Glycaemic index of some commonly consumed foods in western India

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(1) Glycaemic index (GI) was determined in 36 non-insulin-dependent diabetes mellitus (NIDDM) patients.
(2) The subjects were fed 50g carbohydrate portions of six foods consumed widely in India including Varagu (*Plaspalum scorbiculatum*) alone and in combination with whole and dehusked greengram (*Phaseolus aureus Roxb*), Bajra (*Penniseteum typhoideum*), Jowar (*Sorghum vulgare*) and Ragi (*Eleusine coracana*).
(3) The GI of Varagu alone, Varagu in combination with whole greengram and Bajra was significantly lower than that of Ragi which produced a glycaemic response equivalent to that of the glucose load.

Introduction

Diet is considered to be the cornerstone in the management of diabetes mellitus and more so in the case of non-insulin-dependent diabetes mellitus (NIDDM) in which the primary derangement is of carbohydrate metabolism, with secondary abnormalities of lipid and protein metabolism. Dietary management of diabetes involves the reduction of postprandial hyperglycaemia and good glycaemic control. The concept of glycaemic index (GI) emerged as a physiological basis for ranking carbohydrate foods according to the blood glucose response they produce on ingestion, and was introduced by Jenkins et al. (1981)[1]. Few foods, traditionally consumed by the Indian population, have been tested for their glycaemic response. Dilawari et al. (1981)[2], Akhtar et al. (1987)[3] and Mani et al. (1990)[4] have studied the glycaemic response to cereals and a few legumes and dals (dals are dehusked and split legumes). The diet of the rural/tribal population of India is predominantly cereals and millets (coarse cereals) which provide 80% of the total energy. Further, information regarding the GI of millet-based foods is scanty. Hence, the present study was planned to determine the GI of six millet-legume/dal combinations that are important in the diet of rural areas of India.

Methods and materials

Thirty-six confirmed NIDDM patients over 40 years of age and on oral hypoglycaemic drugs were selected for testing the glycaemic responses of the recipes. The clinical data of the subjects is given in Table 1. On the first visit, the patients were subjected to an oral glucose tolerance test using 50g glucose load. Blood glucose was determined by the O-toluidine method of Hultman (1959)[5] in fasting and postprandial 1 hour and 2 hour venous blood samples. Serum triglycerides were determined in fasting and 2-hour postprandial blood samples by the method of Foster & Dunn (1973)[6]. On a subsequent visit (within 2 weeks), the patients were given a test food containing 50g (available) carbohydrate which was consumed over an 8–10 minute interval. The composition of the foods as determined by the food tables compiled by Gopalan et al. (1979)[7] is given in Table 2. Blood glucose response and triglyceride were again monitored for the different groups fed different foods. Blood glucose response curves for the glucose load and the test food were plotted and GI was calculated using the method described by Jenkins et al. (1981)[8] in which the ratio of the areas under the glucose response curve for the food was compared with that of the GTT. The TG response was calculated by finding the per cent increase in mean TG value over mean fasting value for each group.

The six recipes tested were Varagu (*Paspalum scorbiculatum*) (R_1), Varagu in combination with greengram dal (*Phaseolus aureus Roxb*) (R_2), Varagu in combination with whole greengram (R_3), Bajra (*Penniseteum typhoideum*) (R_4), Jowar (*Sorghum vulgare*) (R_5) and

Table 1. Clinical data of the diabetic patients.

Description	Male	Female
Number of patients	18	18
Mean age ± SD (years)	63±12	50±7
Mean % ideal body weight	108±13	127±25
Mean duration of the disease ± SD (years)	7±6	4±3

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Table 2. Composition of foods.

	Botanical name	Raw weight (g)	Energy (Kcal)	Carbo-hydrate g)	Protein (g)	Fat (g)	Crude fibre (g)
R_1-Varagu	*Paspalum scorbiculatum*	76	235	50	6.3	1.06	6.84
R_2-Varagu + Greengram dal	*Paspalum scorbiculatum* *Phaseolus aureus Roxb*	53 +27	163 +90	35 +15	4.4 +6.5	0.74 +0.35	4.77 +1.10
		80	253	50	10.9	1.09	5.87
R_3-Varagu + Whole greengram	*Paspalum scorbiculatum* +*Phaseoilus aureus Roxb*	53 +25	163 +87	35 +15	4.4 +6.1	0.74 +0.30	4.77 +0.20
		78	250	50	10.5	1.04	4.97
R_4-Bajra	*Penniseteum typhoideum*	75	271	50	8.7	3.75	0.9
R_5-Jower	*Sorghum vulgare*	70	244	50	7.3	1.33	1.12
B_6-Ragi	*Eleusine coracana*	70	229	50	5.1	0.91	2.52

Ragi (*Eleusine coracana*) (R_6). Recipes R_1, R_2 and R_3 were pressure cooked at 15lb pressure for 12–15 minutes using 400ml water. The whole greengram in R_3 was presoaked for 12 hours and then cooked with Varagu. Recipes R_4, R_5 and R_6 were given as roasted bread, made from Bajra, Jowar and Ragi flours respectively. Salt and spices were added to all recipes to enhance palatability. No oil was added in any of the recipes.

The glycaemic response at various time points after each test food and after the glucose load, was statistically compared using a paired t-test. Anova was used to compare glycaemic index values among the test foods.

Results

The GI values obtained for the foods are given in Table 3. The GI of R_1-Varagu (*Paspalum scorbiculatum*), R_3-Varagu in combination with whole greengram (*Phaseolus aureus Roxb*) and R_4-Bajra (*Penniseteum typhoideum*) were found to be significantly lower than that of R_6-Ragi (*Eleusine coracana*) which elicited a glycaemic response equivalent to that of the glucose load. Table 4 represents the mean value±SEM of blood glucose responses to a 50g glucose load as well as the various test foods. No significant difference was observed in the blood glucose response after each of the foods at the 1 hour and 2 hour postprandial levels when compared with the corresponding blood glucose response to the 50g glucose load for the same group.

Table 3. Glycaemic indices of the recipes.

No.	Recipe	Glycaemic index (%) (Mean±SE)
R_1 (n=6)	Varagu (*Paspalum scorbiculatum*)	68±8
R_2 (n=6)	Varagu + Greengram dal (*Paspalum scorbiculatum + Phaseolus aureus Roxb*)	78±12
R_3 (n=6)	Varagu + Whole greengram	57±6
R_4 (n=6)	Bajra (*Penniseteum typhoideum*)	55±13
R_5 (n=6)	Jowar (*Sorghum vulgare*)	77±8
R_6 (n=6)	Ragi (*Eleusine coracana*)	104±13

(Note: significant difference at $p<0.05$ between the glycaemic indices for the six different recipes by one-way ANOVA.)

However, when a comparison was done of the means of the glycaemic indices of the various recipes it was seen that there was a significant difference between the glycaemic indices for the six different recipes.

Discussion

Crapo et al. (1977)[9] have shown repeatedly that there are varied metabolic responses to different starches. These differences in postprandial physiological outcome are attributed to various factors such as dietary fibre content of food, food-processing methods (such as polishing of grains, grinding, extrusion under pressure and cooking by different methods like baking, roasting, steaming, etc.), other food components such as anti-nutrients (phytates, tannins, lectins, etc.) that retard the amylase activity and the chemical nature of starchy polysaccharides, eg amylose or amylopectin, all of which might affect the rate of digestion. Understanding the role of these factors can be of help in identifying foods for their suitability for inclusion in a diabetic diet. Very little information is available regarding the GI of millets and the study determined the GI of some millet-based foods that are widely consumed in western India.

Dietary fibre exerts a hypoglycaemic effect in patients with diabetes mellitus. By virtue of its viscous nature, *soluble* dietary fibre can retard the rate of digestion of starchy polysaccharides and can also lower the rate of absorption of the mono- and disaccharides. A study by Jenkins et al. (1978)[8] showed that the dietary fibre galactomannans in legumes and dals (dehusked and split legumes) are more viscous than the fibre content of cereals and millets. Legumes have a higher fibre content than dals (dehusked legumes) and this may explain the lower GI of R_3-Varagu (*Paspalum scorbiculatum*) in combination with whole greengram (*Phaseolus aureus Roxb*) as compared to the GI of R_2-Varagu in combination with greengram dal. However, R_4-Bajra (*Penniseteum typhoideum*) as the lowest GI of the test foods in spite of its lowest fibre content suggesting the presence of some other factor influencing GI. A study by Mani et al. (1985)[10] on the effect of supplemention with wheat bran and blood glucose response to different breads were shown to have found little effect in decreasing hyperlipidaemia in diabetic rats and humans.

The phytin phosphorous content of the test millets is high and its presence may affect digestion. Other anti-

Table 4. Mean (±SE) blood glucose response (mg/dal).

CHO source	Fasting response	Postprandial 1 hour	Response 2 hour
Glucose (n=6)	163±29	296±45	284±47
R_1-Varagu (n=6)	184±28[b]	261±42	251±40
Glucose (n=6)	120±12[a]	244±37	229±20
R_2-Varagu + Greengram dal (n=6)	116±12[b]	227±33	239±38
Glucose (n=6)	186±21[a]	224±26	243±28
R_3-Varagu + Greengram whole (n=6)	176±34[b]	296±36	327±39
Glucose (n=6)	176±30[a]	320±40	313±41
R_4-Bajra (n=6)	189±40[b]	225±39	240±41
Glucose (n=5)	182±74[a]	275±43	256±34
R_5-Jowar (n=5)	196±31[b]	240±40	275±36
Glucose (n=5)	193±34[a]	214±37	227±41
R_6-Ragi (n=5)	180±22[b]	257±25	251±34

(Note: non significant on comparing a with b at $p<0.05$.)

nutrients such as lectins, saponins and tannins, may also influence the glycaemic response.

R_6-Ragi (*Eleusine coracana*) interestingly elicits a glycaemic response equivalent to that of the glucose load. The ground ragi flour used in the recipe may be the reason for this since studies by Mani et al. (1992)[11,12], Cannon & Nuttall (1987)[13], and Wong & O'Dea (1983)[14] have shown that decreasing the particle size of a food produces a higher glycaemic response.

Since studies by Cerami et al. (1987)[15] and Reaven (1987)[16] have shown that diabetes mellitus brings about alterations in lipid metabolism, the TG responses to the food were also determined. R_4-Bajra (*Penniseteum typhoideum*) elicited the highest mean per cent increase in TG over the fasting value and this may be related to its higher fat content: R_4 – 40%, R_1 & R_3 – 31%, R^2 – 34% and R_5 & R_6 – 27%. Further, the TG responses do not correlate with the glycaemic responses.

Conclusion

This study shows that traditional meals consumed in rural areas of India vary in their glycaemic impact. Some, such as 'Ragi', are a glycaemic index similar to an equivalent load of glucose. Others, such as 'Bajra' with a low GI, may play a useful role in the management of hyperglycaemia in diabetes.

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西印度某些常用食物的血糖指數（GI）

摘 要

1、作者測定了36名非胰島素依賴性糖尿病人（NIDDM)的血糖指數(GI)。

2、他們給病人進食一份50克的碳水化合物。這些碳水化合物是來源于印度6種常用食物，包括Varagu (Paspalm scorbiculatum), Varagu+去殼的Greengram (phaseolus aurens roxb) Varagu+全Greengram, Bajra (Penniseteum typhoideum)，Jowar(Sorghum vulgare) 和 Ragi-(Eleusine coracana)。

3、Varagu, varagu+全Greengram和 Bajra的血糖指數（GI）明顯低于Ragi. Ragi 產生的血糖反應與葡萄糖負荷試驗是相同的。