ABSTRACT

BACKGROUND: It is not known which of the commonly consumed fruits in Nigeria are suitable for persons with diabetes mellitus especially with regards to the attendant plasma glucose response (PGR) to consumption of such fruits.

OBJECTIVES: To determine and compare the PGR to commonly eaten fruits in patients with diabetes mellitus.

METHODS: Ten persons with type 2 diabetes mellitus were studied. Fifty gram portions of five fruits containing 50g carbohydrate [banana, Musa paradisiaca; orange, Citrus sinensis; pineapple, Ananas comosus; mango, Magnifera indica; pawpaw, Carica papaya], and glucose were randomly fed to the study subjects at one-week intervals. Blood samples were collected in the fasting state and half hourly over a 2-hour period post-ingestion of the fruits or glucose for plasma glucose determination. Plasma Glucose Responses were assessed by the peak plasma glucose concentration (PPPG), maximum increase in postprandial plasma glucose (MIPG), two-hour postprandial plasma glucose level (2hPG) and incremental area under the curve (IAUGC) were collected in the fasting state and half hourly over a 2-hour period post-ingestion of the fruits or glucose for plasma glucose determination. Plasma Glucose Responses were assessed by the peak plasma glucose concentration (PPPG), maximum increase in postprandial plasma glucose (MIPG), two-hour postprandial plasma glucose level (2hPG) and incremental area under the curve (IAUGC).

RESULTS: The mean ± s.e.m. PPPG in mmol/L were: banana, 9.0±1.6; orange, 8.1±0.8; pineapple, 9.2±1.1; mango, 8.0±1.1; and pawpaw, 7.8±0.9. The mean ± s.e.m IAUGC in mmol.min/l were: banana, 131.7±53.4; orange, 108.7±29.8; pineapple, 115.3±33.2; mango, 101.6±28.7; and pawpaw, 124.1±46.1. However, mango showed the least MIPG (1.8 ±0.5 mmol/l) by followed by orange and pawpaw. The IAUGC also followed this pattern. There were no significant differences among the glycaemic indices of the fruits. Glucose load produced a significantly higher IAUGC than the fruits (orange, pineapple, mango, pawpaw, p<0.005; banana, p<0.025).

CONCLUSION: The plasma glucose response to consumption of Nigeria fruits are similar. The PGR indices to all fruits were less than the PGR after an equivalent carbohydrate load of glucose. It appears safe to recommend these Nigerian fruits to persons with diabetes within the prescribed daily total calorie intake. WAJM 2011; 30(2): 94–98.

Keywords: Glycaemic response, fruits, diabetes mellitus, non-insulin dependent diabetes mellitus, diet.

RÉSUMÉ

CONTEXTE: On ignore encore lequel des fruits les plus consommés est le plus approprié pour les sujets présentant un diabète de type 2, en particulier par rapport à la réponse glycémique plasmatique (RGP) qui entraîne la prise de ces fruits.

OBJECTIF: Déterminer et comparer la RGP des fruits les plus consommés chez les patients présentant un diabète de type 2.

METHODES: Dix patients présentant un diabète de type 2 ont fait l’objet de cette étude. Des portions de 50 grammes de cinq fruits différents [banane, musa paradisiaca; orange, citrus sinensis; ananas ananas comosus; mangue, magnifera indica; papaye, carica papaya], et du glucose ont été administrées de façon randomisée aux patients sur des intervalles d’une semaine. Des prélèvements de sang ont été effectués dans la période de jeun et toutes les trente minutes sur une période de deux heures après l’ingestion du fruit ou du glucose pour la détermination du pic de concentration plasmatique du glucose (PCPG). Les RGP étaient évaluées par la PCPG, le pic maximal de la glycémie post prandiale (PMGP), la glycémie postprandiale à 2h (GP2h), et la surface de l’aire sous la courbe de glycémie (ASCG).

RESULTATS: La moyenne du PCPG étaient exprimée en mmol/l ainsi qu’il suit : banane, 9.0±1.6; orange, 8.1±0.8; ananas, 9.2±1.1; mangue, 8.0±1.1; et papaye, 7.8±0.9. La moyenne de l’ASCG exprimée en mmol.min/l était repartie ainsi qu’il suit : banane, 131.7±53.4; orange, 108.7±29.8; ananas, 115.3±33.2; mangue, 101.6±28.7; et papaye, 124.1±46.1. Cependant la mangue présentait le PMGP le moins élevé , suivi par l’orange, et la papaye. L’ASCG a suivi le même profil. Il n’y avait pas de différence significative sur les indices glycémiques des fruits. La charge en glucose a produite une ASGC significativement plus importante que pour les fruits (orange, ananas, mangue, papaye, p<0.005 ; banane, p<0.025)


Mots Cles: Réponse glycémique, fruits, diabète, diabète non insulino dépendant, Régime alimentaire.
INTRODUCTION

Diet therapy is one of the cornerstones in the management of diabetes mellitus. Recommending readily available foods to persons with diabetes mellitus (PWDM) enhances dietary adherence. Oladele et al. reported the glycaemic responses to eight Nigerian foods. They noted that roasted yam, boiled cocoyam, boiled yam and boiled unripe plantain had high glycaemic responses; boiled beans had low glycaemic response, while “eba” (meal of cassava flour) and rice both had intermediate responses. Ohwovoriole and Johnson reported the glycaemic responses to five Nigerian meals and found high glycaemic responses to rice, yam and “dodo” (fried ripe plantain), intermediate response to “eba” and low glycaemic response to boiled beans. Akanji et al. observed that “lafun” (a form of cassava meal) produced the least glycaemic response compared to cassava meals in the form of eba or parboiled cassava flakes. Balogun also reported high glycaemic responses to boiled yam, rice, “amala” (meal of yam flour); with eba showing intermediate response while beans and rice/bean mixture had low glycaemic responses.

However, none of these Nigerian studies addressed the plasma glucose response to fruits, which are very important items in a balanced diet. Several types of fruits are widely available in Nigeria. They are used as desserts, snacks, and in mixed meals. Fruits are rich in vitamins, minerals, antioxidants and dietary fibres and they are desirable in the diet of all persons with or without diabetes mellitus. Edo and Oladele noted that pineapple had higher postprandial glycaemic response than apple in normal glucose tolerant Nigerians. However, it is not known which of the commonly available fruits in Nigeria are suitable for inclusion in the diet of persons with diabetes mellitus especially with regards to their plasma glucose responses. This study investigated the plasma glucose response to some commonly eaten fruits in Nigerian with a view to identifying suitable fruits for the diet of persons with diabetes mellitus.

SUBJECTS, MATERIALS, AND METHODS

Subjects

The clinical characteristics of the study participants is summarized in Table 1. The study group consisted of ten persons (males, four, females, six) with type 2 diabetes mellitus. The four men had a mean age of 60 years (range, 49–64) and a body mass index (BMI) of 26.5kgm² (range, 24.1 to 29.4). The six females had a mean age of 52.2 years (range, 36 to 66) and a BMI of 26.8 (range, 20 to 29.7) Kgm⁻². Four of the subjects were on treatment with glibenclamide 5mg daily only; one was on metformin 500mg bd; three were on metformin 500mg bd plus glibenclamide; one was on chlorpropamide 250mg daily and another was on rosiglitazone 4mg daily. Subjects took their regular medications 5–10 minutes before commencement of each trial. All subjects had been ON diets that regularly contained at least 150g carbohydrate per day. Subjects came at weekly intervals in the morning after a 10-hr overnight fast to the Metabolic Unit of the Department of Medicine, Lagos University Teaching Hospital, Lagos, Nigeria. All the subjects voluntarily gave informed consent. The Hospital Ethics and Research Committee approved the study.

Meal Composition

The test meals contained 50g carbohydrate equivalent portions of fruits or glucose. The nutrient compositions of the fruits meals were derived from a food table and are shown in Table 2. All fruits were purchased from the open market in April – May 2002. The fruits were peeled and served fresh. Only edible portions of the fruits were used. The fruits were purchased in bulk to minimize variation in the source of the fruits.

Study Design

Subjects had their preprandial blood glucose level determined on arrival at the test venue using a glucometer. If the preprandial blood glucose measurement was between 4.4 and 7.8 mmol/L, then the subject proceeded with the test procedure outlined below after resting for 30 minutes, otherwise, the test procedure was postponed.

A tourniquet was applied to the arm above the elbow. After cleaning the antecubital region with swab and methylated spirit, an indwelling cannula placed into a forearm vein was kept patent with physiological saline. A separate syringe was used to withdraw each test sample from the cannula after removal of the cocking syringe containing the saline to minimize mixture of saline with the blood collected. Fasting blood samples were collected from the indwelling cannula. Thereafter subjects consumed either a test fruit or a glucose load using the latin square design.

The glucose solution was ingested over five minutes while subjects were asked to complete consumption of each fruit within five minutes. The study was considered to have commenced with the first bite of the index fruit. Additional blood samples for determination of postprandial plasma glucose levels were obtained at 30, 60, 90, and 120 minutes after each 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 eight min at 12 500g 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 collection. Glucose estimation was done by the glucose oxidase method of Trinder. The mean within – assay and weekly between – assay precisions (coefficient or variations, CVs) were both <6%.

Table 1: Characteristics of study subjects

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean ± SEM (min-max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>55.3±3.0(36–66)</td>
</tr>
<tr>
<td>BMI (kgm⁻²)</td>
<td>26.7±1.1(20–9.7)</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>96.8±7.0(87–106)</td>
</tr>
<tr>
<td>Duration of DM(years)</td>
<td>4.4±1.2(1.0–15)</td>
</tr>
</tbody>
</table>

Data Management, Calculations and Statistical Analysis

Data were entered into Microsoft Excel Spread Sheet and after cleaning exported to Statistical Package for SSSocial Sciences v.10 for Statistical Analysis.
The results are expressed as mean ± SEM. The cumulative changes in postprandial plasma glucose for each fruit were quantified as the incremental area under the 120-min response curve (IAUGC), which was calculated by the trapezoidal rule with fasting concentrations as the baseline and truncated at zero. Statistical comparisons between subjects at the peak values, maximum increase in plasma glucose values, 2-hour postprandial plasma glucose value, and incremental area under the plasma glucose curve were made by the paired or unpaired student’s t-tests as appropriate. The level of statistical significance is set at p <0.05.

RESULTS

Figure 1 shows the trend of the average plasma glucose response after the ingestion of the five different fruits and glucose drink. Pawpaw gave the lowest postprandial glucose responses at all time points. Pineapple peaked at 30mins; banana, orange, mango and pawpaw peaked at 60mins while glucose load peaked at 90min. Among the plasma glucose responses of the fruits, there was no statistically significant difference in the peak postprandial plasma glucose level, maximum increase in the plasma glucose, two-hour postprandial plasma glucose and incremental area under the plasma glucose curve (see Table 3). Glucose load had a higher peak postprandial plasma glucose level than all the fruits but the difference did not attain statistical significance.

Glucose load resulted in a significantly higher MIPG level than the fruits (mango and pawpaw, p<0.025; orange and pineapple, p<0.01). Significant difference in 2hPG was observed only between post glucose load and ingestion of pawpaw, 7.9±0.9 mmol/L vs 5.5±0.6mmol/L, p<0.05. Mango exhibited the least PGR in terms of MIPG and IAUGC, followed by orange and pawpaw. Banana and pawpaw occupied the first and second positions respectively in terms of IAUGC following fruits ingestion. However, these differences were not significantly different. All the fruits showed a 2-hr postprandial glucose levels that were comparable to their corresponding preprandial plasma glucose levels. All the fruits also showed similar IAUGCs. Postglucose load, however, had a significantly higher IAUGC than all the fruits (orange, pineapple, mango and pawpaw; p<0.005 and banana, p<0.025).

DISCUSSION

The results show that banana, orange, pineapple, mango and pawpaw exhibit similar postprandial plasma glucose response profiles which were lower than those of post-glucose load. Pineapple gave a rapid and early postprandial peaking in blood glucose level. All the fruits and glucose load had similar mean PPPG levels.

The mean 2hPG obtained after ingestion of the different fruits were all within the current maximum target 2hPG (7.5mmol/L) in management of DM recommended by the IDF. Pawpaw showed the lowest 2 PG level followed by mango and orange, the differences among the fruits being insignificant statistically. The implication of these favourable 2hPG values post-ingestion of fruits is that these fruit meals may be included in diets of PWDM without adversely affecting their glycaemic control. The serving portions of the fruits tested in this study were large. We believe smaller portions of these fruits will produce lower plasma glucose response. Gannon et al. reported that in diabetic subjects the blood glucose response increases approximately in proportion to the amount of carbohydrate consumed, at least when the amount of carbohydrate in the meal is less than 50g.

The IAUGC of banana (131.7±53.4mmol/L·min⁻¹) in this study was larger than the IAUGC of 106±17mMx240min reported by Hermansen et al. for over ripe banana in persons with type 2 DM. The IAUGC for under ripe banana was 62±17mM x 240min. in their study. The differences in the mean IAUGC of banana in these studies could be partly ascribed to the effect of the ripeness of banana in increasing its glucose response. Starch is converted to simple sugars as banana ripens. The other contributing factor to the discrepancy in IAUGC of banana may...
Table 2: Nutrients and Caloric Content per 50g Carbohydrate Equivalent Portions of Test Fruits

<table>
<thead>
<tr>
<th>Fruit</th>
<th>N</th>
<th>Calorie</th>
<th>Protein</th>
<th>Fat</th>
<th>Fibres</th>
<th>Serving weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banana</td>
<td>9</td>
<td>414</td>
<td>3.6</td>
<td>1.1</td>
<td>3.6</td>
<td>357</td>
</tr>
<tr>
<td>Orange</td>
<td>9</td>
<td>204</td>
<td>3.1</td>
<td>*</td>
<td>1.2</td>
<td>385</td>
</tr>
<tr>
<td>Mango</td>
<td>5</td>
<td>210</td>
<td>1.7</td>
<td>*</td>
<td>2.7</td>
<td>333</td>
</tr>
<tr>
<td>Pawpaw</td>
<td>6</td>
<td>200</td>
<td>3.3</td>
<td>*</td>
<td>3.9</td>
<td>556</td>
</tr>
<tr>
<td>Pineapple</td>
<td>10</td>
<td>203</td>
<td>1.4</td>
<td>*</td>
<td>1.8</td>
<td>337</td>
</tr>
</tbody>
</table>

N, number of subjects who consumed the index fruit. Orange (Citrus sinensis); Banana (Musa paradisiaca); Pineapple (Ananas comosus); Pawpaw (Carica papaya); Mango (Magnifera indica). *Insignificant amounts. Source, Platt, reference 7.

Table 3: Plasma Glucose Response Indices to Fruit Consumption

<table>
<thead>
<tr>
<th>Test item</th>
<th>Plasma glucose (mmol/L)</th>
<th>IAUGC (mmol.min/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>FPG</td>
</tr>
<tr>
<td>Banana</td>
<td>9</td>
<td>6.8±1.1</td>
</tr>
<tr>
<td>Orange</td>
<td>9</td>
<td>6.4±0.9</td>
</tr>
<tr>
<td>Pineapple</td>
<td>10</td>
<td>7.2±1.2</td>
</tr>
<tr>
<td>Mango</td>
<td>6</td>
<td>6.2±0.9</td>
</tr>
<tr>
<td>Pawpaw</td>
<td>5</td>
<td>5.9±0.7</td>
</tr>
<tr>
<td>Glucose</td>
<td>10</td>
<td>5.4±0.5</td>
</tr>
</tbody>
</table>

Values are mean ± SEM.

PPG, Peak postprandial plasma glucose; MIPG, Maximum increase in plasma glucose; 2hPG, Two-hour postprandial glucose; IAUGC, Incremental area under the 120minute plasma glucose curve. Significance of difference from glucose: *p <0.05,
content even within the same species of fruits. It might be more accurate to chemically analyse the nutrient composition of the fruits before administering them to the study subjects. The GIs of the fruits were not derived among the PWDM because the presence of DM and its treatment have been known to affect postprandial glycaemic response. The GIs of meals are usually derived in non-diabetic patients and the effects of diabetes and its treatment on glucose responses are avoided.11

ACKNOWLEDGEMENTS

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REFERENCES