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Resaerch Application Summary

Effects of substituting fishmeal with black soldier fly larvae (*Hermetia illucens*) on growth performance of exotic layer chicks

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Abstract

An increase in consumption of animal products is expected by the year 2050, and as a result this will result in enormous demand for resources, feed being most challenging because of the limited availability of natural resources. The increasing demand for soybean meal and fishmeal (FM) for use in animal feeds has led to increased prices and moreover their availability in future will be limited. Insect rearing could be a part of the solution as they take a short period to mature, require a small space and fewer resources to start. This study was designed to evaluate the effect of substituting FM with black soldier fly larvae (BSFL) at different inclusion levels as a protein source in chick diets on weight gain, feed intake and feed conversion efficiency (FCE). A total of 250 day old Issa Brown chicks were used for this experiment that ran for a period of eight weeks. The chicks were randomly distributed into five treatments each with five birds per replicate and nine replications. Diets were formulated based on five different inclusion levels of BSFL (0%, 25%, 50%, 75% and 100%). Data on weight gain, feed intake and FCE were analysed using one way analysis of variance (ANOVA). The statistical package R version 3.5.1 was used with completely randomized design (CRD) model. The significance between treatment means was tested at statistical significance level of 5% and separated using Duncan Multiple Range in case of significant difference. The results showed that average final weight, overall weight gain, daily feed intake, average daily weight gain and FCE were significantly different. High performance can be achieved at lower inclusion levels of BSFL up to 50% in chicks' diet. Thus, BSFL is a good protein source for exotic layer chicks.

Key words: Feed intake, fishmeal, *Hermetia illucens*, insects, Issa Brown

Résumé

Une augmentation de la consommation de produits d'origine animale est attendue d'ici 2050, ce qui entraînera une énorme demande de ressources, les aliments étant plus difficiles en raison de la disponibilité limitée des ressources naturelles. La demande croissante de tourteaux de soja et de

farine de poisson (FP) destinés à l'alimentation animale a entraîné une augmentation des prix et, en outre, leur disponibilité à l'avenir sera limitée. L'élevage d'insectes pourrait faire partie de la solution car leur maturation prend peu de temps, nécessite un petit espace et moins de ressources pour démarrer. Cette étude a été conçue pour évaluer l'effet de la substitution de la FP par des larves de mouches noires (LMN) à différents niveaux d'inclusion en tant que source de protéines dans les régimes des poussins sur la prise de poids, la prise alimentaire et l'efficacité de conversion alimentaire (ECA). Un total de 250 poussins Issa Brown âgés de 250 jours ont été utilisés pour cette expérience qui a duré huit semaines. Les poussins ont été répartis au hasard en cinq traitements, chacun avec cinq oiseaux par répétition et neuf répétitions. Les régimes ont été formulés sur la base de cinq niveaux d'inclusion différents de LMN (0%, 25%, 50%, 75% et 100%). Les données sur le gain de poids, la prise alimentaire et le ECA ont été analysées en utilisant une analyse de variance unidirectionnelle (ANOVA). Le progiciel statistique R version 3.5.1 a été utilisé avec un modèle de conception entièrement randomisé (CER). La signification entre les moyennes de traitement a été testée à un niveau de signification statistique de 5% et séparée à l'aide de Duncan Multiple Range en cas de différence significative. Les résultats ont montré que le poids final moyen, le gain de poids global, la prise alimentaire quotidienne, le gain de poids quotidien moyen et l' ECA étaient significativement différents. Des performances élevées peuvent être obtenues à des niveaux d'inclusion inférieurs de LMN jusqu'à 50% dans l'alimentation des poussins. Ainsi, LMN est une bonne source de protéines pour les poussins de couche exotiques.

Mots clés: Apport alimentaire, farine de poisson, *Hermetia illucens*, insectes, Issa Brown

Background

The poultry production sector is a fast growing industry in Kenya. This is due to rising demand for poultry products, hence leading to intensification of poultry farming. About 90% of small-scale farmers in Kenya rear poultry, majority of which are indigenous chicken followed by exotic chicken breeds (Gichohi and Maina, 1992; King'ori *et al.,* 2010). Feed cost forms up to 70% of the total cost of poultry production in Kenya (Al-Qazzaz *et al.,* 2016). However, expensive poultry feed is still a major issue faced by international as well as local industries due to competition for feed materials which are shared by both animals and humans, hence typically low quality raw materials are used in poultry feed production (Abidin *et al.,* 2011).

Fishmeal (FM) is mostly used in poultry diets because it is a high quality animal protein source with an excellent profile of amino acids. However, with the increasing price of this ingredient and high competition for use with humans means less availability of FM for use in poultry farming. This has led to research into the development of insect proteins for poultry and other livestock, which can eventually supplement FM (Al-Qazzaz *et al.,* 2016). Insects have been natural food sources for poultry for a long period of time, and are now considered a fundamental protein source for scavenging chicken. Grasshoppers, crickets, cockroaches, termites, lice, stink bugs, cicadas, aphids, scale insects, psyllids, beetles, caterpillars, flies, fleas, bees, wasps and ants have all been used as complementary food

sources for poultry (Ravindran and Blair, 1993; Makkar *et al.,* 2014).

Black soldier fly larvae (*Hermetia illucens*) are mostly found around manure piles of cattle, sheep, and poultry (Van Huis, 2013). These insects can be reared and used as an alternative to FM in poultry feed at different inclusion levels. The larvae can occur in very dense population on organic wastes such as coffee bean pulp, vegetables, brewer's yeast waste, manure, distillers' waste and fish offal (fish processing by-products). Black soldier fly larvae provide high value feedstuff for cattle, pigs, poultry and fish (Newton *et al.,* 2005). Proximate composition of BSFL varies according to the litter grown on and processing method used. There is minimum documented research on the effect of BSFL on growth performance and survival rates of exotic layer chicks. The objective of this study was to evaluate the effect of substituting FM with BSFL at different inclusion levels as a protein source in exotic layer chicks' diets on weight gain, feed intake and FCE. These parameters are important as they show chicks response to the insect based diet offered for a particular period of time.

Materials and Methods

This research was carried out at the Poultry Research unit of Kenya Agricultural and Livestock Research Organisation (KALRO), Naivasha Kenya. The area is located at an altitude of 1,800 meters above sea level, 0° 43′ 12.85″ South latitude, 36° 25′ 42.71″ East longitude. It receives a mean annual rainfall of 1000mm and 17 to 22°C temperature range. A total of 250 day old Issa Brown layer chicks with initial body weight of 36.39±0.18, were sourced from Kenchic, Nairobi, Kenya and used for the experiment. The birds were placed in a brooder fitted with 250 watts infra-red bulbs and fed for a period of two weeks (adaptation period) with commercial chick mash. They were later assigned to five different dietary treatments in a CRD, each with nine replications of five birds per cage (1x1x1 square feet). Five treatments were formulated and mixed to contain BSFL at 0%, 25%, 50%, 75% and 100% respectively, together with other ingredients to form a complete diet. Chicks were allowed *ad libitum* access to both feed and water. Light was provided 24 hours daily for the entire experimental period. Chicks were immunised against Newcastle disease, infectious bronchitis, fowl typhoid and fowl pox. The birds received vitamins every time feed was changed and after vaccination. Vaccination was important to prevent any disease causing bacteria/virus build up by boosting the birds' immunity and vitamins played a role in reducing stress. Drinkers were cleaned every day and clean water offered to the birds every morning. Feed was placed in plastic feeders each morning at 0830 hours after weighing the left overs. Wood shavings were used as bedding in all the cages and were changed after every 3 weeks to avoid ammonia build up in the house and any bacteria growth.

Black soldier fly larvae used during the feeding experiment were sourced from International Centre of Insect Physiology and Ecology (ICIPE) and Sanergy Company in Nairobi, Kenya, while other ingredients were purchased from local suppliers in Nakuru town. Materials were ground and mixed to form a complete ration which was iso-caloric and iso-nitrogenous at a selected miller.

Growth performance. Average daily feed intake (ADFI) was measured by subtracting left-over feed at the end of the week from the amount of feed offered, divided by 7 days. Total weight of birds in each replicate was measured weekly using a digital electronic (SHIMADZU-TXB6201L)

scale and average daily weight gain (ADG) calculated. Feed conversion efficiency (FCE) was defined as ADG divided by ADFI. Final weight, overall weight gain and mortality rate during the experimental period were recorded. This was performed for chick from 0 to 8 weeks of age.

Data analysis. Data on weight gain, feed intake and FCE were analysed using one way analysis of variance (ANOVA). The statistical package R version 3.5.1 was used with CRD model. Each cage represented an experimental unit in this experiment. The significance between treatment means was tested at statistical significance level of 5% and separated using Duncan Multiple Range test in case of significant difference.

Results

Chick final weight, overall weight gain, ADFI, ADG and FCE were significantly different ($P<0.05$). Initial weight was similar for all the five treatments with ($P = 0.140$). Final weight was significantly different ($P<0.001$) among all the five treatments. Chick ADG was highly significant ($P<0.001$) between treatments. Overall weight gain was significant ($P<0.001$) for all the five treatments with minimal mean differences. Statistical analysis also showed that ADFI was significantly different ($P<0.001$) for all the treatments, with higher mean observed in T1 (36.21) followed by T2 (33.82), T3 (29.82), T4 (27.72) and T5 (24.68). This means increasing levels of insects in layer chicks feed leads to significant decrease in feed intake. FCE was significantly different ($P<0.044$) for all the treatments (Table 1). Mortality level was low during the experimental period, as only 3 birds died; two birds and one bird from T1 and T3, respectively. The cause of death was identified as bacterial infection.

Table 1. Growth performance of exotic layer chicks when fed five different black soldier fly larvae (BSFL)**-based diets**

Parameter	T1	T2	T3	T4	T5	P value
Initial weight (g)	96.15±2.6^{a}	101.25±1.3^{a}	100.93±1.2^{a}	102.12±1.3^{a}	101.25±1.9^{a}	0.140
Final weight (g)	476.15±13.2^{a}	481.45±8.0^{a}	418.02±13.3^{b}	414.67±14.1^{b}	481.45±8.5^{c}	<0.001
Overall weight gain (g)	380.00±14.7^{a}	380.21±8.2^{a}	317.09±14.2^{b}	312.55±14.3^{b}	380.21±8.7^{c}	<0.001
ADG (g)	9.05±0.4^{a}	9.05±0.4^{a}	7.55±0.3^{b}	7.44±0.4^{b}	5.86±0.2^{c}	<0.001
ADFI (g)	36.21±1.7^{a}	33.82±1.5^{a}	29.82±1.3^{b}	27.72±1.3^{bc}	24.68±1.0^{c}	<0.001
FCE	1.76±0.08^{ab}	1.87±0.04^{a}	1.77±0.06^{ab}	1.87±0.04^{a}	1.87±0.04^{b}	0.044

ADG - Average daily gain, ADFI- Average daily feed intake, FCE- Feed conversion efficiency, T- treatment Values = means ± standard error. a, b, c Means in a row with different superscript letters are significantly different at $P<0.05$ as determined by Duncan Multiple Range test.

Discussion

From the results it can be established that BSFL meal can substitute fishmeal without severe losses in body weight gain, FCE and ADFI, up to an extent of 50% for layer chicks. Growth performance of chicks fed the highest level of BSFL meal (BSFL 75% and 100%) was low. However, no signs of nutrient deficiencies or higher mortalities were observed. Rust (2002) explained that, the reason for declining performance of chicks fed on BSFL meal could be brought by chitin content of pre-pupae as this component of the invertebrate exoskeleton might have adverse effects on nutrient digestibility. However, Awoniyi *et al.* (2003) reported negative and insignificant (P>0.05) body weight gain performances at 25% to 100% inclusion levels of insects in poultry diet. ADFI result differs from Mohammed *et al.* (2017) results who reported that feed intake was high for all birds in both treatment groups for the period of his feeding experiment when birds were offered feed substituted with different levels of BSFL. Inclusion of fresh BSFL larvae in chicken feed resulted into improved chicken growth pattern during the rearing period. Besides this effect, other measured parameters were not negatively influenced by inclusion of BSFL. Black soldier fly larvae, is a potentially viable alternative to soybean meal and fishmeal in poultry feed and previous research has also identified BSFL as completely viable for other livestock. There is potential to rear insects and raise chicken on BSFL reared on food waste, as this will improve growth performance of such birds (Gaffigan, 2017).

Conclusion

From the results, black soldier fly larvae meal (BSFLM) is a good alternative protein source for exotic layer chicks. High performance in chicks can be achieved at lower inclusion levels of BSFL that is, not more than 50%. In terms of weight gain, high performance was recorded at 25% and 50% inclusion levels. Black soldier fly larvae meal shows a positive effect on weight gain and can be used successfully without fear of reduced growth performance in exotic chicks. However, the chitin level which is assumed to be fibre in insects may lead to reduced digestibility of feed in chicks. It has been suggested that the BSFL contain natural antibiotics (Newton *et al.,* 2008) thus this minimizes the use of antibiotics in birds during rearing and also mortality rate is reduced. In conclusion, insects contain a high proportion of good quality protein and other necessary feed ingredients such as fibre, energy, vitamins, fat and minerals thus a great potential is available in utilizing insects as protein supplement for poultry production. However, regular diarrhoea that was observed for birds fed 50% BSFL meal was the only abnormality observed during the eight week experimental feeding period.

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