

Carbohydrate quality, glycemic index and glycemic index_{food} of selected tropical Indian fruits



Food Science

KEYWORDS: glycemic index_{food}, glycemic index, glycemic response, tropical fruits, fructose, dose response

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ABSTRACT

Fruits have the potential to reduce risk of communicable and non-communicable diseases due to the vast range of micronutrients and bioactive compounds present but certain sweet fruits are restricted in the diet of individuals with metabolic disorders because only available carbohydrates are considered while estimating GI. GI_{food}, which uses equi-quantity based comparisons, is a more practical index for measuring glycemic quality. Blood sugar response to specific quantity (50g) of selected Indian tropical fruits (Apple, Sapota, Watermelon, and Banana) was recorded in fasting state and at every half hour interval upto 2 hours upon consuming the fruit and compared with that of same amount of white bread (reference food). It was observed that bread induced significantly higher glycemic response compared to fruits ($p < 0.05$) indicating that type of sugar present affects blood glucose with starch being more hyperglycemic than fructose. Fruits with higher moisture content such as watermelon (GI_{food} 18g) and apple (29g) were shown to have lower glycemic impact than sapota (44g) and banana (36g) when compared on equi-quantity basis contrary to their GI value which was highest for watermelon (103). When glycemic response to 100g banana was tested, the GI_{food} value increased by 30% compared to 50g indicating its dose-responsiveness as opposed to GI which is insensitive to change in food quantity. It can be concluded that even in individuals with diabetes, fruits can be included in moderation with careful selection of the type and amount.

INTRODUCTION

Over the years, fruits and vegetables have earned a respectable place in the food plate because of their high concentrations of vitamins, minerals and phytochemicals as antioxidants. Despite the claims on their health benefits, most individuals have the impression that certain fruits, being sweet in taste, can increase weight and blood sugar greatly, especially the diabetic group.

Quality of carbohydrate is as important as quantity. There is a need to change the notions regarding nature of carbohydrates in foods and their specific physiological response. Also, the nutrient density in the given quantum of food should be given priority over its caloric density.

The Glycemic Index which is the most popular method of classifying foods based on their carbohydrate quality places most fruits and vegetables in the high glycemic category (Jenkins et al 1980). But, although they contain large amounts of available carbohydrates, their high moisture content serves to dilute the glycemic impact of the sugar. When we want to observe physiological impact of foods on the postprandial metabolism in the practical setting, comparisons based on equal quantities of whole food should be preferred (Ray and Singhanian 2014). GI_{food} value is defined as the postprandial blood sugar response elicited by a specific quantity of test food compared with that of same quantity of a standard such as glucose or white bread (Monro 2003).

Glucose being a pure carbohydrate product, not a food, Jenkins (1984) suggested that white bread be considered as reference food. When white bread is used as the standard food; GI_{food} is expressed as Glycemic bread equivalent

This type of representation can help provide a handy tool for day-to-day management of blood sugars in individuals with diabetes and also guide food choices for weight-watchers.

MATERIALS AND METHODS

Clinically healthy adult volunteers (n=25) of both sexes (M=9, F= 16)

were enrolled on the basis of consent to adhere to the experimental requirements. Subjects on medication, infectious disease and hormonal problems were excluded. Written Informed consent was taken from all the subjects. University Ethics Committee approval was obtained for the study.

Fruit Selection: Four common Indian Tropical Fruits were selected for the study, namely Apple (*Malus pumila*), Sapota (*Achras Sapota*), Watermelon (*Citrullus vulgaris*) and Banana (*Musa paradisiaca*). The fruits were bought on the day before feeding trial and stored in refrigerator. Same lot of fruits at similar ripening stage was used for feeding as well as proximate analysis.

Experimental design: After an overnight fast, each subject was fed 50g of each of the selected fruits and white bread on different days. A higher dose of 100g banana and white bread was fed to a subset (n=15) in order to study the dose response. Glycemic Index and Glycemic Load were also calculated by feeding test foods and bread providing 50g available carbohydrates on separate occasions.

Chemical Analysis: The selected Fruits were analyzed for total, reducing, non-reducing sugar, starch and moisture content. The sugar content was analyzed by Lane-Eynon Method and moisture by vacuum oven method (Rangana 2003).

Blood sampling and analysis: Blood sugar level at fasting state and at 30, 60, 90, and 120 min after the ingestion of reference food and test food were recorded using capillary finger prick method -Glucometer (Optium Medisense Glucometer manufactured by Abbot Laboratories, United Kingdom). The subjects were restricted to perform any physical activity during 2h of study period. The area under curve was calculated for each of the food for each subject. The net incremental area under the curve (IAUC) is based on simple application of the trapezoid rule to all the blood glucose increments. Paired sample 't' test was applied to compare mean differences among IAUC between test foods or test foods and reference. The level of statistical significance was set to 0.05.

Glycemic Index was calculated as follows:

$$GI_{carb} = \frac{2h \text{ IAUC blood glucose response to } 50g \text{ available carbohydrate in food}}{2h \text{ IAUC blood glucose response to } 50g \text{ glucose}} \times 100$$

IAUC- Incremental Area Under the Curve

Glycemic Load = $\frac{GI \times \text{Total Available Sugar}}{100}$

$$GI_{food} = \frac{2h \text{ IAUC blood glucose response to a specified food}}{2h \text{ IAUC response to glucose equal in weight to the food}} \times \text{Amt. of food}$$

RESULTS

In the present study, it was observed that the postprandial glycemic response to bread is significantly higher than that of same quantity of fruits (p<0.05) (Figure 1).

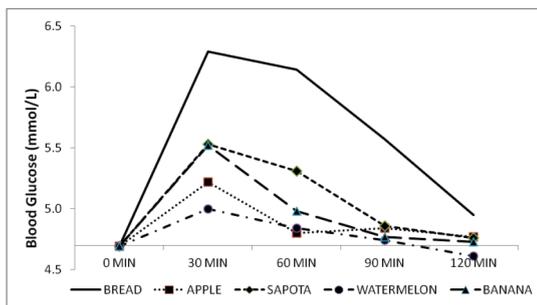


Figure 1: Average Blood Glucose response to fruits (50g) in normal healthy subjects (n=25)

The area under curve glycemic response to bread, constituting refined carbohydrate was found be higher than that of all the fruits including banana and sapota (Figure 1).

Among the fruits, watermelon induced lowest glycemic response, followed by apple, banana and highest for sapota. Interestingly, the glycemic response was found to be indirectly proportional to the moisture content of foods (Table 1). Moisture acts as an energy diluent and reduces total solid alongwith carbohydrate concentration resulting in lower glycemic impact (Ray & Singhania 2014)

Table 1: Quality and quantity of carbohydrates in fruits

Fruit	GI	GL	GIfood (GBE/50 g)	Moisture g%	Available CHO Wet wt. g%	Starch Wet wt. g%
Bread	75*	11*	50	39	46.5	26.5
Watermelon	103	7.20	18	90	7.0	1.1
Apple	52	4.80	29	81	9.0	2.6
Sapota	81	13.6	44	70	16.8	2.3
Banana	67	8.10	36	76	12.2	3.4

*Atkinson FS, Foster-Powell K, Brand-Miller JC. International Tables of Glycemic Index and Glycemic Load Values: 2008. Diabetes Care 2008; 31(12).

The effect of moisture content on glycemic response is further highlighted when we observe the GI and GI_{food} value of watermelon simultaneously. GI of watermelon is 103 despite having the lowest amount of available carbohydrates (Table 1). This is because to obtain 50g available carbohydrates from watermelon nearly 500g edible portion was fed. The glycemic load was found to be very low indicating that the concentration of the sugar is very less in a given serving. The contrasting GI and GL lead to a conflict in the understanding of selection of quality or quantity of carbohydrates.

On the other hand, GI_{food} was calculated by feeding 50g edible portion of watermelon and it induced low glycemic response in accordance with its high moisture content and low total available carbohydrate.

So we can see that GI_{food} truly reflects the physiological response to whole foods as consumed in practical setting taking into account all the factors at once.

This indicates that moisture dense fruits can be easily recommended for all including individuals with glucose intolerance.

Similarly sapota with lower moisture and high available carbohydrate content produced a much higher glycemic response (Table 1) but it is much lower than that of bread. This highlights the difference in nature of carbohydrates wherein refined carbohydrate containing food such as bread produces prolonged hyperglycemia as compared to fruits which have high moisture content and natural sugars.

GI is a static unchanging value which is insensitive to changing food intake quantity. In order to understand whether the GI_{food} value responds to change in doses, 15 clinically healthy adult subjects were given 100g of banana and bread on separate days.

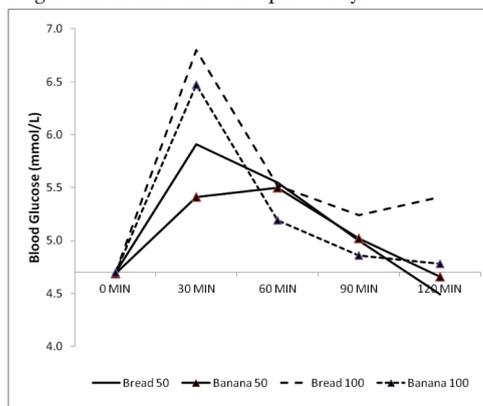


Figure 2: Postprandial Blood Glucose response to 50 & 100g of banana and bread

It was observed that increase in dose from 50 to 100g resulted in an increase in the glycemic response (Figure 2), even though not mathematically proportional. However, even with 100g quantity, the overall AUC response to bread was higher than that of sweet testing banana. The differential postprandial effect can be explained by their composition as total available sugar in banana is partly soluble simple sugar and partly starch alongwith high moisture content whereas bread has lower moisture content and high starch density (Table 2).

Table 2: Sugar and moisture content of the banana and bread

Food	Total Available Sugar		Moisture	
	g%	Wet wt. g%	Dry wt. g%	g%
Bread	26.4	46.5	76.3	38.9%
Banana	3.43	12.2	50.9	72.8%

CONCLUSION

Based on the present study results, the dietary recommendations for normal as well as individuals with metabolic disorders need to undergo some modifications. While sweet tasting fruits are restricted in diets, often bread (more recently -whole wheat, multigrain) is a regular feature. It should be understood, that starch breakdown produces sugar irrespective of whether the food product is sweet in taste or not. The type and amount of sugar released upon breakdown and its rate of absorption is what influences glycemic impact.

So even though sugar quality is hyperglycemic in certain fruits, due to their high water content the GL per serving is low (Foster-Powell,

Holt and Miller 2002) and therefore GI_{food} is low. As can be expected, banana and sapota, with higher total available carbohydrates have found to have higher postprandial glycaemic effect as compared to other fruits but definitely not as high as equal amount of bread. With an increase in dose from 50 to 100g portion, the area under the glucose response curve for bread was much higher than that of banana.

The present study suggests that sweetness of fruits has nothing to do with postprandial effect, while expecting following advantages-

- Fresh fruits supply the antioxidant nutrients which are very important for oxidative stress related disorders like diabetes (Bazzano et al 2008)
- It may satisfy the sweet cravings among diabetic patients and is a better choice than outside sweets and desserts loaded with fats and artificial flavours.
- The high water content of fruits acts as an energy diluent

All of the above factors render antioxidant rich fruits as not are more favourable foods than starch based products. In fact, judicious selection of fresh and seasonal fruits and vegetables can go a long way in prevention of several metabolic and lifestyle disorders.

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