ORIGINAL ARTICLE

Postprandial glucose response to selected tropical fruits in normal glucose-tolerant Nigerians

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Abstract

Background and Objectives: The glycemic response to commonly eaten fruits in Nigeria has not been reported. Therefore, this study assessed the plasma glucose response to selected fruits in Nigeria.

Patients and Methods: Ten normal glucose-tolerant subjects randomly consumed 50 g carbohydrate portions of three fruits: banana (*Musa paradisiaca*), pineapple (*Ananus comosus*), and pawpaw (*Carica papaya*), and a 50-g glucose load at 1-week intervals. Blood samples were collected in the fasting state and half-hourly over a 2-h period post-ingestion of the fruits or glucose. The samples were analyzed for plasma glucose concentrations. Plasma glucose responses were assessed by the peak plasma glucose concentration, maximum increase in plasma glucose, 2-h postprandial plasma glucose level, and incremental area under the glucose curve and glycemic index (GI).

Results: The results showed that the blood glucose response to these three fruits was similar in terms of their incremental areas under the glucose curve, maximum increase in plasma glucose, and glycemic indices (GIs). The 2-h postprandial plasma glucose level of banana was significantly higher than that of pineapple, $P < 0.025$. The mean ± SEM GI values were as follows: pawpaw; 86 ± 26.8%; banana, 75.1 ± 21.8%; pineapple, 64.5 ± 11.3%. The GI of glucose is taken as 100. The GI of pineapple was significantly lower than that of glucose ($P < 0.05$).

Conclusion: Banana, pawpaw, and pineapple produced a similar postprandial glucose response. Measured portions of these fruits may be used as fruit exchanges with pineapple having the most favorable glycemic response.

Key words: Diet, fruits, glycemic index, plasma glucose response

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Introduction

Oli *et al.*[1] reported the glycemic responses to eight Nigerian foods. They noted that roasted yam, boiled cocoyam, boiled yam, and boiled unripe plantain had high glycemic responses; boiled beans had a low glycemic response, while "eba" (cassava flour) and rice had intermediate responses. Ohwovoriole and Johnson[2] reported the glycemic responses to five Nigerian meals and found high glycemic responses to rice, yam, and "dodo" (fried ripe plantain), intermediate response to "eba," and low glycemic response to beans. Balogun[3] also reported high glycemic responses to boiled yam, rice, "amala" (yam flour); "eba" had an intermediate response while beans and the rice/bean mixture had low glycemic responses. None of these Nigerian studies addressed the plasma glucose response of fruits, which are very important items in a balanced diet.

Several types of fruits are widely available in Nigeria and are eaten as desserts and snacks. Fruits contain minerals, vitamins, and soluble dietary fibers. This study assessed the postprandial glycemic response to three commonly eaten fruits in Nigeria.

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Patients and Methods

Patients

The study group consisted of 10 persons (6 males,and 4 females) with normal glucose tolerance (FPG < 5.6 mmol/L). None of them was obese (body mass index < 30 kg/m^2), pregnant, or on any medications known to affect carbohydrate metabolism. Their mean (range) age and BMI was (22- 34) years and 23 (20- 27) kg/m^2 respectively. All subjects had been consuming diets that regularly contained at least 150 g carbohydrates per day. Subjects came at weekly intervals in the morning after a 10-h overnight fast to the Metabolic Unit of the Department of Medicine. All the subjects voluntarily gave informed consent. The Hospital Ethics and Research Committee approved the study.

Operational definitions

Maximum increase in plasma glucose (MIPG) is the maximum increase in the postprandial glucose level above the preprandial plasma glucose level

The incremental area under the 120-min plasma glucose response curve (IAUGC) is the cumulative changes in postprandial plasma glucose for each fruit or glucose load which is calculated by the trapezoidal rule with fasting concentrations as the baseline and truncated at zero.[4]

The glycemic index[5] (GI) was calculated as follows:

$$\text{GI (\%)} = \frac{\text{Incremental area under the 2-h glucose response curve for a 50 g carbohydrate equivalent of the test fruit}}{\text{Incremental area under the 2-h glucose response curve for a 50 g glucose load.}} \times 100$$

Meal composition

The test meals contained 50 g carbohydrate equivalent portions of fruits or glucose. The nutrient composition of the fruit meals were estimated from the food table[6] (as done in previous Nigerian studies on postprandial glycemic response to foods), and are shown in Table 1. All fruits were purchased from the open market. The fruits were peeled and served fresh. Only edible portions of the fruits were used. Only bananas with yellow peel (no green discoloration or brown specks) were used.

Study design

The participants sat and rested for about 30 min before the test procedure was started. A tourniquet was applied to the arm above the elbow. After cleaning the antecubital region with swab and spirit, an indwelling cannula placed into a forearm vein was kept patent with physiological saline. Fasting blood samples were collected from the indwelling cannula. Thereafter, subjects ingested either a test fruit or oral glucose. The oral glucose challenge test was carried out using 50 g anhydrous glucose dissolved in 250 mls of water. The glucose solution was ingested over 5 min and the same time was taken for the consumption of each fruit. The study was considered to have commenced at the first oral contact with the index fruit. Additional blood samples for the determination of postprandial plasma glucose levels were obtained at 30, 60, 90, and 120 min after ingesting the fruit or glucose meal. Blood samples for glucose estimation were put into fluoride oxalate bottles. Blood samples were centrifuged immediately after the end of each trial for 8 min at 12,500 *g* at room temperature. Plasma was pipetted into Eppendorff tubes and stored at -20°C over-night where analysis could not be done on the day of the test. Glucose estimation was done by the glucose oxidase method of Trinder.[7]

Table 1: Nutrient content per 50-g carbohydrate equivalent portions of test fruits

Fruit	N	Nutrient content (g)			Serving weight (g)
		Protein	Fat	Fiber	
Banana	10	3.6	1.1	3.6	357
Pawpaw	9	3.3	*	3.9	556
Pineapple	10	1.4	*	1.8	357

N = number of subjects who consumed the index fruit, *Insignificant amounts

Statistical analysis

The results are expressed as mean ± SEM. Statistical comparisons between subjects at the peak values, maximum increase in plasma glucose values, 2-h postprandial plasma glucose value, and incremental area under the plasma glucose curve were made by the paired Student's *t*-tests and ANOVA as appropriate. The level of statistical significance was set at $P < 0.05$. Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 10.0.

Results

The mean glucose responses to fruits and glucose solution are shown in Figure 1 while the glucose response indices are summarized in Table 2. The postprandial plasma glucose responses to pineapple were higher than those of the other fruits. Plasma glucose levels after the consumption of banana, pineapple, and glucose peaked at 60 mins postprandial while pawpaw peaked at an earlier period after ingestion.

Significant differences in peak postprandial plasma glucose (PPPG) were found between banana and pineapple ($P < 0.05$) and between banana and glucose ($P < 0.005$). No significant differences in the MIPG were found among the fruits. However, glucose had a significantly higher MIPG than banana and pineapple, $P < 0.005$, and pawpaw, $P < 0.025$.

Table 2: Indices of the plasma glucose response by the type of fruit consumed in mean ±SEM.

Test item	N	Plasma glucose (mmol/l)			IAUGC mmol.min/l		GI (%)
		PPPG	MIPG	2hPG	Fruits	Glucose	
Banana	10	5.6 ± 0.2*	1.1 ± 0.2***	4.6 ± 0.2	63.6 ± 11.6**	108.1 ± 15.5	75.1 ± 21.8
Pineapple	10	6.5 ± 0.3	1.0 ± 0.1***	5.5 ± 1.2*	62.6 ± 10.5**	108.1 ± 15.6	64.5 ± 11.3*
Pawpaw	9	6.1 ± 0.4	1.1 ± 0.2	4.9 ± 0.2	63.9 ± 14.1*	97.8 ± 12.9	86 ± 26.8
Glucose	10	6.8 ± 0.3	1.8 ± 0.2	4.7 ± 0.2	108.1 ± 15.5	108.1 ± 15.5	100

PPPG: Peak postprandial plasma glucose; MIPG: Maximum increase in plasma glucose; 2hPG: 2-h postprandial glucose; IAUGC: Incremental area under the 120-min plasma glucose curve; GI: Glycemic index, Significance of difference between glucose and the test item: *$P < 0.05$, **$P < 0.025$, ***$P < 0.005$.

There was a significant difference in the 2-h postprandial plasma glucose (2hPG) between pineapple and banana, $P < 0.025$. When the 2hPG responses after the ingestion of the fruits were compared to those of the post-glucose load, a statistically significant difference was found only between glucose and pineapple, $P < 0.05$.

The AUGCs during the 2-h postprandial period were comparable for all fruits. The post-glucose load IAUGC was significantly higher than that of all the fruits.

There were no statistically significant differences among the GIs of fruits ($P > 0.10$). When compared with the glucose load (GI of glucose is taken as 100), the GIs of banana and paw-paw were similar to those of the glucose load ($P > 0.10$) while that the GI of pineapple was significantly different from that of glucose ($P < 0.05$).

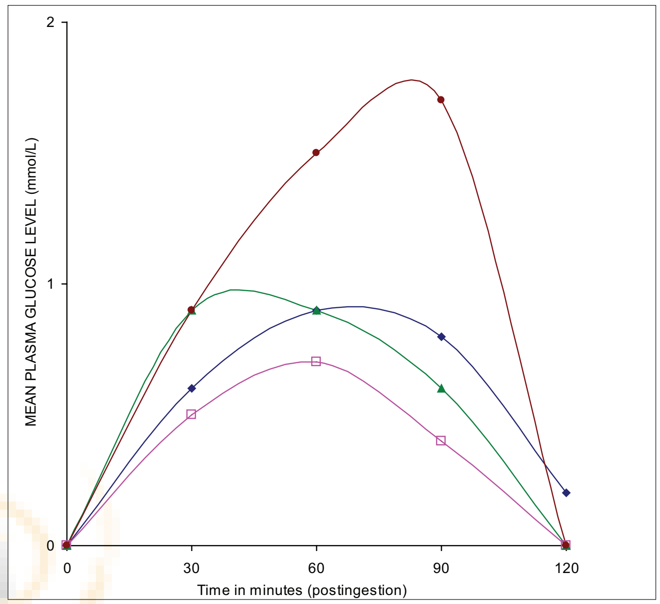

Figure 1: Mean incremental changes in the plasma glucose response of 10 normal subjects after consuming 50-g carbohydrate equivalent portions of three different fruits and glucose

Discussion

This study was designed to determine the postprandial glycemic response to commonly eaten fruits in Nigeria. It was observed that the plasma glucose responses to the ingestion of fruits were generally similar with no significant differences in terms of their MIPG, IAUGC, and GI.

The GIs of these tropical fresh fruits varied from 64.5% for pineapple to 86% for pawpaw. The GI of banana (75.1%) was similar to 74 ± 9% for over-ripe banana documented by Hermansen *et a.l*[8] and 79% reported by Jenkins *et al.*[9] The differences in the postprandial glucose responses of these tropical fruits may have arisen because of differences in the monosaccharide composition, fiber content, and the degree of ripeness of the fruits. Lunetta *et al.*.[10] reported that the plasma glucose responses to eight Italian fruits correlated positively with their glucose content but negatively with their fructose content. Wolever *et al.l*[11] observed only a weak association between the observed blood glucose response and the monosaccharide content. The individual monosaccharide compositions of the fruits were not analyzed in this study because we do not have the facility for such analysis.

Wolever *et al.*.[12] found that ripe banana produced a higher glycemic response than unripe banana; Ercan *et al.*.[13] however, found little variations in glucose responses to bananas of varying ripeness thus suggesting that other factors may be contributory to the differences in glucose responses to fruits. There was no reliable method of ensuring the same degree of ripeness of all the fruits consumed in our study.

The fiber content of the fruits has been suggested to influence their glycemic response. Foods with higher fiber contents are expected to produce lower glycemic responses than foods with less dietary fiber. Wolever[14] observed only a weak correlation between the amount of total dietary fiber and the glycemic response to food. Jenkins *et al.*.[9] found no differences in the GIs of apple juice and that of whole apples and the GIs of orange juice and that of whole oranges. The fiber content of the fruits did not correspond with their glucose response in this study as in earlier studies. Pawpaw and banana that had higher fiber contents than pineapple also had higher GI values.

The serving portions of fruits that had 50 g carbohydrate content were quite large especially those of pawpaw. Smaller portions of the fruits would probably have elicited smaller plasma glucose responses. In future studies on fruits, 25-g carbohydrate equivalent portions should be used. The limitations of this study that included the inability to analyze monosaccharide composition of the fruits and to control for the degree of ripeness of the fruits, did not detract it from generating useful data on the postprandial response to ingestion of banana, pineapple, and pawpaw.

These fruits which are low-calorie and low-fat foods will be potentially useful in the management of overweight and obesity. Fruits will be useful as snacks in place of high-dense snacks from fast food eateries. The glycemic responses to different varieties of the same fruit such as banana also need to be determined in future studies.

Conclusion

It is concluded that banana, pawpaw, and pineapple have similar postprandial glucose response indices in normal glucose-tolerant persons with pineapple being the most commendable of the three fruits.

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