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GLYCAEMIC RESPONSE TO MAIZE, BAJRA AND BARLEY

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Abstract : The postprandial glycaemic response to maize (*Zea mays*), bajra (*Pennisetum typhoideum*) and barley (*Hordeum vulgare*) was studied in a pool of 18 healthy volunteers and 14 patients having non-insulin-dependent diabetes mellitus (NIDDM). In response to maize, none of the variables examined was significantly different as compared to white bread. The glycaemic response to bajra was significantly lower than that to white bread in healthy subjects, but the two responses were indistinguishable in NIDDM subjects. The insulinaemic responses to bajra and white bread were not significantly different in either group of subjects. The glycaemic response to barley was significantly lower than that to white bread in both groups of subjects. But the insulinaemic response to barley was significantly lower than that to white bread only in healthy subjects. In NIDDM subjects, there was a tendency for the response to barley to be higher than that to white bread 0.5 h after ingestion. Barley, with a low glycaemic index (68.7 in healthy and 53.4 in NIDDM subjects) and a high insulinaemic index (105.2) in NIDDM subjects seems to mobilize insulin in NIDDM. This makes it a specially suitable cereal for diabetes mellitus.

Key words: glycaemic response, glycaemic index, postprandial glycaemia, insulin, insulinaemic response, diabetes mellitus, NIDDM, cereals, dietary fibre

INTRODUCTION

Low postprandial glycaemia is now considered a valid and rational feature of diabetic diets. The glycaemic response to a food may be quantified in terms of the glycaemic index (GI) (1, 2, 3, 4). The GI of a food depends to a significant extent on its physical state (5, 6), and the method of cooking or processing employed (7, 8, 9). Therefore the GI of foods needs to be determined locally for the different forms in which it is commonly consumed. Further, the insulinaemic response to a food does not necessarily parallel the glycaemic response to the food (10, 11). Hence, for framing diabetic diets, it is desirable to know both the glyaemic response and insulinaemic response to foods. The present study reports the glycaemic and insulinaemic response to a few coarse cereals commonly consumed in India, viz. maize *(Zea mays)*, bajra *(Pennisetum typhoideum)* and barley *(Hordeum vulgare)*.

METHODS

The study was performed on a pool of 18 healthy volunteers and 14 patients having non-insulin dependent diabetes mellitus (NIDDM). The break-up of subjects and their characteristics are given in Table I.

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TABLE I : Characteristics of volunteers.

Cereal studied	*Health status*	*Sex*	*n*	*Age (years)*	*Body weight (kg)*	*Height (m)*	*Body mass index*[1]
Maize	Healthy	M	5	50-72	52-97	1.60-1.75	19.3-31.7
		F	1	23	64	1.77	20.4
	NIDDM	M	1	48	64	1.76	20.7
		F	1	67	75	1.49	33.8
Bajra	Healthy	M	4	27-67	51-82	1.60-1.75	17.6-28.9
	NIDDM	M	6	58-71	54-80	1.55-1.80	18.9-29.7
Barley	Healthy	M	7	56-70	56-76	1.62-1.77	18.7-28.4
		F	1	59	57	1.56	23.4
	NIDDM	M	4	57-63	50-101	1.62-1.70	19.1-34.9
		F	2	50-52	59-60	1.40-1.52	25.9-30.1

[1]Body mass index = Body weight (kg)/Height^2(m)

The subjects reported after an overnight fast between 9 a.m. and 10 a.m. on two mornings at one week's interval. After a fasting venous sample had been drawn, they were administered either a 50 g - carbohydrate portion of white bread (reference meal) or a 50 g - carbohydrate portion of chapaties made from the cereal being tested (test meal). Each subject received the reference meal and one test meal, but the sequence of the two meals was randomised. Each meal was provided with 200 ml water.

The meal was consumed within 10 min at a steady rate. The midpoint between starting and finishing the meal was taken as zero time. Venous blood samples were drawn at 0.5, 1.0, 1.5, 2.0 and 3.0 h. The blood was analysed for measurement of plasma glucose by the o-toluidine method, and serum insulin by radioimmunoassay, using kits supplied by the Board of Radiation and Isotope Technology (BRIT), Bombay.

Calculations : Serial estimations of blood glucose and insulin were further used to derive the following indices : incremental area under the 3 h glucose curve (Δ AUC-G) and incremental area under the 3 h insulin curve (Δ AUC-I), glycaemic index and insulinaemic index. The areas were calculated using a portable computer (Casio PB 100 F).

The glycaemic index was calculated using the formula (4) :

$$\text{Glycaemic index} = \frac{\Delta\ \text{AUC-G for 50 g carbohydrate from test food}}{\Delta\ \text{AUC-G for 50 g carbohydrate from white bread}} \times 100$$

Similarly the insulinaemic index was calculated using the formula :

$$\text{Insulinaemic index} = \frac{\Delta\ \text{AUC-I for 50 g carbohydrate from test food}}{\Delta\ \text{AUC-I for 50 g carbohydrate from white bread}} \times 100$$

Statistical analysis : The response to the test meal was compared to the corresponding response to white bread by the Student's t-test for paired observations. Differences were considered significant if $p < 0.05$.

Ethical considerations : The protocol of the study had the previous approval of the Ethics Committee of the All India Institute of Medical Sciences. The participation was on a strictly voluntary basis and the subjects knew that they could withdraw from the study at any stage. Every volunteer gave his informed written consent before being admitted to the study.

RESULTS

The glycaemic response to maize and white bread (the reference meal) have been depicted in Fig. 1 and Table II. In healthy volunteers, none of the variables examined was significantly different in response to maize as compared to white bread. In NIDDM subjects, the data is insufficient to draw clear conclusions.

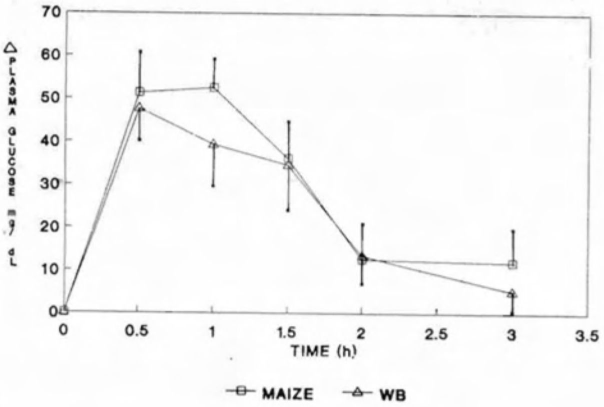

Fig. 1 : **Incremental plasma glucose levels following** ingestion of **maize** as compared to **white bread** in healthy subjects. Points are mean values with their standard errors represented by vertical bars. WB, white bread.

TABLE II : Glycaemic response to maize in NIDDM subjects.

Subject	Meal	Δ Plasma glucose (mg/dL) 0h	0.5h	1.0h	1.5h	2.0h	3.0h	Δ AUC-G (mg dl^{-1}.3h)
1.	WB	0	42	93	100	63	47	188.2
	Maize	0	34	96	124	79	27	199.7
2.	WB	0	92	131	191	178	114	398.0
	Maize	0	41	86	155	157	126	321.7

WB, white bread

The incremental glycaemic responses to bajra and white bread have been depicted in Fig. 2,

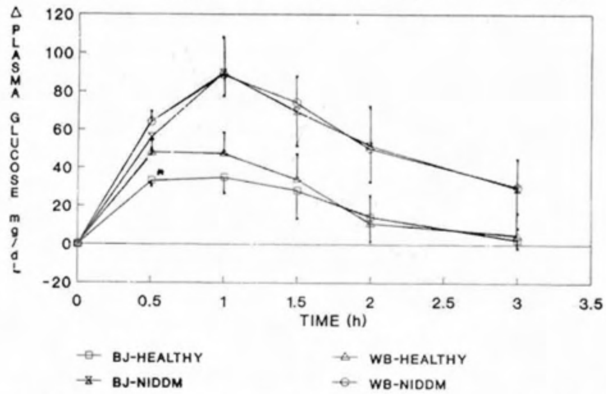

Fig. 2 : **Incremental plasma glucose** levels following ingestion of **bajra** as compared to **white bread** in healthy and NIDDM subjects. Points are mean values, with their standard errors represented by vertical bars. BJ, bajra; WB, white bread; *, P<0.05 as compared to white bread.

and the corresponding insulinaemic responses in Fig. 3. The glycaemic response to bajra, in terms of Δ AUC-G was significantly smaller than that to white bread in healthy subjects, but the two responses were indistinguishable in NIDDM subjects. The insulinaemic responses to bajra and white bread were not significantly different in either group of subjects but there was a tendency for the response to bajra to be lower at 1.0 h in NIDDM subjects.

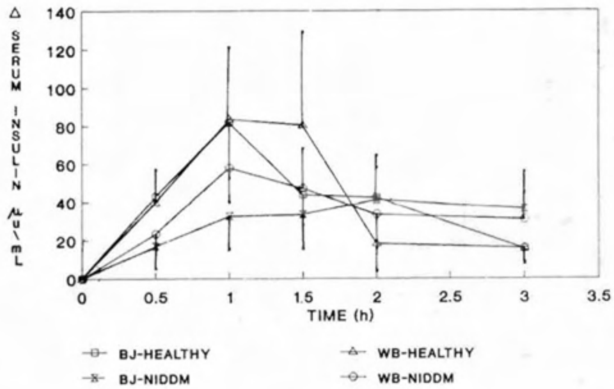

Fig. 3 : Incremental serum insulin levels followig ingestion of bajra as compared to white bread in healthy and NIDDM subjects. Points are mean values, with their standard errors represented by vertical bars. BJ, bajra; WB, white bread.

The incremental glycaemic responses to barley and white bread have been depicted in Figs. 4 and 5, and the corresponding insulinaemic responses in Figs. 6 and 7. The incremental glycaemic response to barley was significantly lower than that to white bread at 1.0 h. 1.5 h and 2.0 h, and in terms of Δ AUC-G in healthy subjects, and at 0.5 h, 1.0 h, 1.5 h and 2.0 h and in terms of Δ AUC-G in NIDDM subjects. The insulinaemic response to barley was significantly lower than that to white bread in terms of ΔAUC-I in healthy subjects. In NIDDM subjects, the insulinaemic responses to barley and white bread were not significantly different, but there was a tendency for the response to barley to be *higher* than that to white bread at 0.5 h.

The glycaemic and insulinaemic indices of the cereals studied have been depicted in Table III.

Bajra had an appreciably low glycaemic index (69.7) only in normal subjects, but it was accompanied by a fairly high insulinaemic index (104.1).

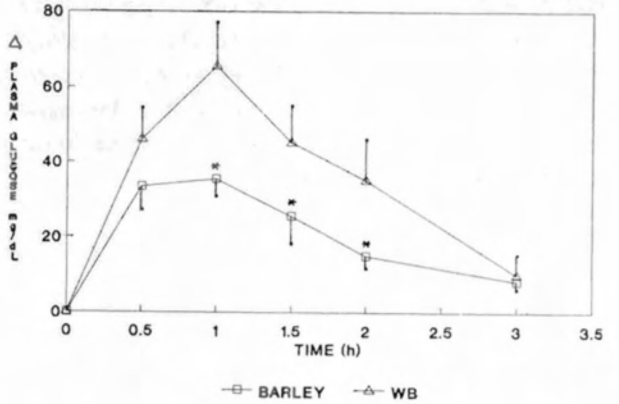

Fig. 4 : Incremental plasma glucose levels following ingestion of barley as compared to white bread in healthy subjects. Points are mean values, with their standard errors represented by vertical bars. WB, white bread; *, $P < 0.05$ as compared to white bread.

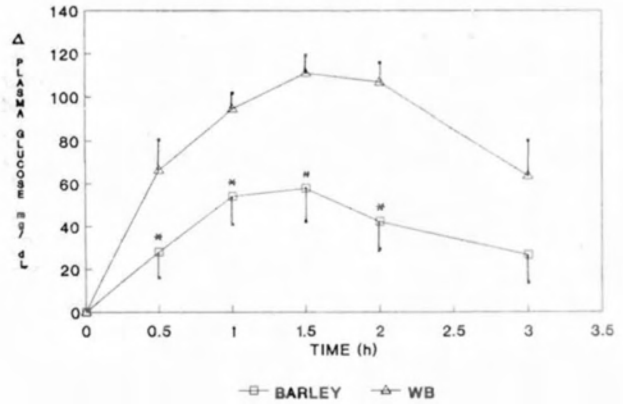

Fig. 5 : Incremental plasma glucose levels following ingestion of barley as compared to white bread in NIDDM subjects. Points are mean values, with their standard errors represented by vertical bars. WB, white bread; *, $P < 0.05$ as compared to white bread.

Barley had low glycaemic indices in both normal (68.7) and NIDDM subjects (53.4) accompanied by a low insulinaemic index in healthy subjects (71.1), but a high insulinaemic index in NIDDM subjects (105.2).

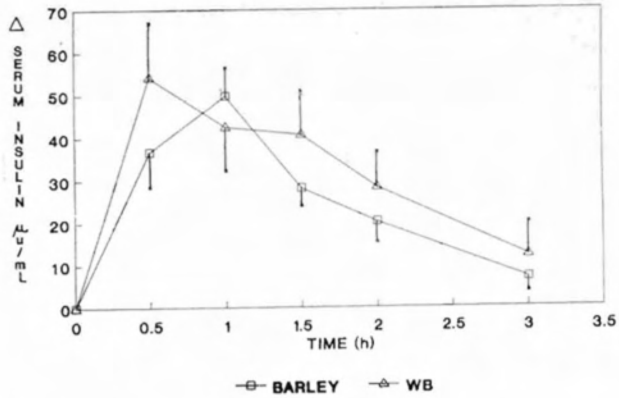

Fig. 6 : Incremental serum insulin levels following ingestion of barley as compared to white bread in healthy subjects. Points are mean values, with their standard errors represented by vertical bars. WB, white bread.

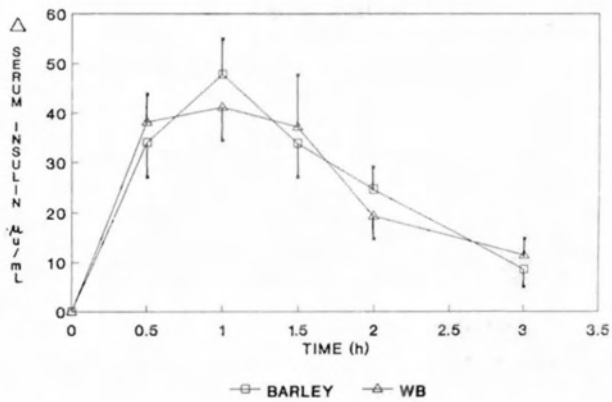

Fig. 7 : Incremental serum insulin levels following ingestion of barley as compared to white bread in NIDDM subjects. Points are mean values, with their standard errors represented by vertical bars. WB, white bread.

TABLE III : Glycaemic and insulinaemic indices of cereals.

Cereal	Glycaemic index		Insulinaemic index	
	Nomal subjects	NIDDM subjects	Normal subjects	NIDDM subjects
Maize	84.7	92.2	-	-
Bajra	69.7	95.7	10.4.1	89.7
Barley	68.7	53.4	71.1	105.2

DISCUSSION

Studies on glycaemic response should preferably be performed on healthy as well as diabetic subjects because although the response of the two groups is fairly well correlated (12), the response may not be identical as seen in this study. Preprandial blood glucose levels above 234 mg/dl are significantly and negatively correlated to the net glycaemic response (13).

Since maize has a rather high glycaemic index (84.7), work on it was abandoned in favour of other cereals.

Bajra has a low GI in healthy subjects (69.7) accompanied by a high insulinaemic index (104.1). But in NIDDM subjects, it has a high GI (95.7) accompanied by a low insulinaemic index (89.7). The observations suggest that bajra evokes insulin secretion in healthy subjects, which results in an attenuation of the glycaemic response. In NIDDM subjects perhaps there is insufficient reserve of insulin, as a result of which bajra fails to mobilise insulin secretion. Hence the GI of bajra in NIDDM subjects is high. This pattern is, however, atypical, because the GI for a given food is generally lower in diabetics than in non-diabetics (14).

Barley has a low GI in healthy (68.7) as well as NIDDM subjects (53.4) but its insulinaemic index in NIDDM subjects is high (105.2). The observations suggest that barley has some insulinotropic factor which is specially effective in NIDDM subjects. The mobilization of insulin brought about by barley in NIDDM subjects' leads to a very low GI. The identity of the insulinotropic factor in barley is, however, unknown. Thus there seems to be some rationale in the traditional prescription of barley for diabetics (15).

We have come across no published data with which our data may be compared directly. The reported GI of cornflakes is 119 and that of porridge oats is 85 (2). Although cornflakes and maize chapati have the same cereal, their physical form, and the mode of cooking or processing involved are quite different. Similarly, although oats and barley are similar cereals, porridge and chapati are quite different modes of consuming them. But still cornflakes emerge as a high GI food like the maize chapati while oats have a relatively lower GI like barley. The Indian studies on GI (16, 17, 18) have been so far on meals or recipes containing more than one ingredient, and therefore cannot be compared to the present study.

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