GLYCAEMIC INDEX OF THREE DIFFERENT MIXED MEALS

Introduction

The recommended carbohydrate intake of diabetics is increasing and dietary guidelines by different Diabetic Associations and W.H.O. have recommended the use of complex carbohydrates and high fibre diets which result in better diabetic control. Although the glycaemic index of individual foods has been determined [1, 2] it is essential to find out the values for mixed meals since individual foods are not consumed as such.

The Objectives of this study were :

a) To evaluate the glycaemic index of three types of mixed meals. b) To determine whether large differences existed, which favoured the use of a particular meal. c) To relate differences to variables like nature of starch, methods of preparation, type and amount of proteins and fibre.

Methods

Motivated diabetic volunteers (NIDDM) were selected from the diabetic clinic. 5 groups of five patients each were designated. The clinical characteristics of the subjects are presented in Table l. The age of the subjects ranged from 40-60 yrs, and duration of the disease from 0-28 yrs. All subjects were within 20% of their ideal body weight. During the experimental period subjects were encouraged to follow their diet strictly and maintain the same physical activity.

Table 1

Clinical Characteristics of Volunteers in Four Groups

	No. SEX	AGE Yr ±SD	Ht (Cm) ±SD	Wt (Kg) ±SD	BMI ±SD	Duration (yrs) ±SD
STD Group	3 M	52.0	164	65.2	24.3	7.0
	2 F	±3.21	±7.21	±8.22	±3.22	9.4
Group A	3 F	53.0	161.6	72.0	27.6	7.4
	2 M	±4.58	±13.35	±10.68	±2.88	10.06
Group B	4 M	52.6	166.0	67.4	24.4	6.8
	1 F	±7.13	±6.78	±12.84	±3.65	8.04
Group C	4 F	48.8	157.4	62.1	25.4	9.0
	1 M	±7.40	±7.30	±6.48	±3.65	12.31
P 0.0	12 patients on O.H.A.		4 patients on Diet alone			

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To test the statistical significance of the differences in the mean value of age, Ht., Wt. and BMI between the 4 age groups i.e. standard; A, B and C, one- way analysis of variance was applied.The mean values of all these parameters in 4 groups was found to be statistically comparable.

Three commonly used Indian meals were prepared in the Hospital Kitchen by dietetic interns. The patients were asked to consume their meal in 10 minutes. The composition of the meals is given in table 2.

Table 2

Composition of the Test Meals

Ingredients	Qty. g	Carbohydrates g	Proteins g	Fats g	Fibre g
Diet 'A'-Chappati					
Whole wheat flour	25				
Bengal gram flour	25	34.0	8.0	--	1.5
Curds	200	8.0	6.0	6.0	-
Green Vegetables	125	7.0	2.0	-	1.0
Cooking oil	5	-	-	5.0	-
		49.0	16.0	11.0	2.5
Diet 'B'-Rice					
Rice	25	19.0	2.0	-	0.1
Sambar	25	15.0	5.0	-	
Curds	200	8.0	6.0	6.0	
Green vegetable	125	7.0	2.0	-	1.0
Cooking Oil	5	-	-	5.0	
		49.0	16.0	11.0	1.1
Diet 'C'-Bread					
White bread slices	60	30.0	4.0	-	-
Cutlet					
Chicken	25	-	7.0	-	-
Potato	50	10.0	-	-	-
Peas	25	2.0	-	-	0.1
Milk	200	8.0	6.0	6.0	-
Cooking Oil	5	-	-	5.0	-
		50.0	17.0	11.0	0.1

Test meals contained 50 g carbohydrate equivalent of specific foods as estimated from food tables of I.C.M.R.

Test meals were compared with a standard of bread + cottage cheese[2] containing 50 g carbohydrate equivalent from bread. Cottage cheese was added to provide same protein in the meal, approximately equal to the one present in test meals. The mean glycaemic index in 5 volunteers with this standard was 98% SD ± 14.

The bread meal was also standardised against 50 g glucose in diabetic subjects. All meals and standard were taken with 1 cup of tea (200 ml) containing milk in known amount.

Volunteers took their oral drugs 1/2 hour before meals and the blood samples were drawn after 1 hour, 2 hours and 3 hours after the ingestion of the meal.

Venous blood was analysed for sugar by orthotoluidine method.

The blood glucose area for each meal was expressed as a percentage of the meal area of that same patient individuals standard (bread + cottage) cheese test. The mean of these values for each meal was defined as the glycaemic index (G.I.)[2] of that meal.

Glycemic Index

$$= \frac{\text{Area under the 3 hour glucose response curve for test meal.}}{\text{100 Area under the glucose response curve for the equivalent amount of bread (standard)}} \times 100$$

Discussion

The difference in the glycaemic response is determined to a large extent by the rate of luminal digestion and hence absorption of foods[3]. The major factors[4,5] influencing the glycaemic response are :

1) Difference in oligosaccharide content (Fructose and, sorbitol vs glucose)
2) Differences in complex carbohydrate (potato vs rice)
3) Nature of starch and its digestibility
4) Physical characteristics of foods - rate of biological degradation
5) Methods of preparation
6) Food combinations
7) Protein and their forms
8) Dietary fibre
9) Enzyme inhibitors
10) Satiety and palatability of foods

Table 3
50 g Carbohydrate of Diet A with Bread Standard Meal

Volunteer		F	1 H	2 H	3 H	G.I.
No. 1	Diet A	160	200	160	120	30000
						-----x 100=66%
	Std.	186	269	300	180	45240
No. 2	Diet A	112	130	100	95	20040
						------x 100=68%
	Std.	113	200	180	110	29520
No. 3	Diet A	117	142	120	100	22260
						------x 100=68%
	Std.	144	220	180	144	32640
No. 4	Diet A	144	125	95	90	19380
						------x 100=71%
	Std.	125	180	150	130	27480
No. 5	Diet A	107	120	100	95	19320
						------x 100=74%
	Std.	140	180	138	100	26280

Mean G.I. of Diet A = 69%
S.D. ± 3.13

Table 4
50 g Carbohydrate of Diet B with Bread as Standard

Volunteer	F	1H	2H	3H	G.I.
No. 1	Diet B	110	167	160	125	26760
						-----x 100=82%
	Std.	138	210	188	151	32580
No. 2	Diet B	140	160	142	120	25920
						-----x 100=79%
	Std.	144	220	180	144	32640
No. 3	Diet B	120	170	150	135	26880
						----- x 100=81%
	Std.	115	210	200	170	33180
No. 4	Diet B	100	130	120	100	21000
						----- x 100=80%
	Std.	140	180	138	100	26280
No. 5	Diet B	125	150	140	110	24480
						----- x 100=82%
	Std.	125	200	180	140	30780

GI - of Diet B
Mean = 80.4%
S.D. = 1.14

Table 5
50 g of Carbohydrate of Diet C with Bread as Standard

Volunteer	F	1H	2H	3H	G.I.	
No. 1	Diet C	125	159	140	128	25560
						-----x 100=81%
	Std.	145	220	180	140	31560
No. 2	Diet C	131	159	145	137	26940
						-----x 100=80%
	Std.	118	215	200	170	33600
No. 3	Diet C	128	162	125	112	24480
						----- x 100=80%
	Std.	125	200	180	140	30780
No. 4	Diet C	120	150	130	100	23400
						----- x 100=80%
	Std.	115	198	180	105	29340
No. 5	Diet C	111	155	120	95	22740
						----- x 100=79%
	Std.	120	192	175	100	28680

GI - of Diet C
Mean = 80%
S.D. = ± 0.71

Table 6
Glycaemic Index of three Mixed Meals (in percentage)

Diet A		Diet B	Diet C
G.I. - 69		80.4	80
S.D. ± 3.13		S.D. ± 1.14	S.D. ± 0.71
Statistical Significance			
T = A : B = 7.64	P<0.001		
= B : C = 0.67	N.S.		
= A : C = 7.36	P<0.001		

The composition of the starch is important and it has been seen that different oligosaccharides like fructose and glucose have different glycaemic response. Carpo[6] and Coulston[7] compared the glycaemic index of bread, rice. potato and corn in normal and diabetic subjects and found that the differences between them was related to the nature of the starch and its digestibility. It was suggested that highly branched amylopectins were digested more rapidly and since legumes contain a high percentage of amylase the digestibility of legume starch is less, and hence, legumes have a lower glycaemic response. Whistler of et al found the amylase content[8] of

Bengal gram to be 33% wheat to be 25 % potato, 23% which was in accordance with the findings of Carp et al and Coulston et al.

Rate of biological degradation and size of the starch is also important. A slower glucose response was observed for raw and large particles as compared to finely ground and cooked particles. [4,9] The findings of Whistler and Charles further strengthened this observation :

Size of starch in wheat is 20-25 microns, in potato is 15 microns, and in rice 5 microns.

Starch digestibility is affected by cooking and the method of preparation. When exposed to heat, starch gets broken down to dextrins which in turn form the readily soluble disaccharide maltose on exposure to the enzyme β amylase. Thorne et al showed that dry cooking (roasting) leads to slower absorption and digestion of starch as compared to wet cooking (boiling). Also a slower glucose response is observed when the cooking time is short.

Food combination like fats and proteins have a role to play. It has been seen that medium chain fatty acids as in coconut oil (12 - 14 C) and long chain fatty acid (14 C and above) as in soya, til, corn and groundnut have slow absorption and utilization, [10] as compared to short chain fatty acids like butter and ghee.

Thorne et al[4] reported that legume proteins have more tightly bound-carbohydrates and hence show a slow glucose response. They also indicated that antinutrients, enzyme inhibitors, phytates, saponins and tannins may hinder digestibility leading to a low glycaemic index.

Reports showing slow utilization of high satiety foods have also been published.

Dietary fibre

A; Vinik[5] has highlighted the role of fibre in the diet, stressing the following points :

1) Delayed gastric emptying and nutrient absorption
2) Prolonged intestinal transit time
3) Altered GEP hormone release

   - release of gastro-entero-pancreatic hormone which enhances insulin secretion.
4) Increase in insulin receptors
5) Antienzyme activity which inhibit hydrolysis of complex carbohydrates
6) May limit physical access of hydrolytic enzymes.

In the present study the amount of carbohydrates, proteins and fats was kept constant with varying amount of fibre, as present in a typical diet. The type of carbohydrate used was however different in terms of wheat, rice and bread.

Diet A containing whole cereal + Bengal gram cooked in the form of chappati had the lowest glycaemic index of 69% as compared to Diet B and C.

This could be attributed to the fact that Diet A had high fibre content and it has been also seen that the cell structure of the bean cell reduces absorption

Glycaemic Index of some Commonly Used Foods as reporrted by (Jenkins) [1,2] is as follows

Cereals		*Legumes & Grams*	
Barley (Jau)	31%	Soya Beans	15%
Buck Wheat (Kottu)	51%	Kidney Beans (Rajmah)	29%
Corn	59%	Red lentil (Masoor)	29%
Oats (Jav)	49%	Black eye peas (Lobia)	33%
		Bengal gram whole (chana)	47%
Vegetable & Fruits		*Milk & Milk Products*	
Plums	34%	Milk	32%
Grape fruit	36%	Milk (whole)	34%
Apples	32%	Curds	36%
Orange	40%		
Miscellaneous Foods			
Fructose	20%		
Peanuts	13%		

of starch. The cooking time of chappati was also less as compared to rice and sambar and it has been shown that increased cooking time increases gelatinization thus increasing starch digestion. Size of the starch particles may also have a role to play as larger particles digest more slowly and wheat has larger particles than rice.

Thus, from the present study it is concluded that meals containing complex carbohydrates with fibre have lower glycemic index. The need to familiarize with Indian foods of low glycaemic index and incorporate them into regional diets is evident.

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