Mal J Nutr 17(3): 393 - 399, 2011

Short Communication

Glycemic Index Determination of Vegetable and Fruits in Healthy Bangladeshi Subjects

Fatema K[1], Sumi N[1], Rahman F[1], Kobura K[1] & Ali L[2]

[1] *Dept of Epidemiology, Bangladesh Institute of Health Sciences (BIHS), 125/1 Darus Salam, Mirpur, Dhaka-1216, Bangladesh*
[2] *Dept of Biochemistry & Cell Biology, Bangladesh Institute of Health Sciences 125/1 Darus Salam, Mirpur, Dhaka-1216, Bangladesh*

ABSTRACT

Introduction: Fruits and vegetables are an important part of the diet especially for their complex carbohydrates, dietary fibre and micronutrients. The present study investigated the glycemic index (GI) of a vegetable [carrot (*Daucas carota)*] and fruits [banana (*Chapa kola*) *Musa Sp.* and plum (*Bau kul*) *Zizyphus mauritiana*] of Bangladeshi origin. **Methods:** Fourteen healthy Bangladeshi subjects, comprising 7 males and, 7 females, with mean age of 26 ± 3 years, BMI 22 ± 3 kg/m^2, waist-hip ratio of 0.89 ± 0.01 and 0.84 ± 0.04 respectively for males and females. Under a cross-over design, they consumed equi-carbohydrate amounts (25 g of total available carbohydrate) of the test foods and two times glucose as reference food (25 g of total carbohydrate), with a run in period of 7 days between the consecutive items. Serum glucose levels were determined at 0, 30, 60, 90, and 120 min. The GIs was calculated. **Results:** The carrot, banana and plum samples showed significantly lower serum glucose values (incremental area under the curve 30.4 $\pm$ 12.6, 37.3 $\pm$ 19.2 and 41.8 $\pm$ 20.7 respectively) than glucose (132.7± 36.0). The carrot showed a lower GI value than banana and plum respectively (23 ± 9, 30 ± 18 and 32 ± 15). **Conclusion:** The vegetable and fruit samples tested of Bangladesh origin were shown to have comparatively low GI values.

Keywords: Carbohydrate, diet, fruits, glycemic index, glycemic load, vegetables

INTRODUCTION

Dietary guidelines recommend increased intake of dietary fibre for better control and proper management of chronic diseases such as diabetes mellitus, cardiovascular disease and cancer (Food and Nutrition Research Institute, Phillipines, 2000). The physical and chemical properties of dietary fibre, for example, its viscosity and fibrous structure, have an important role in the release and absorption of nutrients in spite of having different amounts of carbohydrates. Post-prandial glycemia is influenced by both the amount and the type of carbohydrates in the foods. The nature of carbohydrates is best described by their glycemic indices (GIs) (WHO, 2010). GI is defined as the incremental area under the blood glucose response curve following consumption of a food portion containing 50 g of available carbohydrates relative to

* Correspondence author: Kaniz Fatema; Email: *kfatema@bihs.edu.bd; kanizfatemadina@pushti.org*

that produced by a portion of a control food (either glucose or white bread) containing the same amount of carbohydrate. GI is a useful indicator to rank the biological response of dietary carbohydrates and can be converted to a practical tool referred to as the glycemic load (GL) for routine dietary advice. The GL is determined by multiplying the GI of a food by the grams of carbohydrates in a serving (Foster-Powell, Holt & Brand- Miller, 2002).

Recent evidence suggests that high GI / GL diets may increase the risk for cardiovascular diseases (Liu *et al*., 2000; Amano *et al.*, 2004) and type 2 diabetes (Hodge *et al.*, 2004; Schulze *et al*., 2004). Due to inherent botanical differences of foods from different countries, the GI of food products can differ (Foster-Powell *et al.*, 2002). Emphasis has been given on the need for individual countries to carry out their own GI testing, particularly with raw agricultural products like vegetables, fruits and rice which are more likely to vary from one geographical location to another (Rahman *et al.*, 2011; Fatema *et al*., 2011).

This study was conducted with carrot (*Daucas carota*), banana (*Musa Sp.*) and plum (*Zizyphus mauritiana*) which are very commonly consumed in Bangladesh (Razzaque & Hossain, 2007).

The nutritional value of these fruits and vegetables makes them an excellent choice for both weight control and general health. Carrot contains 87% of water, is rich in calcium and high in fibre (BCSIR, 2009). Plum is a good source of vitamin C (BCSIR, 2009). Both the banana and the plum are the richest sources of calcium (BCSIR, 2009). The objectives of the study were to determine blood glucose response after consuming three types of Bangladeshi vegetables and fruits as well as their GI and GL values in healthy Bangladeshi respondents.

METHODS

Fourteen healthy subjects constituted the sample for this study after obtaining their informed consent. The inclusion criteria for the selection of the subjects were age between 18 to 45 years, BMI below 25 kgm^2, not on any medication and with a fasting blood glucose <110 mg per dl (6.1 mmol per L) (WHO, 1980). They were requested to maintain their usual daily food intake and activity schedule throughout the study period.

The protocol was approved by the Ethical Review Committee of the Diabetic Association of Bangladesh.

The subjects were requested to go through the study protocol on five separate occasions (one trial for each test food and two repeated trials for the reference food) in the morning after a 10–12 h overnight fast. The test with the reference food was repeated to obtain at least two values in each subject, thus improving the precision (Brouns *et al.*, 2005). The test and reference meals were given to the subjects under a cross-over design with a wash out period of 7 days to avoid the 'second meal effect'. The subjects were advised to rely on recommended standard carbohydrate diet and also instructed not to eat legumes in the meal preceding the fast (Table 1).

An intravenous cannula was inserted into a superficial vein in the forearm on the day of experiment to draw the fasting (0 hr) blood sample of the subjects. Subjects were requested to consume the test food with 250 ml plain water (during the protocol of the test foods) or the glucose in 250 ml of water (during the protocol of the reference food) in random order at a comfortable place within 10 min of each intake. Further blood samples were drawn at 30, 60, 90 and 120 min after the initial intake of sample. All the information and data obtained were recorded in a predesigned Case Record Form. Blood samples were centrifuged at 3000 rpm for 15 min. The separated plasma was allocated into labeled Eppendorf tubes and preserved at –70°C until biochemical analysis. Serum glucose was analysed by glucose oxidase (GOD-PAD) method using reagents from SERA PAK, USA.

Table 1. Nutrient composition of the Test Meals (g per 100 g)

Sample	*Moisture (%)*	*Ash (%)*	*Protein (%)*	*Fat (%)*	*Crude Fiber (%)*	*CHO (%)*	*Vit-c (%)*	*Iron (%)*	*Calcium (%)*	*Energy (Kcal/100gm) (Calculation)*
Carrot	87.00	0.30	1.51	0.92	1.0	9.27	6.00	0.80	31.72	51.40
Banana (*Chapa kola*)	74.04	0.66	2.84	0.60	0.40	21.46	15.00	0.50	40.00	102.60
Plum(*Bau kul*)	80.00	0.25	1.50	0.18	0.50	17.57	27.01	1.50	49.11	77.90

Source: Values were taken from Institute of Food Science and Technology (BCSIR), Dhaka, Bangladesh 2009.
Determination of the macronutrient and micronutrient analysis was done by the AOAC method.

All analyses were done using the SPSS version 11.5. The incremental areas under the curve (iAUC) were calculated by the standardised criteria, ignoring the area below the baseline level. The average iAUC for the two glucose tests was used as the reference value and each subject's GI for each food was calculated. The GL for each food was calculated using serving size practised in Bangladesh. Significance between the mean values of GI was calculated using paired *t*-test. All parametric variables are expressed as M ± SD and non-proportional data are expressed in percentages with $p< 0.05$ and $p< 0.001$ considered as statistically significant.

RESULTS

The participants consisted of 7 males and 7 females aged 26 ± 3 years (mean ± SD). Their mean BMI was 22 ± 3 kg / m^2, while their mean waist-hip ratio for the males and females were 0.89 ± 0.01 and 0.84 ± 0.04 respectively.

A significantly different pattern of blood glucose response was observed during the 2 h of dietary regime (Figure 1). The lower serum glucose responses to carrot ($p<0.001$) at 30 and 60 min showed a significant difference compared to glucose. The banana showed a significantly lower serum glucose value compared to glucose at 30 min ($p<0.001$), 60 min ($p<0.01$) and 90 min ($p<0.05$). The banana also showed both significantly lower and higher serum glucose values compared to carrot at 30 min ($p<0.05$) and at 60 min ($p<0.01$) respectively. There were significant lower serum glucose responses to plum ($p<0.001$) at 30 min and ($p<0.01$) at 60 min compared to glucose. The plum showed higher ($p<0.05$) significant differences compared to carrot at 30 and 60 min and was also significantly higher ($p<0.001$) at 30 min compared to the banana. The iAUC values of carrot, banana and plum were significantly lower than that of glucose (incremental area under the curve 30.4 ± 12.6 in carrot, 37.3 ± 19.2 in banana and 41.8 ± 20.7 in plum vs 132.7± 36.0 in glucose; ($p<0.0001$) (Table-2).

Judged against the mean values of the international table (GI: High ≥ 70, Medium 56-69 and low ≤ 55; GL: High ≥ 20, Medium 11-19 and low ≤ 10), the carrot had a lower GI value than the banana and plum [(mean±SD): 23 ± 9 in carrot, 30 ± 18 in banana and 32 ± 15 in plum]. The GL of carrot, banana and plum were 1, 2 and 1.4 respectively (Table-2).

DISCUSSION

The results showed that even at a constant amount of available carbohydrate in the test foods (25 g available carbohydrate), there were significant variations in the glycemic response, confirming that equi-carbohydrate portions of different foods may not

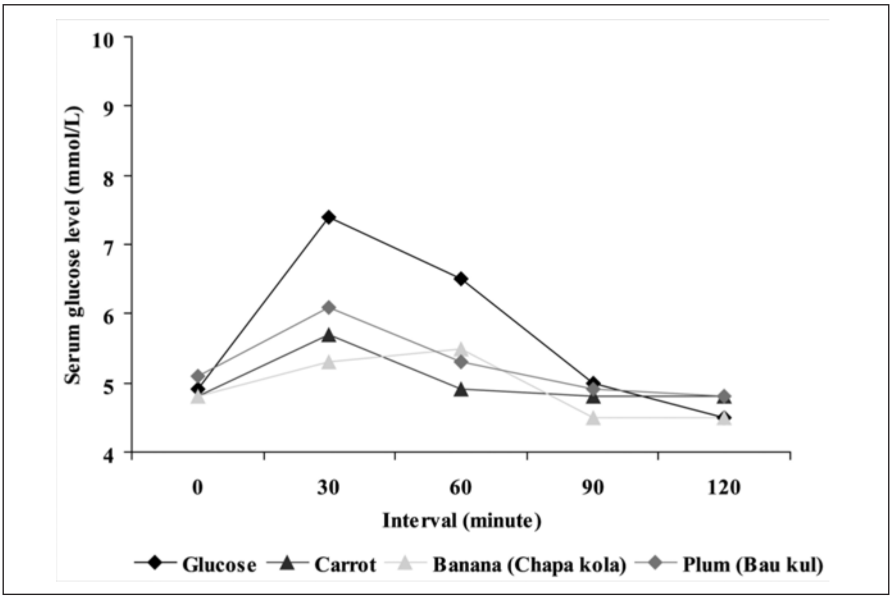

Figure 1. Comparison of three test foods with a reference food (n-14)

necessarily have the same glycemic effect on human subjects. The blood glucose response after consuming carrot was significantly lower when compared with glucose ($p<0.001$). The banana and plum also showed lower glycemic responses compared to glucose. These lower glycemic responses were also reflected in their GI values.

In order to give good dietary advice, it is necessary to know the glycemic index of different foodstuffs in different ethnic and cultural settings. The GI of carrot has been studied in Australia (low GI) but in Canada, it was found to show a high GI on a healthy population study compared with the reference food glucose, respectively (Brand-Miller *et al.*, 1998). A low GI of ripe banana was reported in USA (Brand *et al.*, 1990). Low GIs after consumption of raw plum were reported in Canada, and in Italy on type 2 diabetic subjects compared with the reference food glucose, respectively. These discrepancies between studies may be due partly to the fibre content (Augustin *et al.*, 2002), variations in botanical sources (Brand-Miller *et al.*, 1992) and the moisture content of the fruits and vegetables. This also seems to depend on the adaptation of the gut to specific food types in different populations (Larsen, Rasmussen & Rasmussen, 2000).

In this study we have also calculated the glycemic load (GL) values which express the glycemic effect of realistic serving sizes of different foods. The GL can be defined as the product of the glycemic index (GI) of a food and the amount of carbohydrate in a serving (Foster-Powell *et al.*, 2002). Based on the serving size in Bangladeshi society, the test vegetables and fruits can be considered as very low GL food. So, based on the quality and quantity of carbohydrates, these fruits and vegetables would be very beneficial for diabetic patients as well as for healthy subjects (USDA,USDHHS, 2000).

Fibre rich foods with a low postprandial glycemic response are generally considered valuable. High fibre is believed to be able to reduce the blood glucose response and hence lower the GI value. Vegetables and fruits are excellent components of a diet because of their high nutritional values (particularly with respect to micronutrients). To prescribe

Table 2. Glycemic responses of the study subjects at different time intervals after ingestion of test meals (n=14)

Test foods	*Serum glucose (mmol/l)*					*iAUC (mmol/l)*	*GI (M±SD)*	*GL*
	0 min	*30 min*	*60 min*	*90 min*	*120 min*			
Glucose	4.9 ± 0.5 (100)	7.4 ± 0.9 (149 ± 14)	6.5 ± 1.1 (132 ± 21)	5.0 ± 0.7 (103 ± 14)	4.5 ± 0.5 (93 ± 7)	132.7 ± 36.0		
Carrot	4.8 ± 0.3 (100)	5.7 ± 0.4 (117 ± 6) a***	4.9 ± 0.5 (100 ± 8) a***	4.8 ± 0.4 (99 ± 9)	4.8 ± 0.4 (98 ± 6)	30.4 ± 12.6 a***	23 ± 9	1
Banana (*Chapa kola*)	4.8 ± 0.3 (100)	5.3 ± 0.5 (110 ± 8) a***b*	5.5 ± 0.6 (115 ± 13) a**b**	4.5 ± 0.5 (95 ± 10) a*	4.5 ± 0.3 (95 ± 4)	37.3 ± 19.2 a***	30 ± 18	2
Plum (*Bau kul*)	5.1 ± 0.4 (100)	6.1 ± 0.6 (122 ± 11) a*** b* c***	5.3 ± 0.5 (106 ± 6) a**b*	4.9 ± 0.5 (97 ± 6)	4.8 ± 0.3 (95 ± 4)	41.8 ± 20.7 a***	32 ± 15	1.4

Results expressed as mean ± SD; *$p < 0.05$ and **$p < 0.01$ was taken as the level of significance in paired students *t*-test; a, Glucose; b, Carrot; c, Banana; d, Plum. Carrot, Banana and Plum have 9.27/100 g, 21.46 /100 g and 17.57 /100 g of carbohydrate respectively. To calculate GL, serving size for Carrot was 50 g/serve and for Banana and Plum were 25 g/serve; n, Number of subjects; iAUC, Increment area under the curve. There were no statistically significant differences in GI & GL values.

a particular food, it is important to consider how rapidly the glucose level rises and falls as abrupt rises may lead to unusual demand for insulin secretion from pancreatic β cells. The results of three test meals have shown that at pos-prandial stage after two hours, all the foods maintained the serum glucose levels at the same level.

The study limitations include purchase of the test foods at different times. This might have led to possible differences in glycemic index values, possibly owing to seasonal variations.

ACKNOWLEDGEMENT

The study was supported by grants from the International Program in the Chemical Science (IPICS), Uppsala University, Sweden and Biomedical Research Group (BMRG) of BIRDEM. We express our gratitude to all the subjects who participated in this study.

REFERENCES

Amano Y, Kawakubo K, Lee JS, Tang AC, Sugiyama M & Mori K (2004). Co-relation between dietary glycemic index and cardiovascular disease risk factors among Japanese women. *Eur J. Clin Nutr* 58: 1472-1478.

Augustin LS, Franceschi S, Jenkins DJA, Kendall CWC & La Vecchia C (2002). Glycemic index in chronic disease: a review. *Eur J Clin Nutr* 56: 1049-1071.

Brand JC, Foster KA, Crossman S & Truswell AS (1990). The glycaemic and insulin indices of realistic meals and rye breads tested in healthy subjects. *Diabetes Nutr Metab* 3: 137–42.

Brand-Miller JC, Allwan C, Mehalski K & Brooks D (1998). The glycaemic index of further Australian foods. *Proc Nutr Soc Aust* 22:110 (abstr).

Brouns F, Bjorck I, Frayn KN, Gibbs AL, Lang V, Slama G & Wolever TMS (2005). Glycaemic index methodology. *Nutr Res Rev* 18: 145-171.

Fatema K, Rahman F, Sumi N, Kobura K, Afroz A & Ali L (2011). Glycemic and insulinemic response to pumpkin and unripe papaya in T2DM. *Int J Nutr & Metabol* 3 (1): 1-6.

Food and Nutrition Research Institute (2000) Dietary Guidelines for Filipinos, revised ed. Metro Manila, Philippines: Department of Science and Technology.

Foster-Powell K, Holt SHA, Brand Miller JC (2002). International table of glycemic index and glycemic load values. *Am J Clin Nutr* 76: 5- 56.

Hodge AM, English DR, O'Dea K, Giles GG (2004). Glycemic index and dietary fiber and the risk of type 2 diabetes. *Diabetes Care* 27: 2701-2706.

Institute of Food Science and Technology (BCSIR)(2009). Nutrient Composition of the Test Meals. Determination of the Macronutrient and Micronutrient Analysis. BCSIR, Dhaka, Bangladesh.

Larsen HN, Rasmussen OW & Rasmussen PH (2000). Glycaemic index of parboiled rice depends on the severity of processing: study in type 2 diabetic subjects. *Eur J Clin Nutr* 54: 380-385.

Liu S, Willett WC, Stampfer MJ, Hu FB, Franz M, Sampson L, Hennekens CH & Manson JE (2000). A prospective study of dietary glycemic load, carbohydrate intake, and risk of coronary heart disease in US women. *Am J Clin Nutr* 71: 1455-1461.

Rahman F, Fatema K, Rahim ATMA & Ali L (2011). Glucose, insulin and non-esterified fatty acid responses to ladies finger and pointed gourd in type-2 diabetes mellitus. *Asian J Clin Nutr* 3 (1): 25-32.

Razzaque MA & Hossain MG (2007). The Second Report on Plant Genetic Resources for Food and Agriculture of Bangladesh – The State of Activities. Bangladesh Agriculture Research Council, Ministry of Agriculture. AG-

GCP/RAS/186/JPN, Field Document No.2007/05.

Schulze MB, Liu S, Rimm EB, Manson JE, Willett WC & Hu FB (2004). Glycemic index, glycemic load, and dietary fiber intake and incidence of type 2 diabetes in younger and middle-aged women. *Am J Clin Nutr* 80: 348-356.

US Department of Agriculture (USDA), US Department of Health and Human Services(USDHHS)(2000). Nutrition and Your Health: Dietary Guidelines for Americans. 5th ed. US Government Printing Office, Washington, DC.

WHO Expert Committee on Diabetes Mellitus: second report (1980). World Health Organ Tech Rep Ser; 646:1-80.

World Health Organization. Non-communicable diseases and mental health news (2010). *Newsletter,* 1:13 April.