

# GLYCEMIC AND LIPEMIC RESPONSE OF COMPOSITE FOODS IN NORMAL AND NIDDM SUBJECTS

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## ABSTRACT

Six composite foods which are commonly consumed in Karnataka, viz., jowari roti + whole green gram bhaji, rice + red gram + dhal curry, chapatti + cabbage bhaji, ragi balls + red gram + amaranthus curry, navani rice + curds + milk, and bajra roti + brinjal bhaji were tested for glycemic and lipemic responses in both normal and NIDDM subjects. Blood glucose response after oral glucose tolerance test and the test meals were used to compute glycemic indices (GI). The results revealed a low glycemic index (55-65%) for all the six test meals. The GI of the millet based meal was the lowest, while the rice based meal recorded higher value in both the subjects, being higher in diabetic (60-65%) compared to normals (55-62%). The correlation between protein, fat and fibre content and GI of the test meals were found to be negative in both normals and diabetics. Besides, millet based test meals elicited the lowest triglyceride response and the rice based test meal higher, whereas the rest of the diets had intermediate responses.

**KEYWORDS : GLYCEMIC INDEX : MILLET BASED MEALS.**

## INTRODUCTION :

Diabetes mellitus is a chronic metabolic disorder, which is recognised by a chronic elevation of glucose in blood (hyperglycemia) with or without hyperlipidemia, the condition mainly resulting from an absolute or relative deficiency of insulin, a hormone that controls glucose, fat and amino acid metabolism (1, 2). Hence it is characterized by the primary derangement of carbohydrate metabolism with secondary abnormalities of lipid and protein metabolism (3). It is in fact a syndrome and not a single disease, giving rise to various complications.

The principles of management of diabetes mellitus are dietary modifications, maintaining normal

body weight, adequate physical activity, use of oral hypoglycemic agents and administration of insulin, if necessary (4). Since the normal metabolism and utilisation of food is impaired, diet forms the sheet anchor of treatment of diabetes. The primary objective of treatment i.e. a good control of blood glucose and lipid levels, are supplementation of high complex carbohydrate meals with low fat and high dietary fibre (2,5,6). It is also stressed that more than the quantity of carbohydrates (60-65% of calories of a diabetic diet should be carbohydrate), it is the type of carbohydrate that is eaten, which has a direct bearing on the blood sugar level (7).

Hence, the present study was undertaken to determine the glycemic index of six composite foods which are commonly consumed (cereal/millet based staple diets of Karnataka) in both normal and diabetic subjects (type 2 diabetes mellitus). Since defects in lipid metabolism are particularly prevalent in type 2 diabetes, the lipemic responses of the test meals and serum cholesterol level were also considered.

## MATERIAL AND METHODS :

Eighteen type 2 diabetes, adult subjects (16 males, 2 females) who had registered under the medical officers and 18 healthy adults, non diabetics (male 8, female 10) of Dharwad city and Haliyal town were selected for the study.

The detailed experimental plan of the study is depicted in the flow chart (Table 1). On the first visit an oral glucose tolerance test (GTT) was done with 50 g glucose load for the selected subjects. Venous blood samples were withdrawn at zero minutes i.e. fasting (FBS) and post glucose at 60 minutes (PG<sub>1</sub>BS) and 120 minutes (PG<sub>2</sub>BS). Serum triglyceride was estimated for fasting (FTG) and two hours post prandial (PP<sub>2</sub>TG) samples, serum cholesterol was estimated for fasting samples.

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### Table: 1 Experimental plan

Selection and enrollment of subjects

Visit I

(GTT with 50g GLUCOSE to all the selected subjects)

Visit II

(GTT with 50g test carbohydrate food to each group with three type 2 diabetes patients and three normal subjects)

#### Test Foods:

Group I - Jowar (*Sorghum Vulgare*) roti and greengram (*Phaseolus aureus* bhaji (R<sub>1</sub>))

Group II - Rice (*Oryza sativa*) and redgram dhal (*Cajanus cajan*) curry (R<sub>2</sub>)

Group III - Chapati (*Triticum aestivum*) and cabbage (*Brassica oleracea*) bhaji (R<sub>3</sub>)

Group IV - Ragi (*Eleusine coracana*) balls and redgram dhal + amaranthus (*Amaranthus gangeticus*) curry (R<sub>4</sub>)

Group V - Navani (*Setaria italica*) rice and curds with milk (R<sub>5</sub>)

Group VI - Bajra (*Pennisetum typhoides*) roti and brinjal (*Solanum melongena*) bhaji (R<sub>6</sub>)

The selected diabetic subjects were then randomly divided into six groups consisting of three type 2 diabetics and three normal subjects. After one week interval, on the second visit, subjects from groups I, II, III, IV, V and VI were fed equicarbohydrate test meals viz. R<sub>1</sub> to R<sub>6</sub>, respectively.

The patients were instructed to consume the test meal over 8-10 minutes interval. Venous blood samples were withdrawn in a similar manner as for glucose load.

#### Analysis of blood samples :

The blood glucose, serum triglyceride and cholesterol were analysed by using SPAN diagnostic kits.

#### Standardization of meals :

All the recipes were standardized at laboratory level with respect to equi-carbohydrate (50 g) proportions, amount of water added in cooking, cooking time, addition of other ingredients, like spices such as chillies, salt and oil, to enhance palatability.

#### Determination of glycemic Index (GI) :

Glycemic Index is defined as the area under the blood glucose response curve for a food, expressed as a percentage of the area, after taking the same amount of carbohydrate in the form of glucose. Fifty gram portions of carbohydrate were used to calculate GI.

$$GI = \frac{\text{Area under blood glucose response Curve for 50g test carbohydrate food}}{\text{Area under blood glucose response Curve for 50g glucose}} \times 100$$

### RESULTS AND DISCUSSION :

The confirmed type 2 diabetes, adult patients were on oral hypoglycemic drugs and sugar restricted diet. The diet pattern and physical activity of the subjects were more or less similar. The clinical information about the subjects is given in table 2.

**Table 2**  
**Clinical details of subjects selected for the experiment**  
**(Mean values with their standard deviations)**

	Normal (N=18)		Diabetic (N=18)	
	Males(N=8)	Females(N=10)	Males(N=16)	Females(N=2)
Age (years)	50.3 ± 6.6	56.1 ± 10.7	57.1 ± 10.0	52.5 ± 10.6
Weight (kgs)	35.0 ± 4.5	55.9 ± 6.8	64.1 ± 6.8	66.5 ± 9.2
Duration Of the Disease (years)	-	-	5.5 ± 3.7	5.0 ± 1.4

The blood glucose response curves for the meals in both non-diabetics and diabetics as compared to that for the reference meal (glucose) in the same subjects are shown in fig 1 (a-f) and Table 3.

A steady rise in blood glucose level was seen after the ingestion of all reference test meals, the peak being reached at 60 minutes. In general, the peak values for all the test meals were lower than the reference meal in both the groups, but the blood glucose levels in diabetics being always higher at any point of time.

The glycemic index of the six test meals in non-diabetics and diabetics are shown in table 4. The mean GI values of test meals was 59.02% in non diabetics and 63.01% in diabetic subjects, with reference to glucose being 100%. The mean GI of diets ranged from 55-65% in the test meals, the same being 55-65% in non diabetics and 60-65% in diabetics.

**Table 3**  
**Mean ( ±SD) Blood Glucose responses (mg/dl)**

Carbohydrate Source	Normal Subjects (N=3/test meal)			Diabetic subjects (N=3/test meal)		
	Fasting response	1 hour	2 hour	Fasting response	1 hour	2 hour
Glucose	88.03 ± 9.02	117.82 ± 8.16	99.3 ± 6.80	121.38 ± 15.98	246.37 ± 13.64	186.04 ± 41.33
Test meal R1 (jowar based)	88.03 ± 9.02	106.95 ± 8.09	92.36 ± 8.03	139.49 ± 3.92	217.16 ± 19.21	178.79 ± 24.16
Glucose	89.33 ± 2.39	120.09 ± 3.3	96.93 ± 2.66	105.57 ± 2.79	205.21 ± 13.67	174.98 ± 13.54
Test meal R2 (Rice based)	89.33 ± 2.39	109.29 ± 3.18	93.17 ± 4.37	101.94 ± 5.81	164.89 ± 12.39	137.50 ± 21.5
Glucose	87.63 ± 9.79	124.00 ± 10.43	106.18 ± 14.54	120.92 ± 31.41	231.07 ± 4.27	166.68 ± 10.09
Test meal R3 (Wheat based)	87.63 ± 9.79	108.94 ± 3.7	97.59 ± 9.67	91.79 ± 17.24	158.22 ± 6.33	125.3 ± 16.86
Glucose	88.74 ± 6.92	122.17 ± 3.44	101.96 ± 9.02	109.56 ± 11.38	277.61 ± 38.09	214.37 ± 52.93
Test meal R4 (Ragi based)	88.74 ± 6.92	108.32 ± 3.87	97.93 ± 0.86	118.58 ± 16.38	227.45 ± 22.99	174.14 ± 16.66
Glucose	96.05 ± 5.18	123.10 ± 9.57	110.0 ± 2.31	140.75 ± 22.89	266.42 ± 48.63	209.36 ± 43.5
Test meal R5 (Navani based)	96.05 ± 5.18	112.14 ± 6.6	103.6 ± 3.20	156.07 ± 22.35	237.09 ± 49.07	186.91 ± 36.72
Glucose	93.76 ± 4.04	119.12 ± 7.33	106.1 ± 4.04	108.31 ± 4.88	274.3 ± 49.77	167.17 ± 17.05
Test meal R6 (Bajra based)	93.76 ± 4.04	109.0 ± 5.05	98.45 ± 1.54	111.48 ± 4.93	204.41 ± 15.54	158.7 ± 10.95

**Table 4**  
**Glycemic Index of the test meals in diabetic and normal subjects (Mean ± SD)**

Code	Test meal	Normal subjects	Diabetic subjects
R1	Jowar roti + whole green gram bhaji	58.83 ± 6.11	62.26 ± 3.75
R2	Rice + red gram dhal Curry	62.61 ± 1.91	65.83 ± 9.57
R3	Chapathi + cabbage Bhaji	61.1 ± 6.38	64.08 ± 5.21
R4	Ragi balls + red gram dhāl with amaranthus curry	60.73 ± 5.26	64.46 ± 4.54
R5	Navani rice + curds with milk	55.01 ± 10.74	61.83 ± 6.28
R6	Bajra roti + brinjal bhaji	55.84 ± 7.51	60.11 ± 3.2

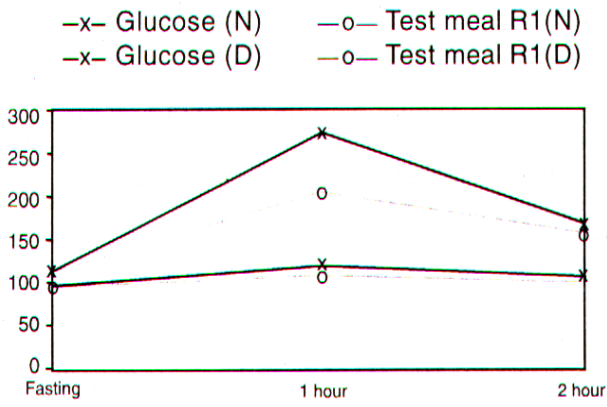
It is evident that the GI of rice with red gram dhal curry test meal (R<sub>2</sub>) was highest in both non diabetics and diabetics. The test meal R<sub>6</sub> (bajra roti with brinjal bhaji) showed lowest GI followed by navani based meal (R<sub>5</sub>), Jowar based meal (R<sub>1</sub>), Wheat based meal (R<sub>3</sub>), ragi based meal

(R<sub>4</sub>) and rice based meal (R<sub>2</sub>). At a glance, it is apparent that low GI was found for millets based meals in both diabetics and non diabetics.

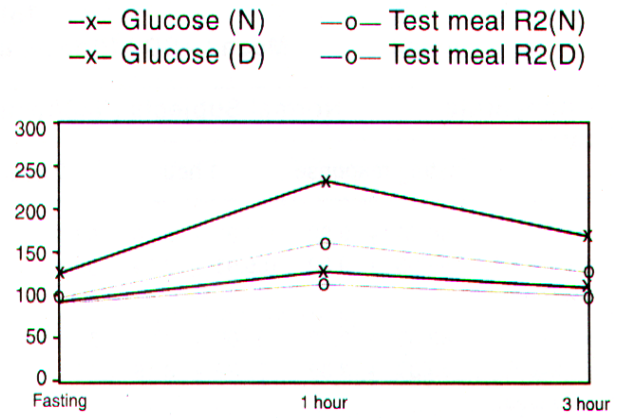
#### **The interrelationship between selected nutrients to GI of test meals:**

Test meals based on millets R<sub>6</sub> and R<sub>5</sub> had high protein content followed by R<sub>1</sub>, R<sub>4</sub>, R<sub>3</sub> and R<sub>2</sub>. Lower GI values for R<sub>5</sub> and R<sub>6</sub> may be partly explained by the protein-starch interaction effect on glycemic response. Test meals R<sub>6</sub> and R<sub>5</sub> had higher protein content and lower GI as against test meal R<sub>2</sub> which had lower protein content comparatively and higher GI. However, it was observed that the relation between protein content and GI of test meals was negative. Although the test meal had a higher fat content, it registered a lower GI.

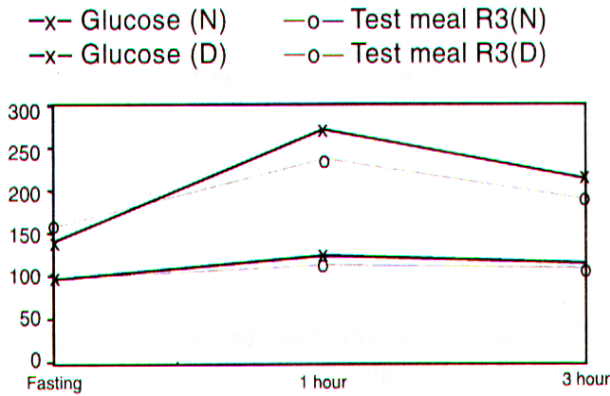
Dietary fibre is known to exert an inhibitory effect on the starch digestibility. Though an insignificant relationship was seen between GI and dietary fibre, there was a negative 'r' value -0.2378 in non diabetics and -0.1383 in diabetics, indicating that as fibre content of test meals increased, the GI values in both decreased.



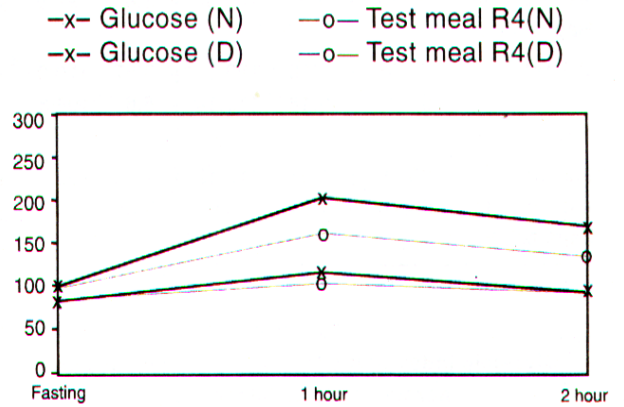
a. Test meal R1-Jowar roti + Whole green gram bhaji



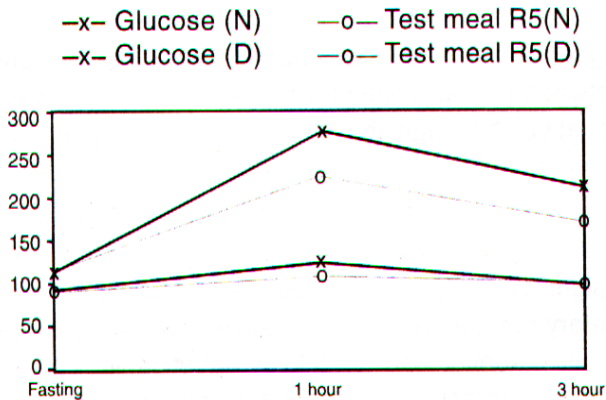
b. Test meal R2-Rice + redgram dhal curry



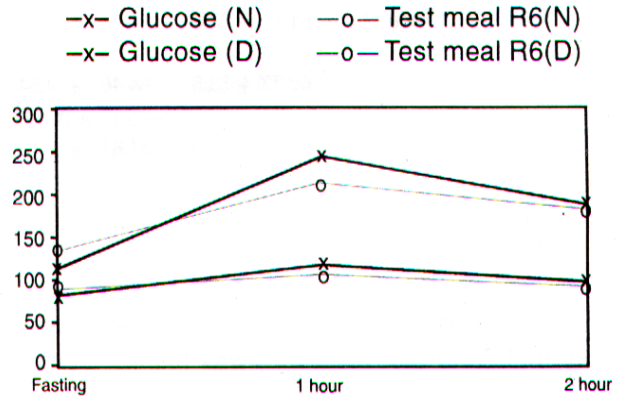
c. Test meal R3-Cabbage bhaji



d. Test meal R4 - Raji balls + redgram dhal with amaranthus curry



e. Test meal R5-Navani rice + curds with milk



f. Test meal R6-Bajra roti + brinjar bhaji

**Fig. 1 Blood glucose response in normal (N) and diabetic (D) subjects to test meals as compared to glucose.**

**Table 5**  
**Mean ( ±SD) Tryglyceride responses (mg/dl) and per increase over fasting**

Sl. No.	Carbohydrate Source	Normal Subjects			Diabetic subjects		
		Fasting response	2 hour Post prandial	percentage change	Fasting response	2 hour post prandial	percentage change
1.	Glucose	87.21 ± 26.36	97.11 ± 22.58		122.97 ± 48.04	114.69 ± 25.17	
	Test meal R1	87.21 ± 26.36	122.88 ± 30.17	40.9	114.69 ± 25.17	162.2 ± 30.23	41.43
2.	Glucose	80.62 ± 27.03	111.88 ± 30.36		171.23 ± 71.4	244.51 ± 108.95	
	Test meal R2	80.62 ± 27.03	128.87 ± 12.11	59.85	149.64 ± 65.88	236.13 ± 108.26	57.79
3.	Glucose	87.51 ± 18.56	109.10 ± 19.65		151.51 ± 21.8	222.47 ± 39.8	
	Test meal R3	87.51 ± 18.56	118.24 ± 32.57	35.12	127.71 ± 28.46	179.04 ± 61.65	40.19
4.	Glucose	85.03 ± 14.02	106.63 ± 23.9		133.44 ± 51.08	181.37 ± 54.22	
	Test meal R4	85.03 ± 14.02	111.83 ± 30.36	31.51	125.39 ± 43.59	167.82 ± 42.18	33.84
5.	Glucose	97.97 ± 22.58	121.96 ± 29.78		105.65 ± 74.81	139.61 ± 82.0	
	Test meal R5	97.97 ± 22.58	120.71 ± 19.34	23.21	100.05 ± 65.47	126.38 ± 78.43	26.31
6.	Glucose	73.00 ± 13.15	87.66 ± 34.86		236.96 ± 59.16	270.85 ± 47.86	
	Test meal R6	73.00 ± 13.15	83.96 ± 20.71	15.01	237.69 ± 61.7	274.54 ± 67.26	15.5

**Mean serum triglyceride response to test meals:**

The mean per cent increase of serum triglycerides of fasting and after two hours of ingestion of test meals is given table 5.

It is interesting to note that the test meals R<sub>6</sub> and R<sub>5</sub> elicited the lowest triglyceride response in both the groups, followed by test meals R<sub>4</sub>, R<sub>3</sub>, R<sub>1</sub> and R<sub>2</sub>. The highest triglyceride response was from rice based test meal. No single test meal was able to decrease the serum triglyceride levels below the fasting value.

**Serum cholesterol level in selected subjects**

The mean serum cholesterol level of non diabetics was 191.29 mg/100ml and of diabetics, 224.79mg/100ml. There is a clear indication that the mean cholesterol level in diabetics was higher than the non-diabetics. The subjects were classified based on serum cholesterol level into categories as suggested by Raghuram et al (7). It was found that more non diabetics (61.1%) had desirable cholesterol levels compared to diabetics (11.1%). As expected 61.1% of diabetics had higher level of cholesterol, compared to 22.2% of non diabetics.

Considering the glycemc and lipemic responses of the test meals, tested in the present study, they may be ranked in the following order depending on their suitability in planning diabetic diets.

1. Bajra roti with brinjal bhaji (R<sub>6</sub>)
2. Navani rice with curds and milk (R<sub>5</sub>)

3. Jowar roti with green gram bhaji (R<sub>1</sub>)
4. Ragi balls with red gram dhal + amaranthus curry (R<sub>4</sub>)
5. Chapati with cabbage bhaji (R<sub>3</sub>)
6. Rice with red gram dhal curry (R<sub>2</sub>)

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