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Research Article
Growth Performance and Haematological Parameters of Cockerel Fed House Fly Larvae as a Substitute to Fish Meal

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Abstract

Background and Objective: Maggots seem to be one of the promising alternatives of animal protein for livestock. One of the characteristics of the Far-North Region, Cameroon, is the abundance of house flies during the hot ambient periods of the year. The present work aims to produce maggots and assess the growth performance and physiological status of cockerel-fed maggot meal as a protein substitute for fish meal. **Materials and Methods:** For this purpose, 40 cockerels (6 weeks), weighing 151.08±35.27 g, all from a producer of layer chicks, were used. Birds were randomly allocated to 4 treatments, each containing 10 cockerels. The 4 treatment groups were respectively fed different diets from the beginning to the end of a 5th week experiment. Formulated diets contained maggot meal (MM) and substituting fishmeal (FM) at graded levels, 0, 25, 50 and 75%. Throughout the experiment, feed intake, weight gain and feed conversion ratio were recorded weekly. At the end of the experiment, haematological parameters and production costs were evaluated. **Results:** The daily feed intake, the daily energy intake, the daily protein intake and the feed conversion ratio were not significantly ($p>0.05$) different between treatments. As compared to a diet containing only fish meal (R_0), the daily body weight gain of cockerels fed on a diet containing 75% maggot meal was significantly lower ($p<0.01$). As compared to a diet containing only fish meal, the feed cost per kg of body weight gain, obtained in cockerels fed a 75% maggot meal diet, increased by 14.5%. Haematological parameters were not affected by treatments ($p>0.05$). **Conclusion:** From this study, it can be concluded that the house fly maggot meal can be used safely in cockerel nutrition but fish meal replacement by house maggot meal should not exceed 50% in cockerel.

Key words: Maggots, fish, growth, physiological response, digestibility, groundnut meal, agroecology

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The growth in poultry production is having a huge effect on the availability of high-quality feeds and consequently on feed cost[1]. High-quality feeds and nutrient balance are critical for high productivity and efficiency. The genetic potential of chicken is well expressed with properly formulated feeds that are protein- and energy-dense[2]. In poultry, protein supplies amino acids for tissue building and reparation, muscle growth and synthesis of egg protein[1]. In most developing countries, the main conventional feed resources of protein are soya bean meal, groundnut meal, cottonseed meal or fish meal. They are expensive and used extensively by other livestock and humans[3]. Among those sources, fish meal is the only source of animal protein. Fish stocks are overexploited and one of the consequences is the low availability of fish meal for livestock[4]. It is well established that animal proteins contain all the essential amino acids meanwhile plant-based proteins are rich in some amino acids but may lack others[5]. Moreover, the chemical analysis of plant sources showed lower protein content as compared to animal sources. Plant sources are also rich in anti-nutritional compounds that reduce digestibility and nutrient assimilation[4]. The attention of researchers has been focused on unconventional alternative sources of animal protein. Such alternatives should have comparative nutritive value but are cheaper than the conventional feed ingredients[6]. Maggots seem to be one of the promising alternatives to animal protein for livestock. Several studies reported that the crude protein content of maggot range between 25-64%, which is comparable to that of fish meal[7,8]. Moreover, the amino acids profiles in black soldier fly larvae and maggots seem to be suitable for poultry. Chemical analysis of maggots showed the presence of all the essential amino acids[9,10]. The effects of the house fly larvae and black soldier fly larvae on poultry production performance have been carried out in early studies. In broiler chicken, it has been reported that maggot meal could suitably replace fish meal in broiler diets[11-14]. Fanadzenyuy *et al.*[15] obtained better carcass characteristics performance in broiler chickens fed 100% maggot meal as a protein substitute for fish meal. Inversely, other authors showed that the growth performance was better with 50% fish meal substitution by maggot meal[6]. In young turkeys, Agodokpessi *et al.*[16] pointed out that fish meal replacement by maggot meal at 50 and 100% in the starter diet, improved the feed conversion ratio. The heterogeneity across findings in studies may reflect the great variation reported in the chemical composition of maggots. Those variations may be related to the type of substrate[8], production locality[17] or production methods[18,19]. Moreover, substrates usually used for maggot production can be a source of the potential accumulation of chemicals and pathogens[20].

The influence of the production locality is likely related to an environmental condition such as temperature or humidity[19]. In Cameroon, many studies on maggot production have been carried out in the soudano-guinean agroecology area but none was done in the Sahelian area such as the Far North. One of the characteristics of this region is the abundance of house flies during the hot ambient periods of the year. The objective of this work was then to evaluate the maggot production during the hottest season of the year and assess the growth performance and physiological status of cockerel fed maggot meal as a protein substitute for fish meal.

MATERIALS AND METHODS

The present work was carried out in two experiments: In the first experiment, the maggot production in the different substrate was evaluated, with and without attractive substances, in the second experiment, maggots produced from ruminal content was used as a protein substitute for fish meal in cockerel.

Experiment 1: Maggot production in the different substrates and attractive substances

Study area: The study was conducted at the Teaching and Research Farm of the University of Maroua, located in Maroua (latitude: 10°35'N, longitude: 14°19'E, altitude 384 m), from March-May, 2021. The climatic characteristics of the city at the time of the study were recorded in Table 1.

Production substrates and attractive substances: To assess the effect of the type of substrate on maggot production, three substrates were used: Ruminal content, cow dung and pig manure. The fresh cow dung and ruminal content were collected at the slaughterhouse of Makabaye in the Maroua 1 subdivision, meanwhile, the pig manure was collected from a private piggery in Makabaye. Fish waste, mango puree and fresh bovine blood were used as housefly attractive.

Experimental design: The maggot production was assessed in two tests. The first testing consisted of evaluating the production of three substrates (ruminal content, cow dung and pig manure) enriched with fish waste. For the second testing, the maggot production was evaluated in ruminal content enriched with fish waste, mango puree or fresh bovine blood. For each test, the experimental design consisted of 3 treatments repeated 3 times. Each repetition consisted of

Table 1: Weather data in Maroua during the experiment

Months	Mean temperature (°C)	Maximum temperature (°C)	Minimum temperature (°C)	Wind speed (km h^{-1})	Humidity (%)
March, 2021	33	40	26	17	22
April, 2021	36	41	30	16	21
May, 2021	36	40	31	15	40

Source: cds.climate.copernicus.eu

Table 2: Ingredients and nutrient composition of experimental diets

Ingredients	R_0	R_{25}	R_{50}	R_{75}
Maize	61	61	61	61
Corn bran	6	6	6	6
Premix*	5	5	5	5
Cotton cake	13	13	13	13
Soybean meal	6	6	6	6
Fish meal	5	3.75	2.5	1.25
Maggots meal	0	1.25	2.5	3.75
Palm oil	2	2	2	2
Bone meal	1	1	1	1
Oyster shell	1	1	1	1
Total	100	100	100	100
Calculated values				
ME (kcal kg^{-1})	3005.8	3012.54	3019.28	3026.02
CP (%)	20.54	20.16	19.78	19.39
Energy/protein	146.33	149.43	152.64	156.06

ME: Metabolizable energy, CP: Crude protein, *Premix: CP = 40%, ME: 2078 kcal kg^{-1}, Calcium: 8%, Phosphorus: 2.05%, Lysine: 3.3% and Methionine: 2.4%

6 half cans of 20 L. In one container, 2 kg of substrate enriched or not with 250 g of attractants were introduced. After 24 hrs of sowing, the containers were covered with non-impregnated mosquito nets. The maggots were harvested on the 5th day after sowing.

Data collection: After harvesting, fresh maggot biomass was determined. The chemical composition was estimated accordingly to the methodology described by Helrich and AOAC[21], at the lab of nutrition and animal feed of the Faculty of Agronomy and Agricultural Sciences (The University of Dschang).

Experiment 2: Growth performance and physiological status of cockerel fed maggot meal as a protein substitute for fish meal

Experimental animals: A total of 40 cockerels (6 weeks), weighing 151.08±35.27 g, all from a producer of layer chicks, were used. They were allowed to acclimate for a week at the farm. Chicks were kept under similar environmental and managerial conditions during the experiment (5 weeks). Feed and water were given ad libitum in adapted equipment.

Experimental design: Birds were randomly allocated to 4 treatments, each containing 10 cockerels. The 4 treatment groups were, respectively fed different diets from the beginning to the end of a 5th week experiment. Formulated diets contained maggot meal (MM) substituting fish meal (FM) at graded levels, 0, 25, 50 and 75% (Table 2). Maggots were produced at the farm and sent for analysis at the Lab of nutrition and animals feed of the Faculty of Agronomy and Agricultural Sciences (The University of Dschang). Other ingredients were purchased from the local market.

Data collection: Feed intake, weight gain and feed conversion ratios were recorded weekly. The economic evaluation was also done by determining: Cost/kg feed consumed, Feed cost/kg weight gain. Estimations were done based on the local cost of each ingredient. In the 5th week of the experiment, blood was collected from an ulnar vein of 6 birds/treatment. Blood was collected into tubes containing the anticoagulant Ethylene Diamine Tetra-acetate (EDTA) to prevent clotting. Each blood sample collected was subjected to haematological analysis of Red Blood Cell (RBC), hemoglobin, Packed Cell Volume (PCV), erythrocyte indices and platelets in the laboratory. Haematological analyses were performed using an automatic analyzer, SNFS BC30S.

Data analysis: Data collected were presented as Mean±Standard Deviation. Data were subjected to a one-way analysis of variance (ANOVA) at a significance level of $p<0.05$ following the general linear model procedure. When differences were significant between means, the Tukey test was used to separate means. All statistical analyses were performed using GraphPad Instat 3.1.

RESULTS

Experiment 1: Maggot production

Type of substrate and attractants in production: The fresh biomass of maggot produced in three substrates (ruminal content, pig manure or cow dung) were presented in Fig. 1. Fresh biomass of maggot was significantly lower ($p<0.0001$) in cow dung as compared to values of this parameter obtained in other substrates.

The fresh biomass of maggot produced in ruminal content enriched with fish waste, mature mango puree or fresh bovine blood as illustrated in Fig. 2. Maggot production in ruminal content enriched with fish waste was significantly higher ($p<0.0001$) than that obtained with other attractants. However, the production registered in ruminal content enriched with mature mango puree or fresh beef blood was statistically ($p>0.05$) comparable.

Type of substrate and attractants on the chemical composition of maggot: The chemical composition of maggot produced in ruminant content, pig manure, cow dung or in ruminant content enriched with fish waste, mature mango puree or fresh bovine blood were summarized in Table 3. The highest values of dry matter, ash and fat and the lowest value of crude protein were recorded with maggot produced in ruminal content.

Maggot produced in ruminal content enriched with fish waste, mature mango puree or fresh bovine blood showed variation in crude protein content. The highest value was obtained with maggot produced in ruminal content enriched with fresh bovine blood.

Experiment 2: Growth performance and physiological response

Growth performance: Growth parameters of cockerel fed on diets containing maggot meal at the graded level were presented in Table 4. Results showed that the daily feed intake, daily energy intake, daily protein intake and the feed conversion ratio were not significantly ($p>0.05$) different between treatments. Although, the highest values of the daily feed intake, daily energy intake, daily protein intake and daily body weight gain were obtained with a diet containing only

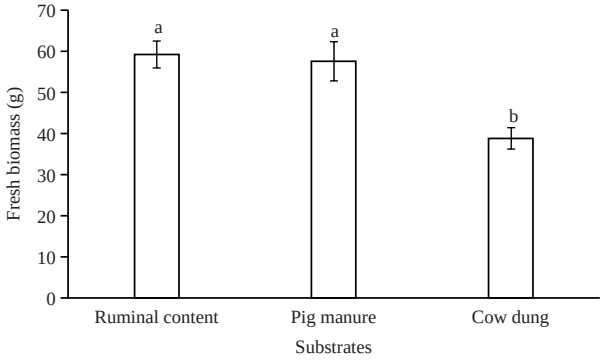

Fig. 1: Fresh biomass of maggot produced in three different substrates

Mean values with a different superscript in a row differ significantly ($p<0.05$)

Table 3: Chemical composition of maggot

	Dry matter	Ash (% DM)	Organic matter (% DM)	Fat (% DM)	Crude protein (% DM)
Type of substrate					
Ruminal content	86.45	9.13	89.44	20.23	25.68
Pig manure	72.1	3.11	96.88	10.08	36.055
Cow dung	76.5	8	89.54	9.035	33.61
Type of attractants					
Ruminal content+fish waste	86.43	8.97	89.62	20.21	25.66
Ruminal content+mature mango puree	85.7	7.62	91.1	22.98	26.83
Ruminal content+fresh bovine blood	86.72	5.915	93.405	18.715	31.09

Table 4: Growth parameters of cockerel fed on diets with different content of maggot meal

Parameters	R_0	R_{25}	R_{50}	R_{75}	p-value
Daily feed intake (g)	49.01±5.01	46.3±5.33	48.48±4.91	45.66±2.66	0.485
Daily energy intake (kcal)	147.34±33.02	139.49±34.66	146.37±31.89	138.17±20.89	0.485
Daily protein intake (g)	10.06±2.25	9.33±2.32	9.59±2.08	8.85±1.33	0.095
Daily body weight gain (g)	15.4±4.09^{a}	13.44±4.99^{ab}	13.61±3.26^{ab}	11.87±2.98^{b}	0.003
Feed conversion ratio	3.16±0.06	3.46±0.34	3.55±0.41	3.94±0.83	0.319
Economic evaluation cost/kg feed consumed (CFAF)	429.02	424.5	419.77	415.14	
Feed cost/kg weight gain (CFAF)	1365.34	1462.37	1495.24	1596.89	

Mean values with a different superscript in a row differ significantly ($p<0.05$)

Table 5: Haematological parameters of cockerel fed on diets with different content of maggot meal

Parameters	R_0	R_{25}	R_{50}	R_{75}	p-value
RBC (10^{12} L^{-1})	2.252±0.105	2.274±0.083	2.216±0.136	2.236±0.163	0.901
HG (g L^{-1})	128.6±6.188	129±5	126.4±7.569	128.2±8.167	0.934
PCV (%)	28.14±1.705	28.28±0.864	27.16±1.745	27.64±1.659	0.654
MCV (fl)	124.86±4.267	124.2±3.607	122.6±4.186	123.76±2.612	0.806
MCH (pg)	57.14±1.192	56.76±1.781	57.18±1.505	57.34±0.618	0.917
MCHC (g L^{-1})	458±9.513	457.2±10.779	466.6±10.039	463.4±5.366	0.343
PLT (10^9 L^{-1})	6.6±1.673	7±3.082	6.4±1.516	5.4±1.516	0.656

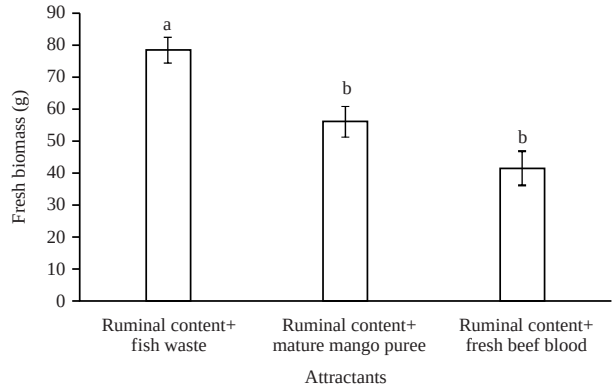

Fig. 2: Fresh biomass of maggot produced in ruminal content enriched with fish waste, mature mango puree or fresh bovine blood

Mean values with a different superscript in a row differ significantly ($p<0.05$)

fish meal (R_0). The lowest value of feed conversion ratio was also registered in cockerel fed diet R_0. As compared to a diet containing only fish meal (R_0), the daily body weight gain of cockerels fed on a diet containing 75% maggot meal was significantly lower ($p<0.01$).

Production cost: The economic evaluation of the diets used in this study was presented in Table 4. It comes out from this table that the cost of kg feed consumed decreases with the increase of maggot meal in the diet. Inversely, feed cost per kg body weight gain increased with maggot meal quantity in diet. As compared to a diet containing only fish meal, the feed cost per kg of body weight gain, obtained in cockerels fed a 75% maggot meal diet, increased by 14.5%.

Haematological parameters: Irrespective of treatment (Table 5), Red Blood Cell count, Haemoglobin, Pack Cell Volume, platelet cell count and other haematological indexes were comparable ($p>0.05$).

DISCUSSION

Maggots of ordinary flies are increasingly considered in the world of animal feed. Numerous studies have thus contributed to highlighting some factors determining the production of maggots in various localities. In the present experiment, results revealed that fresh biomass was significantly lower in cow dung as compared to the quantity obtained in ruminal content of pig manure. This result could be attributed to the ability of each substrate to attract flies. Current results agreed with those of Itongwa *et al.*[22], who reported a higher maggot production in ruminal content as compared to cow dung. Our findings showed that maggot production in ruminal content and pig manure were similar. This result is different from those obtained by Itongwa *et al.*[22] who pointed out a significantly higher production in ruminal content as compared to pig manure. On contrary, Tendonkeng *et al.*[8] reported higher biomass from pig manure. The heterogeneity between findings may be related to the fly families available in each production area or to the environmental temperature and humidity. Itongwa *et al.*[22] revealed that the Muscidae family is more attracted by ruminal content meanwhile, the Calliphoridae family is more attracted by pig manure than by ruminal content. In our study, fish waste was added to all the substrates. Their presence could explain our results since Itongwa *et al.*[22] showed that the Muscidae and Calliphoridae families are well attracted by fish waste. Our study identified those two fly families as predominant in our study area. During our experiment, the mean temperature was between 33-36°C and the humidity between 21 and 40%. These climate conditions were different to those of the study area reported by Tendonkeng *et al.*[8] (21-33°C and >60%) or Itongwa *et al.*[22] (15-19.5°C and 68-75%). The maggot biomass produced from ruminal content enriched with fish waste was significantly higher than those obtained from the same substrate enriched with mango puree or fresh bovine blood. These results agreed with those of Itongwa *et al.*[22], who reported that fish waste is more attractive to Muscidae and Calliphoridae than mango peel.

The chemical composition of maggot revealed heterogeneity of value between substrates. Maggot produced from ruminal content expressed the highest value of fat (20.23% of dry matter) but the lowest content of crude protein (25.68% of dry matter) as compared to the value of the same parameters obtained from pig manure (fat: 10.08%, crude protein: 36.05%) or cow dung (fat: 9.03%, crude protein:

33.61%). These results agreed with those of Itongwa *et al.*[22] who reported that maggots issued from ruminal content have lower crude protein and higher fat content as compared to maggots produced from pig manure or cow dung. As previously reported by Tendonkeng *et al.*[8], the highest value of organic matter was obtained on maggot meal produced in pig manure.

Irrespective of the substrate, the crude protein content (25-36%) was lower than that reported by several authors (38-61%). This would be related to the drying method used. In this experiment, maggot samples were sun-dried while in many other studies, they were oven-dried. Aniebo and Owen[23] stated that the oven-dried method increases fat content and reduces crude protein content of maggot samples. Maggot samples produced in ruminal content enriched with fresh beef blood expressed the highest crude protein content (31.09%). Tendonkeng *et al.*[8] pointed out that as compared to ruminal content, blood-enriched ruminal content produced significantly higher biomass of maggot.

Under similar environmental and managerial conditions, the growth performance of healthy animals is related to the nutritional value of their feed, their feed consumption as well as their digestibility efficiency. In this study, daily feed intake slightly decreased with the increase of maggot meal in the diet. This result can be explained by an adverse effect of maggot meal on the diet. It has been reported that the texture and colour of the feed containing maggots render the feed less palatable[24]. These findings may also be related to the variation in diets energy and protein content. It is well established that any change in poultry nutrition, especially in energy or protein content is reflected in feed intake[2,25]. Poultry eats primarily to satisfy their energy needs[2]. Following this statement, our results showed similar values of daily energy intake between treatments.

Although, feed intake and energy intake were not statistically different between treatments, daily body weight gain was significantly lower ($p<0.01$) in 75% maggot meal (R_{75}) as compared to 100% fish meal diet (R_0). This result can be explained at least by better utilization of the diet containing only fish meals. In fact, with 61.3% of crude protein, a fish meal could provide more essential amino acids than a maggot meal used which contains 30.65% crude protein. According to several authors, maggot meal and fish meal can both provide all the then essential amino acids needed by chickens. However, their concentration depends on several factors among which total protein content of feed[17,26,27]. A diet containing 75% maggot meal as a substitute for a fish meal could have supplied less quantity of essential amino acids needed for maintenance and muscle growth. Current results on daily protein intake showed that the lowest value of this parameter was obtained with a 75% maggot meal diet. This study's findings agreed with those of previous studies which reported that better growth performance in broiler was obtained when fish meal substitution by maggot meal was not higher than 50%[6,17]. Another possible explanation for the decrease of daily body gain of cockerel fed graded maggot meal content may be a result of specific interaction between fish and maggot when combined[14].

Despite that the cost of kg feed consumed decreases with the increase of maggot meal in diet, feed cost per kg of body weight gain, obtained in cockerels fed 75% maggot meal diet, increased by 14.5% as compared to a diet containing only fish meal. These findings were in agreement with the values of the feed conversion ratio obtained in this study. These results showed that a diet containing only fish meal was better converted into body weight than that containing maggot meal used in this study.

One of the most important concerns about the use of maggots in animal feeding is the living model of the house fly, being a vector of pathogens[14]. Haematological parameters are usually used in the diagnosis of physiological or metabolic disorders. They are also used as physiological indicators of environmental or nutritional stressors[28,29]. From current results, red blood cell count, haemoglobin, pack cell volume and platelet cell count were not affected by maggot meal incorporation. The values obtained in this study were within the normal range for chicken, which indicates no harmful effects of maggot meal on the health status of the birds[30]. The present results are in line with the findings of Duwa *et al.*[31] who reported that soybean replacement in rabbits with maggot meal (5%) showed no adverse effects on haematological indices.

CONCLUSION

Ruminal content enriched with fish waste is a good substrate for maggot production during the dry season, in an environment where the main fly families identified are Muscidae and Calliphoridae. Fish meal replacement by maggot meal should not exceed 50% in cockerel. Moreover, the house fly maggot meal can be used safely in cockerel nutrition. However, in the conditions of this experiment, a diet containing only fish meal showed the best growth performance and feed cost for meat. Taking into account the determining effect of temperature and humidity on maggot production, it will be interesting to evaluate the production during the other period of the year, in the same environment.

SIGNIFICANCE STATEMENT

Housefly larvae are increasingly considered a promising alternative to animal protein in the world of animal feed. For this purpose, projects on determining the factors required for optimal production of maggots and utilization have been implemented in various localities. This study identifies the main fly families in the Maroua area and some required conditions for the good production of maggots in the dry season. The present study also contributes to determining the optimal incorporation rate of locally produced maggots as a replacement for fish meals in the starter diet of a cockerel.

REFERENCES

1. Neves, D.P., T.M. Banhazi and I.A. Naas, 2014. Feeding behaviour of broiler chickens: A review on the biomechanical characteristics. Braz. J. Poult. Sci., 16: 1-16.
2. Beski, S.S.M., R.A. Swick and P.A. Iji, 2015. Specialized protein products in broiler chicken nutrition: A review. Anim. Nutr., 1: 47-53.
3. Gadzirayi, C.T., B. Masamha, J.F. Mupangwa and S. Washaya, 2012. Performance of broiler chickens fed on mature *Moringa oleifera* leaf meal as a protein supplement to soyabean meal. Int. J. Poult. Sci., 11: 5-10.
4. Olsen, R.L. and M.R. Hasan, 2012. A limited supply of fishmeal: Impact on future increases in global aquaculture production. Trends Food Sci. Technol., 27: 120-128.
5. Lim, M.T., B.J. Pan, D.W.K. Toh, C.N. Sutanto and J.E. Kim, 2021. Animal protein versus plant protein in supporting lean mass and muscle strength: A systematic review and meta-analysis of randomized controlled trials. Nutrients, Vol. 13. 10.3390/nu13020661.
6. Okah, U. and E.B. Onwujiariri, 2012. Performance of finisher broiler chickens fed maggot meal as a replacement for fish meal. J. Agric. Technol., 8: 471-477.
7. Pieterse, E. and Q. Pretorius, 2013. Nutritional evaluation of dried larvae and pupae meal of the housefly (*Musca domestica*) using chemical- and broiler-based biological assays. Anim. Prod. Sci., 54: 347-355.
8. Tendonkeng, F., E. Miégoué, J. Lemoufouet, M. Mouchili and N.F. Matimuini, 2017. Production and chemical composition of maggots from different type of substrates. Livest. Res. Rural Dev., Vol. 29.
9. Kenis, M., N. Koné, C.A.A.M. Chrysostome, E. Devic and G.K.D. Koko *et al*., 2014. Insects used for animal feed in West Africa. Entomologia, 2: 107-114.
10. El-Hack, M.E.A., M.E. Shafi, W.Y. Alghamdi, S.A. Abdelnour and A.M. Shehata *et al*., 2020. Black soldier fly (*Hermetia illucens*) meal as a promising feed ingredient for poultry: A comprehensive review. Agriculture, Vol. 10. 10.3390/agriculture10080339.
11. Teguia, A., M. Mpoame and J.A.O. Mba, 2002. The production performance of broiler birds as affected by the replacement of fish meal by maggot meal in the starter and finisher diets. Tropiculture, 20: 187-192.
12. Milutin, Đ., R.D. Brana, V. Marijana, M. Baltić and T. Radislava *et al*., 2008. Effects of substitution of fish meal with fresh and dehydrated larvae of the house fly (*Musca domestica* L) on productive performance and health of broilers. Acta Vet. (Beogr.) 58: 357-368.
13. Okubanjo, A.O., E.S. Apata and O.O. Babalola, 2014. Carcass and organoleptic qualities of chicken broilers fed maggot meal in replacement for dietary fish meal. Am. J. Res. Commun., 2: 147-157.
14. Attivi, K., K. Agboka, G.K. Mlaga, O.E. Oke, A. Teteh, O. Onagbesan and K. Tona, 2020. Effect of black soldier fly (*hermetia illucens*) maggots meal as a substitute for fish meal on growth performance, biochemical parameters and digestibility of broiler chickens. Int. J. Poult. Sci., 19: 75-80.
15. Fanadzenyuy, M.H., K.A. Etchu and K. Ndamukong, 2019. Carcass characteristics, hematology, serum chemistry and enzymes in broiler chickens fed maggot meal as a protein substitute for fishmeal. Global J. Med. Res.: G Vet. Sci. Vet. Med., 19: 6-13.
16. Agodokpessi, B.J., Y. Toukourou, I.T. Alkoiret and M.H. Senou, 2016. Zootechnic performances of turkey poults fed with maggot flour -based rations Tropicultura, 34: 253-261.
17. Neumann, C., S. Velten and F. Liebert, 2018. Improving the dietary protein quality by amino acid fortification with a high inclusion level of micro algae (*Spirulina platensis*) or insect meal (*Hermetia illucens*) in meat type chicken diets. Open J. Anim. Sci., 8: 12-26.
18. Sanou, A.G., F. Sankara, S. Pousga, K. Coulibaly and J.P. Nacoulma *et al*., 2019. Production de masse de larves de *Musca domestica* L. (Diptera: Muscidae) pour l'aviculture au Burkina Faso: Analyse des facteurs déterminants en oviposition naturelle. J. Appl. Biosci., 134: 13689-13701.
19. Ganda, H., E.T. Zannou-Boukari, M. Kenis, C.A.A.M. Chrysostome and G.A. Mensah, 2019. Potentials of animal, crop and agri-food wastes for the production of fly larvae. J. Insects Food Feed, 5: 59-67.
20. Charlton, A.J., M. Dickinson, M.E. Wakefield, E. Fitches and M. Kenis *et al*., 2015. Exploring the chemical safety of fly larvae as a source of protein for animal feed. J. Insects Food Feed, 1: 7-16.
21. Helrich, K. and AOAC., 1990. Official Methods of Analysis of the Association of Official Analytical Chemists. 15th Edn., Arlington, VA: The Association, Washington D.C., ISBN-13: 9780935584424.
22. Itongwa, J.A., D.S. Wasso, L.M. Kazamwali, B.N. Patrick and J.P.B. Bajope, 2019. Production trial and chemical composition of maggots obtained from local substrates in South Kivu (DRC). J. Appl. Biosci., 142: 14529-14539.

23. Aniebo, A.O. and O.J. Owen, 2010. Effects of age and method of drying on the proximate composition of housefly larvae (*Musca domestica* Linnaeus) Meal (HFLM). Pak. J. Nutr., 9: 485-487.
24. Moula, N. and J. Detilleux, 2019. A meta-analysis of the effects of insects in feed on poultry growth performances. Animals, Vol. 9. 10.3390/ani9050201.
25. Ferket, P.R. and A.G. Gernat, 2006. Factors that affect feed intake of meat birds: A review. Int. J. Poult. Sci., 5: 905-911.
26. Aniebo, A.O., E.S. Erondu and O.J. Owe, 2008. Proximate composition of housefly larvae (*Musca domestica*) meal generated from mixture of cattle blood and wheat bran. Livest. Res. Rural Dev., Vol. 20.
27. Hwangbo, J., E.C. Hong, A. Jang, H.K. Kang, J.S. Oh, B.W. Kim and B.S. Park, 2009. Utilization of house fly-maggots, a feed supplement in the production of broiler chickens. J. Environ. Biol., 30: 609-614.
28. Afolabi, K.D., A.O. Akinsoyinu, A.R.O. Abdullah, R. Olajide and S.B. Akinleye, 2011. Haematological parameters of the Nigerian local grower chickens fed varying dietary levels of palm kernel cake. Poljoprivreda, 17: 74-78.
29. Albokhadaim, I., 2012. Hematological and some biochemical values of indigenous chickens in Al-Ahsa, Saudi Arabia during summer season. Asian J. Poult. Sci., 6: 138-145.
30. Campbell, T.W., C.K. Ellis and B. Doneley, 2007. Avian and Exotic Animal Hematology and Cytology. 3rd Edn., Blackwell Publishing, Ames, Iowa, USA, Pages: 270.
31. Duwa, H., B. Saleh and J.U. Igwebuike, 2014. The replacement of fish meal with maggot meal on the performance, carcass characteristic, haematological and serum biochemical indices of growing rabbits. Global J. Bio-Sci. Biotechnol., 3: 215-220.