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Research Article
Nutritional Composition and Glycaemic Index of Standardized Traditional Bambara Nut, Corn and Yam-Based Dishes Consumed in the Nsukka Local Government Area of Enugu State, Nigeria

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Abstract

Background and objectives: A lack of information on the composition and nutritional impacts of many traditional foods is a major challenge that limits their utilization. This study aimed to determine the nutrient composition and glycaemic indices (GIs) of standardized Bambara nut, corn and yam-based traditional dishes consumed in South-eastern Nigeria. **Materials and Methods:** Recipes of the dishes were documented from focus group discussions conducted in eight randomly selected communities in the Nsukka LGA, which were further standardized. Nutrient compositions of the prepared dishes were determined using the standard procedure. A serving portion of each dish containing 50 g of available carbohydrates was served to twelve 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 min intervals. The blood glucose curves were plotted and the area under each curve and the corresponding glycaemic index value for each dish were determined. Data were analysed using Statistical Product for Service Solution (SPSS) software. Analysis of variance was used to compare the means, which were considered significantly different when $p \leq 0.05$. **Result:** The three traditional dishes were 'okpa' (Bambara nut pudding), 'igbangwu' (corn pudding) and 'ayaraya ji' (coarsely mashed yam with pigeon pea) were included in the study. The dishes had appreciable proximate, vitamin and mineral compositions, although the protein content of the corn and yam-based dishes were low, ranging from 3.4-3.8 g. The vitamin B_2 and zinc contents of the dishes were also low. Zinc levels ranged from 0.1-0.4 mg, while the three dishes had equal vitamin B_2 contents (0.1 mg). The GIs of the dishes were 51, 54 and 56 for 'igbangwu', 'okpa' and 'ayaraya ji', respectively. **Conclusion:** The dishes had low to medium GI values and thus can be recommended for diabetics, although precautions are needed for 'okpa' and 'ayaraya ji'.

Key words: Bambara nut, corn and yam-based dishes, glycaemic index, Nigeria, nutrient composition, traditional dishes

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Diabetes mellitus, commonly referred to as diabetes, is a group of metabolic diseases characterized by high blood sugar levels over a prolonged period[1]. Symptoms of high blood sugar include frequent urination, increased thirst and increased hunger. If left untreated, diabetes can cause many complications[2]. There are three main types of diabetes mellitus. Type 1: results from the failure to produce enough insulin in the pancreas. Type 2: (which is the most common form) begins with insulin resistance, a condition in which cells fail to respond to insulin properly[2]. As the disease progresses, insulin deficiency may also develop[3]. The primary cause is excessive body weight and lack of exercise[2]. The third form of diabetes is gestational diabetes, which occurs when pregnant women, without a previous diagnosis of diabetes, develop a high glucose level. This type of diabetes is usually diagnosed during the second or third trimester of pregnancy. At this point, the level of insulin-antagonist hormone increases and insulin resistance occurs[4].

The prevalence of diabetes mellitus rose by 49% between 1990 and 2000[5]. In 2012, diabetes resulted in 1.5 million deaths worldwide, making it the 8th leading cause of death[2]. According to Mathers and Loncar[6], more than 80% of diabetic deaths occur in low- and middle-income countries. In Nigeria, the prevalence is 8-10%[7]. Nigeria has the greatest number of people living with diabetes in Africa, which is currently estimated to be approximately 1.7 million and may increase to 4.8 million by 2030[2]. Although, diabetes is not a curable disease, dietary measures are very important and are inevitable to maintain an ideal body weight, control the blood sugar level and prevent acute and long-term complications. The intake of low glycaemic foods potentially contributes to a significant improvement of the condition.

The glycaemic index is a relative ranking of carbohydrates in foods on a scale of 0-100, according to how they affect blood glucose levels after eating[8]. The concept of the glycaemic index was developed to provide a numeric classification of carbohydrates in food, which is useful when glucose tolerance is impaired. The Food and Agriculture Organization and the World Health Organization have endorsed the inclusion of this concept to guide food choices[9]. Carbohydrate-containing foods have a range of effects on the blood glucose level; some foods cause a rapid rise and others do not[10]. Meal planning with the glycaemic index involves choosing foods that have a low or medium glycaemic index[11]. Food with a high glycaemic index raises blood glucose more than food with a medium or low glycaemic index[11]. Low glycaemic index foods produce gradual rises in blood sugar and insulin levels, due to slow digestion and absorption and have been proven to be beneficial for health[8].

Adjusting food choices towards the selection of mainly low glycaemic index foods is most helpful for people attempting to prevent or control type 2 diabetes or to diminish the effect of insulin resistance[12]. A low glycaemic index diet appears to improve overall blood glucose control in people with type 1 and 2 diabetes mellitus[8].

The most popular approaches to treat diabetes and its complications are drug (pharmaco) and diet therapies. Drug therapy is the most common approach but is costly and has numerous unavoidable side effects. The dietary therapy is more natural, economic and feasible. It has been observed that food quality and diabetes mellitus have a close association with each other[13]. Therefore, proper dietary intake can stop the incidence of the disease and even reduce the severity of existing cases.

The high prevalence of diabetes in Nigeria can be attributed to nutrition transition, which is being experienced by both developed and developing countries. Specifically, the term 'nutrition transition' is used to describe the shift from traditional diets, high in fibre and low in fat, to more Western diets, high in sugars, fat and animal sources[14]. Many factors have been identified as driving the nutrition transition in developing countries. They include globalization, technological changes in food production, processing and distribution, higher incomes, demographic shifts and urbanization[15] and adaptation to Western dietary patterns, facilitated by advertisements for unhealthy foods and a lack of exercise[16]. Consequently, Okeke *et al.*[17] observed that many traditional foods are at the brink of obsolescence. The younger generations do not know them, like them or consume them alone.

It is known that little or no information exists on the nutrient composition and glycaemic index of most traditional dishes consumed in Nigeria, particularly in Enugu State. There is a need for this vital information for the development of the Nigerian food composition database, which is an indispensable working tool for nutritionists in the country for dietary counselling and the planning of therapeutic diets. Although, these traditional dishes are available, affordable and accessible, a lack of information on their nutritional composition and glycaemic index have made their incorporation into meal planning and dietary advice for the prevention and management of chronic diseases (such as diabetes) a very challenging task for dieticians and nutritionists. Therefore, this study aimed at determining

the nutritional composition and glycaemic index of some standardized traditional dishes consumed in Nsukka, Enugu State, Nigeria. The information provided will benefit dieticians, nutritionists, other health-related professionals and health-conscious consumers in proper food selection and combination for the prevention and management of chronic non-communicable diseases.

MATERIALS AND METHODS

Study design: A cross-sectional survey was used for recipe documentation, while a quasi-experimental design was used for recipe standardization/harmonization and dietary evaluation.

For glycaemic index measurement, a pure experimental study design was adopted.

Study population: All eight communities in the Nsukka Local Government Area, Enugu State, Nigeria, constituted the population for the recipe documentation aspect of the study.

Study sample: One village was randomly selected from each of the eight communities using a ballot without replacement. A total of 80 women (10 from each community) participated in the focus group discussion.

Data collection

Focus group discussion: A focus group discussion (FGD) was conducted in each of the selected villages in the eight communities, resulting in a total of eight focus group discussion sessions. It consisted of small groups of approximately eight adult women selected with the help of community-based facilitators. Each session lasted for 45-60 min. Recipes of the dishes and traditional methods of preparation were the major information obtained from the focus group participants.

Recipe standardization and preparation: The recipes collected from the FGD sessions were standardized using a modified National Food Service Management Institution method[18] as previously described[19]. The standardized recipes were prepared using the traditional method obtained from the FGDs as outlined below:

Recipe name: 'Igbangwu'

Ingredients Quantity (g): Dried whole corn (yellow): 740, Garden egg leaves (coarsely sliced): 450, Pumpkin leaves (whole): 130, Fermented oil been seeds (finely sliced): 130, Scent leaves (coarsely sliced): 90, Palm oil: 170, Onion (coarsely sliced): 90, Bouillon cube: 10, Fresh pepper (coarsely ground): 26, Salt: 21, Water: 410 mL and Yield: 2670.

Method of preparation:

- Soak the dried corn in hot water overnight or for 8 h
- Drain, wash and drain again
- Mill the corn finely with local grinder/milling machine and mix with 410 g of water
- Add other ingredients, except for pumpkin leaves and mix properly
- Wrap with the pumpkin leaves and steam for 1 h
- Serve hot with the wrapper

Recipe name: 'Okpa'

Ingredients quantity (g): 'Okpa' flour: 293, Palm oil: 173, 'Uzuza' seeds [Piper guineense] (finely ground): 7, Fresh pepper (coarsely ground): 26, Salt: 28, Water: 1100 mL and Yield: 2000.

Method of preparation:

- Put the 'okpa' flour into a bowl
- Add other ingredients and stir
- Add water gradually and stir properly to avoid lumping until all the water is added
- Wrap two spoonfuls of the batter in a cellophane bag and steam for 1 h
- Unwrap and serve hot

Recipe name: 'Ayaraya ji'

Ingredients Quantity (g): Pigeon peas (cream colour): 580, White yam (peeled): 1300, Palm oil: 173, Fermented oil bean seeds (coarsely sliced): 230, Uzuza seeds [Piper guineense] (finely ground): 7, Onion (coarsely sliced): 100, Fresh pepper (coarsely ground): 32, Salt: 48, Water: 6000 mL and Yield: 2850.

Method of preparation:

- Pick the pigeon peas to remove dirt and debris
- Wash the pigeon peas and boil in water for one and a half hours
- Wash the peeled yam and add to the boiling pigeon peas
- Boil for another half an hour and drain

- Mash the cooked yam
- Heat the oil in a pot for one min
- Add other ingredients except for mashed yam and pigeon peas
- Stir very well and fry for five min
- Remove the pot from the heat source, add the mashed yam and pigeon peas
- Stir until all the ingredients are thoroughly blended
- Serve hot

Proximate, vitamin and mineral determination: The prepared dishes were homogenized using an electric bender, properly packaged and then taken to the laboratory for the determination of proximate, mineral and vitamin contents. Protein, moisture, fat, ash, soluble and insoluble dietary fibre, 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 described by the AOAC[20]. Moisture was determined using the air oven method. Crude protein and fat were determined by the Kjeldahl procedure and Soxhlet solvent extraction method, respectively. Total dietary fibre was determined using the enzyme gravimetric method by Prosky *et al.*[21]. Ash was determined by incinerating the samples in a muffle furnace at 550°C for 6 h. Available carbohydrate was calculated by 100-(moisture+protein+fat+ash+dietary fibre). Mineral elements were determined using an atomic absorption spectrophotometer (Perkin-Elmer Model 3110, Perkin-Elmer Inc., Waltham, MA, USA). Phosphorus was determined using the vanadomolybdate method. Vitamins were determined using high-performance liquid chromatography (HPLC). All samples were analysed in triplicate.

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.

Selection of subjects for GI measurement: A total of 12 healthy human volunteers between 18 and 35 years of age were used for the study. They were recruited from students at the University of Nigeria Nsukka.

Informed consent: Written informed consents were signed by the subjects. An interviewer-administered questionnaire covering demographic data, tobacco and alcohol use, past medical and surgical history, comorbidities, medication usage and current health status was completed by the respondents.

Inclusion and exclusion criteria: Only healthy volunteers with no present medical complaints and with no recent history of chronic disease were selected. Subjects were excluded if they had diabetes or hypertension, were younger than 18 years, were on any special diet, pregnant or lactating, or were on any special diet as a result of a medical condition.

Anthropometric measurements: Anthropometric measurements (weight and height) of the respondents were taken following established protocols. The height and weight values obtained were used to calculate the body mass index (BMI) of the respondents.

Measurement of glucose level: The subjects were instructed to report to the Diet Therapy Laboratory of Department of Human Nutrition and Dietetics, University of Nigeria Nsukka in the morning (8:00 am) after a complete overnight fasting (at least 8-10 h) and to rest for 30 min on arrival. They were asked to abstain from heavy exercise and alcohol for 24 h and refrain from smoking on the morning of the visit. The entire test was done on the same day. On the first day of the test, the subjects were fed 50 g of anhydrous glucose dissolved in 250 mL of water. Subsequently, subjects consumed a test meal containing 50 g of available carbohydrate on each occasion. The respondents were asked to consume the served meal within 15 min with 250 mL of water. During the test, the subjects were asked to remain seated, avoiding any physical activity. Finger prick blood samples were collected before each meal (at 0 min) and at 15, 30, 60, 90 and 120 min after the start of the meal. The blood samples were used to measure the blood glucose level of the subjects.

Data analysis

Determination of glycaemic index: The glycaemic index was calculated using the method of Jenkins *et al.*[22]. The values of blood glucose measured at 0, 15, 30, 60, 90 and 120 min for the reference food (glucose) and the test diets were plotted against time. The glycaemic index value for each subject was calculated by dividing the incremental area under the curve (iAUC) for each test food by the iAUC for the reference food (glucose) and multiplying with 100 to get the percentage. The final glycaemic index value for the test food was the mean glycaemic index value for the 12 subjects.

GI was calculated using the formula: GI = (iAUC for test food÷iAUC for reference glucose)×100

Statistical analysis: Data generated from the study were analysed using Statistical Product for Service Solution

(SPSS) version 21.0 (SPSS Inc., Chicago, IL, USA) for descriptive statistics: mean, standard deviation and standard error of the mean.

One-way analysis of variance (ANOVA) was used to separate and compare the means. Significance difference was judged at $p \leq 0.05$.

RESULTS

Table 1 reveals that the moisture content of the traditional dishes ranged from 60.4-72.8 g. 'Igbangwu' had the highest moisture value (72.8 g). Crude protein and fat content were within a range from 3.4-10.4 g and from 1.7-8.7 g, respectively. Carbohydrate composition ranged from 11.6-19.4 g, being highest in 'igbangwu' (19.4 g) and lowest in 'okpa' (11.6 g). Dietary fibre and ash values of the dishes were comparable and ranged from 5.4-9.2 g for dietary fibre and 1.0-1.2 g for the ash.

As shown in Table 2, 'okpa' and igbangwu' had the same vitamin B_1 value (1.1 mg). The vitamin B_2 values of the three dishes were also equal (0.1 mg). In addition, similar vitamin B_3 and B_6 values were observed in the three traditional dishes, which ranged from 3-3.5 mg and from 1.6-1.8 mg, respectively. The vitamin B_3, B_6, E, B_9 and beta carotene composition of the dishes were consistently higher in 'ayaraya ji' and lower in 'okpa'. "Okpa' also had the lowest vitamin C content (13.2 mg) when compared with 'ayaraya ji' and 'igbangwu'.

Table 3 shows that the mineral composition of the traditional dishes were consistently highest in 'ayaraya ji' except for the potassium content, which was highest in 'igbangwu' (571 mg) and the zinc content, which showed equal amounts in 'igbangwu' and 'ayaraya ji' (0.4 mg). 'Okpa' had the least values for most of the minerals analysed except for phosphorus, which was lowest in 'igbangwu'. The iron contents (2.0-2.1 mg) of the dishes were much higher than those of zinc (0.1-0.4 mg).

Figure 1 shows the iAUC of glucose (reference), 'okpa' and 'ayaraya ji'. There was a rise in blood glucose within the first 15 min from 79 mg dL^{-1} at 0 min to 103.31 mg dL^{-1} at 15 min after the intake of glucose drink. The highest rise in the blood glucose concentration was at 30 min, with a mean blood glucose value of 111.92 mg dL^{-1}. Subsequently, there was a decrease in the blood glucose concentration, with a mean blood glucose value of 79.10 mg dL^{-1} at 120 min. For 'okpa', the blood glucose concentration increased from 71.31-90.31 mg dL^{-1} within the first 15 min. The highest rise in blood glucose occurred at 15 min, which was subsequently reduced to 80.39 mg dL^{-1} at 120 min. The highest increase in the glucose concentration for 'ayaraya ji' was at 30 min and lowest at 120 min, with mean glucose concentrations of 92.31 and 80 mg dL^{-1}, respectively. 'Igbangwu' had the highest glucose concentration at 30 min and lowest at 120 min, with glucose concentrations of 90.00 and 68.77 mg dL^{-1}, respectively.

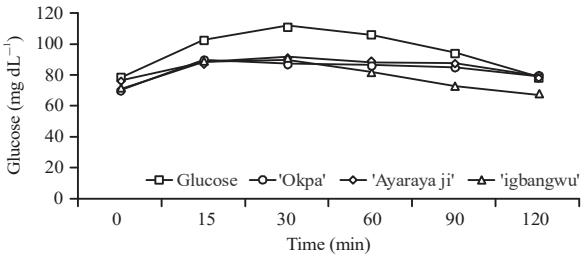

Fig. 1: Blood glucose response of subjects, 'okpa', 'ayaraya ji' and 'igbangwu'

Table 1: Proximate composition of traditional Bambara nut, yam and corn-based dishes in Nsukka LGA (g/100 g)

Dishes	Moisture	Crude protein	Crude fat	Carbohydrates	Dietary fibre	Ash
'Okpa'	60.4±5.01	10.5±1.00	8.7±0.06	18.7±5.38	9.2±0.61	1.0±0.01
'Ayaraya ji'	61.8±0.26	3.8±0.18	3.9±0.38	22.4±1.71	6.9±0.39	1.2±0.01
'Igbangwu'	72.8±0.61	3.4±0.13	1.7±0.07	15.5±0.19	5.4±0.17	1.0±0.62

Mean±standard deviations of three determinations

Table 2: Vitamins and beta carotene, composition of traditional Bambara nut, yam and corn-based dishes in Nsukka LGA

Dishes	Vit B1 (mg)	Vit B2 (mg)	Vit B3 (mg)	Vit B6 (mg)	Vit E (mg)	Vit B9 (µg)	β-carotene (µg)	Vitamin C (mg)
'Okpa'	1.1±0.02	0.1±0.01	3.0±0.03	1.6±0.02	59.8±0.03	81.8±0.01	3124.5±0.02	13.2±0.01
'Anyaraya Ji'	1.3±0.03	0.1±0.01	3.5±0.02	1.8±0.03	67.8±0.03	94.0±0.03	3196.9±0.03	17.7±0.02
'Igbangwu'	1.1±0.02	0.1±0.02	3.2±0.03[a]	1.7±0.03	61.3±0.03	85.3±0.02	3139.5±0.02	17.2±0.03

Mean±standard deviations of three determinations

Table 3: Mineral composition of traditional Bambara nut, yam and corn-based dishes in Nsukka LGA (mg/100 g)

zDishes	Sodium	Potassium	Calcium	Magnesium	Phosphorous	Copper	Zinc	Irons
'Okpa'	187.3±2.03	195.0±2.0	295.7±2.51	313.0±2.0	565.0±2.0	1.3±0.15	0.1±0.01	2.0±0.03
'Ayaraya ji'	211.0±2.0	225.3±1.52	325.0±2.51	362.7±1.52	593.3±2.51	2.3±0.15	0.4±0.42	2.1±0.01
'Igbangwu'	196.0±1.52	571.3±2.08	311.0±2.00	328.0±2.52	214.7±1.53	1.6±0.2	0.4±0.03	2.0±0.07

Mean±standard deviations of three determination

DISCUSSION

The moisture contents of these dishes were consistent with the results obtained by Okeke and Eze[23] for the same dishes ('okpa', 'ayaraya ji' and 'igbangwu'), which were 60.0, 60.0 and 74.1 g, respectively. The result of this study has revealed that the dishes contained high moisture contents. This finding is not striking, since these traditional dishes do not have a shelf life of more than twenty-four hours. Moisture content is an index of water activity. According to Fontana[24], the water activity of food describes the energy state of water in the food and is used to predict the stability and safety of food with respect to microbial growth and rates of deteriorative reactions. The protein contents of 'ayaraya ji' and igbangwu' were low, while that of 'okpa' was moderately high, when compared with the content of other plant-based traditional dishes in the area. For instance, African bread fruit pottage and African salad prepared with African yam beans had up to 16 g of protein[25]. The high protein content of 'okpa' suggests that incorporating it in a meal can help provide enormous benefits to the consumers, such as maintenance of fluid balance, contribution to immune functions and production of enzymes and hormones[26]. The protein content of 'okpa' (16.9 g) reported by Adumanya *et al.*[27] was higher than that obtained in this study. This difference could be attributed to varietal differences as well as moisture contents. The ash content of the dishes was close to that recorded by Ene-Obong and Madukwe[28] for 'okpa' (2 g) but lower than that recorded by the Okeke and Eze[23] for another traditional food in the study area, 'achicha akidi' (4.3 g). Since ash is an indication of the mineral content, the result suggests that the mineral content of 'achicha akidi' may be higher than that obtained from this study. The fat content of 'okpa' (8.9 g) reported by Okeke *et al.*[25] was similar to that of 'okpa' in this study. In the study area, 'okpa' is prepared with a considerable amount of palm oil. That could be the reason why its fat content was higher than that of 'ayaraya ji' and 'igbangwu'. The low-fat content of 'igbangwu' and 'ayaraya ji' implies that these dishes could be incorporated into weight loss menus. The dishes had appreciable dietary fibre values and their consumption could have positive health implications. For instance, the role of fibre in improving bowel function has long been recognized[29]. Studies have shown that dietary fibre is protective against a range of disorders, including obesity, type 2 diabetes mellitus and colon cancer[30]. Fibre binds the cancer-causing chemicals, keeping them away from the cells lining the colon, providing a line of protection from colon cancer[31]. According to Zhao *et al.*[32] the fibre content of foods is an important consideration for people who suffer from elevated cholesterol. The results on the carbohydrate content of the dishes were not in accordance with those of previous studies. For instance, Adumanya *et al.*[27] reported the carbohydrate content of 'okpa' to be 26.6 g. Okeke *et al.*[25] found that the carbohydrate content of 'ayaraya oka' and 'okpa' was 34 and 31.3 g, respectively. The differences observed here could be attributed to the variations in the moisture content of the dishes. The dishes contained appreciable vitamin and mineral values except for vitamin B_2 and zinc. The high prevalence of zinc deficiency in the country makes the low zinc content of these dishes unappealing. According to Awobusuyi *et al.*[33], the prevalence of zinc deficiency in a semi-urban community in Nigeria was estimated to be approximately 50%. 'Okpa' was expected to have a higher zinc value since legumes are a good source. Since 'okpa' is prepared with Bambara nut flour, most zinc might have been lost during processing. The iron content of the dishes was high when compared with that reported for a variety of African salad (0.26-0.57 mg) by Davidson *et al.*[19]. The high iron content of these dishes is very encouraging considering the alarming rate of iron deficiency anaemia in Nigeria. Almost one in two women of reproductive age and 75% of children under five years in Nigeria suffer from anaemia. Fifty percent of these cases are caused by a lack of iron in the body, which is often diet-related[34]. However, the high iron content of these dishes may not make them a good food-based solution to the iron deficiency anaemia in the country due to the low bioavailability of non-haeme iron. This explains why the prevalence of iron deficiency anaemia is still high among population groups consuming iron rich traditional dishes.

The traditional dishes had low to medium glycaemic index values. This finding is in accordance with Evans and Gajere[35], who stated that a greater percentage of Nigerian indigenous food falls into the moderate and low glycaemic index category. However, the result of this study was quite lower than the glycaemic indices of some Nigerian foods, which were 92.3 and 86.8 for two corn-based products (agidi and tuwo masara)[36]. The higher GI values obtained in the corn-based dishes above could be attributed to the processing (grinding and sieving) that the corn was subjected to. According to Wong and O'Dea[37], the physical form of food is what determines the rate at which starch is hydrolysed. Grinding and sieving makes food ingredients finer and increases the surface area for enzymatic action, thereby bringing about the more rapid absorption of glucose. Altering the physical form of carbohydrate changes the postprandial glucose and insulin response to it[37-38]. However, it should be noted that although 'okpa' underwent more processing than

the other two dishes, it still had low glycaemic index value. The low glycaemic index of 'okpa' could be due to its nutritional composition. In comparison with the other two dishes, 'okpa' had the highest protein, fat and dietary fibre content. This result is not surprising since 'okpa' is a legume-based (Bambara nut) dish prepared with a considerable amount of red palm oil. The mechanisms by which protein and fat affect the blood glucose level have been reported in previous studies. High protein meal produces greater gastric inhibitory peptide and insulin responses, thus resulting in a lower postprandial glucose peak[39]. Henry *et al.*[40] stated that fat content has the potential to delay the digestion and absorption of glucose. Fat has an impact on the interaction of plasma glucose insulin and gastric inhibitory peptides[41]. Fibre could decrease the postprandial glucose level by increasing the viscosity of the food and reducing gastric emptying time. The importance of viscosity (a property of fibre content of food) on the postprandial glucose response of food has been indicated by Weickert and Pfeiffe[42], Chutkan *et al.*[43] and Howarth *et al.*[44]. Although, 'okpa' had a low glycaemic index (54), its fat content may make it undesirable for those with diabetes or obesity. Reducing the quantity of red palm oil used in its preparation could make it a good choice for health-conscious individuals. Although, 'ayaraya ji' had a relatively higher protein, fat and dietary fibre values than 'igbangwu', it still had a higher glycaemic index value. The cooking method of 'ayaraya ji' might be responsible for its higher glycaemic index as well as higher protein, fat and dietary fibre values. Traditionally, 'ayaraya ji' is cooked by boiling, while 'igbangwu' is prepared by steaming. Lehmann and Robin[45] noted that boiling in water results in maximum hydrolysis of the starch present, which is associated with increased starch gelatinization and degree of digestibility as well as the blood glucose level. Therefore, to achieve lower glycaemic index, boiling may not be the best option. According to Okafor *et al.*[46] the glycaemic index of boiled yams is 58. The lower glycaemic index obtained for 'ayaraya ji' (56) could be probably due to the presence of pigeon peas (a legume) in the dish. Legumes produce a relatively low glycaemic response in both healthy and diabetic subjects[47]. The components present in legumes, particularly the soluble dietary fibre, can influence the rate at which glucose is released from starch and consequently absorbed from the intestinal mucosa. Soluble fibres have a recognized role in reducing digestion rates, increasing satiety and moderating the postprandial blood glucose levels. Although 'ayaraya ji' had a medium glycaemic index, it may not be recommended for the diabetics since it had the smallest serving portion (223 g) compared with 322 and 499 g for 'igbangwu and 'okpa', respectively. The small serving portion means that a larger quantity may be required to produce satiety.

CONCLUSION

The moisture and total dietary fibre content of 'igbangwu', 'okpa' and 'ayaraya ji' were high. 'Okpa' had the highest protein content when compared with the other two dishes. Except for vitamin B_2 and zinc, the dishes had appreciable vitamin and mineral values. 'Igbangwu' and 'okpa' had low glycemic index values (51 and 54, respectively), while 'ayaraya ji' had a medium glyceamic index value (56). Some of the factors might have affected the blood glucose values of the dishes, including the interaction of starch absorption with the amount of fibre, fat and protein, food form (extent of processing), food component and cooking method. The low and medium glycaemic 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. To achieve this outcome, the fat content of 'okpa' should be reduced and a small serving portion of 'ayaraya ji' should be maintained. The use of these dishes by nutritionists, dieticians (as therapeutic diets) and health-conscious consumers should be maximized.

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