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EFFICACY OF MILLETS(FOXTAIL, KODO, SMALL, BAYRNYARD AND PEARL MILLET) VARIETIES ON POSTPRANDIAL GLYCEMIC RESPONSE IN PATIENTS WITH TYPE 2 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 milletes with low glycemic index, hence can be used as a therapeutic diet. This study was conducted to estimate the effects of a millet *dosas* (Peral, Foxtail, Bayrnyard, Little and Koda millets) compared to a rice *dosa* for breakfast on postprandial glucose levels in patients with type 2 diabetes mellitus (T2DM). The GI of rice dosa and millet dosas *(*Peral, Foxtail, Bayrnyard, Little and Koda millet) were estimated. A total of 25 T2DM participants were randomly selected 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 was compared after a breakfast of millet dosas and rice dosa. 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 dosa 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 dosa (77.96). There was a significant reduction (p= 0.000) in the postprandial glucose level of patients who consumed a millet-based *dosas such* Fox tail 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 volunteers consuming millet dosas when compared to rice dosa. 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 T2DM 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 nutrition play an important role [Ley S.H., *et al.*, 2007]. In the past, numerous studies have enhanced our understanding of the relationship between whole grain and glucose metabolism [Xi P., Liu R.H. 2002]. Prospective studies consistently showed a reduced risk of T2DM with high intakes of whole grains [Cho S.S., Qi L., Fahey G.C. 2013]. Fung et al. 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 [Fung T.T *et al*., 2002].

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

C, *et al.*, 2012) Moreover, millet-based products have markedly slower gastric emptying than rice, (Cisse F *et al.*, 2018).

Previous research has suggested the anti-diabetic effect of finger millet [Kumari P.L *et al.*, 2018]. Millet-derived products such as 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 X *et al.*, 2002]. These characteristics above-mentioned might contribute to the improvement of postprandial blood glucose in diabetics.

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 neutracereal 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 and reputed to have a low GI, and 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 increasing the intake of millets and millet based products 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 dosa) with millets-based 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 dosa on the postprandial level of glucose in patients with type 2 diabetes mellitus (T2DM). The proximate principles of rice and millet dosa are given in Table I.

MATERIAL AND METHODS

Preparation of the rice- and millet-based dosa: For the preparation of the millet dosa, 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 dosa. 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 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 dosas.

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: Proximate principles of Millets & Rice Dosa (weight of the batter adjusted for proving 50 g carbohydrate).

Cereal grain	Batter qty (g)	No.of. dosa	Wt.of dosa (one portion)	Energy (Kcal)	CHO (g)	PROTEIN (g)	FAT (g)	FIBER (g)
Pearl millet dosa	273	3	90	356	50	13.6	4.9	12.0
Small millet dosa	238.50	3	79	309.6	50	11.3	3.2	7.7
Koda millet dosa	235.26	3	77	294.8	50	10.3	2.1	6.6
Foxtailmillet dosa	265.54	3	86	332.1	50	14.4	3.9	8.9
Bayrnyard millet dosa	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 dosa	196.23	3	65	260.9	50	7.9	0.56	3.9

1 serving = 3 number of dosas

Estimation of glycaemic 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 dosas(test food), which provided 50 g of carbohydrate and four slices of bread (reference food) calculated for

available carbohydrate.

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

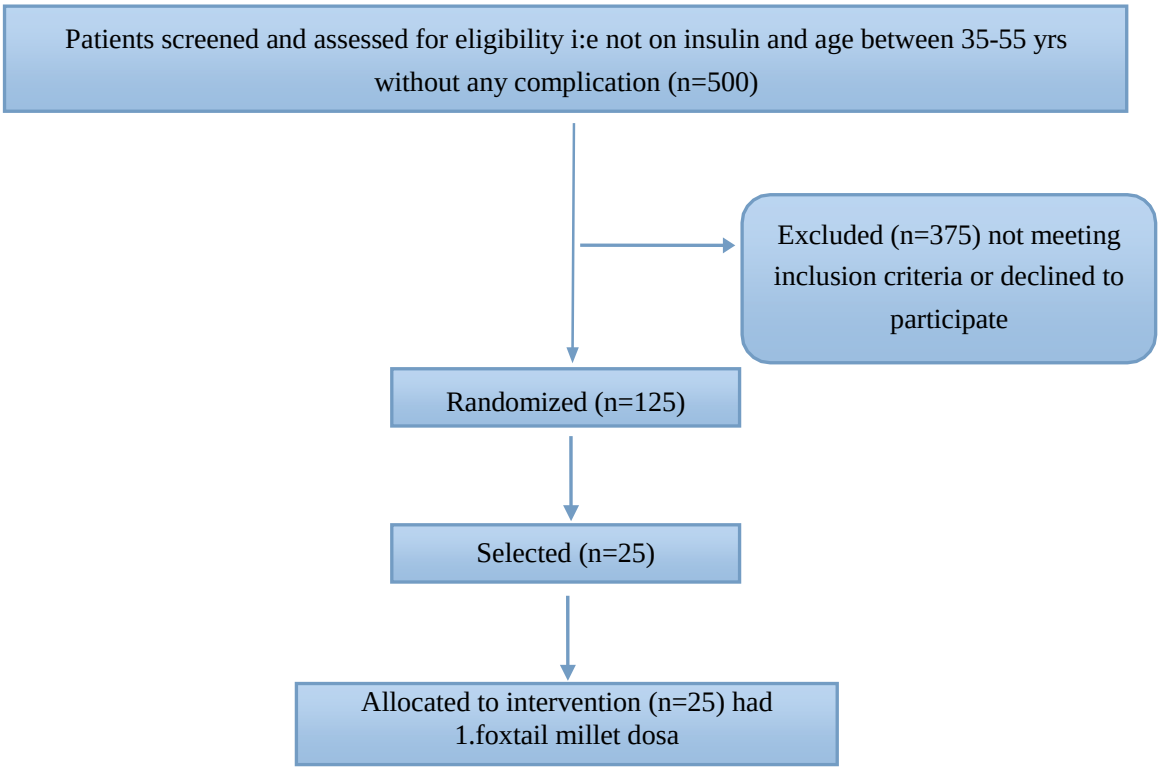
The blood glucose concentrations after the test meal and reference food were used to draw a blood glucose response curve for the two hours period.The values at 75 and 105 min were obtained by extrapolation[Ren X et al., 2018]. The incremental area under the curve (AUC) for each meal and reference food 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).

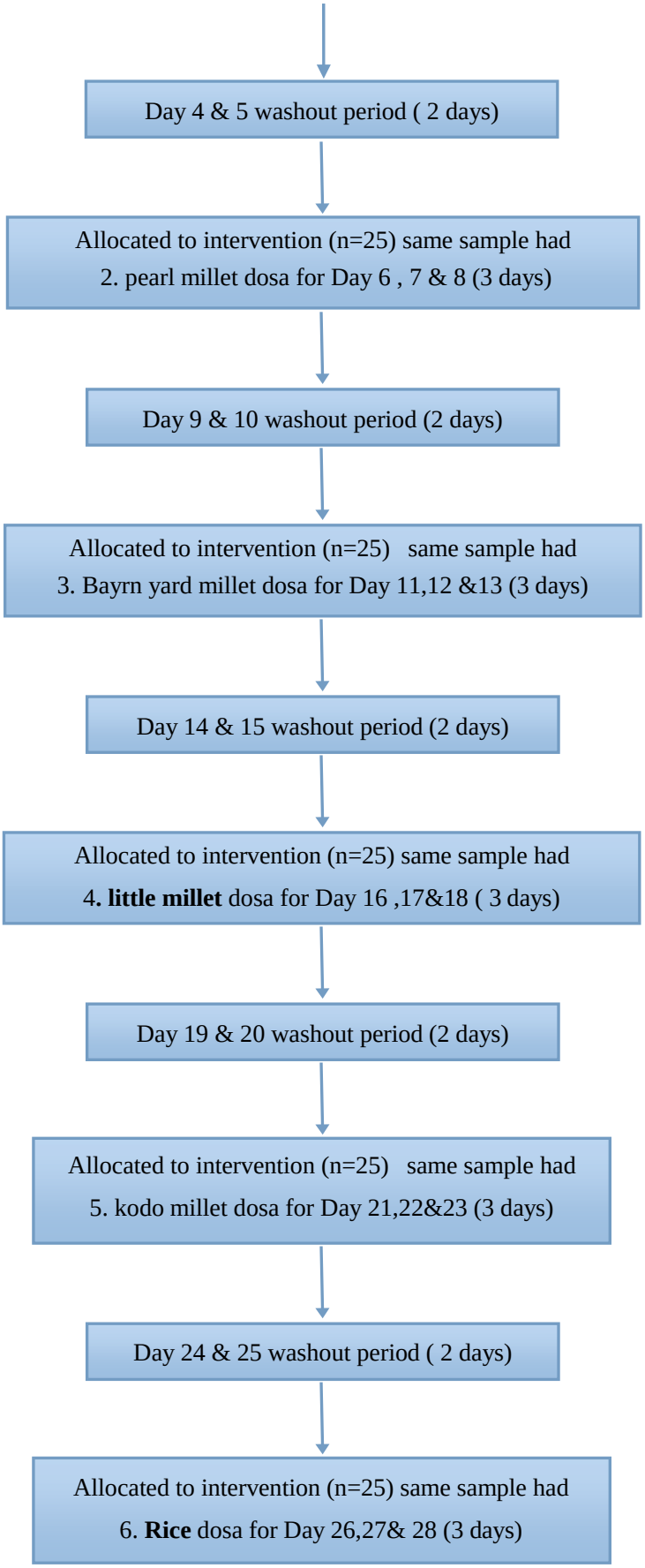
$$GI = \frac{\text{Area under curve for 50 g CHO from test food}}{\text{Area under curve for 50 g CHO from white bread}} \times 100$$

Research design

The study was carried out at Ramakrishna Hospital,Coimbatore and the participants were enrolled over a period of one year in 2013 and 2014 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 105 participants with T2DM (M69:F36) visiting to the Ramakrishna Hospital for Diabetes, Coimbatore, India, who were never on insulin therapy but were on the same oral hypoglycaemic agents (OHA) for one year and whose blood glucose levels were above normal, were randomly selected for the study of an age group between 35 and 55 yr. From 105 eligible participants 25 were randomly chosen based on selection criteria. Significant difference between the intake of millet dosas (pearl, small, koda, foxtail and bayrnyard millets) and rice dosa 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.

The Figure represents the study design, the number of eligible participants and the number included for analysis.




Day 4 & 5 washout period (2 days)
Allocated to intervention (n=25) same sample had
2. pearl millet dosa for Day 6 , 7 & 8 (3 days)
Day 9 & 10 washout period (2 days)
Allocated to intervention (n=25) same sample had
3. Bayrn yard millet dosa for Day 11,12 &13 (3 days)
Day 14 & 15 washout period (2 days)
Allocated to intervention (n=25) same sample had
4. little millet dosa for Day 16 ,17&18 (3 days)
Day 19 & 20 washout period (2 days)
Allocated to intervention (n=25) same sample had
5. kodo millet dosa for Day 21,22&23 (3 days)
Day 24 & 25 washout period (2 days)
Allocated to intervention (n=25) same sample had
6. Rice dosa for Day 26,27& 28 (3 days)

Body weight and height were measured before the study and BMI was calculated. Waist and hip circumference of the participants were also measured. Duration of diabetes and information on educational status of the participants were collected using an open ended questionnaire.

Each individual served as their own control and experimental group. And all 25 participants consumed millet and rice dosa. After collecting the fasting blood samples, the subjects were then asked to consume three millet dosa (test food) and 1 cup (100g) standardized tomato chutney contains 1.8g 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 dosas (Kodu millet, Barnyard Millet, little millet, fox tail millet and pearl millet - (test food) for same groups of subjects and finally with rice Dosa.

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

Statistical Analysis

Statistical analysis was performed for the collected data 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 dosas.

RESULTS AND DISCUSIONS

Glycaemic index

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

Table V: Glycemic Index And Glycemic Load Of Millets & Rice Dosa.

	Name Of The Millet Dosa	GI	GL
1	Little Millet	52	26
2	Bayrn Yard Millet	50	25
3	Foxtail Millet	49.64	24
4	Pearl Millet	55	27
5	Koda Millet	58	29
	Mean	52.928	26.2
	Sd	3.54	1.92
	Rice Dosa	77.96	38

The volunteers participated in this study who consumed millet-based dosa **(Foxtail, Koda, Barnyard, Pearl and Little)** showed a significant reduction in their postprandial glucose levels comparing with consumption of rice dosa. There is, no significant difference in the fasting blood glucose levels as shown in below table VI . 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 III).

Table VI: Mean Fasting and postprandial blood glucose levels (mg/dl) in the study participants with millets and rice dosa.

Blood Gluco se	Rice Dosa (n=25)	Foxtail Millet Dosa (n=25)	Barnyard Millet Dosa (n=25)	Little Millet Dosa (n=25)	Pearl Millet Dosa (n=25)	Koda Millet Dosa (n=25)
FBG	126.16±5.09	128.44±5.40	126.60±5.28	126.16±5.10	126.16±5.10	126.16±5.4
PPBG	186.44±2.56	139.88±5.04	140.30±2.88	145.41±3.06	145.9±3.05	153.16±2.34
FBG- Fasting Blood Glucose; PPBG- Postprandial Blood Glucose; Values are mean±SD						

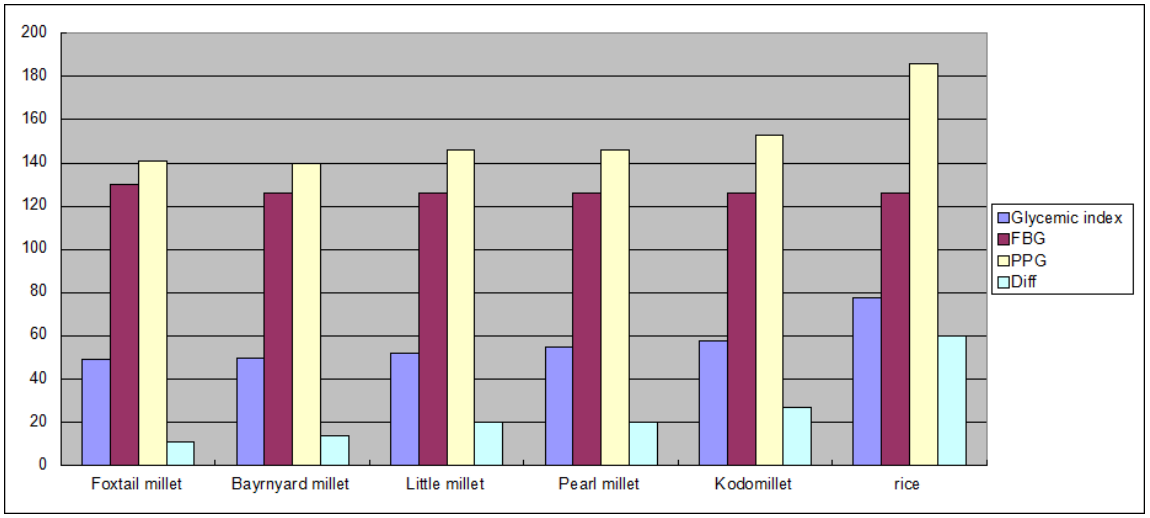


Fig 3: Post prandial blood glucose hike of different millets with Glycemic index.

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

Table VII: Pearson correlation coefficient of mean difference of glucose levels with glycaemic index of millet dosa of study population.

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 dosa 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 dosa with millet-based dosa 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 glycaemic profile. A similar result in the use of low-GI foxtail millet biscuits has been reported**(Lawes et al., 2004)**. foxtail millet based dosa to be added.

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 food24.

Table VIII: Fiber content of the millets.

Barnyard millet	9.5-14
Foxtail millet	4.5-7
Kodo millet	5-9
Little millet	4.0-8.0
Pearl millet	2-2.5

Millets contain 2 to 14 g of crude fibre/100g and rice has only 0.2 g/100 g of crude fibre (Lawes et al., 2004). 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 RM 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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