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GLYCEMIC INDICES OF SELECTED NIGERIAN FLOUR MEAL PRODUCTS IN MALE TYPE 2 DIABETIC SUBJECTS

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SUMMARY

The upsurge in the incidence and prevalence of diabetes worldwide and in Nigeria in particular is a challenge for urgent action in the adoption of appropriate dietary management in patients with diabetes and also in the prevention of diabetes. Knowledge of the glycemic index (GI) of food types is essential for rational advice on calorie recommendation. Unfortunately, the GI of many food types in Nigeria is not known and so this study was undertaken to determine the GI of four staple and predominantly carbohydrate-based food types in Nigeria (yam, cassava, maize and wheat) by an open-labeled method, and to assess the variability of the GI of the tested food types in healthy subjects and those with diabetes. A total of twenty subjects were included in the study, i.e. ten type 2 diabetes mellitus (DM type 2) patients and ten healthy subjects serving as controls. They were given measured portions of the food containing 50 g of digestible carbohydrate. Blood glucose concentrations were determined from capillary blood drawn half hourly with a portable glucometer for two hours after ingestion of the food. Blood glucose curves were constructed to calculate the GI of the food. Values of the GI of the foods were compared using appropriate statistical methods of Microsoft Excel and SPSS v. 11. The results showed that there was wide variability of the GI in all the foods tested in both groups. In healthy subjects, maize flour meal had the lowest GI and cassava flour meal the highest GI. This was in contrast to patients with diabetes, where yam flour had the lowest GI and wheat flour the highest GI. While the method of meal preparation may have an effect on the overall acceptability of the food to our patients with diabetes, it is apparent that carbohydrate from yam should be allowed freely in the menu while that from wheat flour (white bread) should only be allowed sparingly. The results from this study should serve as an encouragement for further studies on the local staple food types in Nigeria to ascertain their suitability or otherwise in their incorporation into the recommended menu in the dietary management of diabetes.

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INTRODUCTION

The concept of glycemic index (GI) (1) was developed to help diabetic patients with blood glucose control when it was evident that high GI food consumption was associated with an increased risk of type 2 diabetes mellitus (type 2 DM) (2,3). Epidemiological and dietary intervention studies suggest that a low-GI diet is beneficial for blood glucose control and consumption of foods with a high GI or glycemic load (GL) is hypothesized to contribute to insulin resistance, which is associated with an increased risk of DM, obesity, cardiovascular disease, and some cancers (4-6). Both dietary GI and GL were independently correlated with several metabolic risk factors in subjects whose dietary GI and GL were primarily determined on the basis of the GI of predominantly carbohydrate foods such as white rice (7). It is thus apparent that GI is an aspect of diet of potential importance in the treatment and prevention of chronic diseases. This is particularly of importance to the understanding and dietary control of diabetes, especially in regions such as Nigeria, a developing tropical country, where carbohydrate food sources form the bulk of diet available to the majority of the population. For most foods in Nigeria, however, GI is yet to be defined.

This study was thus designed to determine the GI of selected flour meal products that form the bulk of the meal available to Nigerians, and to assess the variability of the GI of the tested foods in both healthy subjects and type 2 DM patients. It is hoped that the results of this study will form the basis for proper dietary prescription to diabetes patients, who may not be able to afford Western-type diet.

METHODS

Subject selection

Ten male patients with type 2 DM first diagnosed within the past year, who were controlled only by oral hypoglycemic agents, were recruited for the study. The patients, after giving their informed consent for the study, were selected consecutively from the outpatient department of the University College Hospital, Ibadan, Nigeria. Ten healthy male volunteers, age-matched hospital workers, were included as control subjects. Control subjects did not have previous management for diabetes or hypertension, and no family history of either.

The two groups of subjects followed the study protocol without any prejudice to their social status. Each subject ingested four staple food types (yam flour meal, cassava flour meal, wheat flour meal and maize flour meal) and standard meal (pure glucose) at one-week intervals. Each of the five meal types was taken twice and so the study covered a period of ten weeks. One meal type was served to all subjects at a session. Diabetic subjects continued to use their prescribed drugs throughout the study period.

Food preparation

The food was professionally prepared in the expected quantity and quality by the Dietetic and Catering Department, University College Hospital, Ibadan, Nigeria. The yam, cassava and maize flours were processed from their raw tubers and grains respectively by grinding and sieving. The flour meals were prepared by stirring in a pot of boiling water until they were satisfactorily well cooked and made consistent ready for consumption. Wheat flour was baked as white bread. The same type of soup was served with each of the meals. This was made up of vegetable leaf (of *Corchorus olithorus*), tomato sauce and 25 g of boiled beef meat. The food types are eaten in this culture with a bowl of soup and so it was necessary to serve the meals with soup prepared in a standard and uniform way to avoid the introduction of a possible variable that may affect the study results. The food was portioned with each serving containing 50 g of digestible carbohydrate. Glucose (50 g) was dissolved in 300 mL of water just before drinking (as a standard meal).

The composition, calories and amount of tested food containing 50 g of digestible carbohydrates were obtained and calculated from the table of food composition for use in Africa and the Tropics (8-10). The composition and weight of the flour meals tested are shown in Table 1 and Table 2, respectively.

Table 1. **Composition of flour meals in terms of 100 g edible portion**

Flour meal type	Food energy (calories)	Moisture (%)	Protein (g)	Fat (g)	Total CHO (g)	Fiber (g)	Ash (g)
Yam flour	335	14.2	3.4	0.4	80.0	1.6	2.0
Cassava flour	337	14.0	1.1	0.3	82.2	6.0	1.6
Maize flour	332	10.4	6.5	5.3	70.0	7.8	10.0
Wheat flour	376	6.5	12.9	1.1	77.0	0.4	2.5

CHO, carbohydrate; table adapted from Wu Leung WT, Busson F, Jardin C. Food composition table for use in Africa (8).

Table 2. **Weights of flour meals containing 50 g of digestible CHO before and after preparation**

Flour meal type	Raw weight (g)	Weight after preparation (g)
Yam flour	67.5	280
Cassava flour	60	205
Maize flour	65	250
Wheat flour	66.7	50

CHO, carbohydrate

Table 3. **Study subject characteristics**

	Diabetes patients	Healthy subjects
Age (yrs)	55.1±10.4	52.3±10.2
Weight (kg)	70.95±6.63	69.72±7.78
Height (m)	1.66±0.05	1.67±0.06
BMI (kg/m^2)	26.06±3.37	25.13±2.29

BMI, body mass index (weight in kg/height in m^2); values are mean ±SD.

Glycemic index determination

A modified version of the method of Rasmussen *et al*. (11) was used to determine GI of each flour meal in both healthy and diabetic subjects. A carefully measured portion of the food used for the study was eaten by each of the subjects after an overnight fast. Capillary blood samples were collected from finger prick just before the meal and thereafter every 30 min for 120 min. Total blood sugar level was determined from each of the blood samples with a portable glucometer (One Touch Basic Lifescan Blood Glucose Monitoring System, Johnson & Johnson Company, Ca, USA).

Blood glucose response curve was constructed from the average blood glucose concentration obtained pre- and post-meal ingestion as a function of time after meal ingestion. Incremental area under the curve (IAUC) was calculated for each meal for each subject, as the sum of the surface triangles and trapezoids between the blood glucose curve and the horizontal baseline running in parallel to the time axis from the beginning of the curve to the point at 120 min, to reflect the total rise in blood glucose concentration after eating the tested food. The IAUC for reference (standard) food (i.e. 50 g of pure glucose) was obtained in a similar way (IAUCS).

The GI for each food was calculated from the formula: GI = (IAUC/IAUCS) x 100%.

The average of the two measures for each subject was taken as the GI for that food for the subject. The GI for each food was finally calculated as the mean of the average of the GIs in ten subjects in the group. The GI of each food was compared between healthy and diabetic subjects and also with other food items used in the study.

The Microsoft Excel and SPSS v. 11 statistical programs were used to analyze the data obtained. Results are expressed as mean ± standard deviation (SD). Comparisons between the two groups were made using Student's t-test. Linear correlations were calculated with Pearson test. Statistical significance was set at $p<0.05$.

RESULTS

Table 3 shows the characteristics of type 2 DM patients and healthy subjects included in the study. Diabetes patients were generally older than control subjects. There was no significant between group difference in body mass index (BMI).

Figures 1 and 2 show the mean blood glucose response curves of various flour meals in diabetes patients and healthy subjects, respectively.

From Table 4 it is obvious that wheat flour meal (white bread) had the highest GI (70.1%) and yam flour meal the lowest GI (49.8%) in diabetes patients. In healthy subjects, cassava flour meal had the highest GI (40.1%) and maize flour meal the lowest GI (26.6%). There were substantial variations, however, in the GIs of each food type. Table 5 shows that wide variations in the GI of each food were manifest in the correlation between the GI of the food types in patients with diabetes and healthy subjects.

DISCUSSION

The methods for defining GI are not standardized, with values having large inter- and intra-individual variability as demonstrated in this study as well as in several other studies (11-13). The accuracy of the GI measurements is influenced particularly by several factors, which include the method of calculating IAUC, the method used on blood glucose measurement, defining the amount of tested food which contains 50 g of hyperglycemic (i.e. absorbable, digestible) carbohydrates, variability of the subjects included in GI determination, day to day glycemia variability, and time of the day when the test is carried out. In this study, great care was taken to eliminate the sources of undue variability, as strict adherence to standard protocol was observed throughout the study period.

Carbohydrates form the bulk of staple food in Nigeria and the GI of four such staple food sources in this environment were estimated in this study. The variability which is clearly evident from this study cannot be attributable to other factors except those peculiar to individual handling of carbohydrate.

Figure 1. **Mean blood glucose response curve (diabetes patients)**

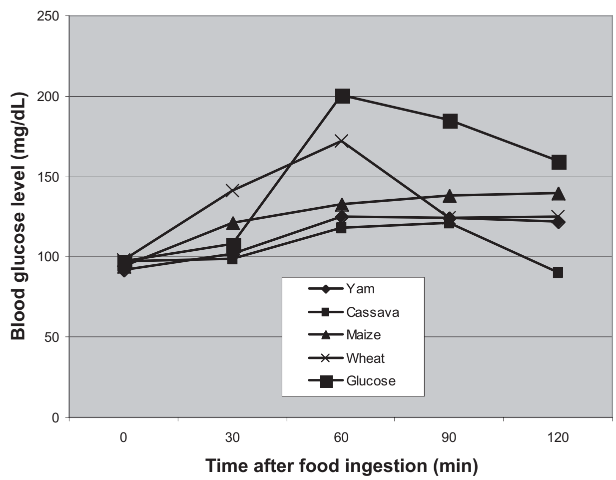

Figure 2. **Mean blood glucose response curve (healthy subjects)**

Table 4. **Glycemic indices (GI) of food types in study subjects**

Food type	Diabetes patients (n=10)	Healthy subjects (n=10)
Yam flour	49.81±10.38	35.30±11.71
Cassava flour	59.34±32.42	40.12±25.27
Maize flour	54.83±26.74	26.61±11.33
Wheat flour	70.10±46.33	37.50±23.21

Values are mean ±SD and presented as %.

Table 5. **Correlations of the glycemic indices (GI) of tested foods between diabetes patients and healthy subjects**

Food type	Pearson correlation (r)	Level of significance (p)
Yam flour	-0.175	0.629
Cassava flour	0.076	0.835
Maize flour	0.069	0.850
Wheat flour	0.083	0.819

Patients with diabetes, as would be expected, had a slower rate of glucose clearance in the blood, hence the peculiar nature of the curves obtained in the blood glucose variability. The healthy subjects, however, had a better blood glucose clearance following ingestion of meals rich in carbohydrates. The soup served with each meal had the same content and so this should not have contributed to the variability of GI to any appreciable extent. Day to day glycemic variability of food (14,15) may not be the predominant factor for the observed variability of GI in this study as the individuals took the same type of food on a particular day of the study and each of the food was taken on two study days by each of the subjects.

The wide variability of GI observed in this study shows that other factors may be at play in the response of individuals to carbohydrate ingestion. In this wise, one should be careful in interpreting the results of determination of GI of foods, especially when such results are used as the sole basis for therapeutic recommendations.

International tables of GI, containing more than 600 different food types, have been published (16), and since none of the Nigerian food types used in this study are included in such tables, the results of this study should guide dietitians in our environment and researchers in the field of nutrition in appropriate dietary recommendations to diabetes patients and to subjects desiring low caloric food intervention.

It is evident from this study, albeit without a strong statistical backing, that white bread should be eaten sparingly by patients with diabetes due to the high GI of Nigerian white bread, and yam-based food products should be used more generously to supply 55%-75% of the recommended daily calorie from carbohydrates. Healthy subjects can also be advised to follow this recommendation, especially those with a family history of type 2 DM. Further studies may be necessary to fine tune the determination of GIs in staple carbohydrate-based Nigerian diets, and until then, the recommendations made herein may be a starting point in arousing the interest for further study.

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