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Postprandial glycemic responses of four common Ghanaian meals

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Abstract
There remains a gap in the conclusiveness of the importance of the glycemic index hypothesis. This study investigated the overall postprandial glycemic effects of four common Ghanaian meals in non-diabetic adult subjects. After an overnight fast, the test meals (*Ampesi, Fufu, Banku and Ga Kenkey*) served as mixed meals were consumed by the participants on separate days. Blood glucose levels were observed at baseline and 30-minutes intervals for three (3) hours. Postprandial outcomes were assessed as the Total postprandial glycemia area under-the-curve, Peak percentage postprandial glycemia and percentage postprandial glycemic retention. The results of the study showed that with little variations, there were no significant differences in the overall postprandial glycemic responses of the meals, despite previously quoted differences in glycemic indexes of the foods. The relative differences in their postprandial glycemic patterns may rather suggest implications in individuals on insulin therapy in terms of dosage and timing.

Keywords: glycemic index, mixed meals, postprandial glycemic responses, ghanaian meals

1. Introduction
It is estimated that almost 450 million people are currently living with diabetes, accounting for about 5.1 million deaths annually [1, 2]. The idea of a nutritional management of blood glucose dysregulation is currently advocated as a strategic target in the prevention and management of diabetes [3]. The relationship between glycemic control and nutritional management of diabetes applies not only to the fasting glycemic values, but also to other markers of glucose regulation, which reflect postprandial glycemic control [4]. The postprandial glycemic response to a meal is not only determined by the amount and individual glycemic indexes of the foods but the composition of both the macro- and micronutrients, preparation methods and the overall form of the food when prepared as a mixed meal [5]. Traditional means of assessing the impact of postprandial glycemia levels have mainly focused on the glycemic index (GI) which typically measures the carbohydrate content and its absorption rate [6]. High GI foods are characterized with a marked elevation in postprandial glycemia, followed by a more or less rapid fall in blood glucose whereas low GI foods produce a relatively smaller postprandial glycemia peak, along with a more gradual decline in postprandial plasma glucose levels [6]. The importance of the glycemic index concept provides a ranking of foods based on their blood glucose responses. However, it does not usually consider the effect of the typical carbohydrate amount in a food portion on postprandial glycemia. This has therefore prompted the suggestion that as a means of improvement of the reliability of predicting the glycemic response of a given food, the glycemic load which is the product of the glycemic index of the food and the amount of carbohydrate in a serving should rather be used [7]. Some previous studies on Ghanaian meals have basically focussed on estimating the glycemic indexes of some common carbohydrate staple foods with the use of the weight-to-weight comparison of a reference food (oral glucose or white bread) containing an equivalent amount of 50g carbohydrate content of a reference food [8, 9, 10]. The aim of the study was to investigate the overall postprandial glycemic responses of four commonly consumed Ghanaian foods served as mixed meals.

2. Materials and methods
2.1 Inclusion criteria
Healthy non-obese adults aged 20 to 44 years.

2.2 Exclusion criteria
1. Age ≥ 45 years
2. Fasting plasma glucose ≥ 7.0 mmol/l
3. Obesity
4. Recent ailment
5. History of any chronic medical condition or medication
6. Smokers
7. Alcohol intake
8. History of gastrointestinal disease

2.3 Ethical consideration
Approval for the research was received from the Committee on Human Research, Publication and Ethics, Kwame Nkrumah University of Science and Technology. All participants gave their informed consent for participation in the study.

2.4 Meal preparation
All meals were prepared by an accredited restaurant known to all the participants. The preparation methods and relative compositions of the ingredients (carbohydrate, fat, and protein) were according to the usual daily procedures of the restaurant so that the meal appearances were known to all researchers and study participants as commonly known and consumed in the general population.

2.5 Meal types
1. 250g*Ampesi* (plantain and cassava in the ratio of 80:20) + 100g mixed vegetable stew+ 100g cooked mutton.

2. 250g *Fufu* (plantain and cassava in the ratio of 80:20) +150g light soup +100g cooked mutton.
3. 250g *Banku*(corn dough and cassava dough in the ratio of 80:20) + 150g (grilled tilapia fish) + 30g *shito*(hot chili pepper, green pepper, tomatoes, and onions).
4. 250g *Ga Kenkey* (fermented corn dough) + 150g (grilled tilapia fish) + 30g *shito*(hot chili pepper, green pepper, tomatoes, and onions).

2.6 Study protocol

An initial screening exercise was done for the selection of participants based on the stipulated criteria. On testing days, baseline blood glucose measurements were done on all participants with Accu Chek™ Glucometer. The total amount of the prepared meal was consumed within 10 minutes with the preferential use of at least 250ml of distilled water. Subjects were then made to be at rest with limited physical activity during the study period. Blood glucose levels were measured at 30 minutes intervals for 3 hours. The whole procedure was repeated for the other meals at 3-days intervals. Means of Total postprandial area under the glucose curve, Peak percentage postprandial glycemia and percentage postprandial glycemic retention were calculated. Analysis of variance (ANOVA) was used to assess differences between the meal groups. Data analysis was done with GraphPad Prism version 7.0.

3. Results & Discussion

3.1 General characteristics of the study participants.

The study included a total of ten volunteer-participants (5 males and 5 females) with a mean age of 40.3 ± 2.98 years. The anthropometric characteristics of the study participants as described in Table 1 showed that the mean BMI was 23.01 ± 1.09 kg/m2 with mean systolic and diastolic blood pressures of 120 ± 15.02 mmHg and 75 ± 5.69 mmHg respectively.

3.2 Overall Postprandial Glycemic Area-under-the Curve responses to test meals.

The postprandial glycaemic responses to the test meals are illustrated in Table 2. The results showed that the mean total peak area under the glucose response curve for *Banku*was the highest whiles *Ampesi*had the lowest mean peak area under the glycemic response curve. However, the differences between the test meals were not significant (*p*-value = 0.670). Additionally, the postprandial glycemia response curve in Figure 1 showed that the peak incremental glycemia for the test meals occurred at 30 minutes after meal consumption.

3.3 Discussion

Previous studies of the postprandial glycemic responses of Ghanaian foods have mainly focussed on estimating only the glycemic indexes of common staple foods. *Eli-Cophie et al*, [9] have reported glycemic indexes of 31 (processed-powdered *Fufu*), 41 (*Gakenkey*), 55 (locally pounded *Fufu*), 68 (*TuoZaaf*), and 73 (*Banku*). Yeboah *et al*, [10] have also reported glycemic indexes of 7, 18, 29, 58, and 69 for *locally made Kokonte, Processed Kokonte, Kafa, Abolo*and *Akple, respectively. The current study typically investigated the glycemic responses and the glycemic retention patterns of the meals as a means of assessing their overall postprandial glycemia pattern. All the meals were prepared and served in portions that reflect the average size usually known and consumed in the general population.*The postprandial glycemic response curves showed that the peak incremental glycemia for the test meals occurred at 30 minutes after consumption, consistent with previously reported results [9,10]. The postprandial glycemic responses of the test meals are summarized as follows:

1. *Ampesi* does not cause an early rise in postprandial glycemia but has a sustained postprandial glycemia effect, implying a slow gradual glucose release.
2. *Fufu* has an early rise in postprandial glycemia but does not lead to sustained postprandial glycemia, implying early absorption and early clearance.
3. *Banku* has the overall highest postprandial glycemia effect. It raises postprandial glycemia earlier with a sustained postprandial glycemia retention.
4. *Kenkey* does not raise postprandial glycemia early and it also has a low postprandial glycemia retention.

Blood glucose levels following a meal is typically determined by the rate of absorption and appearance of glucose in the bloodstream and the rate of its clearance or disappearance from the systemic circulation [11]. The rate of disappearance of postprandial glucose is largely influenced by the levels of insulin secretion and its action on target tissues [12]. The test foods were consumed as mixed meals, suggesting that several other factors contribute to the postprandial glycemic response to the consumed meal. Dodd *et al*, [13] have therefore prompted an intriguing perspective regarding the utility of using a calculated GI for mixed meals. This perspective may arise from the diverse nutrient composition in mixed meals, which may affect the physiological functioning of the digestive system and glucose uptake by target tissues [14]. Physiologically, the main contributor of postprandial glucose response is the carbohydrate content [14]. Many studies have however shown that the presence of other macronutrients, micronutrients, fibre and moisture content and preparation methods in a mixed meal may contribute to the overall post prandial glycemic effect based on their physico-chemical characteristics [5]. Though *Ampesi*and *Fufu* have the same composition of boiled green plantain and cassava composition, *Fufu* is prepared in the pounded form which makes it more gelatinized with higher moisture and lower fibre contents [15]. *Banku*and *Kenkey* are largely maize-based foods. However, *Banku*is prepared from a combination of maize flour and cassava flour whiles *Kenkey* is prepared from only maize flour. The higher carbohydrate and caloric content of cassava flour together with a higher carbohydrate content of maize flour [16] may contribute to the glycemic pattern observed with *Banku*whiles the relatively higher fibre content of solely maize flour *Kenkey* [16] may contribute to its observed post prandial glycemic pattern. The results of the current study showed that though *Banku*had the highest AUC, there were no significant differences in the AUC between the test meals. Several randomized trials that have examined the efficacy of meals consisting of low GI foods to control glycemia have shown mixed results. Though some have shown significant improvement [17-21], others did not show any significant improvement in glycemic control [22-24]. Although a common suggestion from epidemiological studies is that foods with high glycemic index or glycemic load lead to development of type 2 diabetes, a review by the American Diabetes Association [14] revealed that, there is insufficient information to determine whether there is a relationship between glycemic index or glycemic load of diets and the development of diabetes. Of particular importance is the little evidence that total carbohydrate intake is associated with the development of type 2 diabetes, though the existing observations rather suggest an increased intake of dietary fibre and weight reduction are associated with a reducedrisk for the development of type 2 diabetes [14]. The evidence of postprandial hyperglycemia as an independent risk factor in the development of type 2 diabetes and its management is still a growing interest of research [5, 14]. The study foods were consumed as mixed meals with different accompaniments as commonly known in the general population. The results of the current study showed no significant differences in the postprandial glycemia pattern between the test meals. The results tend to support the observational suggestion that glycemic responses to mixed meals involves a complexity of several other factors that are not fully understood, with intra- and inter-individual variations [14]. With the growing interest in the subject of the relationship between GI, postprandial glycemia and insulin therapy [4, 22, 25, 26], it seems plausible that the beneficial importance of the GI concept may be better elucidated in individuals on insulin management. A limitation of the was the use of only healthy non-diabetic adults. However, the results point to the need for advancement in research on the new perspective of identifying the importance of the GI concept.

4. Tables and Figures

Table 1: Anthropometric characteristics of the study participants.

Parameter	Mean
Age (years)	40.3 ± 2.98
BMI (Kg/m^2)	23.01 ± 1.09
Systolic blood pressure (mmHg)	120 ± 15.02
Diastolic blood pressure (mmHg)	75 ± 5.69

Results are expressed as mean ± Standard deviation.

Table 2: Total peak area under the glucose response curve among the study subjects.

Subjects	Ampesi	Fufu	Banku	Kenkey
01	85.7	184.5	133.7	51.3
02	99	298.5	120	82.5
03	204.3	294	178.5	70.4
04	161.3	211.7	170.4	284.4
05	94.5	78.8	121.5	56.5
06	269	60	237	103.5
07	111.6	79.9	177	241.5
08	39	103.5	94.75	57.75
09	32.1	42	174.3	172.5
010	99	99	139.2	99
Mean	119.6 ± 73.1	145.2 ± 95.6	154.6 ± 40.9	121.9 ± 82.8

Results are expressed as mean ± Standard deviation; p value = 0.670

Table 3: Postprandial glycemia retention pattern of the meals.

Post prandial glycaemia (%)	Ampesi	Fufu	Banku	Kenkey	p- value
Peak postprandial glycaemia	21.2 ± 13.1	29.2 ± 24.2	34.5 ± 10.6	23.8 ± 21.1	0.375
Postprandial glycaemia retention	9.5 ± 15.4	0.5 ± 14.4	7.6 ± 8.2	0.6 ± 9.6	0.243

Results are expressed as mean percentages ± Standard deviation.

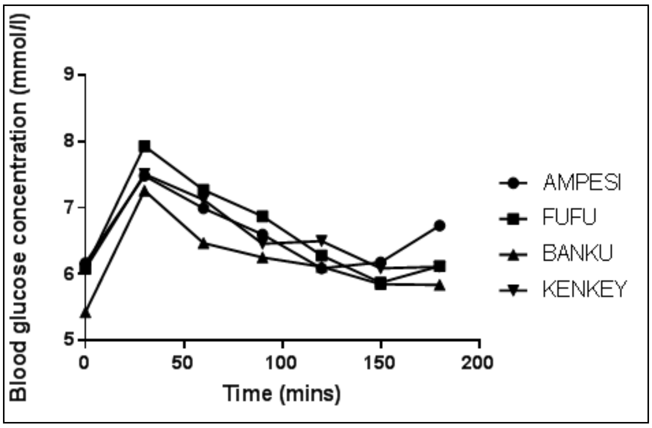

Fig 1: Postprandial glycemic area under the curve for the study meals.

5. Conclusions

With little variations, there are no significant differences in the overall postprandial glycemic responses of the test meals. The relative differences in their postprandial glycemia patterns suggest that these meals may rather have implications in individuals on insulin therapy management in terms of dosage and timing.

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7. The authors have declared that no conflict of interests exists

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