Article

African giant millipede (*Archispirostreptus gigas*) as non-conventional ingredient source in fish nutrition

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Abstract

Arthropods importance can be assessed for beneficial use especially in reducing dependence on scarce animal protein source especially fishmeal in aquaculture nutrition. Biochemical composition of African giant millipede (*Archispirostreptus gigas*) was conducted according to standard methods for proximate, phytochemical, mineral content, fatty acid and amino acid profile. Nutritional content analysis of millipede revealed crude protein of 63.24±0.05%, ether extracts 11.70±0.09% and metabolisable energy (kcal/kg) 3711.22±6.75. Phytochemical composition for phytate, saponin and chitin was high in millipede. Micro mineral content (mg/kg) indicated presence of manganese 36.00, iron 219.50, copper 9.30, zinc 20.60 while macro mineral (%) showed phosphorus 0.036, calcium 0.022, magnesium 0.204, potassium 0.810 and sodium 0.072 to be present in appreciable quantity. The fatty acid profile indicated palmitic and oleic acid to be high with least presence of butyric acid. The essential amino acid revealed high lysine 6.18 (g/100g) content and least tryptophan 0.68 (g/100g); while the non-essential amino acid glutamic acid 11.05 (g/100g) was high and cystine 1.21 (g/100g) least in millipede. The composition of millipede meal revealed potential use in fish nutrition.

Keywords phytochemical; mineral content; fatty acid; amino acid; African giant millipede.

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1 Introduction

Soil-the medium of crop production in agriculture possessed organisms that help in reconditioning nutrients needed for plant growth. These organisms fall into different micro and macro invertebrates. The mode of action on different substrate has been studied and their importance documented for knowledge purposes. Loranger-Merciris et al. (2008) reported that the nitrogen content of the soil ecosystem determines the abundance of millipede in tropical forest. Higher nitrogen content of leaves determines abundance and species diversity of millipede. The African giant millipede, an arthropod has been documented to enhance soil nutrition (Iwashima et al., 2010), affect crop growth (Ebgret, 2006; Cranshaw, 2013), human nutrition (Enghoff et al., 2014), whole millipede used in ethnomedicine/zootherapy (Lawal and Banjo, 2007) and a protein source for livestock production (Afolabi et al., 2019). Millipedes have been identified to influence the fertility of soil through their geophagic and phytophagous habit (Iwashima et al., 2010).

Savanna habitat have been reported to have wide biodiversity of arthropods especially millipede (Druce et al., 2007). Millipedes are confined to tropical countries, belongs to third largest class of artropoda (Diplopoda) following insect and arachnida while quantitatively it exceeds 1000 individual per square meter in forest soil (Golovatch and Kime, 2009). Enghoff et al. (2014) noted the abundance of different species of millipede per time/area. Iwashima et al. (2010) reported that feeding habit of millipede affect decomposition rate of soil leaf organic matter. Millipedes are arthropods covered by exoskeleton, jointed legs, molt, reproduce by laying eggs, sub-cylindrical, slow moving, live in moist areas and are detritivores. Ecologically they are important because they break up leaf litter, thereby aiding bacterial breakdown, which helps retain nutrients in forest soil (Phillips et al., 2016).

The renewable nature of millipede in tropical and temperate clime makes the arthropod worthy of study based on different usage to which it can be put as they can be bred in the laboratory at room temperature with omnivore feedstuff (Sustr et al., 2013). Millipede are part of wildlife biodiversity and some hobbyist now possess them as pet while further studies are being carried out scientifically to advance knowledge on the importance of this arthropod. Millipede through their feeding habit is able to degrade organic materials (Loranger-Merciris et al., 2008) thereby releasing the nutrients embedded in these materials. This mode of feeding allowed millipede to exude some matters which serves as protection against other prey that might be interested in using them further in the food chain (Sustr et al., 2013). These exudates contain different forms of phytochemicals at different levels depending on the species and geographical location of the millipede. These phytochemicals can be used to assess the relative potential of usage of millipede in other nutrition of other animals.

Entomophagy of millipede have been reported in Burkina Fasso (Enghoff et al., 2014) where it serves as meat supplement in delicacy. Ambarish and Sridhar (2015) reported the use of arthropods in human dietetics as food source and ethno-medicinal values been limited to Africa and part of South East Asia. Millipedes do not pose danger or carry diseases that affect people, animals or plants, but do occasionally damage seedlings by feeding on stems, leaves and can devastate ripening fruit plants on the farm due to their scavenging ability on decaying vegetation and leaf litters (Cranshaw, 2013; Gray, 2015). According to Ebregt et al. (2006) *O. sudanica* have been implicated for crop destruction in East Africa. Ebregt (2007) reported millipede as pest of cassava, groundnut and maize, linked with weevils' incidence in sweet potato farms.

According to Sustr et al. (2013), *Archispirostreptus gigas* is one of the largest millipedes (Plate 1) it occurs across wide ecological zones in Africa including Nigeria. The nutritional quality of African giant millipede still has paucity of literature; hence this study adds to knowledge on fatty acid, amino acid, phytochemical and mineral profile of the arthropod. This study revealed more of the importance of amino acid and fatty acid profile of African giant millipede as potential in fish feed.

2 Materials and Methods

2.1 Location and insects

Millipede (Plate1) were collected from the College of Agricultural Sciences (CAS), located in Ayetoro, Yewa North Local Government Area of Ogun State. The College is one of the three mini campuses of Olabisi Onabanjo University (OOU), popularly known as OOUCAS. It covers an area of 1.54 km^2, with latitude 7°13.30´ to 7°14.30´N and longitude 3°3.10´E to 3°4.30´E. (Adewale et al., 2021).

Plate 1 African giant millipede (*Archispirostreptus gigas*).

2.2 Bioassay

Analysis for proximate content was conducted according to AOAC (2005). Determination for mineral analysis was by wet ashing method with perchloric acid and nitric acid while macro and micro element were separated using atomic absorption spectrophotometer (AAS) at the Department of Agronomy, University of Ibadan. Fatty acid profile was determined spectrophotometrically according to the methods of Baker (1964), Lowry and Tinsley (1976); while phytochemical analysis for saponin, phytate, oxalate, cyanogenic glucoside was according to the methods of Harbone (1973) and Marcano and Hasenewa (1991) at the Department of Animal Science, University of Ibadan. Amino acid analysis was by the use of Model 120A PTH Amino acid Analyzer at the University of Jos.

2.3 Statistical analysis

Samples were analyzed in replicate for proximate, phytochemical and fatty acid, data analysis was by descriptive statistics using IBM SPSS 20 and results reported as means ± SE.

3 Results

The proximate composition (Table 1) revealed high content of nutritional parameters except for crude fibre with least quantification. The least phytochemical parameters in Table 2 were the oxalate and cyanogenic glycoside. The mineral content analysis revealed the in the macro mineral calcium was least while potassium was highest (Table 3). In the micro mineral copper was least and iron highest in millipede sample analysed. The fatty acid profile (Table 4) indicated that of the saturated fatty acid, palmitic was highest and butyric least. The mono-unsaturated and poly-unsaturated fatty acid was highest in palmitoleic and linoleic respectively. The amino acid profile (Table 5) revealed methionine and tryptophan to be low among the essential amino acid.

Table 1 Nutritional content of millipede meal.

Parameters	(%)
Crude protein	63.24±0.05
Ether extract	11.70±0.09
Crude fibre	3.16±0.04
Ash content	10.23±0.04
Moisture content	11.03±0.12
Dry matter	88.98±0.12
NFE/CHO	11.68±0.06
ME(Kcal/kg)	3711.22±6.75

Table 2 Phytochemical content of millipede meal.

Parameters	(mg/100g)
Phytate	41.76±0.07
Chitin	24.43±0.04
Saponin	38.89±0.07
Oxalate	9.08±0.03
Cynogenic glycoside	8.23±0.05

Table 3 Mineral content of millipede meal.

Macro minerals	(%)	Micro minerals	(mg/kg)
Calcium	0.022	Manganese	36.00
Phosphorus	0.036	Zinc	20.60
Potassium	0.810	Copper	9.30
Sodium	0.072	Iron	219.50
Magnesium	0.204		

Table 4 Fatty acid profile of millipede meal.

Saturated Fatty Acid (SFA)	%
Acetic acid C2:0	0.64±0.01
Propoinic C3:0	0.27±0.02
Butyric C4:0	0.02±0.00
Valeric C5:0	0.09±0.00
Caprylic C8:0	0.18±0.01
Lauric C12:0	1.14±0.01
Myristic C14:0	2.83±0.04
Palmitic C16:0	35.05±0.06
Margaric C17:0	0.05±0.00
Stearic C18:0	5.41±0.02

Behenic C22:0	0.04±0.01
Ligonoceric C24:0	1.34±0.01
Mono-Unsaturated Fatty Acid (MUFA)	
Palmitoleic C16:1n7	1.16±0.01
Oleic C18:1n9	28.89±0.10
Poly-Unsaturated Fatty Acid (PUFA)	
Linoleic C18:2n6	1.63±0.02
Arachidonic C20:4n6	0.99±0.01

Table 5 Amino acid profile of millipede meal.

Essential amino acid	(g/100g)	Non-Essential amino acid	(g/100g)
Lysine	3.18	Aspartic acid	8.56
Histidine	1.75	Serine	3.45
Arginine	5.85	Glutamic acid	11.05
Threonine	2.99	Proline	2.84
Valine	3.27	Alanine	3.94
Methionine	0.96	Cystine	1.21
Isoleucine	2.55	Tyrosine	3.78
Leucine	6.18	Glycine	3.42
Phenylalanine	3.55		
Tryptophan	0.68		

4 Discussion

The proximate composition reported by Abulude and Folorunso (2003) was lower in terms of crude protein, fat and ash, although the mean protein (24.85%) composition still qualified millipede meal as an animal protein source. Ambarish and Sridhar (2015) composition of *Arthrosphaera fumosa* and *A. magna* ranged in protein content 8-15 %, fat 3.2-4.20 %, energy 941-1068 kJ were lower to this study. Likewise, the values of Ofoegbu et al. (2019) for *Eurymerodesmus spp.* with protein range of 3.67 % to 3.81 %, lipid 2.02 % to 2.14 %, ash content 2.63 % to 3.05 %; while the fibre 5.89 % to 5.98 % content was high than this study result. Similar protein composition (62.87%) was reported by Afolabi et al. (2019) with a lower energy level (2,243 kcal/kg). The presence of phytochemicals in non-conventional feed resources has been implicated for the lack of optimal intake and binding activity with other essential nutrients in the nutrition of livestock (NRC 1993). The phytochemical content of millipede meal (Table 2) revealed phytate, saponin and chitin to be high, while cynogenic glycoside and oxalate was low.

The presence of high phytate is due to the fact that raw millipede was analysed and not subjected to treatment according to Enghoff et al. (2014) and Afolabi et al. (2019). Alegbeleye et al. (2012) and Sule et al. (2021) reported the use of chitin in insect as it affects fish growth. While Ofoegbu et al. (2019) had earlier reported that chitin from *Eurymerodesmus spp.* can be extracted for use, which was in line with high chitin content of this study. Afolabi et al. (2019) reported no cyanogenic glycoside and oxalate in millipede, with a low phytate 6.17 detected. This is contrary to the observation for phytochemicals in this study. Sustr et al. (2013) reported that *A gigas* defensive secretion have medicinal importance as antifungal, antibacterial and antihelminthic properties. These secretions are phytochemicals in nature which have repellant; toxic against predators and antimicrobial effects of beneficial use (Sekulic et al., 2014), and cyanide gland in the diplopods secrets these repugnant defensive fluid (Pearson et al., 2017). According to Enghoff et al. (2014) cyanide level in millipede is tolerable to human and helps in curing mosquito induced malaria infection.

The high content of ash in millipede revealed the presence of beneficial mineral (Table 3) that aid the normal growth and precursor of other essential body functions. Abulude and Folorunso (2003) reported lower micro mineral profile for Zn, Fe and Mn; while Enghoff et al. (2014) reported Fe to be high in millipede. The result from this study aligned with Ambarish and Sridhar (2015) for Na 0.02-0.20 %; Mg 0.21-0.63 %; P 0.29-2.24 %, and contrary to K 0.07-0.46 % and Ca 4.68-12.73 %; while micro mineral elements of Mn 0.03-0.12 %; Zn 0.16-0.99 %; Cu 0.20-1.34 %, Fe 0.01-0.03 % were low in both sexes of *A. fumosa* and *A. magna.* Afolabi et al. (2019) reported Fe was low with high Mg, P and Ca which contradicts this study. Difference in collection location may be adduced to variation in the same species of *A. gigas.* Kania and Lechowski et al. (2014) stated that millipedes are involved in soil leaf litter decomposition and can bioaccumulate mineral element from polluted environment through its saprophytic feeding habit, as it also possesses the ability to detoxify heavy metals in the tissue with mineral concentration Ca, P, K, Mg, Fe and Cu in bodies of *G. hexasticha* reflected their concentration in soils. Adewale et al. (2021) also assert that mineral content of soil may be a factor for the accumulation of high mineral profile in millipede as reported for termite mound soils.

The fatty acid content of millipede meal (Table 4) revealed that of the saturated and mono-unsaturated fatty acid palmitic acid and oleic acid were high, respectively. Sekulic et al. (2014) noted that millipede contain C_{14} – C_{20} fatty acids. The report of Enghoff et al. (2014) on high palmitic acid 43.1 % and oleic acid 36.8 % were contrary to this study, this may be as result of species difference. Ambarish and Sridhar (2015) stated that SFA (Palmitic acid was high in both sexes of *A. fumosa* and *A. magna* with high MUFA (Oleic acid) which aligns with the result (Table 4).

Amino acids are necessary for the production of protein, when the dietary amino acid level have been met deficiency cease to occur due to imbalance. Table 5 revealed the essential and non-essential amino acid present in millipede meal. Amino acid for *T. falcatus* (Enghoff et al., 2014) was lower compared to this study. Ambarish and Sridhar (2015) reported higher methionine and lysine for sexes of *A. fumosa* and *A. magna* millipede. Sule et al. (2020) reported higher methionine and lysine for cockroach than millipede. NRC (1993) millipede meals meets the dietary amino acid requirement for juvenile catfish except for lysine, methionine and phenylalanine; while for Nile tilapia, tryptophan, threonine, phenyalanine, methionine, lysine and isoleucine may need to be supplemented.

This present study showed that millipede meal is a potential substitute for animal protein source with adequate proximate and other essential composition, while amino acid supplementation in diet may be inevitable.

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