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Original Research Article

Impact of consumption of brown rice on glycaemic and lipid profile in type 2 diabetics

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ABSTRACT

Background: Along with pharmacotherapy and exercise, nutrition is also instrumental in comprehensive management of diabetes mellitus (DM). The study aimed to determine the effects of brown rice substitution on glycaemic and lipid profile in patients of type 2 DM.
Methods: A hospital-based, non-blinded, randomized interventional study was conducted for 3-months period on DM patients in which brown rice substitution was assigned to the study group and the control group consumed regular white rice. Compliance for diet and medication was assured with telephonic interviews. Their glycaemic and lipid profile were analysed before the start of intervention and after 3-months and results were compared.
Results: FBG, PPBG and HbA1c were significantly reduced in both study (n=95) and control (n=98) groups after the interventional period, with greater reduction in the study group. In the study group, there was significant decrease in levels of triglycerides, total and LDL cholesterol and increase in levels of HDL cholesterol after the intervention as compared to that of the control group.
Conclusions: Substitution of brown rice with white rice for period of 3 months was associated with better glycaemic control and lipid profile. It has potential as a feasible and sustainable dietary intervention for DM with significant health benefits.

Keywords: DM, Brown rice, Glycaemic profile, Lipid profile

INTRODUCTION

India has emerged as the epicentre of diabetes mellitus (DM) with the second-largest populace of 77 million patients and prevalence of 8.9%, thus representing an economic menace at both household and national level.[1-3]

DM is now listed as 'public health priority' globally attributed to frequent and exhaustive hospital visits experienced by people irrespective of their ethnicity or monetary background. Along with pharmacotherapy and physical activity, medical nutrition therapy is instrumental in attainment of individualized glycaemic and lipids goals to improve health outcomes in diabetics.[4,5]

In an Indian diet plate, cereals usually contribute to two-thirds of total carbohydrates with predilection of refined carbohydrates.[6] White rice is predominantly consumed due to its availability and palatability. It is obtained from milling after removal of bran and germ leaving behind a starchy endosperm making it a food with high glycaemic index (GI) and glycaemic load.[7,8] The PURE study, a large multi-ethnic prospective cohort study, highlighted the significant association of higher consumption of white rice with increased risk of incident diabetes, most pronounced in South Asia (HR 1.61; 95% CI 1.13-2.30; p for trend-0.02) as compared to other regions of world.[9] In the follow-up of 9.5 years, approximately 6000 cases of incident diabetes were recorded in cohort of 132,373

participants from 21 countries. Excessive consumption of white rice can effectuate as post-prandial dysmetabolism characterized by hyperglycaemia and hypertriglyceridemia resulting in oxidative stress, endothelial dysfunction, inflammation, atherosclerosis, all of which may trigger an adverse cardiovascular event.[10,11]

Brown rice differs from white rice due to presence of rice bran which is rich source of various bioactive phytochemicals compounds such as amino-acids, lipids, dietary fibres, γ-oryzanol, tocopherol, flavonoids, gamma amino butyric acid (GABA) and minerals with important nutrigenomic implications and pharmacological properties.[12,13] The glycaemic and insulinemic responses to rice are determined by its amylose-amylopectin ratio, post-harvest processing and consumer processing.[14] Starches with higher content of amylose are more resistant to digestion. Hence consumption of rice with less amount of amylose and low fibre may predispose to insulin resistance and obesity.[15] Brown rice has comparatively lower rate of starch digestion and lower GI.[12] Hence, replacing it for white rice may blunt the post-prandial excursion of glucose and lipids.[16]

Rice is the staple food among Indians. Owing to the escalating incidence and the chronic nature of DM, the bidirectional relationship between diet and health risks needs better understanding and exploration so as to design healthful eating patterns based on scientific evidences and which are personally and culturally acceptable, easy to implement and can be abided for metabolic goals.[4] Improving the quality of carbohydrates in staple food can be a better option for positive health outcomes e.g., replacing white rice with brown rice. The aim of the study was to determine the effects of brown rice substitution on glycaemic control and lipid profile in patients of type-2 DM.

METHODS

This was a hospital-based, non-blinded, interventional study conducted in the out-patient department of general medicine in Gayatri Vidya Parishad institute of healthcare and medical technology, Visakhapatnam, in which participants were subjected to a randomized intervention for three months period. The study was initiated after obtaining institutional ethical committee approval. The study was conducted in compliance with the declaration of Helsinki from April 2019 to July 2019 which included enrollment and the interventional period.

The inclusion criteria were (a) age ≥18 years and ≤ 80 years, (b) Diagnosis of type-2 DM as per American diabetes association guidelines, (c) Having minimum duration of ≥1 year since the diagnosis of type-2 DM.[17]

The exclusion criteria were (a) type-1 DM, (b) uncontrolled DM requiring aggressive management or additional anti-diabetic drugs or frequent change of prescription, (c) individuals who are already consuming brown rice, (d) severe hepatic, renal, vascular or infectious disease or malignancy which may interfere with participation and compliance of the study, (e) history or symptoms suggestive of gastro-intestinal disorders like inflammatory bowel disease, malabsorption disorder, (f) individuals with habits of alcohol or tobacco consumption or drug abuse, (g) history or symptoms suggestive of any psychological disorder, (h) severe cognitive impairment, (i) pregnancy or lactation as well as (j) refusal for participation.

Participation was voluntary and no incentives or rewards was offered in return. Confidentiality was maintained throughout the study.

DM patients who volunteered to participate were initially screened for inclusion in the study. Before enrollment, all the recruited participants were given complete details about the purpose of the study, its design, duration and benefits, the potential risks involved and significance about the compliance and co-operation during the trial. The possible adverse effects because of brown rice consumption like such as diarrhea, flatulence, nausea and/or bloating were also informed to the participants. All those details were also included in the consent document which was signed by each participant during enrollment into study.

All the participants were enrolled 2 weeks before the initiation of the study. They were subjected to face-to-face interviews and clinical examination by physicians. Their medical records were assessed for medical history, drug history and glycemic control. The socio-demographic data included age, gender, marital status, family history and history of substance abuse. Those who meet the inclusion criteria were offered a consultation with dietician who advised them regarding the benefits of brown rice consumption on their health. During the consultation, they also were explained in their own language how to cook the rice as it required more water as well as more time to cook.[13]

People who were motivated for consuming brown rice were assigned into the study group, those who were not willing to change their routine diet were assigned to control group. The study group subjects were advised to consume the same amount of rice that they were consuming previously but instead of their regular white rice, they were advised to consume brown rice. Patients who were habituated in consuming rice two times daily were advised to take brown rice two times and those who eat once were asked to consume once daily. The control group was advised to continue their routine diet and regular medications. All the participants were encouraged to discuss any doubts/ concerns regarding the dietary intervention or study protocol. They were advised to continue their routine lifestyle throughout the study and to avoid changes in other dietary habits and physical activity as much as possible in order to minimize the confounding factors as diet and exercise are known to influence the

blood glucose and lipid levels.[18,19] Also, they were advised to continue their prescribed medications without any changes so as to eliminate the effect of drugs on their biochemical profile.

The baseline laboratory investigations were done on the day of inclusion into the study which included fasting (FBG) and post prandial blood glucose (PPBG) levels, glycosylated hemoglobin (HbA_1C), triglycerides (TG), total cholesterol (TC), high-density cholesterol lipoprotein cholesterol (HDL), low-density lipoprotein cholesterol (LDL), very low-density lipoprotein cholesterol (VLDL).

Fasting period of 12 hours was advised prior to blood collection. With the subject in sitting posture, a venous sample was drawn under all aseptic precaution and processed on the same day in the central laboratory of the institute. HbA1c was analyzed by nephelometry, plasma sugars and lipids by absorption spectrometry using a semi-automatic bio-chemistry analyzer.

All the participants were followed up in the diabetic clinic for 3 months and were assessed for their compliance with diet and medications twice a week via telephonic interviews. After end of 3 months, their glycemic and lipid profile were analyzed and compared with their previous values.

Sample size calculation

The sample size was estimated online sample calculator 2 sample T-test by comparing the two independent means of a previous study by Lee et al in which the mean HbA1c in control group was 7.2%, the mean HbA1c in study group was 6.6% and the standard deviation was 1.[20] Considering the power of 80% and α-level of 5% (two- sided), the minimum of 44 participants were required in each group. Considering the chance of loss of follow-up of thirty-three percentages, an additional 15 participants were added to each group.

Two hundred and sixty-five DM patients volunteered for the study. After screening for participation, 61 patients were excluded from the study due to the reasons cited in Figure 1. Hence, 204 patients were eligible for participating in the study who were dichotomized as study group and control group. They were randomized in 1:1 ratio with 102 participants in each group with age and sex matched subjects and were advised to follow the study protocol. The control group comprised of participants who consumed white rice and the study group comprised of participants who were on brown rice substitution.

Throughout the study period, 11 participants were lost to follow up with 4 and 7 in control and study group respectively. Hence, the data analysis was confined to 98 and 95 participants in control and study group respectively.

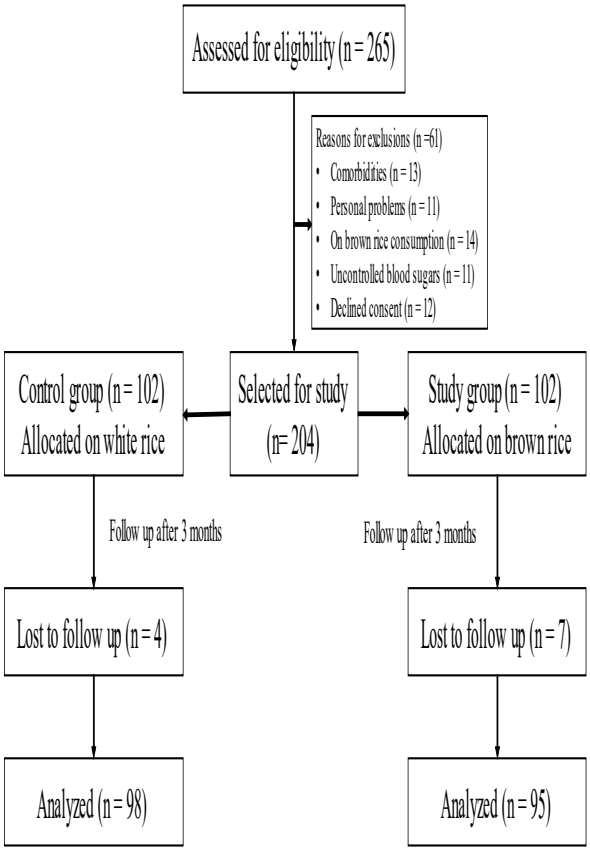

Figure 1: Flowchart of the study design showing recruitment of the participants.

Data analysis

The data was organized in Microsoft Excel sheet and statistical analyses were performed utilizing statistical package for social sciences (SPSS) version-24. Categorical data was organized as frequencies (N) and percentages (%) and was analyzed by Chi-square test. The quantitative variables were computed as mean and standard deviation (SD).

Unpaired 't' test was utilized to compare the values between study and control group. Paired 't' test was applied to determine the statistical significance among the difference between the values of both groups at the baseline and completion of intervention. $P<0.05$ adopted for statistical significance for all the analyses.

RESULTS

The study comprised of 97 males (50.25%) and 96 females (49.75%) (Table 1). The mean age of the study and the control group were 54.87±11.84 years and 52.41±10.91 years respectively. As treatment for DM, 133 (68.91%), 31 (16.06%) and 29 (15.03%) patients were on oral hypoglycemic agents (OHA), insulin and combination of both OHA and insulin respectively. The baseline characteristics of the participants of study and control group were not statistically significant (Table 1). The

baseline glycemic and lipid profile of the study and control group are reflected in Table 2. Statistically significant reduction in the values of FBG (Figure 2), PPBG (Figure 3) and HbA1c (Figure 4) was seen in both study and control groups after the interventional period. However, the reduction in the values were greater in the study group as compared to control group.

In the study group, there was significant decrease in the levels of triglycerides, total and LDL cholesterol and increase in levels of HDL cholesterol (Table 3) after the intervention as compared to the control group. Thus, consumption of brown rice had positive impact on glycaemic and lipid profile.

Table 1: Demographic characteristics of the participants.

Variables	Study group, (n=95)	Control group, (n=98)	P value
Age (years)	54.87±11.84	52.41±10.91	0.1287*
Gender			
Male	46	51	0.2528**
Female	49	47	
Duration of DM (years)	12.38±4.53	13.41±5.85	0.1740*
Treatment			
OHA	62	71	0.3190**
Insulin	15	16	
OHA + insulin	18	11	

DM-diabetes mellitus, OHA-oral hypoglycemic agents, *p calculated by independent 't' test, **p calculated by Chi-square test.

Table 2: Baseline glycemic and lipid profile of the participants.

Variables	Study group, (n=95)	Control group, (n=98)	P value
FBG (mg/dl)	159.60±64.30	150.30±37.12	0.2183
PPBG (mg/dl)	265.97±80.18	249.87±51.31	0.0972
HbA1c (%)	8.62±2	8.16±1.7	0.0904
Total cholesterol (mg/dl)	173.7±27.55	164.93±27.41	0.0278*
Triglycerides (mg/dl)	132.17±25.36	128.80±35.15	0.4471
HDL cholesterol (mg/dl)	36.53±3.62	38.71±3.24	<0.0001*
LDL cholesterol (mg/dl)	113.13±20.05	107.23±20.74	0.0460*
VLDL cholesterol (mg/dl)	33.33±11.22	32.64±12.26	0.6841

FBG-fasting blood glucose, PPBG-post-prandial blood glucose, HbA1c-glycated hemoglobin, HDL-high density lipoprotein, LDL-low density lipoprotein, VLDL-very low-density lipoprotein, *p<0.05-statistically significant.

Table 3: Comparison of parameters of lipid profile of the control and study group at baseline and after completion of the study.

Variables	Baseline	At the end of 3 months	P value
Study group, (n=95)			
Total cholesterol (mg/dl)	173.7±27.55	148.47±21.68	<0.0001*
Triglycerides (mg/dl)	132.17±25.36	118.83±21.25	0.0001*
HDL cholesterol (mg/dl)	36.53±3.62	39.10±4.01	<0.0001*
LDL cholesterol (mg/dl)	113.13±20.05	101.80±15.89	<0.0001*
VLDL cholesterol (mg/dl)	33.33±11.22	30.57±8.73	0.06
Control group, (n=98)			
Total cholesterol (mg/dl)	164.93±27.41	154.23±26.19	0.0057*
Triglycerides (mg/dl)	128.80±23.15	123.77±21.47	0.1164
HDL cholesterol (mg/dl)	38.71±3.24	39.17±4.80	0.4326
LDL cholesterol (mg/dl)	107.23±20.74	105.33±23.42	0.5484
VLDL cholesterol (mg/dl)	32.64± 12.26	30.93± 10.54	0.2964

HDL-high density lipoprotein, LDL-low density lipoprotein, VLDL-very low-density lipoprotein, *p<0.05-statistically significant.

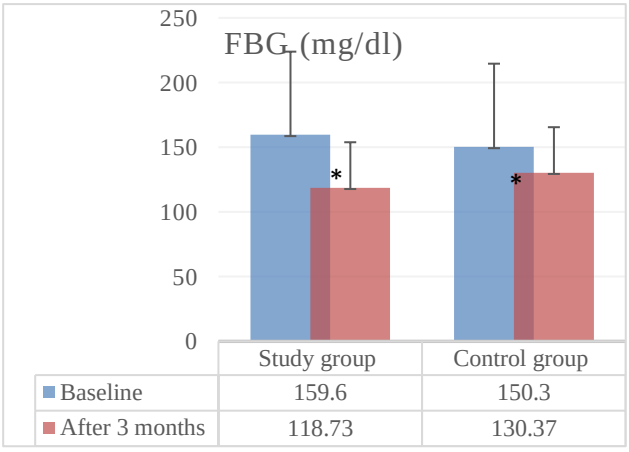

Figure 2: Comparison fasting blood glucose in the control and study group at baseline and after completion of the study.

FBG-fasting blood glucose, *p<0.05-statistically significant.

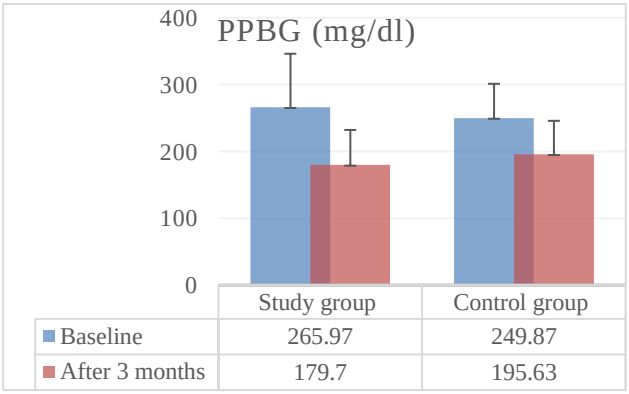

Figure 3: Comparison of post-prandial blood glucose in the control and study group at baseline and after completion of the study.

PPBG-post-prandial blood glucose, *p<0.05-statistically significant.

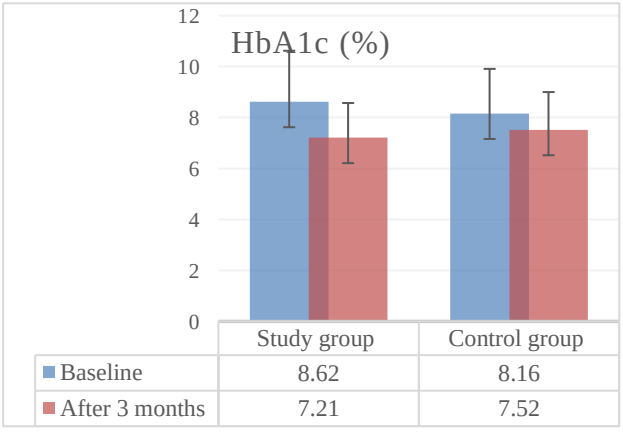

Figure 4: Comparison of HbA1c in the control and study group at baseline and after completion of the study.

HbA1c- glycated hemoglobin, *p<0.05-statistically significant.

DISCUSSION

The pathophysiologic triad of genetic predisposition for abdominal obesity, unhealthy food consumption and sedentary lifestyle has been implicated in acquisition and augmentation of metabolic disorders like DM, CVD, dyslipidaemia etc. Loss of dietary fibres, nutrients and bio-active compounds and an increase in starch content in white rice together attributes to its high GI and post-prandial glucose and lipids spikes.[10, 11] Replacement of white rice with brown rice is expected to provide more proteins, lipids, fibres and phytochemicals which have many nutrigenomic implications.[12,14]

In the present study substitution of white rice with brown rice had resulted in significant reduction in the values of FBG, PPBG and HbA1C as compared to baseline (larger reduction in those consuming brown rice). Similar findings of improved glycaemic control were obtained in a randomized controlled trial on Korean type-2 diabetics who consumed brown-rice based diet for 12 weeks as compared to those on conventional diabetic diet.[20] However, Zhang et al did not observe any significant change in blood glucose levels and HbA1C levels after incorporating brown rice into daily diet for 16 weeks.[21]

The results of systematic review by Ojo et al had demonstrated that low-GI diet was more effective in controlling HbA1c and FBG in patients with type-2 DM as compared with a higher-GI diet.[22] The blood glucose lowering effect of brown rice can be attributed to presence of dietary fibre in bran and higher amylase content which resists gelatinization and digestion, thus resulting in suppression of carbohydrate absorption from gut and blunting of post- prandial glucose excursion.[23] Improvement in PPBG decelerates inflammation, endothelial dysfunction and dyslipidaemia, which are the proximate triggers for an atherogenic event.[12,18] A randomized crossover trial substituting brown rice for white rice conducted by Wedick and his colleagues in Chennai also highlighted the concept of replacing white rice with brown rice as a novel step towards diabetes prevention.[24]

The present study also revealed significant higher reduction in triglycerides, total and LDL cholesterol along with an increase in HDL cholesterol in diabetics consuming brown rice as compared to white rice. The findings are similar to a randomized control trial on 11 diabetic patients after intervention with brown rice consumption for 14 weeks.[25]

Also, Zhang et al had observed significant improvement in lipid profile parameters after 16 weeks intervention of brown rice incorporation into daily diet.[21] These effects of brown rice could be attributed to the reduced lipid absorption, enhanced faecal bile acid excretion and down-regulation of genes involved in lipogenesis, thus suppressing hypercholesterolemia.[12,26]

In the present study, substitution of brown rice for white rice had 100% acceptability by the participants. The reason could be adequate motivation and regular follow up for the compliance. However, acceptance of brown rice into daily diet is challenged by few practical considerations. First is the lower acceptability owing its astringent taste. That can be improved with prolonged cooking and germination process which not only improves texture and palatability but also bioavailability of its nutrients.[12] Second is lack of commercialization due to its less availability, higher cost and shortened shelf life as compared to white rice. The third is less appreciation about health benefits of brown rice which can be addressed through motivation, promotion campaigns and use of information, education, and communication (IEC) materials optimized to cultural and culinary diversity of the population.[4,5]

The study had an important implication for diabetes prevention and management via a food-based strategy to enhance the quality of carbohydrate of staple food. Substitution of brown rice for white rice is a simple, feasible and sustainable dietary intervention with significant health benefits.[24] Global initiative for dietary improvement leveraged with community participation and political commitment may slow disease progression and downscale DM-associated morbidity and mortality.

Limitations

The study had few limitations. The glycaemic index of the meals of the participants were not estimated. Also, the meals between the groups and individuals were not isocaloric as the study group participants were advised to substitute their usual quantity of white rice with brown rice. Studies with larger sample size, calculated dietary meals and of longer duration are required to determine the long-term implications of inclusion of whole grains like brown rice in the diet.

CONCLUSION

In the present study, substitution of brown rice with white rice for period of 3 months was associated with better glycaemic control i.e., significant reduction in FBG, PPBG and HbA1c in patients with type-2 DM. It was also associated with improved lipid profile i.e., significant reduction in triglycerides, total and LDL cholesterol along with an increase in HDL cholesterol. Brown rice also was well accepted by the diabetics.

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REFERENCES

1. India State-Level Disease Burden Initiative Diabetes Collaborators. The increasing burden of diabetes and variations among the states of India: The Global Burden of Disease Study 1990-2016. Lancet Glob Health. 2018;6(12):e1352-62.
2. Oberoi S, Kansra P. Economic menace of diabetes in India. Int J Diabetes Dev Ctries. 2020:1-12.
3. Eshwari K, Kamath VG. Rao CR. Kamath A. Annual cost incurred for the management of type-2 diabetes mellitus-a community-based study from coastal Karnataka. Int J Diabetes Dev Ctries. 2019;39(3):590-595.
4. American Diabetes Association. 5. Facilitating behaviour change and well-being to improve health outcomes: Standards of Medical Care in Diabetes-2021. Diabetes Care. 2021;44(1):S53-72.
5. Chawla R, Madhu SV, Makkar BM. RSSDI-ESI Clinical Practice Recommendations for the Management of Type 2 Diabetes Mellitus 2020. Indian J Endocrinol Metab. 2020;24(1):1-122.
6. Radhika G, Sathya RM, Ganesan A, Saroja R, Vijayalakshmi P, Sudha V et al. Dietary profile of urban adult population in South India in the context of chronic disease epidemiology (CURES-68). Public Health Nutr. 2010; 12:1-8.
7. Shobana S, Lakshmipriya N, Bai MR, Gayathri R, Ruchi V, Sudha V et al. Even minimal polishing of an Indian parboiled brown rice variety leads to increased glycemic responses. Asia Pac J Clin Nutr. 2017;26(5):829-36.
8. Wu W, Qiu J, Wang A, Li Z. Impact of whole cereals and processing on type 2 diabetes mellitus: a review. Crit Rev Food Sci Nutr. 2020;60:1447-74.
9. Bhavadharini B, Mohan V, Dehghan M, Rangarajan S, Swaminathan S, Rosengren A et al. White Rice Intake and Incident Diabetes: A Study of 132,373 Participants in 21 Countries.Diabetes Care. 2020;43(11):2643-50.
10. Bell DS, O'Keefe JH, Jellinger P. Postprandial dysmetabolism: the missing link between diabetes and cardiovascular events? EndocrPract. 2008;14(1):112-24.
11. O'Keefe JH, Bell DS. Postprandial hyperglycemia/hyperlipidemia (postprandial dysmetabolism) is a cardiovascular risk factor. Am J Cardiol. 2007;100(5):899-904.
12. Ravichanthiran K, Ma ZF, Zhang H, Cao Y, Wang CW, Muhammad S et al. Phytochemical Profile of Brown Rice and Its Nutrigenomic Implications. Antioxidants (Basel). 2018;7(6):71.
13. Boers HM, Seijen Ten Hoorn J, Mela DJ. A systematic review of the influence of rice characteristics and processing methods on postprandial glycaemic and insulinaemic responses. Br J Nutr. 2015;114(7):1035-45.
14. Saleh ASM, Wang P, Wang N, Yang L, Xiao Z. Brown Rice Versus White Rice: Nutritional Quality, Potential Health Benefits, Development of Food

Products, and Preservation Technologies. Compr Rev Food Sci Food Saf. 2019;18(4):1070-96.
15. Abubakar B, Zawawi N, Omar AR, Ismail M. Predisposition to insulin resistance and obesity due to staple consumption of rice: Amylose content versus germination status. PLoS One. 2017;12(7):e0181309.
16. Mohan V, Spiegelman D, Sudha V, Gayathri R, Hong B, Praseena K et al. Effect of brown rice, white rice, and brown rice with legumes on blood glucose and insulin responses in overweight Asian Indians: a randomized controlled trial. Diabetes Technol Ther. 2014;16(5):317-25.
17. American Diabetes Association. 2. Classification and diagnosis of diabetes: Standards of Medical Care in Diabetes-2021. Diabetes Care. 2021;44(1):S15-33.
18. O'Keefe JH, Gheewala NM, O'Keefe JO. Dietary strategies for improving post-prandial glucose, lipids, inflammation, and cardiovascular health. J Am Coll Cardiol. 2008;51(3):249-55.
19. Lampman RM, Schteingart DE. Effects of exercise training on glucose training on glucose control, lipid metabolism, and insulin sensitivity in hypertriglyceridemia and non-insulin dependent diabetes mellitus. Med Sci Sports Exerc. 1991;23(6):703-12.
20. Lee YM, Kim SA, Lee IK, Kim JG, Park KG, Jeong JY et al. Effect of a Brown Rice Based Vegan Diet and Conventional Diabetic Diet on Glycemic Control of Patients with Type 2 Diabetes: A 12-Week Randomized Clinical Trial. PLoS One. 2016;11(6):e0155918.
21. Zhang G, Pan A, Zong G, Yu Z, Wu H, Chen X et al. Substituting white rice with brown rice for 16 weeks does not substantially affect metabolic risk factors in middle-aged Chinese men and women with diabetes or a high risk for diabetes. J Nutr. 2011;141(9):1685-90.
22. Ojo O, Ojo OO, Adebowale F, Wang XH. The Effect of Dietary Glycaemic Index on Glycaemia in Patients with Type 2 Diabetes: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Nutrients. 2018;10(3):373.
23. Ou S, Kwok K, Li Y, Fu L. In vitro study of possible role of dietary fiber in lowering postprandial serum glucose. J Agric Food Chem. 2001;49(2):1026-9.
24. Wedick NM, Sudha V, Spiegelman D, Bai MR, Malik VS, Venkatachalam SS et al. Study design and methods for a randomized crossover trial substituting brown rice for white rice on diabetes risk factors in India. Int J Food Sci Nutr. 2015;66(7):797-804.
25. Hsu TF, Kise M, Wang MF, Ito Y, Yang MD, Aoto H, Yoshihara R, Yokoyama J, Kunii D, Yamamoto S. Effects of pre-germinated brown rice on blood glucose and lipid levels in free-living patients with impaired fasting glucose or type 2 diabetes. J Nutr Sci Vitaminol (Tokyo). 2008;54(2):163-8.
26. Ho JN, Son ME, Lim WC, Lim ST, Cho HY. Anti-obesity effects of germinated brown rice extract through down-regulation of lipogenic genes in high fat diet-induced obese mice. Biosci Biotechnol Biochem. 2012;76(6):1068-74.

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