A Prospective Observational Study on the Effect of Millet Incorporated Breakfast on Controlling Glycemic Status in Selected Type II Diabetes

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ABSTRACT : Millets are rich source of dietary fibre and non-starchy polysaccharides with low glycaemic index (GI), The millets such as *Peral, Foxtail, Bayrnyard, Little and Koda millets* are commonly used millets with low glycemic index, hence can be used as a therapeutic diet. This study was conducted to estimate the effects of a millet *idli* (*Peral, Foxtail, Bayrnyard, Little and Koda* millets) compared to a rice *idli* for breakfast on postprandial glucose levels in type 2 diabetes (T2D). The GI of rice *idli* and millet *idlies (Peral, Foxtail, Bayrnyard, Little and Koda* millet) were estimated. A total of 2205 subjects were screened and 634 of them detected as T2DM . 200 T2D were selected from detected diabetes by purposive random sampling for the study. The participants were on oral hypoglycemic agents (OHA) and not on insulin. In this study, each individual served as their own control and experimental group. The postprandial increase in blood glucose level was compared after having a breakfast of millet and rice *idlies* . One way ANOVA were used to note the change in blood glucose levels and the level of the significance. Perason correlation coefficient is used to show the significance of Glycemic index on post prandial blood glucose levels. The Gl of the millet and rice *idli* revealed that, *fox tail millet* has (49.64) was found to be the lowest followed by *barnyard millet* (50), *small millet* (52),*pearl millet* (55), *koda millet* (58) and *rice idli* (77.96). There was a significant reduction (p= 0.000) in the postprandial glucose level of patients who consumed a millet *idli - Foxtail millet* (p= 0.000); *Koda millet* (p= 0.000); *Barnyard millet* (p= 0.000); *pearl millet* (p= 0.000); Little millet (p= 0.000). There is significant decrease of blood glucose levels in diabetes consumed millet *idli* when compared to rice *idli*. No significant reduction was observed in the fasting glucose levels. There is significant correlation between variables used for the analysis with p value, 0.000 which is lesser than that of 0.05 confirms, glycemic index has effect on blood glucose levels. Intake of food that have less GI tend to decrease postprandial blood glucose levels. The results suggested that replacing a rice-based breakfast item with a millet-based breakfast item lowers the postprandial blood glucose levels in T2D patients. Thus, millets may have a protective role in the management of hyperglycemia. Further studies need to be done in all millets and whole cereals in a systematic manner to confirm these findings.

KEYWORDS: Millets, Glycemic index, Postprandial glucose levels, Rice, Type 2 diabetes.

INTRODUCTION

Diabetes, one of the largest epidemics the world has faced, is a major risk factor for public health. The International Diabetes federation (IDF) reports that in 2007 there were 46.5 million people in India with diabetes and this number is expected to go to 80.3 million by 2025 **(IDF 2006)**. The IDF estimates that worldwide there were 194 million people with diabetes in 2003 and this will increase to 334 million by 2025.

Among the established risk factors of T2DM, balanced diet and rational studies have enhanced our understanding of the relationship between whole grain and glucose metabolism [Xi *et al* 2002]. Prospective studies consistently showed a reduced risk of T2DM with high intakes of whole grains [Cho *et al* 2013]. Fung *et al* (2018) followed the men from the Health Professionals Follow-up Study without a history of diabetes or cardiovascular disease (*n*= 42898) for ≤12 years and suggested that a diet high in whole grains was associated with a reduced risk of T2DM .

Millet is one of the most important grain receiving specific attention because of its excellent nutritive value and potential health benefits such as anti-diabetic, anti- oxidant and anti-arteriosclerotic effects [Muninarayana *et al* 2012) Moreover, millet-based products have markedly slower gastric emptying than rice, (Cisse *et al.*, 2018).

Previous research has suggested the anti-diabetic effect of *finger millet* [Kumari *et al* 2018]. Millet-derived products from *Foxtail* had a median glycemic index and a gentle stimulation to pancreatic beta-cell, which could help diabetics to avoid dangerous spike in blood glucose [Ren *et al* 2002]. These characteristics above-mentioned might contribute to the improvement of postprandial blood glucose in diabetes.

Minor millets are claimed to be future foods for better health and nutrition security. In the recent years, they are recognized as important substitutes for major cereal crops to cope up with the reduction of post prandial blood sugar.(Veena *et al* 2009). It is also termed as a nutraceutical in view of good nutritional specialties such as complex carbohydrates, high proportion of dietary fibre and other of phytochemicals with nutraceutical qualities.

Millets are having low glycemic index compare to other cereal**s.**Besides, these are a rich source of dietary fibre, phytochemicals and non-starchy polysaccharides are reputed to have a low GI, hence can be used as a therapeutic diet. Compared to rice, millets release a lesser percentage of glucose and over a longer period. This lowers the risk of diabetes. Recent research has shown that the carbohydrates present in millet are less rapidly digested and assimilated than those present in other cereals.

Based on this, we hypothesized that replacing rice with millets could decrease the blood glucose concentrations and improve the blood glucose tolerance. This study was undertaken to assess and compare the postprandial glycemic response of a common Indian recipe (Rice *idli*) with millet *idlies*recipe (foxtail, Pearl, Kodo, Littleand and bayrnyard millet dosa) in type 2 Diabetes. The aim was also to estimate the effect of a single change in the diet in any one meal (Breakfast) with millet idli on the postprandial level of glucose in patients with type 2 diabetes mellitus (T2DM). The proximate principles of rice and millet idli are given in Table I.

MATERIAL AND METHODS

Preparation of the rice- and millet-based *idli:*

For the preparation of the millet idli , 90 g of unpolished millets (*pearl,small, koda, foxtail* and *bayrnyard* millets) were purchased from the local market along with 20 g of black gram pulses (dal), soaked for four hours and were ground with 90 ml of water. The batter was kept overnight for fermentation. The same recipe was followed for preparing the rice-based dosa with rice substituting the millets.

The final quantity of batter was weighed accurately. The final weight yielded is 290g . This weight (290g) of *(pearl, small, koda, foxtail and bayrnyard)* millet batter provided 53.08 g, 60.80 g, 61.63 g, 54.61 g, and 57.72g of carbohydrate (CHO) respectively, while 290g rice batter provided 77.0 g of carbohydrate. Hence, the batter quantity of different millets were adjusted to provide 50 gms of carb in standard three portions (3 portions) of *idli.* That is 273.20g of *pearl millet* batter (90gm of batter /portion), 238.50 g *small millet* batter (91g of batter/portion), 235.26g of *koda millet* batter(78g of batter/ portion), 265.54 gms *foxtail millet* batter (89 gm of batter/portion) and 251.22 g *bayrnyard millet* batter (84 g of batter/portion) and 196.23 gms of rice batter (65 g of batter/ portion) were used to make 3 *idlies*

Reference food:

White bread was chosen as the reference food (purchased from the local bakery). The available carbohydrate was calculated by subtracting the TDF from total CHO. Therefore, 101 g of bread contained 50 g of available CHO.

Table 1: Nutrient Composition of Millet & Rice *Idli* (with adjusted weight of batter to provide 50 g carbohydrate /portion*).

Cereal grain	Batter qty (g)	No.of. *idli*	Wt.of *idli* (one unit)	Energy (Kcal)	CHO (g)	PROTEIN (g)	FAT (g)	FIBER (g)
Pearl millet idli	273	3	90	356	50	13.6	4.9	12.0
Small millet idli	238.50	3	79	309.6	50	11.3	3.2	7.7
Koda millet idli	235.26	3	77	294.8	50	10.3	2.1	6.6
Foxtailmillet idli	265.54	3	86	332.1	50	14.4	3.9	8.9
Bayrnyard millet idli	251.22	3	83	229.59	50	8.8	2.0	9.9
White bread	200	4 slice	50	245	50	7.8	0.7	2.51
Rice idli	196.23	3	65	260.9	50	7.9	0.56	3.9

1**portion **= 3 number of *idlies

Estimation of glycemic index:

Ten normal volunteers were selected, the reference and test items were given with two-days wash out period. The average fasting blood glucose was 87 ±5 mg/dl (average of three different readings on three different days.) The participants were all females between the age range of 22-24 years and body mass index (BMI) range of 20-22 kg/m2. The purpose of the study was explained to each participant and written consent from the participate for this study were obtained. They consumed three *idlies*(test food), which provided 50 g of carbohydrate and four slices of bread (reference food) .

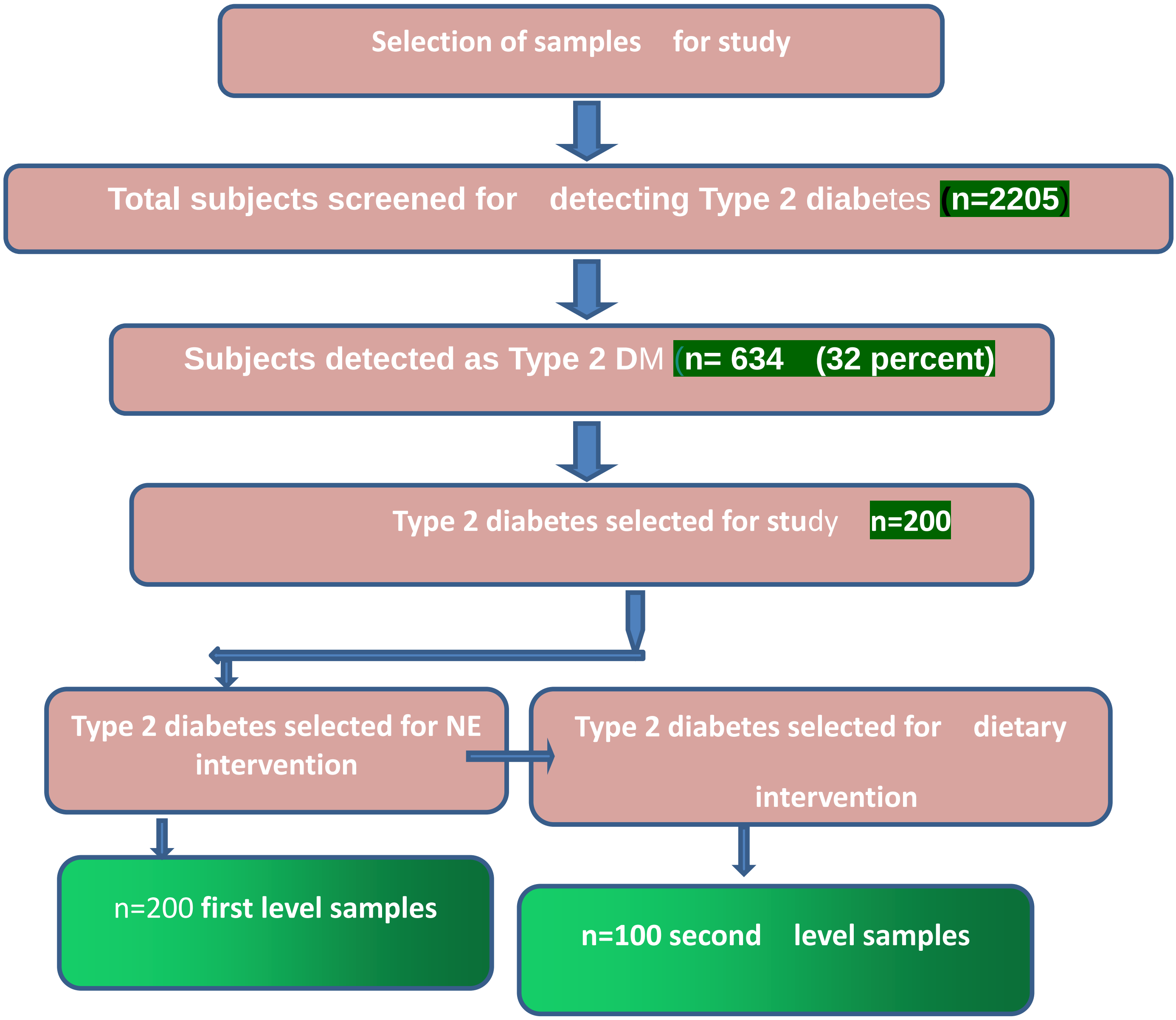
After an overnight fast, finger prick blood samples were investigated at 0 (before test meal), 15, 30, 45, 60, 90 and 120 min [Ren *et al* 2018]. The blood glucose levels at the specified time intervals were measured by glucometer, (Accu-Check meter, Roche, Switzerland).

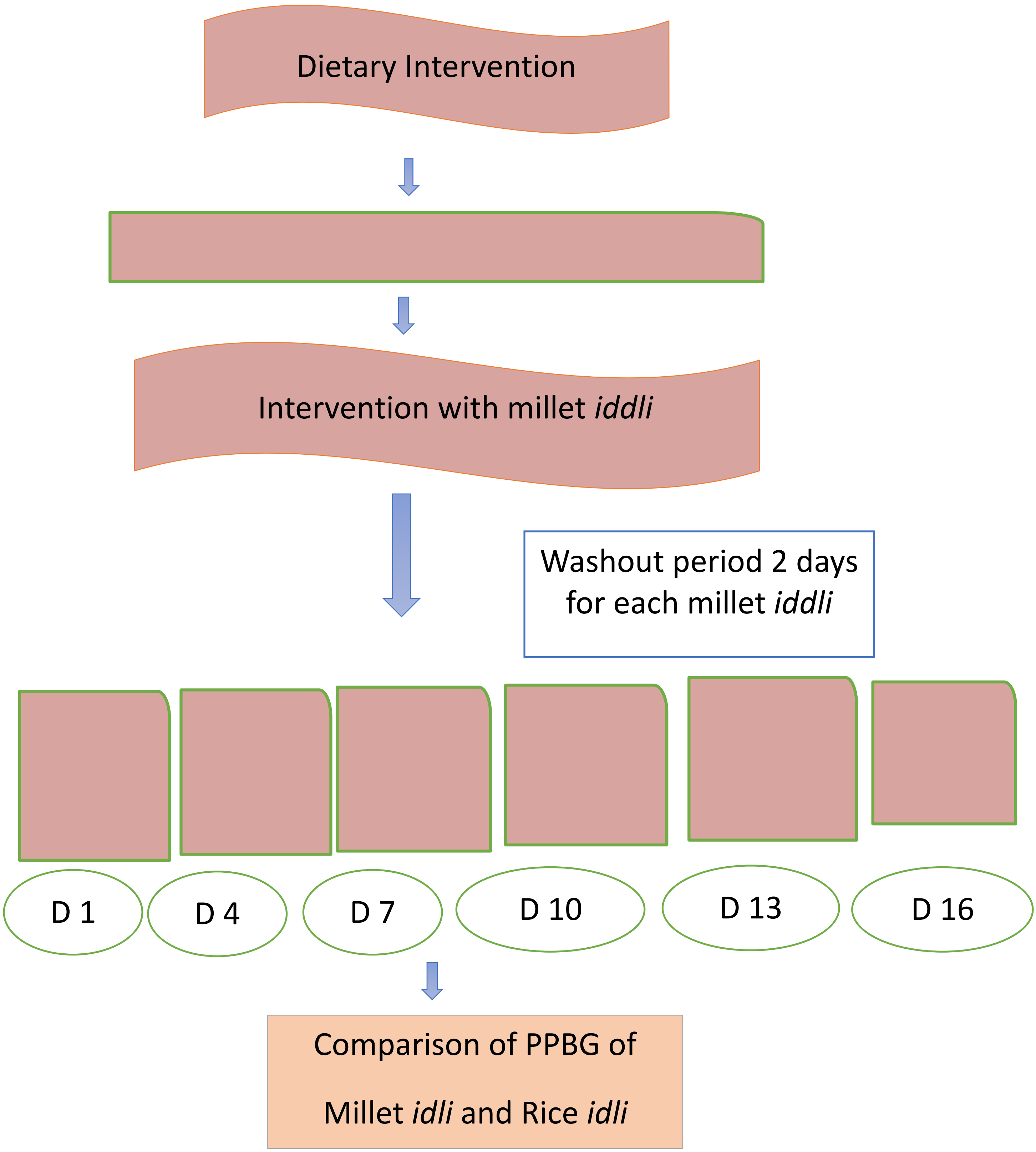
The blood glucose concentrations after the test meal and reference food were used to draw a blood glucose response curve for the two hours period.The values at 75 and 105 min were obtained by extrapolation[Ren X *et al.*, 2018]. The incremental area under the curve (AUC) for each meal and reference food was calculated for each volunteer separately to reflect the total rise in the glucose concentration after eating the test and reference food (Ren X *et al.*, 2018]. The AUC was calculated using the general formula [Ugare R *et al., 2014*]. GI (%) was calculated as follows (Botero *et al*., 2005)

$$GI = \frac{\text{Area under curve for 50 g CHO from test food}}{\text{Area under curve for 50 g CHO from white bread}} \times 100$$

Subjects Research design

The study was carried out at Ramakrishna Hospital,Coimbatore over a period of one year in 2018 and 2019 in the department of Diabetes and Endocrinology of the Hospital.Ethical clearance was obtained from the Institutional Ethics Committee. The study protocol was explained to the participants and those who were willing to participate were enrolled in the study and written informed consent was obtained from each participant. A total of 2205 participants visited were screened and 634 were deducted as T2D visiting to the Ramakrishna Hospital Diabetes screening camp, Coimbatore, India. From this 200 eligible diabetes were selected based on selection criteria an age group between 41 and 50 yr for study (first level sample) subjected to nutrition education (M127:F73) who were never on insulin therapy but were on the some oral hypoglycaemic agents (OHA), 100 sub samples were chosen from first level sample (second level sample) subjected to millet study




Dietary Intervention
Intervention with millet *iddli*
Washout period 2 days for each millet *iddli*
D 1
D 4
D 7
D 10
D 13
D 16
Comparison of PPBG of Millet *idli* and Rice *idli*

200 first level samples are subjected to NE .Anthropometric indices,glycemic status, clinical symptoms and dietary status were assessed before and after NE to know the effect of NE . Duration of NE was four months which includes rapport building,interview and collection of information,pre assessment, NE and post assessment. Information of the subjects were collected using an standardized questionnaire.

Each individual served as their own control and experimental group. And all 100 selected second level samples consumed millet and rice *idli*. After collecting the fasting blood samples, the subjects were then asked to consume three millet *idli* (test food) and 1 cup (260g) standardized tomato chutney contains 5 g of carbohydrate. The blood samples were again collected from the subjects after 2 hours to determine the postprandial plasma glucose levels. The similar testing were carrier out after wash out period of two days with other millet idlies (Koda , Barnyard , littlet, fox tail and pearl millet - (test food) for same groups of subjects and finally with rice idli.

Acceptability of the millet-based *idli* were analyzed using organoleptic rating scale (Rana *et al* 2012) with a score of 1-9. The . Since the rice-based idli is common recipe in everyday breakfast, the organoleptic score was not carried out to estimate the acceptability.

Statistical Analysis

Significant difference between the intake of millet idlis (*pearl, small, koda, foxtail and bayrnyard*) and rice *idli* in both FBG and PPBG conditions were calculated using SPSS software vs 25. Based on the normality assessment, one-way ANOVA was used to determine the changes in blood glucose levels. Two- tailed alfa was set at 0.05. Pearson correlation coefficient analysis used to know the correlation between the mean glucose difference and glycemic index of millet *idli*. The Figure represents the study design, the number of eligible participants and the number included for analysis

RESULTS AND DISCUSIONS

Glycaemic index

The mean GI of millet-based *idli* was 52.9 and that of rice-based *idli* was 77.96.The mean glycemic load of millet were 26.2 and rice *idli* was 38.

Table 2: Mean Glycemic index and Glycemic load of Test and Reference Food

S.NO	NAME OF THE MILLET	GI	SD	GL	SD
1	*Foxtail millet idli*	49.64	± 1.5	11.3	± 1.2
2	*Bayrn yard millet idli*	50	±2.4	12.5	± 1.4
3	*Little millet idli*	52	± 2.4	10.2	±1.7
4	*Pearl millet idli*	55	± 2.4	11.1	± 1.6
5	*Koda millet idli*	58	± 2.7	11.2	± 1.4
6	Rice *idli*	77.96	± 2.1	14.4	± 1.3

The study reveals who consumed millet *idli* **(*Foxtail, Koda, Barnyard, Pearl and Little*)** showed a significant reduction in their postprandial glucose levels comparing with consumption of rice *idli*. There is, no significant difference in the fasting blood glucose levels. The mean fasting blood glucose was similar in all patients, and the postprandial values were significantly (P<0.001) higher in the rice group

Table 3: Mean Fasting and postprandial blood glucose levels (mg/dl) in the selected diabetes with millets and rice *idli* n=100

S.No	Nameof the idli	Glycaemic index	MeanFBG (mg/dl)	Mean PPBG (mg/dl)	Difference in hike (mg/dl)
1	*Foxtail millet*	49±0.12	130±0.12	141±0.14	11±0.12
2	*Barnyard millet*	50±0.15	126±0.15	140±0.13	14±0.14
3	*Little millet*	52±0.14	126±0.12	146±0.17	20±1.45
4	*Pearl millet*	55±0.11	126±0.17	146±0.11	20±1.4
5	*Kodo millet*	58±0.12	126±0.14	153±0.18	27±0.16
6	Rice	77.9±0.14	126±0.12	186±0.14	60±0.13

Glycaemic Index (GI) of selected millet and Rice *idli* shows significant positive correlation between mean difference of glucose levels (FBG and PPBG) in type 2 diabetes, shows correlation coefficient is very high, significantly different from zero (P < 0.000).

Table 4: Pearson correlation coefficient of mean difference of glucose levels with glycemic index of millet *idli* of selected diabetes

Description	Mean Difference of Glucose levels	Mean value of Glycaemic Index
Mean ± SD	56.98 ± 10.78	25.33 ± 17.86
PearsonCorrelation (R)	0.948	
P Value	0.000, significant	

DISCUSSION

The GI of the *idli* prepared from millets were low. This may be due to the high levels of soluble dietary fiber in the millets. It has been reported that the high viscosity of the soluble fiber delays digestion and absorption. (Veena *et al.*, 2009). The glucose levels can be maintained to near normal with the help of dietary modification. It was observed in the present study that replacing rice idli with millet *idli* showed a significant reduction in the postprandial blood glucose levels. The results were in agreement with the previous study(Veena *et al.*, 2009). which showed a 29 per cent decrease in the serum glucose level after consumption of millet-based burfi. After supplementing only one meal with a lower GI food in the meal, namely breakfast in the present study,the participants showed a reduction in their glycemic profile. A similar result in the use of low-GI foxtail millet biscuits has been reported**(**Lawes *et al.*, 2004). Millet *idlies* can be added for better glycemic control in T2D.
There was a significant correlation between the amount of TDF per 50 g carbohydrate portion of food and GI according to Wolever (Salmeron *et al.*, 1997 and Frost *et al.*, 1999). Cellulose content of the food was the best predictor of the GI of the food 24.

Table 5: Fiber content of the standardized millet idlies/portion

Barnyard millet	13.3 g
Foxtail millet	7.5 g
Kodo millet	5.6 g
small millet	7.5 g
Pearl millet	4.5 g

Millets contain 2 to 14 g of crude fibre/100g and rice has only 0.4 g/100 g of crude fibre (IIMR 2020). Low-GI diets favorably influence postprandial metabolism, lowering insulin resistance and lipid and clotting parameters. Together these metabolic effects may explain the long-term benefits of low-GI diets on CVD observed in large cohort follow up studies (Anjana *et al.*, 2011)

In conclusion, our study indicated the potential benefits of millets in reducing post prandial blood glucose level for the patients with type 2 diabetes. However, there is a scope to explore the potential benefits of millets in the management of metabolic disorders through long-term feeding interventions. If used on a long-term basis, it could be beneficial in controlling lipid profile as well as the HbA1c levels in such patients.

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