Arthropods as an Alternative Protein Source in Experimental Rat Feed

Shittu, A.I[1*], Remi-Esan, I.A[2]

[1,2]*Federal Polytechnic Ilaro, Ilaro, Ogun State, Nigeria*

**Corresponding Author*

Abstract: **Research on the use of arthropods in animal diet is on the increase due to increasing fishmeal demand for animal feed. In this study, the use of cockroach, grasshoppers (*Zonocerus variegatus*) and crayfish as alternative protein source for rat feed was conducted and compared with fishmeal feed. The proximate analysis showed that a high crude protein values of 28.27%, 22.88%, 22.11% respectively for crayfish, cockroach, and grasshoppers. These arthropod enriched feeds showed they consist favourable amount of protein higher than fishmeal. Moisture content of 6.72%, 6.4% and 6.0%, crude fat of 16.13%, 14.51% and 3.51%, crude ash of 20.12%, 15.50% and 14.5% respectively. There was a considerable increase in weight of the rats fed with the arthropod enriched feed. The highest mean weight was recorded in rats fed with crayfish feed, followed by grasshopper then cockroach while the least mean weight was recorded in the rats fed with the control (fishmeal). Replacing the dietary fishmeal with arthropod fortified meal did not affect the growth pattern of the experimental rats and this is a positive indication that edible arthropods can be used as a substitute for fish protein in animal feed. It can also be incorporated into animal feed alongside fishmeal to further enrich the animal feed. In general, this study showed that protein meal from arthropods hold a great potential as a source of nutrients for rats.**

***Keywords*: Arthropods, fish meal, growth pattern, protein**

I. INTRODUCTION

Arthropods are ubiquitous and the largest, most populous group of animals in the animal kingdom. A major shift towards diet is characterized by increased consumption of animal products and the growing demand for fish feed is also increasing thus the need for alternative sustainable animal protein sources will become considerable in animal feed [1], [2].

Over the years, researches on nutrient composition of arthropods focus on insects because insects at all stages of their lives are rich sources of animal protein [3]. Insects constitute more species than all species of all other classes combined and are the most successful prolific group of organisms in the animal kingdom [4].

Insects can be considered as valuable sources of protein. Because of the high content of protein/amino acids and other nutrients in arthropods, they could serve as a substitute to traditional food of animal origin, such as milk, meat, and fish in human nutrition [5].Insects have been known to be important natural sources of food for many kinds of vertebrate animals and other mammals [4], [6]. Insects have played an important part in the history of human nutrition in Africa, Colombia, Venezuela, Asia and Latin America [7].[8]reported that scores of species of edible insects are prominent items of commerce in the town and village markets in Africa and semi-tropical regions of the world. Over the last few years, insects have been identified as an important future source of sustainable raw materials for animal feeds in many countries around the world. Crustaceans have also been reported to be nutritionally valuable and rich in high quality protein, minerals and vitamins [9], [10]. They have also been found to have low levels of fat and carbohydrates [11].

Most arthropods meet animals' dietary requirements in terms of nutritional composition, amino acid profile, and, as part of the natural diet of several animal species, feed acceptance [12], [13].The aversion of insects as human food is nothing more than custom and prejudices as rightly asserted by [14]. Hundreds of species of Arthropods have been used as human food in different parts of the world. Some important groups include grasshopper, termites, moth, caterpillars, roaches, crabs, cray fish[15]. Recent high demand and consequent high prices for fishmeal together with increasing aquaculture production, is pushing new research into the development of insect protein for different animal and human feed [16].It is therefore imperative to compare the growth pattern of animals fed with fishmeal and alternative arthropod fortified meal.

II. MATERIALS AND METHODS

A. Study area

The study was conducted in the Research Laboratory of Science Laboratory Technology Department, Federal Polytechnic Ilaro, Ogun State, Nigeria.

B. Insect collection

Three different insects were used for the experiment namely; Cockroach *Periplaneta americana* (an insect, Order Blattodea), Grasshopper *Zonocerus variegatus* (an insect, Order Orthoptera) and Crayfish *Cambarus sp* (a crustacean). Roaches were caught on the campus in homes, hostels and soak-away premises. Grasshoppers were hunted using nets and some were handpicked on fields. Crayfish was bought at Sayedero market in Ilaro. These arthropods were all collected over a period of 3 months to allow for large quantities needed for the experiment.

C. Feed composition

Feed components used were, soybean, wheat, corn and bone meal purchased at Sayedero market. Soybean, wheat, corn, bone meal and cockroach/grasshopper/crayfish were used for the experimental feed while the control feed contained soybean, wheat, corn, bone meal and fishmeal. For every 100g of feed made, 15g of soybean, 10g of corn, 40g of wheat meal, 5g of bone meal and 30g of protein (cockroach, grasshopper, crayfish) was used. For the control, the protein was replaced by 30g of fishmeal while other feed components remained the same quantity.

D. Animal study

A total of twelve rats were used for this experiment were purchased from the animal house at the Zoology Department of the University of Lagos, transported to Ilaro kept in a cage and allowed to acclimatize for 2 weeks while been fed with purchased feed premix, the purchased feed premix was entirely different from the experimental feed. After 2 weeks, the rats were placed in 4 different categories with 3 rats in each group. Rats in group A were given feed made of cockroach protein, Rats in group B were given feed made of grasshopper protein, Rats in group C were given feed made of crayfish while Rats in group D (control) were given feed made of fish protein for a period of 4 weeks. Their weekly weights were weighed and recorded.

E. Proximate analysis

The proximate composition (moisture content, crude protein, crude fibre and crude ash) of the feeds was analyzed in triplicate according to standard procedures in Association of Official Analytical Chemists [17].

Moisture content: 2g of the feed sample was weighed into a silica dish previously dried and weighed. The sample is then dried in an oven for 65^{0}C for 36 hours, cool in a desiccator and weigh. The drying and weighing continues until a constant weight is achieved.

Crude protein: 0.5g of feed sample was used and protein was determined by kjeldahl method. The method involved: digestion, distillation and finally titration with 0.2 NHCl and the crude protein was obtained by multiplying the total nitrogen by a conversion factor of 6.25.

Crude Ash: 2g of the sample was weighed into a pre-heated crucible. The crucible is placed into muffle furnace at 450^{0}C for 4hrs until whitish-grey ash was obtained. The crucible was then placed in the desiccator and weighed.

Crude Fibre: 2g of feed sample was digested with 0.128M H_2SO_4. Filtering and washing with boiling water were done to remove acid. Residue was boiled with 0.223M KOH for 30 minutes, then washed in boiling water and acetone. The residue was then dried in an oven at 130^{0}C for 2 hrs and ignited in a furnace at 500^{0}C for 3 hours. The loss of weight represented the crude fibre.

III. RESULT AND DISCUSSION

TABLE 1. WEIGHT OF CONSTITUENTS USED IN FEED FORMULATION.

Feed constituent/ ingredient	Weight (g) per 100g
Corn meal	10
Wheat meal	40
Soya beans	15
Fish meal/arthropod protein meal	30
Bone meal(animal premix)	5

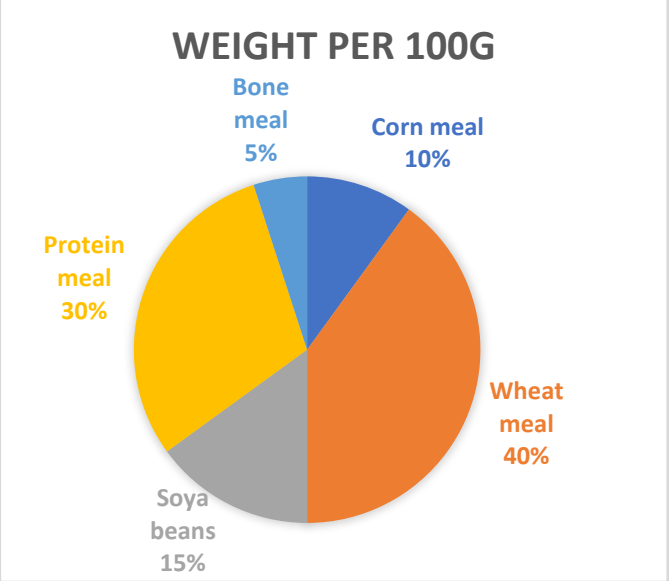

Figure 1: Shows the feed constituents indicating the weight per 100g

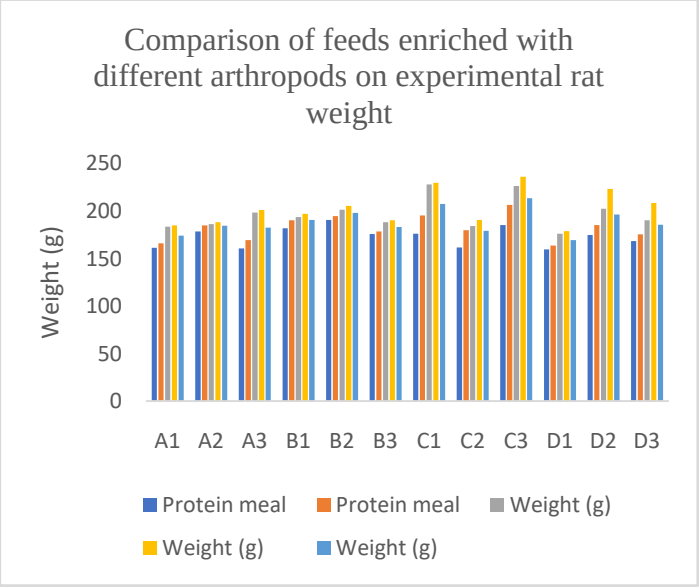

Figure 2: Weight of the rat as compared to the different arthropod-feed given

Key: A- Cockroach feed, B- Grasshopper feed, C- Crayfish feed, D- Fish feed (Control)

TABLE 2: PROXIMATE ANALYSIS OF THE DIFFERENT PROTEIN ANIMAL FEED

Feed CONTROL Composition	**A**	**B**	**C**	**D**
Moisture content	6.40	6.0	6.72	6.5
Crude ash (%)	15.50	14.5	20.12	10.0
Protein	22.88	22.11	28.27	20.78
Crude fat	14.51	3.51	16.13	13.92
Crude fibre	2.56	nil	2.56	3.50
A=Cockroach, B= Grasshopper, C= Crayfish, D= Fish				

Table 1 shows the weight of the constituents of the feed per 100g for the experimental feed used for the study while figure 1 indicates the percentage of each of the constituents used. For every 100g of feed made, 15g of soybean, 10g of corn, 40g of wheat meal, 5g of bone meal and 30g of protein (cockroach, grasshopper, crayfish and fish) were used. The feed containing the fish meal was used as a control in the experiment.

A laboratory animal's nutritional status strongly indicates its capability to reach its genetic potential for growth, reproduction, and longevity and to fight against pathogens and resist other environmental stresses. Figure 2 shows the difference in the weight (g) and the mean weight (g) of the rats used for the experiment over a period of 4 weeks using different protein feeds; cockroach, grasshopper, crayfish and fish meal (control). The chart above showed that in week 4, rat fed with crayfish C1 had the highest weight of 229g while rat fed with control fish meal, D1 had the lowest weight of 178.67 g. For cockroach feed, the highest mean weight was 184.35g while the lowest mean weight of 173.96g. For crayfish feed (B), the highest mean weight was 206.43g while the lowest mean weight was 175.20g. For grasshopper feed (C), the highest mean weight was 197.85g while the lowest was 182.97g. for the control fish feed (D), the highest mean weight was 196.25g while the lowest was 169.36g. Growth and reproductive performance are two important indicators of dietary adequacy. The study showed that all the feeds were of dietary adequacy because none of the rats showed a loss in weight over the weeks.

The mean weight for the different rat feed showed that crayfish, grasshopper and cockroach was higher than mean weight of the control fish feed. Protein is the major growth promoting factor in feed. The proximate analysis as showed in table 2 also indicates than the protein of the different feeds was highest in crayfish enriched (28.27), followed by cockroach enriched feed (22.88), then grasshopper enriched feed (22.11) while fish feed had the lowest protein content of 20.78. This compares favourably higher with the results recorded for fishmeal. [18]also observed a similar trend using Orthopteran and Lepidopteran.

Other proximate analysis showed moisture content was highest in crayfish feed (6.72%) and lowest in grasshopper feed (6.0%).In reference to [13], moisture content reduced to below 8% increases shelf-life of feed during storage. All the feed used for the experiment had moisture content below 8% which indicates that they can be stored for a longer period of time.

Crude ash content was highest in crayfish feed (20.12) and lowest in fish (10.0). Crude fat was also found to be highest in crayfish feed (16.13), followed closely by cockroach (14.51), then fish feed (13.92) and lowest in grasshopper feed (3.51). Crude fibre was found to be highest in the control fish feed and lowest in grasshopper feed in which no value was found.

IV. CONCLUSION

Recent studies aim to investigate the contribution of arthropods as a feed source in animal diets. This study however mainly focused on growth performance and nutrient composition of the different arthropods (crayfish, grasshopper and cockroach) used as substitute for fish feed in experimental rats. The investigation showed a protein content of Crayfish >Cockroach> Grasshopper >Fish feed in their nutritional composition. The growth rate pattern of the experimental rats used for the study also followed the same pattern with the highest mean weight found in the rat given crayfish feed while the lowest mean weight was found in the rat given the control fish feed for a period of 4 weeks.

Further studies on the use of arthropods as protein feed can be better investigated in other animals putting into consideration, the people's point of view about the alternative protein source in farm animals, potential customer's willingness to pay and preferences for this newfeed and assessing the risks and benefits associated with the introduction this new protein-rich arthropod feed.

REFERENCES

[1]. Belghit, I., Liland, N.S., Waagbo, R.; Biancarosa, I., Pelusio, N., Li, Y., Krogdahl, A. and Lock, E.J. (2018). Potential of insect-based diets for Atlantic salmon (Salmo salar). Aquaculture, 491, 72–81.

[2]. Lock, E.R., Arsiwalla, T. and Waagbo, R. (2016). Insect larvae meal as an alternative source of nutrients in the diet of Atlantic salmon (*Salmo salar*). Aquaculture Nutrition 22, 1202-1213.

[3]. Banjo, A.D., Lawal, O.A., Fasunwon, B.T. and Alimi, G.O. (2010). Alkali and heavy metal contaminants of selected edible arthropods in southern Nigeria. *American-Eurasian Journal of Toxicological Sciences*, 2(1):25-29.

[4]. Alamu, O.T, Amao, A.O, Nwokedi, C.I., Oke, O.A. and Lawa, I.O. (2013). Diversity and nutritional status of edible insects in Nigeria: A review. *International Journal of Biodiversity and Conservation*, 5(4): 215-222.

[5]. Shockley, M. and Dossey, A.T. (2014) Insects for Human Consumption. In: Morales-Ramos, J.A., Guadalupe Rojas, M. and Shapiro-Ilan, D.I., Eds., Mass Production of Beneficial Organisms: Invertebrates and Entomopathogens, Academic Press, Cambridge, MA, pp. 617-652.

[6]. Banjo, A.D., Lawal, O.A. and Sangonuga, E.A. (2006). The nutritional value of fourteen species of edible insects in

Southwestern Nigeria. *African Journal of Biotechnology* 5(3): 298- 301.

[7]. Chavunduka, D.M. (2010). Insects as a source of protein to the African. Rhodesian Science News 9:217-220.

[8]. DeFoliart, G.R. (2002) The human use of insects as a food resource. A bibliographic Account in Progress pp. 1-51.

[9]. Adeyeye, E.L. (2002). Determination of the chemical composition of the nutritionally valuable part of male and female West African fresh water crab, *Sudananautes africanus*. *International Journal of Food Science and Nutrition* 53 (3): 189-196.

[10]. Fagbuaro, O., Oso, J.A. Majolagbe, F.A and Oladapo, A.O. (2013) Quality Analysis of Feshwater Crab Cardisoma armatum and Marine Blue Crab *Callinectes amnicola* collected from Yaba, Lagos, Nigeria. *Nature and Science* 11 (8): 22-29.

[11]. Arazu, V.N and Udo, P.J. (2012). Feeding trails and proximate composition of Paraophiocephalus obscurus fed with three types of compounded feeds produced from local raw materials. Nigerian *Journal of Agriculture, Food and Environment*, 8(3): 47-51

[12]. Makkar, H.P.S., Tran, G., Heuzé, V. and Ankers, P. (2014). Review: State-of-the-art on use of insects as animal feed. *Journal of Animal Feed Science and Technology* 197: 1–33.

[13]. Sorensen, J.G. (2003). The evolutionary and ecological role of heat shock proteins. *Ecology Letters*, 6: 1025-1037.

[14]. Kent, G. (2002). Africa's Food security under Globalization. *American Journal of Engineering and Natural Sciences*. 2:22- 29.

[15]. Yoloye, V.L. (2010). Basic Invertebrate Zoology. 1st edition. University of Ilorin Press, Ilorin. pp 192.

[16]. FAO (2010). Review of food consumption data on edible insects: Food and Agricultural Organization/The International Network of Food Data Systems (INFOOD).

[17]. AOAC, (1980) Official Methods of Analysis. 13th Edition., Association of Official Analytical Chemist, Washington, DC., USA., pp. 56-132.

[18]. Omotosho, O.T. and Ogunleye, R. F. (2005). Edible orthopteran and Lepidopteran as protein substitutes in the feeding of experimental albino rats. *African Journal of Applied Zoology and Environmental Biology*, 7: 48-51.