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Effect of Dietary Crude Protein Levels on Egg Production, Hatchability and Post-Hatch Offspring Performance of Indigenous Chickens

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Abstract: Indigenous chickens in Kenya are estimated to be 21.5 million and are found in all the ecological zones in the country. They are 75% of the poultry population and produce 46 and 58% of the egg and meat, respectively. These levels of production are comparatively low compared to their numbers. The low productivity of indigenous chickens in Kenya and other parts of the world is partly attributed to poor management practices, in particular the lack of proper healthcare, poor nutrition and housing. This study was designed to determine the effects of dietary protein levels on egg production, hatchability and post-hatch offspring feed intake, feed efficiency and growth rate of indigenous chickens. Seventy two hens averaging 46 weeks in age, were offered four diets formulated from similar ingredients but differing in protein levels: 100, 120, 140 and 170 g CP/kg DM. Diets were randomly allocated to hens such that each diet had nine replicates each consisting of two hens. The hens were housed in battery cages and diets offered *ad-libitum*. Laying percentage, egg weight and feed intake were measured over an 8-week period. There was an increase ($p<0.05$) in egg weight from 42.9-46 g and laying percentage from 37.8-43.6% with increasing protein levels from 100-120 g CP/kg DM, but not ($p>0.05$) at 120 and 140 g CP/kg DM. The laying percentage of hens offered 170 g CP/kg DM was lower ($p<0.05$) than that of hens offered 100 g CP/kg DM (22 vs. 37.8 %), although feed intake was similar for all the levels of CP. Hatchability of the 328 fertile eggs set in an electric incubator ranged from 66-73% while chicks weighed from 31.6-32.8 g for the four levels of CP tested. The level of CP had no pronounced effects ($p>0.05$) on offspring feed intake (51-56 g), live weight gain (6.5 -8.5 g / day) and feed conversion efficiency (0.13-0.15). It is, therefore, concluded that the dietary crude protein requirement for laying indigenous hens is about 120 g CP/kg and maternal dietary protein level has no effect on hatchability and post-hatch offspring feed intake, feed efficiency and growth rate. The findings will help in the formulation of indigenous chicken layer diet with the appropriate protein content.

Key words: Indigenous chickens, crude protein, feed intake, feed efficiency

INTRODUCTION

Indigenous chickens in Kenya are estimated to be 21.5 million, are kept by about 90% of the population and are found in all the ecological zones in the country. They are 75% of the poultry population and produce 46 and 58% of the egg and meat, respectively (MOLFD, 2004). These levels of production are comparatively low compared to their numbers. The low productivity of indigenous chickens in Kenya and other parts of the world is partly attributed to poor management practices, in particular the lack of proper healthcare, poor nutrition and housing (Mwalusanya *et al.*, 2001). The birds depend primarily on scavenging feed resources, which may be highly variable and inadequate in nutrient supply. The productivity of indigenous chickens can, therefore, be increased through improved management, especially targeting nutrition through supplementation (Ndegwa *et al.*, 1996). To supplement appropriately, the nutrient requirements of indigenous chickens need to be known. The dietary protein requirement for laying birds has been estimated at 140-180 g/kg for light and medium sized exotic birds (Harms *et al.*, 1966; NRC, 1984). Fertility and hatchability are usually the major parameters of reproductive performance that are most sensitive to genetic and environmental influences (Stromberg, 1975). However, information on the protein requirements of laying indigenous chickens and its effect on fertility and hatchability is scarce. This study determined the influence of varying dietary protein levels on laying, hatching and post-hatching performance of offsprings of indigenous chickens.

Experiment 1: This experiment studied the influence of dietary protein level of the hens on hen weight, egg production and weight.

MATERIALS AND METHODS

Animals, housing and experimental design: Seventy two indigenous hens at the age of 46 weeks were used in a completely randomized design. Two birds were

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each randomly allocated to 36 battery cages measuring (40 x 45 x 40cm) with the floor sloping towards the front. Dietary treatments - 100, 120, 140 and 170 g CP/kg DM were randomly allocated to the 36 cages such that each diet was replicated 9 times. The cage was the experimental unit. The experimental duration was 8 weeks.

Feeds, feeding, data collection and analysis: The experimental diets (Table 1) were offered for 8 weeks. The layer diet for every cage was weighed into a plastic paper bag and was offered *ad-libitum*. This feed was put into the feed trough, ensuring that it was halfway full to avoid spillage. At the end of the week, the feed balance in the trough and the paper bag were collected and weighed. The feed intake per cage was calculated as the difference between feed weighed for the cage minus the feed balance in the trough and the paper bag. Drinking water was supplied at all times. Hen weight and egg production were taken weekly, while egg production per cage was recorded daily. A random sample of a tray of eggs for each dietary treatment was weighed weekly. Chemical analysis of the feed was carried out according the procedures of AOAC (1995). All data were analyzed using the General Linear Model (Genstat 5, 1995). Significant means were separated using the Least Significant Difference (Steel and Torrie, 1980).

Table 1: Composition of layer diets

	Diet (quantities in g/kg)			
Ingredient	1	2	3	4
Maize	892	854	815	778
Corn gluten meal	17	32	60	80
Fishmeal	15	65	49	66
Limestone	65	65	65	65
Di-calcium phosphate	6	6	6	6
Iodised salt	2.5	2.5	2.5	2.5
*Premix	2.5	2.5	2.5	2.5
Crude protein (analyzed)	103	123	139	171

*Each g contains:- Vitamins: A-4500 I.u, D3- 900 I.u, E- 8 I.u, k3-1 mg, B1-0.7 mg, B2-1.75 mg, B6 - 1.5 mg, B12 - 0.048 mg, C - 40.0 mg, Nicotinic acid - 17.5 mg, Pantothenic acid - 4.0 mg, Biotin - 0.02 mg, Folic acid - 0.4 mg, Choline Chloride - 140 mg, Caropyll (R+Y) - 13 mg, Minerals: Mn - 48 mg, Fe - 12.8 mg, Zn - 14.4 Cu - 1.6 mg, Co - 0.064 mg, Iodine - 0.448 mg, Se-0.04 mg.

Experiment 2: This experiment studied the influence of the maternal dietary protein level on hatchability and post-hatch offspring performance of indigenous chickens.

Animals, housing, feeding and incubation of eggs: Eighty indigenous hens, at the age of 50 weeks were used. They were housed in eight deep litter pens (2x2 m), each with 10 hens and 1 cock. They were offered diets shown in Table 1 for two weeks before collecting fertile eggs. The eggs were collected for 10 days, graded and set in an incubator (Table 2).

Table 2: Egg weights, number of eggs incubated and chicks hatched per dietary treatment

	Diet*			
	1	2	3	4
Analyzed CP (g/kg)	103	123	139	171
Egg weight (g)	47	48.7	49.1	48.2
No. of eggs incubated	59	90	79	100
First candling (7th day)				
No. of infertile eggs	10	12	6	8
No. of dead embryos	1	5	0	3
Second candling (18th day)				
Dead embryos	1	3	7	2
Eggs hatched (%)				
	43	59	55	69

* see Table 1 for description of the diets.

Candling was done on the 7th and 18th day and the eggs were transferred into a hatcher on the 18th day. Harvesting of chicks was on the 22nd day.

Rearing of the chicks: Day old chicks were weighed after harvesting and reared in an electric brooder for four weeks. They were subjected to the standard feeding regime by offering starter diet for the first 7 weeks and thereafter a grower diet for 7 weeks (Table 3). Standard vaccinations against Marek's, Newcastle and Fowl pox diseases were carried out.

From the 8th week, 40 offsprings from each dietary treatment were randomly allocated to battery cages. Each treatment was replicated 4 times. There were 5 cockerels and 5 pullets per cage. Weekly bird weight, feed intake and efficiency were recorded per cage for 9 weeks (up to 17 weeks of age). All data were subjected to a covariance analysis with the initial bird weight as the covariable (Genstat 5, 1995). Significant means were separated using the Least Significant Difference (Steel and Torrie, 1980).

RESULTS

The results for experiment one that investigated the influence of dietary protein level on egg production, egg weight, hen weight and feed intake are presented in Table 4.

Egg production, expressed as laying percentage was 22.1-43.6%. This was similar ($p>0.05$) between hens fed diets containing 100 and 140 g CP/kg but lower ($p<0.05$) for those fed a diet containing 170 g/kg CP. Egg weight increased ($p<0.05$) between 100 and 120 g CP/kg. The 100 and 170 g CP/kg diets had similar egg weights ($p>0.05$) but different egg production ($p<0.05$). Egg production was lowest (22.1%) for 170 g CP/kg. There was no dietary treatment effect ($p>0.05$) on feed intake and hen weight.

The results for experiment two that investigated the influence of dietary protein level on hatchability and post-

Table 3: Composition of Starter and Grower diets

	Proportion in diet (g/kg DM)	
Ingredient	Starter	Grower
Maize	760	799
Corn gluten meal	157	118
Fishmeal	50	50
Di-calcium phosphate	20	20
Iodised salt	3	3
*Premix	10	10
Crude protein	180	160

*Each g contains:- Vitamins: A-4500 I.u, D3 - 900I.U, E - 8 I.u, K3 - 1 mg, B1 - 0.7 mg, B2 - 1.75 mg, B6 - 1.5 mg, B12 - 0.048 mg, C - 40.0 mg, Nicotinic acid - 17.5 mg, Pantothenic acid - 4.0 mg Biotin - 0.02 mg, Folic acid - 0.4 mg, Choline Chloride - 140 mg, Caropyll (R+Y) - 13 mg, Minerals: Mn - 48 mg, Fe - 12.8 mg, Zn - 14.4 Cu - 1.6 mg, Co - 0.064 mg, Iodine - 0.448 mg, Se-0.04 mg.

Table 4: Influence of dietary protein level on production characteristics of indigenous hens

	Dietary CP (g CP/kg DM)				
Parameter[n]	103	123	139	171	Sed
Laying (%)	37.8^b	43.6^b	43.6^b	22.1^a	4.20
Egg weight (g)	42.9^a	46.0^b	47.2^b	45.5^{ab}	1.40
Hen weight (kg)	1.50	1.50	1.60	1.60	0.07
Feed intake (g/d)	73.9	78.6	83	78.1	4.24

^{a,b,c}Means within a row with different superscripts are different ($p< 0.05$). ^{n} = nine measurements per treatment.

Table 5: Influence of maternal dietary protein level on hatchability and offspring performance of indigenous chickens

	Dietary maternal protein level (g CP/kg DM)				
Parameter*	103	123	139	171	Sed
Hatchability (%)	72.9	65.6	69.6	69.0	
Chick weight (g)	31.8	32.0	32.8	31.6	
Offspring performance					
Av. daily gain (g/bird/d)	6.53	7.36	8.38	8.46	1.10
Feed intake (g/bird/d)	51.8	50.5	55.8	55.5	5.65
Feed efficiency (G/F)	0.13	0.14	0.15	0.15	0.009

*Number of birds per treatment = 40, Number of replications per treatment = 4.

hatch offspring performance are presented in Table 5. Dietary maternal protein level did not significantly ($p>0.05$) influence hatchability, chick weight, feed intake and feed efficiency of the offspring.

DISCUSSION

This study comprised of two experiments. The first experiment studied the influence of dietary protein level of the hens on hen weight, egg production and weight while the second studied the influence of the maternal dietary protein level on hatchability and post-hatch offspring performance of indigenous chickens. The results showed that hen weight was similar for the hens offered diets with 100-170 g CP/kg. This is an indication that the crude protein content of the 100 g CP/kg diet met the maintenance requirements. The results of this study are in agreement with the findings of Leeson and Summers (1989) and Ahmed (2000) who reported that dietary protein levels ranging from 15-20 g CP/kg had no effect on the body weight of laying hens. The average feed intake of laying indigenous chickens in the current study was between 74 and 83 g and was not influenced by the level of dietary protein. This finding is in agreement with that of Cho *et al.* (2004) who reported no increase in feed intake in laying hens offered dried leftover feed with additional protein (150-195 g CP/kg). However, this is contrary to the findings of some studies (Wethli and Morris, 1978; Gous *et al.*, 1987) that have reported increased feed intake with decreasing concentrations of dietary amino acids (crude protein). Birds eat more food to compensate for marginal deficiency of the first limiting amino acid. It can, therefore, be concluded that a 100 g CP/kg diet is not marginally deficient in the first limiting amino acid for laying indigenous hens. Emmans (1987) proposed that birds have a genetically predetermined requirement for nutrients and consequently, eat to meet this requirement for the first limiting nutrient. In the current study, feed intake and efficiency were similar for all maternal dietary protein levels. The birds in the present study were of similar genetic make-up and were reared in similar environment. This possibly explains why they had similar feed intake.

In the present study, egg production (laying percentage) was similar for hens offered diets containing between 100 and 140 g CP/kg. It was, therefore, deduced that approximately a 100 g CP/kg diet met the crude protein requirements for laying indigenous chickens. This study found that altering dietary protein concentrations between 100-140 g CP/kg affected egg weight while Cho *et al.* (2004) reported no increase in egg weight in commercial layers offered diets with protein between 150 and 195 g CP/kg. Gous and Kleyn (1989) reported that the effect of altering the dietary amino acid concentrations was more severe on egg production than on egg weight. The similarity in egg production for hens fed diets containing 100-140 g CP/kg in the present study suggest that hens offered the 100 g CP/kg diet were not in severe deficiency and that protein requirements for indigenous hens are lower than the level recommended by NRC (1984). However, the NRC (1984) recommendations are for hybrid hens that normally have higher protein requirements than indigenous hens. This is because exotic layers have a higher body weight (1.8-2.0 kg), egg production (80%) and egg weight (57-60 g) than indigenous hens that have 1.5-1.6 kg, 22-44% and 43-47 g body, egg production and egg weight, respectively. The requirements for these amino acids should also take account of the relationship between amino acid intake and egg output, which are dependent on both feed intake and level of production (Gous and Kleyn, 1989). Any supply of amino acids that exceeds the requirement for protein synthesis leads to a decrease of efficiency (Hiramoto *et al.*, 1990). This may explain the decrease in egg production of the hens offered the 171 g CP/kg protein diet. Egg production was similar to that reported by Ndegwa *et al.* (1996) for indigenous chickens under improved conditions. The hens in that study had a laying percentage of 41.1, while in the current study it was 43.6%. Ramlah *et al.* (1994) reported similar egg production (24.5%) for hens offered diets containing 120 g CP/kg and 180 g CP/kg. This is in agreement with the findings of the present study that dietary protein levels beyond 100 g/kg did not increase egg production. However, in the study by Ramlah *et al.* (1994), egg production was lower (24.5%) than in the present study (37.8%).

Fertility and hatchability are parameters of reproductive performance that are most sensitive to genetic and environmental influences (Stromberg, 1975). Factors affecting fertility and hatchability include plane of nutrition, conditions and length of storage of eggs, bird strain, egg quality and mating ratio (Stahl *et al.*, 1986; Peebles and Brakes 1987). Diet mainly affects the number and size of eggs rather than their composition (Fisher, 1994). Egg size affects hatchability (Neshiem and Card, 1972; Williamson and Payne, 1978; Mandlekar, 1981). Eggs within the weight range of 45-56 g weight hatch better than lighter ones (Mandlekar, 1981). Asuquo and Okon (1993) reported hatchability of large- (51-56 g), medium- (45-50 g) and small-sized eggs- (37.5-44 g) of 88.2, 84.8% and 72.1%, respectively. In the current study, hatchability ranged from 66-73%, which is lower than for medium-sized eggs reported by Asuquo and Okon (1993) but similar for the smaller eggs. Hatchability at 80-90% for Kenyan indigenous chickens has been reported before (MOALD and M, 1993). Asuquo and Okon (1993) studied exotic chicken (Hypeco white broilers) and for the Kenyan situation (MOALD and M, 1993), the figures reported are mainly for exotic chicken In Kenya, as much of the documentation has been on the commercial poultry sector. Exotic chicken lay large eggs (55-57 g) that have been reported to have a higher hatchability than smaller eggs. The hatchability figures reported by Mandlekar (1981) for large eggs are in agreement with those of Kenyan hybrid chicken that produce eggs with a weight of 55-57 g. Few studies have been done for the indigenous chickens. Ndirangu *et al.* (Pers. Com.) compared the hatchability of eggs of indigenous chickens in Kenya obtained from Kericho, Nyeri and Taita-Taveta districts and reported a range of 50-60% while Chemjor (1998) reported a hatchability of 41-48% for a similar flock. This is lower than that reported for exotic chickens in the country (MOALD and M, 1993). The difference might be due to the method of fertilisation. Chemjor (1998) used artificial insemination to fertilise the hens while natural mating was used in the current study. Dessie (1996) reported hatchability of Ethiopian local chickens ranging from 44-100% whereas Mwalusanya *et al.* (2001) reported 83.6% for Tanzanian local chickens. The high hatchability in the Tanzanian chicken may be due to the high cock to hen ratio (1:5) compared to that of the present study (1:10).

The weight of day-old chicks is directly proportional to egg weight. Al-Murrani (1978) found that chicks hatched from large eggs were heavier than those hatched from comparatively smaller eggs. Embryonic growth is largely affected by protein content and not by the space in the eggshell. More than 97% of the variation in chick weight at hatch is due to the fresh weight of the egg and water loss during incubation (Tullet and Burton, 1982). Chick weight has been reported to range from 62-78% of the fresh egg weight (Merrit and Groove, 1965). Chicks hatched from large eggs (61.8 g) were 71% of the fresh egg weight whereas those hatched from smaller eggs (53.2 g) were 66% of the fresh egg weight. Results from the present study are in agreement with those of Merrit and Groove (1965) and Al-Murrani (1978). Chick weights in the current study ranged from 66-68% of the fresh egg weight (43-47 g). Chemjor (1998) reported chick weights that were 69-71% of the fresh egg weight (43-45 g), which is in general agreement with the findings of Merrit and Groove (1965) and the present study. The day-old chick weights in this study were similar (30-32 g) to those of Nigerian local chicken and their crosses with the exotic egg and broiler type (Isika *et al.*, 2006) but higher than that reported for local chickens of Ethiopia (25.55-29.20 g) by Halima (2007).

It has been reported that growth in animals is influenced by the genotype and the animal's environment (Carlson, 1969; Isika *et al.*, 2006). The growth rate (6.5-8.5 g/d), feed intake (50.5-55.8 g) and feed efficiency (0.13-0.15) of the growers in the current study were similar for all the maternal dietary protein levels. This is due to their similarity in genetics and environmental conditions in which they were reared (Table 5). These parameters (growth rate, feed intake and efficiency) are similar to those of growers of local Nigerian chicken offered diets containing 200 and 240 g CP/kg (Isika *et al.*, 2006). However, the Nigerian local chicken growers had significantly lower body weight and feed conversion rate than local x egg type and the local x broiler type growers offered similar diets (200 and 240 g CP/kg). This indicates that the local chicken genotype had a negative influence on growth and feed conversion rate. The growers in this study had a mean growth rate of 7.8 g per bird per day. This was lower than that reported by Chemjor (1998) where growth rate was 11.4 g/bird/day for indigenous chickens at a similar age. Mwalusanya *et al.* (2001) reported a mean growth rate of 9.3 g per day between 10-14 weeks of age.

The growers in the current study had a mean body weight of 636.2 g at the 17^{th} weeks whereas Chemjor

(1998) reported a mean body weight of 535.3 g at a similar age. Protein intake was 8.6 g/bird/day and feed efficiency 0.14 compared to 6.9 g/bird/day and 0.20, respectively, in the study by Chemjor (1998). Crude protein intake in the present study was, therefore, higher but efficiency (gain: feed) was lower than in the Chemjor (1998) study. This difference could be due to the higher body weight of birds in the current study, which have a higher maintenance requirement and consequently, a lower feed efficiency. Moughan (1989) reported that maintenance requirement is a function of body weight and the protein requirement for maintenance has to be met before the synthesis of new body proteins.

Conclusion: The results suggest that the dietary crude protein requirement for laying indigenous hens is about 120 g/kg and the maternal dietary protein has no effect on hatchability and post-hatch feed intake, feed efficiency and growth rate. This information will be useful in the formulation of indigenous layer chicken diets with the appropriate protein content.

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