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GLYCAEMIC RESPONSE OF FOUR MANGO FRUITS CONSUMED IN ENUGU STATE

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ABSTRACT
Background: Mango fruit is a delicious juicy drupe, commonly consumed in Nigeria. It is a seasonal fruits that is consumed by all. However, diabetic patients sometimes are afraid of spike in their blood sugar after consuming fruits of which mango is one of them. Evidenced based dietary counselling and nutrition eduction of the public requires such an empirical study to establish evidence.
Objectives: This study examined the glycemic response, glycemic index and glycemic load of four mango fruits consumed in Nsukka, Enugu state.
Methodology: Samples of four mango varieties (Opioro, Alphonso, Haden, and Sweet) were randomly selected from different markets in Nsukka, Enugu state, Nigeria. These samples were thoroughly washed in warm water to remove gums. The edible portion of the mango (alphonso, haden and sweet mango was consumed with the peels, while the peel of opioro mango was remove before consumption). The weight of each variety that will give about 25g available carbohydrate was used as the test meal. Voluntary human subjects who were informed about the research were used and withdrawal at any stage was allowed. Ethical approval given by Research Ethics Committee University of Nigeria Teaching Hospital Ituku-Ozalla. Available carbohydrate was determined using standard method. The glycemic response was done using the FAO protocols. Descriptive statistics (mean and standard deviation) was used to present the data obtained while analysis of variance (ANOVA) was used to compare the means and turkey HSD test was used to separate the means.
Results: Available carbohydrate was highest in Sweet mango (6.18g). Alphonso mango significantly ($p<0.05$) had the least effect on blood glucose levels. The glycemic index of the samples was 33 for Opioro, 4 for Alphonso, 15 for Haden and 39 for Sweet mangoes. The glycemic load ranged from 5.18 in Haden mango to 6.18 in Sweet mango.
Conclusion: The study revealed that Alphonso mangoes could be used in planning diets for people with metabolic diseases like diabetes mellitus.

Keywords: *Mango, available carbohydrate, glycemic response, glycaemic index, glycaemic load,*

INTRODUCTION
Fruits are the soft juicy part of a plant that contains seed (1). They are often known to be sweet, but very few are bitter or sour. Common fruits in Nigeria include: banana, mango, watermelon, pineapple, cashew fruit, oranges, pawpaw, dates, avacado pear, lemon, lime and apple. Mango (*Mangifera indica*) also known as *mangue* in French belongs to genus *mangifera* of the flowering plant family Anacardiaceae (2). It is a delicious juicy drupe (fleshy with a single seed enclosed in the endocarp) found in the tropical regions of the world having its origin in India (3). It has been described as the most economically important fruit in the Anacardiaceae family (4). There are over 1000 varieties of mangoes in the world (4)(5). This variation is based on their cultivar type, colour (greenish, greenish-yellow, red, orange or purple), size, taste, shape (e.g. kidney shape, oval or round), flavour, and fibre content of the mango fruits (6). In Enugu state, there are more than 10 commonly consumed varieties of mango.

Changes in diet and lifestyle in our world today has resulted in some chronic non-communicable diseases (coronary heart disease, diabetes, obesity etc) which is causing premature death especially among the youth (7). Mangoes being one of the commonest fruits found in Enugu state has been consumed inadequately by both old and young. Most people are fond of taking 12-15 whole mangoes daily irrespective of their health status while some people barely take 2 whole mangoes daily. Fruits compose of sugars, which may have a high or low glycemic effect in the body. Excessive consumption of high glycemic foods has been implicated in obesity, coronary heart disease (CHD) and diabetes (8). The glycemic response of a food or meal is the effect that food or meal has on the body blood glucose levels after consumption (9). This study

will update the glycemic response of four varieties of mango fruit.

MATERIALS AND METHOD

Samples of four mango varieties (Opioro, Alphonso, Haden, and Sweet) were randomly selected from different markets in Nsukka, Enugu state, Nigeria. These samples were thoroughly washed in warm water to remove gums. The Available Carbohydrate was determined using the phenol-Sulphuric acid method (10). The available carbohydrate here includes simple sugars, oligosaccharides, polysaccharides and their derivatives with free or potentially free reducing groups. The edible portion of the mango (alphonso, haden and sweet mango was consumed with the peels, while the peel of opioro mango was remove before consumption). The weight of each variety that supplied 25g of available carbohydrate was used as the test meal. Voluntary human subjects who were informed about the research were used and withdrawal at any stage was allowed. Ethical approval was given by Research and Ethics Committee of University of Nigeria Teaching Hospital Ituku-Ozalla. Participants were selected from the Nutrition and Dietetics Department.

The glycemic response was done using the FAO protocols. Fourteen (14) healthy subjects were studied on multiple occasions in the morning after a 10-14hours overnight fast. Subjects were asked to do no unusually vigorous activities on the day before the test. They were asked not to drink alcohol or smoke for 24hours before the test. After a fasting blood sample, subjects ate a test meal and have further blood samples at 30, 60, 90 and 120 minutes after eating. In addition, before the test with the food, the volunteer made the blood glucose curve with glucose (50 g in 500 ml of water) for three times on three non-consecutive weeks. Each test meal contained 25g available carbohydrate (total carbohydrate minus dietary fiber). Unavailable carbohydrates such as fructo–oligosaccharides, resistant starch and sugar alcohols were not included as available carbohydrate. About 1-2 cups of water was served with each test meal. Test meals were consumed within 10 minutes. The reference meal was 50g of anhydrous glucose. After determining the glycemic index of each volunteer with the test meal, the areas under the curves of these responses (with glucose and each test meal) was calculated and compared, the Mathematical calculations were performed to determine the glycaemic index (GI) and glycaemic load (GL). Analysis for the glycaemic response curve for each test meal was conducted and the results categorized as low, medium or high based on the recommended classification, which provides: low GI less than or equal to 55; moderate GI 56 – 69 and high GI higher than 70, considering low GI as best. The glycaemic load will also be identified by the product of glycaemic carbohydrate of each test meal in grams determined by glycaemic index divided by 100, as recommended. The GL was categorized as low (less than or equal 10) or moderate (11 – 19) or high (greater than or equal to 20).

The following formula was used to calculate glycaemic index (GI):

$$GI = \frac{IAUC}{1/3\,(IAUCS_1 + IAUCS_2 + IAUCS_3)} \times 100$$

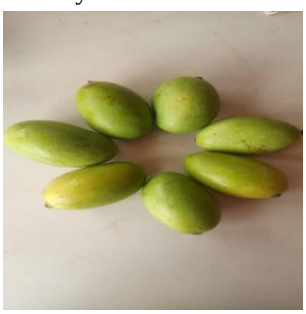
IAUC – Incremental Area Under the blood glucose response Curve for the tested meal

IAUCS – Incremental Area Under the blood glucose response Curve for the standard meal

The Glycaemic Load (GL) was calculated using this formula:

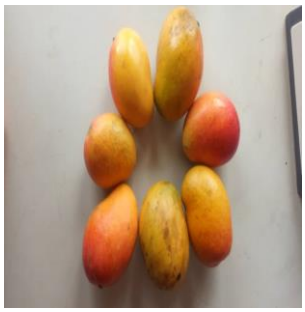
GL = [GI × total available carbohydrate in the food portion]/100

Descriptive statistics (mean and standard deviation) was used to present the data obtained while analysis of variance (ANOVA) was used to compare the means and turkey HSD test was used to separate the means.



Opioro Mangoes

Alphonso mangoes



Haden mangoes

Sweet Mangoes

RESULTS

Table 1 shows the available carbohydrate composition of the four mango varieties per 100 grams. The available carbohydrate composition of the samples was statistically similar ($p>0.05$) with Sweet mango having the highest (6.18) composition.

Table 1: Available carbohydrate composition of the samples.

Mango Varieties	Available carbohydrate (g/100g)
Sample A (Opioro)	$5.69^{a}\pm0.94$
Sample B (Alphonso)	$5.94^{a}\pm1.31$
Sample C (Haden)	$5.18^{a}\pm0.08$
Sample D (Sweet)	$6.18^{a}\pm0.18$

Samples were analyzed in triplicates. Mean values with same super script showed there was no significant difference.

Table 2: Mean values of body parameters of the respondents for glycemic response evaluation.

Parameters	N	Mean (x)	Standard variation
Age (yrs.)	14	24	2.99
Height (cm)	14	168.36	8.65
Weight (kg)	14	64.31	10.43
BMI (kg/m^2)	14	22.67	2.62
RMR (Kcal)	14	1415.43	190.97
Visceral fat	14	4.07	1.54
Body fat (%)	14	27.96	8.22
Muscle mass (%)	14	31.79	5.68

BMI = Body Mass Index; RMR = Resting Metabolic Rate.

Table 3 presented the mean incremental blood glucose (mg/dl) of human subjects given each test food. The Fasting blood sugar (FBS) of the participants was comparable ($p > 0.05$). At 30 minutes, sample B reference significantly ($p<0.05$) raised the blood glucose level (160.8mg/dl) compared to the other test foods while sample A (Opioro mango) significantly ($p < 0.05$) raised the blood glucose level (124.9 mg/dl) compared to the other mango test food. At 60 minutes, sample B (Alphonso mango) significantly ($p < 0.05$) lowered the blood glucose level (94.4 mg/dl) compared to the other test foods. At 90 minutes, the mean incremental blood glucose of reference D was significantly ($p < 0.05$) highest (121.42mg/dl) compared to the other test foods while that of Sweet mango was significantly ($p < 0.05$) highest (109 mg/dl) compared to the other mango test foods. At 120 minutes, sample C (Haden mango) significantly ($p<0.05$) had a lower blood glucose level compared to the other test foods. Statistically, sample B (Alphonso mango) as revealed by the table, had a lower glycemic response effect compared to the other samples.

Table 3: The mean incremental blood glucose (mg/dl) of human subjects given each test food.

Test Samples	FBS (mg/dl)	30 minutes (mg/dl)	60 minutes (mg/dl)	90 minutes (mg/dl)	120 minutes (mg/dl)
Sample A (Opioro)	$99^{a}\pm13.22$	$124.9^{abc}\pm24.18$	$112.2^{ab}\pm16.16$	$106.6^{a}\pm9.78$	$100.3^{a}\pm18.48$
Reference A (glucose)	$89.3^{a}\pm9.09$	$145.9^{bc}\pm25.58$	$130.8^{ab}\pm20.44$	$117.8^{a}\pm25.39$	$102.8^{a}\pm14.65$
Sample B (Alphonso)	$92^{a}\pm25.84$	$98.2^{a}\pm23.25$	$94.4^{a}\pm21.45$	$90^{a}\pm23.76$	$91.6^{a}\pm16.35$
Reference B (glucose)	$84.6^{a}\pm6.27$	$160.8^{c}\pm28.35$	$118^{ab}\pm13.11$	$114^{a}\pm21.39$	$95.6^{a}\pm12.6$
Sample C (Haden)	$91.54^{a}\pm11.34$	$114.85^{ab}\pm17.78$	$97^{ab}\pm17.17$	$91.54^{a}\pm15.28$	$90.92^{a}\pm14.54$
Reference C (glucose)	$84.69^{a}\pm22.76$	$145.69^{bc}\pm38.23$	$141.69^{b}\pm45.64$	$119.15^{a}\pm25.67$	$106^{a}\pm20.26$
Sample D (Sweet)	$95.08^{a}\pm6.99$	$122.5^{abc}\pm14.49$	$118.17^{ab}\pm21.59$	$109^{a}\pm19.33$	$101.75^{a}\pm14.7$
Reference D (glucose)	$84.67^{a}\pm23.78$	$150.75^{bc}\pm39.76$	$140.75^{b}\pm47.54$	$121.42^{a}\pm25.42$	$105.42^{a}\pm21.05$

Mean values with different superscript in the same column significantly ($p < 0.05$) differed while those with the same superscript on the same column are comparable ($p>0.05$).

The glycemic index of the samples was significantly ($p<0.05$) low, but Alphonso mango had the least (4).

Table 4: Glycemic Index and Glycemic Load of the test samples.

Test samples	Glycemic Index (GI)	Available Carbohydrate	Glycemic Load (GL)
Sample A (Opioro)	33	5.69	5.69
Sample B (Alphonso)	4	5.94	5.94
Sample C (Haden)	15	5.18	5.18
Sample D (Sweet)	39	6.18	6.18

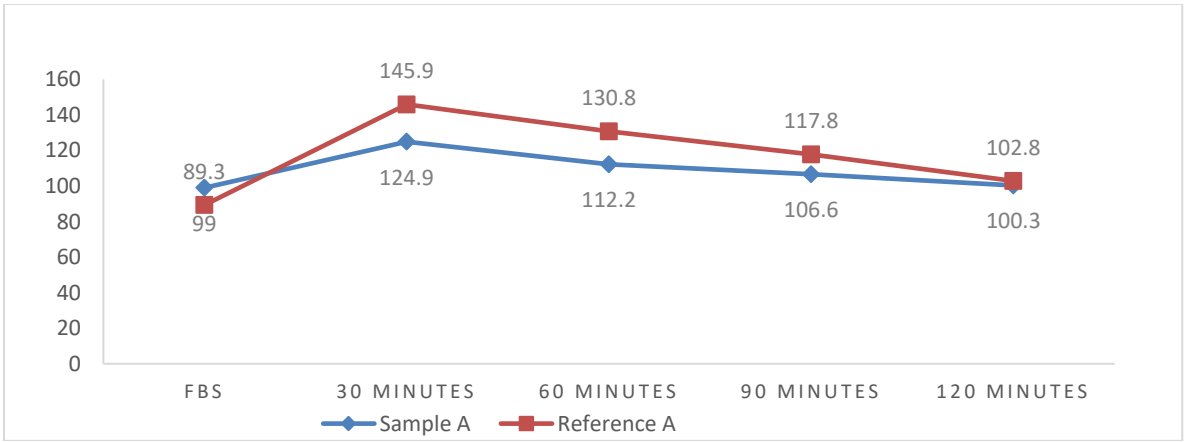


Figure 1: Graphical representation of sample A (Opioro mango) and reference food (glucose D).

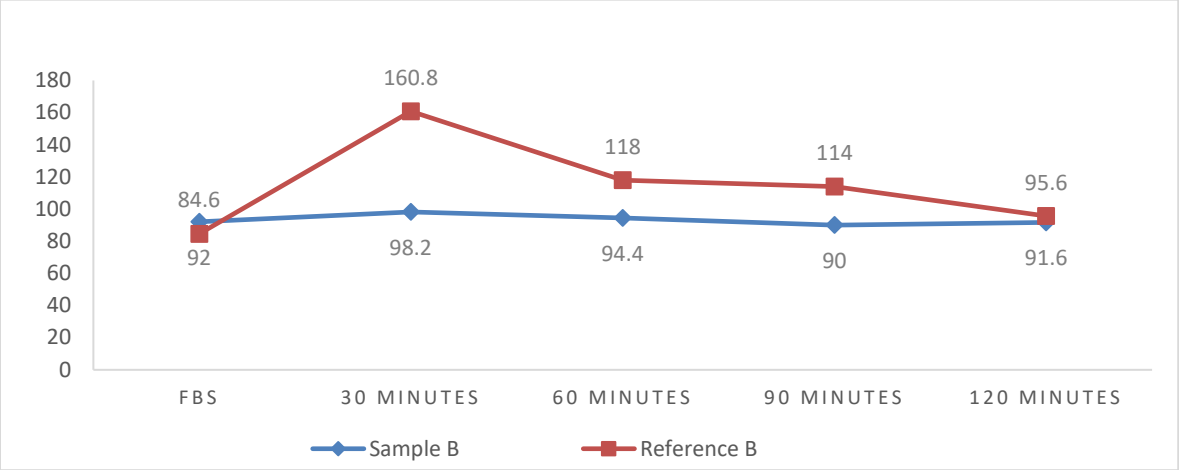


Figure 2: Graphical representation of sample B (Alphonso mango) and reference food (glucose D).

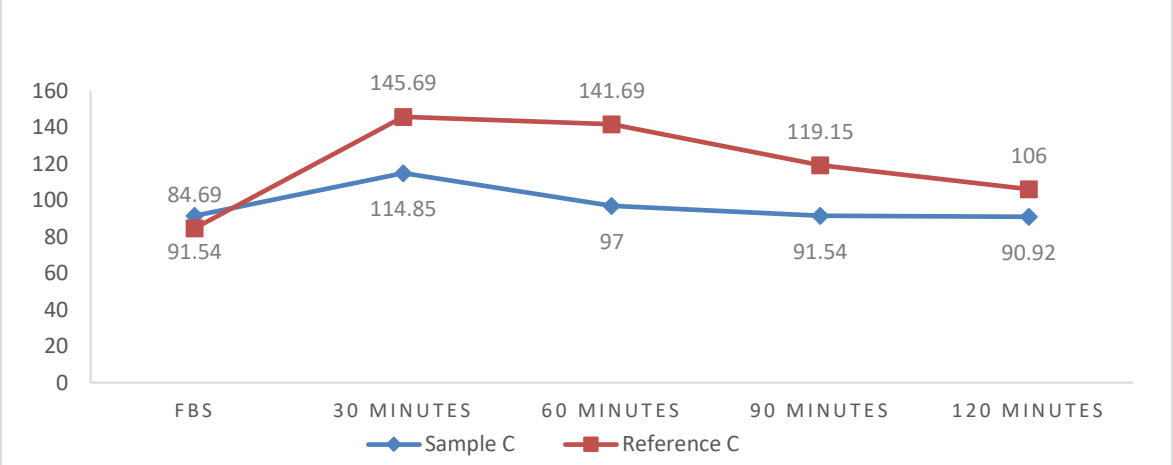


Figure 3: Graphical representation of sample C (Haden mango) and reference food (glucose D).

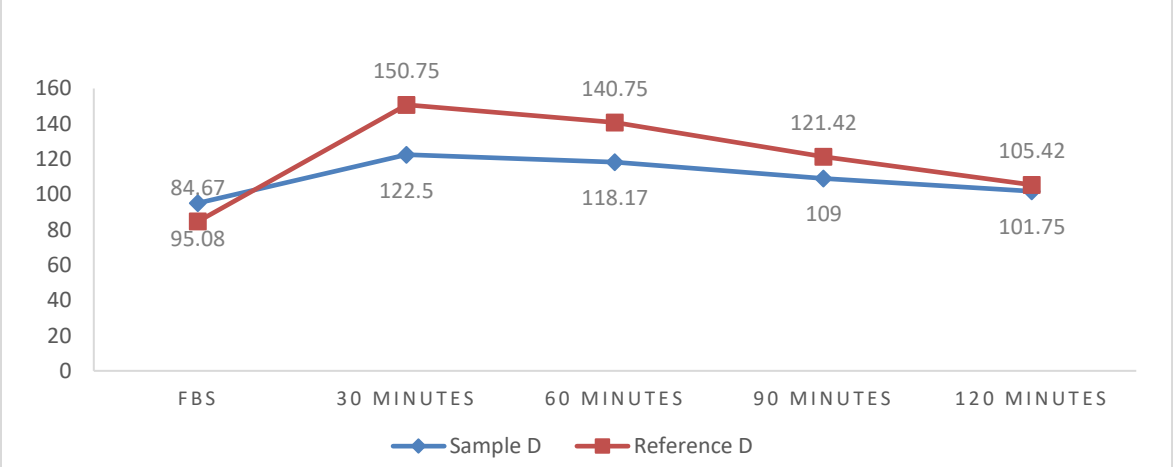


Figure 4: Graphical representation of sample D (Sweet mango) and reference food (glucose D).

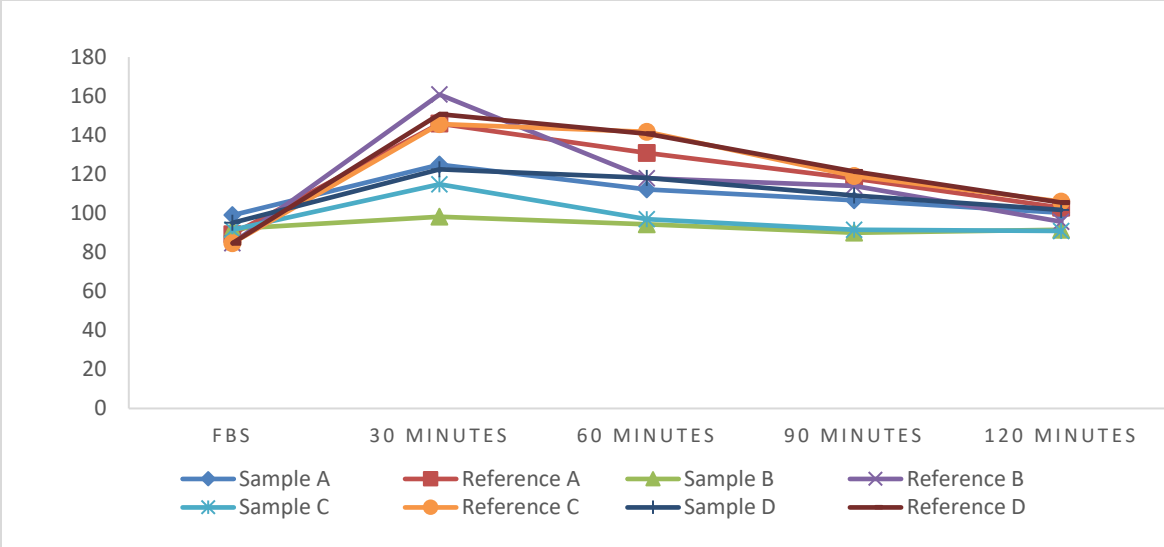


Figure 5: Graphical representation of the glycemic response of all the samples and their reference foods (glucose D).

DISCUSSION

The available carbohydrate content of the samples was lower than that report for pineapple which is another type of fruit (11). There was scarcity of data on the available carbohydrate content of mango. However, it is a known fact that available carbohydrates level of different fruits differ. Mangoes have epicarp (fibrous outermost part) which is consumed as part of the fruit, and there are fibrous tissues in mango pulp which could be the reason for the low available carbohydrate content of the mangoes in this study. The available carbohydrate in foods indicates the metabolizable carbohydrates available for the body (12). This is an important factor used in carbohydrate counting and planning of diets for persons with metabolic diseases like diabetes mellitus (12).

Alphonso mango (sample C) significantly had lowered mean incremental blood glucose. The presence of dietary fiber in fruits leads to a delay in gastric empting of the sugars in consumed fruits. A glycemic index of >70 is high, 55-70 is medium (average) and <55 is lo (13). The glycemic index of the mango varieties reported in this study is similar to that reported on previous study (14). All fruits are generally recommended for good health, but most fruits based on their chemical composition (eg high potassium) are restricted in some certain health conditions such as in diabetes and obesity. Jenkins (8), stated that foods high in sugar are known to have a high glycemic response effect because the metabolism of sugar is very fast causing a quick gastric empting into the blood thereby increasing the blood glucose level but for some fruits high in sugar (fructose, glucose) the presence of a high dietary fiber leads to a delay in gastric empting there by lowering its effect on blood glucose levels.

CONCLUSION

The glycemic index and load of the mango varieties reported in this study was revealed to be low. The study revealed that Alphonso mangoes could be used in planning diets for people with metabolic diseases like diabetes mellitus.

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