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Research Application Summary

Black soldier fly larvae meal as a cheap alternative to expensive conventional protein sources in poultry feeds

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Abstract

In the recent past, high poultry feed costs are driving many vulnerable communities involved in poultry production out of business. The high cost is mainly driven by the protein source, which represents the most expensive component in not only poultry feeds but generally, in animal feed. In conventional poultry feed, the main protein sources are soybean meal and fish meal. Exploring potential cheap alternative sources of proteins in poultry feeds is therefore paramount to sustainability of the poultry industry and profitability of the poultry business. The present study explored potential of partially replacing the conventional protein sources with black soldier fly larvae (BSFL) meal in broiler and layer chicken diets. A conventional diet (C) containing soybean and fishmeal was compared to three experimental diets formulated by inclusion of BSFL meal at 5 (B1), 10 (B2), and 15% (B3) for broiler diets and 5 (L1), 10 (L2), 15 (L3) and 20% (L4) for layer diets. Dietary effects on average daily feed intake, average daily body weight gain, egg production and the economic implication of their use in broiler and layer chicken production were evaluated. The results indicated that replacement of soybean meal and fishmeal with BSFL in the diets did not affect daily feed intake and daily body weight gain. However, egg production increased significantly ($p<0.05$) with the inclusion of BSFL meal in layer chicken diets. For both broiler and layer chicken, inclusion of BSFL in the diets resulted in increase in the Cost Benefit Ratio (CBR) and Return on Investment (RoI). The higher the inclusion of BSFL meal in the broiler and layer diets, the higher the CBR and RoI. The results of the study implies there is need for the promotion of insect mass production enterprises for animal feed protein as well as for income generation and job creation particularly in the developing countries.

Key words: Broilers, chicken diet, Kenya, layers, poultry feed

Résumé

Dans un passé récent, les coûts élevés des aliments pour volaille poussent à la faillite de nombreuses communautés vulnérables impliquées dans la production de volaille. Le coût élevé est principalement dû à la source de protéines, qui représente la composante la plus chère non seulement des aliments pour volaille, mais également des aliments pour les autres animaux en général. Dans les aliments conventionnels pour volaille, les principales sources de protéines sont la farine de soja et celle de poisson. L'exploration de sources alternatives de proteines à bon marché des aliments pour volaille est donc primordiale pour la durabilité de l'industrie de la volaille et la rentabilité de son activité. La présente étude a exploré le potentiel de remplacement partiel des sources de protéines conventionnelles par la farine de larves de mouches soldats noires (BSFL) dans les régimes de poulets de chair et de poulets pondeurs. Un régime conventionnel (C) contenant du soja et de la farine de poisson a été comparé à trois régimes expérimentaux formulés par l'inclusion de farine BSFL à 5 (B1), 10 (B2) et 15% (B3) pour les régimes de poulet de chair et à 5 (L1), 10 (L2), 15 (L3) et 20% (L4) pour les régimes de poulets pondeurs. Les effets de l'alimentation sur l'apport alimentaire quotidien moyen, le gain de poids corporel quotidien moyen, la production des œufs et les conséquences économiques de leur utilisation pour la production de poulets de chair et de poulets pondeurs ont été évalués. Les résultats ont indiqué que le remplacement de la farine de soja et de la farine de poisson par la farine BSFL dans les régimes alimentaires n'affectait pas la prise alimentaire quotidienne ni la prise de poids quotidienne. Cependant, la production des œufs a considérablement augmenté (p <0,05) avec l'inclusion de l'alimentation BSFL dans les régimes de poulets pondeurs. Pour les poulets de chair et les poulets pondeurs, l'inclusion de BSFL dans les régimes alimentaires a entraîné une augmentation du ratio coût / bénéfice (CBR) et du retour sur investissement (RoI). Plus l'inclusion de BSFL dans les régimes de poulets de chair et de pondeurs est élevée, plus le CBR and le RoI sont élevés. Les résultats de l'étude indiquent qu'il est nécessaire de promouvoir les entreprises de production de masse d'insectes pour les protéines animales ainsi que pour générer les revenus et créer des emplois, en particulier dans les pays en développement..

Mots clés: Poulets de chair, régime de poulet, Kenya, pondeuses, aliments pour volaille

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Introduction

Profitability of poultry production largely depends on feed quality, cost and availability and this has a direct effect on the extent of investments in the industry (Agritrade, 2013). In poultry production, depending on the level of intensification, feed cost accounts for 65 to 75% of the cost of production (Bell and Weaver, 2002). The protein ingredients in the poultry feeds are the most expensive part of the feeds. However, they are responsible for the quality of the essential nutrients required by the birds to produce eggs and meat. For instance, for layer chicken, some egg quality characteristics are affected by the nutrition of the birds. This includes Haugh unit, egg yolk quality and egg shell quality (Roberts, 2004). It is therefore important for a laying or meat bird to have constant supply of nutrients according to its nutritional requirement (NRC, 1994). The quality of the protein in chicken diets is also important especially for the essential and limiting amino acids, vitamins and minerals.

The main protein ingredients used in production of poultry feeds in many parts of the world include soybean meal and fishmeal. For instance, in Kenya about 65% of soybean utilized is imported with most of it being utilized for animal feed production especially poultry feed (Chianu *et al.,* 2008). This implies prices are likely to remain high into the future. Fish meal likewise, is faced with the challenge of being an expensive, finite global resource due to depleting global fisheries (Ravindran, 2013). Over 80% of fishmeal utilized for commercial feed production in Kenya is imported (Ardjosoediro and Neven, 2008). This has led to increased price of fishmeal. For instance, in 2009 and 2013 the fishmeal costed US$ 0.26 and 0.65/ kg respectively in Kenya, while in 2015 it cost up to US$1.4/ kg (our unpublished data). These trends have intensified efforts and research into alternative sources of proteins for poultry (van Huis, 2013; Makkar *et al.,* 2014). The authors have proposed the use of insects as alternative sources of proteins which are also good sources of energy (lipids) and micro-nutrients (vitamins and minerals) for the animal feed industry.

To this end, Black Soldier Fly larvae (BSFL) are a potential insect in the animal feed industry. BSFL are easy to rear as they are scavengers and flourish on various kinds of putrefying organic matter producing feed matter that is rich in crude protein content (42-57% DM) and high in essential amino acids depending on the substrate (Makkar *et al.,* 2014).

Materials and Methods

The study was conducted at the Poultry Research Unit, Non-Ruminant Research Institute under the Kenya Agricultural and Livestock Research Organization (KALRO) located in Naivasha, Kenya. For the broiler experiment, two hundred eighty-eight (288) broiler chicks (Cobb 500) were used with four diets (Control (C), B1, B2, and B3) formulated to meet the nutrient requirements for poultry (NRC, 1994). The control diet contained the conventional protein feed ingredients, soybean and fishmeal. For B1, B2 and B3, BSFL was included at a rate of 5, 10, and 15%, respectively. For Layer experiment, five iso-nitrogenous diets were formulated according to NRC (1994) recommendations for layer chicken and to contain BSF larvae meal at different inclusion levels of 0, 5, 10, 15 and 20% of the diet (denoted by C, L1, L2, L3 and L4). Fifty-five (55) improved indigenous chicken layers of the same age (30 weeks) were selected from a flock reared under the same feed and conditions and used in the experiment. The experiments were laid out in completely randomized design and the birds were subjected to the recommended health bio-security procedures and management practices.

Results and Discussion

The results of the economic analysis for the broilers and layers are presented in Table 1 and 2 respectively. The Cost Benefit Ratio (CBR) and Return of Investment (RoI) were used to evaluate the economic effect of replacing soybean and fishmeal with BSFL in broiler chicken diets (Table 1) and Layer chicken (Table 2). In conducting this analysis, it was assumed that the cost of feed ingredients and the sale of live birds for broilers and eggs for layers at the end of the feeding trial were the only source of costs and profits. For broilers, the conventional diet was the most expensive costing up to 3.07 US$ per bird to reach age at slaughter (for combined starter and finisher phases) while for layers, 5% BSFL inclusion diet was the most expensive costing up to 7.9 US$ per bird.

For broilers, diet B3 had the highest CBR (2.9) and RoI (188.2) while the conventional diet had the least CBR (2.5) and least RoI (150.2). The same trend was observed for the layers where the conventional diet had the lowest ($P<0.05$) CBR (1.8) and RoI (74.5) while the two parameters increased with the increased inclusion of BSFL meal in the diets. The increased inclusion of BSFL meal in layer diets also resulted in increased egg production with 20% BSFL meal inclusion having the highest ($p<0.05$) egg production (84.1%). Therefore, the inclusion of BSFL in diets for poultry results in cheaper diets and this coupled with increased production results in more profitability. Khan *et al.* (2016) also observed that costs of poultry feed can be reduced by use of insect meal.

Table 1. Economic analysis of including BSFL meal in broiler diets

	Experimental diets			
	C	B1	B2	B3
Cost of feed (USD/kg)				
Starter feed	0.62	0.60	0.58	0.55
Finisher feed	0.57	0.56	0.54	0.52
Cost of protein in feed (%)				
Starter feed	0.48	0.46	0.45	0.42
Finisher feed	0.66	0.61	0.61	0.58
Total feed intake (g/bird)				
Starter phase	1909.20^{a}	1890.60^{a}	1874.00^{a}	1839.30^{a}
Finisher phase	3304.00^{a}	3411.00^{a}	3289.00^{a}	3165.00^{a}
Entire feeding phase	5213.20^{a}	5301.60^{a}	5163.00^{a}	5004.30^{a}
Cost of feed consumed (USD/bird)				
Starter phase	1.17a	1.13^{ab}	1.08^{b}	1.00^{c}
Finisher phase	1.90a	1.91^{a}	1.77^{ab}	1.63^{b}
Total Feed Cost (C)	3.07a	3.04^{ab}	2.85^{b}	2.63^{c}
Live weight at slaughter (g)	3071.00^{ab}	3182.00^{a}	3006.00^{b}	3033.00^{ab}
Sale of birds1 (S)	7.68^{ab}	7.96^{a}	7.52^{b}	7.58^{ab}
Gross profit margin[2] (P)	4.61^{a}	4.91^{a}	4.67^{a}	4.95^{a}
Cost Benefit Ratio[3] (CBR)	2.50^{b}	2.60^{b}	2.60^{b}	2.90^{a}
Return on Investment[4] (RoI)	150.20^{b}	161.50^{b}	163.90^{b}	188.20^{a}

Currency exchange rate at the time of study (1 US$ for 100 Ksh). Within rows, means followed by same lower case letters are not significantly different at P < 0.05; 12.5 US$/kg Live weight; 2P = S – C; 3CBR = S/C; 4RoI = P/C*100; BSFL= Black solider fly larvae

Table 2. Economic analysis of including BSFL meal in Layer diets

	Experimental diets				
	C	L1	L2	L3	L4
Cost of feed (US$/kg)					
Layers mash	0.42	0.45	0.43	0.43	0.44
Total Feed Intake (g/bird)					
Average daily Intake	105.8^{a}	114.5^{a}	106.8^{a}	104.8^{a}	112.0^{a}
Entire feeding phase	16288.0^{a}	17634.0^{a}	16451.0^{a}	16136.0^{a}	17248.0^{a}
Cost of feed consumed (US$/bird)					
Daily feed cost	0.04^{b}	0.05^{a}	0.04^{a}	0.04^{a}	0.05^{a}
Total Feed Cost (C)	6.8^{b}	7.9^{a}7.1^{ab}	6.9^{ab}	7.6^{ab}	
Egg lay (%)	51.2^{b}	71.7^{a}79.4^{a}	74.5^{a}	84.1^{a}	
Period-in-lay (days)	154.0	154.0 154.0	154.0	154.0	
Total eggs laid	78.9^{b}	110.4^{a}122.3^{a}	114.8^{a}	129.5^{a}	
Sale of eggs1 (S)	11.8^{b}	16.6^{a}18.3^{a}	17.2^{a}	19.4^{a}	
Gross profit margin[2] (P)	5.0^{b}	8.6^{ab}	11.3^{a}	10.3^{a}11.8^{a}	
Cost Benefit Ratio[3] (CBR)	1.8^{c}	2.1^{bc}	2.6^{a}	2.5^{ab}	2.6^{a}
Return on Investment4 (RoI)	74.5^{c}	105.4^{bc}	158.2^{a}	148.7^{ab}	158.3^{a}

Currency exchange rate at the time of study (1 US$ for 100 Ksh). Within rows, means followed by same lower case letters are not significantly different at P<0.05; 10.15 US$/Egg; 2P = S – C; 3CBR = S/C; 4RoI = P/C*100; BSFL= Black solider fly larvae

Conclusion

The current studies have shown that the expensive conventional feed protein ingredients; Soybean and Fishmeal can be replaced with BSFL meal in broiler and layer chicken diets without any detrimental effect on production. The inclusion also results in reduction of cost of feeding the birds which coupled with the enhanced production increases the profitability of poultry production enterprises. The present results indicate a high potential for establishment of new enterprise for insect mass rearing in the African continent that will therefore generate income, create jobs and relieve the current burden on environment while providing alternative protein source for the chicken widely reared in the world, and redirecting fish and soybean to direct human consumption.

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References

Agritrade. 2013. Executive Brief Update, Poultry sector. URL: http://agritrade.cta.int/Agriculture/Commodities/Poultry/Executive-Brief-Update-2013-Poultry-sector

Ardjosoediro, I. and D. Neven. 2008. The Kenya capture fisheries value chain: an AMAP-FSKG value chain finance case study. USAID Micro-Report 122. 58 pp. http://pdf.usaid.gov/pdf_docs/Pnadn416.pdf

Chianu Jonas, N., Vanlauwe, B., Mahasi, J. M., Katungi, E., Akech, C., Mairura, F.S., Chianu Justina, N. and Sanginga, N. 2008. Soybean situation and outlook analysis: the case of Kenya. http://tropicallegumes.icrisat.org/wp-content/uploads/2016/02/rso-sbean-kenya.pdf

Khan, S., Naz, S., Sultan, A., Alhidary, I. A., Abdelrahman, M. M., Khan, R. U., Khan, N.A., Khan, M. A. and Ahmad, S. 2016. Worm meal: a potential source of alternative protein in poultry feed. *World's Poultry Science Journal* 72:93–102.

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

National Research Council (NRC). 1994. Nutrient requirements of poultry, 9th ed. National Academy Press, Washington, DC.

Ravindran, V. 2013. Main ingredients used in poultry feed formulations. pp.67–69. In: FAO (ed.), Poultry Development Review. Rome, Italy. http://www.fao.org/3/a-al705e.pdf

Roberts, J. R. 2004. Factors affecting egg internal quality and egg shell quality in laying hens. *Journal of Poultry Science* 41: 161-177.

Van Huis, A., van Itterbeeck, J., Van Klunder, H., Mertens, E., Halloran, A. and Muir, G. 2013. Edible insects. Future prospects for food and feed security. Food and Agriculture Organization of the United Nations (Vol. 171). http://www.fao.org/docrep/018/i3253e/i3253e.pdf