Mechanism of Low Glycemic Index of Pulses and Pulse-Incorporated Cereal Foods

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INTRODUCTION

Jenkins and co-workers have demonstrated that isocarbohydrate diets of lentils and soya beans raised the blood glucose by only 42% and 14% of the values observed after bread ingestion both in non-diabetics and diabetics (1). They proposed that physical factors like dietary fiber and its viscosity (2) and unabsorbable carbohydrate (3) were responsible for the differences observed. Holt and co-workers (4) proposed that the differences observed were not due to malabsorption but were due to delayed gastric emptying and prolonged absorption.

In India, cereals and pulses form the staple diet. Pulses are particularly rich in their fiber content. Lentils and pulses have a low glycemic index (GI) (1). Mixed meals of different carbohydrate foods exhibit a glycemic index which is intermediate between the GI of each food individually although some investigators were unable to corroborate this finding (7). The within-individual variation was found to be large in IDDs (5). We studied the glycemic and insulinemic indices of cereals, pluses and cereal-pluse mixtures to gain an insight into the mechanism of the differences observed.

PATIENTS AND METHODS

Two different isocarbohydrate meals (50 gms carbohydrate) were used for testing against the standard white bread: (1) whole, wheat flour + Bengal gram flour bread (Chapati) in ratio of 2:1 (2) Bengal gramflour bread (chapati).

The subjects selected for this study were non-insulin dependent diabetics (NIDDs) under fairly good control of their disease and free of significant cardiovascular, renal or neurological complications. Their fasting blood glucose was less than 150 mg/dl and did not vary significantly on different days of testing. The glycemic index of gram flour was studied in 20 non-insulin dependant diabetics (NIDDs). In a group of 10 NIDDs, gram or wheat-gram mixture was tested for glycemic as well as in-sulinemic indices.

TABLE 1

GLUCOSE RESPONSE (AUC, mg-min.) TO STANDARD MEAL (WHITE BREAD) AND GRAM MEAL.

Sr. No.	Name	AUC (mg-min)		Glycaemic Index of gram-meal(%)
		Bread	Gram-Meal	
1.	C.M	8340	4020	48.20
2.	N.S.	7770	3990	51.35
3.	A.L	8100	4470	55.18
4.	S.M.	8265	3750	45.37
5.	M.Q.	9510	4770	50.15
6.	P.C	9660	4560	47.20
7.	J.K.	8775	4290	48.88
8.	H.P.	7800	4110	52.69
9.	M.S.	7710	4350	56.42
10.	P.C.	8460	4455	52.65
11.	R.Y.	7050	3810	54.04
12.	A.A.	7455	3390	45.47
13.	T.D.	5760	2700	46.76
14.	S.A.	9435	3540	37.51
15.	S.S.	8520	3340	41.54
16.	K.R.	7200	3600	50.00
17.	K.P.	6090	3360	55.17
18.	P.S.	9060	4140	45.69
19.	Z.B.	9390	4770	50.79
20.	S.B.	9000	4350	48.33
MEAN		8137	3988	49.16
SEM		243.8	122.82	1.06

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RESULTS

Table 1 presents the area under curve (AUC) of the blood glucose and insulin response in 20 NIDDS with bread (standard) and gram-flour meals. The GI of gram-flour was 49.1 ± 4.7 (Mean ± SD; $p<0.001$)

In-group of 5 NIDDs standard white bread was compared with a wheat-gram flour mixture (ratio of 2:1). The glycemic index of wheat-flour mixture was 66.4 and insulinemic index was 118.6 (Table 2). In another group of 5 NIDDs standard white bread was compared with gram-flour meal. The glycemic index of gram-flour was 48.3 and insulinemic index 202.1 (Table 2). The glycemic as well as insulinemic indices of the two test diets are significantly different ($p < 0.001$) as compared to the standard. There is a graded change towards a lower G. I. and higher insulinemic index with the addition of gram flour. In our earlier studies whole wheat flour bread (Chapati) gave a GI of 86%. The gram-flour gave a GI of 48.3 in this study. Hence the GI of 66.4 observed with wheat-gram mixture in this study is close to the predicted value. The insulinemic index of wheat flour in our earlier studies was 79.8 while the insulinemic index of gram flour in this study was 202.1 The insulinemic index of wheat-gram mixture observed in this study was 118.6, again conforming to the predicted value.

DISCUSSION

Coulston and co-workers (7) have reported that the GI of three test meals developed from varied carbohydrate sources did not vary according to their calculated glycemic potency. On the other hand, Wolever and co-workers (6) have demonstrated that the mean glycemic response areas of different meals ranked according to the predicted GI in every individual. Our data agree with those of Wolever and co-workers. It is possible that we have studied a fairly homogenous group of NIDDs, which has brought out the contribution of each carbohydrate component of the mixed meal clearly. The intra-individual as well as inter-individual variation is expected to be much larger in IDDs (5). Hence, we have confined our observations to NIDDs. It is interesting to note that there is considerable variation in the GI of NIDDs given a wheat-gram flour mixture, but the gram flour meal produced a consistent response in all the subjects studied (Table 2).

TABLE 2

GLYCEMIC AND INSULINEMIC INDICES OF WHEAT-GRAM MIXTURE AND GRAM-MEAL.

Sl. No.	Name	Glucose Response AUC (mg. min.)		Insulin Response (µu. min)		Glycemic Index	Insulinemic Index
		Bread (STD)	Wheat gram	Bread	Wheat-Gram	Wheat-Gram	
1.	SH	12015	6165	2139	845	51.3	39.5
2.	MB	15045	7935	5464	4504	52.7	82.4
3.	PN	4185	4155	535	1279	99.3	259.8
4	DB	13470	5076	2718	3393	37.7	124.8
5	RT	4155	3790	7420	7978	91.2	107.5
						66.4*	118.6*

Sl.No.	Name	Glucose Response AUC (mg. min.)		Insulin Response (µu. min)		Glycemic Index	Insulinemic Index
		Bread (STD)	Gram-Meal	Bread	Gram-Meal	Gram-Meal	
1.	RY	7050	3810	5617	5629	54.0	100.2
2.	TD	5700	2700	2640	6591	46.8	249.6
3.	SA	9435	3540	3243	6481	37.5	199.8
4.	KP	6090	3360	1398	2055	55.1	146.9
5.	SB	9000	4350	2065	6486	48.3	314.0
						48.3*	202.1

* $p < 0.001$ as compared to STD

The serum insulin response has not been studied by most investigators along-with the study of glycemic indices. Hence the lower GI of legumes has been attributed to the viscosity of food (2), high un-absorbable carbohydrate content (3) or delayed gastric emptying (4). In one study high fiber diet was administered over a 6 weeks period (8). In this study the plasma insulin response during a 24-hour profile was not significantly different as compared to the low-carbohydrate diet period. Jenkins and co-workers demonstrated a decrease in the post-prandial insulin and glucose concentration by adding guar and pectin to the carbohydrate meals, (9). This study demonstrates a stimulatory effect of bengal flour on insulin secretion of NIDDs. It appears to be an important mechanism responsible for the low GI of the gram flour. The insulin secretion was doubled by the gram meal. It is possible that gram-flour stimulates insulin secretion because of its aminoacid content, which is different from that of cereals like wheat. The cereals have a low content of lysine, which is present in good concentration in pulses. The reverse is true with respect to methionine, which is more abundant in cereals. In a vegetarian diet, the cereals and pulses are complementary to each other and together provide a fairly balanced aminoacid mixture. It is not likely that this complemetarity is responsible for the higher insulin secretion, because in this study the wheat-gram mixture provoked less insulin secretion than the gram flour alone. Rather, some constituents of gram flour are responsible for the enhanced insulin secretion. All the NIDDs participating in this study were being treated by diet and glibenclamide. Hence we have to bear in mind the possibility that gram flour may exhibit the insulin stimulatory effect due to ongoing treatment with glibenclamide. Sulfonylureas are known to enhance nutrient-induced insulin secretion, in addition to their direct insulin-stimulatory effect (10). It is interesting to note that foods like gram flour can significantly stimulate insulin secretion, to the extent that it may be used therapeutically. It may be possible to utilise this property of pulses like bengal-gram to treat mild NIDDs by dietary means alone or in conjunction with a sulfonylurea. It is a matter of conjecture whether such insulin stimulatory effect will be sustained on long-term therapy or will be elicited in NIDDs of differing severity and types. However, a limited but clear therapeutic role of pulse-based diets is possible in NIDDs.

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