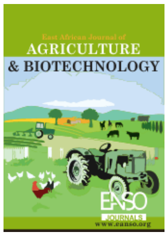

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Original Article

Entomophagus Response of Indigenous Chicken to Diets Enriched with German Cockroach (Blattela germanica) Meal in Kenya

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Cockroach Meal, Chicken, Feed, Intake, Kenya.

ABSTRACT

Feeding accounts for 65-70% cost of production in a chicken enterprise. Fishmeal has primarily been used as a source of protein in chicken feed owing to its excellent nutritional value. However, due to its unstable supply and variation in quality, recent studies have focused on finding alternative protein feedstuff, such as edible insects. A study was carried out to evaluate the effects of substituting fishmeal (FM) with *Blattela germanica* meal (BGM) on the growth of chicks. Seventy-two KALRO improved indigenous chickens (KC), at the grower stage, eight weeks old, comprising an equal number of males and females were used as sampling units in a completely randomized design (CRD) feeding trial. Each of the four treatments was replicated three times. Birds were fed on dietary treatments that were isocaloric and isonitrogenous and comprised - treatments TA (87.5 %FM, 12.5% BGM), TB (62.5 % FM, 37.5 % BGM), and TC (50% FM, 50% BGM) TD (100 %FM, 0% FM)-Control. Data on daily feed intake and weekly live weight was taken for eight weeks and used to calculate the Feed conversion ratio (FCR) and average daily gain (ADG). Data were subjected to a one-way analysis of variance (ANOVA). The feed intake, average daily gain, final weight gain, and feed conversion ratio was not significantly different from the control ($P > 0.05$). Thus, indigenous chicken fed diet with BGM and fishmeal performed similarly. As such, farmers should be encouraged to incorporate cockroaches as their on-farm feed to reduce the feed cost and increase chicken productivity.

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INTRODUCTION

The supply of quality feeds has been one of the major constraints to increased chicken production in developing countries such as Kenya (Omondi, 2019). Even in areas where feeds are available, the high cost of compounded feeds has made them inaccessible to local smallholder farmers (Atela, 2016). Poultry feed production relies on ingredients such as soya beans and fishmeal to supply proteins (Parisi *et al.*, 2020). The poultry feed industry utilizes 85% and 10 % of the world's soya meal and fishmeal, respectively (Zegeye, 2020). Protein ingredients account for over 15% of the cost of chicken feed production (Khan *et al*, 2018). The availability of fishmeal has been diminishing in the last decade due to increased demand for human consumption. It has necessitated research on alternative protein supplies, such as edible insects.

Numerous edible insects have a crude protein content of 20-80 % of dry weight and a considerable proportion of fats, carbohydrates, minerals, and vitamins (Allegretti *et al.*, 2018; Rumpold and Schlüter, 2013). Scavenging chicken has co-evolved to feed on insects as part of their daily diets. Current avian research focuses on including edible insects in conventional chicken diets as a replacement for fishmeal to lower the feed cost partially.

Strategies to increase poultry production through non-conventional feeds such as edible insects as a replacement for fishmeal are gaining popularity among smallholder farmers. Most evaluation tests have been done in broiler feeds with minimum consideration for indigenous chicken, yet the majority (>80%) of chicken produced in Sub-Saharan Africa (SSA) are indigenous. An insect such as oxya replaced 50% of fishmeal in poultry feeds with positive results. Feeding *Acheta domesticus* larvae to poultry increased feed conversion efficiency and weight gain (Oibiokpa *et al.*, 2018). Oyegoke *et al.* (2006), while replacing fishmeal (4 % of the diet) with larvae of *C. forda*, revealed that there were no significant differences between the growth performance of broiler chicks that were fed the compounded larval diets and those fed the conventional fishmeal. Scanty information is available where cockroach has been used as an ingredient in chicken feed thus limiting use as chicken feed. Ayssiwede *et al.* (2011) reported that *Blattela orientalis*, - a cockroach species - had no negative effects when fed to indigenous chickens in Senegal.

The current study investigated the effects of replacing fishmeal with *Blattela germanica* meal on the growth performance and survival of KALRO-improved indigenous chicken. The findings will be

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useful for the farmer, feed manufacturers and policy makers who wish to consider adopting the use of cockroach meal as feed ingredient to optimize chicken productivity.

MATERIALS AND METHOD

Study Site and Design

A study was conducted at Kenya Agricultural and Livestock Research Organization at Non-Ruminant Research Institute, Kakamega.

According to Jaetzold *et al.* (2011), this area lies within Kakamega town at an altitude of 1585 m above sea level, a latitude of $00^{0}16$'N, and a longitude of $34^{0}45$'E. The mean annual rainfall is 1883.96 mm, the mean temperature is 21.00 C, the average maximum temperature is 27.0 ^{0}C, the average minimum temperature is 14.0 ^{0}C, the average evaporation is 120 mm, and the average day length is 12 hours. This agroecology is suitable for crop and livestock production (Jaetzold *et al.*, 2011).

Seventy-two birds, aged 49 -days old mixed-sex KALRO Improved Kienyeji (KC) chicks were randomly allocated to four (4) treatment diets and replicated thrice (3). The number of chicks per replicate was six (6) and eighteen per (n = 18) per treatment. The recommended minimum birds per replicate is five (5). Each of the three replicates consisted of six birds (three males and three females) to make eighteen birds per treatment diet in a completely randomized design (CRD). The design was suitable for the current study because the sampling units (chicks) were similar, homogenous and in a controlled environment.

Experimental Diets

Four experimental treatment diets that were isocaloric and isonitrogenous were formulated using maize grain, wheat bran, soya beans, fishmeal (FM), and processed *Blatella germanica* meal (PBGM) as main ingredients (*Table 1*). Whereas omena (Silver Cyprinid fish) was used as fishmeal, soya beans were roasted using dry heat to remove anti-nutritional factors such as anti-trypsin, but both were ground using a hammer mill. These percentage composition and proximate analyses were determined by (AOAC, 1990) and are shown in *Table 1*. The diets were formulated to meet the nutrient requirements for energy (ME = >2600 Kcal/Kg), crude protein (CP = 16 %), and crude fat (<7 %) based on standard guidelines (*Table 2*) adopted from NRC (1994). Metabolizable energy (ME) was estimated using the following formulae:

ME (kcal/Kg) = 37 x %CP + 81 x %fat + 35.5 x %NFE

Management of Birds Under Experiment

National Commission on Science and Technology (NACOSTI) authorized the research under license No. NACOST/II/P/22/20771. The research was conducted with approval from Jaramogi Oginga Odinga University of Science and Technology ethical committee approval No. 7/19/ERC/10/01/22-07 and following principles and guidelines of KALRO Animal Handling and Care

Chickens were allocated to 12 cages within a standard deep–litter system house, naturally well ventilated, with a daily photoperiod of 12 hours of light. The house, feeders, and drinkers were washed in clean water and disinfectant; it was fumigated before the arrival of the chicks. Each of the 12 pens was an experimental unit and measured one metre by two metres on a floor covered with dry wood shavings.

Each experimental unit had a drinker, and a round feeder was assigned from weeks 8 to 12 after hatching; after that, a feeder was replaced with Naivasha long feeder from week 13 to week 16. Birds were also provided with clean water and fresh feeds at *adlibitum*. Fresh feed was weighed before being added into the feeding trough, and remnants were removed and weighed the next day before the fresh feed was added.

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Before the feeding trial, birds were subjected to standard routine management and vaccinated according to recommended indigenous chicken schedule. On occasions when there was morbidity, the sick birds were isolated and treated with conventional medications and then returned to the flock. The bedding material (wood shaving) was changed weekly, and the experiment lasted eight weeks. Any mortality was removed from cages, and a post mortem conducted to rule out feed-related death.

Data Collection, Presentation and Statistical Analysis

Growth Performance

The birds in each cage were put in a tarred carton box and weighed on weekly basis at 0900 hrs. The weight of individual bird was obtained by dividing the total weight by number of birds in each cage. The average daily gain (ADG) was calculated.

$$Average\ \text{Daily Gain} = \frac{Final\ liveweight - Initial\ Liveweight}{Total\ Number\ of\ Days}$$

Feed Intake

Feed intake was monitored daily and weekly by weighing feed remnants, then emptying the feeders before adding fresh feed (1kg). The Naivasha long feeders used measured (10 cm by 23 cm by 100 cm) and was placed in each cage. The weight of feed consumed by each bird was calculated by obtaining the difference (initial weight + weight of feed remnants). The total feed intake and average daily feed intake per bird was calculated.

Feed Conversion Ratio

The feed conversion ratio (FCR) was calculated using the following formulae;

$$Feed\ Conversion\ Ratio = \frac{Total\ Feed\ intake}{Total\ Weight\ Gain}$$

Data Presentation

Quantitative data was presented in tabular form in both hard and soft copy. It was then cleaned before statistical analysis.

Statistical Data Analyses

Data on weight gain, feed intake and feed conversion ratio were analysed using one way analysis of variance (ANOVA) with the four BGM substitution levels (0 %, 12.5 %, 37 % and 50 % of fishmeal) being factors. Each pen represented an experimental unit. All quantitative data was analysed in R 4.1.2 (RStudio Team, 2020) for analysis of variance to determine difference between treatments. Least square means were obtained using the Bonferroni test and the significance was calculated at a 5% confidence level.

The following statistical model guided analysis:

$Y_{ij} = \mu + \alpha_i + \varepsilon_{ij}$,

Where; **Yij** = Feed intake (g day-1)/ Initial weight/Total Weight gain/Average Daily Weight gain/Final weight/Feed conversion ratio (g/bird/ day); **μ**= is the overall mean; **αi** = is effect of the treatment diet (i = TA…TD); **εij** = is the error term associated with the observation

RESULTS

Composition of Diets

Ingredients used in formulating the diets were similar except for variation in the fishmeal and *B. germanica* meal level, as shown in ***Table 1***. The nutrients of the treatment diets were in tandem with nutrient standards for chicken in the grower phase (National Research Council (NRC), 1994).

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Table 1: Composition of diets with 0 %(TD), 12.5 %(TA), 37 %(TB) and 50 %(TC) substitution of fishmeal with *B. germanica* in growers' diet.

Ingredients (%)	Treatment Diets			
	Diet TA	**Diet TB**	**Diet TC**	**Diet TD**
Maize grain	59	59	59	59
Wheat bran	17	17	17	17
Fishmeal	3.5	2.5	2	4
Cockroach meal	0.5	1.5	2	0
Soya beans	18	18	18	18
Limestone	1.3	1.3	1.3	1.3
DCP	0.3	0.3	0.3	0.3
Vitamin Premix	0.2	0.2	0.2	0.2
NaCl	0.2	0.2	0.2	0.2
MycoBinder	0.1	0.1	0.1	0.1
Calculated Analysis				
Dry Matter (%)	90.53	90.55	90.54	90.53
ME(Kcal/Kg)	2907	2912	2909	2909
Crude Protein %	16.0	15.9	15.91	16.0
Crude Fibre (%)	4.69	4.7	4.71	4.7
Crude Fat (%)	7.3	7.3	7.3	7.31
Methionine	0.77	0.77	0.78	0.78
Lysine	0.80	0.8	0.81	0.81
Determined Analysis				
Dry Matter (%)	89.64	89.89	90.04	90.04
ME(Kcal/Kg)	3255	3329	3356	3298
Crude Protein %	17.71	17.31	17.7	17.7
Crude Fibre (%)	4.99	5.37	5.38	5.38
Crude Fat (%)	6.49	7.24	7.58	7.24
Ash	10.81	10.47	9.81	11.61
Nitrogen Free Extracts (Carbohydrates)	49.64	49.15	49.91	48.47

Vitamin premix to provide the following per kg of diet: Vitamin A, 10,000 IU; Vitamin D_3, 2000 IU, Vitamin E, 5 mg; Vitamin K, 2 mg; Riboflavin, 4.2 mg; Nicotinic acid, 20 mg; Vitamin B_{12}, 0.01mg; Pantothenic acid, 5 mg; Folic acid, 0.5 mg; Choline, 3 mg; Mg, 56 mg; Fe, 20 mg; Cu, 10 mg; Zn, 50 mg; Co, 125 mg; Iodine, 0.08 mg.

Treatment diets were formulated to meet the minimum nutrient requirement of KALRO Improved chicken (KIC) of > 2900 Kcal/kg ME and a crude protein of 16-17 %, as indicated in ***Table 1***. The treatment diets' analysis also shows no great variation between the calculated and analysed proximate composition. A great amount of crude protein was supplied by soya beans, fishmeal and cockroach meal as indicated in *Table 1*. The numerical difference observed for various values were minor.

Feed Intake and Feed Conversion Ratio of Chicken Fed on Diets with *B. germanica* Meal (BGM)

During the fifty-five days of the feeding trial, there was no significant difference in total feed intake, average daily feed intake, and feed conversion ratio ($p > 0.05$) of every bird, as shown in *Table 2*. The highest total feed intake and average daily feed intake were recorded in diet TD (106.54g), while diet TC recorded the lowest value (99.56g).

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Table 2: Feed intake, body weight gain, and feed conversion ratios of chickens fed with 0 %(TD), 12.5 %(TA), 37 %(TB) and 50 %(TC) substitution of fishmeal with *B. germanica* in their grower diet.

Parameter	TA	TB	TC	TD	SEM	CoV	P-value
ADFI (g/ bird /day)	101.31[a]	104.93[a]	99.56[a]	106.54[a]	2.03	7.30	0.665
ATFI (g /bird)	5572.32[a]	5771.20[a]	5476.05[a]	5859.68[a]	111.76	7.29	0.665
FCR	6.74[a]	7.37[a]	7.10[a]	6.32[a]	0.22	10.62	0.384

SEM= standard error of mean, CoV= coefficient of variation, ADFI=average daily feed intake, ATFI= average total feed intake, FCR=Feed conversion ratios, abcd=figures within the same row with different superscripts differ significantly p<0.05

Feed conversion ratio (FCR) was not different among the four diets (p>0.05), the highest FCR was 7.37 for diet TB. FCR in diets TA, TB, and TC was only numerically different.

Final Weight and Average Daily Weight Gain of Chicken Fed on Diets with *Blattela germanica* meal (BGM)

There was a gradual increase in weight of birds for all treatment diets during the whole period of the feeding trial. There was no significant difference (p>0.05) in average weekly weight gain between the diets with BGM and the control.

Table 3: Initial body weight, total weight, and average daily gain of chickens fed with 0 %(TD), 12.5 %(TA), 37 %(TB) and 50 %(TC) substitution of fishmeal with *B. germanica* in their grower diet.

Parameter	Diet TA	Diet TB	Diet TC	Diet TD	SEM	CoV	P-value
MILW (g)	539.72[a]	531.17[a]	543.61[a]	531.94[a]	8.13	5.25	0.9537
MFLW(g)	1368.78[a]	1322.19[a]	1325.11[a]	1458.44[a]	79.62	7.91	0.423
ALWG (g)	829.05[a]	791.19[a]	781.49[a]	926.5[a]	29.62	11.74	0.3178
ADWG (g)	15.0[a]	14.39[a]	14.21[a]	16.85[a]	0.53	12	0.318

ADWG=Average Daily Weight Gain, MILW=Mean Initial Live Weight, MFLW=Mean Final Live Weight, ALWG=Average Live Weight Gain

Initial live weight, total weight gain, and average daily gain of the chicken growers fed on diets with replacement of fishmeal with cockroach meal at 12%, 37%, and 50% of 4 % inclusion of fishmeal did not differ significantly (p>0.05) from the control during the growth phase (weeks 8-16) as indicated in *Table 3*.

DISCUSSION

Composition of Diets

Feed ingredients are vital parameters in determining the nutritional value of a diet and physical characteristics such as colour, smell, and palatability. The treatment diets' analysis also showed no great variation between the calculated and analyzed proximate composition. The results imply that the values used in determining the appropriate formula for mixing the ingredients were a true reflection of the nutrient concentration in the feedstuffs.

Effects of Diets with *B. germanica* Meal (BGM) on Feed Intake and Feed Conversion Ratio of Indigenous Chicken

Feed intake is one of the parameter used to gauge feed palatability in chicken. Birds will take less feed when the diet is not palatable, has poor texture or when they do not like it (Khan *et al*., 2008; Teguia *et al*., 2002). Increased feed intake is observed when the birds either like the feed or it is nutritional imbalanced. Higher values for feed conversion ratios (FCR) are associated with high feed intake and vice versa (Warren and Emmert, 2000). In the current study, there was no significant difference in total feed intake, average daily feed intake, and feed

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conversion ratio ($p > 0.05$) as shown in *Table 2*. The highest average daily feed intake was recorded in diet TD (106.54g) while diet TC recorded the lowest value (99.56g) with average of 103.05g, which is similar to standard average daily intake of 100g. The average daily feed intake for the current study was higher than reported for same species in the similar growth phase (Wanjohi, 2019). In the study, Wanjohi *et al*. (2019) reported lower value of 82.3g that was attributed to inclusion of fibrous *Propis julifora* pods in the diet.

The feed conversion ratio (FCR) was not different among the four diets ($p>0.05$); the highest FCR was 7.37 for diet TB. Despite replacing up to 50 % of fishmeal in the diets, this did not affect daily feed conversion ratio. This could be attributed to the fact that nutritional analysis showed that all diets had similar nutritional values regarding protein and energy. These results are contrary to those of Téguia *et al*. (2002) and Bovera *et al*. (2016) who reported reduced FCR for growers fed on diets with insect meals. Feed intake in chicken has usually been affected by feed factors such as palatability (taste and smell), nutritional composition, and texture. The latter were uniform for treatment diets, but replacing fishmeal was expected to affect the diet's smell and taste. Regarding the results in this study, replacing up to 50 % fishmeal in growers' diets did not significantly alter the physicochemical properties of feed, thus resulting in similar feed intake across the diets.

Effects of Diets with *B. germanica* meal (BGM) on Total Weight and Final Weight

Weight is an important parameter that is used as an indicator of the nutritional status of birds. For birds in the grower phase, it is expected that birds will have a progressive increase in weight when fed on a balanced diet but stagnate or retard in weight when the diets are not providing the required daily nutrient intake. In the current study, the birds had similar initial live weights at the start of an experiment. At the end of the feeding trial, the total weight gain and average daily gain of the chicken growers fed on diets with replacement of fishmeal with cockroach meal at 12 %, 37 %, and 50 % of 4 % substitution of fishmeal did not differ significantly ($p>0.05$) from the control during the growth phase. There is limited information on studies that involved the replacement of fishmeal with the cockroach. The finding of the current study are contrary to the findings of Khan *et al*., (2018) who reported a significantly higher body weight for birds fed on insect meal compared to the control. Current study findings on average daily gain are similar to those reported by Wanjohi *et al*. (2018) for the same bird species.

Parameters such as feed intake, weight gain, and feed conversion ratio are interrelated and mostly used to assess growth performance in animals such as chickens. The similarity in these parameters for chicken fed on diets where fishmeal was replaced with BGM confirms similar nutritional benefits. According to Okello *et al*. (2021), farmers are willing to accept the incorporation of IBF as there is no longer credible information indicating the benefits of a given insect meal. The current study has found utilizing BGM in chicken diets is as good as using conventional fishmeal.

CONCLUSION

Based on the finding from this study, *Blattella germanica* meal has the potential to replace 50% of fishmeal in chicken growers' diets without affecting their growth performance. Using *B. germanica* meal in conventional chicken feed is possible to minimize dependence on fishmeal in Kenya. There is, however, a need for further studies with higher levels of cockroach meal inclusion to determine optimum inclusion levels in poultry-based diets.

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Ethical Approval

The study was conducted with ethical approval from Jaramogi Oginga Odinga University of Science and Technology.

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