ADDIS ABABA UNIVERSITY
COLLEGE OF HEALTH SCIENCE SCHOOL OF VETERINARY MEDICINE
AND AGRICULTURE

EFFECTS OF SKIP-A-DAY FEED RESTRICTION ON PRODUCTION AND CARCASS YIELD CHARACTERISTICS OF KOEKOEK CHICKS

BY

RAHWA SALIH ALI

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DEBRE ZEIT, ETHIOPIA

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ABBREVIATIONS

AACMC	Australian Agricultural Consulting and Management Company
ARC	Applied Reconfigurable Computing
AOEL	Age at Onset Egg Lay
BWG	Body Weight Gain
CACC	Central Agricultural Census Commission
CF	Crude Fiber
CRD	Completely Randomized Design
CP	Crude Protein
CSA	Central Statistics Authority
DM	Dry Matter
DMI	Dry Matter Intake
DNA	Deoxyribo Nucleic Acid
DZARC	Debre Zeit Agricultural Research Center
EE	Ether Extract
FER	Feed Efficiency Ration
GIT	Gastro Intestinal Tract
GLM	General Linear Model
HUS	Haugh Unit score
ME	Metabolisable Energy
NS	Non Significant
RT	Reproductive Tract
SAS	Statistical Analysis Systems
SEM	Standard error of means
TA	Total Ash

ABSTRACT

The effect of feed restriction on the production performances and carcass yield characteristics of Koekoek chicks was studied with the objective of determining to age, on body weight and egg weight at the onset of lay, economic advantages and the effect of feed restriction on carcass yield characteristics. The experimental study was carried out at DZARC. Two hundred fourth day-old chicks were randomly distributed in to 12 pens each with 20 chick's representing 4 feeding treatments, representing of T_1 (unrestricted), T_2 (restricted at 7, 10, 13, 16, 19, 22, 25 and 28 days), T_3 (restricted at 35, 38, 41, 44, 47, 50, 53 and56 days) and T_4 (restricted at 63, 66, 69, 72, 75, 78, 81 and 84 days) of age. The experiment lasted for a period of (23) weeks. Feed intake and body weight changes were monitored. At the end of the experimental period, six pullets from each treatment were randomly selected and slaughtered to evaluate carcass yield, weights and lengths of different parts of gastrointestinal tracts and reproductive organs. The daily and total feed consumption, total DM intake and daily CP intake of chicks had a significant difference. Feed restriction had a significant effect on body weight and body weight gain at the end of feeding starter feed. Age at onset of first laying, shell thickness, albumen height, yolk color and haugh unit score did not differ significantly ($P>0.05$) between feed restricted and unrestricted groups. The yolk diameter had significant difference between the treatment groups. The effect of feed restriction on the slaughter weight and dressing weight were not significant ($p>0.05$). The eviscerated carcass yield weight with abdominal fat and the abdominal fat weight and percentage showed significant ($P<0.05$) difference among treatments. Among the parameters from the length and weight of the GIT, only duodenum empty weight ($p<0.05$) showed, significant differences. Neither the weight nor the percentage of edible offals had a significance association with feed restriction. The weight of white follicles; and the absolute weight and relative weight of infundibulum, magnum and isthmus were significantly ($p<0.05$) different between treatments. Feed restriction is significantly ($p<0.05$) associated with the production costs among treatment. In conclusion, feed restriction at a later stage (T_4) of rearing period decreases the amount of feed by consumed without affecting the AOEL, body weight at the AOEL, egg weight and carcass weight. Therefore, commercial egg producers are advised to restrict chicks at the age of latter stage (T_4).

1. INTRODUCTION

Chickens are kept in most areas of the world and play a vital role in many rural households (Alders *et al.*, 2001). Poultry population in Ethiopia is estimated to be around 34.2 millions from which the native chickens comprises 94.4%, hybrid 3.92% and exotic breeds 0.64% (CSA, 2007). Even if poultry production has a long tradition in Ethiopia, modern poultry production started in 1950's with the establishment of higher learning agricultural institutes and research stations (Tadelle and Paters, 2003).

One of the major problems facing the poultry industry today is the high cost of feed. In commercial broiler production system, profit can be maximized by minimizing feed cost which accounts for more than half (60-70%) (Wilson and Beyer, 2000) of the total cost of production.

Any attempt to improve commercial poultry production and increase its efficiency needs, therefore, to focus on better utilization of available feed resources (DZARC, 1997). Restricting the daily feed offered for some time and stimulating compensatory growth (Ibrahim and Al-Talib, 2002; Naji *et al.*, 2003; Al-Talib, 2007; Novel *et al.*, 2009; Etalem *et al.*, 2011) is one of the means to reduce feed cost.

Feed restriction during the growing period in broiler chickens lowers body weight and carcass fat and improves feed efficiency with compensatory growth during refeeding (Al-Taleb, 2003). In laying traits, feed restriction during rearing decreases adult body weight, delays age of sexual maturity and decreases mortality Bruggeman *et al.*, (2005) and decreases the number of the heavy follicles at the onset of laying (Hocking and Robertson, 2005). Feed restriction in brown layers between 6-18 weeks of age increases egg production with a little increase in feed consumption in the laying period and without affecting egg quality traits (Kim, 2004).

At the onset of egg production, egg weight is not large enough for commercial purpose; thus, the egg size can be increased by delaying the onset of egg production through restricting the duration of light. This increase is concomitant with increased body weight (Plavink and Hurwitz, 1983).

Egg weight is a function of both age and body weight at the onset of egg production (Hurwitz and Plavink, 1989). 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 egg production (Mbugua, 1985).

Koekoek is a dual-purpose breed originated by crossing of the Black Australop with the White Leghorn breed. The average weight at 20 weeks of age is 2.4kg in males and 1.7 kg in females and the chick reaches sexual maturity at 130 days. This breed is well adapted for household production, especially in the rural areas (ARC, 2009).

The history of poultry in the industrialized countries may offer some basic knowledge and guidelines for poultry development in the developing countries as a whole and in Ethiopia in particular, but in view of the particular conditions in different countries and regions, specific research and approaches are needed to determine the optimum production systems and strategy development. Most of the research work is still being carried out on intensive poultry production, with modern housing, and sophisticated feeding systems (AACMC, 1984, Alemu and Tadelle, 1997). Even though a lot of work has been done on feed restriction along with genotype, behavioral change and environmental conditions of broiler breeds (Merlet *et al.*, 2005, Puterflan *et al.*, 2006; Hocking *et al.*, 2007), the effect of feed restriction for Koekoek chicken on their productive performance and economic benefits has not been conducted. In line with this, a proper feeding management was not assessed to obtain better output in terms of body weight gain, egg weight and quality at onset of egg lay for such breeds under Ethiopian conditions.

In this study an attempt was made to examine the effects of skip-a-day feed restriction at different growth stages on the subsequent performance of Koekoek dual purpose chicken with the following specific objectives:

- To evaluate the effects of feed restriction on age, body weight and egg weight at the onset of egg lay,
- To assess the effect of feed restriction on carcass yield characteristics, and
- To evaluate the economic advantages of skipping-a-day feeding system.

2. LITERATURE REVIEW

2.1. Factors affecting chicken performance

2.1.1. Genetic factors

The Ethiopian indigenous chickens vary in color, comb type, body conformation and weight and may or may not possess shank feathers. They are characterized by slow growth, late maturity and low production performance. The mean annual egg production of indigenous chickens is estimated at 60 small eggs with thick shells and a deep yellow yolk colour (Alemu and Tadelle, 1997). The egg laying period and number of eggs laid per period are to some extent higher in urban than in rural areas (CACC, 2003). There has been an increase in the number of exotic breeds of chickens and at present it is estimated that these make up about 2.18% of the national poultry population (CSA, 2005).

Selection and crossbreeding techniques have enabled the laying fowl to produce over 300 eggs a year, as against 100 from unimproved poultry. Growth performance of broiler chickens has been increased spectacularly over the last 30 years mainly due to the genetic progress, improvements of nutrition and controlled environment so that it takes only 33 days to reach finishing BW of about 2 kg (Wilson, 2005). This compares very unfavorably to the figures achieved in the 1930s of 2 kg in fourteen weeks on 10 kg of feed (Smith, 2001).

2.1.2. Age

Age at first egg or age at sexual maturity is a trait in which egg producers are interested. Birds reaching age of production earlier are supposed to be more efficient on feeds consumed (Teketel, 1986). Early maturing pullets grow faster and are usually more profitable layers (Summers *et al.*, 1990). However, the effect of early maturity has always been the depression in egg weights produced subsequently (Summers *et al.*, 1990). Body weight and composition at age of sexual maturity are the major factors influencing egg size both at maturity and throughout the remainder

of the laying period. Earlier maturing pullets has little change in body weight at time of first egg. Fat reserves are essential for puberty, and so it seems likely that body composition is as important as total body mass in influencing the onset of egg production. The local chickens as compared to the exotic breeds in Africa are characterized by their late maturity (Gueye, 1998). Sexual maturity of females is estimated to be 24 weeks in Malawi and Nigeria, 25 weeks in Senegal and 28 weeks in Tanzania (Sonaiya and Olery, 1989). The figures often quoted for chicken of Ethiopia range from 26-30 weeks (Tadelle, 1996). Commercial hybrids (layers and broilers) all over the world are being propagated for production of eggs and meat. The hybrid layers usually start laying at about 20 weeks of age and peak egg production is attained during the first production cycle (Mahmood *et al.*, 2007).

2.1.3. Feed and feeding

The level and quality of production, apart from the genotype of fowl, can be controlled by the level and system of feeding (Ashenafi, 1997). The domestic fowl requires the same class of nutrients as other farm animals; water, carbohydrates, proteins, fats, vitamins and minerals. The performance of any poultry farming, measured as eggs or live weight gain, can be obtained after the demands for maintenance have been satisfied. Dietary factors influences feed intake, especially if dietary nutrient composition is either deficient or in great excess relative to the bird's requirement (Ferket and Gernat, 2006).

Ad libitum feeding is an artificial condition, an outcome of modern management, and restriction of feeding brings the animals back to their natural conditions (Dunnington *et al.*, 1992). Furthermore, food scarcity or abundance is accompanied by adaptive mechanisms. Selection for body weight is accompanied by an increase in body fat and abdominal fat. Nutrient restriction during the early life of chicks was investigated for reducing abdominal fat and body fat at market age without loss in general performance characteristics (Plavink and Hurwitz, 1990; McMurtry *et al.*, 1988). However, in the majority of cases increase in fat deposition resulting from compensatory growth has been reported (Summeers *et al.*, 1992).

Laying chickens require a completely balanced diet to sustain maximum egg production over time. Inadequate nutrition can cause hens to stop laying. Inadequate levels of energy, protein or calcium can cause a drop in egg production. This is why it is so important to supply laying hens with a constant supply of nutritionally balanced layer food. Feeding whole grains, scratch feeds and table scraps will cause the birds diet to become imbalanced and inadequate. In moderate environmental temperatures high producing White Leghorn hens require 300-320 kcal of metabolisable energy per hen per day. Local birds are low producers of small sized eggs and live weight is lower than that of the White Leghorn (Tadelle, 1996). Solomon, (1996) found out that the egg production performance of the layers was linearly related to the levels of supplement offered. The same author further stated that scavenging plus 30 g/day of supplement failed to support maintenance requirement and resulted in gradual body weight losses and death of 50% of the birds. The birds which received intensive feeding and scavenging plus 120 g/day of supplement were equally productive, 0.57, eggs/day.

2.2. Compensatory growth

A simple and practical description of compensatory growth is defined as the abnormally rapid growth relative to age within a breed of an animal after early growth retardation (Lippens, 2003). An animal whose growth has been slowed by nutritional deprivation may exhibit an enhanced rate of growth when realimented. If this exceeds the maximal rate of gain when adequate nutrition has been provided, the animal is said to have undergone compensatory or catch-up growth (McMurtry *et al.*, 1988). The mechanisms underlying compensatory growth are not yet fully understood. It is indeed a very complex matter because it involves genetic, physiological, nutritional, metabolic, endocrine and behavioral aspects (Lippens, 2003). However, it is suggested that it is related to a reduced maintenance energy expenditure, increased gut fill and diet digestibility and reduced energy content of the body mass gain (Carstens *et al.*, 1991; Murphy and Loerch, 1994). Some researchers (Yu *et al.*, 1990) did not observe compensatory growth in broilers but this might be caused by the excessive period of feed restriction and/or the use of a feed restriction regime that was not sufficiently severe.

As stated by (Mersmann *et al.*, 1987) the magnitude of increase in growth rate following feed restriction may well be affected by the change in physiological status imposed by the weight loss during restriction. In poultry, the limits seem to be more narrowly defined, because the days to market are quite low which reduces the amount of time they have to "catch up" from previous interruptions in growth. Feed restriction of not more than 7 and 5 days for male and female broilers respectively, starting at 6 days of age, appears to allow for complete recovery of body weight in broiler chickens (McMurtry *et al.*, 1988). In swine, a longer period of restriction can be employed lasting from 2-4 weeks in duration (Prince *et al.*, 1983). Many studies have shown that complete compensation is possible provided the restriction is not too severe. Contrary to the situation with broilers, finishing pigs have more time in which to exhibit a compensatory response, although days to market is still economically very important to producers. Beef steers appear to be able to recover from a wider range of feed restriction programs, again related to the fact that they have a much longer time in which to attain market weight.

Plavink *et al.* (1986) pointed out that compensatory growth was obtained after short periods of restriction, whereas longer periods diminish recovery and may result in delay in achieving normal weight or in a permanent stunting of the animal. Moisier (1986) explained that compensatory growth occurred because the body has a set point for body size, appropriate for age. It is likely that early feed restriction resulted change of the growth pattern. The finding suggests that the body weight during feed restriction period might have an important role on the occurrence of compensatory growth (Jones and Ferrell, 1992). If it is the case, its severity, duration of feed restriction, the degree of feed restriction, initiated age of feed restriction, and sexes should be considered when designing feed restriction in order to keep lower growth rate or body weight stasis during period of feed restriction.

2.2.1. Control of compensatory growth

The mechanism governing compensatory growth has been studied by a number of workers (Mosier, 1986 andPitts, 1986). Two theories have been proposed to explain how compensatory growth is regulated. First, compensatory growth mechanisms may involve a set-point or reference for body size appropriate for age and that the control resides in the central nervous system

(Mosier, 1986). The system producing increased growth hormone (GH) is related to compensatory growth control but is not directly responsible for growth acceleration. The link between the compensatory growth control and GH release is regulated by photoperiod. Thus, after a period of under nutrition, the body tries to attain a size appropriate for age in the shortest possible time (Zubair, 1994). According to (Mosier, 1986), the mechanism for sensing a deficit in body size and for stimulating compensatory growth acceleration remains unknown.

The second theory relates to the so called "peripheral control" which suggests that tissues, control body size through cell number or by the total content of DNA (Zubair, 1994). As suggested by (Pitts, 1986), the number of DNA units is usually the principal determinant of mature size. In studies with adult rats, the same author found that nutritional deprivation reduced the size, but not the number of DNA units. Because the number of DNA units remained unchanged, it was felt that after nutritional stress, a certain memory mechanism took over to realiment the animal back to its appropriate size for age. If nutritional stress was imposed at too younger ages, then the number of DNA units was changed, meaning that realimentation was not as successful, since the memory mechanism was unable to function properly.

2.2.2. Factors influencing compensatory growth

The factors influencing compensatory growth capacity during the period of realimentation include the nature, severity and duration of the undernutrition as well as the age of the start of undernutrition and the degree and pattern of realimentation. Moreover, the time between restriction and slaughter age is obviously determining the ability of the bird to realize compensatory growth. However, also genetic factors such as sex and strain seem to have their impact (Lippens, 2003).

- **Duration and timing of the feed restriction**

In general, the longer the period of undernutrition, the more difficult it is for the bird to recover and to compensate for the reduction in weight gain (Lippens, 2003). A feed restriction to 167.4 kJ ME/day of broiler chick starting at the age of 5 days, for 3 or 5 days did not result in any weight

gain depression at 54 days of age, whereas a slight depression occurred when this restriction was continued for 7 days (Lee and Leeson, 2001).

Concerning age at restriction, Urdaneta-Rincon and Leeson (2002) reported no difference in overall response when a 7-day restriction period was applied to male broilers at various ages between 3 and 11 days. According to these authors however, for females the restriction should begin before the age of 5 days. On the other hand, according to Cristofori *et a.,* (1997) no mutual difference in final body weights (42 d of age) were observed when females were fed an amount just satisfying their metabolic requirements during an early (7 to 21 d) or a late feed restriction (21-35 d). Final weights on both restriction patterns were however significant lower (6 to 8 %) than the control group. Also the time between the restriction and age of slaughter yield should be taken into account. In the studies of Urdaneta-Rincon and Leeson (2002) very prolonged trial periods are used (around 56 days of age), which gives the bird the opportunity to recover more easily in comparison with common practice circumstances (42 d or less).

- **The severity of the feed restriction**

Usually the level of restriction imposed is calculated to meet the maintenance energy requirement (Zubair, 1994). But, during a period of undernutrition animals may be fed at, above or below maintenance energy requirements. The more severe the restriction, the greater the initial catch-up growth is, however, the less the ability of the bird to recover completely. Lee and Leeson (2001) got even relative heavier birds at 49 days of age when restricting birds to only 3.1 kJ x W0.67 for 4 days (imposed at 6 days of age) in a first trial. However, compensation was lacking in the following trials with similar restrictions. Also in own research (Lippens *et al.*, 2002) Ross male broilers restricted to maintenance energy requirements as short as 4 days starting from day 4 resulted in final body weights (at 42 d of age) being significantly lower (-144 g) in comparison with the ad libitum fed group. Contrary to these results, other researchers (Robinson *et al.*, 1992) were unable to demonstrate complete recovery of broilers subjected to similar levels of feed restriction.

As suggested by Jones and Ferrell (1992), it may, therefore, be advantageous to split up the period of restriction into several discrete periods interspersed with *ad lib* feeding. Jones and Ferrell (1992) showed no real advantage to a discontinuous system of feed restriction, although they did suggest that those birds were less nervous and flighty compared to those 2-3 days into a long continuous restriction period.

- **Stage of development of the animal**

As Zubair and Leeson, (1994) reported that undernutrition in the earlier stages of growth is more detrimental to an animal than is restricted at a later stage. Consequently, the age at which an animal is subjected to undernutrition may be as important as the severity of undernutrition. However, for broilers, depending on the sex of the bird it is generally recommended that feed restriction starts at approximately 6 days of age which usually allows for full recovery of body weight.

Other workers (Plavink and Hurwitz, 1988) have shown that feed restriction at any age between 3 to 11 days post hatch in male broilers seems to permit complete body weight recovery by 8 weeks of age. However, Fontna *et al.*, (1992) showed that broilers restricted to 40 kcal ME per bird per day from 4-11 days of age, had significantly lower mean body weights than did not restricted controls at 49 days of age. Female broilers have been found to respond better if feed restriction is initiated before day 6 post hatches (McMurty *et al.*, 1988). Washburn and Bondari (1978) initiated feed restriction after 3 weeks of age and found little evidence of compensatory growth, likely because insufficient time was allowed for recovery. Similar results were found by (Arafa *et al.*, 1983) who restricted broilers in the final stages of production (5-8 weeks of age).

2.3. Effects of feed restriction

2.3.1. Feed intake

Various methods of undernutrition have been used to retard or even stop growth during the restriction period. These methods include: physical feed restriction, limiting the level of

consumption of food in time (skip-a-day feeding) or reducing the hours of illumination of feeding (Religious *et al.*, 2001), diet dilution, chemical methods of feed restriction and use of low protein or low energy diets (Zubair and Lesson, 1996). Restriction based on limiting the accessibility of birds to feed leads to alterations in feeding behavior; chicken learn to consume large quantities of feed in a relatively short time. Thus under quantitative feed restriction, the bird is not only subjected to suboptimal level of nutrient, but the efficiency of utilization of these nutrients may be altered. During feed restriction practices during rearing period of 7-20 weeks, more feed is saved in white egg type light genotypes than brown type. In addition, there are differences in feed consumptions according to the feeding techniques in rearing period (Ergul *et al.*, 1992). Although, Kim *et al.*, (2004) indicates differences in feed consumptions between the feed restriction periods of 6-18 weeks and 12-18 weeks of brown layers; Leeson *et al.*, (1997) found no differences between *ad libitum* and protein level decreasing feeding in the rearing period in light layer genotypes. Practicing feed restriction short periods before laying have no differences in feed consumptions of *ad libitum* and restricted feeding and did not provide the inevitable advantages in following production period (Sandoval and Gernat, 1996). But particularly in breeders, programs applied both in early and late periods had more effects (Tolkamp *et al.*, 2005).

Investigation on the effect of intermittent feeding shows that food intake was consistently higher during each day of replenish for the intermittent birds than that of the *ad libitum* fed. They were not, however, able to compensate fully in feed intake. Restriction based on limiting the accessibility of feed lead to alterations in feeding behavior (Etalem *et al.*, 2009).

2.3.2. Body weight gain

Body weight and composition are important factors in rearing pullets of any strain for maximum egg production. Most strains of White Leghorn chickens have relatively low body weights and do not tend, under normal feeding, to become obese. There may be times when, for various reasons, pullets are to be delayed in coming into production. Under such circumstances, feed restriction is necessary to restrict body weight gain of the pullets. In brown-egg strains of chickens, some degree of restriction is often practiced (~90% of *ad lib* feeding), the effect of the difference in

body weights can change according to chicken age. Feed restriction practices cause a decrease in body weight in Leghorn layers (Fassbinder-Orth and Karasov, 2006).

Some type of feed restriction program is particularly important for broiler strain pullets, which tend to become obese if fed ad lib. The broiler breeder also is restricted in feed intake during the laying period. Pullets come into production and reach peak production weeks earlier than they did several years ago. This is true both for commercial layers and broiler breeders (Peter, 2005).

Growth rate of feed restricted birds was slower than that of broilers given ad libitum access to feed. But when access to feed is again unrestricted, the birds exhibit an accelerated rate of body weight gain typical of compensatory growth (Fontana, 1992; Jones and Ferrell, 1992, Scheilder and Baugnma, 1993). Susbilla *et al.*, (1994) reported that the mean relative growth rate for the 50 and 75% restricted broilers to the feed eaten by the control groups from 5 to 11 days of age was significantly less than the control birds during the period of feed restriction. But following the period of feed restriction the mean relative growth rate of birds which have been previously restricted was greater than the control. Susbilla *et al.*, (1994) clearly demonstrated that compensatory growth occurred in the strains of broiler that used following a period of decreased growth rate caused by feed restriction. This result further confirmed the findings reported by the former investigators who demonstrated compensatory growth following feed restriction in other strains of broilers, which have been fed at similar or more restrictive level.

2.3.3. Feed efficiency ratio

Many workers (Plavnik and Hurwitz 1985; 1988; Plavink *et al.*, 1986) have shown that exposing broiler chickens to an early and temporary maintenance level feed restriction initially reduced weight gain but because of compensatory growth during the subsequent *ad libitum* feeding phase, body weight at market age was restored. In addition, carcass and abdominal fat contents were reduced together with an improvement in feed efficiency. A concave growth trajectory of this kind, where initial growth depression is followed by compensatory growth, is also obtained by exposing broiler chicks to intermittent lighting at a young age (Plavink *et al.*, 1986). Moreover, Mengistu, (1998) stated that during the feed restriction, levels had been effective in limiting the

amount of feed consumed. In addition, in broilers, feed restriction also resulted in improved feed efficiency and reduced carcass fat apparently by limiting the number of adiposities (Cartwright *et al.*, 1986). The improved feed efficiencies observed indicated a lowered maintenance requirement or reduced wastage for birds on restricted feeding, an observation supported by the fact that all treatment groups produced similar egg numbers (Kar, 1977). In a later trial, (Plavnik and Hurwitz, 1991) found that a mild feed restriction of broilers at 7 day of age (allowing for 60 to 75% of normal growth) could offer an economic advantage over a continuous *ad libitum* feeding program. In addition, feed conversion efficiency, both overall and during the period after feed restriction, was superior in all restricted treatments compared to that of the control group. Therefore, the severity of the restriction, as well as its duration, plays an important role in the realimentation response.

Broilers that were subjected to feed restriction at an early age had significantly lower feed conversion at 28 (experiment 3 and 4) and 49 (experiment 1 and 2) days of age than birds eating ad libitum (Fontana, 1992). Feed intake and Feed efficiency ratio were decreased but the difference were not significant between birds that consumed feed *ad libitum* and those restricted to 20% of their daily feed intake for 4 days either at 7, 21, or 28 days of age (Jones and Ferrell, 1992).

In addition, while imposing various early feed restriction regimes, (Yu *et al.*, 1990) observed that male broilers restricted to 23 kcal per bird per day from 8 to 14 days had significantly lower body weights at 56 days of age than birds eating *ad libitum*. However, it is interesting to note that both groups of researchers (Summer *et al.*, 1990; Yu *et al.*, 1990) observed similar feed efficiencies for restricted and unrestricted broilers at the conclusion of their experiments.

2.3.4. Age at onset of egg laying

Layers may have to be restricted to prevent them becoming too fat. Breeding flock must be monitored regularly and weighed weekly to make sure they are uniform and not overweight. Severe restriction may be required in broiler breeders to avoid over fattiness (Peter, 2005).Age a sexual maturity age is the most distinct trait which is affected by feed restriction and genotype. In

this study, age at 50% egg production was determined as the indicator of sexual maturity age and body weights at this age were considered as the sexual maturity weights. The onset of sexual maturity and subsequently, the number of eggs that are produced, are profoundly affected by the intake of nutrients during growth. 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). Although growth of broiler breeder hens is routinely restricted to improve egg production restricting the energy intake of egg producing and dwarf broiler breeder hens may also improve subsequent performance in the laying house (Etches, 1996). Delaying the onset of egg production also reduces the number of small eggs that are undesirable in both the table egg and hatching egg markets. The physiological mechanisms responsible for an increase in egg production when nutrient intake is limited are unknown but may be related to the observation that plasma concentrations of luetnizing hormone are lower in hens given free access to feed during the remaining period (Etches, 1996).

Bornstein and Lev (1984), in breeder broiler chickens found that decreased body weight due to feed restriction resulted in delayed onset of egg production, suggesting that a minimal body weight was required for sexual maturity. The same authors showed that when feed was restricted in egg type pullets, egg production could commence even if body weight was reduced. The reduction in adult body weight if maintained during the production period could diminish the maintenance energy requirement and improve feed efficiency during that time.

2.3.5. Egg quality

The effect of feed restriction on egg quality of shell thickness, albumen height, yolk color and haugh unit score of eggs was not influenced by feed restriction(Kar *et al.,* 1977). 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 same author reasons out that the increase in liver size may increase the effectiveness of yolk synthesis for large egg weight.

2.3.6. Gastrointestinal tract development

The factors regulating feed intake are related in part to the anatomical adaptation of the gastrointestinal tract, for example its increase in weight and in digestive enzyme activity (Pinchasove *et al.*, 1985). However, the anatomical adaptation of the gastrointestinal tract might not be sufficient to allow the chick consume feed greater than control chicks in order to induce compensatory growth (Santoso, 1993). Fjeld *et al.* (1989) suggested that protein might be a limiting nutrient during recovery period after a period of malnutrition. Plavink and Hurwitz (1989) also suggested that essential amino acid requirements were higher in order to maximize growth in the first few weeks following feed restriction. The absence of compensatory growth and the limitation of protein deposition during the recovery period are due to an inadequate supply of dietary protein as noted by (Yu *et al.*, 1990).

2.3.7. Reproductive tract development

The avian oviduct is important as the organ is the core source of egg production (Sharma, 2000). Arias and Fernandez (2001) reported the avian oviduct involved in egg formation is a tubular organ responsible for the transport of the egg and the secretion of the components surrounding the yolk.

The upper most part of the oviduct having funnel shape is named as infundibulum. It is the site for fertilization. The narrower and lower, glandular portion of the infundibulum is known as the "chalaziferous region," and secretions from this region of an outer perivitelline layer are likely to contribute to the formation of the chalazae. The chalaziferous region is also one of two known sperm storage sites in the oviduct (Proudman, 2000). It is around 9-10 cm in length, and the developing egg spends around 15-30 minutes to cross the infundibulum (Lakhotia, 2002).

The isthmus is a short section of the oviduct, which forms the shell membrane around the developing egg. Narrower and thinner walls characterize it, and by luminal folds less voluminous

than those found in the magnum (Proudman, 2000) and has 10 cm length and developing egg requires 1.5 hours in chicken. It is around 5-10 cm in length (Lakhotia, 2002).

The layers of broiler breeders fed *ad libitum* recruit and ovulate more than one follicle per day and this results in disrupted egg formation and low productivity (Hocking *et al.*, 1987; Katanbaf *et al.*, 1989). The process of multiple recruitment and ovulation is controlled by feed restriction which decreases body weight during rearing to approximately 0.4% of *ad libitum* fed birds (Hocking, 1993b).

Feed restriction decreases recruitment if applied after 14 weeks of age when the ovary begins to show follicular activity (Hocking *et al.*, 1989). In general, the number of yellow follicles was linearly related to body weight in experiment with broiler breeders, turkeys and ducks which had been fed throughout rearing to achieve different proportions of the body weight (Hocking and Whitehead, 1990; Hocking, 1990, 1992). These results led to the hypothesis that ovarian function at the onset of lay was directly proportional to body weight at first egg. This was confirmed in a subsequent experiment which showed that the numbers of yellow follicles at the onset of lay were unaffected by the degree and age of restriction from 14 weeks to photo stimulation (Hocking, 1993a).

2.3.8. Mortality

The studies by Oyedeji and Atteh, (2005) and Etalem *et al.*, (2011) reported that feed restriction had no effect on mortality of the chickens. However, contrary to the present results of Saleh *et al.*, (2005) who reported that level of feed restriction had effects on mortality of the broiler chickens. Holloszy, (1992) hypothesized that feed restriction decreases mortality rate possibly by decreased formation of toxins and/or carcinogens, and/or decreased accumulation of waste products. However, it is likely that longer period of starvation and more its severity decreased chick viability because of the crisis in nutrient intake leading to impairment in metabolic processes (Holloszy, 1992).

3. MATERIALS AND METHODS

3.1. Description of the study area

This experimental study was carried out at Debre Zeit Agricultural Research Center (DZARC) at 45 km south east of Addis Ababa. The research center is located 8.44°N latitude and 39.02°E longitude at an altitude of 1900 meters above sea level. The rainfall pattern is bimodal in which the long rainy season occurs from June to October and the short rainy season from March to May. The average annual rainfall and average maximum and minimum temperature for the area are 1100 mm, and 28.3 ^{0}C and 8.9 ^{0}C, respectively (DZARC, 2003).

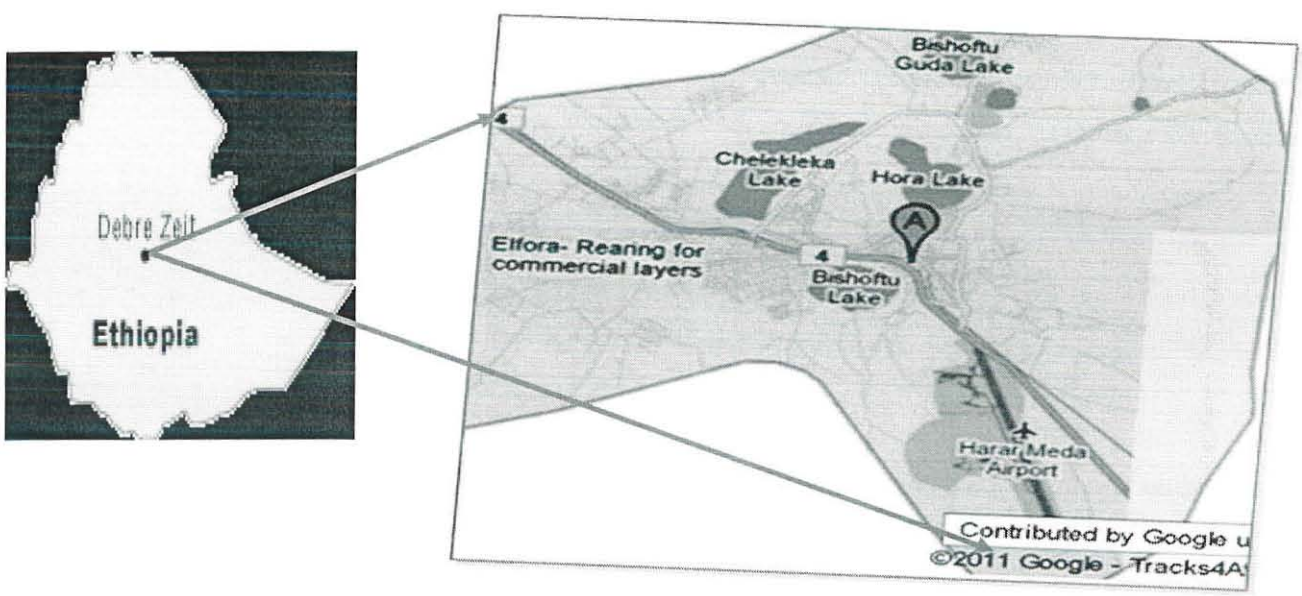


Figure 1: Map of the study area

Source: ***http://www.maplandia.com/ethiopia/oromiya/east-shewa/debre-zeyit/*** Modified on 8 June 2011 at 19:52.

3.2. Experimental design, treatments and birds

Completely Randomized Design (CRD) was used with four feeding treatments each with three replications. A total of 240 Potchefstroom Koekoek day-old chicks, were randomly distributed into 12 pens with 20 chicks in each pen and the four feeding treatments assigned randomly to each replication (Table 1).

Table 1. Layout of the experiment

Treatments	Rep.	Number of chicks per replication		
		R_1	R_2	R_3
T_1: Unrestricted(control)at DOC to 23week	3	20	20	20
T_2: Restricted at 7, 10, 13, 16, 19, 22, 25 and 28 days of age	3	20	20	20
T_3: Restricted at 35, 38, 41, 44, 47,50,53 and 56 days of age	3	20	20	20
T_4: Restricted at 63,66, 69, 72, 75, 78, 81 and 84 days of age	3	20	20	20

T_1, T_2, T_3 and T_4=are treatments $_{1, 2, 3}$ and 4, Rep=replication; R_1, R_2 and R_3= are replications $_{1, 2}$ and $_3$.

Day old chicks were weighed to determine their initial body weights. Chicks were fed with commercial starter ration according to the feeding manual of Koekoek breed for a week until the beginning of the feeding trial. The chicks were fed twice a day in the morning at 8:00 AM and afternoon at 1:00 PM throughout the experimental period for the control group and non-feed restricted days of treatment groups of birds. Plastic fountain drinkers were used for water supply. Feed were offered by round plastic plate and cubic metallic plate feeders depending on the age of the chick. They were vaccinated against Newcastle disease, Gumbro, Fowl Pox and Fowl typhoid as per plan given by breeders (Annex Table 3).

Daily offered feeds were weighed by using sensitive balance of. The refusals were collected, weighed and recorded every other day and pooled samples were taken from each treatment for chemical analysis.

3.3. Data collection

3.3.1. Feed intake

The daily as well as total feed consumption of the birds were recorded as the difference between the amount of feed offered and refused. DM (dry matter) intake was computed by multiplying feed offered with DM percentage in the feed offered. Dry matter refusal was computed by multiplying amount of feed with DM refusal percentage by feed refused. The DM intake was computed by the subtracting of DM refused from DM offered.

Crude protein (CP) intake was computed by multiplying CP offered percentage of feed offered by amount of feed offered and the CP of feed refusal was computed by multiplying CP refusal percentage to their feed refusal The CP intake was computed by subtracting CP refused from those CP offered.

Metabolizable energy (ME) offered was determined by multiplying the percentage of ME offered in feed to feed offered and the ME refused was calculated by multiplying the percentage of ME in refused feed to refused feed. The ME intake was computed by subtracting ME refused from those offered.

3.3.2. Body weight gain

Birds were weighed in groups per pen on weekly basis with sensitive balance of 5g to 40 kg capacity. The average body weight of a chick under each replication computed by taking the difference of final average body weight for the replication and average initial body weight within each 7^{th} day of the experiment.

3.3.3. Age at first egg lay

Age at onset of egg laying was fixed as the age at which the first egg was laid by at least 5% birds of the flock under each replication.

3.3.4. Egg quality

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 measurement of quality traits 12 eggs per treatment and 4 per replication were taken and then averages were computed for each of the above quality parameters.

Egg weight: The egg weight was determined by weighing the first laid egg of 12 birds under each treatment, using a sensitive balance of 0.000lg to 205g capacity.

Shell thickness: was taken as the average thickness at the broad, middle and narrow points of the egg and were measured using a digital caliper.

Albumen height: was measured using a tripod micrometer unit.

Haugh Unit Score: Were calculated using the following formula

$$HU=100 \log (AH-1.7EW^{0.37}+7.6)$$ (Haugh, 1937)

Where, HU=haugh unit, AH=albumen height, EW=egg weight

Yolk color: Was determined by using the "Roche color fan" as a range scale consists of a series of fifteen colored plastic strips, with one rated as very pale yellow to a deep intense reddish orange.

3.3.5. Feed conversion ratio

The mean dry matter conversion ratio was determined as the mean total dry matter intake (DMI) divided by mean total body weight gain (BWG) (Ensminger *et al.*, 1990).

3.3.6. Carcass yield characteristics

At the end of the feeding trial (23 weeks), 6 randomly selected pullets from each treatment group were starved for 12 hours, and weighed immediately before slaughter which was considered as

slaughter weight. After slaughtering the birds were dry de-feathered by hand plucking, eviscerated carcass cuts and non-carcass include, non-edible and edible offals components were determined according to the procedure described by (Kubena *et al.*, 1974 and Kekeocha, 1985).

Dressed carcass weight: was measured after the removal of blood, legs, head and feather and the dressing percentage calculated as the proportion of dressed carcass weight to slaughter weight multiplied by 100.

Eviscerated carcass weight: was determined after removing blood, feather, lower leg, head, kidney, lungs, gastrointestinal and urogenital tracts. The eviscerated carcass percentage was determined as the proportion of the eviscerated weight to slaughter weight multiplied by 100.

3.3.7. Gastrointestinal tract, reproductive tract and edible offals

The weights of the crop, proventriculus, duodenum, jejunum and ileum, caeca and large intestines were weighed with and without undigested contents. Abdominal fat was determined to assess the effects of feed restriction on fat deposition. Fat around the proventriculus and gizzard and against the abdominal wall and the cloacae were collected and weighed using a sensitive balance to the nearest gram. Its percentage was calculated as the proportion of slaughter weight multiplied by 100. The relative weights were calculated as a proportion of weight of gastrointestinal tract (GIT) parts to slaughter body weight.

The lengths of the different parts of the GIT and reproductive tract (RT) were measured by using a mater tape and ruler in centimeters. The relative empty weight and length, and absolute weight with contents of esophagus, crop, proventriculus, gizzard, small intestine (duodenum, jejunum and ileum separately), caeca and large intestine were measured. The relative and absolute weight of liver and heart were also noted. Weight of ovary including yellow and white follicles as a whole, excluding white follicles and excluding yellow follicles and separately were taken. The numbers of yellow follicles was counted. Absolute and relative weights and lengths of the infundibulum, magnum, isthmus, uterus and vagina were also measured separately. The oviduct was measured as a whole.

Edible offals (giblets): which include the heart, gizzard and liver, were weighed and percentages were calculated in relation to slaughter weight.

3.4. Mortality

Dead chicks from the entire experimental period of the replication was recorded as mortality and expressed as percent mortality at the end of the experiment. The mortality percentage was determined as follows:

3.5. Chemical Analysis

Feed samples from the respective treatments were analyzed. Proximate (Weende) analysis (AOAC, 1990) was used to determine DM, CF, TA and EE contents. Kjeldahl procedure of nitrogen estimation was used to determine the CP content determined by multiplying N by 6.25. The CF and EE were done at Jije Labo Glass private limited company, Alemegena. DM, CP, TA, Calcium and phosphorous were determined using atomic absorption spectophoto meter (AOAC, 1990) done at DZARC soils laboratory. Metabolisable energy (ME) of the experimental diets was determined by indirect method according to Wiseman (1987) as follows:

$$ME\ (Kcal/kg\ DM) = 3951 + 54.4\ EE - 88.7\ CF - 40.8\ Ash$$

3.6. Economic consideration

To estimate the economic benefit of feed restriction in pullets rearing, the partial budget was analyzed taking into consideration the whole feed expense, labor cost and prices of live pullets sale 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.

3.7. Statistical analysis

The data collected were analyzed using General Linear Model (GLM) procedures of SAS (SAS, 2002). Tukeys 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 experiment

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

Where,

Y_{ij} = an observation (experimental unit)

μ = overall mean

T_i = feed restriction effect of i^{th} restriction level and

e_{ij} = error term

4. RESULTS

4.1. Chemical composition of feeds

The laboratory chemical analysis results of feeds used in the experiment are shown in Table 2.

Table 2. Chemical composition of feed samples

Feed Samples	DM%	CP%	EE%	Ash%	CF%	Ca%	P%	ME (kcal/kgDM)
Starter ration offered	89.5	19.56	5.51	17.5	6.13	0.55	4.32	3108.29
Starter ration refused								
$^{1}T_1$	92.3	20.55	5.59	15.5	9.68	2.21	5.70	2764.08
T_2	92.4	20.96	5.85	16	9.10	5.50	5.57	2809.27
T_3	93.5	20.20	5.53	16	8.95	3.89	4.1	2805.16
T_4	92.4	23.24	8.51	16	8.35	1.96	5.67	3140.99
Grower ration offered	91.3	17.40	6.74	12.5	10.00	0.55	2.88	2895.63
Grower ration refused								
T_1	91.7	16.55	5.82	12.5	7.91	2.00	4.50	3055.99
T_2	92.3	18.4	6.56	13.5	9.07	3.24	5.17	2952.55
T_3	91.3	17.47	7.29	17.5	11.75	1.78	5.83	2836.15
T_4	91.7	18.51	4.41	14	8.97	4.94	7.33	2824.07

Where: DM = Dry Matter, CF = Crude Fiber, CP = Crude Protein, EE = Ether Extract, Ca = Calcium, P = Phosphorous total, ME Kcal/kg DM = Metabolisable Energy kilo calorie per kilo gram of Dry Matter, ^{1}T = Treatmenst

4.2. Feed intake

Mean values for parameters associated with feed intake are shown in Table 3. The result of this study showed that daily feed consumption, total feed consumption, total dry matter intake and daily crude protein intake were significantly ($p< 0.05$) different.

Table 3. Least squares means for feed intake under feed restriction of chicks

Variables	Treatments				SEM	P-value
	T_1	T_2	T_3	T_4		
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	*
Daily dry matter intake (g)	89.88	86.08	86.24	85.53	1.01	NS
Total DM intake (kg)	9.24^{a}	9.09^{ab}	8.98^{ab}	8.72^{b}	0.11	*
Daily crude protein intake(g)	17.27^{a}	16.32^{ab}	16.54^{ab}	16.05^{b}	0.21	*
Daily ME intake (kcal)	2974.07	2889.73	2908.57	2908.57	31.74	NS

^{a,b,c}= Means within a row with different superscripts are significantly different; * =significantly different at $p<0.05$, NS=Non significant; SEM= standard error of means; g=gram; kg=kilogram, kcal= Kcal calories

4.3. Body weight gain and feed conversion ratio

Final body weight, BWG and DM intake of starters were significant ($p<0.05$), while the final body weight and BWG feed and feed efficiency ratio of growers were not significantly different (Table4).

Table 4. Least squares means for body weight gain and Feed conversion ratio under feed restriction of chicks

Variables	Treatments				SEM	P-value
	T_1	T_2	T_3	T_4		
Initial body weight of starters(g)	38.99	39.30	42.87	40.62	1.59	NS
Final body weight of starters(g)	282.86^{ab}	268.60^{bc}	259.13^{c}	299.77^{a}	4.24	*
BWG of starters (g/day)	5.81^{ab}	$5.46b^{c}$	5.15^{c}	6.10^{a}	0.11	*
DM intake of starters(g)	20.80^{a}	16.75^{b}	18.39^{b}	20.53^{a}	0.39	*
FCR of starters(g/g)	3.58^{a}	3.07^{b}	3.58^{a}	3.30^{ab}	0.01	*
Final body weight of growers(g)	1674.91	1528.26	1568.13	1522.85	70.58	NS
BWG of growers(g/day)	11.50	10.41	10.82	10.11	0.59	NS
DM intake of growers (g)	69.09^{a}	69.34^{a}	67.86^{ab}	65.00^{b}	0.87	*
FCR of growers(g/g)	6.01	6.75	6.28	6.47	0.32	NS

^{a,b,c}= Means within a row with different superscripts are significantly different; * =significantly different at $p<0.05$, NS=Non significant; SEM= standard error of means; Initial body weight (g) = at 7-day old, Final body weight = at 23 weeks old; g=gram; kg=kilogram

The growth performance of chicks over the experimental period is shown in figure 2.

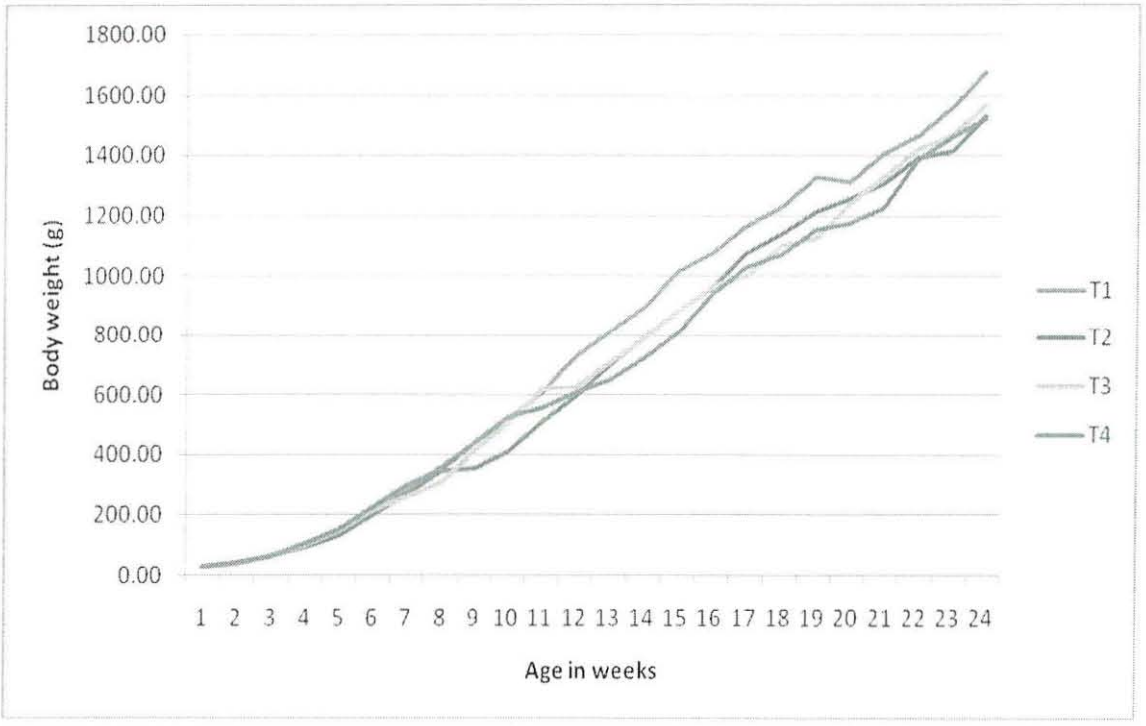


Figure 2. Body weights of chicks up to 23 weeks of age as affected by feed restriction.

4.3. Effect of feed restriction on age at onset of egg laying

The effect of feed restriction was computed for age at onset of egg laying (AOEL), egg weight, shell thickness, albumin height, egg color, yolk weight and HUS and yolk diameter (Table 5). The statistical analysis results indicated that feed restriction results in a significant difference on yolk diameter ($P<0.05$).

Table 5. Least squares means for the age at onset of egg laying, body weight and egg quality traits under control and restriction of chicks.

Variables	Treatment					
	T_1	T_2	T_3	T_4	SEM	P-value
AOEL(days)	156.33	154.00	157.00	155.33	1.43	NS
Egg weight(g)	40.55	46.97	35.50	39.99	3.32	NS
Body weight at AOEL (g)	1529.59	1410.67	1467.28	1428.56	68.94	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 thickeness(mm)	40.19	43.29	40.47	40.06	2.22	NS
Egg 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; * =significant different at $p<0.05$; NS=Non significant; SEM= standard error of means; cm=centimeters, g=gram, mm= milimeters

4.4. Eviscerated carcass yield

The analysis of variance indicated that there were insignificant ($p>0.05$) different for most carcass traits among the treatment groups, except for the weight of carcass with abdominal fat, and the result seen in (Table 6).

Table 6. Least squares means for carcass components under control and feed restrictions of chicks.

Variables	Treatments					
	T_1	T_2	T_3	T_4	SEM	P-value
Slaughter weight (g)	1737.80	1574.98	1526.43	1491.53	84.09	NS
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 Carcass with abdominal fat (g)	1158.23^{a}	1017.87^{ab}	943.26^{b}	947.32^{b}	38.21	*
Eviscerated Carcass with abdominal fat %	61.87	61.06	53.65	63.69	5.54	NS
Feather weight (g)	122.55	117.32	121.58	14.28	0.37	NS
Leg length (cm)	14.50	14.62	14.52	103.45	11.67	NS

^{a,b} = Means within a row with different superscripts are significantly different;* =significant different at $p<0.05$; NS=Non significant; SEM=standard error of means; cm=centimeter; g=gram

4.5. Weight and length of gastrointestinal tract

The experiment indicated that restricted feeding did not affect the length and empty weight of GIT except the duodenum empty weight. As shown in Table 7, the empty weight of the duodenum was significantly ($p<0.05$) different between the treatment groups.

Table 7. Least squares means of length and empty weight of different GIT components in control and restricted chicks.

Variables	Treatment					
	T_1	T_2	T_3	T_4	SEM	P-value
Esophagus(g)	2.28	2.65	2.27	1.95	0.37	NS
Esophagus(cm)	11.80	8.33	8.01	9.27	1.24	NS
Proventriculus(g)	9.97	9.18	9.37	8.70	1.46	NS
Proventriculus (cm)	10.80	10.28	9.38	10.00	10.80	NS
Crop (g)	5.52	6.30	6.37	4.48	2.38	NS
Crop (cm)	6.57	4.13	3.88	4.31	0.45	NS
Gizzard (cm)	4.88	4.80	5.01	5.68	0.74	NS
Duodenum (g)	9.47^{a}	7.31^{b}	7.85^{ab}	8.45^{ab}	0.04	*
Duodenum (cm)	22.10	22.36	21.53	21.91	0.46	NS
Jejunum (g)	27.20	23.57	26.30	23.90	1.04	NS
Jejunum (cm)	105.87	90.91	98.17	95.67	0.01	NS
Ileum (g)	5.02	6.10	5.13	4.20	1.22	NS
Ileum (cm)	14.27	16.60	16.20	16.40	1.44	NS
Caeca (g)	6.52	5.57	5.97	4.92	0.73	NS
Large intestine(g)	4.87	7.68	10.91	5.53	1.53	NS
Large intestine(cm)	11.65	12.35	12.56	10.75	1.40	NS

^{abcd} = Means within a row with different superscripts are significantly different;* =significant different at $p<0.05$; NS=Non significant; SEM=standard error of means; cm=centimeter; g=gram;

4.6. Edible offal weight and percentage

The mean values for weight and percentage of edible offal's parts for control and feed restriction group are shown in Table 8. The experiment indicated that edible offal weight and percentage were not significantly ($p>0.05$) different between treatments. The abdominal fat weight and abdominal fat weight percentage were significantly ($p<0.05$) different between treatments.

Table 8. Least squares means for weight and percentages of giblet (edible offal) and abdominal fat in control and feed restriction of chicks.

Parameters		Treatments					
		T_1	T_2	T_3	T_4	SEM	P-value
Heart	Weight(g)	6.67	6.63	5.85	6.20	0.45	NS
	Percent (%)	0.38	0.42	0.38	0.42	0.03	NS
Liver	Weight(g)	35.95	34.17	31.07	32.08	2.47	NS
	Percent (%)	2.08	2.16	2.02	2.16	0.11	NS
Gizzard	Weight (g)	34.33	31.13	26.12	32.75	2.38	NS
	Percent (%)	1.99	1.99	1.71	2.19	0.16	NS
Giblet	Weight (g)	76.95	71.93	63.03	71.03	4.15	NS
	Percent (%)	4.47	4.57	4.12	4.77	0.23	NS
Abdominal	Weight(g)	86.77^{a}	56.35^{b}	51.45^{b}	48.15^{b}	4.95	*
fat	Percent (%)	4.97^{a}	3.62^{ab}	3.33^{b}	3.25^{b}	0.32	*

NS=Non-significant, g=gram, SEM=Standard error of means, *= significant different

4.7. Weight and length of different parts of reproductive tract

The weight of ovary and number of ovarian follicles recorded from the experimental chicks are shown in Table 9. There was no significant difference between all the treatment groups in the ovary weight, yellow follicle number and yellow follicle weight ($P>0.05$). However, the white follicle weight varied between treatments ($p<0.05$).

Table 9. Least square means of weight of ovary and number of ovarian follicles under control and feed restrictions of chicks.

Parameter	Treatment					
	T_1	T_2	T_3	T_4	SEM	P-value
Ovary(g)	3.53	3.47	3.75	2.10	0.47	NS
Yellow follicle(number)	12.67	13.50	10.67	10.17	1.44	NS
Yellow follicle(g)	40.48	38.52	29.63	32.53	4.23	NS
White follicle(g)	5.22^{a}	3.10^{b}	3.58^{ab}	4.50^{ab}	0.38	*

[a,b =] Means within a row with different superscripts are significantly different; * = significant at P<0.05, NS=Non-significant, g=gram

The results of the effect of feed restriction on absolute and relative weight of oviduct are presented in Table 10. The effect of feed restriction had significant effect on the weight and percent of infundibulum, magnum, isthmus and oviduct. However, weight and percent of uterus and vagina and also the percent of oviduct were not affected by feed restriction (p>0.05).

Table 10. Least squares means of the absolute and relative weight of oviduct in the control and feed restriction of chicks.

Items	Treatment					
	T_1	T_2	T_3	T_4	SEM	P-value
Infundibulum (g)	1.43^{b}	1.30^{b}	1.30^{b}	2.76^{a}	0.23	*
Infundibulum (%)	0.08^{b}	0.08^{b}	0.09^{b}	0.18^{a}	0.01	*
Magnum (g)	25.35^{a}	20.88^{a}	12.83^{b}	11.88^{b}	1.50	*
Magnum (%)	1.46^{a}	1.33^{b}	0.84^{ab}	0.81^{a}	0.10	*
Isthmus (g)	4.32^{a}	2.82^{b}	3.75^{ab}	4.22^{a}	0.27	*
Isthmus (%)	0.25^{ab}	0.18^{b}	0.27^{a}	0.28^{a}	0.02	*
Uterus (g)	9.93	10.25	9.57	8.22	1.10	NS
Uterus (%)	0.57	0.65	0.62	0.56	0.08	NS
Vagina (g)	3.98	3.03	3.08	4.37	0.86	NS
Vagina (%)	0.23	0.19	0.20	0.29	0.05	NS
Oviduct (g)	45.07^{a}	38.25^{ab}	30.87^{b}	31.44^{b}	2.61	*
Oviduct (%)	2.59	2.44	2.02	2.14	0.18	NS

[a,b=] Means within a row with different superscripts are significantly different; * = P<0.05, NS=Non-significant, g=gram

4.7. Mortality

Feed restriction did not have any impact ($p>0.05$) on the mortality of Koekoke chicks up to the end of the experimental period. The mean percentage mortality of chicks for control group, T2, T3 and T4 were 8.51%, 12.31%, 12.11% and 12.21% respectively.

4.8. Economic consideration

The economic return in terms of partial budget from pullets reared under different feed restrictions is presented in Table 11. Accordantly there was significantly ($p<0.05$) different in the cost of feed consumed, total feed consumed, labor cost, and also total profits. However, the sale price was not affected ($p>0.05$) by the treatments.

Table 11. Partial budgeting for effects of feed restriction on net benefit from pullets rearing

Terms	Treatment					
	T_1	T_2	T_3	T_4	SEM	P-value
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 (Birr)	33.89^{ab}	36.92^{a}	35.37^{c}	35.43^{b}	1.45	*
Labor cost[1] (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
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,b,c,] Means within a row followed by different superscripts are significantly different, *=significant difference at $p<0.05$, TBWG = total body weight gain, [1]= 0.071 Birr/chick/day

5. DISCUSSIONS

The laboratory chemical analysis results of feeds used in the experiment revealed the crude protein and energy contents of the commercial feeds were 19.56% and 3108.29 ME kcal/kg DM for the starter diet and 17.40% and 2895.63 ME kcal/kg DM for grower, respectively. The CP and ME contents of the diets were within the range of the recommended CP and ME levels of starters and growers which are 18% and 2950 ME kcal/kg and 17% and 2850 ME kcal/kg, respectively (Leeson and Summers, 2001).

The feed restriction of skip- a- day had a significant effect on the daily and total feed consumption, total DM intake and daily crude protein intake of chicks of different treatment groups. Chicks on (T_2) of feed restriction had similar daily and total feed intake, daily CP intake and total DM intake ($P>0.05$) to those on (T_3) of feed restriction but lower than the control group and higher than (T_4) feed restriction. The reason for T_4 to lower feed intake is the amount of feed given to the chicks per day was higher amount of feed offered was restricted than the other restricted groups. T_4 had less feed consumption than Control, T_2 and T_3 groups ($p<0.05$). Eight days of every other two days gap feed restriction caused 369.15g, 300.05 g and 470. 74g less feed consumption per chicks than the control group in the T_2, T_3, and T_4 restriction period, respectively. The feed intake of chicks determines the daily crude protein intake and total DM intake because the composition of the feed is similar among the treatment groups. Thus, the difference for daily CP intake and total DM intake comes from the daily as well as total feed intake. There are three general management factors that can have additive effects on feed intake of chicks are access to feed and water; environmental stress; and disease challenge (Ferket and Gernat, 2006).

The feed restriction of skip- a- day had a significant effect on the final body weight of feeding, starter feed and daily body weight gain of chicks between treatment groups of feeding starter feed. During the time of feeding starter feed chicks restricted to feed on (T_2) had similar body weight gain ($P>0.05$) to that of (T_3) feed restricted groups. This result agrees with (Mazzuco *et al.*, 2000 and Hassanien, 2011). Whereas feed restricted chicks on (T_2) and chicks on (T_3) had

less body weight than the control and chick on (T_4). At this period chicks in T_2 and T_3 were restricted to feed that made them to take less amount of feed than the unrestricted group of T_4 and control. The present results are in agreement with the finding of (Sandilandsa *et al.*, 2006) and (Hassanien, 2011) the mean body weight of the control treatment in starter period was higher than restricted ones.

Even if feed restriction had significant effect on daily and final body weight gain at the end of starter feeding, feed restriction had no significant effect on the final body weight gain of chicks at the end of the experiment between the treatment groups. Numerically chicks kept under feed restriction program had less daily and final body weight than the control group. Leu *et al.*, (2002); Oyedeji and Atteh, (2005) and Fassbinder-Orth and Karasov, (2006) also observed that feed restricted chicks gained less weight than full-fed (control) chicks. Similarly, Cabel and Waldroup (1990) reported that feed restriction resulted in reduced weight gain. In addition the present results agreed with the finding of Etalem *et al.*, (2009) who reported that the feed restriction at different age groups did not affect the performance of the chicks in terms of body weight change. The result of the present study is agree with those of Fontana (1992); Zhong *et al.*, (1995) and Zubair and Leeson, (1996), who observed similar weight gain in feed restricted and ad libitum fed birds. However, this result disagreed with that of Ohtani and Leeson, (2000) and Lee and Leeson, (2001), who reported higher weight gain in feed restricted birds.

The insignificance difference of body weight gain in chicks between different treatment groups may be due to the occurrence of compensatory growth during feed restriction period in feed restricted birds. Jones and Ferrell, (1992) suggested that the body weight during feed restriction period might have an important role on the occurrence of compensatory growth. Although, Yu *et al.*, (1990) reported little compensatory growth in feed restricted broilers after 3 weeks of age, likely because insufficient time for recovery until market age; the present study provides ample time 24 weeks for chicks to have enough compensatory growth. However, Susbilla *et al.*, (1994) clearly demonstrated the occurrence of compensatory growth in the strains of broilers that used following a period of decreased growth rate caused by feed restriction that was in agreement to the present findings.

The result of the experiment indicated that Feed efficiency ratio had significant difference between the treatment groups during the time of starter feeding (before 43 days) and had no significant difference during grower feeding (between 43 days to 23 weeks). The Feed efficiency ratios were not affected by skip-a-day feeding program at different age groups of bird. The findings are in agreement with the reports of Sahota and Bhatti, (2001); Etalem *et al.*, (2009) and Sarica *et al.*, (2009) a non significant effect of the feed restriction on feed conversion efficiency of laying hens.

Age the first laying was statistically insignificantly ($P>0.05$) different between treatment groups (Table 5). The restricted chicks at T_3 delayed to lay their first egg than the control and other treatments. The onset of first egg laying associated with the body weight gain of the chick during the growing period. The reason for the delaying age at the onset of egg laying for T_3 is the body weight gain of the chick during growing period (before 43 days) is much lower than other treatment groups (Table 4). According to Bovans Brown Commercial Layer General Management Guide (2008) the best possible diets should be fed in the first few weeks of life since good critical growth is take place in this period in which frame and internal organ development occurs. From the result the number of yellow follicles is higher in early feed restricted groups (T_2) than other treatment groups. Similar to the present findings, different researchers Hocking and Whitehead (1990; Hocking (1992) stated as the number of yellow follicles was linearly related to body weight in experiment with 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 growth. Sahota and Bhatti (2001) showed a reduction in feed intake and body weight of pullets and delayed in age of sexual maturity due to feed restriction.

Shell thickness, albumen height, yolk color and HUS did not differ significantly ($P>0.05$) between feed restricted and the unrestricted chicks (Table 4). The results of the present study is in agreement with the findings of Kar *et al.,(* 1977), who reported that shell thickness of eggs was not influenced by feed restriction. However, yolk diameter differed ($P<0.05$) between treatments and chicks in T_2 had performed well than the control.

The yolk diameter had significant difference between the treatment groups and also T_2 had heavier egg weight and thick shell wall as compared to other groups (Table 5). From the present results, it could be indirect that yolk diameter associated with the large egg weight and thick shell. 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 same author reasons out that the increase in liver size may increase the effectiveness of yolk synthesis for large egg weight. Similarly the present study showed that the percent of liver weight to eviscerated weight was higher for T_2 than that of control and T_3 groups.

The effect of feed restriction on the slaughter weight and dressing weight were not affected between the birds in the feed restricted and the control group at different ages. This result agree with the finding of the Etalem *et al.*, (2011) who reported that there were no different on the slaughter weight and dressing weight between feed restriction and the control group.

The statistical analysis of eviscerated carcass yield weight with abdominal fat showed significant ($P<0.05$) differences between treatments. The chicks on T_1 exhibited significantly ($P<0.05$) different with high eviscerated carcass yield weight with abdominal fat compared to chicks on the restricted feeding system. Among the feed restricted groups, T_3 and T_4 had similar eviscerated carcass yield weight with abdominal fat. Under feed restriction the eviscerated carcass yield weight with abdominal fat had less than to the control group. The results were in agreement with the findings of (Etalem *et al.*, 2011).

The feed restriction method did not affect ($P>0.05$) the feather weight and leg length. The results were in agreement with the findings of Etalem *et al.*, (2011), who reported a skip- a- day feed restriction did not had an effect on weights of feather and legs.

The experiment results inducted that there was no significant ($P>0.05$) different in weight, length and percentage of most GIT parts among the treatment groups. However, duodenum empty weight ($P<0.05$), were significantly different between treatments.

The different in empty weight of duodenum was difficult to relate with the feed restriction, but it seems probable that growth of the digestive tract during the critical period of feed restriction was preferentially retained above that of the demanded organs. This selective maintenance of growth of the digestive tract could have contributed to the ability of the birds to achieve compensatory growth following feed restriction by improving efficiency of the digestive process. The present finding was agreed with the finding of Etalem *et al.*, (2011), in her reported that empty weight of duodenum had significant different between the control group and the feed restricted group.

The lack of significant difference in most GIT parts empty weight and length reflected the fact that the feed restriction did not result in extension of the parts during re-feeding that could have accumulate more feed in the GIT. The probable reason again might be the fact that the amount of feed offered during non restricted period was based on the previous day feed intake. Results in this study agreed with the findings of Novele *et al.*, (2008), in his reported that level of feed restriction caused a non-significant increase in the size of digestive organs concerned.

Mean values regarding various slaughter characteristics and relative organ weight of the present study from different treatment groups have been shown in Table 7. Statistical analysis of the data regarding edible offal weight and percentage of heart, liver, gizzard, and the giblet did not show any different in the mean values among the treatment groups due to any feed restriction programs when compared to those of control group. Similar findings have been reported with respect to the effect of feed restriction on the liver, heart, spleen and gizzard weights by (Mahmood *et al.*, 2005; Mohmood *et al.*, 2007 and Hassanien, 2011). The present findings were not in agreement with results of Etalem *et al.*, (2011), in her reported significant difference in the mean values of the liver among the feed restricted groups and the control group. Susbilla *et al.*, (1994) and Jones, (1995) indicated that no significant difference in organ weight (heart and lungs) at slaughter which was in line with the present results. In addition, the later also reported similar result to the present findings with regard to the lack of difference between the restricted and ad libitum fed birds in weights of the gizzard and proventriculus. However; Katanbaf *et al.*, (1989) and Al-Talib, (2007) did obtain a significant increase in gizzard weight and reduction in relative weight of the heart at 56 days of age following short term restriction.

The analysis of abdominal fat weight and percentage showed significant ($P<0.05$) different among treatment groups. Chicks on the restriction feeding system had less amounts of abdominal fat than the control group. These might be the less abdominal fat weight during feed restriction time due to distribution of energy to fulfill the composer growth body weight. T_2 had higher abdominal fat weight than the other restricted groups this is due to slightly greater total dry matter intake even though the statistical analysis revealed non-significant ($P>0.05$) different between treatments. The results of Al-Talea,(2007) and Etalem *et al.*, (2011) discovered that body fat was depressed when chickens were exposed to feed restriction. Inconsistently, Mansour *et al.*, (2004) observed an increased level of abdominal fat percentage with advancing slaughter age. However, findings of several investigators Mohmood *et al.*, (2007) and Novel *et al.*, (2009) virtually indicated no change in absolute quantity of abdominal fat in 42 to 49 days old broiler chicks subjected to feed restriction from 35 to 39 days of age.

As indicated in table 8 the weight of ovary and number of ovarian follicles recorded from the experimental chicks. There was no significantly ($P>0.05$) different between all the treatment groups in the ovary weight, yellow follicle number, yellow follicle weight. However; there was significantly ($p<0.05$) different in the white follicle weight. Chicks under the group of early feed restriction (T_2) have much lower weight for white follicle than other groups. This result agrees with the finding of Etalem *et al.*, (2009) the white follicle had significant difference. In addition according to Bovans Brown Commercial Layer General Management Guide (2008) the best possible diets should be fed in the first few weeks of life since good critical growth is take place in this period in which frame and internal organ development occurs.

The weight and relative weight of infundibulum, magnum and isthmus had significantly different among the treatment groups. Magnum contributes all the thick albumen of the egg weight and in turn results in higher egg weight (Lakhotia, 2002). The relative to body weights of magnum was significantly ($P< 0.05$) higher for chicks under T_2 and control compared to T_3 and T_4. Thus higher egg weight for T_2 reflected due the higher magnum weight which is responsible for the synthesis thick albumen. This is inconsistent with Etalem *et al.*, (2009) who reported chicks that have higher magnum produce large eggs. The lengths of magnum was not significantly ($P>0.05$) different between treatment groups and the control. Thus the thick wall albumen formation is

dependent up on the relative weight rather than the length of the magnum. Even if the shell membrane quality were not measured, absolute as well as relative weight and length of isthmus, which is responsible for egg shell membrane formation, was significantly ($P<0.05$) different between treatments. Feed restriction at T_2 tended to improve the egg size by promoting the development of cumulative oviduct part than other feed restriction stages. A threshold of oviduct weight must be achieved before sexual maturity is attained Etalem *et al.*, (2009). The overall ($P<0.05$) weight of oviduct was significantly lower in chicks kept under T_4 and T_3 group compared with the control and T_2. This associated with the egg weight in which birds with heavier oviduct produces eggs having higher weight. Thickness of the wall of the oviduct might be associated with secretary activity (Etalem *et al.*, 2009).

The mean percentage mortality of chicks for T_2, T_3, T_4, and control group were 12.31%, 12.11%, 12.21% and 8.51% respectively. Even if the mean percentages of the treatment groups are numerically different, feed restriction had no significant effect on mortality ($p>0.05$). Similarly Oyedeji and Atteh, (2005) and Etalem *et al.*, (2011) reported that feed restriction had no effect on mortality of the chickens. However, contrary to the present results of Saleh *et al.*, (2005) who reported that level of feed restriction had effects on mortality of the broiler chickens. The reason for high percentage mortalities for the feed restricted groups than the control group is other problems rather than feed such as disease. Diseases like salmonella and coccidiosis were occurred in all experiment groups as observed from clinical and post mortem examination

The economic return based on the partial budget analysis results from pullets reared under different feed restrictions showed significant ($p<0.05$) different among treatment. As the experiment result inducted all feed restricted T_4, T_3, T_2 are economic efficient than the control group. The highest net benefits of 3.55 Birr per chick was obtained from the sale of pullets reared under the feeding regimen of feed restriction (T_4) as compared to chicks that were not restricted. The better performance of chicks which were under T_4 might be due to the fact that feed restriction at this age group might not affect body growth as chicks accumulated enough reserves in the earlier periods. The net benefit obtained decreased with chicks under T_2 and better for chicks under treatment T_3 and least for the control group. Similarly, Novele *et al.*, (2009); Etalem *et al.*, (2011) and Hassanien, (2011) reported that level of feed restriction caused some economic

advantage over *ad libitum* feeding mainly by enhancing feed utilization. The live pullet's sale was the same for all treatment due to the chicks show compensatory growth at time of AOEL and the sale price is base on observation not on body weight. In addition, in this study the day at onset of first egg laying, egg weight and carcass weight does not affected by feed restriction. Thus, restricting chicks at latter age had economic benefit by decreasing the cost for feed and labor.

6. CONCLUSION AND RECOMMENDATIONS

Feed restriction at a later stage (T_4) of rearing period decreases the amount of feed consumed (470.93g/chick) without affecting the AOEL, body weight at the AOEL, egg weight and carcass weight. On the other hand, restricting chicks to feed at the latter stage of rearing period decreases the amount of abdominal fat. Compensatory growth in feed restricted chicks when they are off from feed restriction make chicks to have relative equal body weight to that of non restricted chicks at the age onset of egg laying. Thus later stage feed restriction is beneficial by decreasing the amount of feed consumed. Feed restriction has no effect on the GIT parameters that may have an effect in the body weight gain, likewise it has no significant on the weight of the ovary and yellow follicles in which they affect egg weight.

Based on the above conclusions the following recommendations are forwarded.

- Since the economic benefit of feed restriction is highest at latter stage (63 to 84 days of age), commercial poultry producers are recommended to restrict chicks at this period instead of restricting at 7 to 28 days of age and 35 to 56 days ages.
- It is also recommended that measurements on egg laying performance and hatchability be undertaken.

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8. ANNEXES

Annex 1. GLM model for feed consumption, body weight, RT and egg quality parameters

Table 1. GLM for daily feed consumption of the bird

Source	Degree of freedom	Sum of Square	Mean Square	F-value	F-tabulated 5%	F-tabulated 1%	Prob.
Treatments	3	18.49	6.16	3.88	4.07	7.59	0.556
Error	8	12.71	1.59				
Total	11	31.21					

Coefficient of Variation= 2.07%

Table 2. GLM for total feed consumption of the chick

Source	Degree of freedom	Sum of Square	Mean square	F-value	F-tabulated 5%	F-tabulated 1%	Prob.
Treatments	3	0.49	0.16	3.86	4.07	7.59	0.0563
Error	8	0.33	0.04				
Total	11	0.82					

Coefficient of Variation= 2.07%

Table 3.GLM for DM intake means of the chick

Source	Degree of freedom	Sum of Square	Mean square	F-value	F-tabulated 5%	F-tabulated 1%	Prob.
Treatments	3	35.55	11.85	3.86	4.07	7.59	0.0561
Error	8	24.54	3.09				
Total	11	60.09					

Coefficient of Variation= 2.01%

Table 4.GLM for daily crude protein intake means of the chick

Source	Degree of freedom	Sum of Square	Mean square	F-value	F-tabulated 5%	F-tabulated 1%	Prob.
Treatments	3	2.46	0.89	5.99	4.07	7.59	0.0193
Error	8	1.10	0.14				
Total	11	3.56					

Coefficient of Variation= 2.23%

Table 5.GLM for initial body weight of starter (g) of chick

Source	Degree of freedom	Sum of Square	Mean square	F-value	F-tabulated 5%	F-tabulated 1%	Prob.
Treatments	3	28.066	9.35	1.23	4.07	7.59	0.3598
Error	8	60.72	7.59				
Total	11	88.79					

Coefficient of Variation= 6.81%

Table 6.GLM for final body weight of starter (g) of chick

Source	Degree of freedom	Sum of Square	Mean square	F-value	F-tabulated 5%	F-tabulated 1%	Prob.
Treatments	3	2823.06	941.02	17.46	4.07	7.59	0.0007
Error	8	431.11	53.88				
Total	11	3254.17					

Coefficient of Variation= 2.64%

Table 7.GLM for daily body weight gain of starter (g) of chick

Source	Degree of freedom	Sum of Square	Mean square	F-value	F-tabulated 5%	F-tabulated 1%	Prob.
Treatments	3	1.75	0.58	16.20	4.07	7.59	0.0009
Error	8	0.29	0.036				
Total	11	2.03					

Coefficient of Variation= 3.36%

Table 8. GLM for initial body weight of grower (g) of chick

Source	Degree of freedom	Sum of Square	Mean square	F-value	F-tabulated 5%	F-tabulated 1%	Prob.
Treatments	3	2823.06	941.021	17.46	4.07	7.59	0.0007
Error	8	431.12	53.89				
Total	11	3254.17					

Coefficient of Variation = 2.64%

Table 9. GLM for final body weight of grower (g) of chick

Source	Degree of freedom	Sum of Square	Mean square	F-value	F-tabulated 5%	F-tabulated 1%	Prob.
Treatments	3	44772.78	14924.26	1.00	4.07	7.59	0.4417
Error	8	119588.83	14948.60				
Total	11	164361.61					

Coefficient of Variation =7.77%

Table 10.GLM for body weight gain of grower (g) of chick

Source	Degree of freedom	Sum of Square	Mean square	F-value	F-tabulated 5%	F-tabulated 1%	Prob.
Treatments	3	3.40	1.13	1.07	4.07	7.59	0.4136
Error	8	8.44	1.06				
Total	11	11.84					

Coefficient of Variation = 9.44%

Table 11.GLM for mean of yolk diameter (cm) of chicks

Source	Degree of freedom	Sum of Square	Mean square	F-value	F-tabulated 5%	F-tabulated 1%	Prob.
Treatments	3	1.50	0.50	7.21	4.07	7.59	0.0116
Error	8	0.55	0.7				
Total	11	2.05					

Coefficient of Variation= 7.55%

Table 12.GLM for mean of duodenum empty weight

Source	Degree of freedom	Sum of Square	Mean square	F-value	F-tabulated 5%	F-tabulated 1%	Prob.
Treatments	3	7.65	2.55	4.63	4.07	7.59	0.037
Error	8	4.41	0.55				
Total	11	12.06					

Coefficient of Variation=8.98%

Table 13.GLM for mean of absolute and relative length of isthmus

Source	Degree of freedom	Sum of Square	Mean square	F-value	F-tabulated 5%	F-tabulated 1%	Prob.
Treatments	3	51.26	17.09	4.79	4.07	7.59	0.0340
Error	8	28.55	3.57				
Total	11	79.80					

Coefficient of Variation= 22.71%

Table 14.GLM for mean of weight of white follicle

Source	Degree of freedom	Sum of Square	Mean square	F-value	F-tabulated 5%	F-tabulated 1%	Prob.
Treatments	3	8.02	2.67	6.26	4.07	7.59	0.0171
Error	8	3.42	0.43				
Total	11	11.44					

Coefficient of Variation=15.94%

Annex 2. Costs of feed ingredients and selling price of pullets

Items	Prices	Source
Commercial starter feed/100 kg	600 Birr	Debre zait research center
Commercial grower feed/100 kg	540 Birr	Debre zait research center
Day-old chick	6 Birr	Debre zait research center
Pullet (6 months old)	95 Birr	Debre zait research center
Labor cost/day	17 Birr	Debre zait research center

Annex 3. Time schedule for vaccination

Day	Week	Name and type of vaccination	Route of administration
0	1	Marek's	Sub-cuntainious
0	1	NCDV(HB1)	Ocular(eye droplet)
7	1	Gumboro	Drinking water
21	3	Gumboro	Drinking water
27	3	NCDV(lasota strain vaccine)	Drinking water
45	6	Fowl typhoid	Sub-cuntanious
63	8	NCDV(lasota strain vaccine)	Drinking water
90	12	Fowl typhoid	Sub-cuntanious
105	14	Fowl pox	Wing-web
120	16	NCDV(lasota strain vaccine)	Drinking water

Annex 4. Feed intake record sheet

Experiment type: feed restriction

Breed type: Koekoek

Treatment No: _____Pen No: _____Replication No:_____ .

Day	Date	Week	No of chicks	Feed offered (g/chick)	Feed offered (g/total)	Feed refusal(g/chick)	Feed refusal (g/total)	Mortality	Remark

Remark: reason for mortality, any observed changes on chicks, vaccination, vitamin supplement, etc.

Annex 5. Body weight record sheet

Experiment type: feed restriction

Breed type: Koekoek

Treatment No:____Pen No:_____Replication No:_____

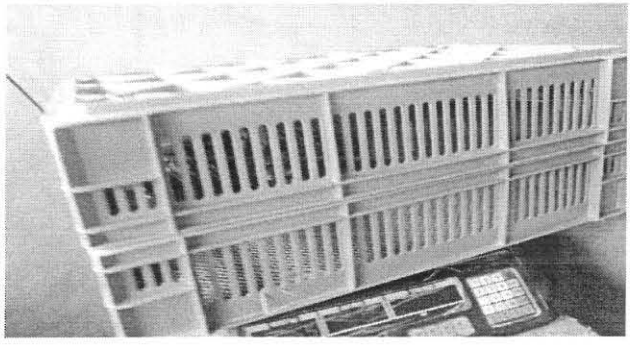
Day	Date	Week	No Of chicks	Total weight (g)	Average weight (g)	Remark

Remark: reason for mortality, any observed changes on chicks, vaccination, vitamin supplement, etc.

Annex 6. Different photos during the study time

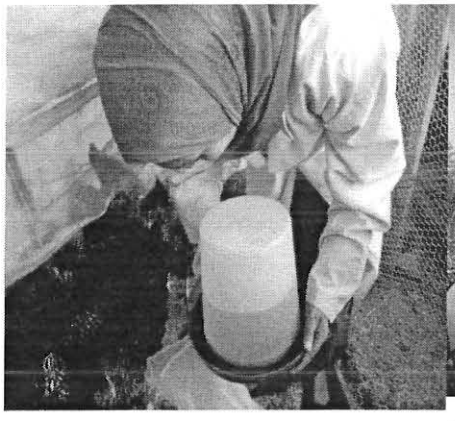


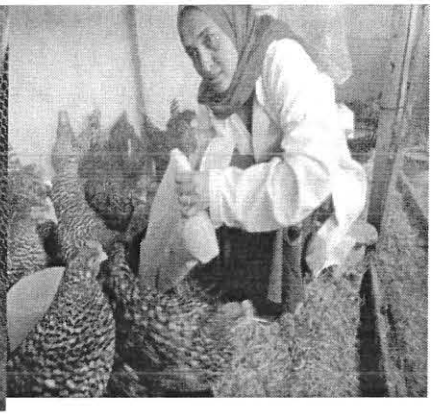
Koekoek photo at the time of day old chicks

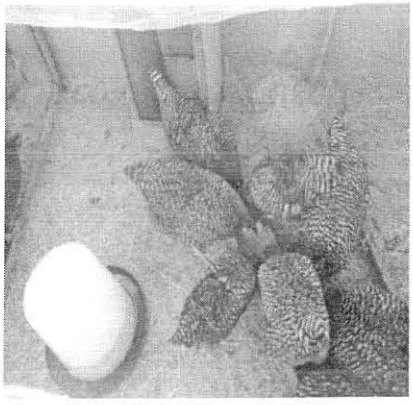




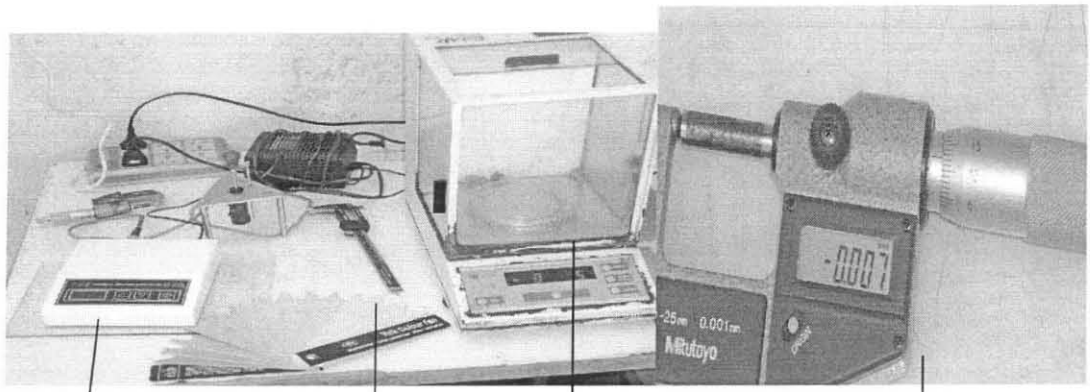
During the time of body weight measure







Watering and feeding time



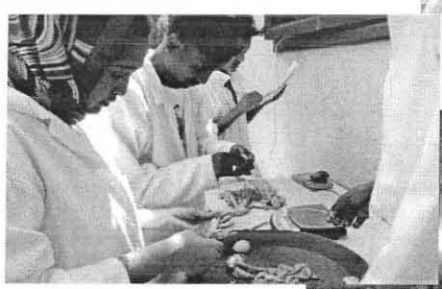
Tripod micrometer Roche color fan Sensitive balance Digital caliper

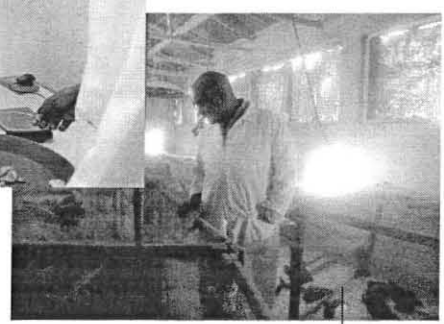
Egg quality measurement instrument











During the time of carcass measurement taking

At time of Dr. Berhan Tamir follow up the work