GLYCAEMIC AND INSULIN RESPONSES TO SOME BREAKFAST ITEMS IN DIABETIC SUBJECTS

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ABSTRACT

The glycaemic and insulin responses to four common breakfast items namely iddli, pongal, uppuma and bread were studied in South Indian non-insulin dependent diabetic subjects and compared with 75 gms of glucose. The breakfasts provided 300 K cals of which complex carbohydrate contributed 68-81%, proteins 12-14% and fat 8-19% of total calories, while the dietary fibre contents varied from 3.8 g to 7.4 g in 300 K cal portions. The results indicated that pongal, uppuma and iddli were suitable for diabetics as their glycaemic responses to the test foods were low. Bread was considered unsuitable as its glycaemic response was as high as that of glucose. A number of parameters like the mode of cooking and processing, the form of food and the differences in food constituents which affect digestion, absorption and metabolism seem to influence the glycaemic and insulin responses.

INTRODUCTION

Diet is the sheet anchor in the treatment of diabetes mellitus. The usefulness of the change over from a restricted carbohydrate to high carbohydrate diet was recognised by us as early as 1958 and follow-up studies were documented by 1968 (1,2). It is now widely recognised that a high carbohydrate high fibre diet is most suitable for the diabetic patients (3-5). In our country, the diet of a common man, consisting of cereals, pulses and vegetables, contain large amount of complex carbohydrates, and adequate amounts of proteins and food fibre. Studies carried out at our centre over the past 25 years have clearly shown that a calorie-restricted, high carbohydrate high fibre diet (HCHF) adequate in proteins, is ideal for the treatment of the diabetic patients (6,7). The diet is distributed in three main meals with small feeds in between. Rice or wheat is the major source of carbohydrates which constitute 60-70% of the calories.

Proteins are mainly of vegetable origin contributing about 20-25% of calories and the fats are also chiefly of vegetable origin and are rich in essential fatty acids. No artificial fibres are included in the diet, as the diet itself is rich in natural fibres.

This study was conducted to evaluate the glycaemic response in diabetic individuals of four breakfast items which are commonly used in the southern parts of India. Although all of them contain complex carbohydrates they differ with respect to the type of fibre and quality of the proteins present. The insulinogenic response of the test diets has also been determined.

MATERIAL AND METHODS

Fifteen non-insulin dependent diabetic patients (NIDDM) who were being regularly reviewed and treated at the Diabetes Research Centre and M.V. Hospital for Diabetes, Madras were selected for the study. They were being treated with the HCHF diet (1600 to 2000 calories, as per individual requirement) and glibenclamide (2.5 to 10 mg/day). Their post prandial plasma glucose were below 200 mg/dl. The clinical details of the patients are shown in Table I.

Table I. Clinical characteristics of the patients

Item tested	Pongal	Iddli	Uppuma	Bread	Glucose
No. of subjects	7	7	8	8	15
Male:Female	5:2	5:2	4:4	4:4	9:6
Age (Years)	61.0± 7	61.0± 7	55.0± 11	55.0± 11	58.0± 10
Duration of diabetes (Years)	9.0± 6	9.0± 6	6.0± 4	6.0± 4	7.0± 5
Body Mass Index	22.7± 3.4	22.7± 3.4	23.9± 3.7	23.9± 3.7	23.9± 3.6
HbA1 (%)	9.31± 1.01	9.31± 1.01	9.01± 1.03	9.01± 1.03	9.20± 1.01

Values are Mean ± S.D.

The drugs were stopped at least 24 hours prior to the test. The test meal was given at 8.00 A.M. after drawing the fasting blood sample for plasma glucose and radioimmunoassay of insulin (IRI). Thereafter, the blood samples were collected at half hourly intervals for 2 hours for plasma glucose and insulin. Glucose was estimated immediately using glucose oxidase method (Boehringer Mannheim kit). Plasma samples for IRI were stored frozen at -20°C till the assay was performed using the method of Herbert et al (8). The kits were supplied by Bhabha Atomic Research Centre, Bombay. Four isocaloric breakfast items - iddli, uppuma, pongal and white bread - each of 300 K calories were tested. The patients were divided into two batches and two different test meals were tested in each batch on alternate days and on the third test day, glucose challenge (75 gms) was given. The time taken for consumption of the test meal was 10-15 minutes and the meal volume was 500 ml.

Table II below gives the method of preparation of the food items and the ingredients used.

Table II Food items - Ingredients and preparation

Item	Ingredients	(g)	Preparation
1. Iddli	Rice	57	Soak, wetgrind, mix, ferment, steam.
	Black gram - split skinned	19	
2. Pongal	Rice	48	Add water, cook and season.
	Green gram - split skinned	17	
	Oil	4	
3. Uppuma	Semolina (Wheat)	62	Seasoning, add water cook.
	Onion	20	
	Oil	4	
4. Bread	White	103	'Modern' white bread
5. Chutney	Tomato	50	Cook, macerate, add seasoning.
	Onion	25	
	Oil	2	
6. Coffee	Skim milk	50 ml	--
	coffee	50 ml	

The composition of the food preparation is shown in Table III.

Table III Composition of breakfast food items

Item	Energy (K cal)	Carbohydrate (g)	Fat (g)	Protein (g)	Dietary fibre (g)
Iddli	263	56	0.5	8.2	6.8
Chutney	41	5	2.0	1.2	1.2
	304	61	2.5	9.4	8.0
Pongal	261	47	4.4	7.3	6.2
Chutney	41	5	2.0	1.2	1.2
	302	52	6.4	8.5	7.4
Uppuma	262	49	4	6.6	2.6
Chutney	41	5	2	1.2	1.2
	303	54	6	7.8	3.8
Bread	252	53	0.7	8	2.8
Chutney	41	5	2.0	1.2	1.2
	293	58	2.7	9.2	4.0
Coffee*	15	2.3	-	1.2	-

*Served with every item.

Glycaemic response of each food item was calculated as follows. Area under the glucose stimulation curve ($\nearrow G$) was calculated by summing up the 4 glucose values obtained after stimulation and similarly for each meal test also. The G of glucose was taken as the index value of one and the ratio of each food item in relation to G was calculated.

$$\frac{\nearrow G \text{ of food item}}{\nearrow G \text{ of glucose}} = \text{glycaemic response}$$

Statistical analysis of the results was done using the 't' test. All values are expressed as the mean $\pm$ standard deviation.

RESULTS

Proximate Principles in the diet

The carobohydrate content varied from 52 gms in pongal to 61 gms in iddli. Protein content varied from 7.8 gms to 9.4 gms. The fat contents of uppuma and pongal were 6.0 and 6.4 gms respectively and in iddli and bread, they were low (2.5 and 2.3 gms). Dietary fibre contents were higher in iddli and pongal (8 and 7.4 gms) than those in uppuma and white bread (3.8 and 4.0 gms).

Glycaemic response

Table IV shows the mean plasma glucose values in response to each test meal and the G.T.T. values.

Table IV. Plasma glucose response of the patients to different diets

Items tested		Plasma Glucose (mg %) 0′	30′	60′	90′	120′	∆G	Peak-FBS*	G.R.*
Glucose (n=15)	Mean	134	218	269	274	242	1003	148	1.00
	±S.D.	19	27	29	31	45	110	28	
Pongal (n=7)	Mean	138	188	212	217	201	818	91	0.79
	±S.D.	14	14[c]	15[c]	19[c]	41[a]	52[c]	23[c]	0.07
Iddli (n=7)	Mean	144	199	249	239	228	914	108	0.88
	±S.D.	13	27	17[a]	7[c]	15	38[b]	13[c]	0.05
Uppuma (n=8)	Mean	121	163	202	182	161	708	94	0.74
	±S.D.	10	12[c]	12[c]	18[c]	21[c]	34[c]	15[c]	0.09
Bread (n=8)	Mean	129	203	242	258	211	914	131	0.95
	±S.D.	19	27	25[a]	31	45	103	32	0.08

*G.R. Glycaemic response; *FBS Fasting blood sugar;
P values in comparison with values obtained with glucose;
a=P <0.05; b=P <0.01; c=P <0.001.

The glycaemic response of bread was found to be very similar to that of glucose (0.95 ± 0.08).

The overall glycaemic stimulus (∆G) and the plasma glucose values at each time point following the stimulation was significantly low with uppuma and pongal (P <0.001). The glycaemic stimulus of iddli was also

significantly low (P <0,01); but less as compared to uppuma and pongal.

Plasma insulin response to different diets

Table V shows the mean insulin responses elicited by each test item. Pongal and iddli elicited lower insulin responses (Δ I); but statistically significant differences were seen only with iddli at 30′ and 90′ following the stimulus. The insulinogenic value (ΔI/ΔG) of uppuma was significantly higher (P <0.05) compared to glucose and other food items used. However, the total amount of insulin secreted in response to uppuma (ΔI) is not higher than glucose or any of the other food items.

Table V Plasma insulin response of the patients to different diets

Items tested		Insulin response (uU/ml) 0′	30′	60′	90′	120′	ΔI	ΔI/ΔG
Glucose (n=15)	Mean	19	43	62	73	53	221	0.24
	±S.D.	6	14	19	37	36	89	0.11
Pongal (n=7)	Mean	14	36	53	53	24	168	0.21
	±S.D.	11	23	24	30	11	80	0.10
Iddli (n=7)	Mean	12	25	39	36	46	145	0.16
	±S.D.	11	22	38	24	24	96	0.11
			P<0.05		P<0.01			
Uppuma (n=8)	Mean	14	47	75	79	53	254	0.36
	±S.D.	6	30	29	37	29	113	0.15
								P<0.05
Bread (n=8)	Mean	17	45	71	75	62	252	0.28
	±S.D.	9	19	36	29	20	78	0.10

DISCUSSION

In the present study, the glycaemic response of diabetic subjects to four isocaloric breakfast foods (300 K cal) as compared to that obtained with 75 gm of glucose has been determined. We used 75 gm glucose as recommended by the WHO Expert Committee on diabetes mellitus (9) and adjusted the breakfast meals to a total of 300 K cal. The consumption of different kinds of complex carbohydrates is known to elicit markedly different post prandial rise in

plasma glucose and insulin responses (10). It is also known that combination of foods with different glycaemic indices can give rise to different results (11). A number of factors such as the physical structure of foods, the form of foods, the proportion of carbohydrate, protein and fat and dietary fibre influence the glycaemic index of foods. Moreover in the case of diabetics the total calorie intake is also important (12). Therefore, the diets used in this study have been on an isocaloric basis so as to obtain the glycaemic response to the food consumed as a whole rather than to the carbohydrate content of the food consumed.

In this study, the three breakfast items uppuma, pongal and iddli are found to be suitable for diabetic patients as their glycaemic responses are low. White bread is found to be unsuitable as its glycaemic response was as high as that of glucose itself. Further, the insulinogenic index of these 3 items were also not higher than glucose. However, uppuma which produced the lowest glycaemic response elicited the highest insulinogenic index.

All the four items tested had similar carbohydrate content and thus the differences in glycaemic responses could arise mainly due to the type and form of carbohydrate available from each food item and to the presence of non carbohydrate constituents ie fats, proteins and unavailable carbohydrates which differ in digestion, absorption and metabolism. Bread which had slightly lower carbohydrate content (58 gms) than iddli (61 gms) showed higher glycaemic response and this was probably related to the presence of refined form of carbohydrate. The presence of lower dietary fibre content (4 gms) also could have resulted in higher blood sugar values. However, the role of dietary fibre in influencing the glycaemic response is variable as uppuma which also contained low fibre content (4 gms) elicited the lowest blood sugar response. Though pongal and iddli were identical with respect to the fibre contents (7.4 gms and 8 gms respectively), pongal produced a lower blood sugar rise. Thus the contribution of food fibre in influencing the glycaemic response of these food items appears to be inconclusive. It may be that the metabolic effects of dietary fibre were not noticeable as it did not possess the desired quality and its ratio to other nutrients in the diets was not sufficiently high (13).

The biological value of the proteins in iddli and pongal are higher than those present in uppuma and bread.

However, the effect of such differences on the glycaemic response is not known.

Fat content of the food items may have had some influence as the two items, uppuma and pongal with higher fat contents showed lower glycaemic responses.

Reports of studies on the effects of dietary starch on post prandial plasma glucose and insulin responses indicate there are differences in response to different starchy foods owing possibly to differences in the rate of digestion and absorption (14,15). The differences are even more exaggerated in patients with frank glucose intolerance. Gastric emptying time, physical availability to the hydrolytic enzymes and differences in stimulation of gastric intestinal insulinogenic hormones have been implicated as influencing factors. Post prandial plasma insulin response is known to be partially dependent on the ability of food constituents like protein and fat to stimulate the secretion of a number of gastro intestinal insulinogenic hormones (16-18).

The results of this study corroborate the observation of several other workers (8,11-13) that the mode of cooking, the form of food and processing the food influence the glycaemic response as shown by results obtained with uppuma and white bread. In this study, the two breakfast items which contain mixed contents of cereals and pulses namely pongal and iddli are found to be suitable for the diabetic patients. Uppuma was also found to be better than bread. Hence these food items are suitable for diabetic patients.

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