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Effects of Feed Restriction on Production Performance and Carcass Characteristics of Koekoek Chickens in Ethiopia

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Abstract

This study was conducted to examine the effects of feed restriction on production performance as well as traits relating to egg and carcass yield in Potchefstroom Koekoek dual purpose chicken bred under Ethiopian conditions. A total of 240 one-day-old dual purpose Koekoek chicks were randomly distributed into 12 experimental pens, representing 4 feeding treatments to evaluate the performance of chicks on body weight and age at onset of laying eggs (AOLE), egg quality, and carcass parameters. Treatments were control (unrestricted feed), R7-28 (restricted feed at 7, 10, 13, 16, 19, 22, 25 and 28 days of age), R35-56 (restricted feed at 35, 38, 41, 44, 47, 50, 53 and 56 days of age) and R63-84 (restricted feed at 63, 66, 69, 72, 75, 78, 81 and 84 days of age) groups. The results showed a significant difference between the control and R63-84 group's birds in both daily and total feed consumption ($P < 0.05$). There was a significant ($P < 0.05$) difference in body weight at the end of the starter period, where R63-84 group's birds had a heavier body weight and body weight gain than R7-28 and R35-56 groups' birds, but not control birds. Yolk diameter was significantly lower in R35-56 group than R7-28 and R63-84 groups ($P < 0.05$). Feed restriction also did not affect slaughter and dressed weight, but the eviscerated weight was significantly lower in R35-56 and R63-84 groups than control ($P < 0.05$). Feed restriction was associated with production costs of the treatments, and the feeding regime of R63-84 group significantly decreased the amount of feed consumed by birds ($P < 0.05$). Thus, feed restriction during 63 to 84 days of age (R63-84 group) can be useful because of improving the production profitability of rearing chicks without affecting the AOLE, body weight at AOLE, egg weight, and carcass parameters.

Introduction

One of the major problems faced by the poultry industry is the high cost of feed. In a commercial broiler production system, profit can be maximized by minimizing the feed cost which accounts for 60-70% of the total cost of production (Wilson and Bayer, 2000). Attempts to improve commercial poultry production and increase its efficiency should focus on better utilization of available feed resources.

Periodic restriction of the daily feed offered to simulate compensatory growth is a mean to reduce the feed cost. Feed restriction during the

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growing period in broiler chicken lowers body weight and carcass fat, while improves feed efficiency with compensatory growth during re-feeding (Al-Taleb, 2007). In laying hen, feed restriction during rearing decreases adult body weight, delays age of sexual maturity, decreases mortality, and the number of heavy follicles at the onset of laying (Bruggeman *et al.*, 2005). Feed restriction in brown layers between 6-18 weeks of age increases egg production without affecting egg quality traits, but slightly increases feed consumption in the laying period (Kim *et al.*, 2004). Feed restriction has been used to regulate the rate of growth and to control the age of sexual maturity in replacement pullets (Mbugua *et al.*, 1985). However, most of the research on feed restriction and its associated genotypic and behavioral changes have been conducted in heavy broiler breeds (Merlet *et al.*, 2005; Puterflam *et al.*, 2006; Hocking *et al.*, 2007).

In light of this, the present study was conducted to examine the effects of skip-a-day feed restriction during different growth stages on production performance as well as traitsrelating to egg and carcass yield in Potchefstroom Koekoek dual purpose chicken bred under Ethiopian conditions.

Materials and Methods

Animals, experimental design, and treatments

Experiment was conducted at Debre Zeit Agricultural Research Center (DZARC), located at an altitude of 1900 meters above sea level (8°44'N, 38°38′E) (DZARC, 2003). A total of 240 Koekoek one-day old dual purpose breed chicks were randomly distributed into 12 pens with 20 chicks in each pen. The chemical composition of feed ingredients was determined according to the proximate analysis method (Table 1) from which experimental diets was prepared (Table 2). The chicks were randomly assigned to four treatments (feeding regimes): control (unrestricted), R7-28 (restricted at 7, 10, 13, 16, 19, 22, 25 and 28 days), R35-56 (restricted at 35, 38, 41, 44, 47, 50, 53 and 56 days) and R63-84 (Restricted at 63, 66, 69, 72, 75, 78, 81 and 84 days). Chicks in all treatments received the same feed. Experimental pens, watering, and feeding troughs were thoroughly cleaned, disinfected, and sprayed against external parasites before the onset of the experiment. Birds were vaccinated against Newcastle, Gumbro (Infectious Bursal Disease), Fowl Pox, and Fowl typhoid diseases. On feeding days, birds were fed twice a day (08:00 a.m. and 17:00 p.m.). Clean water was available at all times for both the control and restricted groups. Diets were offered in a long feeder and water was available in a plastic fountain. Chicks were brooded using 250-watt infrared electric bulbs in a deep litter house covered with Teff straw.

Table 1. Chemical composition of ingredients

Ingredients	Corn grain	Wheat middling	Soybean meal	Nougseed cake
[1] DM (%)	91.8	92.1	93.8	91.6
[2] CP (%DM)	8.3	19.8	39.8	33.8
[3] CF (%DM)	3.1	8.5	6.9	18.1
[4] EE (%DM)	4.3	5.0	6.8	7.3
Ash (%DM)	3.4	3.9	6.1	10.5
[5] ME (Kcal/kg DM)	3470	3130	3498	2430
Calcium (%DM)	0.04	0.12	0.30	0.28
Phosphorus (%DM)	0.30	1.12	0.68	0.67

[1] dry matter, [2] crude protein, [3] crude fiber, [4] ether extract, [5] metabolizable energy

Measurements

Daily and total feed consumption were recorded, as well as the difference between the amount of feed offered and refused. Chicks were weighed to determine the average initial body weight (BW) at one day old and then every week in groups per pen to determine weekly BW. Average BW gain (ABG) was computed by taking the difference of final and initial BW per days in every week of the experiment. The feed conversion ratio (FCR) was determined as total feed consumption divided by change in BW (Ensminger *et al.*, 1990). Age at onset of laying an egg (AOLE) was fixed as the age at which the first egg was laid by at least 5% of the flock in each treatment. Egg quality parameter was assessed in terms of egg weight, shell thickness, yolk color, albumen height, yolk diameter, and Haugh Unit Score (HUS).

Table 2. Proportion of ingredients used in formulating diets for the experiment (%)

Ingredients	Starter period (0-8 weeks)	Growers period (9-23 weeks)
Corn grain	58.50	60.00
Wheat middling	8.00	11.4
Soybean meal	23.67	17.0
Nougseed cake	6.00	8.00
*Vitamin-mineral premix	0.50	0.50
Salt	0.30	0.30
Limestone	2.70	2.47
L-Lysine	0.15	0.20
DL-Methionine	0.18	0.13
Chemical composition		
Metabolizable Energy (Kcal/kg)	2986	2800
Crude Protein (%)	19	17.5
Crude Fiber (%)	5.5	5.8
Ether Extract (%)	6.5	6.8
Calcium (%)	1.03	1.15
Phosphorus (%)	0.51	0.52
Methionine	0.45	0.32
Methionine+Cystine	0.80	0.70
Lysine	1.00	0.80

*Vitamin-mineral premix = 50 kg contains, Vit A 1000000 IU, Vit D_3 200000 IU, Vit E 10000 mg, Vit K_3 225 mg, Vit B_1 125 mg, Vit B_2 500 mg, Vit B_3 1375 mg, Vit B_6 125 mg, Vit B_{12} 1 mg, Niacin 4000000 mg, Folic acid, 100 mg, Choline chloride 37500 mg, Anti-oxidant (BTHT) 0.05%, Manganese 0.60%, Zinc 0.70%, Iron 0.45%, Copper 0.05%, Sodium 0.01%, Selenium 0.004%, Calcium 2.7%.

To measure these traits, averages of 12 eggs per treatment were used. Egg weight at first lay was determined by weighing the first eggs in each replicate. Shell thickness was taken as the average thickness at the broad, middle and narrow points of the egg and was measured using a digital caliper. Albumen height was measured using a tripod micrometer unit. Haugh Unit Score was calculated using the following formula: HUS=100 log (h - 1.7 $EW^{0.37}$ + 7.6) (Haugh, 1937) where, HUS = Haugh unit score, h = albumen height, EW = egg weight. Yolk colors were assessed by the Roche fan which contained a series of fifteen colored plastic strips in a range scale, from very pale yellow to a deep intense reddish orange.

At the end of the feeding trial (23 weeks), six randomly selected pullets from each treatment group were starved for 12 hrs and weighed immediately before slaughter to determine the slaughter weight. After slaughtering, the birds were dry de-feathered by hand plucking. Carcass cuts as well as edible and non-edible offal were determined according to the procedure described by Kekeocha (1985). Dressed carcass weight was measured after the removal of blood, feather, legs, and head while the dressing percentage was calculated as the proportion of dressed carcass weight to slaughter weight. Eviscerated carcass weight was determined after removing blood, feather, legs, head, kidney, lungs, gastrointestinal, and urogenital tracts. The eviscerated carcass percentage was determined as the proportion of the eviscerated weight to the slaughter weight. The edible offal's (giblet) weight (the sum of weights of heart, gizzard and liver) were weighed and the percentage was calculated in relation to the slaughter weight.

Economic consideration of feed restriction in pullet rearing was estimated in terms of partial budgeting. The partial budget was analyzed in consideration of whole feed expense, labor cost, and costs of live pullets at DZARC at that time according to the principles developed by Upton (1979), whereby other costs were assumed to be similar for all the treatments.

Statistical analysis

Data collected were analyzed using General Linear Model (GLM) procedures of SAS (SAS, 2003). Tukey Kramer test was used to separate means which were significant in the least squares analysis of variance. The following model was used for the experiment:

$Y_{ij} = \mu + T_i + e_{ij}$,

where Y_{ij} = an observation (experimental unit)

μ = overall mean

T_i = i^{th} feed restriction level

e_{ij} = error term

Results

Feed consumption, body weight, and feed conversion ratio

The feed restriction regimen resulted in a significant ($P < 0.05$) difference in daily as well as total feed consumption (Table 3). Birds feed-restricted at the age of 63, 66, 69, 72, 75, 78, 81 and 84 days' age (R63-84 group) had significantly ($P < 0.05$) lower daily and total feed consumption. There were significant differences between treatments for final body weight, ABG and FCR during starter stage, with birds from R35-56 group having the lowest final body weight as well as ABG, but the lowest FCR belonged to R7-28 group. However, there were no significant differences during the pullet stage between all treatments in BW, ABG and FCR (Table 3).

Table 3. Effect of skip-a-day feed restriction on birds feed consumption, body weight, and feed conversion ratio

Variables	Treatments				*SEM* [1]	*P*-value
	Control	R7-28	R35-56	R63-84		
Daily feed consumption (g)	62.27[a]	61.31[ab]	60.59[ab]	58.87[b]	0.07	*
Total feed consumption (kg)	10.15[a]	9.99[ab]	9.87[ab]	9.60[b]	0.12	*
Initial body weight (g)	38.99	39.30	42.87	40.62	1.59	NS [2]
Starters final body weight (g)	282.86[ab]	268.60[bc]	259.13[c]	299.77[a]	4.24	*
Starters ABG (g/day)	5.81[ab]	5.46b[c]	5.15[c]	6.10[a]	0.11	*
Starters FCR (g/g)	3.58[a]	3.07[b]	3.58[a]	3.30[ab]	0.01	*
Pullets final body weight (g)	1674.91	1528.26	1568.13	1522.85	70.58	NS
Pullets ABG (g/day)	11.50	10.41	10.82	10.11	0.59	NS
Pullets FCR (g/g)	6.01	6.75	6.28	6.47	0.32	NS

[a-c] Means within a row with different superscripts are significantly different; *significantly different at $P < 0.05$.
[1] standard error of the means; [2] Non significant; Final body weight of pullets = at 23 weeks' old

Table 4. Effect of skip-a-day feeds restriction on age at onset of laying egg, body weight and egg quality traits of birds

Variables	Treatments				*SEM* [1]	*P*-value
	Control	R7-28	R35-56	R63-84		
AOLE (days)	156.33	154.00	157.00	155.33	1.43	NS [2]
Body weight at AOLE (g)	1529.59	1410.67	1467.28	1428.56	68.94	NS
Egg weight (g)	40.55	46.97	35.50	39.99	3.32	NS
Albumen height (mm)	5.80	6.07	5.67	6.04	0.40	NS
Yolk diameter (cm)	3.48[ab]	3.67[a]	2.91[b]	3.59[a]	0.15	*
Shell thickness (mm)	40.19	43.29	40.47	40.06	2.22	NS
Egg yolk color	3.00	3.33	2.67	3.30	0.29	NS
HUS (HU)	82.11	86.79	82.96	83.92	3.29	NS

[a,b] Means within a row with different superscripts are significantly different at $P < 0.05$.
[1] standard error of the means; [2] Non significant

Age at onset of laying egg and egg quality

The effect of feed restriction was assessed for age and BW at AOLE, and egg quality traits such as egg weight, shell thickness, albumen height, yolk color, yolk weight and HUS and yolk diameter (Table 4). No significant ($P > 0.05$) differences were observed among the treatments in AOLE and most egg quality parameters measured except the yolk diameter which was slightly shorter in R35-56 group than R7-28 and R63-84 groups.

Carcass yield and characteristics

There were no significant ($P > 0.05$) differences among the treatments in slaughter, dressed, feather, and giblet weights (Table 5). However, the eviscerated carcass showed a significant ($P < 0.05$) difference among treatments with birds from R35-56 and R63-84 groups having reduced weights relative to the control group.

Economic considerations

The economic return in terms of partial budget analysis results from pullets reared under different feed restriction regimens is presented in Table 6. There was a significant ($P < 0.05$) difference in total feed consumed, the cost of feed consumed, labor cost, and total profits. The total profit obtained from the sale of pullets from R63-84 group was highest compared to the other treatments.

Table 5. Effect of skip-a-day feeds restriction on carcass yield and characteristics of birds

Variables	Treatments				*SEM* [1]	*P*-value
	Control	R7-28	R35-56	R63-84		
Slaughter weight (g)	1737.80	1574.98	1526.43	1491.53	84.09	NS [2]
Dressed weight (g)	1575.20	1394.12	1367.17	1320.21	65.57	NS
Dressing percentage (%)	66.60	64.63	61.80	63.51	2.04	NS
Eviscerated weight (g)	1158.23^{a}	1017.87^{ab}	943.26^{b}	947.32^{b}	38.21	*
Feather weight (g)	122.55	117.32	121.58	114.28	0.37	NS
Giblet Weight (g)	76.95	71.93	63.03	71.03	4.15	NS
Giblet (%)	4.47	4.57	4.12	4.77	0.23	NS

^{a,b} Means within a row with different superscripts are significantly different at $P < 0.05$.
[1] standard error of the means; [2] Non significant

Discussion

These results showed that feed restriction regimen from 63 to 84 days resulted in a lower daily and total feed consumption. Birds during this age may require more feed because of higher maintenance requirements. These results were in agreement with the findings of Tesfaye *et al*. (2009; 2011) but in contrast to those of Pinchasove *et al*. (1985) and Ballay *et al*. (1992) who reported intermittent feeding led to considerably greater feed consumption on the following day than did *ad libitum* fed chickens. Feed restriction regimen in this study had a significant effect on the final BW and ABG of starters among treatments. The depressed growth rate observed in birds feed restricted at R7-28 and R35-56 groups compared to birds in R63-84 group might be due to a lack of compensatory growth. This result was not supported by the findings of Sandilandsa *et al*. (2006) and Hassanien (2011) who reported that the mean body weight of the control treatment in starter period was higher than restricted ones. Body weight and ABG of pullets were not affected by skip-a-day feed restriction at the end of the experiment, a finding in agreement with that of some research groups (Fontana, 1992; Zhong *et al*., 1995, Zubair and Leeson, 1996; Tesfaye *et al*., 2009) but not others (Ohtani and Leeson, 2000; Lee and Leeson, 2001). Feed conversion ratio had a significant difference between the treatment groups during the starter phase (before 43 days) but not in pullets (between 43 days to 23 weeks). These findings are in agreement with those of Sahota and Bhatti (2001), Sarica *et al*. (2009), and Tesfaye *et al*. (2011) who reported an insignificant effect of feed restriction on feed efficiency of pullets.

Table 6. Partial budgeting for effects of feed restriction on net benefit from pullets rearing

Items	Treatments				*SEM* [3]	*P*-value
	Control	R7-28	R35-56	R63-84		
Total feed consumed (kg/bird)	10.15^{a}	10^{ab}	9.88^{ab}	9.60^{b}	0.12	*
Cost of feed consumed (Birr)	55.40^{a}	54.46^{ab}	53.86^{ab}	52.41^{b}	0.65	*
Cost of feed/kg TBWG [1] (Birr)	33.89^{ab}	36.92^{a}	35.37^{c}	35.43^{b}	1.45	*
Labor cost [2] (Birr)	11.71^{a}	10.71^{b}	10.71^{b}	10.71^{b}	0.00	*
Live pullet sale (Birr/bird)	95.00	95.00	95.00	95.00	0.00	NS [4]
Live pullets sale/feed cost	1.71^{a}	1.74^{c}	1.77^{b}	1.81^{b}	0.02	*
Total Profit (Birr)	28.33^{d}	29.83^{c}	30.43^{b}	31.88^{a}	0.65	*

$^{a-d}$ Means within a row followed by different superscripts are significantly at $P < 0.05$.
[1] total body weight gain; [2] 0.071 Birr/chick/day; [3] standard error of the means; [4] Non significant

The lack of difference in AOLE may be due to an insignificant effect on pullet growth performance. The results were in contrast to the reports of Hurwitz and Plavink (1989) who found that feed restriction resulted in a delay in the onset of egg production, leading to an increase in egg weight. Shell thickness, albumen height, yolk color, and HUS were not affected by feed restriction in the present study, which is in agreement with the findings of Kari *et al*., (1977) who reported that shell thickness was not influenced by feed restriction. It is possible that yolk diameter is associated with a large egg weight and thick shell. However, the deposition of yolk in the egg requires the participation of the liver and adrenal gland to control of ovarian function. Interactions between these tissues may coordinate the assembly of the yolk and to prepare the largest follicle for ovulation (Etches, 1996).

The birds in R35-56 and R63-84 groups had reduced eviscerated carcass weights (with abdominal fat) compared to the control group. This may be due a higher accumulation of fat in their body. This finding is similar to that of Tesfaye *et al*. (2011) who reported that there was no difference in the slaughter weight and dressing weight between feed restricted and the control group but an influence on the carcass with abdominal fat.

Birds feed-restricted at R63-84 group yielded a higher total net profit (3.55 Birr/Bird) compared to control birds. The net benefit obtained significantly decreased with decreasing age of feed restriction in chicks. Thus, restricting feed to chicks in R63-84 group had an economic benefit as the daily feed consumption also increased in this oldest age group. Similarly, Novel *et al*. (2009), Hassanien (2011), and Tesfaye *et al*. (2011) reported that level of feed restriction caused economic advantage over *ad libitum* mainly by enhancing feed utilization.

Conclusion

Feed restriction at the age of 63, 66, 69, 72, 75, 78, 81, and 84 days (R63-84 group) decreases the amount of abdominal fat and feed consumed by chicks without affecting the AOLE, BW at the AOLE, egg weight, and carcass weight. Compensatory growth in feed-restricted chicks when they are off from feed restriction results in relatively equal body weight to that of non-restricted chicks at the AOLE. In the present study, the economic benefit of feed restriction was highest when birds restricted to feed at the age of 63 to 84 days of age (R63-84 group), because of decreasing feed consumption. Hence, commercial poultry producers can practice feed restriction in chicks during this period.

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