RESPONSES TO LEGUMES IN NIDDM SUBJECTS: LOWER PLASMA GLUCOSE AND HIGHER INSULIN LEVELS

M. Viswanathan, A. Ramachandran, P. Indira, Sherry John, C. Snehalatha, V. Mohan and P.K. Kymal

Diabetes Research Centre and
M.V. Hospital for Diabetes,
Madras - [illegible], India

ABSTRACT

The blood glucose and corresponding insulin responses to five different isocaloric - 300 K. cals. - legume preparation 'adai' were assessed in nine NIDDM subjects and nine normal controls and the values were compared with that of 75 gm - 300 K. cal of glucose. The preparation contained 40.3 to 41.2 gms of carbohydrate, 12.9 to 14.7 gms of proteins, 9 gms of fat and 8.8 to 9.3 gms of dietary fibre. The glycaemic responses of legumes in controls were 0.85 Bengal gram (BG), 0.83 black gram (BL.G), 0.84 green gram (G.G.), 0.79 red gram (R.G.) and 0.84 lentil (L) and the corresponding values in diabetics were 0.67 (B.G.), 0.66 (BL.G.), 0.73 (G.G.), 0.70 (R.G.) and 0.72 (L) respectively. Thus it was seen that the legumes produced low glycaemic responses in normal controls and lower values in diabetic patients. There was no statistical difference, however, between different legumes in the controls and diabetic subjects.

In normal controls, the legumes produced lower plasma insulin responses compared to glucose. The Δ I and $\Delta I/\Delta G$ values for all the legumes were lower than that produced by glucose in control subjects. On the other hand in the NIDDMs the Δ I values in response to legumes were comparable to that produced by glucose. The $\Delta I/\Delta G$ ratios gave higher values when compared to that given by glucose.

Thus the study indicates that the legume preparations are useful in the management of diabetes on account of the lower glycaemic and higher insulin responses produced. The factors responsible for these changes need to be evaluated in greater detail.

INTRODUCTION

The Diabetes Research Centre, Madras, evolved a calorie restricted High Carbohydrate High Fibre diet (HCHF) twenty years ago and found it to be highly efficient in the management of diabetes as a result of extensive clinical studies (1,2). More recently, we have studied the insulin and glycaemic responses to four common breakfast food items rich in complex carbohydrate to evaluate their suitability for diabetics (3). The results

showed that three of them, namely, iddli, pongal and uppuma were superior to bread in this respect. Two of the foods viz iddli and pongal contained legumes. The HCHF diets invariably contain legumes which are rich in proteins, complex carbohydrates and dietary fibre. Legumes are regularly used in a variety of Indian preparations. They form an excellent supplement to cereal diets where they improve the biological value of the protein by mutual supplementation of lysine from the legumes and methionine from cereals. The present study has therefore been designed to investigate the insulin and glycaemic responses of diabetic subjects to five different common dehusked split legumes (dhals) - Bengal gram, black gram, green gram, red gram and masoor (lentil).

MATERIALS AND METHODS

Subjects - Nine NIDDM patients - 5 women and 4 men - who were under treatment at the M.V. Hospital for Diabetes, Madras participated in the study. They were on the HCHF diet (1,2) and glybenclamide, the dose varying from 2.5 to 10 milligrams per day. Their mean post prandial plasma glucose was 144 ± 22 (SD) and glycosylated haemoglobin (HbA1) was 8.9 ± 0.75% at the start of the study. The mean age of the patients was 56.6 ± 11 years, the duration of diabetes 5.6 ± 5.2 years and the body mass index (BMI) was 24.4 ± 7 kg/square meter. Nine normal volunteers with no history of glucose intolerance were also chosen for the study. There were 7 females and 2 males with an age of 37 ± 15 years and their BMI was 22.7 ± 3.5 kg/square meter. The mean post prandial blood sugar was 107 ± 11 and the corresponding HbA1 was 7.5 ± 3.5%

Test meals - The test meals included 1) Adai preparation based on legume and rice in the ratio of 2:1. 2) Chutney and 3) Coffee. Five different legumes - namely Bengal gram (Cicer ariatinum), green gram (Phaseolus aureus Roxb), black gram (phaseolus mungo Roxb), red gram (Cajanus cajan) and lentil (Lens esculenta), all split dhals without skin were used in different adai preparations.

Food preparations - Adai was prepared by soaking the legume concerned (46 gms) and rice (20 gms) per person per meal, wet grinding, mixing with salt, pepper, cumin and asafoetida and baking over hot plate smeared with fat. Five different adai preparations were made based on a different legume for testing. Chutney which goes with adai is made by frying cut onion (25 gms per serving) with fat and seasonings, adding cut ripe tomatoes (50 gms per serving), and cooking with the addition of water. Coffee is made from skimmed milk (40 ml per person) and coffee decoction.

Chemical analysis - The nutrient contents of the test susbtances were determined by chemical analysis excepting for the carbohydrate content which was calculated by difference. The composition of the test meals based on different legume preparations is given in Table I.

Table I. Nutrient composition of test meals

Nutrients in 300 K.cal portion	Bengal Gram Adai	Black Gram Adai	Green Gram Adai	Red Gram Adai	Lentil Adai
Protein (gms)	12.9	14.2	14.2	13.5	14.7
Fat[1] (gms)	9.0	9.0	9.0	9.0	9.0
Available Carbohydrate[2] (gms)	40.7	40.3	41.2	40.9	40.8
Dietary fibre (gms)	9.0	9.3	8.8	9.1	9.2
Total net calories	297	302	305	301	304

[1]includes fat present naturally in foods plus the fat used for baking adai and seasoning chutney

[2]Carbohydrate = 100 - (Moisture % + Protein % + Fat % + Minerals% + Dietary fibre %)

Procedures - The test meals were each of 300 K. cals and the dextrose load was 75 gms. The test meal was given at 8.00 A.M. after drawing the fasting blood sample for plasma glucose and insulin estimations. Thereafter the blood samples were collected at half hourly intervals for estimation of plasma glucose and insulin. The five legume preparations were tested on all the nine patients and nine controls leaving at least one day between tests. The glucose challenge (G.T.T.) was also tested on all subjects on the last test day. The time taken for consumption of the test meal was 10-15 minutes and the meal volume was 500 ml. Glucose was estimated using glucose oxidase method (Boehringer Mannheim Kit) and insulin was assayed using the method of Herbert et al, as reported previously (3). Glucose increment, Δ G was obtained by adding the 4 glucose values obtained after the test stimulation. Δ IRI was the sum of the 1 hr and 2 hr insulin values. Statistical analysis was done by the Wilcoxon rank-sum test.

RESULTS

Composition of test meals - The protein content of the five meals varied from 12.9 to 14.7 gms, the available carbohydrate from 40.3 to 41.2, the dietary fibre from 8.8 to 9.2 gms. The fat content was 9 gms in all cases. The calorie content of every meal was 300 K. cals.

Glycaemic responses - Table II gives the mean plasma glucose values in the controls and patients for each test meal and for the G.T.T. The mean values are also shown in Fig 1. The legumes gave lower glucose responses than glucose challenge both in the controls and patients. In the patients the Δ G of all legume preparations were significantly lower than oral glucose at P <0.001. In the controls the level of significance for Bengal gram, black gram, and lentil was P <0.01 and it was P <0.001 for red gram and P <0.05 for green gram. There were no significant differences between legumes, neither in the diabetic subjects nor in control subjects.

Table II. Plasma glucose response to different legumes

Glucose Response mg %	Bengal Gram Adai	Black Gram Adai	Green Gram Adai	Red Gram Adai	Lentil Adai	Glucose G.T.T.
CONTROLS (n=9)						
0′	88±5	89±4	92±7	85±9	91±9	94±5
30′	105±13	101±11	107±15	99±11	109±15	143±11
60′	98±12	97±12	100±18	91±11	96±14	110±18
90′	94±11	89±13	92±15	87±10	94±10	109±19
120′	87±10	87±12	87±13	82±11	88±8	94±16
Δ G	386±39[a]	383±55[b]	385±51[c]	361±35[b]	381±40[a]	455±56
G.R.*	0.85	0.83	0.84	0.79	0.84	
PATIENTS (n=9)						
0′	120±23	136±36	132±40	135±27	131±31	142±30
30′	172±22	177±26	185±31	175±23	184±37	219±35
60′	177±25	173±28	193±37	178±22	185±27	267±48
90′	151±23	160±23	170±28	173±17	168±33	269±50
120′	140±17	145±23	149±28	154±16	151±28	236±67
Δ G	646±75[b]	649±93[b]	695±93[b]	680±70[b]	687±113[b]	997±180
G.R.*	0.67	0.66	0.73	0.70	0.72	

*Glycaemic response (G.R.) = Δ G of test meal/Δ G of glucose.

P values in comparison with values obtained with glucose:- a = P <0.01, b = P <0.001, c = P <0.05

FIGURE 1

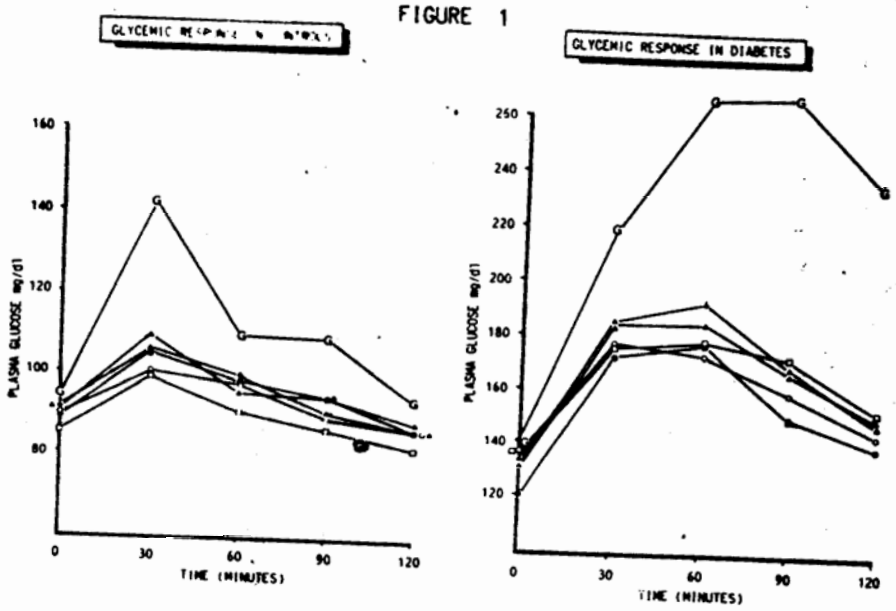
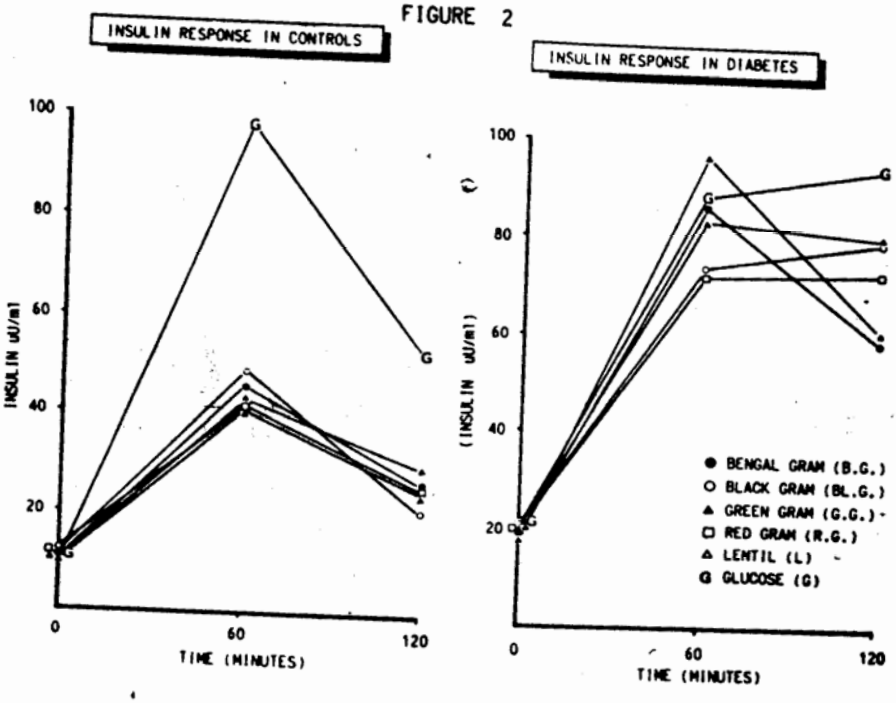


FIGURE 2



Insulin responses - Table III gives the insulin responses in the different groups. The mean values are shown in Fig 2. In the controls the Δ I given by test meals was lower than that of glucose for Bengal gram P <0.01, black gram P <0.01, green gram P < 0.01, red gram P <0.001, lentil P <0.001. The Δ I/ΔG ratios were also significantly lower compared to glucose at P <0.001 for all legumes. However in the diabetic patients there was no significant difference in the insulin response produced by legumes and that given by glucose load. The Δ I/ΔG ratios were in fact higher compared to glucose eventhough not statistically significant.

Table III. Plasma insulin response to different legumes

Insulin Response uU/ml	Bengal Gram Adai	Black Gram Adai	Green Gram Adai	Red Gram Adai	Lentil Adai	Glucose G.T.T.
CONTROLS (n=9)						
0′	11±6	12±6	11±5	13±5	10±4	11±7
60′	46±27	49±26	43±23	42±17	41±15	98±47
120′	27±12	21±9	30±11	26±20	25±15	53±50
Δ I	74±33[a]	67±25[a]	71±2[a]	62±25[b]	62±13[b]	118±29
ΔI/ΔG	.37±.18[c]	.38±.16[c]	.38±.18[c]	.38±.10[c]	.34±.08[c]	.61±.22
PATIENTS (n=9)						
0′	19±13	21±18	18±16	20±18	20±8	21±16
60′	86±48	74±32	96±65	72±41	83±55	88±40
120′	59±18	79±36	61±29	73±31	80±50	94±29
Δ I	146±51	153±53	157±89	144±64	159±97	182±65
ΔI/ΔG	.49±.12	.50±.19	.47±.29	.43±.23	.48±.33	.37±.15

1. P values of insulin response of legumes obtained in comparison with that of glucose:- Δ I for controls a = P <0.01; b = P <0.001; for diabetics differences are not statistically significant.

2. P values for ΔI/ΔG c = P <0.001 for all legumes in controls and not statistically significant for diabetics eventhough the legumes gave higher values than glucose.

DISCUSSION

The legume preparations used in this study gave lower glycaemic responses compared to glucose in control subjects as well as diabetic patients. The lowering of glycaemic response was more marked in the diabetic patients. This observation is in general agreement with the findings of other workers who reported similar results in dried beans and other leguminous seeds in normal and diabetic patients (4,5,6,7). These studies however have used 50 gm carbohydrate portion with varying total calorie content. In this study we have compared isocaloric diets of 300 K. cals against 75 gms of oral glucose which also provides 300 K. cals of energy.

It is interesting to note that the legumes produced higher insulin responses in the patients where as the corresponding values were lower in the controls. In a study of Krezowski et al (7) it was reported that the insulin responses produced by oat meal, lentils, kidney beans and amylose corn muffins were higher than that produced by glucose itself. The plasma insulin remained elevated even after five hours, even though, the plasma glucose had returned to fasting level. It has been suggested that this was probably influenced by the continued stimulation of insulin secretagogues from the gut by the modest amount of food remaining in the upper intestine. It is known that in hyperglycaemia amino acids cause greater insulin output. Amino acids like leucine, arginine and phenyl alanine which are potent insulin secretagogues were administered intravenous in amounts varying from 5 gms to 30 gms along with or preceding glucose for measuring the extent of potentiation (8,9,10). The amino acid content contributed by the test meals in the present study was on an average of 1 gm of arginine, 0.7 gm of phenyl alanine and 1 gm of leucine which by itself was presumably insufficient to explain the observed increased production of insulin. The insulin response to ingested protein like casein and gelatin 50-100 gms and beef 50 gms (14,15) was excessive in diabetics. In normal subjects 50 gm beef protein was much less potent in stimulating insulin than was 50 gm glucose (14). The response was merely additive in normal but synergestic in diabetic individuals. In a recent study (15) the ratio of carbohydrate to protein was 2:1 with 25 gm protein in the form of beef, turkey, gelatin, egg white, cottage cheese, fish and soy. The meal produced insulin response of 360% in the case of cottage cheese and 190% with egg white compared with glucose alone of 100%. The insulin response to gelatin which is an incomplete protein was the next

best to cottage cheese with beef and turkey remaining high next to gelatin. It appears that the responses are not quite related to the biological values of the proteins. The response elicited by egg white was lower than that of gelatin. Other factors seem to play more 'significant' influences. It is known that orally administered glucose causes a greater rise in insulin output than intravenous glucose. The effect is likely caused in part by the release of gastrointestinal peptide (GIP) induced by oral glucose. However in the absence of concomitant hyperglycemia GIP is not known to cause insulin release (8). In the present study the insulin response to the legume meals in controls was less prominent than in diabetic subjects indicating that GIP and other gut peptides and neural effects might be influencing the observed high level of insulin. It is interesting to note that the insulin increase in diabetics was produced with a level of 12.9 to 14.7 gm of protein present along with 40.3 to 41.2 gm of complex carbohydrate in the legume meals.

A significant relationship has been reported between the rate at which the products of digestion of foods are liberated and the degree to which they raise the blood glucose (11,12). The rate of digestion of carbohydrates present in legumes is slower than those of cereals. The nature of starch in legumes affects the rate of digestibility and blood glucose level (13). Legumes contain dietary fibre, protein, enzyme inhibitors and other factors like antinutrients which influence digestibility and glycaemic response (11,12,13).

The results of the study indicate that the legumes are beneficial in reducing the post prandial hyperglycaemia in diabetic patients and also in improving the insulin secretory pattern. Further studies may be needed to throw more light on the factors responsible for these changes in diabetic subjects.

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