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Full Length Research Paper

Effects of feed restriction on production and reproductive performance of Rhode Island red pullets

Etalem Tesfaye[1]*, Berhan Tamir[2], Aynalem Haile[3] and Tadelle Dessie[3]

[1]Debre Zeit Agricultural Research Center, Debre Zeit, Ethiopia.
[2]Faculty of Veterinary Medicine, Addis Ababa University, Ethiopia.
[3]International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia.

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The study examined the effect of skip a-day feed restriction on Rhode Island red chicken and evaluated the effect in relation to age, body weight, egg quality, weight of reproductive tract and liver at the onset of egg laying. Two hundred 40 day-old chicks with mean body weight of 48.92 ± 1.53 g were randomly distributed to 12 pens each with 20 chicks, representing 4 feeding regimen of T1 (unrestricted, control), T2 (restricted at 7, 14, 21 and 28 days of age), T3 (restricted at 35, 42, 49 and 56 days of age) and T4 (restricted at 63, 70, 77 and 84 days of age). Feed restriction was based on skipping a-day once in a week and the next day's feed offer was based on the previous day's feed intake. The average day to lay first egg was significantly longer ($P < 0.05$) for T3 treatment groups compared with the others. The values were 140.8 ± 0.8, 140.17 ± 2.5, 147 ± 2.2 and 143.83 ± 2.3 days for T1, T2, T3 and T4 groups, respectively. There was also highly significant ($P < 0.01$) difference in body weight (1305 ± 13.2, 1374.3 ± 23.2, 1352 ± 23.5 and 1429.23 ± 44.5 g for T1, T2, T3 and T4 groups, respectively) and the values were higher for birds restricted at later age of growth. Egg weight at the onset of egg lay for the respective treatments were 42.68 ± 0.72, 42.43 ± 1.91, 47.9 ± 0.87 and 41.88 ± 0.77 g. Pullets of T4 group had significantly ($P < 0.01$) heavier uterus weight and longer length in absolute term than the control. Except for yolk diameter and shell thickness ($P < 0.05$), the egg quality parameters considered were not significantly ($P > 0.05$) different between the treatment groups. The result revealed the conclusion that feed restriction by skip a-day feeding system at T3 resulted in higher egg weight and can be considered as the optimum age for pullet rearing. Additionally, feed restriction at T4 could also be recommended due to heavier uterus weight and longer length in absolute term as these attributes indicate good consistency for the subsequent egg production.

Keywords: Body weight, egg quality, feed restriction, onset of egg laying, skip a-day.

INTRODUCTION

In commercial poultry production system, profit can be attained by minimizing feed cost which accounts for more than half of the total cost of production. According to Wilson and Beyer (2000) feed cost accounts for 60 - 70% of the cost for poultry production. Any attempt to improve commercial poultry production and increase its efficiency therefore, needs to focus on better utilization of available feed resources (DZARC, 1997). One of such means is restricting the amount of daily feed offer for sometime and stimulating compensatory growth (Dunnington et al., 1992). Hurwitz and Plavink (1989) applied feed restriction in growing egg type pullets and reported the delay in the onset of egg production leading to some increase in egg weight and improved overall feed efficiency. At the onset of egg production, egg weight is not large enough for commercial purpose. A delay in the onset of egg production caused by restricting the duration of light and/or feed increased egg size (Bornstein and Lev, 1984). This increase is in concomitant with increased body weight (Plavink and Hurwitz, 1983). Hurwitz and Plavink (1989) concluded that egg weight is a function of both age and body weight at the onset of egg production. Feed restriction has been used to regulate rate of growth and to control age of sexual maturity in replacement pullets. It has led less consistently to other benefits such as lower laying hen mortality and increased as

*Corresponding author. E-mail: etalemtes@yahoo.com.

lower laying hen mortality and increased egg production (Mbugua, 1985). Feed restriction usually involves regulating the consumption of a well balanced diet or limiting the intake of specific nutritional factors as energy or amino acids.

This paper reports the effect of feed restriction at different growth stages on the performance of Rhode Island Red chicken in relation to age, body weight and egg weight at the onset of egg lay.

MATERIALS AND METHODS

Animals, experimental design and treatments

The experiment was conducted at poultry farm of Haramaya university, located at an altitude of 1980 m.a.s.l, 9 0 26 ' N latitude and 42 0 3' E longitude (AUA, 1998). A total of 240 chicks with mean body weight of 48.92 ± 1.53 g were randomly distributed into 12 pens each with 20 chicks. The chicks were randomly assigned to the four feeding treatments [T1 (Unrestricted, Control), T2 (Restricted at 7, 14, 21 and 28 days of age), T3 (Restricted at 35, 42, 49 and 56 days of age) and T4 (Restricted at 63, 70, 77 and 84 days of age] using a completely randomized design (CRD). The birds maintained in deep litter system 15 cm depth and pen was designed 1.5 m x 1.5 m in width and length each with 2 round feeder and drinker throughout the experimental period. The chicks reared together until 84 days of age the period when the skipping days ended and then the male birds were culled from the pens as there is no reason keeping them till point of egg lay. After 12 weeks of age till the point of egg lay a total of 108 female birds were fed ad lib by measuring the daily intake and refusal per pen.

Feeds and feeding

Birds were fed on a commercial starter layer diet until the age of 6 weeks and on commercial grower layer diet up to the end of the experiment (at age of 22 weeks). Feed was offered to the birds twice a day except at days of feed restriction for T2, T3 and T4. The laboratory chemical analysis results of feeds used in the experiment revealed the crude protein and energy contents of the commercial feeds of 20.22% and 3144 ME kcal/kg DM for the starter diet and 18.52% and 2883 ME kcal/kg DM for grower’s layer feed offered, respectively. The CP and ME contents of the diets were within the range of the recommended CP and ME levels of starters and growers of 18% and 2950 ME kcal/kg and 17% and 2850 ME kcal/kg, respectively (Leeson and Summers, 2001).

Feed restriction was based on skipping a-day (restrict daily ration) once in a week, totally 4 days at different age of development for each treatment for the whole experimental period and the next day’s feed offer was based on the previous day’s feed intake. The feed restriction was done after the completion of one treatment then the other was followed (T3 started when T2 was finished and then T4 was followed). On the feed restriction day only water was given. The daily feed intake was measured as the difference between feed offered and refused.

Measurements and observations

Data on feed intake, age at first egg laying, body weight, egg quality and weights of reproductive tract and liver were recorded. Age at onset of egg laying (AOEL) was fixed as the age at which the first egg was laid by 5% of the flock and the average date was taken for each treatment. The weight of the first laid egg in the trial in each group was determined by weighing the egg using the sensitive balance of 0.01 g precision and the date the egg was laid, pen number and egg weight were marked on it for later identification. Egg quality was assessed in terms of egg weight, shell thickness, egg yolk color, albumen height, yolk diameter and Haugh unit score (HUS). For the measurements, 12 eggs per treatment and 4 per replication were taken and the average was computed for each quality parameters. The shell thickness was the average of the blunt, middle and sharp points of the egg and was measured using a micrometer gauge. Albumen height was measured by tripod micrometer unit and HUS was read from Haugh unit. The yolk color was described by the so-called Roche color fan as a range scale consists of a series of fifteen colored plastic strips, with one rated as very pale yellow and 15 a deep intense reddish orange. A description of the fan and the colors comprising it is given by Vuilleumier (1969).

At the end of the feeding trial (22 weeks), 6 randomly selected pullets from each treatment group were starved for 12 h and weighed immediately before slaughter. Weight of ovary including yellow and white follicles as a whole, excluding white follicles (less than 6 mm in diameter) and excluding yellow follicles (generally greater than 6 mm in size or 0.3 g in weight) were taken. The diameter of a large yellow follicle was also measured by centimeter tape taking from each 2 slaughtered pullets and the averages were computed for the treatments. The number of yellow follicles was counted. Absolute and relative (relative to body weight) weights and lengths of infundibulum, magnum, isthmus, uterus and vagina were also measured separately. The oviduct was measured as a whole using the sensitive balance.

Statistical analysis

Data were analyzed using the general linear model (GLM) procedures of SAS (SAS, 2002). The fixed effect fitted in the model included the effect of treatment (Control, T2, T3 and T4). Tukey Kramer test was used to separate means which were significant in the least squares analysis of variance (SAS, 2002). The following model was used for the analysis.

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

Where,

Y_{ij} = an observation (experimental unit)
μ = overall mean
T_i = feed restriction effect of ith restriction level and
e_{ij} = error term

RESULTS AND DISCUSSION

Dry matter intake and body weight

The feed restriction of skip a-day program didn’t result in a significant ($P > 0.05$) difference in average daily DM intake between treatments and the control group (Table 1). The non significant difference in daily feed intakes between the control and treatment groups were not in agreement with the findings of Nir and Nitsan (1979), Pinchasove et al. (1985) and Dunnington et al. (1992) who reported that intermittently fed group consumed considerably more on the following day than did ad libitum fed chickens. The similarity in daily DM intakes might be due to the fact that the amount of feed offered to birds on the next day was based on the previous day’s feed intake of the control group. The total DM intake where-

Table 1. Least squares means (± SE) for dry matter intake and body weight change as affected by feed restriction.

Parameters	Treatments					
	T_1	T_2	T_3	T_4	SE	P-value
Number of observation = 240						
Daily dry matter intake (g)	70.54 ± 3.19	66.68 ± 3.13	68.33 ± 1.32	64.69 ± 3.77	0.98	NS
Total DM intake (g)	11.17^{a} ±0.51	10.56^{ab} ± 0.50	10.82^{ab} ± 0.21	9.97^{b} ± 0.34	0.17	*
Initial body weight (g)	48.51 ± 0.34	48.48 ± 0.77	49.03 ± 0.67	49.65 ± 1.00	0.23	NS
Daily body weight gain (g)	8.933 ± 0.23	8.967 ± 0.60	9.133 ± 1.22	9.067 ± 0.61	0.19	NS
Final body weight (g)	1433.00±82.23	1438.00 ± 95.02	1464.00 ± 89.30	1451.00 ± 92.31	28.94	NS

a, b, c = Means within a row with different superscripts are significantly different; * = P < 0.05; NS = Non-significant; SE = Standard error; T_1 = Unrestricted, Control, T_2 = Restricted at 7, 14, 21 and 28 days of age, T_3 = Restricted at 35, 42, 49 and 56 days of age and T_4 Restricted at 63, 70, 77 and 84 days of age.

Table 2. Least square means (± SE) for effect of feed restriction on age at onset of egg laying, body weight and egg qualities.

Parameters	Treatments					
	T_1	T_2	T_3	T_4	SE	P-value
Number of observation = 108						
Age at onset of egg laying (days)	140.80 ± 0.80^{bc}	140.17 ± 2.50^{c}	147.00 ± 2.20^{a}	143.83 ± 2.30^{b}	0.96	*
Body weight (g) at first egg	1305.00 ± 13.20^{b}	1374.30 ± 23.20^{ab}	1352.00 ± 23.50^{ab}	1429.23 ± 44.50^{a}	15.18	**
Egg weight (g)	42.68 ± 0.72^{b}	42.43 ± 1.91^{b}	47.9.00 ± 0.87 ^{a}	41.88 ± 0.77^{b}	0.79	**
Shell thickness (mm)	0.26 ± 0.01^{ab}	0.25 ± 0.00^{b}	0.26 ± 0.01^{ab}	0.29 ± 0.01^{a}	0.01	**
Height of albumen (mm)	8.38 ± 0.38	7.84 ± 1.26	8.65 ± 0.41	7.60 ± 0.09	0.21	NS
Diameter albumen (cm)	6.69 ± 0.63	6.72 ± 0.28	7.12 ± 0.28	7.03 ± 0.16	0.11	NS
Diameter of yolk (cm)	3.47 ± 0.06^{ab}	3.44 ± 0.06^{ab}	3.49 ± 0.01^{a}	3.38 ± 0.06^{b}	0.02	*
Yolk color (Roche fan)	4.33 ± 0.58	4.33 ± 0.29	4.50 ± 0.50	4.67 ± 0.29	0.11	NS
HUS	95.43 ± 2.03	93.07 ± 4.75	95.75 ± 2.25	86.52 ± 9.38	1.75	NS

a, b, c = Means within a row with different superscripts are significantly different; ** = P < 0.01; * = P < 0.05; NS= non-significant; SE= standard error; T_1 = unrestricted, control, T2 = restricted at 7, 14, 21 and 28 days of age, T_3 = restricted at 35, 42, 49 and 56 days of age and T_4 restricted at 63, 70, 77 and 84 days of age.

as were significantly (P < 0.05) different between the groups. Birds under T4 consumed less feed during the period compared to the control group (Table 1). The reason might be due to the fact that the feed restriction applied at later age and at the time the daily requirement was high and it was reduced the total consumption than the other groups relatively due to skipping feed. The results obtained in the present experiment were similar to the findings of Zubair and Leeson (1994) and McMurtry et al. (1988) who reported that significantly less feed was needed per unit of weight gain as did controls that after undergoing nutritional stress by consuming a diluted diet.

There were no significant (P > 0.05) differences in initial body weight, final body weight as well as average daily weight gain of the birds under feed restricted and the unrestricted groups (Table 1). The results indicated that the feed restriction at different age groups did not affect the performance of the birds in terms of body weight change. These findings were in agreement with the reports of Zubair and Leeson (1994), who suggested that increased growth was due, in some way, to better nutrient utilization. In addition, the results obtained in the present study were also in agreement with the findings of Plavink and Hurwitz (1985), Calvert et al. (1989), Fontana et al. (1992), Jones and Ferrell (1992) and Scheilder and Baugnma (1993) who reported the lower food intake of food restricted birds than that of birds given *ad libitum* access, but when access to feed was again unrestricted the birds exhibited an accelerated rate of body weight gain typical of compensatory growth.

Age at onset of egg laying and egg quality

There was a difference (P < 0.05) in age at the onset of egg laying among the treatment groups (Table 2). The feed restricted birds in T3 delayed significantly (P < 0.05) to lay their first egg among the treatment groups. Similar to the present findings, different researchers (Hocking and Whitehead, 1990; Hocking, 1990, 1992) indicated the linear relationship between the number of yellow follicles and body weight in broiler breeders, turkeys and ducks which had been fed throughout rearing to achieve different proportions of the body weight. The reason might be due to the distribution of available energy to different organs during the feed restriction to make priority for tissue

Table 3. Least square means (± SE) for effect of feed restriction on relative weight of the different parts of oviduct.

Parts of oviduct	Treatments					
	T_1	T_2	T_3	T_4	SE	P-value
Number of observation = 108						
Infundibulum (%)	0.08 ± 0.01^b	0.07 ± 0.01^b	0.12 ± 0.02^a	0.08 ± 0.01^b	0.01	**
Magnum (%)	1.45 ± 0.01^a	1.13 ± 0.10^b	1.58 ± 0.15^a	1.33 ± 0.08^{ab}	0.06	**
Isthmus (%)	0.35 ± 0.01^a	0.23 ± 0.01^c	0.31 ± 0.04^b	0.31 ± 0.01^b	0.01	**
Uterus (%)	1.20 ± 0.04	1.10 ± 0.07	1.23 ± 0.16	1.32 ± 0.10	0.04	NS
Vagina (%)	0.25 ± 0.01	0.20 ± 0.01	0.23 ± 0.03	0.23 ± 0.01	0.01	NS
Oviduct (%)	3.55 ± 0.12^a	2.83 ± 0.08^b	3.60 ± 0.42^a	3.44 ± 0.20^{ab}	0.11	*

a, b, c = Means in the same row with different superscript are significantly different from each other, ** = P < 0.01, * = P < 0.05, NS = Non-significant, SE = standard Error; T_1 = Unrestricted, Control, T_2 = Restricted at 7, 14, 21 and 28 days of age, T_3 = Restricted at 35, 42, 49 and 56 days of age and T_4 Restricted at 63, 70, 77 and 84 days of age.

growth. Sahota and Bhatti (2001) showed a reduction in feed intake and body weight of pullets and delayed age of sexual maturity due to feed restriction. Body weight at the onset of egg laying was also significantly (P < 0.01) different between T4 and the control groups. Similarly, egg weight was higher (P < 0.01) for T3 compared to T2, T4 and the control group (Table 2). These results agreed with the findings of Bornstein and Lev (1984), who reported delayed onset of egg laying and increased egg size as the result of feed restriction. In addition, it was in agreement with the reports of Hurwitz and Plavink (1989) who found that feed restriction resulted in delay in the onset of egg production, leading to some increase in egg weight. However, Baloch et al. (2001) found no significant differences in egg weight as a result of starvation or feeding regime. Restricting caloric and/or protein intake before sexual maturity delays the onset of egg production and increases the number of ova that are packaged in to complete eggs throughout the laying cycle (Etches, 1996).

The present study revealed that birds that attained higher body weight at earlier age laid smaller eggs. The results concur with findings of Summers et al. (1990) who indicated that the effect of early maturity is associated with the depression in egg weight produced subsequently. However, the results of Plavink and Hurwitz (1983) indicated that body weight was positively correlated with age at onset of egg production and egg weight. Birds can start egg laying if higher body weight is attained at earlier ages (Bornstein and Lev, 1984) which is in agreement with the present results. The initial similarity of the sexual maturity plots for birds feed restricted at T2 and T4 with the control might be due to a similar number of birds in both feeding regimens having already reached the necessary body weight or body composition threshold for reproductive development (Brody et al., 1980, 1984).

Shell thickness significantly (P < 0.01) varied between the feed restricted and unrestricted groups (Table 2). The pullets reared under feed restriction at early (T2) had thin egg shell than T4. The results of the present study were not in agreement with the findings of Kar et al. (1977), who reported that shell thickness of eggs were not influenced by feed restriction. The higher shell thickness in the groups might be due to the fact that the birds might have accumulated adequate amount of Ca and developed bones well for later Ca mobilization when feed restriction had occurred than the chicks feed restricted at early age of development (T2). Height and diameter of albumen, yolk color and Haugh unit score (HUS) did not significantly (P > 0.05) differ between feed restricted and the unrestricted birds (Table 2). Yolk diameter differed (P < 0.05) between treatments and birds in T4 had performed poorly than T3. The result might imply improvement in the subsequent performance of the laying house in terms of egg weight for the group (T3). It could be noted that larger yolk diameter associated more with the large egg size.

Development of the reproductive tract

Weight and length of the different parts of oviduct: The least squares means of the effect of feed restriction on the relative weight and length of the different parts of oviduct are given in Tables 3 and 4.

The overall percent (P < 0.05) weight of oviduct was significantly lower in birds kept under T2 group compared with the control and T3. This indicated that the thickness of the wall of the oviduct might be associated with secretary activity and was much more in birds under feed restriction group T3 and the control. This higher proportional weight of the oviduct possibly indicates that adequate and preferential development of reproductive organs instead of other organs occurs at T3, T4 and control groups compared to early age (T2) restriction. The weight of infundibulum was higher (P < 0.01) in birds restricted at T3 (Table 3). The relative to body weights of

Table 4. Least squares means (±SE) for effect of feed restriction on relative length of the different parts of oviduct.

Parts of oviduct	Treatments					
	T_1	T_2	T_3	T_4	SE	P-value
Number of observation = 108						
Infundibulum (%)	0.49 ± 0.03	0.50 ± 0.02	0.54 ± 0.07	0.55 ± 0.05	0.01	NS
Magnum (%)	2.02 ± 0.06	2.08 ± 0.12	2.15 ± 0.20	2.08 ± 0.18	0.04	NS
Isthmus (%)	0.77 ± 0.04^{ab}	0.67 ± 0.03^{bc}	0.61 ± 0.06^{c}	0.83 ± 0.06^{a}	0.03	**
Uterus (%)	0.60 ± 0.04^{b}	0.53 ± 0.04^{b}	0.49 ± 0.07^{b}	0.77 ± 0.06^{a}	0.04	**
Vagina (%)	0.44 ± 0.02	0.38 ± 0.08	0.41 ± 0.05	0.43 ± 0.01	0.01	NS
Total (%)	4.32 ± 0.13	4.16 ± 0.18	4.19 ± 0.43	4.65 ± 0.35	0.09	NS

a, b, c, d = Means in the same row with different superscript are significantly different from each other, ** = P < 0.01, NS = non-significant, SE = standard error, T_1 = unrestricted, control, T_2 = restricted at 7, 14, 21 and 28 days of age, T_3= restricted at 35, 42, 49 and 56 days of age and T_4 restricted at 63, 70, 77 and 84 days of age.

Table 5. Least square means (± SE) for effect of feed restriction on ovarian follicles.

Parameters	Treatments					
	T_1	T_2	T_3	T_4	SE	P-value
Number of observation = 108						
Percentage weight of ovary	55.00 ± 2.00	48.90 ± 11.40	51.03 ± 3.20	50.77 ± 7.80	2.09	NS
Weight of white follicles (g)	5.80 ± 0.30^{a}	5.70 ± 0.30^{ab}	5.20 ± 0.10^{b}	6.10 ± 0.30^{a}	0.12	*
Weight of yellow follicles (g)	48.80 ± 2.00	43.10 ± 1.80	45.70 ± 3.30	44.70 ± 2.50	0.89	NS
Number of yellow follicles (No)	9.50 ± 1.00	8.30 ± 0.80	8.20 ± 0.60	9.00 ± 1.30	0.29	NS
Diameter of yellow follicle (cm)	2.60 ± 0.10	2.40 ± 0.26	2.90 ± 0.13	2.70 ± 0.20	0.07	NS
Percentage weight of liver	2.34 ± 0.20	2.48 ± 0.22	2.75 ± 0.32	2.52 ± 0.33	0.08	NS

a, b = Means in the same row with different superscripts are significantly different; * = P<0.05; NS= non-significant, SE= standard Error; T_1=unrestricted, control, T2= restricted at 7, 14, 21 and 28 days of age, T_3= restricted at 35, 42, 49 and 56 days of age and T_4 restricted at 63, 70, 77 and 84 days of age.

magnum, which is normally responsible for thick egg white synthesis was significantly (P < 0.01) higher for birds under T3 and control compared to T2. The recorded higher egg weight for T3 reflected the higher magnum weight that weight that could synthesis larger egg components. Lakhotia (2002) reported that magnum contributes all the thick albumen of the egg weight and in turn results in higher egg weight. The lengths of magnum was not significantly (P > 0.05) different between treatment groups and the control. Absolute as well as relative weight and length of isthmus, which is responsible for egg shell membrane formation, was significantly (P < 0.01) different between treatments. The T4 birds had greater weights of isthmus relative to body weight.

Pullets of T4 group had significantly (P < 0.01) longer length than T2, T3 and the control group. This might indicate that this group of birds may have good consistency for the subsequent egg production since they had showed good feed efficiency. Information in the literature on the effect of feed restriction on weight of oviduct, infundibulum, magnum, isthmus, uterus and vagina is generally scanty and therefore, comparison with our findings could not be made sufficiently. In general, the overall absolute length of oviduct was significantly (P < 0.01) different between treatments. Feed restriction at T3 tended to improve the egg size by promoting the development of cumulative oviduct part than other feed restriction stages. This finding probably indicates that a threshold of oviduct weight must be achieved before sexual maturity is attained, whatever the feeding regimen might be.

Weight of ovary and number of ovarian follicles: The mean weight of ovary including yellow and white follicles from the 4 feeding regime is shown in Table 5. There was no difference (P > 0.05) in mean weight of ovary between treatments and the control. The white follicles were smaller (P < 0.05) in T3 as compared to the control and T4 group of the treatments. This might be due to the fact that birds under T4 may produce enough follicle stimulating hormones which are responsible for follicle development as a result of improved feed utilization. The weight, diameter and number of yellow follicles were not significantly (P > 0.05) affected by feed restriction.

The entry of number of follicles into the growing phases was similar in both feed restricted and the control group. Similarly, Hocking (1993a) confirmed that the numbers of yellow follicles at the onset of lay were unaffected by the degree and age of restriction from 14 weeks of age.

Liver weight

Pullets reared under T3 had significantly ($P < 0.05$) heavier liver and there was no significant ($P > 0.05$) difference on liver percentage among the pullets reared on feed restriction and the unrestricted feeding regimen (Table 5). The increase in liver weight was due to the reason for effective synthesis of available energy to lipid for egg yolk formation during the re-feeding time. The deposition of yellow yolk in the egg requires participation of the liver and the adrenal gland may participate in the control of ovarian function. Interactions between these tissues might require to coordinate the assembly of the yolk and to prepare the largest follicle for ovulation (Etches, 1996). The reason might be due to the fact that the increase in liver size may increase the effectiveness of yolk synthesis for large egg weight (Etches, 1996).

The same reason might be given for the fact that birds in T3 laid comparably larger egg than the other feed restricted groups and the control. Pinchasove et al. (1985) found that intermittent feeding was accompanied by a consistent increase in the relative weight of the liver.

However, Katanbaf et al. (1989), Susbilla et al. (1994) and Jones (1995) reported a non significant difference in relative weights of liver by the feeding regime at the slaughter. The inconsistency of the result might be due to the effect of age at which feed restriction applied and type of feeding management (Jones and Ferrell, 1992).

Conclusions

The findings of this study revealed that feed restrictions by skip a-day feeding system at middle age of development (T3) resulted in higher egg weight and this can be considered as the optimum age for pullet rearing. Additionally, feed restriction at latter ages (T4) could also be recommended due to heavier uterus weight and longer length in absolute term as these attributes indicate that this group of birds has good consistency for the subsequent egg production. Future work may consider the incorporation of additional days on skip a-day feeding system by increasing the total days either twice per week or more to obtain better performance on pullet rearing without sacrificing the bird's production efficiency. In addition, the feed restriction method may also be tested at different laying phase of the birds and on total egg production.

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