion, our study, investigating the impact of KR on reducing glycemic response in normal individuals, yielded promising results indicating its potential as a beneficial dietary component. However, it is important to note that the findings may have limitations in their generalizability to diabetic patients. Individuals with diabetes often exhibit different physiological responses to food compared to those without diabetes, potentially affecting how konjac grain influences their glycemic response. Therefore, further research specifically targeting diabetic populations is warranted to better understand the potential benefits of konjac in managing blood sugar levels in this group. The mechanisms at play, including viscosity, satiety and potential effects on gut health, warrant further exploration. Furthermore, a personalized approach to dietary recommendations and KR usage may hold the key to optimizing its benefits for individuals at risk. The findings presented here contribute to the growing body of evidence supporting glucomannan as a valuable tool in the fight against these prevalent and debilitating health conditions.

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Corresponding author
Hendy Wijaya can be contacted at: hendy_wijaya@ukwms.ac.id

A novel konjac rice formula with glucomannan and tapioca starch improve postprandial glycemic response – a randomized single-blind clinical trial

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