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Research Article

# Glycaemic and Insulin Response of Some Common Ugandan Foods in Patients with Type 2 Diabetes

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## ABSTRACT

**Background:** Measuring glycaemic response to foods enables selecting the most appropriate in diabetes management.

**Objective:** To determine the glycaemic and insulin response of three selected Ugandan meals in persons with type 2 diabetes namely: Katogo, Bushera and Chai-no-Mugati.

**Methods:** Six type 2 diabetes and six matched healthy control participants were studied. On the day of testing, an indwelling sampling catheter was inserted in an antecubital vein from which blood samples were collected to assay for c-peptide and plasma glucose. Plasma glucose samples were obtained at 0, 15, 30, 45, 60, 90, and 120 min following consumption of foods. C-peptide samples were collected at 0 and 120 minutes. Participants reported every three days and consecutively consumed the Katogo, Bushera and Chai-no-Mugati as breakfast. Glucose response curves were plotted and insulin response calculated as difference between fasting and 120 minutes post meal.

**Results:** Glycaemic response was highest in Katogo (107.3%), then Bushera (71.9%) and lowest in Chai-no-Mugati (89.4%) ($p<0.001$). Similarly, insulin response was highest in Katogo, but least in Bushera.

**Conclusion:** Katogo elicited the highest glycaemic response, Bushera elicited the lowest; and Chai-no-Mugati was intermediate. The Katogo used in this study is associated with high insulin response and unfavourably high glycaemic response.

**Keywords:** Glycaemic; Diabetes; Consumption; Insulin; Antecubital vein

## INTRODUCTION

The effectiveness of medical nutrition therapy in managing diabetes is well established [1]. Carbohydrate is the main dietary component affecting insulin secretion and postprandial glycaemia [2], implicating it in the pathophysiology of Type 2 Diabetes (T2DM). This should be considered in diabetes management.

The FAO/WHO Report on carbohydrates in human nutrition suggests that the concept of glycaemic index, a measure of the glycaemic response to food, helps to select the most appropriate carbohydrate containing foods for the treatment of diabetes [3]. In recent clinical trials, a low glycaemic index diet improved glycaemic control and decreased cardiovascular disease risk in T2DM [4].

The objective of this study was to determine the glycaemic and insulin response of three common Ugandan foods for breakfast: Bushera (*Euleucine coracana*/millet beverage); Katogo (*Musa acuminata*/Matoke and a sauce) and Chai-no-Mugati (Tea with milk and two slices of bread with a thin spread of margarine) in patients with type 2 diabetes.

## MATERIALS AND METHODS

The glycaemic and insulin response of Katogo, Bushera, and Chai-no-Mugati was determined in an experimental study design among six individuals with confirmed T2DM and six healthy matched controls.

The study was carried out at St. Francis hospital Nsambya, Kampala, Uganda and ran from 15$^{th}$ January 2018 to 15$^{th}$ February 2018.

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The participants who volunteered were above 18 years age and were selected conveniently.

The study was approved by the hospital research ethics committee and participants provided written informed consent.

Participants required to have; confirmed T2DM; age above 30 years; T2DM diagnosis made within three months; HbA1C ≤ 8.5 (within three months); no history of gastrointestinal surgery.

In addition participants should not have been on; Insulin or sulfonylureas; substances of abuse; beta-blocker, corticosteroid therapy or herbal medicines.

Participants were asked to fast for 8 hours prior to the morning of testing; not to engage in strenuous physical activity, and to avoid smoking, alcohol or coffee in this time.

Katogo consisted of 4 green bananas (matoke) plus soup made by adding a medium sized tomato, medium sized onion and 10 g of cow butter in 250 ml water, and all boiled together to satisfactory cooking; Bushera® consisted of 300 ml of commercially packed millet porridge (Kirunga (U) Ltd); Chai-no-Mugati (factory-made bread (Ntake®), each slice consisting of 15 g available carbohydrate in each) taken with 300 ml milk (Jessa Farm®). Reference meal glucose consisted of 50 g anhydrous glucose dissolved to make 250 mL solution with water.

These portions were considered because they represent typical traditional sizes, and are considered exchangeable based on their satisfying level rather than on the carbohydrate content.

On the day of testing, an indwelling sampling catheter (with saline lock) was inserted in an antecubital vein from which blood samples were collected to assay for c-peptide and plasma glucose. Plasma glucose samples were obtained at fasting (taken as time 0), 15, 30, 45, 60, 90, and 120 min following consumption of test foods. C-peptide samples were collected at fasting and 120 min.

Participants reported every 3 days for reference meal glucose; Katogo; Bushera and Chai-no-Mugati. Blood samples were analyzed for glucose (by glucose oxidase method) and C-peptide (by ELISA) in the laboratory.

Glucose response curves were plotted and incremental area under curves (IAUC) calculated using the trapezoid rule [5].

The glycaemic response in an individual was taken as the IAUC, whereas, the relative glycaemic response was taken as the IAUC of the test food divided by IAUC of the reference food of the same individual expressed as a percentage. The glycaemic response of the foods was calculated using the "ratio of means" and "mean of ratios" methods as described by Brouns, et al. [6]. The insulin response was taken as the incremental change in C-peptide level, whereas the relative insulin response was taken as the rise in the C-peptide level of test food divided by the rise in C-peptide level of reference food of the same individual. Data was analyzed using Microsoft excel and Statistical Package for Social Sciences (SPSS) software version 20 (IBM SPSS Statistics Inc., North Castle, New York, US). P-value of less than 0.05 was taken as significant.

# RESULTS

Six with type 2 diabetes and six healthy men participated in the study. The socio-demographic and clinical characteristics are displayed in Tables 1 and 2.

**Table 1:** Socio-demographic and clinical characteristics of study participants.

| **Characteristics** | **Groups** | |
|---|---|---|
| | **T2DM subjects (n=6)** | **Normal healthy subjects (n=6)** |
| Age in years, mean ± SD | 44.7 ± 8.3 | 43 ± 7.9 |
| BMI, mean ± SD | 26.7 ± 2.9 | 25.5 ± 3.2 |
| Waist circumference, mean ± SD | 95.3 ± 10.3 | 93.3 ± 12.5 |
| **Level of education,** (%) | | |
| O' level | 2 (33.3) | 0 (0) |
| A' level | 3 (50) | 4 (66.7) |
| University | 1 (16.7) | 2 (33.3) |
| **Alcohol intake,** (%) | | |
| No | 4 (66.7) | 2 (33.3) |
| Yes | 2 (33.3) | 4 (66.7) |

**Note:** T2DM: Type 2 Diabetes; BMI: Body Mass Index in kg/m²

Table 2 below shows the glycaemic responses across the different foods.

**Table 2:** Glycaemic and insulin responses of glucose solution, Katogo, Bushera, and bread plus milk portions among Diabetic (DM) and Non-Diabetic (Non DM) subjects.

| Variable, means ± SD | Glucose solution | Katogo | Bushera | Chai-no-Mugati | p-value* |
|---|---|---|---|---|---|
| GR, DM | 9513.9 ± 2288.9 | 9977.0 ± 2141.6 | 6750.1 ± 1445.9 | 8489.9 ± 2315.0 | <0.001 |
| GR, Non DM | 3329.0 ± 1287.9 | 5654.5 ± 3103.9 | 2508.3 ± 1139.6 | 3452.5 ± 2144.4 | 0.001 |
| RGR, DM | - | 107.3 ± 23.6 | 71.9 ± 8.8 | 89.4 ± 10.1 | 0.002 |
| RGR, Non DM | - | 143.9 ± 60.6 | 70.9 ± 7.7 | 82.6 ± 15.8 | 0.031 |
| IR, DM | 1.54 ± 0.87 | 1.82 ± 1.29 | 0.85 ± 0.17 | 2.03 ± 0.73 | 0.005 |
| IR, Non DM | 2.62 ± 1.27 | 2.75 ± 0.83 | 0.90 ± 0.74 | 2.83 ± 0.98 | 0.009 |
| RIR, DM | - | 1.23 ± 0.88 | 0.66 ± 0.26 | 1.53 ± 0.78 | 0.024 |
| RIR, Non DM | - | 1.28 ± 0.78 | 0.39 ± 0.35 | 1.41 ± 0.88 | 0.011 |

**Note:** GR: Glycaemic Response; RGR (in %): Relative Glycaemic Response; IR: Insulin Response; RIR: Relative Insulin Response; DM: Diabetes Mellitus participants

*p-values obtained by repeated (paired) measures ANOVA using Generalized Linear Models (GLM)

The below Figures 1 and 2 show the mean glucose response curves for test foods among T2DM subjects and the normal healthy subjects

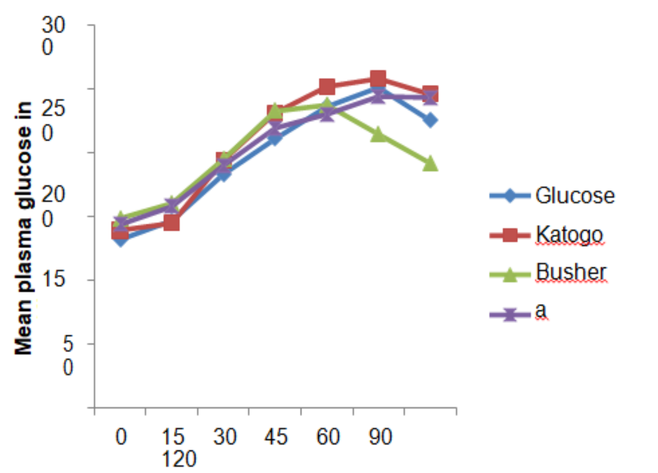


**Figure 1:** Mean glucose response curves for test foods among T2DM subjects.

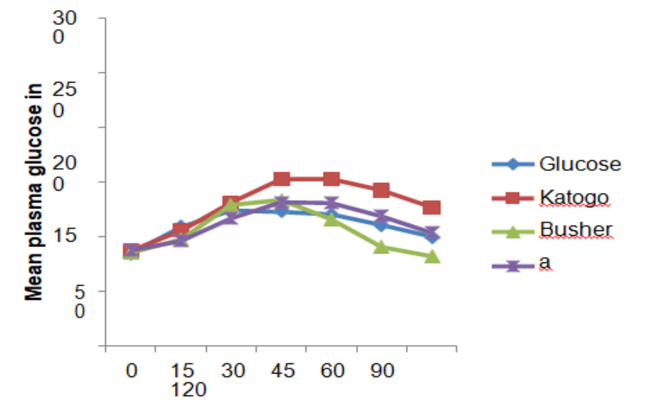


**Figure 2:** Mean glucose response curves for test foods among the normal healthy subjects.

Mean IAUC of diabetes subjects was greater than mean IAUC of healthy controls (P<0.05) for all foods. There was, however, no statistically significant difference in mean relative glycaemic response between T2DM subjects and their healthy controls for all foods (Table 3).

**Table 3:** Glycaemic responses of T2DM subjects versus their healthy control subjects.

| Variable, means ± SD | Diabetic | Normal | p-value |
|---|---|---|---|
| GR glucose solution | 9513.9 ± 2288.9 | 3329 ± 1287.9 | 0.001 |
| GR Katogo | 9977 ± 2141.6 | 5654.5 (3103.9) | 0.019 |
| GR Bushera | 6750.1 (1445.9) | 2508.3 (1139.6) | <0.001 |
| GR Chai-no-Mugati | 8489.9 (2315.0) | 3452.5 (2144.4) | 0.003 |
| RGR glucose solution | - | - | - |
| RGR Katogo | 107.3 (23.5) | 172.3 (80.8) | 0.088 |
| RGR Bushera | 71.9 (8.8) | 73.9 (12.0) | 0.743 |
| RGR Chai-no-Mugati | 89.4 (10.1) | 100.9 (45.4) | 0.556 |

**Note:** GR: Glycaemic Response; RGR: Relative Glycaemic Resonse.
*p-values obtained by student's t-test.

There was no statistically significant difference in mean insulin response (ΔCP) and mean relative ΔCP between T2DM participants and their controls for all foods tested (Table 4).

**Table 4:** Insulin responses of T2DM subjects versus their healthy control subjects.

| Variable, means (SD) | Diabetic | Normal | p-value |
|---|---|---|---|
| IR for glucose solution | 1.54 (0.87) | 2.62 (1.27) | 0.114 |
| IR for Katogo | 1.82 (1.29) | 2.75 (0.83) | 0.169 |
| IR for Bushera | 0.85 (0.17) | 0.90 (0.74) | 0.875 |
| IR for Chai-no-Mugati | 2.03 (0.73) | 2.83 (0.98) | 0.138 |
| RIR for glucose solution | - | - | - |
| RIR for Katogo | 1.23 (0.88) | 1.28 (0.78) | 0.914 |
| RIR for Bushera | 0.66 (0.26) | 0.39 (0.35) | 0.167 |
| RIR for Chai-no-Mugati | 1.53 (0.78) | 1.41 (0.88) | 0.8 |

**Note:** IR: Insulin Response; RIR: Relative Insulin Response. *p-values obtained by student's t-test

# DISCUSSION

## Comparison of glycemic response of the different foods among T2DM participants

There was a difference (p<0.001) in mean IAUCs across foods; Katogo (9977), glucose solution (9513.9), Chai-no-Mugati (8489.9) and Bushera (6750.1). There was, also, a statistically significant difference in the relative glycaemic responses of these foods (p<0.001). The mean relative glycaemic response to Katogo was 107.3%, Bushera 71.9% and Chai-no-Mugati 89.4% (Figure 2).

Of the three test foods, therefore, Katogo elicited the highest glycaemic and relative glycaemic response and Bushera the lowest. The approximate carbohydrate content by analysis for Katogo, Bushera and Chai-no-Mugati is 125 g, 28 g and 45 g respectively [6,7]. The positive correlation between the carbohydrate content of the meals and their glycaemic responses reaffirms the importance of available carbohydrate in a meal, toward affecting postprandial glycaemia and/or glycaemic response.

Current recommendation is that adult T2DM should consume 45 g to 60 g of carbohydrates at each meal [8]. We considered a glucose solution to be a pure 50 g digestible carbohydrate reference food and therefore its glycaemic response was considered the reference. The estimated carbohydrate content of Chai-no-Mugati (45 g) coupled with its determined glycaemic response suggests that it is an acceptable meal for persons with T2DM while Katogo is unfavourable.

### Comparison of insulin response of the different foods among T2DM participants

There was a difference in mean ΔCP and mean relative ΔCP between glucose solution, Katogo, Bushera and Chai-no-Mugati ($p<0.05$) with the latter eliciting the highest and Bushera the lowest insulin response. The lower insulin response of Bushera may to a large extent be explained by the low estimated digestible carbohydrate content of the meal in comparison to the others, and that would correlate with the insulin response.

Although Katogo elicited the highest glycaemic response, it was Chai-no-Mugati that elicited the highest insulin response. This is in conformity with studies that have shown that postprandial glucose responses do not predict postprandial insulin responses. This implies other factors affecting insulin secretion other than the plasma glucose rise (or even amount of available carbohydrate in meal). Such factors include presence of other nutrients for example fat and protein [10-12].

### Strengths of the study

This comes down as a novel study in Uganda that has examined glycaemic response of some local foods. This contributes towards evidence based dietary recommendations to manage diabetes.

Unlike studies done using the classic GI methodology, this study considers typical portion size of the foods which is a major determinant of postprandial glycaemia.

This study assesses insulin response to the foods unlike most studies which assess only glycaemic response. This importantly affects postprandial glycaemia. Systematically measuring insulin response is recommended for completeness [13].

In this study, blood samples are withdrawn every fifteen minutes in the first hour, unlike many studies where they withdrew every thirty minutes. More frequent withdraws serve to improve the precision in calculating the IAUC.

## CONCLUSION

Katogo elicited the highest glycaemic response, while Bushera elicited the lowest; and Chai-no-Mugati was intermediate. Katogo in this study is associated with high insulin response and unfavourably high glycaemic response.

## LIMITATIONS OF THE STUDY

Whereas the portions of food in this study are considered typical, they may not reflect true usual portions consumed by certain individuals, as they may be consuming less or more of the sizes that were tested. This should be put in context when making dietary recommendations.

## RECOMMENDATIONS

Katogo portion as served traditionally is an unfavorable breakfast meal, as it elicits high glycaemic response. Bushera portion as described in this study would be preferable.

Further study is required to examine what would be the more appropriate Katogo portion size for patients with diabetes in relation to breakfast or snack.

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