NUTRITIONAL EVALUATION OF AFRICAN GIANT BLACK MILLIPEDE (*Archispirostreptus gigas)* MEAL AS ALTERNATIVE FEED RESOURCE IN LIVESTOCK PRODUCTION

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ABSTRACT

African Giant Black Millipede (Archispirostreptus gigas) was oven dried, milled and subjected to chemical analyses of proximate, gross energy, minerals, vitamins and anti-nutritive factors. The analysis revealed that the dried millipede meal contained dry matter, 86.83%; crude protein, 62.87%; crude fibre, 2.53%; ash, 9.07%; ether extract, 12.37% and gross energy (2,243 Kcal/kg). It also contained (mg/100g) iron (16.37), magnesium (55.53), phosphorus (310.94), phosphate ions (971.70) and calcium (778.30), Niacin (0.80), Retinol (2.70), Thiamine (0.20), Riboflavin (0.10), Ascorbic acid (0.77) and oxalate (6.17). Cyanogenic glycosides and oxalates were however not detected. The protein, minerals and vitamin composition of fish meal compared favourably with those of highly proteinaceous feed ingredients like fish meal, meat meal, blood meal but superior to those of peanut cake, soybean meal and other vegetative protein sources. African giant black millipede (Archispirostreptus gigas) is available in tropical rain forest zone of Nigeria. The millipede is rich in protein, ether extract, minerals and vitamins and can serve as substitute for fish meal and other high protein source ingredients as valuable feed ingredients in livestock production.

Key words: Millipede, Proximate composition, Minerals, Anti-nutritional factors, Feed ingredients.

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INTRODUCTION

High cost of feed ingredients in Nigeria is seriously reducing the profit margin and discouraging many farmers from rearing poultry all the year round. Alternative source of animal protein in poultry feed from non-conventional sources that are of no direct use to humans to meet the ever-increasing demand for animal protein had been extensively advocated. Insects like lepidopteran larvae, , coleopteran larvae, a number of different species of grasshoppers and locusts, crickets, cockroaches, lice, stink bugs, cicadas, aphids, scale insects, and several species of termites, (*Macrotermes bellicosus* (Smeathman), *Macrotermes subhyalinus*, *Macrotermes falciger* and *Macrotermes natalensis*), black soldier fly (*Hermetica illucens* Linnaeus), common housefly (*Musca domestica* L.) and yellow mealworm (*Tenebrio molitor* L.), lake flies, black ants, palm weevil (*Rynchophorous spp.*), rhinoceros beetles (*Oryctes spp.*) and caterpillars, flies, bees, wasps, ants, worms and worm castes have all been used as complementary food sources for farm animals like poultry (Kelemu *et al*., 2015; Gbogouri *et al*., 2013; Riggi *et al*., 2013; Rumpold and Schlüter, 2013; Womeni *et al*., 2009;DeFoliart, 2005; Tchibozo *et al*., 2005; Van Huis, 2003; Ravindran and Blair, 1993; Farina *et al*., 1991).

Millipedes are a group of arthropods that are characterized by having two pairs of jointed legs on most body segments. They are known scientifically as the class Diplopoda, the name being derived from this feature. The name "millipede" was derived from the Latin word that means "thousand feet", although no known species has 1,000 feet except for *Illacme plenipes* that has 750 legs. There are approximately 12,000 named species classified into 16 orders and around 140 families; making Diplopoda the largest class of myriapods, an arthropod group which also includes centipedes and other multi-legged creatures (Wikipedia, 2014). Most millipedes have very elongated cylindrical or flattened bodies with more than 20 segments, while pill millipedes are shorter and can roll into a ball.

Millipedes (Diplopoda) have so far not been in focus as mini livestock. Indeed, most orders of millipedes (Glomerida, Polyzoniida, Siphonocryptida, Platydesmida, Siphonophorida, Callipodida, Julida, Spirobolida, Spirostreptida, and Polydesmida) are known for their chemical defenses and, unlike their relatives, the centipedes (Chilopoda), which in several cultures (China, Alto Orinoco in Venezuela, and Korea) have been used as medical remedies and/or food items (Pemberton, 2005, Paoletti and Dufour, 2005), no information on millipedes as human food and livestock feed has been available until now. However, the Bobo tribe at Kou village in Burkina Faso have been reported to boil and dried Gomphodesmid species of millipede such as *Tymbodesmus falcatus* and *Sphenodesmus sheribongensis* as food (Enghoff *et al*., 2014).

Among the Yoruba people of Nigeria, millipedes are used in medicines for pregnancy and business rituals. Crushed millipedes are used to treat fever, whitlow, and convulsion in children (Lawal and Banjo, 2007). In some cultures, the millipede is kept as a pet. There is a dearth of information on the nutritive value of millipedes in animal nutrition. The nutritional composition of oven-dried African Giant Black Millipede (*Archispirostreptus gigas)* meal is hereby assessed.

MATERIALS AND METHODS

Source of millipedes: The millipedes used in this study were collected from rubber plantation of Rubber Research Institute of Nigeria, Iyanomo, Benin City, Edo State, Nigeria on daily basis. The millipedes were collected into a tin with cover and then taken to the laboratory where they were killed by dipping into boiled (100^0C) water for 15 minutes before they were removed and oven-dried at 70^0C for 6 hours and then milled. The millipede meals were kept in air tight container until analyzed.

Chemical Analysis: The millipede meal was subjected to chemical analysis. The Dry Matter (DM) contents were determined by oven-drying samples at 105^0C to a constant weight. The proximate composition was determined according to the procedure of AOAC (2010). Nitrogen Free Extract (NFE) and carbohydrate content were estimated from the values obtained. That is NFE = 100 – (CP + Ash + EE +CF) while the carbohydrate content is the sum of the NFE and the crude fibre content. The gross energy values were calculated from the relationship that exists between fat, crude protein and carbohydrate (i.e. 39.4EE + 23.5CP + 17.7 carbohydrates) according to Fisher (1982).

The mineral contents (Mg and Fe) of millipede meal were determined using the atomic spectrophotometer as described by the methods of AOAC (2010). Phosphorus and calcium were determined calorimetrically (AOAC, 2010). Each sample was analyzed in triplicates and all readings were done in duplicates.

Qualitative test and quantification of anti-nutritional factors: The procedures of Harborne, (1973); Marcano and Hasenawa (1991) and Sofowora,(1993), and were used for the analysis. Oven dried millipedes were milled to powder.

Test for oxalates: Calcium chloride was added to aqueous solution of the sample. A white precipitate (of calcium oxalate) which is insoluble in acetic acid indicates that oxalate ion is present. (WikiBooks, 2013).

*Test for cyanogenic glycosides (mg/100g)***:** To 5ml of the extract was added 2.5ml of dilute H_2SO_4 in a test tube and boiled for 15minotes, cooled and neutralized with 10% NaOH. Fehling's solution A and B were added. A brick red precipitation of reducing sugars would indicate the presence of glycosides.

*Determination of phytate content***:** One gramme **(**1g) of the sample was extracted with 0.2M HCl. To 0.5ml of extract was added 1ml Fe^{3+} solution (ferric ammonium sulphate). To 1ml of supernatant was added 1.5ml of 2, 2-Bipyridine solution. The absorbance was measured at 519nm with distilled water as blank.

Statistical Analysis: Data obtained were subjected to descriptive statistical analysis of GENSTAT (2005).

RESULTS AND DISCUSSION

The proximate and gross energy composition of millipede meal is as presented in Table 1 below. The analysis revealed that oven-dried millipede meal contained dry matter, 86.83%; crude protein, 62.87%; crude fibre, 2.53%; ash, 9.07% and ether extract, 12.37% (Table 1). It also contained 15.70% carbohydrate and 2,243 Kcal gross energy. The Crude Protein (CP) content obtained (62.87%) is comparable with the values (62.2 – 79.3%) reported for mechanically extracted menhaden, anchovy, Herring, white Gadidae, Lophiidae, Rajidae and white fish meals (McDonald et al., 2010; Chiba, 2014, NRC, 1994) but lower than 80 – 91.9% CP reported (Babayemi *et al*., 2014; Chiba, 2014; McDonald *et al*., 2010; NRC, 1994) for blood meal. The value is also higher than the crude protein content reported for meat meal (50.6 – 54.0%), peanut meal (48.9 – 53.10%), and 45.7 – 49.5% CP for soyabean meal (Chiba, 2014). It showed that millipede meal is rich in protein and will be a good source of protein in livestock diets if incorporated.

The ash content (9.07%) which is an indication of mineral content of the sample obtained in this study is higher than the values earlier reported (Chiba, 2014; Afolabi and Akpaka, 2013; McDonald et al., 2010; NRC, 1994) for peanut meal (4.7 – 6.3%), soyabean meal (5.4 – 6.90%), meat meal (4.2%), rubber seed cake (4.43%) and blood meal (4.0%) but lower than the values (12.2 – 23.8%) reported for fish meal.

The crude fibre content of millipede meal (2.53%) is low. The crude fibre found in millipede can be due to the cell wall of the vegetative matter that it feeds on since it is an animal without cellulose cell wall. It is an herbivore that feeds on leaves, stem barks, soil debris and other vegetative matters. The fibre content is higher than 0.52 – 1.10% reported for fishmeal, comparable with 2.30 – 2.90% reported for meat meal but lower than the range of values reported (Chiba, 2014; McDonald et al., 2010; NRC, 1994) for plant feedstuffs like soyabean meal (3.5 – 5.8%) and peanut meal (6.2 – 6.70%).

The ether extract obtained for millipede meal in this study (12.37%) is higher than the range of values reported for major protein source ingredients such as meat meal (8.90 – 14.8%), fish meal (4.1 - 9.8%), peanut meal (5.6 – 6.0%), and soyabean meal (1.0 - 1.30%), but lower for what obtained for full fat soybean, 22.2%; palm kernel meal, 16.7%; sunflower meal, 16.2%; rubber seed cake, 16.87% (Chiba, 2014; Afolabi and Akpaka, 2013; McDonald *et al*., 2010).

Based on the proximate composition of millipede meal, it is evident that dried millipede meal is rich in protein and ash and moderate in energy. The protein content can compare favourably with notable animal protein source like fish meal and meat meal and blood meal; and richer than plant protein source like soyabean meal, peanut meal or groundnut cake and can replace up to 100% of these ingredients in livestock ration. It would be a valuable feed resource for both monogastric and ruminant animals if appropriately harnessed.

Table 1: The proximate (g/100gDM) and gross energy (Kcal/kg) composition of Millipede meal

Parameters	Mean ± SD	SEM	CV(%)
Dry Matter	86.83 ± 0.25	0.15	0.29
Crude protein	62.87 ± 0.45	0.26	0.72
Ash	9.07 ± 0.21	0.12	2.30
Crude Fibre	2.53 ± 0.25	0.14	9.93
Ether extract	12.37 ± 0.21	0.12	1.68
Nitrogen free extract	13.17 ± 0.25	0.15	1.91
Carbohydrate	15.70 ± 0.44	0.25	2.78
Gross energy (kcal/kg)	2,243.43 ± 5.0	3.0	0.00

SD = Standard deviation; SEM = Standard error of mean; CV = Coefficient of variation.

The mineral and vitamin composition of dried millipede meal (mg/100g) is as shown in table 2. The result of mineral and vitamin analyses (Table 2) revealed that millipede meal contained (mg/100g) iron (16.37), magnesium (55.53), phosphorus (310.94), phosphate ions (971.70) and calcium (778.30). The iron content obtained for millipede meal (16.37mg/100g) in this study is higher than the values reported (Chiba, 2014; McDonald *et al*., 2010; NRC, 1994) for soyabean meal (13.04 – 14.06mg/100g) but lower than the range of values reported for peanut meal (29.60 – 32.01mg/100g), fish meal (21.47 – 54.46mg/100g) and meat meal (49.04 – 65.32mg/100g). Iron (Fe) is essential in the body of animal as haem component of the blood which assists in distribution of oxygen and removal of CO_2 from the system.

The magnesium content obtained for millipede meal (55.53mg/100g) is lower than the values reported for fish meal (140 – 250mg/100g), meat meal (250 – 1020mg/100g), soyabean meal (290 – 320mg/100g). Magnesium acts as enzyme activator especially in transferases decarboxylases and acyl transferases. Its deficiency can lead to hypomagnesemic tetany in animals.

The phosphorus content of dried millipede meal (310.94mg/100g) obtained in this study is lower than the range of values reported (Chiba, 2014; McDonald *et al*., 2010; NRC, 1994) for fish meal (1670 – 3970 mg/100g), meat meal (4580 – 4960 mg/100g), soyabean meal (640 – 690 mg/100g) and pea meal (560 – 0.66 mg/100g) and higher than the values reported for blood meal (200 mg/100g), corn grain (270 mg/100g), rice grain (110 mg/100g) and sorghum silage (60 mg/100g). The calcium content obtained for millipede meal (228.30mg/100g) in this study is within the range of calcium value reported (Chiba, 2014) for soyabean meal (260 – 300mg/100g), peanut meal (200 – 360mg/100g) and blood meal (220mg/100g) but lower than the values reported for fishmeal (2190 – 6640mg/100g) and meat meal (8610 – 10000mg/100g). Calcium and phosphorus are essential for bone, legs, skull, teeth, formation, growth fertility and development in farm animals.

Values obtained for niacin (0.80mg/100g) in this study is lower than the range of values reported (Chiba, 2014; McDonald *et al*., 2010; NRC, 1994) for fish meal (8.05 – 5.46mg/100g), meat meal (5.10 – 5.60mg/100g), blood meal (2.22mg/100g) and soyabean meal (2.15 – 2.77mg/100g). Niacin promotes growth and help to prevent enteritis and dermatitis.

Values obtained for retinol (Vitamin A) content of millipede's meal is 2.70mg/100g. The value obtained is higher than the Vitamin A requirements (NRC, 1994; Morand-Fohr, 1981) for chicken (1,500 – 2,000 IU/kg or 0.045 – 0.06 mg/100g), swine (0.04 – 0.12mg/100g), turkey and goats (5,000 IU/kg or 0.15mg/100g), meaning that millipede meal can adequately meet animals' requirements for vitamin A. Vitamin A is essential for maintenance, growth, reproduction, sight, smooth hair coat, coordination, egg production and hatchability. Its deficiency leads to eye problems, skeletal malfunctions, reduced growth and reproductive failure.

Thiamine (Vitamin B_1) content obtained for millipede meal (0.20mg/100g) is higher than the range of values reported (Chiba, 2014) for blood meal (0.03mg/100g), fish meal (0.038 – 0.168mg/100g) and meat meal (0.016 – 0.022mg/100g) but lower than the values reported (Chiba, 2014) for soyabean meal (0.31 – 0.598mg/100g). The thiamine content of millipede meal can also meet thiamine requirements (NRC, 1998 and 1994) for chicken (0.08 – 0.18mg/100g), Japanese quail (0.2mg/100g) and swine (0.1 – 0.15mg/100g). Thiamine serves as co-enzyme in oxidative decarboxylation of pyruvic acid. Its deficiency leads to reduced lactic acid products, accumulation of pyruvic acid. In pigs it leads to reduced appetite and growth; vomiting and respiratory problems. Its deficiency leads to nerve degeneration and paralysis in chicks.

Riboflavin content obtained for millipede meal (0.10mg/100g) in this study is lower than the range of values reported (Chiba, 2014; McDonald *et al*., 2010; NRC, 1994) for fish meal (0.48 – 0.97mg/100g), meat meal (0.47 - 0.52mg/100g) and soyabean meal (0.27 – 0.33mg/100g). The riboflavin content of oven dried millipede meal is lower than the riboflavin requirements (NRC, 1994 and 1998) for chicken (0.18 – 0.36mg/100g), ducks, turkey and Japanese quail (0.4mg/100g) and swine (2.0 – 4.0mg/100g). It aids in electron transfer and oxidation-reduction reactions. Its deficiency leads to poor hatchability, embryonic abnormalities in hen, poor appetite, slow growth, vomiting, skin and eye problems in pigs, curled toe paralysis (from nerve degeneration) in chicks.

Values obtained for ascorbic acid in dried millipede's meal is 0.77mg/100g. Vitamin C is required for electron transport and important in various oxidation-reduction mechanisms in living cells; and its deficiency symptoms include oedema, weight loss, emancipation, diarrhea, structural defects in teeth, bone, cartilage, connective tissue, muscle, enlarged adrenal gland and delayed wound healing, fatty infiltrations and necrosis of liver.

Table 2: Mineral and vitamin composition of dried millipede meal (mg/100g)

Parameters	Mean ± SD	SEM	CV (%)
Iron	16.37 ± 0,06	0.03	0.35
Magnesium	55.53 ± 0.25	0.15	0.45
Phosphate ions	971.70 ± 10.4	6.00	1.10
Phosphorus	310.94 ± 3.20	2.00	1.10
Calcium	778.30 ± 25.7	14.80	3.30
Niacin	0.80 ± 0.10	0.06	12.50
Retinol (Vitamin A)	2.70 ± 0.17	0.10	6.42
Thiamine (Vitamin B_1)	0.20 ± 0.01	0.01	0.60
Riboflavin (Vitamin B_2)	0.10 ± 0.01	0.01	10.00
Ascorbic acid (Vitamin C)	0.77 ± 0.15	0.09	19.92

SD = Standard deviation; SEM = Standard error of mean; CV = coefficient of variation.

The screening for anti-nutritional factors and their composition in dried millipede meal is as shown in Table 3 below. Cyanogenic glycosides and oxalate were not detected. This can be attributed to the effect of dipping in hot water followed by oven-drying whereby boiling could have degraded the cyanogenic compounds to release the hydrogen cyanide gas to detoxify the gomphodesmids (Enghoff *et al*., 2014). The presence of hydrogen cyanide and its precursors has been demonstrated in many species of the order Polydesmida (Zagrobelny *et al*., 2008; Shear *et al*., 2007; Makarov *et al*., 2010; Kuwahara *et al*., 2011), including two species of Gomphodesmidae millipede. The HCN has been identified in the secretion of *Strodesmous laxus* from East Africa (Eisner *et al*., 1978), and its precursor, mandelonitrile, in *Aplogomphodesmus pavani* (Barbetta *et al*., 1966).

The screening revealed that dried millipede meal contained phytates (6.17mg/100g). The values obtained for these anti-nutritional factors will have no deleterious effect on animals if millipede meal is used in formulating their diet as protein source since it will not constitute up to 40% of the feed composition. Phytates if present in large quantity can bind minerals like phosphorus, zinc and iron and reduce their absorption.

Table 3: Anti-nutritional constituents of dried millipede meal (mg/100g)

Parameters	Qualitative test	Mean ± SD	SEM	CV(%)
Cyanogenetic Glycosides (mg/100g)	-ve	0.00 (ND)	-	-
Oxalates (mg/100g)	-ve	0.00 (ND)	-	-
Phytates (mg/100g)	+ve	6.17 ± 0.58	0.33	9.36

SD = Standard deviation; SEM = Standard error of mean; -ve = Absent; +ve = Present; ND = not detected.

CONCLUSION

- Oven dried African giant black millipede (*Archispirostreptus gigas)* meal is rich in protein, ether extract, minerals and vitamins and has a potential to serve as substitute for fish meal and other high protein source ingredients as valuable feed ingredients in livestock production.

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