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ANTI-NUTRIENTS, AMINO ACID QUALITY AND PERFORMANCE CHARACTERISTICS OF "NDUDUAGWORAGWO" TRADITIONAL DIET

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ABSTRACT

A "nduduagworagwo" is a traditional food of Akokwa people in Imo State, South eastern, Nigeria. Based on the recent linkage of natural foods to health, the anti-nutrients, amino acid quality and performance characteristics of "nduduagworagwo" traditional food was studied. Low levels of cyanogenic glycoside (0.09±0.03mg/100g), phytate (0.04±0.00 mg/100g), and oxalate (0.29±0.05 mg/100g) anti-nutrients were observed in the studied food. Anti-nutrient/nutrient interactions; oxalate/calcium (0.73), phytate/calcium (0.01), and phytate/iron (0.02) in "nduduagworagwo" were lower than their critical values. Essential and non-essential amino acids were also obtained in the food. The chemical scores for observed amino acids compared favourably with those of reference food materials and some other existing traditional foods. The performance characteristics in this study indicated that "nduduagworagwo" could be an intermediate protein food that can enhance the body with good digestibility (96.00± 2.87%) and biological (58.06± 1.04%) values. The present study has revealed the anti-nutrients, amino acid quality, and performance characteristic of "nduduagworagwo" traditional food.

Keywords: Amino acids, anti-nutrients, "nduduagworagwo", performance characteristics, amino acids, chemical scores

INTRODUCTION

Food is any edible substance that provides the necessary nutrients required for the proper functioning of the body (**Uwakwe and Ayalogu, 1998**). In the past, the nutritional status of a group, locality, community or society was in relation to the types of food they eat (**Amadi *et al.*, 2011; Kyle and Cole, 2001**), although this is not obtainable again since the emergence of fast foods. **Okaka and Okaka (2005)** noted that food is a mixture of chemicals. The authors went further to state that these chemicals join together to give colour, shape, taste, and flavour to foods. Some of these chemicals are also important due to their roles in energy supply, repair of worn-out body tissues, synthesis of new tissues, and maintenance of several other body functions, etc (**Olusanya, 2008; Okaka and Okaka, 2005; Onwuka, 2005**). Food chemicals that play such roles are classified as food nutrients. Food nutrients include proteins and the subunit amino acids, carbohydrates, lipids (fats and oils), vitamins, minerals etc. (**Amadi *et al*., 2011; Olusanya, 2008; Okaka and Okaka, 2005; Onwuka, 2005**). Aside food nutrients, there are other food chemicals that are not nutrients but play protective roles in the body. These food chemicals aid food nutrients to boost immunity although their ability to do this depends on their levels in the system. Such food chemicals are known as phytochemicals (**Njoku and Akumufula, 2007; Stray, 1998**). Phytochemicals could become toxic in the body or act as anti-nutrients in food at increased levels. The protective and bioactive activities of these chemicals have been confirmed by different authors (**Okigbo *et al*., 2008; Okwu and Josiah, 2006; Okwu, 2004; Okwu and Okwu, 2004**). Most foods both the synthetic and natural foods have nutrients but those that bear phytochemicals are mostly natural foods. The chemical constituents of most natural foods have been determined but information on local foods in Nigeria is still very limited. "nduduagworagwo", a traditional diet made from boiled "ndudu" seeds (*Vigna unguiculata* subsp. *Sesquipedialis*), palm oil, "ugba" (fermented sliced *P.macrophylla* seed), potash, salt, ground paper, "uziza" seed (*Piper guineense*), "utazi" (*Gongronema latifolium*) and crayfish., is one of the local foods whose chemical constituents is not well understood. It is a common food among Akokwa people in Ideato North L.G.A of Imo State, Nigeria. It is being said that a visit to Akokwa is incomplete if the visitor did not eat prepared "nduduagworagwo". The people of Akokwa are proud of this food because it is their existing traditional food and showcases their culture.

Due to recent linkage of foods eaten in their natural forms with better health, there is need to investigate the anti-nutrients, amino acid quality, and growth performance characteristics of "nduduagworagwo". This may engineer a renewed interest on local foods especially in this era of increasing cost of convention foods and shortage of resources.

MATERIALS AND METHODS

Sample collection

A "ndudu" (vegetable cowpea seed; botanically it is *Vigna unguiculata subsp. sesquipedalis*),palm oil, "ugba" (fermented sliced *P.macrophylla* seed), and potash, used in this study were purchased from Akokwa central market. "utazi" (*Gongronema latifolium*), "uziza" seed (*Piper guineense*) were collected from Imo State University school farm while the crayfish and salt used in the "nduduagworagwo" preparation were purchased from Owerri main market in Imo State, Nigeria.

A "nduduagworagwo" preparation

A "nduduagworagwo" was prepared following the traditional method. The "ndudu" seed purchased was sorted for the good ones, which were washed thoroughly with plenty of water. The washed "ndudu" was soaked in water for eight hours to shorten the cooking time. The soaked "ndudu" was then placed in a pot, 4litres of water was added; followed by boiling for about 3hours before it was confirmed fit for consumption. The excess water was drained from the pot and 10g of ground pepper, 2g of ground potash, 200ml of red palm oil, 18g of ground crayfish, 8g of "uziza" seed, and three wraps of "ugba" were added. While mixing the whole components, the filtered water earlier used in cooking the "ndudu" was gradually added at intervals. 75g of salt was added to taste. Finally, the boiled "ndudu" was garnished with some sliced "utazi leaves to form "nduduagworagwo", ready to be served.

Tiny stones and debris remove from Ikg weight of "ndudu"(*Vigna ungulculata subsp. Sesqulpedalis*).

↓ The damaged ones got further discarded and the good ones selected.

Selected "ndudu" (*Vigna ungulculata subsp. Sequlpedalis*) washed and soaked for eight hours to shorten the cooking time.

↓

Soaked "ndudu" (*Vigna unguiculata subs. Sesquipedalis*) + 4 litres of water + heat for 3 hours.

↓ The cooked "ndudu" water was filtered in container and kept

Ten grams of ground pepper, 2g of ground potash,200ml of red palm oil,18g of ground crayfish, 8g of "uziza" seed (*Piper guineense*), and three wraps of "ugba" (fermented sliced *P.macrophylla* seed) were added and mixed together with the cooked "ndudu"

↓ Some filtered water used in cooking "ndudu" kept in the container was added at interval

Seventy- five grams of salt was added to taste + sliced "utazi" (*Gongronema latifolium*) leaves

↓

"nduduagworagwo" ready to be served

Figure 1 Flow-chart showing "nduduagworagwo" preparation

Sample preparation for analysis

The prepared "nduduagworagwo" was oven dried at 70^{o}C for 48 hours. The dried sample was ground into flour using hand mill device. The ground sample was stored in air tight container till needed for analyses.

Amino acid determination

The methods of **Akubugwo *et al*., (2006)** and **Ojiako and Akubugwo (1997)** were used for amino acid screening while the method of **Speckman *et al*., (1958)** was used for quantitative amino acid analysis of the studied diet. Chemical scores of the individual amino acids were obtained as the ratio of the individual essential amino acids found in "nduduagworagwo"to that of the same amino acid in a reference protein (whole egg of hen).

Anti-nutrient analysis

Anti-nutrients such as saponins, alkaloids, tannins, flavoniods, cyanogenic glycosides and oxlates were screened with the methods of **Harborne (1973)** using different extract. Qantitative determination of anti-nutrients considered in the studied food sample were carried using the methods of **AOAC (1990).**

Anti-nutrient/nutrient ratio

For anti-nutrient/ nutrient ratio, minerals such as calcium, magnesium, zinc, and iron were determined using atomic absorption spectrophotometer (Buck Scientific, East Norwalk, CT, USA). Anti-nutrient/ nutrient ratio was calculated using the methods of **Hassan *et al*., (2011)**.

Basal diet

The protein free or basal diet (D_2) was formulated by adding 120g sucrose, 150g cellulose powder, 80g red palm oil and 10g of vitamin and mineral mixture to 640g of corn flour in a bowl and mixed homogenously to give one kilogram of the basal diet.

Reference diet

The commercial infant food, Nutrend^{TM} (from Nestle Foods Nigeria PLC) served as the reference diet (D_1).

Rat feeding study

Onyeike *et al*., (1995) method was adopted for rat feeding study. Eighteen disease free stocks of weanling albino rats of the Wistar strain were used in the feeding, which lasted for twenty eight days. The rats were weighed and allowed to acclimatize to their new environment with a commercial rat feed for four days and reweighed. Their initial weights were however taken after acclimatization. The rats were then allocated on the basis of weight and litter origin to three diet groups (D_1, D_2, and D_3) of six rats each in such a way that the group mean weight did not differ by more than ±2.00g/mean rat weight. Each of the rats was housed in a single cage with facilities for food, water, faecal and urine collection. Each diet group was given one of the three diets; the compositions of the diets are presented in Table 1.

Table 1 Composition of formulated diets (g/kg) assigned to the different diet group of rats

Components	**Diets**		
	D_1	D_2	D_3
Nutrend ^{TM}	1000	-	-
Corn Flour		640	
Sucrose	_	120	_
Vitamin and mineral mixture	_	10	_
RPO	_	80	_
Cellulose powder	_	150	_
"Nduduagworagwo"	_	_	1000
Total (kg)	1.0	1.0	1.0

Key=D_1:Nutrend; D_2:Basal diet; D_3:"Nduduagworagwo"; RPO: Red palm oil

D_1 received the reference diet consisting of 1000g Nutrend^{TM}, D_2 received the basal diet; and D_3 received the test diet "nduduagworagwo". Feed and water were administered to the rats *ad libitum* for a period of twenty-eight days. The rats were weighed weekly. The daily feed intake was recorded, while the faeces were collected daily and dried for analysis. At the end of the feed and water administration period (28 days), the rats were finally weighed and then sacrificed with the help of chloroform in a closed container (authanization). Their carcasses were weighed and appropriately labeled. Incisions were made into thoracic and body cavities of the rats to excise their liver, kidneys, heart, spleen, lungs and pancreas. Their weights were also taken. The organs were returned into the individual carcasses and each carcass was dried in an oven at 80^{0}C for 72h, weighed, ground and stored in a desiccator for further nitrogen determination. The feed, faecal and carcass nitrogen contents were analyzed according to standard methods (**AOAC, 2006**). The methods described by **Onyeike and Morris (1996)** were used for food conversion ratio (FCR), protein efficiency ratio (PER), net protein utilization (NPU), true digestibility (TD) and biological value (BV).

Statistical analysis

Data were expressed as means and standard deviations of triplicate determinations. The date were subjected to analysis of variance (ANOVA). Least Significant Difference(LSD) tests was used to establish significance. The significant level of $p<0.05$ was considered significantly different.

RESULTS AND DISCUSSION

Anti-nutrients of "nduduagworagwo" (Table 2) showed that tannins content was the highest in the food (54.16 mg/100g), followed by saponins (24.7 mg/100g). Tannins and saponins due to their respective astringent and better taste may affect palatability and digestibility of food (**Okwu and Ndu, 2006; Akwaowo *et al*., 2000; Osagie, 1998**). The value of saponins (Table 3) in the present study was the highest when compared to those of "onunu" and "mgbam" traditional foods, while its tannins content (Table 3) was significantly ($p<0.05$) higher than that of "onunu" and significantly ($p<0.05$) lower than that of "mgbam" (**Amadi *et al*., 2011**). The importance of alkaloids and flavonoids in foods and in the biological system cannot be overemphasized (**Olowokudoejo *et al*., 2008; Ninmh, 1996**). Alkaloid content of the studied food was the highest (Table 3) against that of "onunu" and "mgbam" foods while its flavonoid content was the lowest when compared to those of "mgbam" and "onunu" (**Amadi *et al*., 2011**). A daily intake of 450mg of oxalic acid has been reported to interfere with metabolism (**Akawaowo *et al*., 2000**). High oxalate levels in food may reduce the bioavailability of such metals as calcium, magnesium, and zinc thereby interfering with their utilization (**Omorayi *et al*., 2007; Oluyemi *et al*., 2006; Pingle and Ramastrin, 1978**). Phytic acid intake of 4-9 mg/100g reduces iron absorption by 4-5 folds in humans (**Hurrel *et al*., 1992**). The phytate content observed in the studied food was the lowest (Table 3) when compared to those of "onunu" and "mgbam" while its oxalate content was comparable to that of "mgbam" (Table 3). The cyanogenic glycoside when in small amount in food poses no threat to the body. The observed cyanogenic glycoside content of "nduduagworagwo" in the present study poses no threat to the human system due to its low level and was comparable to those of "mgbam" and "onunu" traditional foods (Table 3).

Hassan *et al.*, (2011), Akwaowo *et al.*, (2000) and **Hurrel *et al.*, (1992)** noted the ability of some anti-nutrients to interact with some nutrients. These interactions may hinder the bioavailability of these nutrients. The values of mineral elements such as calcium (0.40±0.08mg/100g), magnesium (0.24±0.03mg/100g), zinc (0.10±0.01mg/100g), and iron (0.16±0.07mg/100g) detected in the "nduduagworagwo" were used to determine the anti-nutrient/nutrient ratio of the studied recipe (Table 4). The values obtained for oxalate/calcium, oxalate/ [calcium + magnesium], phytate/zinc, phytate/calcium, phytate/iron and [calcium][phytate]/[zinc] interactions were lower than their critical values (Table 4). The implication herein could be that both oxalate and phytate constituents of the studied food will not have effect on the bioavailability of its calcium, zinc, magnesium, and iron mineral elements.

Okaka and Okaka (2005) noted that some amino acids must be obtained from diets. According to **Olusanya (2008)**, amino acids that must be obtained from diets are addressed as essential amino acids. Essential amino acids observed in the present study (Table 5) include valine, isoleucine, methionine, leucine, phenylalanine, threonine, lysine, histidine, and arginine. Non-essential amino acids found in the studied food (Table 7) include asparagine, serine, proline, glycine, cystine, and tryrosine.

Table 2 Anti-nutrient constituents of "nduduagworagwo"

Anti-nutrients (mg/100g)	"nduduagworagwo"
Saponins	24.70±0.12
Alkaloids	7.65±0.38
Tannins	54.16±1.20
Flavonoids	12.70±0.71
Cyanogenic glycosides	0.09±0.03
Phytate	0.04±0.00
Oxalate	0.29±0.05

Results are means and standard deviations of triplicate determinations.

Table 3 Anti-nutrient constituents of "nduduagworagwo" compared to those of "onunu" and "mgbam"

Anti-nutrients (mg/100g)	"nduduagworagwo"	"onunu"	"mgbam"
Saponins	24.70±0.12[c]	12.70±0.20[b]	10.65±0.20[a]
Alkaloids	7.65±0.38[c]	5.06±0.18[b]	1.82±0.10[a]
Tannins	54.16±1.20[b]	43.20±1.10[a]	93.60±2.00[c]
Flavonoids	12.16±0.71[a]	23.76±0.18[b]	77.88±2.00[c]
Cyanogenic glycosides	0.09±0.03[a]	0.08±0.40[a]	0.12±0.16[a]
Phytate	0.04±0.00[a]	5.06±1.05[c]	1.82±0.10[b]
Oxalate	0.29±0.05[b]	0.14±0.02[a]	0.26±0.07[a]

Results are means and standard deviations of triplicate determinations. Values bearing different superscript in row vary significantly (p<0.05). Data for anti-nutrient constituents of "onunu" and "mgbam" sourced from **Amadi *et al.*, (2011)**.

Table 4 Anti-nutrient/ nutrient ratio of "nduduagworagwo" compared to their critical values

Anti-nutrient/nutrient ratio	"nduduagworagwo"	Critical values
Oxalate/calcium	0.73	2.50
Oxalate/[calcium+magnesium]	0.45	2.50
Phytate/zinc	0.05	10.00
Phytate/calcium	0.01	0.20
Phytate/iron	0.03	0.40
[calcium][phytate]/zinc	0.02	0.50

Critical value for each ratio sourced from **Hassan *et al.*, (2011)**.

Table 5 Essential amino acid composition of "nduduagworagwo'' (mg/g Nitrogen)

Essential amino acid	"nduduagworagwo"
Valine	228±0.23
Isolucine	290±0.10
Methionine	70±0.24
Leucine	410±0.31
Phenylalanine	321±0.49
Threonine	180±1.20
Lysine	309±0.70
Histidine	186±0.31
Arginine	410±0.80

Results are means and standard deviation of triplicate determination.

Table 6 Essential amino acid composition of "nduduagworagwo" compared to those of reference foods (mg/g Nitrogen)

Essential amino acid	"nduduagworagwo"	Whole hen`s egg	Casein	Cow`s milk
Valine	228	428	438	362
Isolucine	290	393	345	295
Methionine	70	210	178	157
Leucine	410	551	607	596
Phenylalanine	321	358	334	336
Threonine	180	320	297	278
Lysine	309	436	518	487
Histidine	186	152	186	167
Arginine	410	381	239	205

Data for essential amino acids in reference foods sourced from **FAO (1972)**.

Table 7 Non-essential amino acid composition of "nduduagworagwo'' (mg/g Nitrogen)

Non-essential amino acid	"nduduagworagwo"
Asparagine	428±1.90
Serine	183±0.56
Glutamin acid	ND
Proline	193±0.37
Glycine	2861±0.22
Alanine	320±1.83
Cystine	120±0.39
Tyrosine	273±0.10

Results are means and standard deviation of triplicate determinations.
ND: Not detected

Table 8 Non-essential amino acid composition of "nduduagworagwo" compared to those of reference foods (mg/g Nitrogen)

Non-essential amino acid	"nduduagworagwo"	Whole hen`s egg	Casein	Cow`s milk
Asparagine	428	601	455	481
Serine	183	478	385	362
Glutamin acid	ND	796	1406	1390
Proline	193	260	738	571
Glycine	286	207	126	123
Alanine	320	370	196	217
Cystine	120	152	23	51
Tryrosine	273	260	337	297

Data for non-essential amino acids in reference foods sourced from **FAO (1972)**.
ND: Not Detected.

Table 9 Chemical scores (%) of "nduduagworagwo" food

Chemical Score	"nduduagworagwo"
Valine	53.27±0.13
Isoleucine	73.79±0.29
Methionine	33.33±0.10
Leucine	74.41±0.28
Phenylalanine	89.66±0.31
Threonine	56.25±0.62
Lysine	70.87±0.80
Histidine	122.37±0.21
Arginine	107.61±0.03

Results are means and standard deviation of triplicate determinations.

Table 10 Chemical scores of "nduduagworagwo" compared to those of "onunu" and "mgbam" traditional foods

Chemical score	"nduduagworagwo"	"onunu"	"mgbam"
Valine	53.27±0.13[b]	49.00±4.06[a]	71.26±1.00[c]
Isoleucine	73.79±0.29[b]	66.15±0.15[a]	82.09±2.69[c]
Methionine	33.33±0.10[b]	28.57±4.04[a]	85.71±2.50[c]
Leucine	74.41±0.28[a]	99.89±0.41[b]	127.04±7.01[c]
Phenylalanine	89.66±0.31[b]	78.21±0.21[a]	100.43±1.88[b]
Threonine	56.25±0.62[a]	71.87±1.87[b]	97.18±1.96[c]
Lysine	70.87±0.80[a]	69.03±1.22[a]	72.70±0.40[a]
Histidine	122.37±0.21[a]	118.42±2.42[a]	173.02±1.20[b]
Arginine	107.61±0.03[a]	107.61±0.61[a]	190.20±12.21[b]

Results are means and standard deviations of triplicate determinations. Values bearing different superscript in row vary significantly (p<0.05). Chemical scores of "onunu" and "mgbam" sourced from **Benjamin *et al.*, (2011)**.

Table 11 Performance characteristics of rats fed"nduduagworagwo"

Performance characteristics	"nduduagworagwo"	Basal feed	Nutrend
Body weight change (g)	60.27±1.99[b]	5.52±0.17[a]	84.14±0.12[c]
Total food intake (g)	258.33±3.05[c]	5.52±0.20[a]	234.63±1.29[b]
Carcass nitrogen (g)	4.01±0.16[a]	231.70±3.11[b]	5.94±0.74[a]
Faecal nitrogen (g)	3.52±0.31[a]	3.18±1.20[a]	3.33±0.10[a]
Total nitrogen intake (g)	4.90±0.82[b]	0.84±0.13[a]	6.98±0.19[c]
Total protein intake (g)	32.06±1.01[b]	1.16±0.29[a]	43.67±0.73[c]
Food conversion ratio	0.19±0.08[a]	7.24±0.15[b]	0.34±0.01[a]
Protein efficiency ratio	1.67±0.29[b]	0.021±0.01[a]	1.93±0.28[b]
Net protein retention	1.33±0.10[b]	0.00[a]	1.80±0.30[b]
Net protein utilization (%)	53.08±1.31[b]	0.00[a]	55.00±1.22[b]
True digestibility (%)	96.95±2.87[c]	0.00[a]	64.00±0.13[b]
Biological value (%)	58.06±1.04[b]	0.00[a]	87.10±0.14[c]

Results are means and standard deviations of triplicate determinations. Values bearing different superscript in row vary significantly ($p<0.05$).

Table 12 Performance characteristics rats fed "nduduagworagwo" compared to those of "onunu"and "mgbam" traditional foods

Performance characteristics	"nduduagworagwo"	"onunu"	"mgbam"
Body weight change (g)	60.27±1.99[c]	32.10±1.14[a]	54.31±4.14[b]
Total food intake (g)	258.33±3.05[c]	240.82±2.14[b]	5.12±0.06[a]
Carcass nitrogen (g)	4.01±0.16[b]	3.99±0.03[b]	1.14±0.03[a]
Faecal Nitrogen (g)	3.52±0.31[b]	0.94±0.02[a]	5.15±0.09[c]
Total nitrogen intake (g)	4.09±0.82[a]	4.61±0.10[ab]	5.15±0.09[b]
Total protein intake (g)	32.06±1.01[a]	28.87±0.50[a]	32.19±0.58[a]
Food conversion ratio	0.19±0.08[a]	0.13±0.004[a]	0.22±0.005[a]
Protein efficiency ratio	1.67±0.29[b]	1.11±0.02[a]	1.68±0.03[b]
Net protein retention	1.33±0.10[b]	0.91±0.22[a]	1.51±0.20[b]
Net protein utilization (%)	53.08±1.31[b]	42.50±0.03[a]	60.00±0.02[c]
True digestibility (%)	96.00±2.87[a]	97.00±0.05[a]	93.00±0.04[a]
Biological value (%)	58.06±1.04[b]	43.77±5.37[a]	63.64±6.54[c]

Results are means and standard deviations of triplicate determinations. Values bearing different superscript in row vary significantly ($p<0.05$). Data for performance characteristic of rats fed "onunu" and "mgbam" diets were sourced from **Benjamin *et al*., (2011**).

Comparing these amino acids to those of reference foods (Tables 6 and 8) showed that their levels are appreciable in the studied food sample. **Sharon and Davis (2008)** noted the importance of these amino acids in the human system. Chemical scores of "nduduagworagwo" food (Table 9) revealed the presence of amino acids in the following order; arginine > histidine> phenylanine> isoleucine> lysine>threonine>valine> methionine. Methionine is therefore the limiting amino acid in the present study. The low methionine content observed in the present study is in line with **Okaka and Okaka (2005)** who noted that legumes are low in sulphur containing amino acids such as methionine and cystine. Histidine is very essential for infants **(Olusanya, 2008)** hence the observed high value of histidine in the present study may qualify "nduduagworagwo" as a suitable food for growing infants.

Table 10 compared the chemical scores of observed amino acids in "nduduagworagwo" to those of "onunu" and "mgbam" traditional foods. Observed results showed that apart from leucine and threonine, chemical scores of valine, isoleucine, methionine, phenylalanine were significantly ($p<0.05$) higher in "nduduagworagwo" against those of "onunu". Lysine, arginine and histidine amino acids in "nduduagworagwo" were comparable to those of "onunu" traditional food. The chemical scores of all the observed amino acids apart from phenylalanine and lysine, were significantly ($p<0.05$) higher in "mgbam" traditional food than "nduduagworagwo". The chemical scores of phenylalanine and lysine in "nduduagworagwo" and "mgbam" in this study are comparable. The observed chemical scores of the present study could mean that "nduduagworagwo" is higher than "onunu" and lower than "mgbam" in terms of protein quality.

Olusanya (2008) noted that the measurement of protein quality of a foodstuff is determined by its ability to promote growth which in turn is dependent on the essential amino acids. Aside the simple procedure of using chemical scores to determine protein quality of a food material, a more biological approach of using the food material as a feeding stuff to laboratory animals (growing rats for example) also exist (**Olusanya, 2008**). Table 11 revealed the performance characteristics of rats fed "nduduagworagwo" to those given nutrend and basal diets. The total food intake was highest in rats placed on "nduduagworagwo" than those on nutrend and basal diets. This could be due to palatability of the food over nutrend and basal diet. **Benjamin *et al*., (2012)** and **Anyika *et al*., (2009)** noted that food intake can be influenced by palatability, source of nitrogen and essential amino acid profile. Rats placed on the studied food gained relative higher weight over rats on basal diet but lower than those on nutrend. This could be attributed to the constituents of the diets. Total nitrogen intake (TNI), and total protein intake (TPI) were highest in rats placed on nutrend followed by rats placed on "nduduagworagwo" diet. Carcass nitrogen (CN), and food conversion ratio (FCR) were highest in rats placed on basal diet. Protein efficiency ratio (PER) is based on the fact that weight gain in a growing animal is proportional to the gain in body protein (**Mortimore, 1982**). According to **Benjamin *et al.*, (2012)**; and **Friedman (1996)** protein efficiency ratio (PER) value below 1.5 indicates a protein of poor quality; between 1.5 and 2.0 an intermediate quality and above 2.0 good quality proteins. It could therefore be inferred that "nduduagworagwo" food and nutrend used in the present study with protein efficiency ratio (PER) values of 1.67 and 1.93 are intermediate quality proteins and this could be behind the body weight gained by the rats placed on these two recipes than rats on basal diet. The net protein retention (NPR) and net protein utilization (NPU) were insignificantly ($p<0.05$) affected in rats placed on "nduduagworagwo" when compared to those on nutrend. True digestibility (TD) was the highest in rats placed on "nduduagworagwo" when compared to true digestibility (TD) in rats placed on basal diet and nutrend. The biological values (BV) was significantly higher ($p<0.05$) in rats placed on "nduduagworagwo" against those on basal diets but lower when compared to those on nutrend. This could be indication that "nduduagworagwo" can enhance growth, relatively increase weight, and will be well digested when consumed in the system. On comparing performance characteristics of rats placed on "nduduagworagwo" to those of "onunu" and "mgbam" traditional foods (Table 12), it was observed that rats placed on "nduduagworagwo" had highest body weight change (BWC) and total food intake (TFI) to those of "onunu" and "mgbam" diets. This could be related to digestibility and palatability of the studied food."nduduagworagwo" also compared favourably in other performance characteristics such as carcass nitrogen (CN), total nitrogen intake (TNI), total protein intake (TPI), net protein utilization (NPU), true digestibility (TD) and biological value (BV) to those of "onunu" and "mgbam" traditional foods.

CONCLUSION

This study has shown the anti-nutrients, amino acid quality and performance characteristics of "nduduagworagwo" traditional food. From the observations of the present study, "nduduagworagwo" had low anti-nutrients and anti-nutrient/ nutrient ratio interactions, appreciable amino acid quality and produced better growth performance characteristics in rats than basal diet and some traditional foods. "nduduagworagwo" could therefore be a good source of protein and some mineral elements in the body.

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