GLYCEMIC INDEX OF SPRIULINA SUPPLEMENTED MEALS

Uma Iyer*, Shilpa deshmukh*, Uliyar Mani*.

ABSTRACT :

Glycemic index (GI) of four Indian regional meals (Punjabi, South Indian, Gujarathi, and West Bengali) supplemented with 2.5 g of spray dried spriulina powder, was determined in twenty four normal subjects in the age group of 20-25 years. The subjects were fed equicarbohydrate meals providing 75 g of carbohydrates. The GI of Punjabi meal supplemented with 2.5 g of sprirulina was the lowest whereas the GI of Gujarathi meal supplemented with the same amount of spirulina was the highest.

KEY WORDS : Glycemic index; Indian regional meals

INTRODUCTION :

Dietary composition affects metabolic control in subjects with impaired glucose tolerence and diabetes. Current dietary recommendations emphasize an increased consumption of complex carbohydrate (CHO) or strachy foods. This has spawned a new area in research leading to the concept of glycemic index (GI). This is logical and reproducible tool for ranking CHO foods on the basis of blood glucose response they produce. GI has been supported by many studies and has wide clinical and therapeutic applications. As foods are not consumed in isolation but as mixed meals, it was found that the GI is also applicable to mixed meals. The glycemic indices of the mixed meals could be predicted from the glycemic indices of the compound carbohydrate foods. Spirulina, a blue-green algae, is known for its potential to bring about a nutrition revolution in developing countries. It is known for its various therapeutic implications, one of them being its hypoglycemic effects studied in diabetes. Spriulina supplimentation is helpful in retarding the progration of secondary complications in patients with non insulin dependent dibetes mellitus by bringing down the primary as well as secondary metabolites such as the fasting blood glucose levels, lipid profile and glycated serum proteins[1]. As the literature available on Indian meals is very sparse, and taking into consideration the hypoglycemic effect of spriulina, the present study was planned to determine the GI of four Indian regional meals (Punjabi, South Indian, Gujarathi and West Bengali) supplemented with 2.5 g of spirulina powder in normal subjects. As hyperlipidemia is a common complication associated with diabetes, the triglyceride (TG) response of these recipes were also monitored.

METHODS AND MATERIALS :

Twenty four normal subjects in the age group of 20-25 years were selected for testing the glycemic responses of the recipes. These were than randomely divided into four group each consisting of six subjects. The clinical data of the subjects. The clinical data of the subjects is given in Table 1. On the first visit, an oral glucose tolerance test with 75g of glucose was conducted for all the subjects. Serum glucose was determined by glucose oxidase method in fasting and post prandial, one and two hour venous blood samples. Serum triglycerides were determined in fasting and two hour post prandial blood samples by the method of McGawan (1983) [2]. On the subsequent visit (within 2 weeks), the subjects were given a test meal containing 75g carbohydrate which was consumed over an 8-10 minute interval. The composition of the food was determined by the food tables complied by Gopalan et al (1983)[3]. Blood glucose response and triglycerides were again monitored for the different groups, fed different meals. Blood glucose response curves for the glucose load and the test food were plotted and GI was calculated using the method described by Jenkins et al (1981) [4] in which the ratio of the areas under the glucose

Table 1 : Clinical profile of the subjects

Variable	Mean ± SD
Number of subjects	24
Age (years)	22.0 ± 1.55
Height (m)	1.58 ± 0.05
Weight (kg)	50.5 ± 10.73
Body Mass Indes (BMI)	19.69 ± 3.72
Waist (cm)	68.18 ± 9.27
Hip (cm)	95.21 ± 7.58
Waist/Hip ration	0.71 ± 0.05

* Department of Foods and Nutrition, M.S. University of Baroda, Vadodara 390 002.

response curve for the food was compared with that of the glucose tolerence test (GTT). The TG response was calculated by finding the percent increase in mean TG value over mean fasting value for each group. The recipes tested were Punjabi meal with spriulina (R1), South Indian meal with spirulina (R2), Gujarathi meal with spirulina (R3), and West Bengali meal with Spirulina (R4). R1 consisted of roti, rajmah curry, rice and curd. R2 consisted of rice, sambhar, vegetable (cluster bean, pumkin) and curds, R3 consisted of phulka, rice, dal and vegetable (cauliflower, potato and tomato) and R4 consisted of rice dal, charchari and fried fish. The composition and nutritive value of all the four recipes is given inTable2.

Table 2: Nutrient compostion of recipes

Recipe I (Punjabi meal)
Roti, Rajmah, curry, Rice, Curd

Ingredients	Amounts (g)	Energy (Kcal)	Protein (g)	Fats (g)	CHO (g)	Fibre (g)
Roti						
Wheat flour	60	205	7.26	1.02	41.69	1.1
Oil	4	45	-	5	-	-
Rajmah Curry						
Rajmah	30	104	6.87	0.39	18.18	1.44
Onion	30	18	0.58	0.5	3.78	0.18
Tomatoes	30	6	0.27	0.06	1.08	0..24
Ginger	2	1	0.04	0.01	0.2	0.04
Garlic	2	3	0.13	0.002	0.29	0.01
Oil	10	90	--	10	--	--
Rice	10	35	0.68	0.04	7.82	0.02
Curds	100	60	3.1	4.0	3	--
Total..		567	18.93	20.57	76.04	3.07

Recipe II (South Indian meal)
Roti, Sambhar, Vegetable, Curd

Ingredients	Amounts (g)	Energy (Kcal)	Protein (g)	Fats (g)	CHO (g)	Fibre (g)
Rice	60	207	4.06	0.29	46.92	0.12
Sambhar						
Redgram Dal	25	84	5.57	0.42	18.18	1.44
Onion	30	18	0.58	0.5	3.78	0.18
Tomatoes	30	6	0.27	0.06	1.08	0..24
Ginger	2	1	0.04	0.01	0.2	0.04
Garlic	2	3	0.13	0.002	0.29	0.01
Oil	10	90	--	10	--	--
Rice	10	35	0.68	0.04	7.82	0.02
Curds	100	60	3.1	4.0	3	--
Total..		484	15.45	15.14	76.38	3.2

Recipe III (Gujarathi meal)
Phulka, Vegetable, (cauliflower, potato, tomato) Dal, Rice.

Ingredients	Amounts (g)	Energy (Kcal)	Protein (g)	Fats (g)	CHO (g)	Fibre (g)
Phulka						
Wheat flour	60	204	7.26	1.02	41.64	1.14
Oil	5	45	--	5.0	--	--
Vegetable						
Cauliflower	25	7	0.65	0.1	1.0	0.3
Ptotato	20	19	0.32	0.02	4.52	0.08
Tomatoes	30	6	0.27	0.06	1.08	0.24
Onions	25	15	0.45	0.02	3.15	0.15
Oil	5	45	--	0.02	--	--
Dal						
Redgram dal	15	49	6.69	0..25	8.62	0.11
Jaggery	5	17	--	--	4.5	--
Oil	5	45	--	5	--	--
Mustard seed	2	6	0.4	0.78	0.48	0.02
Rice	15	52	1.02	0.07	11.73	0.03
Total..		484	15.45	15.14	76.38	3.2

Recipe IV (West Bengali meal)
Fried Fish, Dal, Charachari, Rice

Ingredients	Amounts (g)	Energy (Kcal)	Protein (g)	Fats (g)	CHO (g)	Fibre (g)
Fried Fish						
Fish (Katla)	80	89	15.6	1.92	2.32	--
Oil	5	45	--	5.0	--	--
Dal						
Green gram dal	25	87	6.12	0.3	14.9	0.2
Coconut fresh	5	22	0.22	2.08	0.65	0.18
Oil	2.5	22	--	2.5	--	--
Ghee	2.5	22	--	2.5	--	--
Ginger	2	1	0.04	0.01	0.2	0.04
Sugar	2	8	--	--	2.0	--
Rice	55	190	3.74	0.27	43.0	0.11
Charchari						
Brinjal	40	10	0.56	0.12	1.6	0.52
Potato	20	19	0.32	0.02	4.52	0.08
Sweet Potato	20	24	0.24	0.06	5.64	0.08
Sugar	1	4	--	--	1.0	--
Oil	10	90	--	10.0	--	--
Total..		634	26.8	24.8	75.8	1.29

Table 3: Glycemic index of Spirulina supplemented recipes (Mean ± SD,%)

	Recipe	Glycemic Index	F Value
R1	Punjabi meal	24.0 ± 16.64	
R2	South Indian meal	52.8 ± 21.18	1.35 NS
R3	Gujarati meal	60.6 ± 21.89	
R4	West Bengali meal	58.0 ± 8.87	

RESULTS :

The GI values obtained for the recipes are given in Table 3. The GI of R1 – Punjabi meal was found to be lowest whereas the GI of R3 ---- Gujarathi meal with spirulina was found to be the highest. Table 4 represents the mean value of blood glucose responses to a 75g glucose load as well as of the various test recipes.

Table 4 : Blood glucose responses of oral glucose tolerance test and spirulina supplemented recipes (Mean ± SD, mmol/L)

Carbohydrate Source	Fasting Blood Glucose Response	Post Prandial Blood Glucose Response 1h	2h
Glucose	4.32 ± 9.47	6.21 ± 16.92	4.66 ± 12.35
R1	3.99 ± 6.47	4.6 ± 8.07	4.05 ± 8.55
Glucose	4.6 ± 5.75	6.60 ± 10.62	5.04 ± 9.95
R2	4.48 ± 8.88	5.49 ± 14.79	4.55 ± 6.07
Glucose	4.43 ± 11.36	5.99 ± 11.21	4.99 ± 9.75
R3	4.49 ± 8.51	6.38 ± 19.58	4.66 ± 12.22
Glucose	4.16 ± 6.61	8.04 ± 16.05	5.32 ± 21.66
R4	4.16 ± 8.85	6.27 ± 6.76	5.38 ± 10.22

DISCUSSION :

Diabetic patients are advised to select carbohydrate foods that minimise post prandial blood glucose fluctuations. The systematic classification of carbohydrate foods was first done by Otto and colleagues who after testing individual foods, allowed their incorporation into the diabetic diet in proportion to their glycemic responses.

Studies carried out by Jenkins et al[5], Hoover Plow et al[6]. Krezowski et al[7], Wolever et al[8] showed equicarbohydrate foods eliciting wide variations in their glycemic responses and thus supporting the concept of GI and its therapeutic utility by ranking foods in terms of their glycemic responses, and identification and incorporation of foods producing relatively flat glycemic responses in the diets of diabetics.

Starch digestion is an important determinant of the glycemic responses produced by a carbohydrate food. There are large differences in the degree to which different starch containing foods affect the blood glucose levels[9] and these differences are attributed to factors like nature of digestibility of starch, nutrient starch interaction, antinutrients, method of cooking and processing and also protine, fat, and fiber content of the diet. Several studies carried out earlier (10-12) indicate that addition of legumes or pulses and green leafy vegetables, helps to increase the fiber content of the recipes, thereby bringing down the glycemic responses.

Two Polysaccharides, amylose and amylopectine are present in various ratios in food starches [13]. Amylose is more resistance to cooking and digestion than amylospectin which is more readily gelatinised and hydrolysed. In vivo studies of whole legumes (30-40% amylose) have indicated that they are produce lower glycemic response than cereals (25-30% amylose)[14]. The integrity of the cotyledon cell had also been suggested as a major determinant of starch digestion both in vitro and in vivo[15]. Studies conducted by Throne et al[9] on reconstitued precooked red kidney bean flours with and without cell enclosed starch indicated that starch is digested at lower rate when present within the intact cell wall. Also, a study conducted by Rea et al[16] showed that lectin affects the rate of starch digestion and foods high in lectin concentration elicit low GI. Red kidney beans are rich in lectin and in present study, R1 elicited the lowest GI as compared to other recipes, which could be attributed to the presence of kidney beans in R1.

Rice has higher amylopectin content. The amylopectin branching pattern affects the physical characteristics of starch with regard to its cooking quality and digestibility thus resulting in high GI[15]. R2 and R4 were rice based meals. The higher GI of these two meals as compared to R1 can be attributed to the presence of rice in higher amounts in R2 (60 g) and R4 (55g) as compared to R1 (10g).

The coingestion to fat is important while predicting the blood glucose response of starchy foods since fat is known to reduce the rate of gastric emptying[17]. R4 had highest fat content (24.8g) and consequently showed a low GI compared to R3 with fat content of 17.1g. R1 had higher fat content (20.6g) as compared to R2 (15.5g). Thus, the association of fats with carbohydrates results in a lower glucose response.

Fibre is also one of the important component, of the diet which helps in reducing the glycemic responses. Legumes contain substantial quantity of both water soluble and water insoluble fibre. The lente nature of the legumes in the diet is attributed to its high content of viscous dietary fibre and high amylose to amylopectin ratio. In the present study R1 and R2 had higher fibre content and thus elicited a lower GI as compared to R3 and R4.

Apart from the fibre rich foods, efforts are on the way to look for foods which are rich in complex carbohydrates, low in fat and high in protein. In this regard spirulina has gained a lot of attention due to its nutritive value. In the present study, it was observed that the addition of 2.5 g spirulina powder brought about glycemic response in the range of 34-60.6%. Earlier in our department, GI of the various regional meals of india without spirulina were determined and the results are tabulated below[19].

Regional Meals	Mean ± SD Without spirulina (Normals)	With Spirulina (Normals)
Punjabi Meal	68.0 ± 19.21	34.0 ± 16.64
South Indian Meal	63.3 ± 4.26	52.8 ± 21.18
Gujarati Meal	83.3 ± 11.41	60.0 ± 21.89
West Bengali Meal	69.9 ± 16.5	58.0 ± 3.87

Iyer et al[20] determined the GI of five rice based recipes (plain rice, rice + green gram dal, rice + red Gram dal, rice + peas, vegetables pulao with curd) supplemented with spriulina at 2.5 g level in normal subjects. The GI ranged from 37-58% for the recipes supplemented with spirulina, with rice showing the highest GI and rice + red gram dal showing the lowest GI.

Hypertriglyceridemia is commonly present in patients with NIDDM. Studies done by Cerami et al[21] and Reaven et al[22] have shown that diabetes mellitus brings about alterations in lipid metabolism. Hence, dietary recommendations must aim at reduction of post prandial lipemic response along with glycemic response. In view of this, the triglyceride response of the test meals were also monitored. The percentage of triglyceride rise in the test meals is given in Table 5.

Table 5 : Triglyceride responses of oral glucose tolerance test and spriulina supplemented recipes (Mean ± SD, mmol/L)

Carbohydrate Source	Fasting Response	Post Prandial 2 Hour	%Rise Over Fasting
Glucose	0.55 ± 0.05	0.56 ± 0.08	
R1	0.60 ± 0.07	0.62 ± 0.03	3.3
Glucose	0.53 ± 0.04	0.49 ± 0.04	
R2	0.72 ± 0.16	0.77 ± 0.32	6.9
Glucose	0.55 ± 0.05	0.53 ± 0.09	
R3	0.63 ± 0.19	0.92 ± 0.12	46.0
Glucose	0.70 ± 0.13	0.65 ± 0.08	
R4	0.55 ± 0.06	0.65 ± 0.08	18.2

The least percentage rise from fasting to two hour post meal was found for Punjabi meal was found for Punjabi meal supplemented with spirulina (3.3%). The remaining three test meals showed a rise in the range of 6.9-46%.

Wolever et al[23] have reported that low GI diets brought about a 20% reduction inTG levels in patients with hypertriglyceridemia. A study carried out to determine the glycemic and lipemic responses of various rice based spirulina supplemented recipes indicated a low rise in serum triglyceride levels[20].

CONCLUSION :

The results of the present study support the primary findings regarding the hypoglycemic and hypolipdemic effect of spirulina. Hence spray dried spirulina powder can be incorporated into a diabetic diet for improving the carbohydrate and lipid diet for improving the carbohydrate and lipid metabolism in diabetics.

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