Glycemic Indices Of Pineapple, Banana, Jollof Rice And Wheat Flour Dough

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ABSTRACT

Background: *Information on glycemic index of staple foods are required to develop appropriate nutrition education materials to promote informed food choices.*

Objective: *This study was designed to determine the glycemic index of four Nigerian staple foods, namely pineapple, banana, jollof rice and wheat flour dough.*

Method: *The study was descriptive cross-sectional in design. Ten apparently healthy postgraduate students (4 males and 6 females, 25.8±2.0 years; BMI: 22.68±2.69 kg/m^2; fasting blood sugar: 92.1±3.38 mg/dl) randomly consumed 50 g available carbohydrate portions of test foods and glucose over a five-day period. Blood samples were collected in the fasting state and half-hourly over a 2-h period post-ingestion of test and reference foods to determine plasma glucose concentrations, incremental area under the glucose curve, glycemic index and glycemic load.*

Results: *A 50 g available carbohydrate is equivalent to 176 g of banana, 199 g of jollof rice, 229 g of wheat dough and 322 g of pineapple. The Incremental Area Under the Curve for jollof rice, wheat dough and pineapple showed no significant difference when compared with glucose, while of banana was significant at P<0.05 when compared with glucose. The glycemic index was 94.88%, 97.37%, 98.9% and 99.3% and the corresponding glycemic load was 47.43%, 48.69%, 50.47% and 50.67%, for pineapple, wheat flour, jollof rice and banana, respectively.*

Conclusion: *Banana, jollof rice, wheat flour dough and pineapple have high glycemic index values and post-prandial glucose response is similar for jollof rice, wheat flour and pineapple. Efforts should be intensified on promoting portion size control for improved glycemic response.*

Keywords: Glycemic load, Glycemic index, Plasma glucose response, Fruits, Staple foods

INTRODUCTION

The rising prevalence and projected increase in the global burden of diabetes mellitus have resuscitated interest in the glycemic index of foods and further strengthen the need to promote healthy food choices (1). Dietary intake is a central determinant of blood glucose levels, and thus, in order to achieve normal glucose levels, it is imperative to make food choices that induce normal postprandial (after-meal) glycemic responses (2).

Glycemic index refers to the incremental area under the glucose response curve of a 50g carbohydrate portion of a test food expressed as a percent of the response to the same amount of carbohydrate from a standard food consumed by the same subject (3). It is a scale used to classify the quality of carbohydrate consumed and also rank carbohydrate-containing foods according to their potential to increase blood glucose levels. Carbohydrate-containing foods with low glycemic index are digested and absorbed slowly, while those with high glycemic index are digested and absorbed rapidly (4). Glycemic Response (GR) is the effect a food has on blood sugar after consumption. The glycemic response to a food depends on the glycemic index and the total amount of carbohydrates ingested. Glycemic Load (GL) is a property of the quantity of total carbohydrate in a food and it accounts for the amount of carbohydrate in a food and how each gram of carbohydrate in the food raises blood glucose levels. The GL is classified as follows: low (< 10), intermediate (11-19) and high (> 20), and is a metric used as a basis for weight loss, or diabetes control (5).

Available evidence has shown that reductions in daily glycemic load may reduce the risk of non-communicable diseases particularly type 2 diabetes, cancers and coronary heart disease (1). In Nigeria, 2.7 million adults are diabetics and many people are ignorant of their diabetes status (6). Projection has shown that about 8 million Nigerians aged 20-79 years have glucose intolerance and this may hit about 18 million by 2045 (7).

In Nigeria, there are limited information on the glycemic index of local staples and these are required to develop appropriate diabetes education materials and help consumers to make informed food choices. Pineapple, banana, jollof rice and wheat flour dough constitute popular foods that are widely consumed across all the agroecological zones of Nigeria. Pineapple and banana are popular and widely consumed tropical fruits and serve as good sources of dietary fibre and selected vitamins, minerals and sugar (8, 9). Wheat flour is used for the production of several pastries, bread and dough meals while jollof rice is a popular mixed dish among various age groups. The aim of this study was to determine the glycemic index of four Nigerian staple foods, namely pineapple, banana, jollof rice and wheat flour dough.

MATERIALS AND METHODS

Study design

The study was descriptive cross-sectional.

Study Area

This study was carried out at the Departments of Environmental Health Sciences and Human Nutrition and Dietetics Laboratory, Faculty of Public Health, College of Medicine, University College Hospital, along Mokola-Roundabout road, Ibadan, the capital of Oyo State, South West Nigeria. Ibadan North is a Local Government Area in Oyo State, Nigeria. Its headquarters is at Agodi in Ibadan and has an area of 27km^2.

Study population

This study involved postgraduate students in Faculty of Public Health, College of Medicine, University of Ibadan, who agreed to participate in the study and gave informed consent. Fifteen participants volunteered for this study and 10 participants (4 males and 6 females) agreed to participate after reading the protocol and gave informed consent. Participants were considered eligible if he/she was a registered postgraduate student in the Faculty of Public Health, University of Ibadan, aged 24-30 years, had no history of metabolic disease and consented to participate in the study.

Test foods for the study

The test foods were jollof rice, wheat flour, pineapple and banana. Rice grain (*Oryzae sativa*), honey well whole wheat flour (*Triticum aestivum*), banana (*Musa paradisiaca*) and pineapple (*Ananas cosmosus*) samples were all purchased from Oje market, Ibadan, Oyo State, Nigeria. The rice was washed with water and parboiled for 10 minutes. The parboiled rice was washed with clean water. A sauce containing blended pepper, tomato and onion was fried in groundnut oil and seasonings were added. The parboiled rice is added to the sauce and cooked for 30 minutes. The wheat flour was cooked in boiling water and stirred continuously for five minutes to create a stiff paste. The pineapple and banana were peeled to remove the peel and cut into smaller sizes. The test foods were analysed for proximate composition (moisture, ash, crude fiber, crude protein, crude fat and crude carbohydrates) using the Association of Official Analytical Chemist (AOAC) methods. The portioning of the test foods containing 50g available carbohydrate was calculated using the results of proximate analysis, and an analytical balance. The reference food consumed was 50g of Munroe Glucose D dissolved in 200ml of water. The water used was Eva water produced by the Nigerian Bottling Company (NBC).

Data Collection Procedure

A semi-structured questionnaire was designed to collect information on socio-demographic characteristics, pregnancy status, medications (current and past), health status, smoking status and food allergy. Anthropometric assessment of participants was conducted using standard procedure after a 12-hour (8pm-8am) fast. Weights (kg) and heights (m^2) were assessed using a standard body weighing scale and a height meter fixed to the wall, respectively. The Body Mass Index (BMI) of the participants were calculated as the weight in kilograms divided by the square of the height in meters (kg/m^2).

Determination of glycemic index

Glycemic index was determined by the method of Wolever *et al.* (10). Measured portion of each of the reference food and four test foods containing 50g available carbohydrate were served to 10 participants at 8:00am, breakfast time. Capillary blood samples were obtained by finger prick using the Accu-chek glucometer. Blood samples were collected at intervals of 30 minutes for 2 hours (0, 30, 60, 90 and 120 minutes) after the consumption of the test food. The blood glucose concentrations were determined using a glucometer (Accu-chek) with a glucose test strip. The protocol followed was the consumption of reference food on day 1, jollof rice on day 2, wheat dough and vegetable soup on day 3, pineapple on day 4 and banana on day 5. The glycemic index and glycemic load of the tested foods and fruits were calculated using the formulas below:

$$\text{Glycemic index (GI)} = \frac{\text{Incremental area under the curve (IAUC) of a test food}}{\text{Incremental area under the curve (IAUC) of a reference food}} \text{X100}$$

$$\text{Glycemic load (GL)} = \frac{\text{GI x available carbohydrate (g)}}{100}$$

Statistical analysis

All data were entered into Graphpad Prism 7.0. Descriptive statistics (means, standard Deviation and standard error of mean) were used to summarize quantitative data. IAUC was calculated using the trapezoidal rule ignoring the area beneath the base line concentration. The glycemic indices of the foods and fruits were calculated from the curve. Inferential statistics (paired student t-test) was used to compare the mean of the Incremental Area Under the glucose Curve (IAUC) of the standard / reference food with each of the test foods. Statistical significance was set at $p<0.05$. The study was conducted according to the guidelines in the Declaration of Helsinki. The study was approved by the University of Ibadan/University College Hospital, Ibadan Ethics Committee (UI/UCH EC Registration Number NHREC 105/01/2008a)-UI/EC/19/0107).

RESULTS

Characteristics of the participants

This study engaged 10 apparently healthy young adults with mean age of 25.8±2.0 years, mean height of 1.67±0.15 m, weight of 63.2±8.7 kg, body mass index of 22.68±2.69 kg/m^2, and fasting blood sugar 92.1±3.38 mg/dl (Table 1).

Proximate composition of the test foods

The proximate composition of the test foods is presented in Table 2. The moisture content ranged from 66.67% in jollof rice to 83.52% in pineapple. Protein content was low and ranged from 0.67% in pineapple to 5.4% in wheat flour. Jollof rice had the highest fat (3.7%), fiber (0.9%) and ash content (1.32%). The carbohydrate contents were 28.36%, 24.17%, 21.88% and 15.51% for banana, jollof rice, wheat flour and pineapple, respectively.

Portion sizes, incremental area under the curve, glycemic index and glycemic load.

The portion sizes of various test foods yielding 50 g available carbohydrate, glycemic index and glycemic load of the test foods is presented in Table 3 and the capillary blood glucose responses to reference and test foods are summarized in Figure 1. A 50 g available carbohydrate was obtained from each of 176 g of banana, 199 g of jollof rice, 229 g of wheat flour and 322 g of pineapple.

There was an increase in blood glucose for standard food (glucose), jollof rice, wheat flour, and pineapple which decreases after 30 minutes, while the glucose level for banana remain steady after 30 minutes and decreased after 60 minutes. At 2 hours, the blood glucose for standard food, pineapple, and wheat flour increases, while those of jollof rice and banana decreased (Figure 1).

The blood sugar concentration (mg/dl) was 90±3.10, 109.6±7.65, 106.2±4.09,

Table 1: Basic characteristics of the participants

Measures	Mean±SD
Age (years)	25.80±2.00
Weight (kg)	63.20±8.75
Height (m)	1.67±0.15
Body Mass Index (kg/m^2)	22.68±2.69
Fasting blood glucose (mg/dl)	92.10±3.38

Table 2: Proximate composition of the tested samples

Proximate composition (%)	Jollof rice	Wheat flour dough	Pineapple	Banana
Moisture content%	66.67±0.06	71.94±0.33	83.52±0.10	68.90±0.01
Crude protein%	3.14±0.02	5.41±0.04	0.67±0.01	1.82±0.01
Crude fat%	3.70±0.03	0.17±0.00	0.05±0.00	0.33±0.26
Crude fiber%	0.90±0.00	0.79±0.01	0.52±0.00	0.84±0.01
Ash%	1.32±0.12	0.44±0.01	0.24±0.00	0.85±0.00
Carbohydrate%	24.17±1.01	21.88±0.14	15.51±0.11	28.36±0.01

SEM-Standard Error of Mean

104.0±3.61, and 97.7±2.39 at 0, 30, 60, 90 and 120 minutes, respectively. The corresponding values for wheat flour dough (92.7±3.9, 111.5±3.63, 98.9±5.32, 93.4±4.81 and 95.4±3.51), pineapple (93.2±8.43, 107.8±6.6, 92.4±4.68, 84.8±4.71, and 99.3±5.2), banana (101.1±4.97, 105.2±6.92, 105.8±6.92, 100.6±7.32, and 97.3±5.13) and glucose (90.9±3.4, 114.3±3.9, 102.1±5.28, 97.5±3.88, and 98.4±2.39) for 0, 30, 60, 90 and 120 minutes, respectively (Figure 1). The Incremental Area Under the Curve (IAUC) for the test foods (jollof rice and wheat) and the test fruits (pineapple) showed no significant difference when compared with the IAUC of the reference food (glucose). The incremental increase in blood glucose at 0 min was significantly different between the IAUC of banana and glucose.

The glycemic index of the test foods was 94.88%, 97.37%, 98.8% and 99.3% for pineapple, wheat flour dough, jollof rice and banana, respectively and the corresponding glycemic load was 47.43%, 48.69%, 50.47% and 50.67%, for pineapple, wheat flour, jollof rice and banana, respectively. The GI and the GL values obtained ranged from 94.88.74 to 99.3 and 47.43 to 50.67 respectively, which classified them as high-GI and high- GL foods (Table 3).

Table 3: Classification of glycemic index (GI) and glycemic load (GL)

Test foods and fruits	Available Carbohydrate(g)	Portion size(g)	GI (%)	GL value (%)	Classification
Jollof rice	50	199	98.9	50.47	High
Wheat flour	50	229	97.37	48.69	High
Pineapple	50	322	94.88	47.43	High
Banana	50	176	99.3	50.67	High

*GI - Glycemic Index; GL -Glycemic Load

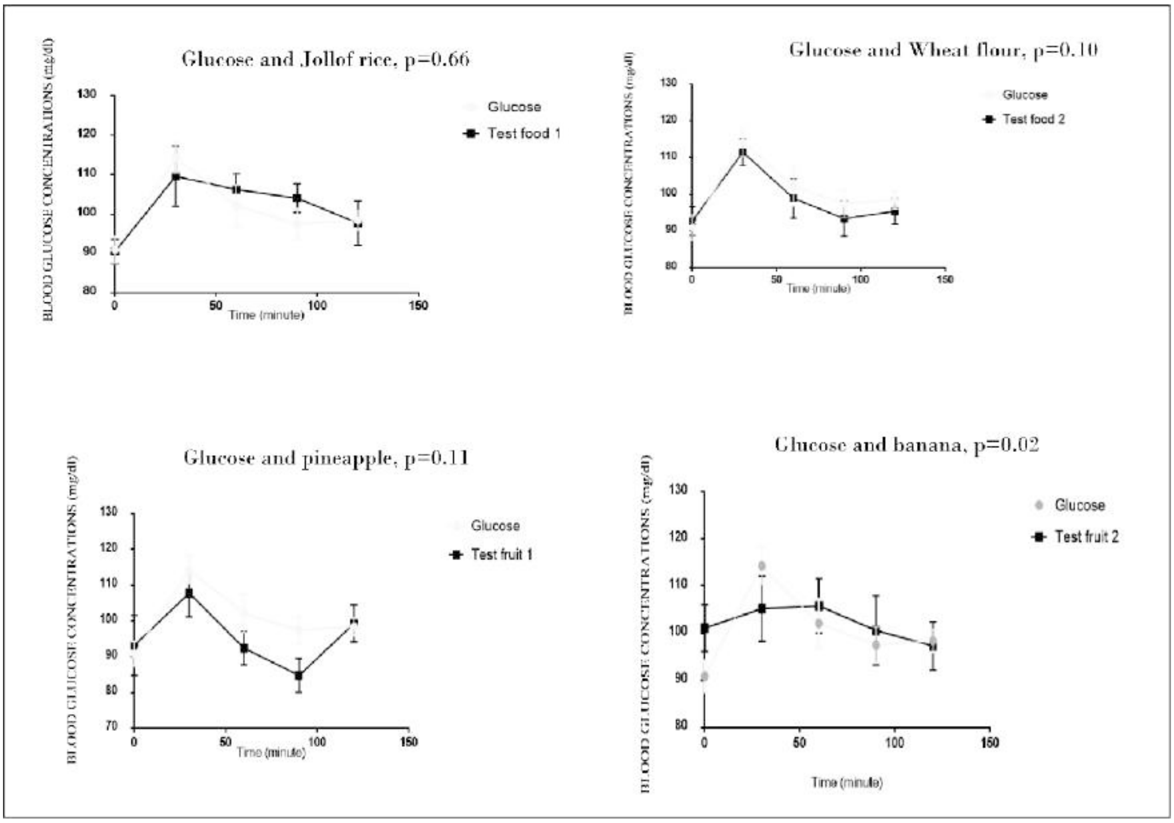

Figure 1: Graphical representation of the glucose response area for test foods

DISCUSSION

The rising prevalence of diabetes in Nigeria is worrisome and this could increase health care burden if it remains unchecked. Lifestyle factors particularly dietary practice are key contributors to this trend. In Nigeria, the staple foods are largely plant-based and carbohydrate-rich, and these are rarely complemented with adequate quantities of other food groups. These carbohydrate foods have varying glycemic values depending on the chemical structure of the foods, particle size, degree of processing, storage, ripening, methods of cooking and presence of fat and dietary fiber and other components, and portion sizes consumed (11, 12). Evidence has shown that reducing glycemic index of foods despite high carbohydrate intake may reduce the risk of diabetes mellitus (13). Repetition(deleted)

In this study, pineapple fruit has the largest portion size, lowest glycemic index and produced the lowest glycemic load while banana, another fruit has lowest portion size, the highest glycemic index and produced the highest load. Also, 199g of rice has a glycemic index of 98.9 and produced glycemic load of 50.47 while 229 g of wheat flour has a glycemic index of 97.37 and glycemic load of 48.69. In addition, the fiber content of the test foods did not correspond with the glycemic response, as jollof rice and banana with higher fiber content than wheat flour dough and pineapple have higher glycemic index. The high glycemic indexes of jollof rice and banana may be due to the higher carbohydrate and lower moisture contents compared to pineapple and wheat flour.

Previous studies have reported similar range of values for banana despite the higher content of fiber than observed in pineapple (14, 15). The finding in this study is in agreement with the submission that the sugar and dietary fiber contents only partly explain the glycemic index of food (14). The glycemic index of banana and pineapple is higher than reported by a previous study (15) and this could be attributed to the variation in the species and agronomical properties of fruits. The glycemic index of pineapple (94.88%) observed in this study was higher than 80% reported by Francis (16) and 64.5% reported by Edo *et al.* (15). The glycemic index of banana (99.3%) observed in this study was higher than the 75.1% reported by Edo *et al.* (15). The glycemic index of banana in this study is also higher than 62% and 74% reported in unripe and over-ripe banana, respectively (17). These differences may be due to variations in locations, growing conditions, differences in sugar composition, time of harvesting, duration and methods of storage of the fruits (11, 18).

Though jollof rice and wheat flour dough are both cereal-based foods, the variation in the glycemic indices could be as a result of cooking methods and the presence of other ingredients in jollof rice (19). The high glycemic index in wheat may be attributed to the processing methods such as grinding into a powdered form (20). Nevertheless, wheat flour dough had a lower glycemic index compared with jollof rice, which may be due to the higher protein and lower carbohydrate contents in wheat flour. The high glycemic index (97.37%) of wheat in this study is similar to 95.80% and 95.28% reported for wheat semovita and wheat semolina in an earlier study (19). A study in Botswana study also reported a higher glycemic index for wheat-based foods as 103.1% (21). The differences in the glycemic index values may be attributed to cooking methods and ethnicity of the participants. The glycemic index of jollof rice (98.9%) in this study was higher than reported in boiled white rice (56%) (12), brown rice (60.24%) (22) and *tuwo shinkafa* (95.30%) (19). These differences may be attributed to the variety of the rice and the degree of processing. The presence of fat for example may alter blood glucose response indirectly by slowing down gastric emptying, resulting in slower rate of digestion with subsequent reduction in glucose absorption (23, 24). Overall, all the test foods are considered to be high glycemic foods and therefore should be consumed with caution possibly by reducing the portion size consumed or ensuring consumption with low glycemic foods.

CONCLUSION

The four staple foods, banana, jollof rice, wheat flour and pineapple have high glycemic index values and can be digested and absorbed rapidly, leading to a prolonged increase in blood glucose levels. Efforts should be intensified on promoting portion size control and healthy food choice for improved glycemic response and reduced risk of diabetes mellitus.

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Conflict of interest

The authors declare no conflict of interest.

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