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Original article

Variations in nutrient composition and glycemic index of standardized traditional cocoyam and corn-based dishes consumed in Nsukka Local Government Area of Enugu State, Nigeria

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Summary. *Background and objectives:* Glycaemic index (GI) is an important parameter of food quality that compares the hypoglycaemic effect of a test meal with pure glucose. Low glycaemic index diets have been recommended for diabetics. The study was to determine the glycaemic index (GI) of standardized cocoyam and corn-based traditional dishes consumed in south-eastern Nigeria. *Methods:* Focus group discussions were conducted in eight randomly selected communities in Nsukka LGA to document the variations of each dish and their recipes. These were standardized and prepared. Nutrient compositions of the prepared dishes were determined using standard procedures. A serving portion of each dish containing 50g of available carbohydrate was served to ten healthy adult subjects. Glucose was used as the reference food. The postprandial blood glucose response of the test and the reference meals were measured over two hours at 30 minutes interval. Blood glucose curves were plotted, area under each curve and corresponding glycaemic index value for each dish determined. Data were analyzed using Statistical Product for Service Solution (SPSS). Analysis of variance was used to compare the means. *Result:* Three variations of cocoyam-based dishes were documented: '*achicha*' (dried cocoyam chips, soaked and steamed) with pigeon pea, '*achicha*' with fresh '*akidi*' (fresh cowpea in pod) and '*achicha*' with vegetable (fluted pumpkin leaves). The corn-based dish had two variations: '*ayaraya oka*' (coarsely ground soaked, steamed corn) with pigeon pea and '*ayaraya oka*' with fresh '*akidi*'. The dishes had appreciable proximate, vitamin and mineral composition though theier vitamin B_2, iron and zinc content were low. The GI of '*achicha*' with vegetable was 69%, followed by '*achicha*' with fresh '*akidi*' (49%) and '*achicha*' with pigeon pea (47%). The GI of the cocoyam-based dishes were, therefore, within the range of 47 and 69% being highest in '*achicha*' with vegetable and lowest in '*achicha*' with pigeon pea. The GI of '*ayaraya oka*' with pigeon pea and '*ayaraya oka*' with fresh '*akidi*' were 69 and 57%, respectively. *Conclusion:* '*Achicha*' with pigeon pea, '*achicha*' with fresh '*akidi*' and '*ayaraya oka*' with fresh '*akidi*' had low glycemic index and could be recommended for diabetics.

Key words: traditional dishes, cocoyam and corn-based dishes, recipe variation, nutrient composition, glycemic index, Nigeria

Introduction

Global estimate of diabetes mellitus indicated that there were 171 and 285 million people in the world with diabetes in 2000 and 2010 respectively with type2 making up about 90-95% of all diagnosed cases (1). This estimate is projected to increase to 366 million by 2030 due to population growth, aging, urbanization and increasing prevalence of obesity and physical inactivity. Diabetes mellitus if not properly managed can result to death (1). In Nigeria, with over 195.88 million people (2012 census), an estimated six million people have full blown diabetes mellitus (2). In 2007, it was listed as a contributing factor to an additional 160,022 death certificates (3), bringing the total number of deaths resulting from diabetes in that year to

231,404. The disease has resulted in premature death of thousands of Nigerians, in addition to permanent disabilities like blindness, amputation of limbs, impotence, kidney failure and still births (2).

Carbohydrates that breakdown quickly during digestion have high glycemic index (GI) because their B-glucose response is fast and high while those that breakdown slowly have a low GI (4). Low GI foods by virtue of their slow digestion and absorption, produce gradual rises in blood sugar and insulin levels and have proven benefit for health. GI appears to be a significant factor in dietary programs targeting metabolic syndrome, insulin resistance and weight loss. According to Omoregie and Osagie (5), there are many proven benefits of using the GI in nutrition which includes decreased risk of cardiovascular diseases, better diabetes management and more successful body weight management. High blood glucose and excessive insulin secretion are thought to contribute to the loss of the insulin-secreting function of the pancreatic B-cells that leads to irreversible diabetes (6). The intake of low glycemic index food potentially contributes to a significant improvement of the condition associated with poor glycemic control and affords efficient control over postprandial insulin and glucose excursion as opposed to high glycemic index foods. For healthy eating particularly in persons with diabetes, obesity and insulin resistance, food with low GI are recommended as they may help keep the euglycaemia and the normal spectrum of lipoproteins (7).

Traditional food system plays a vital role in maintaining the well-being and health of indigenous people (8). At the community level, traditional food system may contribute to health via other economic and social pathways such as forming the basis of non-cash economy (9). Additionally, the activities related to traditional food systems also confer health benefits through increased physical activity. It may be impossible to define the complex nutritional benefits of traditional foods separately from the health benefits of traditional food system. However, emerging information suggests that traditional diets are able to supply a healthier pattern of fats and a greater amount of vitamins and minerals. In addition, traditional foods tend to be lower in simple carbohydrates including sugars (10) and high in fibre which are important in conditions such as obesity and diabetes. Traditional foods go beyond just avoiding packaged and processed foods:- it is about choosing the best food options available for budget, individual chemistry and location and consuming it in a way that allows the body to extract the maximum nutrition from such items (11).

While industrialization has had some positive effects on the people of the African continent, it has had a deleterious effect on the health of the Africans as it has promoted a nutrition transition in which the healthy, wholesome, nutritious traditional foods have been replaced by processed, high fat, high sugar foods of significantly lower nutritional value. The general results of nutrition transition as noted by Turner and Turner (12) are that many people, indigenous and non-indigenous, are eating foods that are higher in unhealthy fats and refined carbohydrates, lower in essential vitamins and minerals, and costlier than the original food to which they were genetically and culturally better adapted. In addition, to the decreased physical activity levels associated with improved technology and infrastructure, nutrition transition has contributed to an increase in obesity and diseases of lifestyle such as heart disease, diabetes, hypertension and some forms of cancer. Most indigenous staple foods in Nigeria are plant based and the use of plant foods for therapeutic purposes such as diabetes management represents one of the biggest human uses of the natural flora of the world and can be used to reduce the morbidity and mortality rate caused by high blood glucose. Irrespective of the nutritional and health potentials of traditional foods in Nigeria, Dieticians cannot maximize their use as therapeutic diets. This is because nutrient data are frequently lacking for most foods as consumed. According to Natural Standard Research Collaboration (13), majority of the available nutritional information is based on raw and unprocessed foods.

Studies have shown that commonly consumed traditional dishes in Nigeria vary greatly due to several factors which includes the different types of ingredients used in their preparation (14,15). Food component is also one of the various food factors that are known to influence the postprandial glucose and insulin responses to a carbohydrate-containing mixed diet (16.17). Since food components is a major factor that affect the GI of foods, a comprehensive evaluation of the different variations of traditional dishes will reveal those with nutritional and health potentials that can be employed in disease management. Such foods have a lot of advantages over exotic ones since they are more affordable, accessible and ac-

ceptable. Few studies have been carried out in Africa with regards to the glycemic index of standardized traditional dishes variations which are quite different from those of the western world. It is not surprising therefore that in spite of proven benefit of low GI foods, management of diabetes mellitus often revolves around insulin and drug with rare thought given to dietary change. For the African diabetics to benefit from the new concept of dietary management of diabetes, it is important to determine the glycemic index of local dishes with the aim of identifying those with low glycemic index that can be used in formulating diets for the diabetic patients.

Methodology

2.1 Study design

A cross sectional survey was adopted for recipe documentation, quasi-experimental design was adopted for recipe standardization/harmonization and dietary evaluation while pure experimental design was adopted for the glycemic index measurement.

2.2 Study population

For the recipe documentation, the population of the study consisted of all the communities in Nsukka Local Government Area, Enugu State, Nigeria.

2.3 Study sample

One village was randomly selected from each of the eight communities that made up Nsukka, Local Government Area.

2.4 Data collection

2.4.1 Focus group discussion

Focus group discussion was conducted in each of the selected villages in the eight communities making a total of eight focus group discussion sessions. It comprised small groups of about 6-8 adult women selected with the help of community-based facilitators. Each session lasted for 45-60 minutes. Recipes of the dishes, their variations and traditional methods of preparations were the major points supplied by the focus group.

2.4.2 Recipe standardization

The recipes collected were standardized using a modified National Food Service Management Institution (18) method as outlined in Davidson *et al*., (15).

2.4.3 Recipe preparation

FGD revealed that the cocoyam-based dish ('*achicha*') had three variations while the corn-based dish ('*ayara-ya oka*') had two variations. The standardized recipes of all these variations were prepared using the traditional method obtained from FGD.

Recipe name: '*Achicha*'

	Quantity (g) of different variations		
	1	**2**	**3**
Ingredients	**'*Achicha*' with pigeon pea**	**'*Achicha*' with fresh 'akidi'**	**'*Achicha*' with vegetable (fluted pumpkin leaves)**
'*Achicha*' (Dried cocoyam chips)	810	810	910
Pigeon pea (Cream colour)	560	-	-
Fresh '*akidi*' (Fresh cowpea in pod)	-	812	-
Palm oil	350	350	260
Fluted pumpkin leaves (sliced)	-	-	300
Sent leaves (sliced)	-	100	100
'*Ukpaka*' (fermented African oil bean seed	230	230	260
Fresh pepper (ground)	45	45	40
Onion (diced)	90	90	70
Salt	32	38	20
Water	12500	6000	3000
Yield	3350	3000	2600

Method of preparation

1. Pick the pigeon pea, wash and put it into the pot with water and place on fire (variation 1)
2. Break the dried cocoyam ('*achicha*') into small bits, wash 3 times and soak in water for 40minutes (all variations)
3. Wash twice, press or squeeze to drain out water from the cocoyam chips, put two cooking spoonful in cellophane bag and wrap (all variations)
4. Use hand and cut the fresh '*akidi*' into small sizeable bits (about an inch long) and wash (variation 2)
5. After boiling the pigeon pea for an hour, add the

wrapped cocoyam into the pot and cook for another 1hr 30minutes (variation 1)
6. Put water in the pot, add the washed fresh '*akidi*' (variation 2) and the wrapped cocoyam and place on fire to cook (variation 1 and 2).
7. Cook for 1hr 15minute (for variation 2) and for 1hr 30minutes (variation3)
8. Remove from the fire and unwrap the cocoyam, sieve out water from the pigeon pea or fresh '*akidi*' (variation 1 and 2)
9. Place another pot on the fire and allow to dry and add palm oil (all variations)
10. Allow the palm oil to heat for 2minutes (all variations)
11. Add salt, fresh pepper, onions and '*ukpaka*' (all variations)
12. Allow to heat for 3minutes (variation 1)
13. Allow to heat for 2 minutes, add sent leaves (variation 2 and 3), fluted pumpkin leaves (variation 3) and heat for another 2 minutes
14. Remove from the fire, add the pigeon pea (variation 1), fresh 'akidi' (variation 2) cocoyam in the pot and mix very well (all variations)
15. Serve hot.

Recipe name: '*Ayaraya oka*'		
	Quantity (g) of different variations	
	1	**2**
Ingredients	**'Ayaraya oka" with pigeon pea**	**'Ayaraya oka' with fresh 'akidi'**
Pigeon pea (cream colour)	560	480
Corn (yellow variety)	640	640
'*Ukpaka*' (fermented African oil bean seed)	110	110
Palm oil	410	450
Onion (sliced)	100	90
Bitter leaves (sliced)	200	200
African spinach (*Amaranthus spp*)	450	-
Sent leaves (sliced)	90	90
'*Uzuza*' (*Piper guineense*)	10	10
Fluted pumpkin fruit (cubed)	-	50
Fresh '*akidi*' (fresh cowpea in pod)	-	570
Fresh pepper (ground)	35	50
Salt	25	25
Water	4000	6500
Yield	3850	3600

Method of Preparation
1. Soak the dry corn in hot water (for 6-8hrs)
2. Sieve out the corn from the water
3. Grind without adding water
4. Boil the pigeon pea for 2hrs 30mins
5. Slice bitter leaves and add to the pigeon pea when it is about to be done
6. Drain the pigeon pea when it is done
7. Pour it back into the pot and add fresh water (water level should be below the pigeon pea)
8. Add the pumpkin fruit (variation 2 only)
9. Put the fresh 'akidi' on top of the pumpkin fruit (variation 2 only)
8. Mix the corn with 100g of oil
9. Spread it on top of the pigeon pea (variation 1) or fresh 'akidi' (variation 2) (don't allow it to touch the cooking water
10. Cook for 8mins
11. Add the vegetables on top of the corn
12. Cook for 3mins
13. Bring the food down and gradually remove the food from the pot
14. Set the pot back on fire and allow it to dry
15. Heat the oil
16. Add fresh pepper, onions, 'ukpaka', salt, 'uziza' to the oil and cook for 5mins
17. Bring down and mix the pigeon pea, corn and vegetables
18. Serve hot

Chemical analysis

Sample preparation

The prepared dishes were homogenized with the use of electric blender. Five grams of each sample was used to determine the actual moisture at 100°C, while the rest (except the sample for dietary fibre analysis) were stored in the freezer and analyzed fresh. Samples for dietary fibre determination were dried at 60°C milled and packaged in air-tight containers and taken to the laboratory for analysis.

Proximate, vitamins and minerals determination

Protein, moisture, fat, ash, soluble and insoluble dietary fiber, minerals (calcium, magnesium, iron, zinc, sodium, potassium, copper and phosphorus) and vitamins (A, B_1, B_2 and B_3) were determined according to

the method of AOAC (19). Moisture was determined using the air oven method. Crude protein and fat were determined by Kjeldahl procedure and Soxhlet solvent extraction method respectively. Total dietary fibre was determined using enzyme gravimetric method. Ash was determined by incineration of samples in a muffle furnace at 550°C for six hours. Available carbohydrate was calculated by difference 100 - (moisture + protein + fat + ash + dietary fibre). Dietary fibre content of the dishes as consumed was calculated using the water conversion factor described by Food and Agriculture Organization (FAO)(20). Mineral elements were determined using the Atomic Absorption Spectrophotometer (Perkin–Elmer Model 3110, USA). Phosphorus was determined using the vanadomolybdate method. Vitamins were determined using a high performance liquid chromatography (HPLC). All samples were analysed in triplicates.

Selection of Subjects for GI measurement

Male and female final year students aged between 18 and 35 years of the Department of Nutrition and Dietetics, Faculty of Agriculture, University of Nigeria, Nsukka, Enugu State were used for the study. After explaining the objectives and research protocols to the students, fifteen of them volunteered to participate in the experiment. Three out of the fifteen respondents could not measure up with the rudiments of the experiment and were dropped so only twelve respondents completed the experiment.

Informed consent

An informed written consent was signed by the respondents to confirm his/her willingness to participate in the experiment

Anthropometric measurements

The height of the respondents were measurement using the height meter while their weight (Kg) were measured using the bath room scale. Their body mass index (BMI) were subsequently calculated using the formula $\text{BMI} = \frac{\text{Weight (Kg)}}{\text{Height(M)2}}$

2.9 Inclusion and exclusion criteria

Only healthy respondents with no past medical history of chronic diseases were selected for the glycemic index measurement.

Respondents were excluded if they have diabetes, hypertension, if they are younger than 18 years, on any special diet, pregnant or lactating.

Ethical clearance.

Ethical clearance was obtained from the ethical committee of the University of Nigeria Teaching Hospital, Enugu State. The study commenced after approval was granted.

Measurement of glucose level

Subjects for the study were instructed not to eat later than 8:00pm (an overnight fast of 10-14 hours) and not to do any strenuous activity on the day of the tests. The test started by 9:00am each morning and lasted for 2 hrs. They were given 250ml of water containing 50g of glucose as reference food. The glucose test was done twice and the average GI values obtained. GI tests using the different variations of the dishes were then carried out at one-day interval. The serving size of the test diet containing 50g available carbohydrate was given to the subjects each day and the food was eaten within 15mins. Blood sampling time was at 0min (baseline), followed by 15, 30, 45, 60, 90 and 120min after the consumption of each test diet. Subjects' thumbs were cleaned with cotton wool dipped in mentholated spirit and a drop of blood obtained through finger prick using a hypodermic needle. Each drop of blood was made to cover the reagent pad of a test strip which was inserted into a calibrated glucometer. The subjects consumed different quantity of food (based on the serving size of each dish) on a day interval, same period, throughout the study duration.

2.12 Glycemic index determination

The changes in blood glucose over time was plotted as a curve for the 2hr period, using the blood concentration before meal (time 0) as a baseline. The incremental area under the curve (AUC) was calculated to reflect the total rise in blood glucose level after eating the test diet, using the trapezium rule. The glycemic index value was calculated by dividing the AUC for each test food by the AUC for the reference food (glucose) and multiplied by 100 to get the percentage as described by Brand Miller *et al.,* (21). This was done for all the twelve subjects for

Table 1. Proximate composition (g) of traditional dried cocoyam- and corn-based dishes consumed in Nsukka LGA.

Samples	Moisture	Protein	Ash	Fat	Dietary fibre	Available carbohydrate
'*Achicha*' with pigeon pea	55.2[c]	4.5[b]	1.9[a]	7.4[b]	8.0[b]	23.1[e]
'*Achicha*' with vegetable	54.0[b]	5.6[c]	2.9[b]	8.3[c]	11.4[e]	17.9[c]
'*Achicha*' with fresh '*akidi*'	64.7[d]	4.9[b]	1.8[a]	6.0[a]	10.0[d]	12.6[a]
CV%	10.8	27.9	10.1	16.2	17.4	29.3
'*Ayaraya oka*' with fresh '*akidi*'	68.8[e]	3.8[a]	2.0[a]	6.1[a]	5.6[a]	13.7[b]
'*Ayaraya oka*' withpigeon pea	50.8[a]	6.0[d]	1.8[a]	11.8[d]	9.2[c]	20.2[d]
CV%	32.7	6.3	21.2	44.6	34.2	27.4

The values are means of triplicate analysis; Values with different superscripts in the same column are statistically significantly ($p< 0.05$); CV-Coefficient of variation

the different variations of the dishes. The average of the glycemic index rating from all the twelve subjects was published as the glycemic index of the test diet.

GI was calculated using the formula:

GI = IAUC for test food ÷ IAUC for reference glucose × 100

Statistical analysis

Data was analyzed using Statistical Product for Service Solution (SPSS) version 21.0 for descriptive statistics such as means, standard deviation and standard error of mean. Analysis of variance (ANOVA) was used to compare the means. A significant was accepted at $p< 0.05$.

Results

Table 1 revealed that moisture content of the dishes ranged from 50.81 to 68.75%. Protein in the dishes was within the range of 3.80-6.09%. A significantly ($p<0.05$) higher protein content was found in ayaraya oka without fresh 'akidi' (6g) while the least protein was found in '*ayaraya oka*' with fresh '*akidi*'(3.8g). Dietary fibre in the dishes ranged from 5.63g in '*ayaraya oka*' with fresh '*akidi*' to 11.41g in '*achicha*' with vegetable. Similarly, the available carbohydrate in the dishes ranged from 12.61g in '*achicha*' with fresh '*akidi*' to 20.23% in '*ayaraya oka*' with pigeon pea '. Coefficient of variation (CV) of 'achicha' and 'ayaraya oka' variations were within the range of 10.1-29.3 and 6.3-44.6%, respectively.

With the exception of vitamin B_2, all the variations of '*achicha*' and '*ayaraya oka*' had appreciable vitamin values (Table 2). A consistent pattern was observed in the vitamin composition of these dishes. Except for the beta carotene value of 'acicha' prepared with vegetable (376.8 µg) that was exceptionally low, '*achicha*' prepared with pigeon pea had the least vitamin and beta carotene values followed by '*achicha*' prepared with

Table 2. Vitamins and beta carotene, composition of traditional dried cocoyam- and corn-based dishes consumed in Nsukka LGA

Dishes /CV	Vit B1 (mg)	Vit B2 (mg)	Vit B3 (mg)	Vit B6 (mg)	Vit E (mg)	Vit B9 (µg)	β- carotene (µg)	Vitamin C (mg)
'Achicha' withpigeon Pea	1.4[a]	0.2[a]	3.8[a]	1.9[a]	69.2[a]	97.8[a]	3206.7[a]	18.8[a]
'Achicha' with fresh '*Akidi*'	1.9[b]	0.3[b]	4.2[b]	2.1[b]	71.9[b]	103.3[b]	3312.7[b]	18.8[b]
'Achicha' with vegetable	2.5[c]	0.4[c]	4.6[c]	2.2[c]	78.3[c]	116.4[c]	376.8[c]	19.9[c]
CV	30.2%	34.7%	9.7%	9.3%	6.4%	9.0%	72.4%	3.2%
'*Ayaraya oka*' with fresh '*akidi*'	2.0[b]	0.3[b]	4.3[b]	2.2[b]	73.6[b]	109.8[b]	3328.5[a]	19.4[b]
'*Ayaraya oka*' withpigeon pea	1.6[a]	0.0[a]	3.9[a]	1.9[a]	69.9[a]	101.5[a]	3269.7[a]	18.6[a]
CV	15.2%	117.9%	6.6%	7.9%	3.7%	5.6%	1.3%	2.9%

The values are means of triplicate analysis; Values with different superscripts in the same column are statistically significantly ($p< 0.05$); CV-Coefficient of variation

Table 3. Mineral composition (mg) of traditional dried cocoyam and corn-based dishes consumed in Nsukka LGA

Dishes	Na	K	Ca	Mg	P	Cu	Zn	Fe
***'Achicha'* with pigeon pea**	219.0[a]	602.3[a]	335.0[a]	395.3[a]	233.0[a]	2.6[a]	0.4[a]	0.6[c]
'Achicha'with fresh 'akidi'	241.3[b]	616.3[b]	370.7[b]	407.3[b]	265.0[b]	3.9[b]	0.5[a]	0.4[a]
'*Achicha* with vegetable	259.7[c]	631.3[c]	386.0[c]	426.7[c]	291.7[c]	6.1[c]	0.4[a]	0.5[b]
CV	8.5%	2.4%	7.2%	3.9%	11.2%	41.2%	14.2%	28.2%
'*Ayaraya oka'* with fresh '*akidi*'	247[b]	623.7[b]	381.0[b]	415.3[b]	279.0[b]	5.4[b]	0.4[a]	0.5[b]
'*Ayaraya oka'* with pigeon pea	227.3[a]	610.3[a]	353.7[a]	402.7[a]	250.0[a]	3.3[a]	0.3[a]	0.8[d]
CV	5.9%	1.5%	5.3%	2.2%	7.8%	34.1%	4.2%	30.6%

The values are means of triplicate analysis; Values with different superscripts in the same column are statistically significantly ($p< 0.05$); CV-Coefficient of variation

fresh '*akidi*', leaving '*achicha*' prepared with vegetable with the highest vitamin composition. Similar pattern was also observed in '*ayaraya oka*'. The one prepared with fresh '*akidi* had higher vitamin and beta carotene (3328µg) content when compared with the variation prepared withpigeon pea. The CV of the vitamins and beta carotene in the three variations of '*achicha*' ranged from 6.4-72.4% while that of '*ayaraya oka'* was within the range of 1.3-117.9%

As already observed in the vitamin composition of the dishes, '*Achicha*' prepared with pigeon pea had the least mineral values while the one prepared with vegetable had the highest (Table 3). '*Ayaraya oka*' prepared with pigeon pea also had lower mineral values than its counterpart. Highest CVs were seen in the copper and iron composition of '*achicha*' (41.2 and 28.2%) and '*ayaraya oka'* (34.1 and 30.6%) variations. Potassium had the least CV in both '*achacha*' (2.4%) and '*ayaraya oka'* (1.5%).

Figure 1: shows that a rise in blood glucose level was observed at 15th minutes for the glucose drink and a subsequent decrease at 120th minute. A similar pattern of response was observed for the test diets except that '*achicha*' with pigeon pea had the lowest glucose response. The highest peak for all test diets was at the 30th minute, compared to 15th minute for the reference diet. Figure 2 revealed that a rise in blood glucose concentration was observed in the 15th minute for the glucose drink. For the variation of '*ayaraya oka'*, blood glucose concentration had its highest concentration at the 30th minute which was followed by a gradual decrease till the 120th minute.

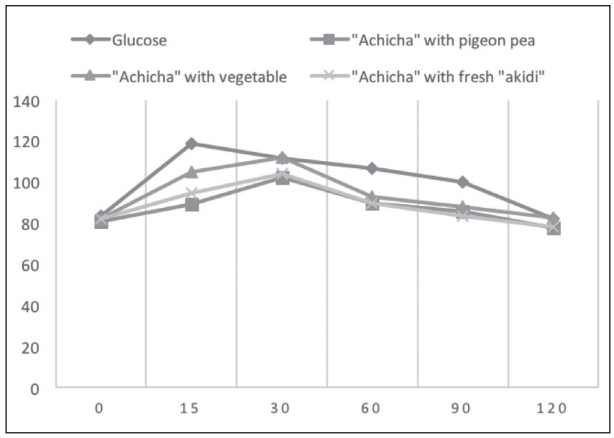

Figure 1. Blood glucose response of subject after the consumption of glucose drink and the three variations of 'achicha'.

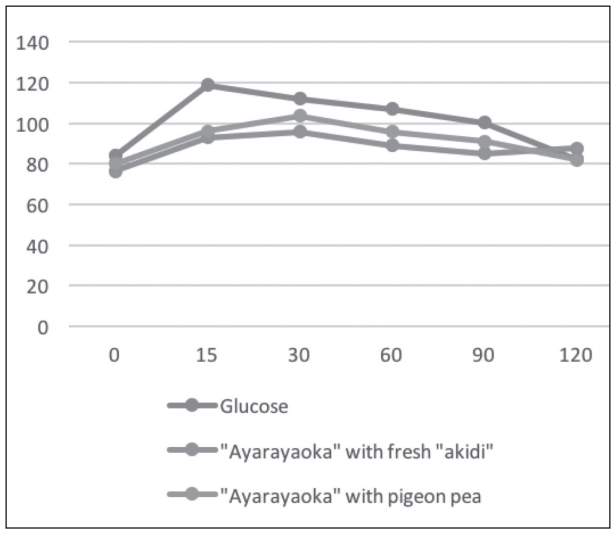

Figure 2. Blood glucose response of subject after the consumption of glucose drink and the two variations of 'ayaraya oka'

Discussion

Nutrient composition of variations of traditional dishes

Moisture values obtained from this study are in line with previous studies. Davidson *et al.,* (15), reported that the moisture content of variations of '*abacha*' (a traditional meal consumed in south-eastern Nigeria) ranged from (53.8-65.6%). Kayode *et al.,* (22) also obtained moisture content within the range of 63.11to70.44% from dishes consumed in south-east Nigeria. According to Okeke *et al.,* (23) moisture content of '*ayaraya oka*' was 70.02%. The implication of these results is that traditional south-eastern Nigeria dishes are high in moisture. Moisture content is a widely used parameter in the processing and testing of food. It is an index of water activity of many foods and inversely related to their shelf life.

The protein values obtained in this study were lower than what were reported by Nnanyelugo (24) on the protein content of '*achicha*' with pigeon pea (12.9%) and '*achicha*' with '*akidi*' (10.8%). Compared with another dish consumed in south-eastern Nigeria, the protein values obtained from this study were similar with the report of Okeke and Eze (25) on the protein content of '*Ayaraya ji*' (3.08%). Awogbenia and Ugwuona (26) reported a protein content of 3.10-5.07% in traditional dishes consumed in Nassarawa State, Nigeria. The differences observed in protein content of these dishes in relation to previous reports could be attributed to variations in the quantity and quality of ingredients used in preparing them which have been established as the major determining factors to the nutrient compositions of dishes (15).

Ash is an indication of mineral contents of foods (27). The ash content obtained from this study were higher than what was reported by Ogbuji and David-Chukwu (28) in different food forms of cassava (0.27-0.43%) which could be attributed to the type of food studied. Fat values obtained from '*achicha*' (3.98g) by Okeke *et al.*,(23) was lower than what was obtained from this study. Palm oil is the major source of fat in these dishes. The differences in the fat values of the variations of cocoyam and corn-based dishes could be due to different quantities of palm oil used in their preparation. Fat is needed for the support of certain metabolic activities within the body of living organisms and is also a source of energy. Studies done in Kwazulu-Natal area of South Africa by Minse (29) recorded that *'isijibane'*, a mixture of crushed cocoyam and amaranthus leaves had dietary fibre value of 2.83% which was also lower than what was reported in the present study. The observed differences in dietary fibre contents of the dishes may be attributed to other component of the recipes as well as laboratory technique employed in their evaluation. However, close range in dietary fibre content was recorded for some Ivorian dishes by Kouamé *et al.*, (30). According to the authors, rice with groundnut sauce, pounded yam with eggplant sauce and cassava paste with granulated palm nut sauce had dietary fibre values of 1.9, 10.2 and 11.9%, respectively. High dietary fibre observed in the dishes can have some beneficial biological effects such as laxative effect on GIT, increased fecal bulk and reduction of plasma cholesterol level (31). Studies have shown the importance of dietary fibre in glycemic control and improved morbidity of diabetic patients (32). According to Tsang (16), fibre slows down the digestion of starch, therefore, high fibre foods have lower glycemic index. The fact that none of the variation of the dishes had high glycemic index could therefore be partly due to their high dietary fibre content. The level of available carbohydrate found in this study, does not place these dishes as very rich sources of carbohydrate. Their consumption by the diabetic patients may therefore be encouraged. Available carbohydrate in some traditional dishes consumed in Ivory coast were (15.8, 21.6, 25.3, 28.8 and 46.4g) for '*placali*', which is a cassava-based traditional dish, maize meal stiff porridge, pounded yam, pounded cassava/plantain and '*attieke*' which is also a popular cassava-based traditional dish in Ivory Coast (33). High available carbohydrate was reported for pounded yam with eggplant sauce, cassava paste with granulated palm nut sauce and rice with groundnut sauce (50g, respectively) by Kouamé *et al.*, (33). Such dishes with high available carbohydrate may not be suitable for diabetics as they may cause rapid increase in blood glucose level.

Most of the vitamins and minerals, were significantly higher in '*achicha*' prepared with vegetable when compared with the other two variations. Sheela *et al.*, (34) and Kubmarawa *et al.*, (35) reported that leafy vegetables are generally good sources of vitamins and

minerals and are highly beneficial for the maintenance of good health and prevention of diseases. Vitamin and mineral values of all the dishes were however, appreciable with the exception of vitamin B_2, iron and zinc content. Low iron and zinc content of these traditional dishes have serious negative implications due to the high prevalence of their deficiencies not just in the study area but in the country as a whole. Iron in particular is a mineral of public health importance in Nigeria. Almost one in two women of reproductive age and 75% of children under five years in Nigeria suffer from anaemia and fifty percent (50%) of these cases are caused by a lack of iron in the body, which is often diet-related (36). According to Unilever (37) prevalence of zinc deficiency in Nigeria was estimated to be about 50%. This situation reveals the need for nutrition education to encourage increase in consumption of locally available micro nutrients rich foods such as fruits and vegetables on a daily basis.

Glycemic indices of variations of traditional dishes

The result of this study revealed that the dishes were of low glycemic indices except for '*ayaraya oka*' with pigeon pea and '*achicha*' with vegetable that fell in the medium glycemic index category. This finding is supported by Evans and Gajere (38) who stated that a greater percentage of Nigerian indigenous food fall into the moderate and low GI category. The rise in blood sugar at the 30th minute after consuming the dishes showed that the meal were slowly digested and assimilated into the blood stream. Slow digestion of these dishes probably due to their high fibre content which have been indicated earlier on have some positive health implications. Burkitt and Trowel (39) have suggested that foods that are more slowly digested and absorbed may have metabolic benefits in relation to diabetes and in the reduction of coronary heart diseases. The finding of Ogbuji and David-Chukwu (28) revealed that cassava-based dishes consumed in Nigeria had high glycemic index. They reported that '*abacha*', '*tapioca*', '*garri*' and 'fufu' had glycemic index of 84.88, 78.67, 92.36 and 84.06%. A higher glycemic index was also reported in another study by Omoregie and Osagie (5). They reported that '*amala*', '*agidi*', '*tuwo*', '*tuwo dawa*' and '*tuwo shinkafi*' among others had glycemic index of 84.35, 92.30, 86.80, 85.30 and 95.30%. Studies done in Northern Sri Lanka by Pirasath *et al*., (40) revealed that glycemic index (GI) values of cooked white rice, brown rice and parboiled rice were 66.61, 60.24 and 55.97%, which were similar to some of the glycemic index values obtained in this present study. Similarly, the same authors (40) reported that boiled potatoes and cassava had glycemic index of 78.70 and 75.20%, respectively. The lower glycemic index obtained in this present study compared to most of the previous studies could be attributed to the intrinsic and extrinsic factors affecting the glycemic responses of food such as food form, rate of digestion, food component, physiological effect and methods of processing (41).

It is interesting to note that the variation of the dishes though prepared with the same basic ingredients (cocoyam or corn) had varied nutrient composition as well as glycemic index. '*Achicha*' prepared with pigeon pea and the one prepared with fresh '*akidi*' holds promise in the dietary management and prevention of diabetes due to their low glycemic index. However, the vitamin and mineral compositions of these two variations of '*achicha*' were lower than that of '*achicha*' prepared with vegetable. To improve the nutrient composition of '*achicha*' prepared with pigeon pea and the one prepared with fresh '*akidi*', their recipes could be modified by adding vegetables. This is not likely going to affect the glycemic index negatively since vegetables are high in fibre and low in carbohydrate content. '*Ayaraya oka*' prepared with fresh '*akidi*' has been shown to be a better choice over '*ayaraya oka*' withpigeon pea since it is richer in most nutrients and of a lower GI value. Variations of '*achicha*' and '*ayaraya oka*' prepared with pigeon pea and fresh '*akidi*' all had lower GI values compared to the variation without them. This implies that the addition of pigeon pea or fresh '*akidi*' to a recipe that originally did not have them could lower the glycemic index of their dishes. This result has proved that the manipulation of ingredients in a recipe does not only affect it nutrient composition as reported by Davidson *et al*., (15) but the glycemic index as well. Dieticians should therefore employ this principle when prescribing diets for the diabetic patients.

Conclusion

The study provided the nutrient composition of variations of cocoyam and corn-based traditional

dishes consumed in Nsukka L.G.A. of Enugu State Nigeria. The dishes were high in moisture, dietary fibre and most of the vitamins (vitamin B_1, B_3, B_6, B_9, C and E) and minerals (potassium, calcium, magnesium, phosphorus and cupper). The available carbohydrate content was moderate while vitamin B_2, iron and zinc content were low. Glycemic index of the dishes were low except for that of '*achicha*' with vegetable and '*ayaraya oka*' with pigeon pea that had moderate glycemic indices. Due to the low glycemic index of most of these dishes, their use as therapeutic diets in the dietary management of diabetes is recommended.

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