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Effect of Matta Rice Vs. White Ponni Rice on Post Lunch Blood Glucose Levels among People with Type 2 Diabetes: A Randomized Crossover Study from South India

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KEYWORDS

Post Lunch Blood Glucose Levels
Kerala Matta Rice
Tamil Nadu Ponni Rice
Type 2 Diabetes
South India
Crossover Study

ABSTRACT

Background: People in Kerala and Tamil Nadu consume Matta rice (MR) and White Ponni rice (WPR) respectively. Less evidence available on the effect of these rice consumption on postprandial blood glucose levels in people with type 2 diabetes (T2DM). Hence, this study aimed to see the effect of post-lunch blood glucose (PLBG) levels after consumption of these rice in people with T2DM.

Methods: A randomized crossover study was conducted in a tertiary care center for diabetes. A total of 70 Individuals with T2DM who were on oral hypoglycemic agent (OHA) and not on insulin were included. Group 1 (n = 35) received MR for first 2-weeks and WPR for the subsequent 2-weeks. Group 2 (n = 35) received WPR for first 2-weeks and later MR for the subsequent 2-weeks after 1-week washout period. PLBG levels were measured at baseline (BL), 7th and 14th day. Calorie intake using 24 hr-dietary recall was assessed at BL and 14th day. VAS was used to assess satiety and acceptability of the rice.

Results: Median PLBG levels significantly reduced from MBL (Matta baseline) (195.5 mg/dl) to M7th day (164.5 mg/dl, p = 0.03) and further to M14th (159.5 mg/dl, p = 0.02), WP7th day (160 mg/dl; p = 0.02) and WP14th day (158 mg/dl; p = 0.01), but no difference from MBL to WPBL (196 mg/dl, p>0.05) in group 1. While significant reduction observed from WPBL to M14th day (167 vs. 152 mg/dl; p <0.01) in group 2. Mean difference of PLBG (–31.5 vs. –6.5 mg/dl; p = 0.007) and calorie intake (220 vs. 136 kcal) between MBL-M14th day and WPBL-WP14th day was highly significant. Study participants reported higher satiety (Matta vs. Ponni; 63.8 vs. 6.4%; p < 0.001), and fullness (68.1 vs. 4.3%; p <0.001) after MR consumption while they were very satisfied (Ponni vs. Matta; 66 vs. 23.4%; p <0.001) and stated very tasty (80.9 vs. 21.3%; p < 0.001) with WPR.

Conclusion: The consumption of Matta rice showed potential reduction on PLBG levels and helped to restrict calorie intake with good satiety and fullness when compared to white rice among participants with T2DM.

INTRODUCTION

Rice is the major cereal that people in the southern part of India regularly eat and their diets are high in carbohydrates [1]. The type of starch, amount of dietary carbohydrate, fiber, protein, fat, size of the particles, food processing method and food consumption practice have an impact on the blood glucose levels [2]. Cereal based diets are mostly linked to the rising incidence of metabolic syndrome in the population of south India [1]. Diabetes is increasing globally and prevalent in 10.5% of the adult population in the age group of 20–79 years as per IDF estimates in 2021 [3].

Hyperglycemia is characterized by elevated blood glucose levels, and the pathophysiology of the postprandial hyperglycemia includes hyperglycaemic

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spikes that result in oxidative damage [4]. Untreated hyperglycaemia will lead to occurrence of micro and macrovascular complications. Thus, hyperglycaemia needs to be managed effectively and efficiently to prevent the complications [5].

Rice includes high carbohydrate (CHO) content and also a good source of vitamins and minerals [6]. CHO also act as an energy source and helps in the regulation of blood glucose levels in people with diabetes [7]. The nutritional value and quality varies according to the Strain or color (i.e. white, brown, red, and black/purple), soil cultivation, level of milling and the method of preparation before consumption [8,9]. There are rice varieties such as Kuruva, Ponni, Sonam, Komal, Sona Masoori, Kerala rose matta, Rajaboham, Samba, and Jeeraga Pulungal available in the market [10].

The Glycemic Index (GI) refers to the amount of CHO present in a particular food and its' breakdown rate (Low, Medium and Fast) by which the postprandial blood glucose (PPBG) will vary accordingly. The GI value for food items are categorized into three different ranges such as (Low- <55), (Medium- 56–69) and (high- >70). The glycemic load refers to the quantity of CHO in grams per serving of a particular food. The GL values are categorised as (Low- < = 10), (Medium- 11–19), and (High- > = 20) [11].

Kerala rice, referred as Matta rice (MR), a type of rice that is traditionally cultivated in the Indian state of Kerala. Anthocyanin, a naturally occurring pigment found in the grain's outer layer, is responsible for the distinctive red colour of rice [10]. The Glycaemic index of the MR is 59.2 [12]. White Ponni rice (WPR) is widely grown and commonly used in the Indian state of Tamil Nadu [10]. The Glycemic index of the Ponni rice is 73 [13]. Both the rice is used in various traditional recipes, including steamed rice, porridge, pulav and biryani.

Very limited studies have investigated the effect of commonly used South Indian rice varieties of Matta and white Ponni. Therefore, this study was conducted to compare the effect of Matta and white Ponni rice on the Post lunch blood glucose (PLBG) levels in people with T2DM. The main objectives of this study were to compare the crossover effect of MR and WPR on PLBG levels within and between consumption of Matta and white Ponni rice study groups and to assess and compare dietary intake and calories at the baseline and at end of the study. We also aimed to compare visual analog satiety scores after the consumption of MR and WPR.

MATERIALS AND METHODS

A randomized crossover study was conducted between March to May 2023 in a tertiary care centre for diabetes in Chennai, South India. A total of 154 participants with T2DM who visited the out-patient department for their treatment were screened and recruited around 70 participants based on study inclusion criteria. Individuals with T2DM aged between 25–60 years; both male and female, HbA1c <7.5%, individuals on oral hypoglycemic agents for the past one year and those who were willing to participate were included in the study. All the participants were explained about the study protocol and a written informed consent was obtained from them prior to the enrolment. The study was approved by the Institutional Ethical Committee (IEC/N-006/03/203).

The exclusion criteria were people with T2DM who were on insulin, type 1 diabetes, gestational diabetes, thyroid dysfunction, uncontrolled T2DM and with diabetes complications, other conditions like malabsorption syndrome, any other severe illness and individuals on weight loss program and unwilling to sign the informed consent.

Sample Size: Based on a previous study [12], assuming 80% power and 95% confidence level, and 20% drop out rate, the minimum sample size required was 20 in each group.

Socio-demographic details, such as age, gender, education, behavioral habits, clinical and biochemical profile such as duration of diabetes, diabetic drugs, fasting, postprandial and HbA1c% and were collected at baseline. Anthropometric measurements which included height, weight, and waist circumference were recorded at baseline, 7th and 14th day before and after the washout period. Dietary assessments were done using 24-hr. dietary recall at similar time points. Pre-lunch and Post lunch capillary blood glucose (CBG) levels were measured using glucometer (One-Touch Verio) at the baseline, 7th and 14th day before and after the wash out period.

INTERVENTION

The eligible participants were randomly allocated into two groups using computer generated random numbers. In the first 14 days Group 1 (n = 35) was given MR and Group 2 (n = 35) had white PR. There were 11 and 10 participants dropped out in the study groups 1 and 2 during this period. After one-week washout period, in the next 14 days Group 1 (n = 24) and Group 2 (n = 25) were given WPR and MR. There were 2 participants dropped out only in Group 2 during this period. Out of selected 70 participants with T2DM, 47 participants completed the study in Group 1 (n = 24) and Group 2 (n = 23) respectively. Figure 1 shows the flow chart for the screening, recruitment and follow up of the participants. The participants were advised to take a standard portion size of 150 gm of cooked rice, 50 gm of dhal, and 100 gm of vegetables during the intervention period. Participants were also taught soaking and cooking method of rice. An appropriate

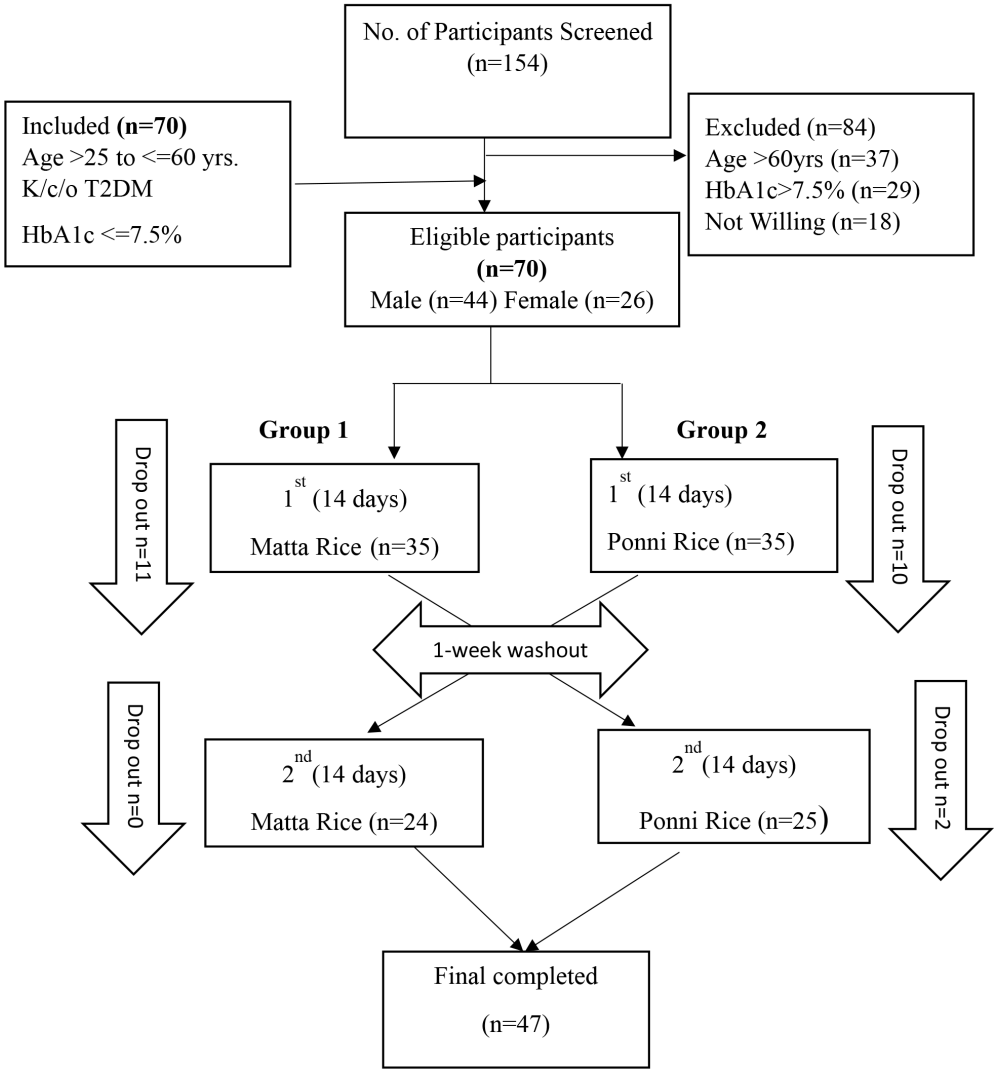

Figure 1. Screening and enrolment of the participants.

dietary advice was given to all the individuals at the baseline and reinforced at each follow up visit by a trained Nutritionist. Calorie intake was calculated using the nutritive value of Indian Foods [14]. The study participants were advised and also ensured that they did not change their drug intake or physical activities during the study period.

Visual Analog Scale (VAS) was used to assess the individual's level of hunger, satiety, satisfaction of portion size and taste of the MR and WPR consumption at the end of 14th day.

This scale was created based on a previous study [15] included the aspects mentioned above and the participants were asked to give a score to each item which ranges from 1–10. A higher score (>7), reflects less hunger, greater fullness, greater satiety and better taste.

FOLLOW UP AND ADHERENCE

The participants were followed up through periodic telephonic calls to ensure the dietary compliance and also the meal plated was consumed completely. Compliance was also evaluated during 24-hr dietary recall at each follow up. The participants were asked to make an in-person visit to the center for the first follow up at 7th day to reassess the anthropometric and biochemical parameters and 24-hr. dietary recall. The second follow up at the 14th day to repeat all the assessments and VAS scale.

STATISTICAL ANALYSIS

Mean ± SD and median (range) were reported for continuous variables and frequency and proportions were given for categorical variables. Student t test/ Mann-Whitney U tests and paired t-test or Wilcoxon tests were used to assess the statistical significance respectively.

All statistical analysis was performed using IBM SPSS 29 for Windows (SPSS Inc., Chicago, IL, USA). All the statistical tests were based on two-tailed hypothesis tests, where the significance level was defined as $p < 0.05$.

RESULTS

Table 1 presents baseline characteristics of the study participants. The median age of the participants was 52.3 years. Around 63.4% were male and 36.6% were female participants. The median BMI was 27.4 (20.1, 36.2) kg/m^2, whereas 20% were overweight and 45% were obese among overall participants. The median waist circumference of the male participants was 100 (81.3, 119.3 cm) and in female participants was 92.1 (73.5, 121.2 cm). The median duration of diabetes was 7.4 years, HbA1c was 6.7%, and mean Fasting Blood Glucose (FBG) was 121 ± 23 and PPBS was 191 ± 48 mg/dl. Majority 85% of the participants was on Sulfonylureas, 11% Alpha-glucosidase inhibitors and remaining 4% DDP-4 inhibitors. The smoking habit and alcohol consumption were 30.2% and 40.3% respectively. Majority 70.2% of the participants had completed middle school and 30.3% were engaged in mild physical activity every day.

Figure 2A shows the changes in 2 hr PLBG levels within group 1. It was observed that within the group who consumed Matta rice first there was a significant reduction in median PLBG from MBL to M 7th day (195.5 vs 164.5 mg/dl; p = 0.03) and MBL to M 14th day (195.5 vs. 159.5 mg/dl; p = 0.02) and there was no significant difference noted from M 7th to M 14th day. After 1 week washout period the same individuals who consumed WPR showed significant reduction in median PLBG from WP BL to WP 7th day (196 vs. 160 mg/dl; p = 0.04) and it remains similar till WP 14th day. There was a significant reduction found in median PLBG from M BL to WP 7th day (195.5 vs 160 mg/dl; p = 0.02) and WP 14th day (195.5 vs. 158), p = 0.01), but no difference in PLBG level from MBL to WPBL consumption in group 1.

Characteristics	n = 70
Age (yr)*	52.3 (28.3, 59.4)
Gender	
Male	44 (63.4%)
Female	26 (36.6%)
Educational Status	
Illiterate	28 (20.4%)
School	57 (70.2%)
College	15 (9.4%)
Height (cm)*	161.3 (138.2, 185.1)
Weight (kg)*	70.6 (49.6, 87.9)
Body Mass Index (kg/m^2)*	27.4 (20.1, 36.2)
Waist Circumference (cm)*	
Male	100.2 (81.3, 119.3)
Female	92.1 (73.5, 121.2)
Duration of diabetes (yr)*	7.4 (2.6, 10.4)
HbA1c (%)*	6.7 (5.2, 7.5)
Fasting blood glucose (mg/dl)**	121 ± 23
Post prandial blood glucose (mg/dl)**	191 ± 48
Antidiabetic Drugs	
Sulfonylureas	40 (85%)
Alpha-glucosidase inhibitors	5 (11%)
DDP-4 inhibitors	2 (4%)
Smoking	
Yes	6 (30.2%)
No	94 (69.8%)
Alcohol Consumption	
Yes	12 (40.3%)
No	88 (59.7%)
Physical Activity	
Yes	26 (30.3%)
No	74 (69.7%)

Values are in n (%), *Median (Mini, Max), **Mean ± SD.

Table 1. Baseline characteristics of the study participants.

Figure 2B shows the changes in 2 hr PLBG levels within group 2. It was observed that there was a significant reduction in median PLBG from WPBL to 7th day (167 vs. 157 mg/dl; p = 0.04) but there was an increase from WP 7th to WP 14th day (157 vs. 165 mg/dl; p = 0.02) and there was no significant reduction in WPBL to WP 14th day. After 1 week washout period the same individuals who consumed Matta rice showed no significant reduction from MBL to M 7th day and M 14th day. But there was a significant reduction found in median PLBG from WPBL to M 14th day (167 vs. 152 mg/dl; p <0.01).

Figure 3 presents changes in 2 hr PLBG levels within the respective rice MR (n = 47) and WPR (n = 47) of baseline, 7th and 14th day. There was a significant reduction in M BL to M 14th day (169 vs. 156 mg/dl; p = 0.03) and there was no significant reduction in M 7th to M 14th day. PLBG levels were significantly reduced from WP BL to WP 7th day (175 vs. 158 mg/dl; p = 0.04) and there was no significant reduction from WP 7th to WP 14th day.

Table 2 shows a significant reduction in PLBG levels at 14th day from baseline (31.5 mg/dl vs. –6.5 mg/d; p = 0.007) in MR group as compared to WPR group. MR also showed reduced pre-lunch blood glucose levels compared to WPR (–4.2 mg/dl vs. –1.4 mg/dl; p = 0.015).

Figure 4 shows the energy intake between MR and WPR from baseline, 7th and 14th day. It was observed that there was a significant reduction in calorie intake among the participants when they consumed Matta rice M BL vs. M 14th day (1474 vs. 1254 kcal; p <0.01). But there was an increase in the calorie intake while the participants consumed WPR from baseline to 14th day (1657 vs. 1793 kcal; p = 0.09).

Table 3 shows the comparison of visual analogue scale for satiety assessment between MR and WPR. Majority of them were felt less hungry, very full when they consumed MR than the WPR and the difference was statistically significant (63.8 vs. 6.4%; p <0.001), (68.1 vs. 4.3%; p <0.001) and whereas participants felt very satisfied and very tasty with WPR compared to MR (66.0 vs. 23.4%; p <0.001) and (80.9 vs. 21.3%; p <0.001).

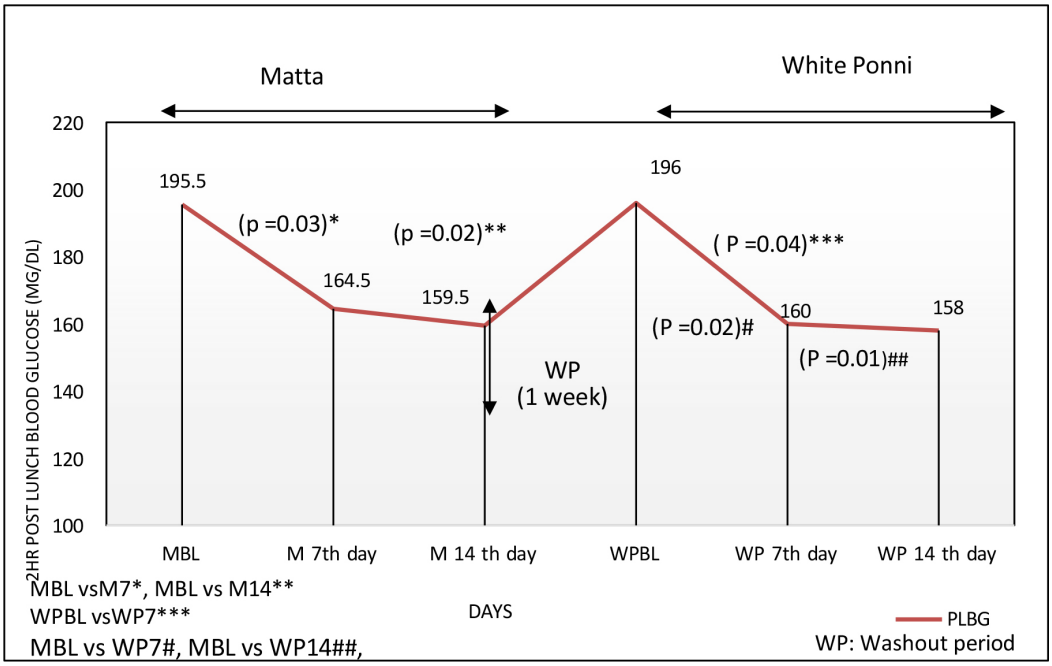

Figure 2A. Changes in 2 hr post lunch blood glucose levels within group 1. MBL: matta baseline; WPBL: white ponni baseline; PLBG: post lunch blood glucose.

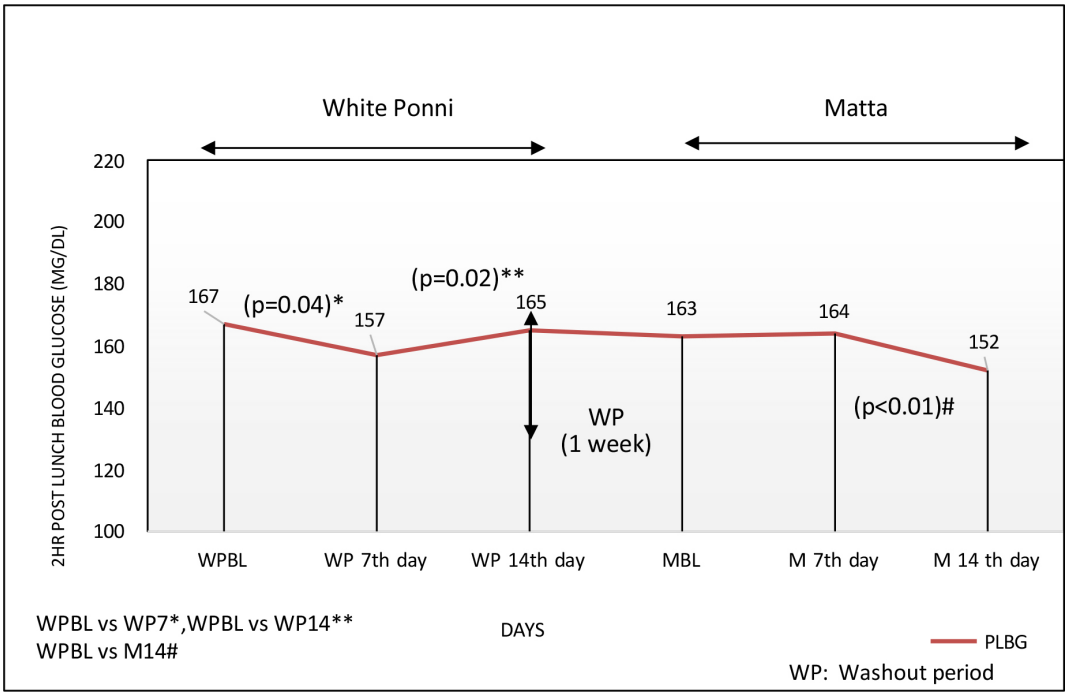

Figure 2B. Changes in 2 hr post lunch blood glucose levels within group 2. MBL: matta baseline; WPBL: white ponni baseline; PLBG: post lunch blood glucose.

DISCUSSION

Rice consumption in people with diabetes has been observed as a significant contributor for higher PPG levels. The effect of Matta and Ponni rice consumption on 2-hr PLBG levels among people with T2DM depicted that there was a significant reduction in PLBG levels in people who consumed MR compared to WPR. Similarly, a randomized controlled study conducted by Nivedita et al., [12] showed significant reduction in FBG, PPBG levels, HbA1c, insulin, HOMA-IR and also lipid profile after consumption of low-GI (LGI) diet for 24-weeks compared to the control group. In this study, the intervention was the replacement of entire meal of the participants for 24 weeks with LGI diet which includes whole wheat flour, oats and red rice puttu for breakfast and rose MR meal for the lunch and broken wheat upma or broken wheat + green gram + fenugreek seeds kanji (porridge) or whole wheat flour roti for dinner respectively. While, only the lunch was replaced with a standard MR meal plate in our study for a period of

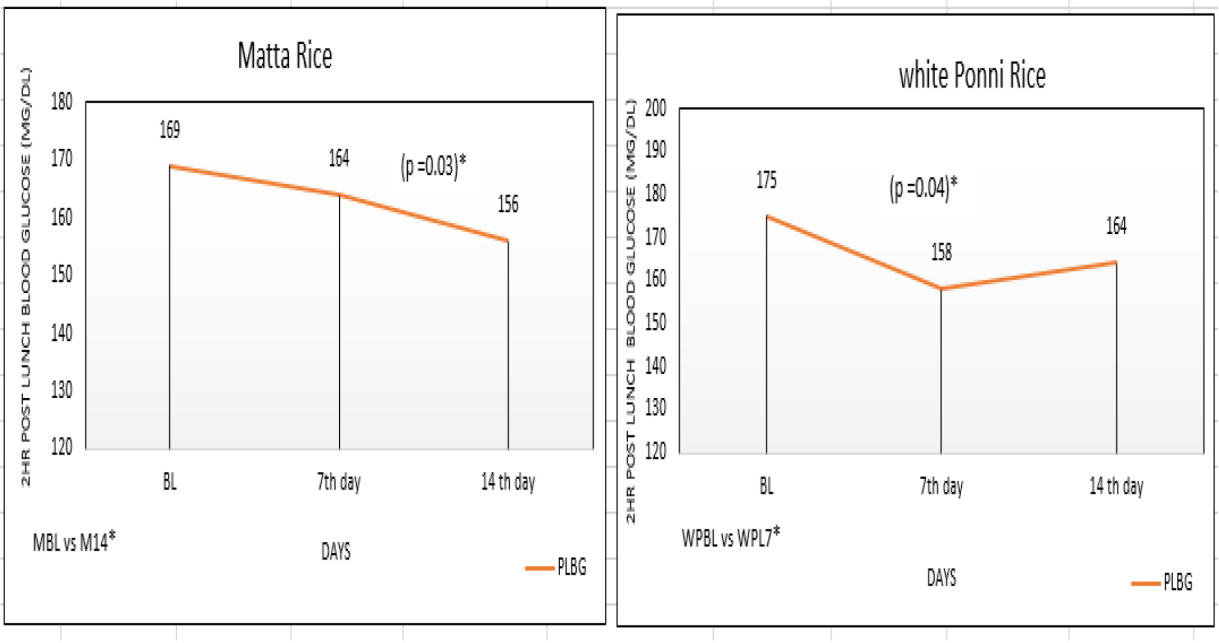

Figure 3. Changes in 2 hr post lunch blood glucose levels within the rice. MBL: matta baseline; WPBL: white ponni baseline; PLBG: post lunch blood glucose.

Variables	MBL vs M14 Mean difference	WPBL vs P14 Mean difference	p value
Pre-lunch blood glucose (mg/dl)	−4.15 ± 2.9	−1.38 ± 0.98	0.015
Post-lunch blood glucose (mg/dl)	−31.5 ± 22.3	−6.51 ± 4.6	0.007

Values are in Mean ± SD.

Table 2. Comparison of difference in 2 hr post lunch blood glucose levels between the rice varieties.

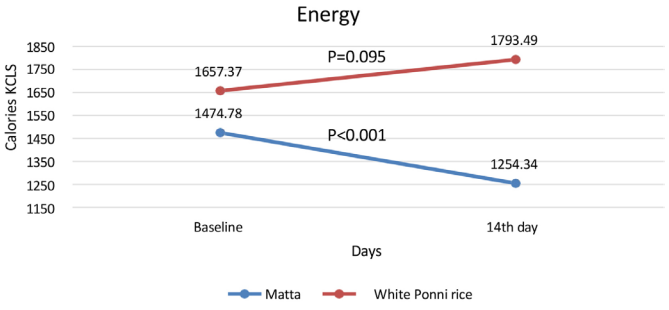

Figure 4. Energy intake between Matta and White Ponni rice.

Visual analogue scale (VAS)	Matta rice (n = 47) n (%)	White Ponni rice (n = 47) n (%)	p Value
1 How much hungry you felt after your meals?			
Very hungry	4 (8.5)	40 (85.1)	
Not hungry at all	13 (27.6)	4 (8.5)	<0.001*
Less hungry	30 (63.8)	3 (6.4)	
2 How much full you were after your meals?			
Very full	32 (68.1)	2 (4.3)	
Not full at all	4 (8.5)	15 (31.9)	<0.001*
Greater full	11 (23.4)	30 (63.8)	
3 How much satisfied you were after your meals?			
Very satisfied	11 (23.4)	31 (66.0)	
Not Satisfied at all	5 (10.6)	8 (17.2)	<0.001*
Better satisfied	31 (65.9)	8 (17.0)	
4 How tasty is your meals?			
Very tasty	10 (21.3)	38 (80.9)	
Not tasty at all	7 (14.9)	4 (8.5)	<0.001*
Better taste	30 (63.8)	5 (10.6)	

Values are in n (%).

Table 3. Comparison of visual analogue scale (VAS) for satiety assessment between rice varieties.

two weeks. It showed significant reduction (–31.3 in PLBG levels on 7th and 14th day follow up from baseline. While another study conducted by Sally et al., [16] to see the effect of different constitution of rice between brown and white rice (25:75%, 50:50%, 75:25%, & 100% brown rice) in persons with diabetes after consumed 100% brown rice meal showed significantly less PLBG levels compared to lesser proportion of brown rice. A study conducted in Rome compared the effect of corn rice and white rice dishes in two groups of college students on 2 hr postprandial blood glucose levels and showed no difference in blood glucose levels among the groups [17].

Another important finding in our study was the effect on calorie intake after consumption of Matta rice. A total of 220.79 kcal reduced from baseline to 14th day

among those who consumed MR compared to WPR (136.12 kcal). In contrast, another study [12] conducted in Kerala showed no significant changes in calorie intake among people with diabetes who consumed LGI diet compared to standard diet but there was a significant reduction found in carbohydrate consumption at 24th week.

Our study used VAS for satiety assessment among the participants to compare MR and WPR. More than one-third of our participants were felt less hungry, very full and better satisfied with MR compared to WPR whereas higher proportion of them reported better taste in WPR than MR. Our results were consistent with other studies [16,17]. A study conducted in Nigeria which examined the acceptability and tolerability in order to substitute brown rice meals for white rice with different composition of brown and white rice. The results showed 49% of the participant's preferred 100% brown rice while 19% and 18% of the participants preferred 25% and 50% brown rice meals respectively. While Natalia et al., [15] reported consumption of whole grain high-fiber barley decreased hunger among the study participants when compared to consumption of whole grain wheat and refined rice-based foods.

Evidence suggests that high white rice consumption was associated with a higher diabetes risk [18,19]. A prospective study conducted on adult Japanese individuals showed an association between rice consumption and a higher incidence of T2DM [20] and also an increase in post prandial hyperglycaemia in people with diabetes. Another prospective study showed diet replaced white rice with same amount of brown rice and whole grains reduced diabetes risk at 16% and 36% respectively [21]. Hence, consumption of standard portion of high fibre cereals like MR might be beneficial in people with diabetes to maintain their good glycaemic status.

The selection of cross over study design is an added strength in which we had an opportunity to observe the PLBG levels in the same individuals taking two different varieties of rice. The rice portion size was strictly measured and separately labelled with grams by the researcher and given to the participants for 14 days at baseline and after the washout period. Estimation of the PLBG levels after 2-hr of the meal consumption might only reflect the effect of rice intake.

Our study's limitations include the observation of high dropout rate during the MR intervention. The reasons given by the participants were extended cooking and soaking.

Further research is needed to investigate the impact of both rice consumptions on other glycemic biochemical markers. A prospective study with longer duration of intervention with larger sample size might help us to generalize our study findings.

CONCLUSION

Consumption of Matta rice showed significant reduction in post lunch blood glucose levels compared to white Ponni rice among people with T2DM. Restricted calorie intake, good satiety level and fullness was reported by those who consumed MR. Hence, consumption of MR might be beneficial for people with diabetes who experience post prandial hyperglycaemia.

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CONFLICTS OF INTEREST

None.

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