

ESTABLISHMENT OF DIETARY SUPPLEMENT USING BLACK SOLDIER FLY LARVAE (*Hermetia illucens*) AS AN ALTERNATIVE SOURCE OF PROTEIN FOR GROWTH PERFORMANCE AND GENERAL WELLBEING OF POULTRY BROILER.

M Abdulkarim¹, G Yerima², R Sabo¹, B A Jinjiri¹, M Ali³, M A Saleh¹

¹Department of Science Laboratory Technology; Mai Idriss Aloomo Polytechnic P.M.B 1020 Geidam, Yobe State, Nigeria.

²Department of Biological Sciences; Yobe State University P.M.B 1144, Damaturu, Yobe State, Nigeria.

³Department of Intergrated Sciences; College of Education and Legal Studies P.M.B 021, Nguru, Yobe State, Nigeria.

Abstract

Backyard and large scale poultry farming largely relied on using well balance feed to effectively improve productivity, this resulted in increasing production cost which account for approximately 60-70% of total expenditure. To cut down this unnecessary expenses, there is a need to develop an alternative, inexpensive and effective substitute to replace the expensive ingredients especially protein during general feed formulation. Black soldier fly Larvae contains high quality protein which scientifically believed to be a recipe to replace expensive protein source like fish meal. The present research is aimed to established a dietary supplement using Black Soldier Fly Larvae (*Hermetia illucens*) as an alternative source of protein for growth performance and general wellbeing of poultry broilers. A total of 256 broiler chicks (day- old) were randomly allocated to 4 dietary treatments of 64 birds each as replicate. The group consist of; BSFL₀ (control), followed by BSFL₁, BSFL₂, and BSFL₃ with different BSFL meal inclusion levels of 0%, 5%, 10% and 15% respectively. There is no clinical sign and mortality recorded during the course of the trial. However, the experimental group BSFL₃ recorded the highest final body weight(4006g) which is significantly ($p<0.05$) different compare to BSFL₁ with final body weight of (3886g), but significantly ($p>0.05$) similar to BSFL₀ (control) and BSFL₂ groups with final body weight of (3972g) and (3956g) respectively. In regards to their average daily feed intake (ADFI), there is no significance different between all the groups. The present study have revealed that, the conventional protein source; fish meal can be replaced with black soldier fly larvae meal in broiler diets without any adverse effect on growth performance and general wellbeing of poultry broiler.

Index Terms: Broilers, Black Soldier Fly Larvae, poultry feed, protein source, Fish meal.

1. Introduction

Insects are increasingly proposed as a component of feed for monogastric animals such as poultry and fish, as a replacement for conventional protein sources that are becoming increasingly expensive and considered unsustainable (van Huis 2013; van Huis et al. 2013; Makkar et al. 2014). Fly larvae are particularly recommended for this purpose because they contain a high amount of animal protein (Makkar et al. 2014) and because they can be produced rapidly and at low costs on organic wastes (Diener et al. 2011a; van Huis 2013; Kenis et al. 2014, Pastor et al. 2015). The demand for animal-derived protein sources will increase due to the combined effects of the growing human population and rising living standards in developing countries (FAO, 2009). Scarcity of resources has increased prices of animal feedstock during the last years, which represents 60-70% of production costs of animal production systems and results in competition between human food and animal feed. For instance, use of ingredients like fishmeal, fish oil, soybean meal and grains is on the rise in both human food and animal feed (Van Huis, 2013). Insects are proteinaceous (Bosch et al., 2014) and have high feed conversion efficiencies and growth rates (Van Huis, 2013), making them a high quality and potentially profitable feedstuff for animals production (DeFoliart, 1989; Veldkamp et al., 2012) The black soldier fly (BSF; *H. illucens*) is native to the Americas and is widespread from Argentina to central USA, throughout tropical and temperate regions (Sheppard et al., 1994). Transported by humans, BSF has established in Australia, India, Africa and Europe (Gujarathi and Pejaver, 2013; Martínez-Sánchez et al., 2011), because BSF can tolerate a broad range of environmental conditions (light, temperature, humidity).

For use as animal feed, BSF has several major advantages over other insect species. The species is polyphagous and its gut extracts have high amylase, lipase and protease activities (Kim et al., 2011). Thus, it is employed in sustainable recycling of animal waste (Myers et al., 2008; Nguyen et al., 2013; Newton et al., 2005b; Sheppard et al., 1994), faeces (Diener et al., 2009; Lalander et al., 2013; Oonincx et al., 2015a), and other types of organic waste (Diener et al., 2011; Green and Popa, 2012; Gujarathi and Pejaver, 2013; Kalová and Borkovcová, 2013; Nguyen et al., 2013; Rachmawati et al., 2010), turning bio-waste into a high quality nutrient source for animal feed (Veldkamp et al., 2012). As a result, BSF larvae have been used as feed for a variety of animals, including swine, poultry, and fish, and is being explored as an important ingredient for pet food.

Moreover, BSF is not a pest, so its rearing requires no specific precautionary measures and it reduces the presence of harmful bacteria (Erickson et al., 2004; Liu et al., 2008) in contrast to other dipteran species such as the house fly, *M. domestica*. The list of ‘services’ that have been developed includes the conversion of liquid manure and other domestic and agro-industrial waste types into a source of animal proteins (Caruso et al., 2014). Because of the valuable nutrient content of the Black soldier fly larvae, they can be employed as the basis of a highly promising technology to sustain a circular economy, which is the concept of an economy that is producing no waste and reducing consumption of raw materials and energy by improving their utilisation, based on the interrelationships between the environment and economics. This concept will contribute to remediating the expected future scarcity of sufficient, nutritious and healthy food.

Black soldier fly larvae and prepupae, grown on swine manure or kitchen waste, have been used satisfactorily as a feed additive for young chicks (Hale, 1973). Partial replacement of soymeal (10-20%) for broilers showed a production performance, feed efficiency, mortality and carcass traits similar to those fed on commercial diets (Arango Gutiérrez, 2005; Cullere et al., 2016; Zhang et al., 2014b). The partial (50%) or full replacement of soybean cake by partly defatted BSF larval meal in a diet for layers did not affect their laying performance, nor feed efficiency, if compared to organic standard diets for layers (Maurer et al., 2016).

The high apparent metabolisable energy and the amino acid apparent ileal digestibility coefficients of BSF larval meal, also make it a valuable ingredient for use in the formulation of broiler feeds (De Marco et al., 2015). Additionally, Arango Gutiérrez (2005) suggested BSF larvae have a suitable mineral content for the nutrition of poultry, according to broiler mineral requirements, cited by the National Research Council (NRC, 1994).

According to Gura (2008), competition between food, feed and agro-fuels is expected to increase prices of poultry feeds that enforce poultry farmers to look for alternative and locally available feed sources. The current research was designed to establish dietary supplement using BSF Larvae as an alternative protein source to replaced fish meal at different inclusion levels on growth performance of broiler chicks.

1.2 Nutritional Composition of BSF Larvae

The DM content of fresh larvae is quite high (35–45%), which makes them easier and less costly to dehydrate than other fresh by-products (Newton et al. 2008). Proximate analysis of BSF larvae contained 41.1–43.6% crude protein (CP), 15.0– 34.8% ether extract (EE), 7.0% crude fibre (CF), 14.6–28.4% ash and 5278.49 kcal/kg gross energy (GE) on DM

basis (Arango Gutierrez et al. 2004; St-Hilaire et al. 2007). Arango Gutierrez et al. (2004) reported that larvae are rich in calcium (Ca; 5–8% DM) and phosphorus (P; 0.6–1.5% DM), however, other minerals profile is potassium (K; 0.69% DM), sodium (Na; 0.13% DM), magnesium (Mg; 0.39% DM), iron (Fe; 0.14% DM), manganese (Mn; 246 mg/kg DM), zinc (Zn; 108 mg/kg DM) and copper (Cu; 6.0 mg/kg DM).

.2.0 Materials and Methods

2.1 Study Site

The study was conducted at Mai Idriss Aloomo Polytechnic Geidam , department of Science Laboratory Technology. Geidam is one among the 17 local government area of Yobe State , with a longitude 12⁰ 53'49''N and latitude 11⁰ 55'49''E. It has an area of 4,357km² and a population of 157,295 according to 2006 census.

2.2 Rearing of BSF Larvae

The male and female species of Black soldier fly was obtained from population stock and subjected to grow invitro under aseptic care in laboratory where mass production of the larvae were carried out using the method described by Devic et al., (2014). the culture of the larvae were harvested, washed and dried for two hours in electric oven. The dried larvae were grounded in to powder and used for feed formulation at different inclusion levels.

2.3 Experimental Animal

Two hundred and fifty six (256) Broilers day old chicks were purchased from reputable hatchery for the research. Upon arrival, the chickens was subjected to one week acclimatization and were fed with commercial feed.

2.4 Experimental Diets

Four experimental diets were formulated for both starter and finisher phases of broilers. In the experimental diets, BSFL completely replaced fish meal in BSFL1, BSFL2 and BSFL3 respectively whiles the remaining component of the diets remained same in all the treatments.

2.5 Experimental Design

The experimental design were consisted of four (4) groups of 64 broiler chickens each as replicates, and were treated with different experimental diet for the period of eight weeks (2 months).The groups consisted of

BSFL₀; Serve as control group, chicks were fed with 100% conventional /commercial diet + 0% BSFL meal.

BSFL₁; Fish meal replaced with 5% BSFL meal.

BSFL₂; Fish meal replaced with 10% BSFL meal.

BSFL₃; Fish meal replaced with 15% BSFL meal .

2.6 Management of Experimental Bird

As the experiment did not required any form of restriction, feed and water were provided to the chicks ad libitum. Routine and periodic management practices such as vaccination and maintenance of cleanliness of the poultry cages were carried out. Sanitation and isolation of sick birds aimed at preventing diseases were put in place throughout the period of the experiment.

2.7 Growth Performance

Clinical sign and mortality of the chicks were monitored on a daily bases throughout the period of the experiment. Body weight and feed intake was recorded on a weekly bases until the end of the study period of two (2) months (56 days).

2.8 Statistical Analysis

Data on weight gain , feed intake and mortality was analysed using a one way analysis of variance (Anova) with the four BSFL meal inclusion levels (0% , 5% , 10% , and 15%) being the factors. Significance was declared at 5% ($p < 0.05$)

3.0 Results and Discussion

3.1 Body weight

There is no clinical sign and mortality recorded during the course of the trial. However, the experimental group BSFL₃ (15% bsfl meal inclusion) recorded the highest final body weight(4006g) which is significantly ($p < 0.05$) different compare to BSFL₁ (5% bsfl meal inclusion) with final body weight of (3886g), but significantly ($p > 0.05$) similar to BSFL₀ (control) and BSFL₂ (10% bsfl meal inclusion) groups with final body weight of (3972g) and (3956g) respectively as shown in Figure 1. In term of average daily feed intake (ADFI), BSFL₃ have slightly higher ADFI, although not significantly different compare with other experimental groups.

This result indicated the potency of black soldier fly larvae meal as a valuable source of energy and digestible amino acids for chicken, thus being a potential feed ingredient for poultry broiler diets in the near future(De Marco M et al, 2015). The result agree with other trial that tested BSFL as an alternative source of protein to replace conventional protein sources like fish meal and soybean meal, and revealed positive results in terms of productive performance (Oluokun J A et al , 2000). Cullere et al., (2016) reported similar results when intensively reared growing quails were fed on defatted BSFL meal. Elwert et al., (2010) observed similar results when full fat BSFL meal were included in broiler starter

diets. Leiber et al., (2015) conducted a study to determine the effect of including BSFL meal as an insect based protein source in slow growing organic broilers diets on the growth performance and physical meat quality of the birds. Their finding indicated that similar feed efficiency and product quality can be attained when part of conventional protein sources are replaced by insect meal in broiler diets. Therefore, it can be deduced that dietary inclusion of BSFL meal in broiler diets had no adverse effect on growth performance and general wellbeing of broiler chicken.

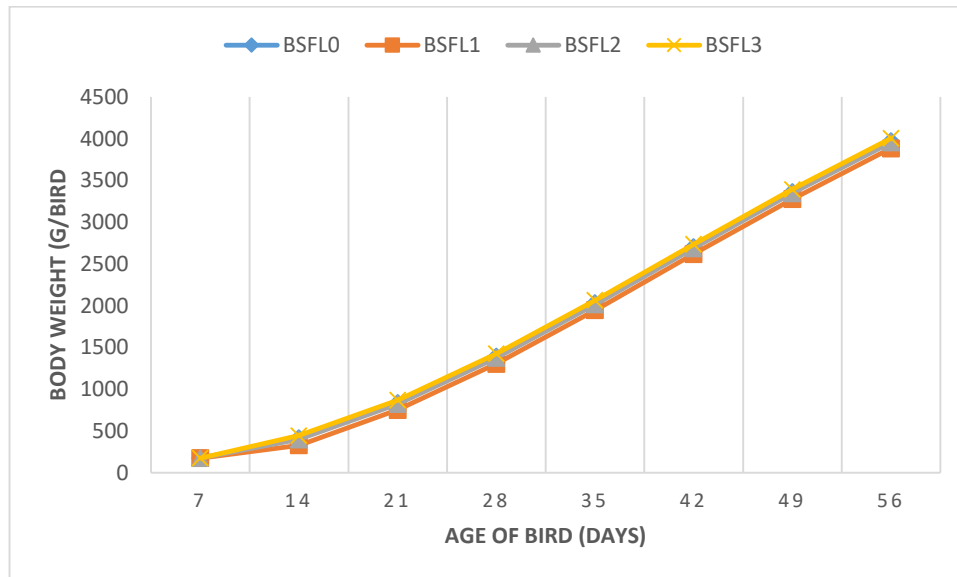


Figure 1: Effect of dietary replacement of fish meal with BSFL meal in broiler diets on body weight.

Conclusion

The present study have revealed that, the conventional protein source; fish meal can be replaced with black soldier fly larvae meal in broiler diets without any adverse effect on growth performance and general wellbeing of poultry broilers. Although these results are promising, BSF Larvae are not common in the study area and therefore further work to promote its rearing and commercialization is needed in order to achieve the full potential of its use as an alternative protein source for broiler chickens and redirecting fish and soybean to direct human consumption.

Acknowledgements

The authors thank Tertiary Education Trust Fund (TETFund) for funding this research and the management of Mai Idriss Aloomo Polytechnic Geidam for their support.

References

- Arango Gutiérrez, G.P., 2005. Aportes nutricionales de la biomasa de *Hermetia illucens* L. (Diptera: Stratiomyidae) en la cría de pollos de engorde. MSc thesis, Universidad Nacional de Colombia, Bogotá, Colombia.
- Arango Gutiérrez, G.P., Vergara Ruiz, R.A. and Mejía Vélez, H., 2004. Compositional, microbiological and protein digestibility analysis of the larva meal of *Hermetia illucens* L. (Diptera: Stratiomyidae) at Angelópolis Antioquia, Colombia. *Revista Facultad Nacional de Agronomía, Medellín* 57: 2491-2500
- Booth, D.C. and Sheppard, D.C., 1984. Oviposition of the black soldier fly, *Hermetia illucens* (Diptera: Stratiomyidae): eggs, masses, timing, and site characteristics. *Environmental Entomology* 13: 421-423.
- Bosch, G., Zhang, S., Oonincx, D.G.A.B. and Hendriks, W.H., 2014. Protein quality of insects as potential ingredients for dog and cat foods. *Journal of Nutritional Science* 3(e29): 1-4. 17
- Caruso, D., Devic, E., Subamia, I., Talamond, P. and Baras, E., 2014. Technical handbook of domestication and production of Diptera black soldier fly (BSF), *Hermetia illucens*, Stratiomyidae. IRD, Jakarta, Indonesia, 141 pp. Available at: <http://tinyurl.com/n7t8bt4>.
- Cullere, M., Tasoniero, G., Giaccone, V., Miotti-Scapin, R., Claeys, E., De Smet, S. and Dalle Zotte, A., 2016. Black soldier fly as dietary protein source for broiler quails: apparent digestibility, excreta microbial load, feed choice, performance, carcass and meat traits. *Animal* 10: 1923-1930.
- De Marco M et al 2015 *Anim. Feed Sci. Technol.* 209211-218.
- Diener S, Zurbrügg C, Gutiérrez FR, Nguyen DH, Morel A, Koottatep T, Tockner K (2011b) Black soldier fly larvae for organic waste treatment—prospects and constraints. In: *Proceedings of the WasteSafe — 2nd international conference on solid waste management in the developing countries, Khulna, Bangladesh, 13–15 Feb 2011*
- FAO, 2009. Report of the FAO expert meeting on how to feed the world in 2050. An analysis of the poultry Sector in Ethiopia, poultry Sector Country Review. <ftp://ftp.fao.org/docrep/fao/012/ak542e19.pdf>
- Gobbi, P., Martínez-Sánchez, A. and Rojo, S., 2013. The effects of larval diet on adult life-history traits of the black soldier fly, *Hermetia illucens* (Diptera: Stratiomyidae). *European Journal of Entomology* 110: 461.
- Gura, S., 2008. Industrial livestock production and its impact on smallholders in developing countries. Consultancy Report to the league for pastoral peoples and Endogenous Livestock Development, Germany, pp;65. http://www.pastoralpeoples.org/docs/gura_ind_livestock_pro.pdf 18
- Gujarathi, G. and Pejaver, M., 2013. Occurrence of black soldier fly *Hermetia illucens* (Diptera: Stratiomyidae) in biocompost. *Research Journal of Recent Sciences* 2: 65-66.

- Makkar HPS, Tran G, Heuzé AP (2014) State-of-the-art on use of insects as animal feed. *Anim Feed Sci Tech* 197:1
- Mangesha, M. and S. Abda, 2010. Performance and carcass characteristics of broilers fed selected energy source feeds. *Res. J. Poult. Sci.*, 3; 54-57
- Newton GL, Watson DW, Dove R, Sheppard C, Burtle G (2005) Using the black soldier fly, *Hermetia illucens*, as a value added tool for the management of swine manure. Report for Mike Williams, Director of the animal and poultry waste Management Center, North Carolina State University, Raleigh
- Oluokun J A 2000 Niger J. Anim. Sci. 3. Available at: <http://www.ajol.info/index.php/tjas/article/view/49768>.
- Pastor B, Velasquez Y, Gobbi P, Rojo S (2015) Conversion of organic wastes into fly larval biomass: bottlenecks and challenges. *J Insects Food Feed* 1:179– 193
- Sheppard, C.D., Tomberlin, J.K., Joyce, J.A., Kiser, B.C. and Sumner, S.M., 2002. Rearing methods for the black soldier fly (Diptera: Stratiomyidae). *Journal of Medical Entomology* 39: 695-698.
- Sheppard, D.C., 1983. House fly and lesser fly control utilizing the black soldier fly in manure management systems for caged laying hens. *Environmental Entomology* 12: 1439-1442.
- Sheppard, D.C., Newton G.L. and Burtle, G., 2008. Black soldier fly prepupae a compelling alternative to fish meal and fish oil. Public comment prepared in response to a request by the National Marine Fisheries Service Nov. 15, 19 2007, NOAA 15/11//2007-29/2/2008. Available at: <http://tinyurl.com/l28f34a>
- Sheppard DC, Newton LG, Thompson SA, Savage S (1994) A value added manure management system using the black soldier fly. *Bioresour Technol* 50:275– 279
- Sheppard DC, Tomberlin JK, Joyce JA, Kiser BC, Sumner SM (2002) Rearing methods for the black soldier fly (Diptera: Stratiomyidae). *J Med Entomol* 39:695–698
- Tomberlin, J.K. and Sheppard, D.G., 2002. Factors influencing mating and oviposition of black soldier flies (Diptera: Stratiomyidae) in a colony. *Journal of the Entomological Society* 37: 345-352.
- Zhang J, Huang L, He J, Tomberlin JK, Li J, Lei C, Sun M, Liu Z, Yu Z (2010) An artificial light source influences mating and oviposition of black soldier flies, *Hermetia illucens*. *J Insect Sci* 10:202.