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EFFECT OF PLANTAIN AND COCOYAM SUBSTITUTION ON GLYCEMIC INDEX OF APPARENTLY HEALTHY NIGERIANS

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Abstract: Consumption of high and easily digestible carbohydrate foods could give higher glycemic index leading to higher risks of diabetes and other nutritional diseases. Thus, careful combination of slowly digestible starchy food staples such as cocoyam and plantain could give appreciable low glycemic index and the required nutritional value. Hence, this study evaluated the proximate and glycemic index (GI) of meals produced from formulated cocoyam-plantain (CP) flour blends of 95:5, 75:25 and 50:50 respectively. Ten apparently healthy volunteers (5 males and 5 females) aged 19 – 30 years were fed for four days with the meals (“amala”) from the flour blends to determine pro-pandial blood glucose level. Blood sample were taken by prickling (fingertip) method for two hours at 30 minutes interval. Glycemic index were calculated using incremental area under curve. Levels of significance were determined at 5% using Analysis of Variance. Results showed that the GI ranged from 58 to 72 and glycemic load (92 – 218) for the meal. . Thus CP meals in 50:50 level of combination could be recommended as low GI diets.

INTRODUCTION

In Nigeria, West Africa, majority of the staple or core meal is from carbohydrate source and is eaten alone without combining with other food group. For instance, pounded yam “iyan”, dried yam flour “elubo”, Garri paste “eba”, bean pudding “ewariro”, steamed beans “moinmoin”, fermented cassava paste “fufu”, boiled yam etc.Each of these food group supply majorly carbohydrate except beans which supply protein to the human body. Lately, in order to create varieties of meal, people tend to mix their diet e.g. yam is eaten with beans, beans with maize, bread with beans. Mixed diet is known to show reduced overall glycemic index of the meal [1]. Most starch products contain a portion that digests rapidly, a portion that digest slowlyand a portion that is resistant to digestion in the time frame of the test [2]. Rapidly digestible food result into fast absorption of glucose into the blood stream which may cause glucose spike in the blood sugar. Starch products vary in digestibility thus, the rate and extent of digestion is reflected in the magnitude and duration of glycemic response and how quickly a carbohydrate turned into glucose and release in the blood stream affects the amount of insulin that the pancreas released to control blood sugar level. Blood glucose response is commonly estimated using the Glycemic Index (GI), which relate to the response of a test food to that of a reference food and it is usually obtained by dividing the incremental postpandial glucose produced after ingestion of an equal carbohydrate of the reference food. The glycemic effect of food is a measure of how fast, how high the blood glucose rises and how quickly the body responds by bringing it back to normal after food ingestion [3].The nutritional quality of food is related to its glycemic index (GI) [1]. Differences in glycemic and insulinemic responses to dietary starch are directly related to the rate of starch digestion. A product that provides the nutritional benefits of starch but that does not produce the post prandial hyperglycemic and hyperinsulemic spikes associated with the rapidly digestible foods is most desirable. According to Jenkins et al [4], clinical data show that a low GI diet is linked with a reduced risk of diabetes and cardiovascular disease. Also, Slowly Digested Starch would provide a longer, more consistent source of systemic glucose [5]. Most Slowly Digested Starch rich foods have a low Glycemic Index. So, foods containing high levels of Slowly Digested Starch that result in a diet with a low Glycemic Index are of real public health value [5]. Healthy living comprising of healthy diet reduce the emergence of nutritional diseases. For instance, one of the goals in diabetes management is to reduce meal – associated with hyperglycemia. This can be achieved through incorporating slowly Digestible Starch in the meals. Cocoyam tuber is an excellent source of carbohydrate which gives energy. Its starch is highly digestible because of the small size of the starch granule [6]. Starch from plantain is known to belong to the slowly digestible starch which result to low blood glucose response. More recipes are needed to be developed for all age group. Hence, the objective of this work was to produce mixed meal paste from cocoyam substituted with plantain at various level (5% to 50:50) and to determine the glycemic index of the composite.

MATERIAL AND METHOD

Informed Voluntary and Ethical Consent

The subject before admission into the study were clearly instructed about the requirement of the study and the importance of compliance with the procedure for successful execution of the study. An informed consent was sought and obtained from each subject prior to the commencement of the study. Also, ethical consent letter ref No OOUTH/DA.326/490 was secured from the Ogun State University Teaching Hospital, Sagamu Nigeria west Africa were given to all the volunteer.

Method of Data Collection

For the purpose of this study, a well-structured questionnaire was used to collect the following data:

Socio – demographic data: This consists of age, sex, marital status, religion, occupation, educational qualification.

Anthropometric data: This contains weight and height of the volunteers

Weight

The weights of the subject were taken with a calibrated bathroom scale without shoes and in light clothing the measurements were taken to the nearest 0.1kg. Each subject was weighed four times in an upright position with the two hands by the sides and the measurements were averaged.

Height

The measurement will be taken in such a way to give distance between the sole of the feet and the crown of the head. A calibrated meter rule was placed horizontally against the wall to measure the height of the respondents. The subjects were made to stand erect without shoes against the calibrated metric rule which were placed against the wall. The measurement was taken to the nearest meter.

Body Mass Index (BMI)

This was calculated using formula: weight / $(height)^2$ to know if any of the respondents volunteers were overweight. This was measured in kg/m^2.

Food Preparation / Standardization

The ''Amala'' Dough was professionally prepared in the expected quantity and quality in the Dietetics kitchen of Department of Nutrition and Dietetics. Moshood Abiola Polytechnic, Abeokuta, Ogun State, Nigeria. The meals from the composite flour were prepared by stirring in a pot of boiling water until they are satisfactory well cooked and made consistent ready for consumption (''amala'' dough). 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 boiled Titus fish. The meal was served 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 50g of digestible carbohydrate. Glucose (50g) was dissolved in 300ml of water and served as control.

Standardization

The consumption, calories and amount of tested food containing 50g of digestible carbohydrates was calculated.

Subject Selection

This was done with reference to Fasanmade and Anyakudo [7] with modification. Ten (10) apparently healthy volunteers were recruited for the study. Volunteers with history of hypertension and Diabetes were excluded from the study. The willing and available volunteers were given informed consent form to fill. The ten (10) volunteers were served with the cooked pasta in a session. The control (glucose) was served for the first day over a period of two hours, the blood glucose response were taken and recorded at 30 minutes intervals. This was followed by the meal formulated. Each of the meal type of from the blends was taken once per day so the study covered a period of four (4) days.

Blood Glucose Determination

The blood glucose responses of the volunteers fed with the control were recorded for the first day over a period of two hour at 30 minutes interval. The fasting blood sugar (FBS) were taken each day as (0 base) before feeding the test diet (formulated meal)

Test for Available Carbohydrate

Available carbohydrate is the sum of starch plus sugars, including sugar alcohols and other slowly absorbable sugar derivatives.
A total of three (3) samples from blends of 95:5, 75:25 and 50:50 were analyzed to obtain the starch and sugars which were used to calculate the 50g available carbohydrate of the diets.

Procedure for determination of blood glucose response of the test meals (GI)

The tomb of the respondent was cleaned with a methylated spirit. The glucometer, trade named ACCU – CHEK (Active) serial number GC 17095233 was set by inserting the stripe: The thumb of the subject was punctured using the accu-chek sterile soft Lancet. The blood was placed on the inserted accu-chek stripe. The blood glucose was read and recorded in mg/dl. The procedures were carried out for the control diet (glucose) and test meal respectively.

Data collected per meal for all subject were used to draw a glucose response curve with time and area under the curve was calculated as glucose AUC. The area under the curve (AUC) was calculated to reflect the total rise in blood glucose levels after eating the test foods. The Glycemic Index rating (%) was calculated by dividing the AUC for the test food by the AUC for the reference food (same of amount of glucose) and multiplying by 100. The use of a standard food is essential for reducing the confounding influence of differences in the physical characteristics of the subjects. The average of the GI ratings for all thirty (30) healthy volunteers was recorded as the GI of that food.

Glycemic Load (GL)

The glycemic load (GI) of a specific food period is an expression of how much impact or power the food will have in affecting blood glucose levels. This was calculated by taking the percentage of the food's carbohydrate content per portion and multiplying it by its Glycemic Index value.

RESULTS

Table 1: shows the result of proximate composition of oven dried cocoyam/plantain flour blends.

The starch and sugar content decreased with increase in the addition of the plantain to the cocoyam. The ranged were from 74.82 ± 0.06% to 69.88 ± 0.63% and 9.37 ± 0.18% to 9.08 ± 0.05% respectively.

Table 1: Proximate Content of the Oven Dried Cocoyam/Plantain Flour

BLENDS	STARCH %	SUGAR%
95:5	71.82± 0.06[a]	9.37 ± 0.18[a]
90:10	71.72 ± 0.01[a]	9.33 ± 0.013[a]
85:15	71.61 ± 0.25[a]	9.30± 0.13[a]
80:20	71.52 ± 0.19[a]	9.24 ± 0.05[b]
75:25	71.49 ± 0.10[a]	9.21 ± 0.08[b]
70:30	71.32 ± 0.04[ab]	9.20 ± 0.09[b]
65:35	71.28 ± 0.06[ab]	9.17± 0.17[b]
60:40	71.14 ± 0.08[ab]	9.17 ± 0.04[c]
55:45	71.02 ± 0.11[c]	9.10 ± 0.10[c]
50:50	69.88 ± 0.63[c]	9.08 ± 0.05[c]

[abc]: Mean values with different superscript along the column were significantly different ($p<0.005$)

Table: 2 Mean Effect of Sugar Content of Meal Produced from Cocoyam/Plantain.

RATIO	Sugar Content %	Starch Content %
95:5	7.43±0.04[a]	70.32±0.04[a]
75:25	7.26±0.02[b]	56.20±0.06[b]
50:50	6.29±0.01[c]	48.43±0.29[c]

[abc]: mean with different superscript are significantly different ($p < 0.05$)

Table 3: mean effect of glucose content of different meals produced from cocoyam/plantain (''Amala'')

RATIO	BLOOD GLUCOSE(mg/dl)
95:5	64.92±0.37[a]
75:25	61.61±0.91[b]
50:50	54.60±0.28[c]

[abc]: mean with different superscript are significantly different ($p < 0.05$)

Table 4: Available Carbohydrate and Glycemic Loads of Cocoyam-Plantain.

''Amala paste''	% Starch	%Sugar	Total Available Carbohydrate per 100g	Weight that supply 50g available carbohydrate	Serving size	Available Carbohydrate Per serving	Glycemic index	Glycemic load
95:5	70.32	7.34	77.66	64.38	500	388	67	260
75:25	56.50	7.26	63.76	78.42	500	319	63	201
50:50	48.43	6.26	54.72	91.37	500	274	58	159

Table 5: Glycemic index of cocoyam-plantain

Test Diets ''Amala paste''	IAUC of Food	IAUC of glucose	Glycemic index of food	Classification
95:5	867±38	578±33	67	High
75:25	913±48	578±33	63	Medium
50:50	992±49	578±33	58	Low

RESULT AND DISCUSSION

The fibre content decreases with the addition of plantain. The high content of fibre observed with the blend of 95:5 (cocoyam:plantain) may be due to the high content of carbohydrate in cocoyam. This report is in agreement with the findings of Amandikwa [8] who reported similar valuesin solar and oven dried red species of *xanthosoma.* Blends 95:5 for cocoyam: plantain had the highest starch content and decreases with increase addition of plantain. The total starch content in this report agrees with the report of Liu et al [9] which observed that, the main nutrient supplied by cocoyam as well as other roots and tubers is dietary energy provided by the carbohydrates.

The glycemic index obtained in this report elicited by 95:5, 75:25 and 50:50 blends of cocoyam: plantain showed high, medium and low glycemic index respectively in the various blends which correlates with International Standard Organization classification guide [10].The small particle size in cocoyam resulted in faster gelatinization of the starch, thereby increasing the GI. This trend could also be attributed to the starch components of the cocoyam and plantain. The fibre content could be responsible for decreasing post prandial glucose by increasing viscosity of the digestible and reduce gastric emptying time.The glycemic index obtained in the study is found to be lower than what other researchers reported [11]. This could be due to the combination of the blends. Similarly, Miller *et al.*[13] and Goddard [14] reported that the amylase-amylopectin ratio of rice with higher amylase content was accompanied by lowered metabolic response and lower GI values.Furthermore, variations in the physiochemical properties of complex carbohydrates have been shown to elicit dissimilar physiological effects when consumed [15]. The glycemic index calculated by Zakir, *et al.[16]* for a related tuber crop was low, which is not too different from the value obtained for cocoyam: cowpea in this study. Both values are lower than reported in U.S. Dietary Guidelines and the values reported for cooked sweet potato Atkinson *et al.[16].* The reproducible low values are beneficial for consumers. The low glycemic index will allow for a slow rate of glucose absorption, thus maintaining low blood glucose levels. Other factors like the raffinose, Oligosaccharides components [17], which are not digested in the gastro intestinal tract; and the structure of starch and fibre present in the plantain after processing could be responsible for low glycemic index.It was observed that all other blends (75:25) apart from 50:50 blends gave medium glycemic index. The glycemic index obtained in the study is relatively fair and found to be lower than what other researchers reported [11].

The combination of blends of plantain and cocoyam could be the reason while glycemic index obtained was low. The glycemic loads recorded in this study were higher than what other researchers recorded in their studies [12]. This could be due to the combination of the blends (mix diets).The results from this study show that the substituting effect on the various blends 95:5, 75:25 and 50:50 lowers the GI values when compared to frying, baking and roasting as reported by other Researchers. This may be linked to the chemical structure of the starches, Also, some complex carbohydrate rich foods are undeniably beneficial and do not cause blood glucose levels to spike any greater than some simple sugars. Ratio 95:5 in Cocoyam: plantain compared to ratio 75/25, 50/50 blends elicited high glycemic index. It was observed that as the level of substitution increased, the glycemic responses decreased. This may be due to the starch structure and fibre content in the plantain. Also the presence of protein in low amount might be the reason.Based on the universal classification of Glycemic index of foods [10], 50:50 blends of cocoyam:plantain elicited low glycemic index. Thus, the consumption of foods produced from mixed blends by apparently healthy individuals may be beneficial by delaying onset of nutritional diseases caused by over consumption of foods that can cause a rise in the blood sugar.

CONCLUSION

The glycemic index of cocoyam: plantain blends showed that 50:50 had lowest glycemic index which cause persistent low blood sugar in healthy individuals while the glycemic index of cocoyam:plantain blends 95:5 and 75:25 have high and medium glycemic index respectively, these are beneficial to adolescent and adults that require higher energy foods

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