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Comparative Evaluation of Glycemic index (GI) of some Traditional Dishes consumed in Enugu North Senatorial zone of Enugu State, Nigeria

Umerah Nkemjika Nnedinso[1*]

[1]Department of Food Science and Technology, Enugu State University of Science and Technology, Enugu, Nigeria.

*Corresponding author: nkemumerah@yahoo.com

Abstract
The study was undertaken to evaluate the glycemic index (GI) of 'ayarayaoka', 'okpa' and 'achichca and agbugbu' a traditional dish consumed in Enugu North Senatorial zone. The recipes were standardized and prepared accordingly. 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 glycemic index value for each dish determined. Data were analyzed using Statistical Package for Social Sciences (SPSS). The dishes had appreciable proximate composition, were moisture ranged from 46.20-62.55%, ash 2.68-3.56%, fat 5.30-8.20%, protein 4.90-17.80%, fibre 0.23-7.20% and carbohydrate 16.31 to 31.22%. The blood glucose concentration of 'ayarayaoka', 'okpa', 'achicha and agbugbu', and glucose reference at 120 minutes were 75.28, 72.80, 80.28 and 88.30 respectively. The glycemic index (GI) and glycemic load (GL) of 'ayarayaoka', 'okpa' and 'achicha and agbugbu' were 47.52, 50.80- and 59.20 for index while 7.75, 10.32 and 18.48 for load respectively. The increametal area under blood glucose response curve showed that glucose standard had 124.93, ayarayaoka had 59.37, okpa had 63.46 while 73.96 were recorded for achicha and agbugbu. Conclusion Glycemic index of the dishes were low except for that of 'achicha and agbugbu' that had medium glycemic indices and they can be recommended for diabetics.
Key word: Glycemic index, diabetes mellitus, traditional dishes*, Okpa, ayarayaoka, achicha and agbugbu.*

Introduction
Diabetes mellitus poses a serious challenge to health care globally and have high prevalence all over the World. In 2012 Nigeria census, it was observed that an estimate of over 195.88 million people in the Country have diabetes mellitus (Sunny, 2014). The prevalence rate increased due to population growth, change in lifestyle and food habit, aging, urbanization and increasing prevalence of obesity and physical inactivity.

Glycemic index (GI) is the impact of digested carbohydrate food in the body in respect to their blood glucose level. Carbohydrates that breakdown quickly during digestion have high (GI) because their Beta-glucose response is fast and high while those that breakdown slowly have a low GI (Jenkins *et al.*, 2002). Glycemic index were classified into high (GI ≥70), medium (GI = 56-69) and low (GI ≤ 55) relative to pure glucose (GI= 100). Jenkins *et al*. (2002), opined that low glycemic index diet, promotes weight loss and good health. Glycemic index could be a Nutrition therapy intervention for diabetics and low glycemic index foods may reduce postprandial blood glucose levels (ADA, 2009).

There is a strong correlation between carbohydrate intake with nutritional status, energy balance, and chronic disease risk (Cho et al.,2003; Jenkins et al.,2002; Liu et al., 2000; Oh, Willett, Fuchs, &Giovannucci, 2004). Carbohydrates differ in their ability to influence immediate and long-term metabolic responses. These physiologic responses have important implications for energy balance, cardiovascular disease, and cancer.

Food processing had some positive effects on food security of the African continent on the other hand, it hasgross effect on the health of the Africans as it has promoted a nutrition transition in which theirunique healthy traditional meals have been replaced by processed foods which predisposes one to cardiovascular diseases. Turner and Turner (2007) noted that both indigenous and non-indigenous people consume foods with unhealthy fats and refined carbohydrates which are lower in essential vitamins and minerals and at the same time more expensive than their traditional meal.

Most meals in the south eastern Nigeria are generally not eating as a singlefoods, but eat as a mixed meals for example "*agbugbu* and *ji*" beans and plantain, "*achicha* and *agbugbu*", rice and beans, beans and yam, *akara*and pap etc. Food components is a major factor that affects 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. The plant foods that are commonly used in the dietary management of diabetes in Nigeria include unriped Plantain and African yam beans. However, the need for diversity of dietary choices due to complaints of dietary monotony among diabetic consumers has prompted the search for other foods with anti-diabetic potentials.

Traditional foods are more affordable, accessible and acceptable by the people. Few traditional meals from Enugu South Senatorial zone has been studied to determine their GIand glycemic load.It is imperative to study the glycemic index of all the traditional diet consumed within a locality, this will help to identify the ones with low glycemic index and advocate the increase in the consumption of these diet through Nutrition advocacy programme highlighting their ethnobotanical benefit.

Enugu North Senatorial zone of Nigeria has wide range of traditional food with high nutritional value. In this study attempt has been made to study the glycemic index of some foods in Enugu North Senatorial zone of Nigeria.

Materials and Methods

Study Design

Random sampling was used to select three local dishes of the people. The selected local meals are; *Ayarayaoka* (test food 1), *okpa* (test food 2) and *agbugbunaachicha* (test food 3).

Standardization of Recipe

The recipe selected were standardized using a modified method of National Food Service Management Institute (2010).

Method of Preparation of "*Ayaraya Oka*"(test food 1)

Table 1: List of ingredients of test food 1.

Ingredients	Quantity
Pigeon pea	500g
Yellow maize	750g
*Ukpak*a (African oil bean seed)	200g
Onions	100g
Red oil	100ml
Amaranthus spp	Bunch
Scent leaves	50g
Fresh Pepper	25g
Salt	2 table spoon
Water	5,000ml
Knorr (Seasoning)	16g
Total Yield	4360g

After sorting and cleaning, the pigeon pea seeds were soaked in portable water for 24 h prior to cook. It was drained, washed and placed in a hot water and boiled for 2 h. Then the already sorted, cleaned and soaked for 6 h maize grains were drained, washed and coarse milled with little addition of water to form bread-like crumb. Thereafter, it was placed into a large foil wrapped tightly and immersed into the boiling pigeon pea seeds and allowed to boil for 30 min, followed by addition of already cut pieces of vegetable leaves to steam them for 2 min. Then, the maize, pigeon pea and vegetable leaves were drained off water and set aside. One hundred millilitres of palm oil were boiled followed by addition of sliced onions, grounded pepper, salt, seasoning cube and "*ukpaka*". Thereafter, the boiled maize, pigeon pea and vegetable leaves were mixed together in a large pot and the already boiled red oil were poured into the pot and mixed properly with turning stick. The resulted "*ayarayaoka*" was placed in a cleaned flask and covered until used.

Plate 1: The image of *Ayarayaoka* food

Preparation of Bambara groundnut *"Okpa"*

Table2: List of ingredients of test food 2.

Ingredients	Quantity
Bambara groundnut	1kg
Red oil	150 ml
Fresh pepper	25g
Salt	2 table spoon
Red oil	100ml
Knorr (Seasoning)	16g
Water	2 litres

The already fine-milled bambara groundnut flour was sieved into a big bowl. Approximately, 150ml of oil was poured into the flour. Thereafter, already boiled lukewarm water measuring 400ml was poured subsequently into the mixture and kneaded until a smooth watery fluid was formed, thensalt, smashed seasoning cubes was added. Then the grounded pepper was added into the mixture and a turning stick was used to stir it and set it aside. Five litres of water was boiled in a pot, then the "*okpa*" mixture was tied in prepared banana leaves and insert into the already boiling water and allowed to boil for 2 h. Thereafter, the resulting okpa obtained was placed in a clean flask and covered until used.

Plate 2: The image of *Okpa*food

Preparation of "*Achicha and Agbugbu"*

Table3: List of ingredients of test food 3.

Ingredients	Quantity
Pigeon pea	500g
Dried Cocoyam (Achicha)	750g
*Ukpak*a (African oil bean seed)	200g
Onions	100g
Red oil	150ml
Scent leaves	10g
Fresh Pepper	25g
Salt	2 table spoon
Water	5,000ml
Knorr (Seasoning)	16g
Total Yield	4420g

Pigeon pea seed were sorted and cleaned; then the seeds were soaked in portable water for 24 h prior to cook. It was drained, washed and placed in hot water and boiled for 1 h. Then, an already ground and 6 h soaked dry cocoyam was wrapped in a banana leaves and immersed into the boiling pigeon pea and continued cooking until they both were done. They were drained of the water and separately spread on the trays to cool. One hundred and fifty millilitres of palm oil were fried followed by addition of sliced onions, grounded pepper, salt, seasoning cube and "*ukpaka*". Thereafter, the boiled cocoyam and pigeon pea were mixed together in a large pot and the already fried red oil was poured into the pot and mixed properly with a turning stick. This resulted "*agbugbunaachicha*" was placed in a cleaned flask and covered until used.

Plate 3: The image of *Achicha and agbugbu*

Proximate Analysis

Proximate analysis was carried out for the three test foods. Total carbohydrate, ash, moisture content, crude fibre, crude fat and crude protein content will be determined using the methods of the Association of Official Analytical Chemists (AOAC, 2005).

Determination of Moisture Content

The moisture content of the sample was determined using the hot air oven method of AOAC (2005). Two gram (2g) of each sample (B) was weighed and put into a washed and dried previously weighed (A) petri-dish and placed in an oven at a temperature of 80ºC for 2 hours and at 105ºC until the weight was constant. The samples was cooled in a desiccator and weighed and the weight was recorded as (C). The weight loss obtained as the moisture content was calculated from the formula:

% Moisture Content = B-CB-A X 1001

Where A = Initial weight of empty crucible
B = Weight of crucible + sample before drying
C = Final weight of crucible + sample after drying

3.4.2 Determination of Protein Content

The crude protein of the samples was determined by the Micro Kjeldahl technique as described by AOAC (2005). Two grams (2g) weight (W) of the sample was put into a Kjeldahl flask. Four grams (3g) of anhydrous sodium sulphate and two (2g) of hydrated copper sulphate (catalyst) were added into the flask. Then 20mL of concentrated tetraoxosulphate (IV) acid (H_2S0_4) was added to digest the sample. The digestion was continued under heat until a clear solution was observed. The clear solution was cooled and made up to 100mL with distilled water. A digest of about 5mL was collected for distillation. Also, 5ml of sodium hydroxide (NaOH) was put into the distillation flask and distillation was allowed to take place for some minutes. The ammonia that was distilled off was absorbed by boric acid indicator and titrated with 0.01M hydrochloric acid (HCl). The titrevalue (T) of the endpoint at which the colour changed from green to pink was taken. The crude protein was calculated as:

% Crude Protein = 0.0001401 x T x 100 x 6.25W X 5
Where: T= Titre value
W= Weight of sample dried.

Determination Ash Content

The ash content of the sample was determined by the method of AOAC (2005). A silica dish was heated to about 60ºC and cooled in a desiccator weighed and recorded as (A). Two grams (2g) each of the sample was weighed (B) and put into the silica dish and transferred to the furnace. The temperature of the furnace was allowed to reach about 500ºC after placing the dish in it. The temperature was maintained until whitish-grey colour was obtained which was an indication that all the organic matter of the sample had been destroyed. The dish was brought out from the furnace and cooled in a desiccator, then re-weighed and recorded as (C). The percentage ash content was calculated as:

% Ash Content = C-AB-A X 100

Where: A = Weight of empty dish

B = Weight of empty dish + sample before ashing

C = Weight dish + ash

Determination of the Fat Content

The Solvent extraction method of AOAC (2005) was used. The extraction flask was washed with petroleum ether and then dried, cooled, weighed and recorded as (B). Two gram (2g) of the sample was weighed (A) into the extraction thimble. It was placed back in the Soxhlet apparatus. The washed flask was filled to about three-quarter of its volume with petroleum ether (that has the boiling point range of 40-60ºC). The apparatus was set up and extraction was carried out for a period of 5 hours after which complete extraction was made. The petroleum ether was recovered leaving only oil in the flask at the end of the extraction. The oil in the extraction flask was dried in the oven, cooled and finally weighed (C). The fat content was expressed as a percentage of raw materials. The difference in weight of empty flasks and the flask with oil content was calculated as:

% Fat Content = C-BA X 100

Where; A = Weight of sample

B = Weight of empty flask

C = Weight of flask + oil

Determination of Crude Fibre Content

This was determined by the method of AOAC (2005). In its determination, the bottom flask and beaker were rinsed with clean water, dried in an oven at 100ºC for 5 minutes and cooled. The defatted sample after fat extraction was used. Two grams (2g) of sample (A) was transferred into a 500mL flask and 200mL of pre-heated 1.25% H_2SO_4 was added and the solution was gently boiled for 30 mins, maintaining a constant volume of acid by the addition of hot water. The residue obtained was washed 3 times with hot water and returned to the beaker. The 200mL of pre-heated 1.25% NaOH was added and boiled for another 30 min. This was filtered under suction and then washed thoroughly with hot water and twice with ethanol. The residue was dried at 65ºC for about 4 hrs, weighed and recorded as (B). The residue was transferred into a crucible and placed in muffle furnace and ashed at 550ºC for 4 hours. It was cooled in a desiccator and weighed (C).

% Crude Fibre Content = C-BA X 100

Where C= Weight of crucible + sample before ignition

B= Weight of crucible + ash after ignition

A= Weight of sample.

Determination of the Carbohydrate

The Carbohydrate content of each sample will be determined by difference. % Carbohydrate = 100 % - (protein + fat + fibre + ash + moisture) (AOAC 2005).

Determination of Serving Sizes

The glycemic index (GI) test was based on 50g in each test food of available carbohydrates. Therefore, the portion size of each test food was varying according to the quantity of carbohydrates available in that food. Fifty grams of available carbohydrate was calculated from the results obtained from the proximate analysis of the test samples, the weight of the samples that delivered fifty grams of available carbohydrates. The dry weight was determined using the calculation below.

Dry weight (DW) =100−moisture content

Weight of carbohydrate in 100 g dry weight = CHO of test sample 100 X DW

3.7 Selection of the Subjects

Thirty (30) subjects (15 males and 15 females), aged between 18 and 30 years, were selected for the study and all the subjects were given an informed consent form to sign and participate in the study. All subjects were recruited from Enugu State University of Science and Technology, Enugu for voluntary participation in the study. The subjects chosen were healthy, they were also non-smokers, not pregnant or diabetic and none of them had a family history of diabetes. The subjects were given full details of the study protocol and were opportune to ask questions before the study. The protocol and procedures employed were reviewed and approved by the Ethics Committee of the College of Medical Sciences, Enugu State University Teaching Hospital, Enugu. The procedures followed were also in accordance with the ethical standards of the responsible committee on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. The subjects were randomized into three groups (A, B and C) of 10 individuals each (5 males and 5 females). The subjects were asked not to undertake vigorous activities on the day before the test and to avoid caffeine-containing drinks 24 h before the test. Instructions concerning meals of the previous day was not provided, because the fat and carbohydrate content of the evening meal before GI testing does not influence the blood glucose response. The foods that was consumed by each group are as described below; All groups (A, B and C): Consumed the Standard Food (Glucose). Group A Subjects: Consumed Test Food 1 (*ayayrayaoka*), Group B Subjects: Consumed Test Food 2 (*okpa*) and Group C Subjects: Consumed Test Food 3 (*agbugbu and achicha*).

3.8 Anthropometric Measurements

2.8.1 Weight Measurement

To ensure reliable measurements of body weight using the mechanical bathroom scale (HANA mechanical bathroom scale; P.M.HANA, Central Hong Kong, Hong Kong) the scale was zeroed before the respondent stepped onto it. The respondent was each asked to remove any "heavy" items from their pockets and any heavy items of clothing. They were asked to look straight ahead and stay still on the scales. The needle/digital screen was allowed to settle before the measurement was recorded. The body weight (kg) was measured to the nearest 0.5 kg.

Height Measurement

Height measurement of each of the subjects was taken using a "drop-down" tape fixed at about 2 m on a finely constructed wood. The respondents were asked to remove their shoes and stand with their back to the scale, looking directly forward. The back of their feet, calves, upper back and the back of their head was in contact with the wooden scale. They were positioned directly underneath the drop down measuring tape fixed on the wood. The measuring scale was held firm until it rested gently on the top of the respondent's head and the height (m) to the nearest 0.5 cm was recorded.

Determination of BMI

All anthropometric measurements were taken after a 12 h fast with the subjects wearing light clothes and no shoes. Body Mass Index (BMI) was calculated as the weight in kilograms divided by the square of the height in meters (kg/m2).

$$\text{BMI} = \frac{\text{Weight kg}}{\text{Height m}^2}$$

Determination of the Glycemic Indices of the Subjects

Glucose Level of the Subjects

Glycemic index (GI) of each subject was determined according to the method of Wolever*et al.* (2001). The GI of the test foods was determined by feeding each test food to 10 healthy individuals. Blood was obtained by finger prick using the AccuChekSoftclix lancing device (Accu-CheckR Active). The finger was chosen at random. Before the finger prick, the subjects were encouraged to warm their hands (by rubbing the palms together) to increase blood flow. Blood samples was punctured and placed on a test strip at intervals of 30 min for 2 h (0, 30, 60, 90 and 120 min). The blood glucose concentrations were determined using a glucometer with a glucose test strip (Accuchek Active).

Glycemic Indices of the Subjects

Volunteers for the investigation fasted overnight. They were asked not to perform any strenuous activities or take long walks. They were requested to remain seated for the duration of the test. Capillary pricked-finger blood samples were taken at baseline (0 min), 30, 60, 90, 120 and 180 mins after consumption of the food. The blood sample was placed immediately on a test strip which was inserted into a calibrated Glucometer (Evolve^{R}) which gives direct readings after a few seconds.

Day 1

The study started in the morning after an overnight fast by the individuals. A fasting blood sample was taken at 0 min; then after this, the subjects consumed 50 g of standard food (50 g of glucose powder dissolved in water) in a comfortable place. The standard food was constituted with 200 ml of water. Blood samples were taken at 30, 60, 90, 120, and 180 min. The blood glucose concentration was determined immediately using the glucometer.

Day 2

After an overnight fast, the test foods consumed by the same group of subjects. Blood samples was taken at 0, 30, 60, 90,120 and 180 min. The blood glucose concentrations were determined immediately using the glucometer.

The incremental areas under the glycemic response curve were calculated geometrically (Wolever and Jenkins, 1986). The GI was calculated by expressing the glycemic response area for the test food as a percentage of the mean response area of the glucose drink taken by the same subjects. The following formula was applied:

$$GI = \frac{\text{Area under the curve for 50g carbohydrate from test food X 100}}{\text{Area under the curve for 50g carbohydrate from glucose}}$$

The GI for the food and control was calculated as a mean from the respective average GI of the individuals.

Calculation of glycemic load

The glycemic load, which assesses the total glycemic effect of the diet is the product of the dietary GI and total dietary carbohydrate;

$$GL = GI100 \text{ X Carbohydrate content (g).}$$

Statistical Analysis

Data collected was subjected to analysis of variance (ANOVA), using SPSS (Statistical Package for Social Sciences) and least significance difference (LSD) test at 5% level of probability was used to compare the significant treatment mean.

Results

Table 4: Proximate Composition of Test Foods (%)

Sample	TF1	TF2	TF3
Moisture	$62.55^{a}\pm0.25$	$50.24^{b}\pm0.37$	$46.20^{c}\pm0.83$
Ash	$3.56^{a}\pm0.09$	$3.20^{b}\pm0.02$	$2.68^{c}\pm0.11$
Fat	$5.30^{b}\pm0.04$	$8.20^{a}\pm0.21$	$7.80^{a}\pm0.43$
Protein	$6.78^{b}\pm 0.13$	$17.80^{a}\pm0.18$	$4.90^{c}\pm0.71$
Fibre	$5.50^{b}\pm0.32$	$0.23^{c}\pm0.02$	$7.20^{a}\pm0.12$
CHO	$16.31^{c}\pm0.53$	$20.33^{b}\pm0.55$	$31.22^{a}\pm0.87$
Energy (kcal)	$140.06^{c}\pm0.13$	$226.32^{a}\pm1.10$	$214.68^{b}\pm0.55$

Values are mean ± standard deviation of 3 replication

Key: TF1= Ayarayaoka,
TF2=Okpa,
TF3=Agbugbu and achicha.

Table 5: Blood Glucose Concentration (mg/dl) of Subjects

Sample	Glucose drink	TF1	TF2	TF3
0 mins	$76.20^{a}\pm0.13$	$73.52^{b}\pm0.16$	$76.90^{a}\pm0.23$	$74.76^{b}\pm0.48$
30 mins	$126.25^{a}\pm0.06$	$90.40^{c}\pm0.52$	$81.50^{d}\pm0.15$	$105.20^{b}\pm0.25$
60 mins	$118.72^{a}\pm0.42$	$86.76^{c}\pm0.08$	$76.20^{d}\pm0.32$	$93.63^{b}\pm0.14$
90 mins	$95.84^{a}\pm0.37$	$78.52^{c}\pm0.57$	$73.40^{d}\pm 0.63$	$83.48^{b}\pm0.06$
120 mins	$88.30^{a}\pm0.62$	$75.28^{c}\pm0.61$	$72.80^{d}\pm0.56$	$80.28^{b}\pm0.21$

Values are the mean ±standard deviation of ten individual per group (n=40). Value within the same column with different superscript are significantly different ($p<0.05$).

Key: TF1= Ayarayaoka, TF2=Okpa, TF3=Agbugbu and achicha

Table 6: The calculated carbohydrate in 100g of prepared food and serving size used for the determination of glycemic index and glycemic load.

Samples CHO 100g	Calculated size (g)	Serving GI	GL	Classification	
TF1	16.31	306.56	47.52	7.75	Low
TF2	20.33	245.94	50.80	10.32	Low
TF3	31.22	160.15	59.20	18.48	Medium

Values are mean ± standard deviation of 3 replication

Key: TF1= Ayarayaoka, TF2=Okpa, TF3=Agbugbu and achicha

Table 7: Incremental area under the blood glucose response curve (IAUC)

Samples	IAUC±SEM	p-value
Glucose	124.93±8.96	
TF1	59.37±3.24	.5210
TF2	63.46±5.02	.6153
TF3	73.96±13.56	.4756

Values are mean ± standard deviation of 3 replication

Key: TF1 = Ayarayaoka, TF2 = Okpa, TF3 = Agbugbu and achicha.

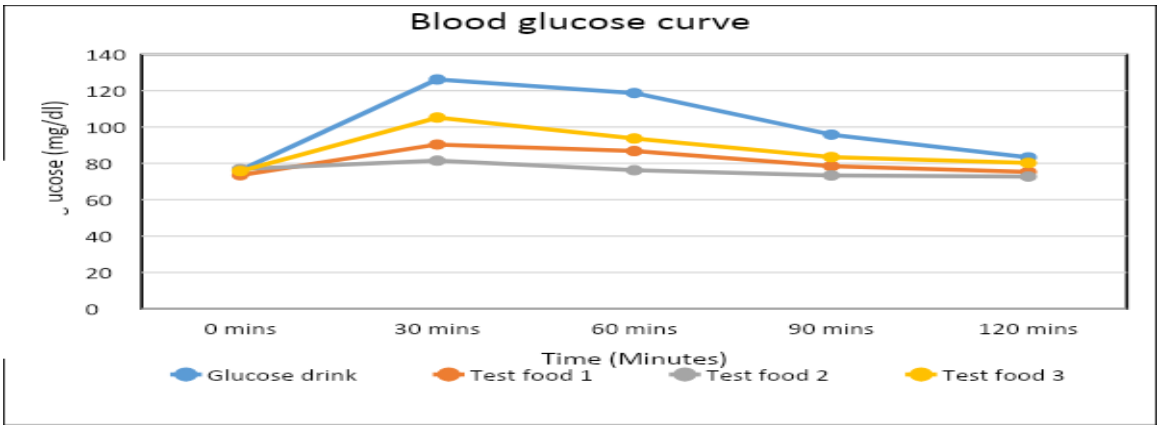

Fig 1: The mean Blood glucose curve of subjects after consumption of the three test foods compared with the control (glucose drink).

Discussion

Proximate Composition

Table 4 presents the proximate composition of the three local dishes. From the Table, *Ayarayaoka* had 62.55% moisture, 3.56% ash, 5.30% fat, 6.78% protein, 5.50% fibre and 16.31% carbohydrate. *Okpa*contained 50.24% moisture, 3.20% ash, 8.20% fat, 17.80% protein, 0.23% fibre and 20.33% carbohydrate while *Agbugbu and achichi* had 46.20% moisture, 2.68% ash, 7.80% fat, 4.90% protein, 7.20% fibre and 31.22% carbohydrate. There is significant difference among the means of all the nutrient values.

Moisture: Moisture values obtained from this study are in line with previous studies. Davidson *et al*. (2017), reported that the moisture content of different kinds of'achicha' (a traditional meal consumed in South-Eastern Nigeria) ranged from (53.8-65.6%). Kayode *et al*. (2010) also obtained moisture content within the range of 63.11to70.44% from dishes consumed in southeast Nigeria. According to Okeke *et al*. (2009) moisture content of 'ayarayaoka' was 70.02%. The implication of these results is that traditional South-Eastern Nigeria dishes are high in moisture. The high moisture content of all the dishes were not a surprise because the foods are cooked in water. Along with other liquids, water helps to get rid of wastes through urine, skin and bowel evacuation.

Ash: Ash is an indication of the mineral contents of foods. The ash content obtained from this study was higher than what was reported by Ogbuji and David-Chukwu (2016) in different food forms of cassava (0.27- 0.43%) which could be attributed to the type of food studied. The ash content of the dishes were close to that recorded by Ene-Obong and Madukwe (2001) for '*okpa*' (3%) but lower than that recorded by Okeke and Eze (2006) for another traditional food in the study area, *'achichaand akidi'* (4.3%). Since ash is an indication of the mineral content, the result suggests that the mineral content of these foods will be high. Combination of different foodstuffs in the preparation of a meal would help improve the nutrient content of food. This is because all the foodstuff will help contribute to the improvement of the overall nutrient content of the meal as is common with traditional meals in South Eastern Nigeria.

Fat: Fat values obtained from '*achicha' (*3.98g) by Okeke and Eze (2006) was lower than what was obtained from this study. Palm oil and African oil bean seed is the major source of fat in these dishes. The differences in the fat values of the various dishes could be due to different quantities of palm oil and African oil bean seed 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. Fat help in the absorption of fat-soluble vitamins. The fat content of 'okpa' (8.9%) reported by Okeke *et al*. (2009) was similar to that of 'okpa' in this study.

Protein: The protein values obtained in this study were lower than what were reported by Nnanyelugo (1985) on the protein content of 'achicha and agbugbu' (12.9%) and 'achicha' with 'akidi' (10.8%) except in the case of okpa with the protein content of 17.80%. Compared with other dishes consumed in South-Eastern Nigeria, the protein values obtained from this study were similar to the report of Okeke and Eze (2006) on the protein content of 'Ayarayaoka' (4.08%). Awogbenia and Ugwuona (2012) reported a protein content of 3.10- 5.07% in traditional dishes consumed in Nassarawa State, Nigeria. The protein content of the dishes are of interest, especially in the community were the dishes are common. Frequent consumption of this meals will ensure proper growth of the consumer and lead to replacement of worn out tissues.

Fibre: Minse (2009) recorded that 'achicha', 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 except in the case of okpa. The observed differences in dietary fibre contents of the dishes may be attributed to other components of the recipes. However, close range in dietary fibre content was recorded for some indigenous dishes by Kouamé*et al*., (2014). According to the authors, achicha with local beans, ayaraya with pigeon pea and abacha had dietary fibre values of 5.9, 6.2 and 8.9%, 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 (Okoye, 1992). Studies have shown the importance of dietary fibre in glycemic control and improved morbidity of diabetic patients (Odenigbo*et al*., 2011). According to Tsang (2011), fibre slows down the digestion of starch, therefore, high-fibre foods have a lower glycemic index. The fact that none of the various dishes had a high glycemic index could therefore be partly due to their high dietary fibre content.

Carbohydrate: 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 were (16.31%, 20.33%, and 31.22%) for 'ayarayaoka', 'okpa' Bambara groundnut and 'achicha and agbugbu' which is also a popular cocoyam-based traditional dish. High available carbohydrate was reported for pounded yam with eggplant sauce, cassava paste with granulated palm nut sauce and rice with groundnut sauce (50%, respectively) by Kouamé*et al*. (2015). Such

dishes with high available carbohydrates may not be suitable for diabetics as they may cause rapid increase in blood glucose level.

Energy: The energy values obtained from this study are in line with previous studies. The values of energy 140.06 to226.32kcal that were obtained in this study conformed with the reported findings (156.83-245.30kcal) of Ene-Obong and Madukwe (2001) in local dishes consumed in Nsukka. Davidson *et al*. (12017), reported that the energy content of different kind of'achicha' (a traditional meal consumed in South-Eastern Nigeria) ranged from (185.8-205.6%). The low energy content of '*ayarayaoka'* and '*agbugbu* and *achicha*' implies that these dishes could be incorporated into weight loss menus (Okeke and Eze, 2006).

Blood Glucose Concentration (mg/dl) of Subjects

Table 5 presents the blood glucose concentration of glucose drinks and the three local dishes. From the Table, glucose drink showed 76.20mg/dl at 0 min, 126.25mg/dl at 30 min, 118.72mg/dl at 60 min, 95.84mg/dl at 90 min and 88.30mg/dl at 120 min. Ayarayaoka showed 73.52mg/dl at 0 min, 90.40mg/dl at 30 min, 86.76mg/dl at 60 min, 78.52mg/dl at 90 min and 75.28mg/dl at 120 min. Okpa showed 76.90mg/dl at 0 min, 81.50mg/dl at 30 min, 76.20mg/dl at 60 min, 73.40mg/dl at 90 min and 72.80mg/dl at 120 min while Agbugbu and achichi showed 74.76mg/dl at 0 min, 105.20mg/dl at 30 min, 93.63mg/dl at 60 min, 83.48mg/dl at 90 min and 80.28mg/dl at 120 min. The result of the test diets on blood glucose concentration showed that the blood glucose response to okpa was significantly ($P<0.05$) elevated but with time as an additional factor, achicha and agbugbu diets seem to be the next threatening diets when compared to ayarayaoka and okpa. Okpa diet was shown to have the highest rate when compared with the other diets. This could suggest higher glucose uptake with okpa diet compared to the other diets, thereby decreasing the concentration of glucose in the blood; hence, preventing hyperglycaemia. The variability in the blood glucose responses to these diets may be attributed to the nature of the starch (amylose/amylopectin content) present. High amylose starch has been shown to be digested far more slowly than high amylopectin starch (Behall*et al*., 2011). This was supported by the work of Kabir *et al*. (1998), which reported that when starches with different amylose amylopectin ratios are incorporated into a meal, the one with the higher amylopectin starch showed a higher glycaemic index than that of the low amylopectin starch for normal and diabetic rats. This was in agreement with the work of Thannoun and Al-kubati (2005) which showed that a higher ratio of amylose to amylopectin in foods decreases the digestion of the total starch and consequently decreases the glycaemic index values.

Glycemic indices and loads of the traditional dishes

Table 6 presents the glycemic indexes and glycemic load concentration of the three local dishes. From the Table, Ayarayaoka contained 16.31g calculated carbohydrate, 306.56g serving size, 47.52 glycemic index, 7.75 glycemic load and was classified as low. Okpa contained 20.33g calculated carbohydrate, 245.94g serving size, 50.80 glycemic index, 10.32 glycemic load and classified as low while Agbugbu and achichi contained 31.22g calculated carbohydrate, 160.15g serving size, 59.20 glycemic index, 18.48 glycemic load and classified as medium.

The result of this study revealed that the dishes were of low glycemic indices except for 'achicha and agbugbu' which fall in the medium glycemic index category. This finding is supported by Evans and Gajere (2012) 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 30^{th} minute after consuming the dishes showed that the meal was slowly digested and assimilated into the bloodstream. Slow digestion of these dishes probably due to their high fibre content which have been indicated earlier on has some positive health implications. Burkitt and Trowel (1977) 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 (2016) revealed that cocoyam based dishes consumed in Nigeria had high glycemic index than corn-based ones. Similarly, (Pirasath*et al*., 2015) 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 food component of the meals.

Incremental Area under the Blood Glucose Response Curve

Table 7 presents the increamental area under the blood glucose response curve of the three local dishes. From the Table, glucose had 124.93. *Ayarayaoka* contained 59.37. *Okpa* contained 63.46 while *Agbugbu*

and *achichi* contained 73.96. The GI is intended to be an index of the relative blood glucose-raising potential of the available carbohydrate in different foods. For this concept to be valid and useful, the GI value of the same food must be the same in different subjects. Glycemic responses vary from day to day within subjects and also vary between subjects. GI is not only the measure of carbohydrate absorption in the small intestine directly, but also indicates the effect of other factors in the foods tested that can influence the rate of carbohydrate absorption in the small intestine. This study shows that there are significant differences in the glycemic responses to different mixed meals. Significant differences were found in the IAUC between the standard and the test foods for each group. This findings show that the selected test foods ('ayarayaoka', 'okpa' and 'achicha and agbugbu') consumed have low-GI values. The low-GI food consumed by the subjects could not increase their risk of cardiovascular diseases. However, this may not be a common phenomenon since they are often prepared using a varieties of substance, some of which help in protecting against cardiovascular diseases.

Conclusion

The study provided the nutrient composition of 'ayarayaoka', 'okpa' and 'achicha and agbugbu' as traditional dishes consumed in Enugu North Senatorial zone, Enugu State Nigeria. The dishes were high in moisture, dietary fibreand protein. The available carbohydrate content was low.

Glycemic index of the dishes were low except for that of 'achicha and agbugbu' that had medium glycemic indices. Ayarayaoka' and 'okpa' had low glycemic index and loads values, while 'achicha and agbugbu' had a medium glyceamic index value. A low glycemic indices diets can help to lose weight or keep a healthy weight. It may help in management of a diabetes plan.

The low and medium glyc.emic values of the dishes imply that they could cause a delayed rise in blood sugar and slow down gastric emptying time. Therefore, regular consumption of these dishes may not quickly make one feel hungry, thus suppressing the desire to eat more food. When such eating patterns become habitual, there is the likelihood of losing weight as a result of less eating, thus reducing the prevalence of obesity and diabetes mellitus, especially among those prone to the disease.

Reference

1. American Diabetes Association (2009). Diabetes and Impaired Glucose Tolerance. In: IDF Diabetes Atlas, IDF (Eds.). 4th Edn. Chapter 2.1.1, International Diabetes Federation, Brussels, Belgium, pp: 22-29.
2. AOAC *(*2005*)Official Methods of Analysis*. (17th Edn.) *The Association of Official Analytical Chemists, Gaithersburg*, MD, USA. Pp. 925-974.
3. Awogbenja, M.D. and Ugwuona, F.U. (2012). Nutrient and Phytochemical Composition of Some Commonly Consumed Traditional Dishes of Nasarawa State, Nigeria. *Prod. Agric. and Tech.*; 8 (1):30 -39.
4. Behall KM, Scholfield DJ, Hallfrisch J. (2011)The effect of particle size of whole grain flour on plasma glucose, insulin and TSH in human subjects. Journal of American College of Nutrition; 18: 591-597.
5. Burkitt, D.P. and Trowell, H.C. (1977). Dietary fibre and western diseases. *Iranian Medical Journal*; 70: 272–7.
6. Cho, E., Spiegelman, D., Hunter, D.J., Chen, W.Y., Colditz, G.A. and Willett, W.C. (2003). Premenopausal dietary carbohydrate, glycemic index, glycemic load, and fibre in relation to risk of breast cancer. *Cancer Epidemiology, Biomarkers and Prevention*; 12: 1153–1158.
7. Davidson, G.I, Ene-Obong, H.N and Chinma, C.E. (2017). Variations in Nutrients Composition of Most Commonly Consumed Cassava (*Manihot esculenta*) mixed dishes in South-Eastern Nigeria. *Journal of Food Quality*; 7:1-15.
8. Ene-Obong, H.N. and Madukwe, E.U. (2001). Bioavailability of trace elements in South-Eastern Nigerian meals and the effect of dietary components. *Nigerian Journal of Nutritional Science*; 22: 4-12.
9. Evans, E.C. and Gajere, Y. (2012). The glycemic index and load of different Nigerian food forms. *International Research Journal of Biochemistry Bioinformation*; 7(1): 001-011.
10. Jenkins, D.J., Kendall, C.W., Augustin, L.S., Franceschi, S., Hamidi, M., Marchie, A. and Axelson, M. (2002). Glycemic index: overview of implications in health and disease. American Journal of Clinical Nutrition, 76: 266S–273S.
11. Kabir, M., Rizkalla, S.W., Champ, M., Luo, J., Boillot, J. and Bruzzo, F. (1998). Dietary amylose amylopectin starch content affects glucose and lipid metabolism in adipocytes of normal and diabetic rats. *Journal of Nutrition*; 128: 35-43.
12. Kayode, O.F, Ozumba, A.U, Ojeniyi, S, Adetuyi, D.O and Erukainure, O.L. (2010). Micro Nutrient Content of Selected Indigenous Soups in Nigeria. *Pak J Nutri*.; 9: 962-965.

13. Kouamé, C.A., Kouassi, K.N. and Coulibaly, A. (2014). Glycemic Index and Glycemic Load of Selected Staples Based on Rice, Yam and Cassava Commonly Consumed in Côte. *Food and Nutrition Science*; 5: 308-315
14. Kouame, C.A., Coulibaly, A., N'dri, Y.D., Tiahou, G.G., Adrien, L. and Amani, G.N. (2015). Glycaemic Index and Load Values Tested in Normoglycemic Adults for Five Staple Foodstuffs: Pounded Yam, Pounded Cassava-Plantain, Placali, Attieke and Maize Meal Stiff Porridge. *Nutrients*; 7: 1267-1281
15. Liu, S., Willett, W.C., Stampfer, M.J., Hu, F.B., Franz, M., Sampson, L. and Manson, J.E. (2000). A prospective study of dietary glycemic load, carbohydrate intake, and risk of coronary heart disease in US women. *American Journal of Clinical Nutrition*, 71: 1455–1461.
16. Minse, M. (2009). The nutritional and modified traditional foods in kwazulu-natal. A thesis for the degree of Master of Agriculture (Food Security), African Centre for food Security School of Agricultural sciences and Agribusiness, Faculty of Science and Agriculture, University of KwaZuluNatal, Pietermaritzburg. Pp. 23-75.
17. National Food Service Management Institute (NFSMI) (2010). Measuring success with standard recipe. http//www,nfsmi.org/resource review.apex?ID-88
18. Nnanyelugo, D. (1985). Nutritional status of children in Anambra state: A comprehensive treatise. University of Nigeria press, Nsukka.
19. Odenigbo, U.M., Odenigbo, U.C., Oguejiofor, O.C. and Adogu, P.O. (2011). Relationship of Waist Circumference, Waist Hip Ratio and Body Mass Index as Predictors of Obesity in Adult Nigerians. *Pakistan Journal of Nutrition*; 10 (1): 15-18.
20. Oh, K., Willett, W.C., Fuchs, C.S. and Giovannucci, E. (2004). Glycemic index, glycemic load and carbohydrate intake in relation to risk of distal colorectal adenoma in women. *Cancer Epidemiology, Biomarkers and Prevention*, 13: 1192–1198.
21. Ogbuji, C.A. and David-Chukwu, N.P. (2016). Phytochemical, Antinutrient and Mineral Compositions of Leaf Extracts of Some Cassava Varieties. *African Journal of Environmental Science, Toxicology and Food*; 2016*: 5-8*
22. Okeke E.C and Eze, C. (2006). Nutrient composition and nutritive cost of Igbo traditional vendor foods and recipes commonly eaten in Nsukka. *J Agric Fd Environ Exten*; 5 (1):36- 44.
23. Okeke, E.C., Ene-Obong, H.N., Uzuegbunam, A.O., Ozioko, A., Umeh, S.I., Kuhnlein, H. (2009) Nutrient composition of traditional foods and their contribution to the energy and nutrient intakes of children and women in rural households in Igbo culture area. *Pakistan Journal of Nutrition; 8(4): 304-312*.
24. Okoye, Z.C. (1992). Biochemical Aspects of Nutrition. PrenticeHall of India, New Delhi. Pp. 147-195
25. Pirasath, S., Balakumar, S. and Arasaratnam, V. (2015). Glycemic Index of Traditional Foods in Northern Sri Lanka. *Endocrinology and Metabolic Syndrome*; 4 (1): 12-16.
26. Sunny, C. (2014). Diabetes Association of Nigeria. Nigeria National Diabetes Centre. A proposal.
27. Thannoun, M.A. and Al-Kubati, A.N. (2005). Blood glucose response and glyceamic Index of breads and some wheat products in normal human subjects. *Mesopotamia Journal of Agriculture*; 33: 8-18.
28. Turner, N.J. and Turner, K.L. (2007). Traditional Food Systems, erosion and renewal in Northwestern North American. Indian Journal of Traditional Knowledge;6(1)57-68.