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Nutritional comparison of the pallid emperor moth, *Cirina forda* and the Atlantic mackerel, *Scombrus scomber*

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Abstract
Lack of adequate animal proteins in human diets and its malnutrition consequences has led to advocacy for entomophagy. However, many edible insects are yet to be proven comparable to meat or fish. This study compared the nutritional quality of Pallid Emperor moth, *Cirina forda* and Atlantic mackerel, *Scomber scombrus*. Proximate and anti-nutrients quantities of the samples were determined using standard AOAC methods, mineral elements were measured using flame photometry and Atomic Absorption Spectroscopy, while amino acid were determined by HPLC method. The data obtained were analyzed using t-test at $P<0.05$. The results showed that there was no significant difference in the quantity of crude protein (43.07% and 43.65%) of the two samples. The mineral elements in both samples were adequate for human consumption, though most of them showed significantly higher quantity in *S. scombrus*. However, *C. forda* had significantly higher total amino acids, essential to non-essential amino acid ratio, Predicted Protein Efficiency Ratio (P-PER), Amino Acid Score and Protein Digestibility Corrected Amino Acid Scores (PDCAAS). Moreover, about 77.8% of essential amino acids in *C. forda* satisfied the Recommended Daily Allowance for humans. The study showed that the nutritional quality of *C. forda* compared well with that of *S. scombrus* and therefore recommended for human consumption.

Keywords: Amino acids, anti-nutrients, entomophagy, malnutrition, proximate

1. Introduction

Proteins from animal sources are very important in human nutrition because they are able to supply the body with more of the essential amino acids required for proper functioning of the body [46]. Meats from all sorts of animals ranging from fish, chicken, cattle, wildlife etc have been the major sources of animal protein from time immemorial. The world consumption of meat in 2005 was estimated to be 41.2kg/person/year with sub-Sahara Africa consumption stood at 13.3kg/person/year. With the world population estimated to be about 9.6 billion by 2050, the consumption of meat has been predicted to increase by 76% [4]. Such increase in meat consumption will require an increase in production of livestock which could consequently results in habitat destruction, climate change and deteriorating human health [25]. The environmental and health implications of increasing the production of livestock for meat therefore calls for alternative animal protein sources which are eco-friendly and yet meet the demands of human dietary protein requirements. Such an alternative to meat is the consumption of edible insects.

In comparison to convectional livestock production, insect have higher feed conversion efficiency, higher fecundity [32], can be raised on organic wastes and need less space in rearing process, produce less greenhouse gases [38], use less water and less dependent on soil [26, 49]. Edible insects transmit less zoonotic diseases and their consumption does not predispose humans to risks of carcinogenic and cardiovascular diseases [51]. Lastly and most importantly, edible insects are highly nutritious with high quality fats, proteins, minerals and vitamins contents depending on the species [43].

In Africa, about 524 species of insects belonging to various orders are consumed by humans [52]. Prominent among these edible insect orders is the Lepidoptera which comprises of the moths and butterflies. Lepidoptera larva especially the family saturniidae is collected in large quantity for food and sale in many Africa countries.

Among the edible African saturniids, *Cirina forda* caterpillar is well accepted in many regions of West Africa such as Ghana, Togo, Cote-d-voire and Nigeria [6, 16, 10]. In Nigeria the caterpillar is cherished and known by different name by different ethnic groups such as Kaani or monimoni by the Yorubas, manni by the Nupes, suzza kadenya by the Hausas and Awigu by the Igbos [5].

C. forda has also significantly contributed to livelihood in both rural and urban areas of West Africa. In Togo, the retail price of 1Kg dry *C. forda* larva is about 1250 FCFA and the profit margin per kilogram of collectors, wholesalers, middle men and retailers could be as high as 96%, 31%, 17% and 10% respectively [10]. In Burkina-Faso, the least market price of *C. forda* larva is about 100 FCFA and the prepared caterpillar is being exported to France for the Africans in Diaspora [28].

In Markudi Benue State Nigeria, 1kg of dry *C. forda* larva could be sold for as much as ₦500 [2]. Similar booming commercial activities are associated with the insect in other regions of Nigeria where it is found. No wonder the insect has been reported to be the most commercialized insect in Kwara State, Nigeria [20].

Despite this huge nutritional and commercial potentials of *C. forda* larva, does it nutritionally compared with other commonly consumed animal protein sources like fish? This research therefore was aimed at comparing the nutritional quality of *C. forda* with a common cherished fish consumed in Nigeria, the Atlantic mackerel, *Scomber scombrus.*

2. Materials and Methods

1. Collection and Preparation of Samples

Mackerel fish, *S. scombrus* was bought from old market Kontagora. The fish was cut into parts, washed and boiled without adding table salt. The bones were removed and sundried and later grinded into fine particles using mortar and pestle.

The grinded sample was wrapped in aluminum paper foil and stored in an air tight labeled plastic container. Moreover, last instars larvae of *C. forda* were collected by hand from the host plants on the field at Km 51 Bida-Mokwa road, Kutigi Niger State Nigeria. The larvae were soak in hot water and afterward sundried. The dried larva was grinded into fine particles with the aid of mortar and pestle. The sample was also wrapped in aluminum paper foil and stored in a labeled air tight plastic container.

2. Proximate analysis

The moisture content, ash, crude fat and crude protein contents were determined using the methods of the Association of Official Analytical Chemists [7]. The total carbohydrate content was obtained by difference as follows:

%Carbohydrate = 100% - (% Moisture + % Crude fat + % Crude protein + % Ash)

The energy values of the samples were determined by calculation as follows:

Energy (KJ/100 g) = [(%Crude Protein x 4) + (%Crude Fat x 9) + (%Carbohydrate x 4)]

3. Mineral analysis

The mineral elements were determined using Atomic Absorption Spectrophotometric method. Potassium, Magnesium, Calcium and sodium were determined by flame photometry while phosphorous level was determined using the phosphovanado molydbdenate method [7]

4. Antinutrient analysis

Oxalate was determined by extraction of the samples with water for about three hours and standard solutions of oxalic acid prepared and read on spectrophotometer (Bulk Scientific AAS; Model: Accusys 211: USA) at 420 nm. The absorbance of the samples was also read and amount of oxalate estimated. Phytate was determined by titration with ferric chloride solution [48].

Cyanide was determined by a modified procedure of the method described by [39]. The tannin content was determined by extracting the samples with a mixture of acetone and acetic acid for five hours, measuring their absorbance and comparing the absorbance of the sample extracts with the absorbance of standard solutions of tannic acid at 500 nm [22].

Saponin was also determined by comparing the absorbance of the sample extracts with that of the standard at 380 nm [29]

5. Determination of Amino Acids

Amino acid analysis was done by ion exchange HPLC chromatography [13], using the Applied PTH Amino Acid Analyzer (Model 120A). About 2 g of each of the samples was defatted using chloroform/methanol (2:1) [8] and then hydrolyzed at 110^{O}C under nitrogen atmosphere for 22 hrs with 6M hydrochloric acid.

Tryptophan was determined separately by hydrolyzing 2g of each of the samples with 4.2M sodium hydroxide for 22 hrs and then neutralized to pH 7.0 with 6M of hydrochloric acid.

These hydrolysates were then injected into the amino acid analyzer for separation and characterization. Quantification was obtained by using external amino acid standards and the results were corrected for the recoveries. All analyses were conducted in triplicates for each sample.

6. Estimation of Amino Acids Quality

The total Amino Acid (TAA), total Essential Amino Acid (TEAA), total Acidic Amino Acid (TAAA), total Sulphur Amino Acid (TSAA) and total Aromatic Amino acid (TAAA) were estimated.

The Predicted Protein Efficiency Ratio (P-PER) was determined using the equation developed by [1] as:

P-PER = -0.468 + 0.454 (Leu) - 0.105 (Tyr)

The Amino Acid Score for Essential Amino Acid was calculated as:

$AA_{score} = AAA / AAA_{RP}$

Where

AAA is the amount of limited amino acid in the sample protein (mg/g), while AAA_{RP} is the amount of the same amino acid in the reference protein (mg/g)

The digestibility of *C. forda* and *S. scombrus* were obtained from published data as suggested by [21].

The Protein digestibility corrected for amino acid score (PDCAAS) for each protein were estimated using the formula:

PDCAAS = Amino Acid Score × % true digestibility [45]

7. Statistical Analysis

Triplicate data of the samples were expressed as mean ± standard deviation were subjected to t-test at $P<0.05$ in order to compare the means of their nutritional parameters.

3. Results

Table 1 below shows the result of proximate composition of dry *C. forda* larva and *S. scombrus*. The moisture content of *C. forda* was 6.97% while that of *S. scombrus* was 8.44%. Fat content of 13.58% in *C. forda* was lower compared to 18.32% in *S. scombrus*. Total crude protein of 43.07% and 43.65% obtained in *C. forda* and *S. scombrus* were not significantly different.

The ash content of 5.31% in *C. forda* was significantly higher than 2.23% in *S. scombrus*. Higher fibre content of 9.80% was also detected in *C. forda*. However, *S. scombrus* has significantly higher carbohydrate and energy values of 26.49% and 447.27KJ/100g respectively.

Table 1: Proximate composition of *C. forda* and *S. scombrus* (%)

Parameter	*C. forda*	*S. scombrus*
Moisture	6.97 ± 0.65^a	8.44 ± 0.11^b
Ash	5.31 ± 0.36^a	2.23 ± 0.16^b
Crude Protein	43.07 ± 1.50^a	43.65 ± 1.06^a
Fibre	9.80 ± 0.27^a	0.82 ± 0.07^b
Oil	13.58 ± 0.68^a	18.32 ± 0.86^b
Carbohydrate	21.46 ± 1.93^a	26.49 ± 0.41^b
Energy (KJ/100g)	379.59 ± 5.43^a	447.27 ± 1.54^b

The values given in the table above are mean and standard deviation (means ± SD) of triplicate analysis

Mean values in the same row with the same superscript letters are not significantly different (t-test, $P < 0.05$)

The mineral compositions of *C. forda* and *S. scombrus* are shown in Table 2 below. Calcium and magnesium had the highest values of 634.30mg/100g and 277.64mg/100g respectively in *C. forda*. In *S. scombrus*, potassium and calcium had the highest values of 3040mg/100g and 985.73mg/100g respectively. Comparatively, the mineral contents of *C. forda* were significantly ($P<0.05$) lower than in *S. scombrus* with the exception of magnesium. The mineral ratios were significantly ($P>0.05$) higher in *S. scombrus* than in *C. forda* with the exception of Ca^{2+}/K^+

Table 2: Mineral composition of *C. forda* and *S. scombrus* (mg/100g)

	C. forda	*S. scombrus*
Magnesium	277.67 ± 6.13^a	110.67 ± 2.49^b
Phosphorus	120.90 ± 2.42^a	140.70 ± 0.62^b
Calcium	634.30 ± 4.23^a	985.73 ± 2.42^b
Sodium	42.26 ± 1.06^a	424.33 ± 1.70^b
Potassium	166.13 ± 2.46^a	3040.00 ± 0.89^b
K^+/Na^+	3.39 ± 0.15^a	7.16 ± 0.02^b
Ca^{2+}/P	5.25 ± 0.14^a	7.01 ± 0.05^b
Ca^{2+}/Mg^{2+}	2.28 ± 0.03^a	8.90 ± 0.02^b
Ca^{2+}/K^{2+}	3.82 ± 0.03^a	0.32 ± 0.01^b

The values given in the table above are mean and standard deviation (means ± SD) of triplicate analysis

Mean values in the same row with the same superscript letters are not significantly different (t-test, $P < 0.05$)

The result of anti-nutritional composition is shown in Table 3. Saponin was the highest in *S. scombrus* (514.87mg/100g) while phytate was highest in *C. forda* (269.27mg/100g). Cyanide contents of *C. forda* and *S. scombrus* were 46.10mg/100g and 43.85mg/100g respectively. Oxalate was the lowest in concentrations in both samples. Cyanide, oxalate and phytate were significantly ($P>0.05$) higher in *C. forda* while tannin and saponin were significantly ($P>0.05$) higher in *S. scombrus*

Table 3: Antinutrient composition of *C. forda* and *S. scombrus* (mg/100g)

	C. forda	*S. scombrus*
Cyanide	46.10 ± 0.33^a	43.83 ± 3.49^b
Oxalate	44.92 ± 0.10^a	9.08 ± 0.38^b
Phytate	269.27 ± 0.47^a	40.43 ± 0.17^b
Tannin	97.28 ± 0.06^a	143.04 ± 16.67^b
Saponin	264.60 ± 0.59^a	514.87 ± 2.17^b

The values given in the table above are mean and standard deviation (means ± SD) of triplicate analysis

Mean values in the same row with the same superscript letters are not significantly different (t-test, $P < 0.05$)

Table 4 shows the amino acid compositions of *C. forda* and *S. scombrus*. About 66.6% of the essential amino acids (Leucine, Isoleucine, tryptophan, valine, histidine and threonine) had significantly ($P>0.05$) higher values in *C. forda* than in *S. scombrus*. However, amino acids proline, cysteine, glutamic acid, glysine and alanine were significantly ($P>0.05$) higher in *S. scombrus*. These also satisfied the FAO recommended Daily Allowance (RDA) for humans. The daily recommended intake of indispensable amino acids has shown in the brackets revealed that minimum of 55.85g and 58.71g of *C. forda* and *S. scombrus* respectively are needed to satisfy the protein requirements of adult humans. Percentage Total Essential Amino Acids (%TEAA), Essential to Non-essential amino acids (∑TEAA/∑TNEAA) and Protein Efficiency Ratio (P-PER) were higher in *C. forda* than in *S. scombrus.*

Table 4: Amino acid composition of *C. forda* and *S. scombrus* (g/100g)

	RDI*	**g/100g of protein**	
Amino acid	**g/70kg body weight**	***C. forda***	***S. scombrus***
Leucine	2.70	7.36 ± 0.12^a (36.68)	6.82 ± 0.05^b (39.59)
Lysine	2.10	7.05 ± 0.05^a (29.79)	8.07 ± 0.01^b (26.02)
Isoleucine	1.40	4.01 ± 0.04^a (34.91)	3.62 ± 0.06^b (38.67)
Phe + Tyr**	1.75	7.52 ± 0.06^a (23.27)	6.44 ± 0.04^b (27.17)
Tryptophan	0.28	2.25 ± 0.04^a (12.44)	0.81 ± 0.02^b (34.57)
Valine	1.05	4.94 ± 0.03^a (21.26)	4.22 ± 0.03^b (24.88)
Met + Cys**	1.05	1.88 ± 0.04^a (55.85)	3.30 ± 0.03^b (31.82)
Histidine	0.70	3.39 ± 0.03^a (20.65)	2.06 ± 0.03^b (33.98)
Threonine	1.82	5.89 ± 0.01^a (30.90)	3.10 ± 0.02^b (58.71)
Proline		4.60 ± 0.03^a	4.87 ± 0.04^b
Arginine		9.63 ± 0.04^a	5.17 ± 0.03^b
Tyrosine		4.31 ± 0.03^a	2.92 ± 0.02^b
Cysteine		0.57 ± 0.06^a	0.74 ± 0.04^a
Alanine		5.29 ± 0.04^a	4.79 ± 0.03^b
Glutamic acid		9.99 ± 0.05^a	12.72 ± 0.04^b
Glysine		5.28 ± 0.02^a	6.23 ± 0.03^b
Serine		4.20 ± 0.03^a	4.06 ± 0.03^a
Aspartic acid		8.32 ± 0.03^a	8.10 ± 0.02^b
∑TAA		91.91 ± 0.41^a	84.42 ± 0.23^b
TEAA		39.40 ± 0.26	34.83 ± 0.11
TNEAA		52.51 ± 0.15	49.59 ± 0.12
TSAA		1.89 ± 0.05	3.30 ± 0.01
TArAA		9.76 ± 0.09	7.29 ± 0.02
∑TEAA/∑TNEAA		0.75 ± 0.01^a	0.70 ± 0.01^b
P-PER		2.42 ± 0.05^a	2.32 ± 0.02^a

Values are mean of triplicates measurement
Mean carrying the same superscript are not significantly different (t-test, $P<0.05$)
Values in bold represent minimum recommended daily intake in grams of samples for adult humans
*RDI = WHO Recommended Daily Intake [55]
Phe + Tyr** = Phenylalanine + Tyrosine.
Met + Cys** = Methionine + Cysteine

Table 5 shows the Amino Acid Scores and Protein Digestibility Corrected for Amino Acids Scores (PDCAAS) for *C. forda* and *S. scombrus*. The amino acid score in *C. forda* was 0.75 while in *S. scombrus* it was 0.74. About 88.8% PDCAAS values in *C. forda* were above 75, while about 77.7% of the PDCAAS in *S. scombrus* were higher than 75. The lowest PDCAAS values in *C. forda* and *S. scombrus* were 60.78 and 51.52 respectively.

Table 5: PDCAAS Scores for *C. forda* and *S. scombrus* proteins [%]

Amino acid	**Standard FAO/WHO (1991) (g/100g protein)**	***C. forda***	***S. scombrus***
Digestibility (%)		81.71$^{\mathbf{a}}$	92.20$^{\mathbf{b}}$
Leu	6.60	91.12	95.27
Lys	5.80	99.31	128.29
Ile	2.80	117.02	119.20
Phe + Tyr$^{\mathbf{d}}$	6.30	97.53	**51.52**
Tryp	1.10	167.13	67.89
Val	3.50	115.33	111.17
Met + Cyst$^{\mathbf{e}}$	2.50	**61.45**	94,41
His	1.90	145.79	99.96
Thr	3.40	145.55	84.06
Amino acid score		0.75	0.74

PDCAAS = Protein Digestibility Corrected for Amino Acid Score
PDCAAS score of *C. forda* and *S. scombrus* in relation to standard protein are typed bold fonts.
a [35]
b [50]
c [18]
d Phenylalanine + Tyrosine.
e Methionine + Cysteine.

4. Discussion

The results obtained from the nutritional analysis of *C. forda* and *S. scombrus* showed that they are good sources of food nutrients and minerals. The crude proteins of 43.07% and 43.65% in *C. forda* and *S. scombrus* respectively were not significantly different and both satisfied the 23-60% recommended for human consumption [17]. The protein content of *C. forda* in this study was higher than the value (31.40%) reported by [40] for the same insect. This was however lower than the range of 54.36 - 56.78% reported by [23] for *C. forda* from Makurdi, Nigeria. The crude protein content of *C. forda* in this study falls within the range of 15-60% reported for other edible lepidopterous insects [42].

The ash content of 5.31% obtained for *C. forda* was higher than 2.23% obtained for *S. scombrus*. The ash content of *C. forda* in this study was lower than 7.62% and 7.12% reported by [40] and [3] respectively. This was however higher than the range of 2.91-3.97% reported by [23]. The ash content is a measure of the amount of minerals in the insect [53].

The fat content in *C. forda* (13.58%) was lower than (18.32%) in *S. scombrus*. Both values satisfied the recommended daily requirement of (15-60%) for humans. The percentage fat obtained for *C. forda* in this study falls within the range of 11.07-13.38% reported by [23], lower than 16.12% reported for *C. forda* by [40] but however higher than the 4.68% reported for *C. forda* by [37]. Moreover the fat content of *C. forda* fell below the range of 15-35% which makes it not liable to rancidity during storage [41]. Fats and oil is a good source of energy in the body and they help in maintaining cell membrane structure as well as transportation of some nutritionally essential fat soluble vitamins like vitamins A, D, E and K.

The moisture content of 6.97% and 8.44% obtained in *C. forda* and *S. scombrus* respectively are low and advantageous. The low moisture content recorded in this study shows that the samples can be stored for long period without spoilage. This is because many proteolytic, lipolytic spoilage bacteria proliferation are enhanced at moisture level of 15% and above [24].

C. forda and *S. scombrus* are good sources of essential macro elements. Magnesium, phosphorus, calcium, sodium and potassium are abundant in the two samples and could contribute positively to the health of humans if consumed. Sodium concentration of 42.26mg/100g in *C. forda* is similar to 45.50 and 45.26mg/100g reported by [40] and [37] respectively for the same insect. Sodium helps in the maintenance of proper acid-balance and in the control of osmotic pressure that exist between blood and cells [40]. The potassium content of 166mg/100g obtained in *C. forda* was higher than 65.04mg/100g reported by [40], however it was lower than the value of 1160mg/100g reported for potassium in *C. forda* by [31]. Potassium plays an essential role in the production of amino acids and proteins and its intake has been associated with lowering blood pressure and other cardiovascular risk. The K^+/Na^+ of 3.93 for *C. forda* make it consumption good for the management of hypertension. Both ions are important body electrolytes and increasing potassium and reducing sodium in diet synergistically reduces blood pressure [54]. The Calcium level of 634.3mg/100g for *C. forda* was higher than the value reported by [40, 31, 37]. Calcium is very essential in the diets of children and adults because it helps in the development of bones and teeth, nervous conduction, muscle contraction, blood clotting and membrane permeability. Ca^{2+}/P of 5.25 in *C. forda* makes it nutritionally beneficial because a ratio of one is considered good while a ratio of less than 0.5 is considered poor [36]. In fact a ratio of above two enhances the absorption of Calcium from the small intestine [34]. Ca^{2+}/K^+ is usually referred as thyroid ratio because both minerals are important in the regulation of thyroid gland. The ratio of 3.82 obtained for *C. forda* in this study meets the requirement for maintaining thyroid activity [9].

Phosphorus is an important component of bone mineral and as soluble phosphate ion in many soft tissues. It places an important role in energy metabolism of nutrients. The value in *C. forda* of 120.90mg/100g is lower the value of 140mg/100g in *S. scombrus*. However this value is higher than 110.8mg/100g reported by [12] and 110.0mg/100g by [40]. The value of phosphate in *C. forda* is an indication that the insect is a good source of dietary phosphorus. Ca^{2+}/Mg^{2+} ratio of 2.28 and 8.90 in *C. forda* and *S. scombrus* fall within the recommended range of (2-16) which is good for enhancing mental and emotional stability in human. A ratio above 16.0 or below 2.0 is associated with emotional and mental disturbance [9]. Understanding mineral ratio or interrelationship is much more efficient than knowing the concentration of individual mineral when evaluating the nutritional value of any food substance. Mineral ratio often helps in determining nutritional deficiencies and excesses. It could also be an index of hidden future metabolic dysfunctions [36].

The concentration of anti-nutrients obtained in *C. forda* and *S. scombrus* are high for saponin, tannin and phytate. Anti-nutrients are secondary metabolites of plants which are used as defense against herbivores. The high level of some of these could be attributed to the fact that both *C. forda* and *S. scombrus* are herbivorous feeders. However proper cooking could drastically reduce their content in food substances. Anti-nutrients are known to hinder bioavailability of some essential elements in food into human body when consumed in large quantity.

The amino acids composition of *C. forda* showed that with the exception of phenylalamine and methionine, all other essential amino acids meet the [18] recommended daily allowance (RDA). Apart from this, the insect is very rich in non-essential amino acids arginine, alamine, glutamic acid, and aspartic acid. The high level of lysine and tryptophan obtained for *C. forda* in this study disagrees with the submission of [47] who said that lysine and tryptophan are the first limiting amino acids in most edible insects. This result however corroborates that of [15, 33, and 27] who earlier reported deficiency of methionine and cysteine in some edible insects. High concentration of lysine in *C. forda* makes the insect a dietary supplement to many of the cereal proteins which have lower lysine content [35].

The percentage essential amino acids of 42.87% and 41.26% obtained for *C. forda* and *S. scombrus* respectively satisfies the dietary recommendations of 39% for infants, 26% for children and 11% for adult humans [19]. They also satisfy the recommended value of 0.6 of essential to non-essential amino acids ratio for human diet [17]. The predicted protein efficiency ratio (P-PER) was higher in *C. forda* than in *S. scombrus*. The predicted protein efficiency ratio of 2.42 in *C. forda* is very close to the value of 2.50 obtained in casein. The result also showed that a minimum daily consumption of 55.85g of *C. forda* and 58.71g of *S.*

scombrus will meet the amino acid requirement of adult humans. Digestible Indispensable Amino Acid score (DIAAS) for *C. forda* showed that all except for Met + Cys were higher than 75%. In *S. scombrus*, however Phe + Cys and tryptophan were the only one less than 75%. Greater numbers of essential amino acids in *C. forda* were excellent with DIAAS values greater than 100%, while few others with DIAAS values ranging between 75-99% are regarded to be good. DIAAS values of 61.45% and 51.52% in *C. forda* and *S. scombrus* represent their Protein Digestibility Corrected for Amino Acid (PDCAAS) respectively. Though *C. forda* has higher PDCAAS than *S. scombrus*, both cannot fully supply all indispensable amino acid requirements for adult humans, hence both needed to be supplemented by other food rich in their limiting amino acids.

C. forda is limited by the sulphur amino acids (methionine and cysteine) while *S. scombrus* is limited by aromatic amino acids (phenylalanine and tyrosine). However, because humans always feed on combinations of diets and under such situations, high quality proteins can be used to supplement low quality proteins in order to meet the required amino acids for proper growth and maintenance [11]. The DIAAS values obtained in this study could be used to suggest diets that could be appropriate supplement for *C. forda* and *S. scombrus*. For instance *C. forda* can be a good protein food source in developing countries like where cereals diets like maize, millet and rice with limiting amino acid lysine but with higher quantity of sulphur amino acids [14, 44, 30] have being the major staple food sources.

5. Conclusion

This study revealed that *C. forda* is nutritionally comparable to *S. scombrus* as indicated by various nutritional parameters determined. The crude proteins were high in both *C. forda* and *S. scombrus*; mineral salts like magnesium, phosphorus, calcium and potassium were also high and adequate for human consumption, with tolerable level of anti-nutrients. The insect also has excellent amino acids composition based on the various amino acids quality indices tested; protein efficiency ratio, essential to non-essential amino acids ratio, amino acid scores and protein digestibility corrected amino acid scores were good. The insect was however limited by sulphur amino acids, but rich in lysine and could be used in complementing cereal food known to be deficient in lysine. The findings showed that *C. forda* is not nutritionally inferior to *S. scombrus* and therefore appropriate and adequate for human consumption.

6. References

1. Adeyeye EI. Amino acid composition of three species of Nigerian fish: *Clarias anguillaris*, *Oreochromis niloticus* and *Cynoglossus senegalensis*. Food Chemistry 2009;113(1):43-46.
2. Agbidye FS, Akindele SO, Ofuya TI. Some edible insect species consumed by the people of Benue state, Nigeria. Pakistan Journal of Nutrition 2009;8:946-950.
3. Akinnawo O, Ketiku, AO. Chemical composition and fatty acid profile of edible larva of *Cirina forda*, African Journal of Biomedical Research 2000;3:93-96.
4. Alexandratos N, Bruinsma J. World Agriculture towards 2030/2050: the 2012 revision. ESA working paper No. 12-03. Rome, FAO
5. Ande AT. Consider the ways of Ants and be wise" The 169 Inaugural Lecture, University of Ilorin. Unilorin press 2017, Pp50.
6. Ande AT. The protein quality of *Cirina forda* caterpillar. Nigeria Journal of Biochemistry and Molecular Biology 2003;18(1):69-74.
7. AOAC. Official Methods of Analysis (18th edition) Association of Official Analytical, Chemists International, Maryland, USA 2005.
8. AOAC. Official Methods of Analysis (18^{th} Edition), Association of Analytical Chemists, Washington, DC, USA 2006.
9. ARL. Basic ratios and their meaning. Analytical research labs. Inc 2012;(602):955-1580. www.arltma.com/Articl/Ratio.Doc.htm.
10. Badanaro F, Amevoin K, Lamboni C, Amouzou K. Edible Cirina forda (Westwood, 1849) (Lepidoptera: Saturniidae) caterpillar among Moba people of the Savannah Region in North Togo: from collector to consumer Asian Journal of Applied Science and Engineering 2014;3:13-24.
11. Bailey HH. Stein, Can the digestible indispensable amino acid score methodology decrease protein malnutrition. Animal Frontier 2019;9(4):18-23
12. Banjo OA, Lawal EA. Songonuga. The nutritional value of fourteen species of edible insects in South Western Nigeria. African Journal of Biotechnology 2006;5:298-301.
13. Benitez LV. Amino Acid and fatty acid profiles in aquaculture nutrition studies, p. 23- 35.in S.S. De Silva (ed.) Fish Nutrition Research in Asia. Proceedings of the Third Asian Fish Nutrition Network Meeting. Asian fish. Society Special Publication1989;4:166p. Asian Fisheries Society, Manila Philippines.
14. Cervantes-Pahm, Liu Y, Stein HH. Digestible indispensable amino acid score and digestible amino acids in eight cereal grains. British Journal of Nutrition 2014;111:1663-1672, doi:10.1017/S0007114513004273
15. DeFoliart GR, Finke MD, Sunde ML. Potential value of the Mormon cricket (Orthoptera: Tettigoniidae) harvested as a high-protein feed for poultry," Journal of Economic Entomology 1982;75:848-852.
16. Dwomoh E, Akrofi A, Ahadzi SK. Natural enemies of the shea defoliator, *Cirina forda*. Tropical Science 2004;44(3):124-127.
17. FAO/WHO. Energy and protein requirements. Technical report series no. 522. Geneva, Switzerland: WHO 1973.
18. FAO/WHO. Protein quality evaluation. Report of joint FAO/WHO expert consultation. FAO food and nutrition paper 51. Italy: Rome 1991.
19. FAO/WHO/UNU. Energy and protein requirement, WHO technical report series no. 724. Geneva, Switzerland: WHO 1985.
20. Fasoranti JO, Ajiboye DO. Some edible insects of Kwara State, Nigeria. *American Entomologist*, 1993;39:113-116.
21. Food and Agriculture Organization of the United Nations (FAO), Dietary protein quality evaluation in human nutrition. Report of an FAO expert group. FAO food and nutrition paper 92. Rome: Food and Agriculture Organization of the United Nations 2013.

22. Griffiths DW, Jones DI. Cellulase inhibition by Tannins in the testa of field beans Journal of Science, Food and Agriculture 1977;28(11): 938-989.
23. Igbabul BD, Agude C, Inyang CU. Nutritional and microbial quality of dried larva of *Cirina forda*. International Journal of Nutrition and Food Sciences 2014;3(6):602-606.
24. Kaneko S. Smoked meat and microorganisms. New Food Ind. 18, 17-23. In a review of Japanese studies. Fish smoking and drying. The effects of smoking and drying on the nutritional properties of fish (ed. T. Moto) (1988). Elsevier Applied Science (ed. J. R. Burt), pp. 91-120.
25. King JM, Parsons DJ, Turnpenny JR, Nyangaga J, Bakara P, Wathes CM, *et al*. Modelling energy metabolism of Friesians in Kenya smallholdings shows how heat stress and energy deficit constrain milk yield and cow replacement rate. Animal Science 2006;82:705-716.
26. Koneswaran G, Nierenberg D. Global farm animal production and global warming: impacting and mitigating climate change. Environmental Health Perspective 2008;116:578-582.
27. Landry SV, DeFoliart GR, Sunde ML. Larval protein quality of six species of Lepidoptera (Saturniidae, Sphingidae, Noctuidae)," Journal of Economical Entomology 1986;79:600-604
28. Makhado R, Potgieter M, Tshikudo P, Mawela K, Maluleke-Nyathela H, Tchibozo S, *et al*. Cloutier J. Edible insects in Africa: An introduction to finding, using and eating insects. Edited by A. Van Huis, Agromisa 2015, Pp86
29. Markkar AOS, Goodchild AV. Quantification of Tannins. A Laboratory Manual. International Centre for Agricultural Research in Dry Areas (ICARDA) Press, Aleppo, Syria 1996, p4-25.
30. Mathai Y Liu, Stein HH. Values for digestible indispensable amino acid scores (DIAAS) for some dairy and plant proteins may better describe protein quality than values calculated using the concept for protein digestibility-corrected amino acid scores (PDCAAS). British Journal of Nutrition,2017, 490-499. doi:10.1017/S0007114517000125
31. Morgane PMA, Aboubacar T, Athanase KO, Chantal YZ, Essetchi PK. Nutritional qualities of edible caterpillars *Cirina butyrospermi* in southwestern of Burkina Faso. International Journal of Innovation and Applied Studies 2016;18(2):639-645
32. Nakagaki BJ, Defoliart GR. Comparison of diets for mass-rearing *Acheta domesticus* (Orthoptera: Gryllidae) as a novelty food, and comparison of food conversion efficiency with values reported for livestock. J. Econ. Entomol 1991;84(3):891-896.
33. Nakagaki BJ, Sunde ML, DeFoliart GR. Protein quality of the house cricket, *Acheta domesticus*, when fed to broiler chicks, Poultry Sciences 1987;66:1367-1371.
34. Niemann DC, Butterworth DE, Nieman CN. *Nutrition*. Brown, Dubuque, IA 1992, 237-312
35. Oibiokpa FI, Akanya HO, Jigam AA, Saidu AN, Egwim EC. Protein quality of four indigenous edible insect species in Nigeria. Food Science and Human Wellness 2018;7:175-183.
36. Olagbemide PT. Nutritional Values of Smoked *Clarias Gariepinus* from Major Markets in Southwest, Nigeria. Global Journal of Science Frontier Research: D Agriculture and Veterinary 2015;15(6):32-42.
37. Omotoso OT. Nutritional quality, functional properties and anti-nutrient compositions of the larva of *Cirina forda* (Westwood) (Lepidoptera: Saturniidae). Journal of Zhejiang University. Science. B 2006;7:51-55.
38. Oonincx DGAB, van der Poel AFB. Effects of diet on the chemical composition of migratory locusts (*Locusta migratoria*). Zoo Biol 2010;28:1-8.
39. Orjiekwe CL, Solola A, Iyen E, Imade S. Determination of cyanogenic glucosides in cassava products sold in Okada, Edo State, Nigeria. African Journal of food Science 2013;7(12):468-472
40. Paiko YB, Dauda BEN, Salau RB, Jacob JO. Preliminary data on the nutritional potentials of the larvae of edible dung Beetle consumed in Paikoro Local Government Area of Niger State, Nigeria. Continental Journal of Food Science and Technology 2012;6(2):38-42.
41. Plahar WA, Pace RD, Lu JY. Effects of storage methods on the quality of smoked-dry herring (Sardinella eba). Jnl Sci. Fd Agric 1991;57:597-610.
42. Ramos-Elorduy J, Moreno JMP, Prado EE, Perez MA, Otero L, Guevara OL. Nutritional value of edible insects from the state of Oaxaca, Mexico., Journal of Food Composition and Analysis 1988;10:142-150.
43. Rumpold BA, Schluter OK. Nutritional composition and safety aspects of edible insects. Molecular Nutrition and food Research 2013;57(5):802-823.
44. Rutherfurd SM, Fanning AC, Miller BJ, Moughan PJ. Protein digestibility-corrected amino acid scores and digestible indispensable amino acid scores differentially describe protein quality in growing male rats. Journal of Nutrition 2015;145:372-379. doi:10.3945/jn.114.195438
45. Schaafsma G. The protein digestibility-corrected amino acid score (PDCAAS)-A concept for describing protein quality in foods and food ingredients: A critical review. J. AOAC Int 2005;88:988-994.
46. Schönfeldt HC, Pretorius B, Hall N. The impact of animal source food products on human nutrition and health. South African Journal of Animal Science 2013;41(3):395-412
47. Solomon M, Prisca M. Nutritive value of *lepidoptara litoralia* (edible caterpillar) found in Jos Nigeria: implication for food security and poverty alleviation," African Journal of Food, Agriculture, Nutrition and Development 2012;12(6):6737-6747
48. Sudarmadji S, Markakis P. The Phytates and phytase of Soya beans Tempeh. Journal of Science, Food and Agriculture 1977;28(4):381-383
49. Thornton P. Livestock production: recent trends, future prospects. Phil. Trans. R. Soc. B, 2010;(365):2853-2867.
50. Usydus Szlinder-Richert J, Adamczyk M. Protein quality and amino acid profiles of fish products available in Poland. Food Chemistry 2000;112:139-145.
51. Van Huis A. Potential of insects as food and feed in assuring food security. Annual Review of Entomology 2013;58:563-583.

52. Van Huis A. Insects as food in sub-Saharan Africa. Insect Science and its Application 2003;23(3):163-185.
53. Verkerk MC, Tramper J, Van Trijp JCM, Martens DE. Insect cells for human food, Biotechnology Advances, 2007; 25: 198-202.
54. Vasuki JB. Stacey, Relationship of Dietary Sodium, Potassium and the Sodium-to-Potassium Ratio to Blood Pressure. Journal of Medical - Clinical Research and Reviews 2019;3:1-5.
55. WHO/FAO/UNU, Expert consultation protein and amino acid requirements in human nutrition. http://apps.who.int/iris/bitstream/10665/43411/1/WHO_TRS_ 935_eng.pdf?ua=1/(accessed April 2019) 2007.