

On the following day, millet incorporated chappathis weighing 75 g (three numbers, 25 g each) providing 50 g of carbohydrate was given as breakfast to the diabetics. These diabetics were grouped in such a way that their mean fasting blood glucose level was almost the same. After consuming the test recipes, blood glucose levels were tested every half an hour for two hours. Similarly, on the next day also millet incorporated chappathis incorporated with 30 g of fenugreek leaves weighing 75 g (three numbers, 25 g each) providing 50 g of carbohydrate was given as breakfast to the diabetics and their blood glucose level was estimated as done previously.

Computation of glycemic index of the test recipe

Glycemic index is defined as the incremental area under the blood glucose curve of a 50 g carbohydrate portion of a test food expressed as a percentage of the response to 50 g carbohydrate of a reference food taken by the same subject, on a different day. Using white bread as the reference food, glycemic index of the test recipes were calculated using the formula,

$$\text{Glycemic Index} = \frac{\text{Area under the test food curve}}{\text{Area under the white bread curve}} \times 100$$

TABLE I
Blood Glucose Profile of the Diabetics

Blood glucose	Male (100)	Female (100)	Total (N=200)
Fasting (mg/dl)			
<120	2	3	5
120-150	85	90	175
>150	13	7	20
Postprandial (mg/dl)			
>200	3	5	8
200 – 250	81	82	163
>250	16	13	29
Glycosylated haemoglobin level (%)			
Normal (<5.6)	2	3	5
Good control (5.6-7)	35	3	67
Fair control (7-8)	43	52	95
Unsatisfactory control (8-10)	20	13	33
Poor control (>10)	Nil	Nil	Nil

Results and Discussion

The selected subjects belonged to the age group of 40-55 years and a majority of (76%) of male and female (68%) subjects were literate. Regarding the type of activity, 86 per cent of male diabetics and 91 per cent of female diabetics were engaged only in sedentary activity. Dietary pattern revealed that 63 per cent of male and 62 per cent of female diabetics preferred non-vegetarian food in their diet.

Biochemical analysis

Table I presents the blood glucose profile and glycosylated haemoglobin level of the diabetics.

Blood glucose profile of the diabetics revealed that majority of the diabetics (male 85% and female 90%) had fasting blood glucose level between 120 to 150 mg/dl. Thirteen and seven per cent of male and female diabetics did not maintain normal blood glucose level and they had fasting

blood glucose level greater than 150 mg/dl. Only a minimum of diabetics were health conscious and they maintained normal blood glucose levels. The same trend was also reflected in their postprandial blood glucose level.

Glycosylated haemoglobin level is an excellent index of long-term diabetes control, preceding over two to three months. A majority of diabetics (male 45%, female 52%) had fair control over diabetes while 20 per cent of male and 13 per cent of female diabetics had unsatisfactory control over diabetes. Only less than three per cent of the diabetics had normal glycosylated haemoglobin level.

In chappathi, minor millets thenai, bajra, varagu and white oats were incorporated at 20 per cent, 40 per cent and 60 per cent levels and the scores were given on a five point rating scale. Millet flour incorporated chappathi at 40 per cent level was most acceptable. Chappathi developed

TABLE II

Nutritive Value (Per 100g) of the Millet Incorporated and Standard Chappathi

Incorporation	Energy (kcal)		Protein (g)		Fat (g)		Carbohydrate (g)		Total dietary fibre (g)	
	with fenu-greek leaves	without fenu-greek leaves	with fenu-greek leaves	without fenu-greek leaves	with fenu-greek leaves	without fenu-greek leaves	with fenu-greek leaves	without fenu-greek leaves	with fenu-greek leaves	without fenu-greek leaves
Thenai (40%)	337	351	12.2	13.5	2.7	3.0	66	68	17.4	18.8
Bajra (40%)	349	363	11.9	13.2	3.0	3.3	69	70	12.0	13.4
Varagu (40%)	328	342	10.6	11.9	1.6	1.9	68	70	22.6	24.0
White oats (40%)	354	369	12.7	14.0	4.1	4.3	67	69	11.5	12.9
Standard (40%) (Whole wheat)	341	356	12.1	13.4	1.7	2.0	69	71	12.5	13.9

incorporating 60 per cent of millet flours was unacceptable because of the hardness, off flavor and after taste which was due to the high fibre content and lack of gluten in the millets. Chappathi developed incorporating at 20 per cent level was similar to the standard chappathi and hence not selected for the study.

Nutritive value of the millet incorporated chappathi

Table II presents the data regarding the nutritive value of the millet incorporated chappathi fed as breakfast to the subjects for the evaluation of glycemic index.

The total dietary fibre content of all the millet incorporated chappathi was high compared to the standard. Fenugreek leaves incorporated millet chappathi had total dietary fibre content higher than the millet flour incorporated chappathi. It was inferred from the data that the protein content of the white oats incorporated chappathi was fairly increased compared to the standard. There was not much difference in the other nutrients because millets belonged to the cereal category and have the nutrient contents almost similar to wheat.

Mean blood glucose responses of the millet incorporated chappathi

Table III presents the data regarding the mean blood glucose responses for the selected diabetics after consumption of standard and millet incorporated chappathi.

The fasting blood glucose levels of the type II diabetics selected for the evaluation of glycemic index ranged from 120 mg/dl to

160 mg/dl. The diabetics were grouped in such a way that their mean fasting blood glucose levels were almost similar. One hour after consumption of millet incorporated chappathi, bajra incorporated chappathi registered low blood glucose response (228.6 ± 66.4 mg/dl) followed by white oats incorporated chappathi (255.6 ± 61.0 mg/dl). Standard chappathi prepared out of whole wheat flour registered the highest blood glucose response with a peak value of 328.3 ± 11.2 mg/dl. At postprandial state, bajra incorporated chappathi registered low blood glucose response of 146.2 ± 47.0 mg/dl followed by white oats incorporated chappathi (173.4 ± 53.5 mg/dl). Standard chappathi prepared out of whole wheat flour registered highest blood glucose response of 199.7 ± 11.2 mg/dl. Hence, it was inferred that millet incorporated chappathi brought down the post prandial blood glucose levels as near as the fasting blood glucose levels than the standard chappathi. It was also inferred that chappathi prepared with fenugreek leaves registered low blood glucose response one hour after consumption (256.3 ± 53.6 mg/dl) and also at post prandial state (160.1 ± 38.8 mg/dl) compared to the chappathi prepared without fenugreek leaves (277.2 ± 59.9 mg/dl). This difference in the blood glucose responses was reflected in the glycemic index value also. Statistical analysis revealed that at postprandial state, there was a significant difference at 5 per cent level between group I, group II, group IV and group V. It was also evident that there was a significant difference at five per cent level between white bread, chappathi without fenugreek leaves and with fenugreek leaves.

TABLE III
Mean Blood Glucose Response of the Millet Incorporated Chappathi

Group	Fasting				1 Hour				2 Hours			
	White bread	Without fenugreek leaves	With fenugreek leaves	Mean ± S.D.	White bread	Without fenugreek leaves	With fenugreek leaves	Mean ± S.D.	White bread	Without fenugreek leaves	With fenugreek leaves	Mean ± S.D.
I Thenai (40%)	152.6 ± 44.0	146.2 ± 36.0	141.3 ±31.0	146.7 ^a ± 35.4	334.2 ± 38.0	309.8 ±30.8	269.7 ±34.1	304.6 ^a ±42.2	218.0 ± 65.3	193.0 ±51.8	159.0 ±34.4	190.0 ^a ±54.9
II Bajra (40%)	132.00 ± 26.2	125.3 ± 26.6	102.7 ± 36.3	120.0 ^b ± 36.3	250.2 ± 77.9	225.7 ±70.8	209.8 ±53.9	228.6 ^b ±66.4	165.5 ±52.2	145.7 ±48.3	129.3 ±41.7	146.2 ^b ±47.0
III Varagu (40%)	165.8 ±41.2	160.0 ± 39.2	155.8 ± 38.6	160.6 ^c ± 37.5	287.0 ± 60.4	268.0 ±59.5	248.8 ±45.8	267.9 ^c ±54.7	209.2 ±48.1	186.3 ±49.0	166.5 ±40.0	187.3 ^{cd} ±46.7
IV White Oats (40%)	133.3 ± 24.0	127.7 ± 21.4	128.0 ± 22.1	129.7 ^b ± 21.3	275.0 ± 76.5	253.5 ±53.5	238.2 ±55.9	255.6 ^c ±61.0	190.3 ±65.0	171.3 ±52.3	158.5 ±46.6	173.4 ^c ±53.5
V Standard (Whole wheat)	151.0 ± 2.9	147.0 ± 2.4	145.0 ± 2.4	147.7 ^a ± 3.5	341.0 ± 2.4	329.0 ±2.4	315.0 ±2.4	328.3 ^d ±11.2	213.0 ±2.4	199.0 ±2.4	187.0 ±2.4	199.7 ^d ±11.2
Mean± S.D.	146.9 ^a ± 31.8	141.2 ^a ± 29.4	134.6 ^b ± 35.9	140.9 ± 32.5	297.5 ^b ± 64.8	277.2 ^b ±59.9	256.3 ^b ±53.6	277.0 ±61.3	198.8 ^a ±52.4	179.1 ^b ±46.1	160.1 ^c ±38.8	179.3 ± 48.3

Any two means with same superscript are not significantly different

Figure 1 (a - e) shows the variation in the glycemic response of different millet incorporated recipes. With regard to the chappathi prepared without fenugreek leaves, the incorporation of millets namely thenai, bajra, varagu and white oat showed reduced post prandial blood glucose level of 193 mg/dl, 145 mg/dl, 186 mg/dl and 171 mg/dl respectively when compared to 199 mg/dl for standard and 213 mg/dl for white bread. With regard to chappathi prepared with fenugreek leaves, the incorporation of millets namely thenai, bajra, varagu and oats showed reduced post prandial blood glucose level of 159 mg/dl, 129 mg/dl, 166 mg/dl and 158 mg/dl respectively when compared to 187 mg/dl for standard and 213 mg/dl for white bread.

Glycemic Index of the millet incorporated chappathi

Table IV presents the data regarding the glycemic index of the millet incorporated recipes and the standard chappathi.

All the millet incorporated chappathi is registered low glycemic index compared to

the standard which may be due to the high fibre content of the millets. Millet incorporated chappathis prepared with fenugreek leaves registered low glycemic index than the millet incorporated chappathi without fenugreek leaves. This is due to the hypoglycemic effect of fenugreek leaves attributed to its nature of fibre and its viscosity which perhaps caused delayed gastric emptying, decreased intestinal transit time and delayed nutrient absorption⁶.

With regard to millet incorporated chappathi without fenugreek leaves, bajra registered a low glycemic index (90.5) when compared to the standard (94.4) followed by white oats (91.8), varagu (92.5) and thenai (93.3). With regard to millet incorporated chappathi prepared with fenugreek leaves, thenai registered a low glycemic index (81.9) when compared to the standard (89.8) followed by bajra (84.8), white oats (85.1) and varagu (85.9). Diets rich in whole grains have been associated with a reduction in the rise of coronary heart disease and type II diabetes due to its low glycemic index and greater particle size⁷.

TABLE IV

Glycemic Index of the Millet Incorporated and Standard Chappathi

Group	Glycemic Index	
	With fenugreek leaves	Without fenugreek leaves
I Thenai (40%)	93.3	81.9
II Bajra (40%)	90.5	84.8
III Varagu (40%)	92.5	85.9
IV White Oats (40%)	91.8	85.1
V Standard (whole wheat)	94.4	89.8

DEVELOPMENT AND EVALUATION OF MILLETS INCORPORATED CHAPPATHI ON GLYCEMIC RESPONSE IN TYPE II DIABETICS

Figure a (Thenai)

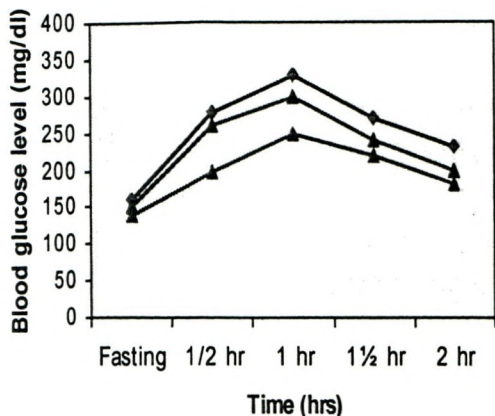


Figure b (Bajra)

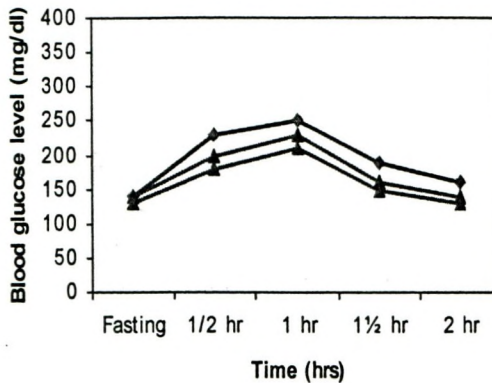


Figure c (Varagu)

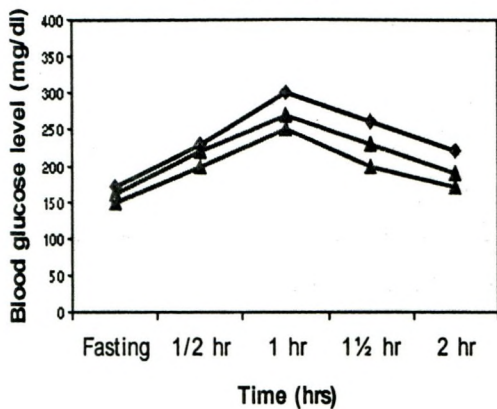


Figure d (White oats)

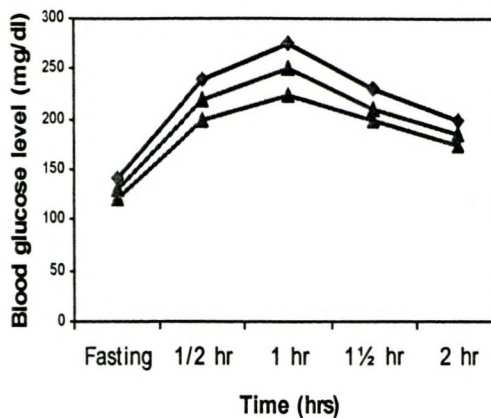


Figure e (Standard)

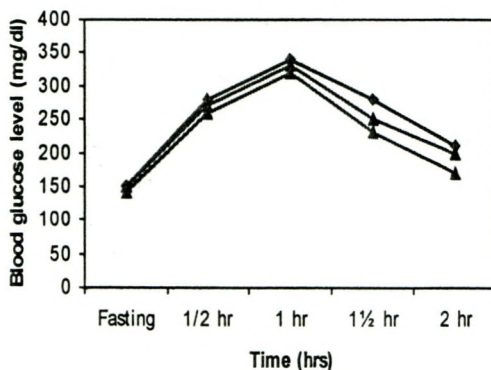


Figure-1 (a-e)
Mean blood glucose response of the millet incorporated and standard chappathi

Summary and Conclusion

Millet flours such as thenai, bajra, varagu and white oats were incorporated at different levels along with wheat flour and chappathis were prepared and standardized. Variations were made by incorporating 30 g of fenugreek leaves in 100 g of wheat flour and millet flours and chappathis were prepared. These chappathis were given to the selected type II diabetics to determine the glycemic index. Bajra incorporated chappathi registered low blood glucose response followed by white oats incorporated

chappathi, when compared to standard chappathi prepared out of wheat flour. When chappathi with fenugreek leaves was fed, blood glucose response was comparatively lower than for chappathi without fenugreek leaves. This difference was reflected in glycemic index values too. The findings showed that inclusion of millet and fenugreek leaves incorporated chappathis in the daily diet do not cause a rapid rise in blood glucose levels and would prove to be an effective and economically affordable dietary modification for the effective management of type II diabetes.

REFERENCE

1. Augustin, L.S, Franceschi, S., Jenkins, D.J.A., Kendall, C.W.C. and Vecchia, C. Glycemic index in chronic disease; A Review, *Euro. J. Pub. Health*, 2002, **90**, 1409-1415.
2. Liu, S., Manson, J.E. and Stamfer, M.J. A prospective study of whole grain intake and risk of type II diabetes mellitus in US women, *Amer. J. Pub. Health*, 2002, **90**, 1409-1415.
3. Salvin, J.L., Jacobs, Marquart and Wiemer. Epidemiologic and clinical studies on whole grains, *Nutr. Today*, 2001, **3**, 71-75.
4. Lankin, J. and Jenkins, D.J.A. Carbohydrate digestibility and metabolic effects. *J. Nutr.*, 2005, **137**, 2539s-2541s.
5. Prabhakaran, S. and Sandeep, S. Methods of establishing a surveillance system for cardiovascular disease in Indian Industrial population. *Bull. World Health Org.*, 2006, **84**, 217.
6. Wanle, Xuanshe, Jian, Jonghue and Ruijuan, Effect of *Trigonella foenum graecum* (fenugreek) extract on blood glucose, blood lipid and hemorheological properties in streptozotoin – induced diabetic rats. *Asia Paci. J. Clin. Nutr.*, 2007, **16**, 442-446.
7. Mickleown, N.M., Meigs, J.B., Liu, S. and Wilson, P. Whole grain intake is favorably associated with metabolic risk factor for type II diabetes and cardiovascular diseases in Framingham offspring study. *Am. J. Clin. Nutr.*, 2002, **6**, 390-398.