CHAPTER 3

Effect of restricted feeding and season on the carcass characteristics of Koekoek chickens

Abstract

This experiment was conducted to evaluate the impact of feed restriction and season on carcass characteristics of Koekoek chickens. Two hundred and seventy hens and twenty-seven cocks were randomly allocated to four treatments in a completely factorial randomized design being AA, AR RA and RR. The trial was done in summer and winter. Each treatment had seven replicates (10 animals per replicate) with the exception of the RR treatment that had six replicates (10 animals per replicate). Collected data was subjected to SPSS (17.00) package and analyzed by using multifactorial analysis of variance (ANOVA). Feed restriction resulted in reduced slaughter weight, defeathered weight, dressing weight, skin weight, breast muscle weight, shank width, chest width and heart girth in the rearing phase. Intestine weight, liver weight and abdominal fat weight were higher in chickens that were full-fed. Chickens that were allocated to summer treatment had higher shank width, slaughter weight, defeathered weight, chest width, heart girth, breast muscle weight, skin weight and the relative skin percentage. Shank length, dressing percentage and the muscle dressing percentage were higher in chickens that were reared in winter. Chickens that were reared in summer had higher abdominal fat weight, abdominal fat percentage, intestine weight and liver weight. Chickens that were raised in winter registered higher absolute and relative gizzards weights. Abdominal fat weight, abdominal percentage, intestine percentage, liver weight, gizzard weight and gizzard percentage were higher in *ad libitum* fed chickens. The season demonstrated a role on the performance of internal organs of chickens.

Key words: Koekoek chickens, full-fed, feed restriction, carcass characteristics, abdominal fat, organs, season and temperature.

3.1 Introduction

For many years, indigenous poultry production has been a major supplier of poultry meat at village level in Lesotho though this is difficult to quantify, given the unavailability of statistics. Nutritionally, people eat poultry meat for its high quality protein and its low fat content. Animal protein sources like mutton are very expensive, whereas beef has a limited use due to its high cholesterol content. Therefore, chicken production may help in reducing the gap between supply and demand of animal protein. Higher amount of fat has become a major concern in poultry industry due to its health hazards and this has forced a significant number of people to shift to lean poultry meat (Attia *et al.,* 1998; Novele *et al.,* 2008).

Restricted feeding is one of the management strategies in reducing carcass fat in chickens. The study of Melnychuk *et al*. (2004) reported a higher fat content in full fed broiler breeder hens as opposed to restricted fed ones at sexual maturity. Broiler chickens raised on restricted feeding during the rearing period and later shifted to normal feeding programme usually have reduced carcass fat and low incidences of leg disorders (McGovern *et al.,* 2000). Some studies showed that feed restriction improves the relative breast muscle percentage of broiler breeder chickens (Renema *et al.,* 1999a; Crounch *et al.,* 2002c and Melnychuk *et al.,* 2004). In a study done on Large White turkey hens Crounch *et al.* (2000c) stated feed restriction as a course of decrease in the breast muscles, shank lengh and width. Feed restriction lowered the intestine weight of the broiler chickens as explained by Novele *et al.* (2008) and Yagoub and Babiker (2008). The greater liver and gizzard weights were reported in *ad libitum* fed broiler chickens (Renema *et al.,* 1999a; Pishnamazi *et al.,* 2008).

The season in which chickens are reared has a significant role in the carcass characteristics of birds. Broiler chickens reared in summer result in accumulted abdominal fat pad (Blahova *et al.,* 2007). The increased temperature reduces the breast muscle, liver and gizzard and intestine weights of broiler chickens (Aksit *et al.,* 2006; Rosa *et al.,* 2007 and Rajini *et al.,* 2009).

Therefore, in the interest of reducing the carcass fat and improving the quality of carcass characteristics in Koekoek chickens this study was focused mainly on the level of feeding management of Koekoek chickens at different seasons of the year.. The information on the carcass characteristics of Koekoek chickens will assist poultry farmers in rural communities to sustainable produce quality and desirable chicken at affordable feeding costs at different seasons of the year.

3.2 Materials and Methods

Two hundred and seventy (270) hens and twenty- seven (27) cocks of Koekoek chickens were bought at eight weeks of age. The chickens were housed in twenty- seven (27) pens. Ten hens and one cock were randomly selected and placed in each pen. The chickens were given a stress pack in water to combat traveling stress and lasoda vaccine in water to prevent Newcastle disease. They were fed pullet grower mash from arrival day up to 18 weeks of age, and then fed laying mash from 19 to 32 weeks. Koekoek chickens under restricted feeding were fed 70% feeds of the full-fed. Chickens were offered fresh water without restriction and fed the same commercial feeds but at different quantities per day. The experiment was designed as a four feeding levels × two seasons (summer and winter) factorial arrangement in a completely randomized design.

Table 3.1 Description of different feeding levels in Koekoek chickens during the rearing and laying phases

Treatments	**Description of feeding treatments**
AA	Chickens were full-fed during rearing (8-18 weeks) and laying phases (19-32 weeks).
AR	Chickens were full-fed in the rearing phase (8-18 weeks) and shifted to restricted feeding during the laying phase (19-32 weeks).
RA	Chickens were fed restricted feeding during rearing phase (8-18 weeks) and shifted to full feeding in the laying phase (19-32 weeks).
RR	Chickens were fed restricted feeding in the rearing (8-18 weeks) and laying phases (19-32 weeks).

Treatment AA, AR and RA were replicated seven (7) times except treatment RR that was replicated six (6) times. Therefore, there were twenty-seven (27) experimental units.

At 18 and 32 weeks of age, one Koekoek chicken (hen) per replicate was slaughtered from chickens that were allocated to AA, AR, RA and RR treatments. Birds were starved for 12 hours before slaughtering. The slaughtering procedure was followed as outlined by Jones (1984). The slaughter weights (body weights) for chickens were determined just before slaughtering. Post slaughter weights (weight after bleeding) were taken. Birds were weighed again after plucking (defeathered weight). Then birds were eviscerated and dissected. The dead birds were weighed individually. Carcass dressing weight, liver weight, gizzard weight, skin weight, intestinal weight and abdominal fat weight were taken using a digital weighing scale. Fat surrounding the gizzard and intestine extending within the ischium and surrounding the bursa of fabricus was considered as abdominal fat. The shank length and heart girth were measured by measuring tape while shank width as well as chest width were measured using Vernier Caliper. Chest width was measured by placing a caliper under the wings, 2.5 cm posterior to the cranial. The chest (heart girth) girth was measured using a tape at the widest point on the breast positioned under the wings and this measurement was taken during exhalation (Renema *et al.*, 2007). Chest and shank measurements are considered to be growth and development monitoring parameters in chickens. The pectoralis major muscle and pectoralis minor muscle (breast muscles) were removed and weighed. The relative weight percentage of all the carcass components was based on the slaughter weight.

The collected data was entered on to a computer Excel Spread Sheet. Data was transformed and then subjected to SPSS (17.00) package and analyzed with the use of multifactorial analysis of variance (ANOVA). The arrival weights of birds were used as covariates. The significant levels were based on $p<0.05$ unless otherwise stated. The experiment was done in summer and winter seasons.

3.3 Results and Discussion

<u>3.3.1 Effect of restricted feeding and season on carcass characteristics of Koekoek chickens at 18 and 32 weeks of age</u>

The results on the carcass characteristics of Koekoek chickens are presented in Tables 3.2 and 3.3. These results indicate a significant effect of restricted feeding and season on a number of carcass traits of Koekoek chickens at 18 and 32 weeks of age. A significant difference was recorded between the two groups of birds that were under different feeding levels namely the full-fed and restricted feeding. Birds that were full-fed (AA and AR) weighed 370g higher than those that were reared under feed restriction (RA and RR). The relative percentage of the defeathered weight suggests that apart from accelerating body weight of chickens full feeding also had a significant effect in the development of feathers. The results of the present study indicate that in the full-fed chickens 13.5% of the body weight was contributed by feathers while in restricted fed chickens, feathers contributed 17.2 to 19.1 % of the slaughter weight. This suggests that chickens that were exposed to restricted feeding either had faster feather development compared to those that had free access to feeding or they were not losing their feathers as fast as the ones that were full-fed. The results from this study also indicated a positive ($p<0.01$) correlation ($r=0.953$) between the slaughter weight and defeathered weight.

Table 3.2: Carcass characteristics of Koekoek chickens that were subjected to different feeding level treatments

	Treatments				
Parameters	**AA**	**AR**	**RA**	**RR**	**S.E**
Rearing phase (18 weeks)					
Shank length (mm)	66.6	65.3	65.9	65.7	0.25
Shank width (mm)	8.9^{a}	8.7^{a}	8.1^{ab}	8.0^{b}	0.10
Slaughter weight (g)	1743^{a}	1697^{a}	1339^{b}	1361^{b}	2.52
Post slaughter wt (g)	1677^{a}	1647^{a}	1292^{b}	1293^{b}	12.62
Defeathered wt (g)	1502^{a}	1471^{a}	1100^{b}	1103^{b}	4.04
Defeathered %	86.2^{a}	86.7^{a}	82.6^{b}	80.9^{b}	0.49
Chest width (mm)	53.5^{a}	50.3^{a}	45.8^{b}	44.2^{b}	0.59
Chest girth (mm)	266.0^{a}	263.5^{a}	249.4^{b}	239.6^{b}	1.95
Dressing weight (g)	1229^{a}	1168^{ab}	948.5^{b}	940.4^{b}	9.60
Dressing. %	70.6	69.1	71.0	69.1	0.44
Muscle breast wt (g)	107.7^{a}	99.1^{a}	87.1^{b}	81.2^{b}	2.03
Muscle breast %	4.1^{a}	4.1^{a}	5.4^{b}	5.2^{b}	0.05
Skin wt (g)	120.4^{a}	114.1^{a}	83.4^{b}	83.5^{b}	0.81
Skin %	6.9^{a}	6.7^{a}	6.2^{b}	6.1^{b}	0.08
Laying phase (32 weeks)					
Shank length (mm)	69.6^{a}	68.6^{ab}	69.6^{a}	67.3^{b}	0.38
Shank width (mm)	12.1^{a}	10.9^{b}	11.3^{b}	11.^{ab}	0.13
Slaughter weight (g)	2372^{a}	1888^{b}	2351^{a}	1824^{b}	19.6
Defeathered wt (g)	2221^{a}	1732^{b}	2210^{a}	1533^{b}	35.2
Defeathered %	93.9	92.0	94.2	84.8	1.80
Chest width (mm)	65.2^{a}	61.4^{ab}	63.9^{a}	59.3^{b}	0.34
Chest girth (mm)	293.3^{a}	271.9^{b}	290.9^{a}	267.8^{b} 1	0.65
Dressing weight (g)	1723^{a}	1369^{b}	1707^{a}	1264^{b}	1.42
Dressing %	72.2	72.7	72.0	69.2	0.92
Muscle breast wt (g)	124.6^{a}	91.9^{b}	127.5^{a}	102.8^{b}	3.12
Muscle breast %	5.2	4.8	5.5	5.6	0.14
Skin wt (g)	175.1^{a}	125.6^{b}	159.6^{c}	122.0^{b}	2.7 7
Skin %	7.5^{a}	6.7^{b}	6.8^{ab}	6.7^{b}	0.12

^{ab} Means within a row without a common superscript differ significantly ($p<0.05$).
Foot note:
AA-full feeding during rearing and laying. AR-full feeding during rearing and restricted during laying, RA-restricted feeding during rearing and full feeding during laying, RR-restricted during rearing and laying, S.E-standard error.

During the laying phase, birds that were full-fed (AA and RA treatments) had heavier ($p<0.05$) slaughter weights and defeathered weights than those that were fed restrictedly (AR and RR treatments). The slaughter weights of chickens that were under the AA treatment were 484, 21 and 548g heavier than those under the AR, RA and RR treatments respectively. The observed defeathered weight measurements were 2221g, 1732g, 2210g and 1533g for birds that were in the AA, AR, RA and RR treatments respectively. The non-significant difference between Koekoek chickens that were in the AA and RA treatments signify the compensatory growth pattern shown by birds that were feed restricted earlier and later shifted to full feeding (RA). The fact that the slaughter weights of birds that were feed restricted for the entire study (RR) were not insignificantly different (p>0.05) from birds that were in the AR treatment suggests that birds in the RR group grew at the constant rate from rearing to laying phase which might be because of their bodies being acclimatized to the lower level of feeding. The results also demonstrated a good relationship between the feed intake and weight gain on both slaughter and defeathered weights.

Table 3.3: Carcass characteristics of Koekoek chickens reared in either summer or winter

	Season		
Parameters	**Summer**	**Winter**	**S.E**
Rearing phase (18 weeks)			
Shank length (mm)	64.4^{a}	67.41^{b}	0.51
Shank width (mm)	9.8^{a}	7.1^{b}	0.20
Slaughter weight (g)	1673^{a}	1397^{b}	25.03
Weight after slaughter (g)	1617^{a}	1337^{b}	25.24
Defeathered weight (g)	1383^{a}	1205^{b}	28.05
Defeathered %	82.3^{a}	86.0^{b}	0.98
Chest width (mm)	60.4^{a}	36.7^{b}	1.19
Chest girth (mm)	260.2^{a}	249.0^{b}	0.91
Dressing weight (g)	1141^{a}	1002^{b}	19.2
Dressing %	68.4^{a}	71.6^{b}	0.88
Muscle breast %	4.1^{a}	5.3^{b}	0.12
Muscle breast wt (g)	108.4^{a}	79.2^{b}	4.07
Skin wt (g)	114.6^{a}	86.1^{b}	1.63
Skin %	6.8^{a}	6.2^{b}	1.15
Laying phase (32 weeks)			
Shank length (mm)	66.9^{a}	70.6^{b}	0.75
Shank width (mm)	10.8^{a}	12.1^{b}	0.26
Slaughter weight (g)	2332^{a}	1885^{b}	39.29
Defeathered weight (g)	2115^{a}	1733^{b}	70.40
Defeathered %	90.4	92.0	3.40
Chest width (mm)	70.2^{a}	54.8^{b}	0.69
Chest girth (mm)	294.5^{a}	267.4^{b}	3.31
Dressing weight (g)	1715^{a}	1317^{b}	42.84
Dressing %	73.1	69.9	1.83
Muscle breast wt (g)	23.7	99.6	6.54
Muscle breast w %	5.3	5.3	0.28
Skin wt (g)	152.6^{a}	138.6^{b}	5.55
Skin %	6.5^{a}	7.1^{b}	0.24

^{ab} Means within a row without a common superscript differ significantly (p<0.05), S.E=Standard Error.

The results of this study indicate that the mean slaughter weight of Koekoek chickens that were shifted from restricted feeding to full feeding (RA) at 32 weeks of age was mainly contributed by the carcass weight rather than the feathers even though it was not different from chickens that were full-fed for the entire study (AA). The relative feather weight percentage of chickens that were in the RA treatment was lower than in the AA, AR and RR treatments by 0.3%, 2.2% and 10.1% respectively. The slaughter weight was highly ($p<0.01$) positively correlated ($r=0.813$) with the defeathered weight. This positive relationship suggests that the differences in the slaughter weights of Koekoek chickens were not because of the weights of the feathers.

The results of the current study are in agreement with the findings of Richards *et al.* (2003) who pointed out that birds that were on restricted feeding had significantly lower body weights compared to the *ad libitum* fed chickens. Vakali *et al.* (2000) and Bochno *et al* (2007) shared the same sentiments in demonstrating higher body weights of broilers that were fed on a daily basis compared to those that were under the skip a day treatment.

It was not possible to relate the effect of restricted feeding on defeathered weight in chickens because this subject has not been dealt with in previous studies and therefore the findings of this study should be regarded as the reference to the studies that would follow.

Table 3.3 illustrated that chickens that were reared in summer had a higher slaughter weight compared to those that were subjected to winter conditions at 18 and 32 weeks of age. The chickens that were raised in summer were 16.5% and 19.2% higher than in winter at 18 and 32 weeks of age respectively. Despite the absolute defeathered weights being higher in chickens that were reared in summer it was revealed that an average relative defeathered percentage of chickens that were kept in winter was higher than the defeathered percentage of those that were exposed to warm summer conditions. These results clearly show that the featherweight contributed to dissimilar slaughter weights of chickens that were kept in different seasons. The featherweight contributed 17.7% of total slaughter weight in Koekoek chickens that were reared in summer while featherweight contribution in those that were under winter treatment was only 13% at the age 18 weeks. Fourteen weeks later (32 weeks) chickens that were on summer treatment had a higher ($p<0.05$) absolute defeathered weight (2115g) in comparison with chickens that were raised under winter conditions (1733g). These results indicate that chickens that were raised under warm conditions had more feather coverage than the ones that were raised under cool conditions. Therefore, the present results suggest that birds in summer treatment were more efficient in converting feeds into both meat and feathers than those that were raised in winter. It is assumed that more protein was used for energy in winter and less was left for feathering.

The results show no interaction ($p>0.05$) between the effect of restricted feeding and season on the slaughter weight and defeathered weight of Koekoek chickens (Table 4.6). The findings of the present results show the interactive effect ($p<0.01$) of feeding level and season on the defeathered percentage of chickens at the age of 18 weeks. The results indicate that chickens that were in the AA and AR treatments in winter had a higher ($p>0.01$) defeathered percentage than those that were in the AA and AR during the summer by approximately 2.18%. This implies that Koekoek chickens that were reared in winter had a lower ($p<0.05$) feather percentage than chickens that were kept in summer regardless of the feeding level. The differences in the feather performance of chickens could be possibly because chickens were using some of the energy to generate heat in winter as opposed to feather development. The other scenario that might have contributed to less feather coverage in winter could be the stress effect, which could have prompted moulting in chickens.

During the laying phase (32 weeks), feeding level and season interaction ($p<0.01$) affected the slaughter weight of chickens. The highest slaughter weight (2724g) was obtained in chickens that were in the AA treatment in summer (SAA) followed by chickens that were full-fed only during the laying phase (RA) in summer (SRA) with slaughter weight of 2677g. The lowest slaughter weights were recorded in chickens that were under feed restriction (RR and AR) in winter with the slaughter weights of 1713g and 1784g respectively. The results on an effect of the feeding level and season interaction on defeathered weight as shown in Table 4.6 reflect the same pattern as in slaughter weight performance.

The defeathered weight performance of chickens in the AA, AR, RA and RR treatments in summer were 22.7%, 2.6%, 21.4% and 22.6% higher than in winter. In terms of defeathered percentage, the results reflected the non-significant differences between chickens that were subjected to various feeding level treatments. These results imply that the differences in the defeathered weights of chickens that were subjected to different interactive treatments were mainly due to the differences in the slaughter weights of chickens.

The results of the present study suggest that the summer conditions in Lesotho do not influence negatively the growth parameters of Koekoek chickens. This shows that Lesotho temperatures are only a problem in winter for the production traits that are related to growth. Therefore, these results cannot be compared with previous studies, which stated that high temperature would negatively affect the final body weights of chickens because of the reduced appetite caused by increased environmental conditions (Yalcin *et al.,* 1997a; Deeb and Cahaner, 1999; Aksit *et al.,* 2006; Plavnik and Yahav, 1998). The reason for being incomparable is attached to the fact that summer conditions in Lesotho cannot go as high as the 32^{o}C that was observed in the previous studies.

The chickens that were full-fed had heavier absolute dressing weights than those in the restricted feeding with the difference of 254g. The similar carcass dressing percentages between the different treatments signify that the differences in the dressing weights were because of the different slaughter weights. This can be verified by a higher ($p<0.01$) correlation ($r = 0.939$) between slaughter weight and dressing weight of Koekoek chickens. The slaughter weight and the relative carcass dressing percentage were inversely correlated ($r = -0.312$, $p<0.05$) at the age of 18 weeks (Table 3.3).

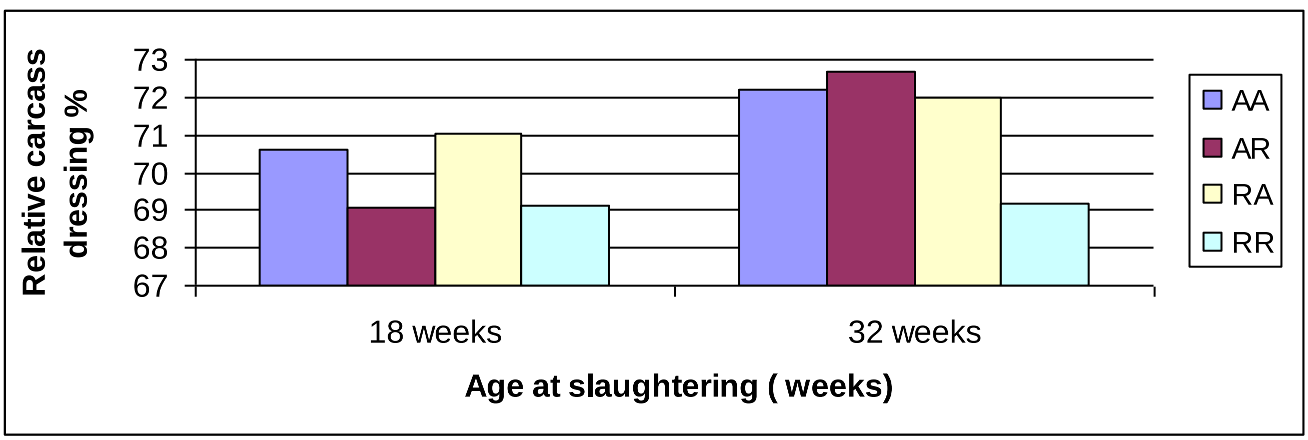

Figure 3.1: The carcass dressing percentage of Koekoek chickens subjected to different feeding levels

Footnote:
AA-full feeding during rearing and laying. AR-full feeding during rearing and restricted during laying, RA-restricted feeding during rearing and full feeding during laying, RR-restricted during rearing and laying..

Koekoek chickens that were full-fed (AA and RA) in the laying phase had heavier ($p<0.05$) carcass dressing weights than those that were under restricted feeding. The insignificant differences in carcass dressing weights between chickens that were in the AA and RA treatments illustrate that birds that were in the RA treatment had a compensatory growth. This can be verified by the fact that chickens that were in the RA treatment had carcass dressing weight increase of 758.5g as opposed to those in the AA, AR and RR treatment with the carcass dressing increments of 429g, 201g and 323.6g respectively. The fact that chickens that were in the AR treatment gained the lowest dressing weight between 18 and 32 weeks of age proved the point that they took some time to acclimatize to restricted feeding unlike those that were fed restrictedly for the entire study (RR). The similar dressing percentages between the four feeding level treatments imply that the differences ($p<0.05$) in the dressing weights could simply be attached to slaughter weights differences of chickens subjected to different treatments. The results of this study demonstrated a relationship ($p<0.01$; $r = 0.936$) between the slaughter weight and the carcass dressing weight while the correlation between slaughter weight and the carcass dressing percentage was 0.279 (Table 3.3).

In support of these results, Saleh *et al.* (2005) demonstrated that male broilers that were in the *ad libitum* feeding significantly had higher carcass dressing weight compared with the feed restricted chickens. The study by Yagoub and Babiker (2008) also indicated a similar carcass dressing performance of broiler chickens that were subjected to either *ad libitum* or restricted feeding which is in line with the findings of the present study.

Contrary to the findings of the present study, Mahmood *et al*. (2007) observed non-significant differences on the dressing weight between broiler chicken groups that were kept on feed restriction programmes of various durations. Novele *et al*. (2008) also reported that chickens that were on 50% *ad libitum* feeding had a lower dressing percentage than those on *ad libitum.* This partially contradicts the findings of the present study that clearly showed that the carcass dressing percentage of Koekoek chickens that were in the RR treatment was 2.8% less than the dressing percentages of those that were at one time during the course of the study exposed to full feeding. The results show an insignificant increase in carcass dressing percentage between chickens that were slaughtered at 18 and 32 weeks of age across the four feeding level treatments (Figure 3.1). This tells us that the carcass dressing percentage does not increase or decrease with age in Koekoek chickens.

The average carcass weights in summer were 12.2% and 23.2% higher than in winter at 18 and 32 weeks of age respectively. However, the relative dressing percentage was higher ($p<0.05$) in chickens that were allocated to cold winter conditions (71.6%) than the ones of birds that were exposed to warm summer condition (68.4%). The relative dressing percentage of chickens exposed to different seasons was not significant at 32 weeks of age. The results also portrayed an interaction ($p<0.01$) between feeding level and season on the carcass dressing performance of Koekoek chickens (Table 4.6). At the age of 18 weeks, an average carcass dressing weight of chickens that were full-fed in summer was 5.1% higher than in winter. The results on the carcass dressing weight demonstrated that chickens that were reared in summer always performed better than their counterparts reared in winter. With reference to the carcass dressing percentage the difference between chickens that were subjected to the AA and AR treatments in winter and summer was 1.9%. These results indicate that chickens that were reared in winter out-competed those that were kept in summer regardless of whether they were full-fed or feed restricted.

During the laying phase (32 weeks) the dressing weights in Koekoek chickens that were in the AA and RA treatments in summer were 650 and 660g respectively higher than those in winter. The differences in the dressing weights of chickens in the AR and RR treatments in summer and winter were 100 and 190g respectively. This means that the difference between the chickens that were reared in summer and winter was much better in the full feeding regime than in the restricted feeding regime during the laying phase. In spite of the differences in the carcass dressing weights of chickens it was revealed that there was no interaction ($p>0.05$) between the feeding level and season on the carcass dressing percentage. This implies that the differences in the carcass dressing weights were due to the different slaughter weights between the different interactive treatments of Koekoek chickens at 32 weeks of age.

It was not possible to compare this study on the effect of season on dressing weight of chickens with previous studies due to the unavailability of literature on this subject and therefore the findings of this study could probably be used as the basis for the future studies. However, the carcasses dressing performance of chickens followed the same pattern as the slaughter weight and in that way the same arguments that were used on slaughter weight would still apply on an effect of season on the dressing weight.

There were significant differences observed on the skin weights between Koekoek chickens that were full-fed and restricted fed. During the growing phase (18 weeks), birds that were full-fed were 33.8g and 8.8% heavier ($p<0.05$) than the feed restricted chickens in terms of absolute and relative skin weight. The differences ($p<0.05$) in the relative skin percentages between the full-fed and restricted fed chickens imply that the differences in the skin weights were not primarily due to the differences that were observed in the slaughter weights of chickens. These results suggested that the absolute and relative skin weights were positively correlated with slaughter weights of chickens. These results disclosed that heavier chickens had higher skin weights. The slaughter weight had a positive ($p<0.01$) correlation with the absolute skin weight ($r = 0.881$) and relative skin percentage ($r = 0.357$). During the laying phase (32 weeks), the skin weight of birds that were in the RR treatment was only different from the one in the AA treatment with a difference of 30.3%. Chickens that were slaughtered at 18 and 32 weeks of age had almost similar relative skin percentages.

In this study, it was established that there was a positive relationship (($p<0.01$; $r = 0.743$) between slaughter weight and skin weight because the more the bird had access to feed intake, the more the skin weight gained. Relative skin percentage did not correlate significantly ($r=-0.106$) with slaughter weight (Table 3.4). No information is available in the literature on the effect of restricted feeding on relative skin percentage in chickens. The present data probably provide a good estimate of the effects of restricted feeding on the relative skin percentage in Koekoek chickens and could probably be used as a base line study.

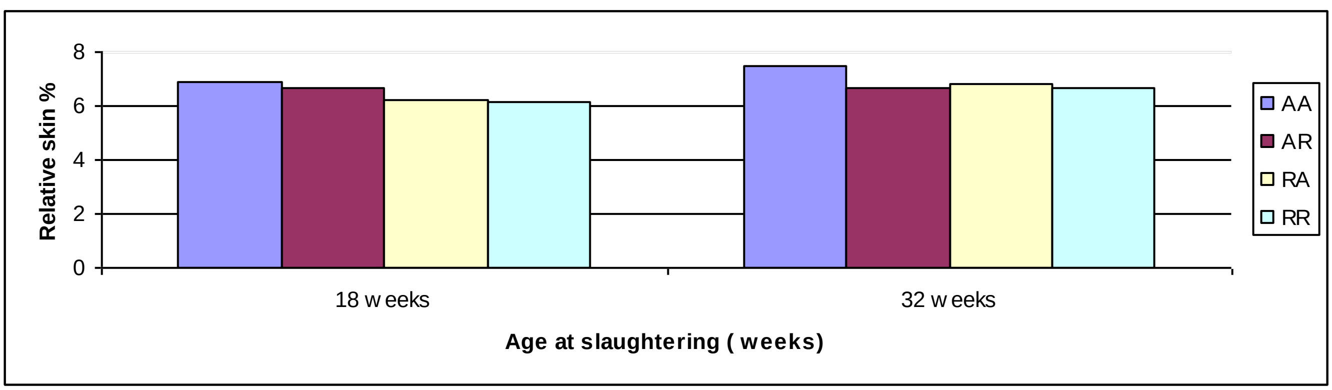

Figure 3.2: The relative skin weights of Koekoek chickens that were subjected to different feeding levels
Footnote:
AA-full feeding during rearing and laying. AR-full feeding during rearing and restricted during laying, RA-restricted feeding during rearing and full feeding during laying, RR-restricted during rearing and laying, S.E-standard error.

The results illustrate that the average, the absolute and relative skin weights of chickens were higher in summer than in winter by 24.9% and 8.2% respectively at 18 weeks of age (Table 3.5). The skin weights of chickens that were kept in summer corresponded positively with the body weights of chickens. During the laying phase, chickens that were reared in summer had heavier skin weight by 14g but the relative skin percentage was lower by 8.5% than in winter. The reason why the skin weight was relatively higher in chickens that were kept in winter could possibly be attached to their low laying performance as well as an increased feed intake in winter. Chickens in winter were consuming comparatively more than in summer and at the same time their laying performance was significantly reduced which might have been due to the reduced number of sunlight hours chickens were receiving per day. In that way it is possible that chickens were storing a lot of fat, hence they had fatty skins in winter, which influenced the skin weight.

As demonstrated in Table 3.6 the results pointed out an effect of feeding level and season interaction ($p<0.01$) on the skin performance of Koekoek chickens. In the rearing phase (18 weeks), birds that were full-fed and restricted fed in summer were on average 26.7% and 7.4% respectively heavier than in winter. The results on how the interaction between feeding level and season affected the relative skin percentage of Koekoek chickens showed that the differences in the skin weights were not because of the differences in the slaughter weights but were due to interactive treatment effects.

During the laying phase the results indicate that the skin weights of chickens in the AA, AR and RA treatments in summer were higher ($p<0.05$) than in winter by 30, 4.3 and 30g respectively. On the RR treatment the skin weight was lower ($p<0.05$) in summer (118g) compared to winter (126g). On the other hand, the relative skin percentage of chickens that were full-fed in winter (WAA) was higher in summer by 1.9%. The results of the present study demonstrate that chickens that had higher ($p<0.05$) relative skin percentages were those were reared in winter as opposed to those kept in summer.

There was no difference ($p>0.05$) on shank length observed between the full-fed and restricted fed chickens during the rearing phase (Table 3.1). The findings also portrayed an insignificant correlation between the slaughter weights and the shank lengths of Koekoek chickens. These results imply that the growth of shank lengths was statistically similar ($p>0.05$) regardless of the significant differences in the slaughter weights of chickens. During the laying phase (32 weeks) it was observed that Koekoek chickens that were in the AA (69.6mm) and RA (69.6mm) treatments had the longer ($p<0.05$) shanks than those in the AR (68.6mm) and RR(67.3mm) treatments. These results indicate a non-significant correlation ($r= -0.2$) between chickens' slaughter weight and shank length. This reveals that shank lengths of chickens did not positively correspond with the slaughter weights. These results imply that the shank length cannot be used as an estimate for either the slaughter weight or carcass dressing weight in Koekoek chickens.

The results of this study are in agreement with the findings of Pishnamazi *et al*. (2008) who observed no difference in the shank lengths of the broiler breeders aged 12 or 16 weeks. In addition, Ingram *et al*. (2001) reported that shank length was less sensitive to feed restriction as well as keel length and head width. Renema *et al*. (1999a) and Yu *et al.* (1992) indicated that restricted fed birds had significantly shorter shank lengths in comparison with those in the *ad libitum* feeding. They also showed that restricted fed birds had shank length of 9.2 cm with 1.9kg body weight in comparison to *ad libitum* fed chickens that had 10.8cm with body weight of 4.2kg.

The shanks of chickens that were raised in winter were 5.5% longer than in summer. During the laying phase it was discovered that Koekoek chickens that were subjected to summer conditions had shorter ($p<0.05$) shanks compared to those that were exposed to lower winter temperatures. Birds that were reared in winter had an average shank length of 70.6 mm which was longer ($p>0.05$) than those of chickens that were exposed to summer conditions (66.92 mm). This showed that Koekoek chickens that were subjected to cold winter conditions had longer ($p<0.05$) shanks from rearing up to laying phase. The results depicted non-significant interaction between restricted feeding and season on the shank length at the age of 18 and 32 weeks.

These results imply that the heavier chickens in summer had reduced shank lengths while the small body weights of chickens that were kept in winter resulted in longer shanks. The longer shanks in chickens that were raised in winter suggest that the reduced body weight was not suppressing the vertical growth of the shanks. It is also possible that the reduced egg production in winter contributed to the accumulation of calcium in bones hence the shank development.

The results of this study are in agreement with the findings of Bruno *et al.* (2007) who emphasized that chickens that were kept at low temperature had increased leg yield compared to those that were kept in high temperature. Leeson and Caston (1993) also reported an increased leg weights of chickens that were exposed to low temperature and in that fashion one would suppose that the longer the shank the heavier it is, so in that way the results of Lesson and Caston (1993) are in agreement with the findings of the present study. Contrary to the results of the present study, N'dri *et al*. (2006) observed an increased leg yield in chickens that were subjected to hot environmental conditions. The results obtained by Mcgovern *et al.* (2000) neither support the findings of neither the present study nor other previous studies since they stated that temperature fluctuations did not affect the lengths of chickens' shanks.

The results for the effect of restricted feeding on shank width indicate that Koekoek chickens that were full-fed had thicker ($p<0.05$) shanks as compared to those that were exposed to feed restriction. The average shank width of full-fed chickens was thicker than the restricted fed ones by 8% at 18 weeks of age. At the age of 32 weeks, the shank widths of Koekoek chickens that were allotted to the AR treatment were 90%, 96.5% and 96.6% of the ones in the AA, RA and RR treatments respectively. A positive ($p<0.05$) correlation of 0.324 and 0.550 at the age of 18 and 32 weeks respectively was noted between the shank length and shank width of Koekoek chickens. This means that chickens that had longer shanks also attained higher circumferences of shanks. When looking at the relationship between slaughter weight and shank circumference, the results revealed a positive correlation ($p<0.001$; $r=0.716$) at 18 weeks of age, which means that 51.3% ($r^2 = 0.513$) of the variation in shank circumference is explained by slaughter weight. On the other hand, a non-significant negative correlation ($r= -0.158$) was noticed between the slaughter weight and shank width at the age of 32 weeks. The results of the present study suggest that at a young age the shank circumferences of Koekoek chickens grew proportionally to body weight. The inverse relationships at the age of 32 weeks though insignificant imply that it does not automatically guarantee that a chicken with a higher body weight and carcass dressing weight would have thicker shank circumference.

The results of this study are in agreement with the findings of Crounch *et al.* (2002c) who indicated that the shank circumference was reduced in feed restricted turkey hen breeders more especially in the rearing stage since turkeys that were *ad libitum* fed had higher shank circumferences. This was confirmed by Robinson *et al.* (2007) who explained that the body frame of broiler breeders was hindered when feed restricted.

The findings at the age of 32 weeks disagree with the results of Crounch *et al.* (2002c) and Robinson *et al.* (2007) who stipulated that the shank circumferences were reduced in hens that were restricted fed for a longer period of time.

The shank widths of chickens that were exposed to summer and winter conditions were 9.8 and 7.1mm respectively. These measurements were different ($p<0.05$) from one another during the rearing phase (18 weeks) by 27.6%. During the laying phase, the results indicate that the shanks widths of chickens that were kept in summer were 10.7% less than in winter. It is assumed that the possible reason for Koekoek chickens that were reared in winter to have thicker shanks compared to those in summer could be due to the different laying patterns of chickens. Since birds that were kept in summer had a higher laying percentage at 32 weeks of age, it is possible that they withdrew a lot of calcium from the bones hence why they did not have thicker shank circumferences as compared to those that were reared in winter. The laying performance of chickens was lower in winter meaning that the calcium from the bones was not over-drawn hence the thicker shanks.

The findings of the present study as presented in Table 4.6 demonstrate that feeding level and season interaction had no effect ($p>0.05$) on the circumferences of the shanks at the age of 18 weeks. At 32 weeks of age it was established that chickens that were reared in winter and either full-fed or restricted fed had higher ($p<0.05$) shank widths compared to those that were kept in summer.

There were differences ($p<0.05$) observed between the full-fed and restricted fed birds during the rearing phase (18 weeks). The breast muscles of the chickens in the full-fed treatment were 19.2g heavier than restricted fed chickens. Nonetheless, chickens that were feed restricted had a higher ($p<0.05$) relative breast muscle weight expressed as a percentage of the body weight by 22.2%. This explains that restricted fed chickens significantly had more breast muscles in proportion to their body weight compared to chickens that were fed unrestrictedly.

During the laying phase (32 weeks) the breast muscles of Koekoek chickens that were in the RA were 2.3%, 27.9% and 19.4% higher than those in the AA, AR and RR treatments respectively. This indicates that birds that were in the RA treatment had the benefit of compensatory growth since they were able to accumulate more weight than others were during the laying phase. The observation from these results is that the breast muscle weights of chickens in the AR treatments developed at a lower rate compared to those that were fed restrictedly during both rearing and laying phases (RR). This can be verified by the fact that chickens in the RR treatment were 10.9g heavier than those in the AR treatment regardless of the fact that the breast muscle weights of chickens in the AR treatment were already heavier than the ones of the chickens in the RR treatment at the age 18 weeks by almost 18.2%. The results of this study indicated a positive relationship between body weights at which chickens were slaughtered and breast muscle weights. The results demonstrate that breast muscle weights responded positively to the body weights of chickens during both rearing and laying phases. The correlation ($p<0.01$) between slaughter weight and breast muscle weight during the rearing ($r=0.730$) and laying ($r=0.717$) phases was significant.

In terms of absolute breast muscle weights, these results are in conformity with the findings of Renema *et al*. (1999a) who reported that feed restriction resulted in a reduction in breast muscle weight because of reduced weight gain. These results were further supported by Robinson *et al.* (2007a) who gave an evidence of variability in the breast weight percentage due to diverse feed allocations. Melnychuk *et al*. (2004), Saleh *et al*. (2005) and Renema *et al*. (1999a) also observed that full-fed birds had significantly heavier breast weights than feed restricted birds. Contrary to the results of the present study, Crounch *et al.* (2002c) indicated that restricted fed turkey hens would have high breast muscle weights at 30 and 32 weeks. With respect to compensatory growth displayed by chickens that were in the RA treatment these results are not in harmony with the findings of Crounch *et al.* (2002c) who pointed out that turkeys would have the lower breast muscle weights if they are feed restricted early in their lives.

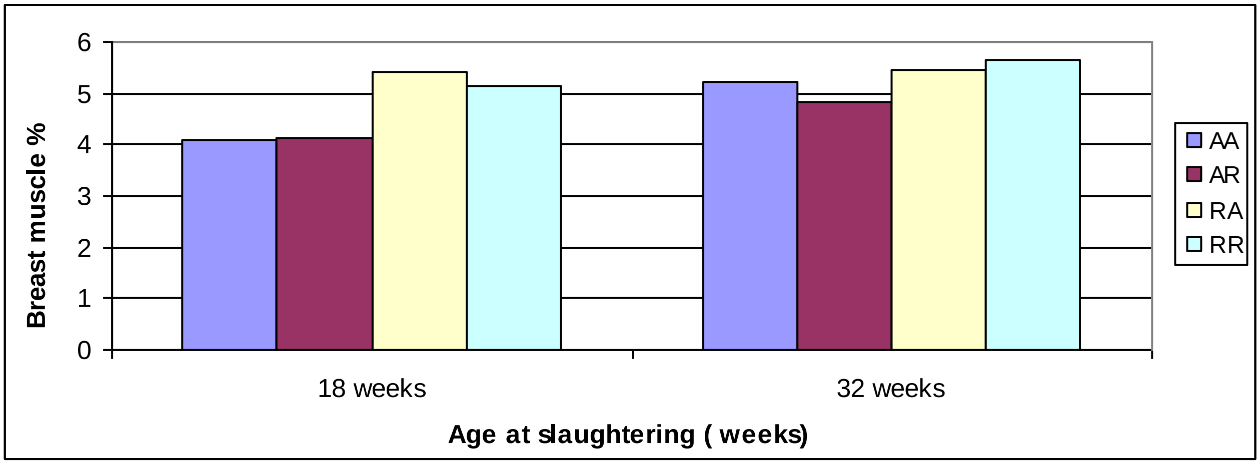

Figure 3.3: The relative breast muscle percentages of Koekoek chickens subjected to different feeding levels

Footnote:

AA-full feeding during rearing and laying. AR-full feeding during rearing and restricted during laying, RA-restricted feeding during rearing and full feeding during laying, RR-restricted during rearing and laying, S.E-standard error.

Season played an important role on the breast muscle weights of Koekoek chickens. At the age of 18 weeks, the cold winter conditions slowed down the development of chicken breast muscles by almost 26.9%. With regard to the relative percentage of breast muscle it was discovered that chickens that were reared in winter performed better ($p<0.05$) than chickens reared in summer by 22.6%. During the laying phase (32 weeks), chickens that were in the summer and winter treatments had similar absolute and relative breast muscle weight performance. This means that at 32 weeks of age the breast muscle of Koekoek chickens were not affected ($p<0.05$) by cold winter conditions as compared to when they were 18 weeks of age. This tells us that the chicks are more prone to unfavourable winter conditions than the grown up chickens hence heat supply is important to chicks.

Koekoek chickens that were subjected to the full and restricted feeding in summer had higher ($p<0.05$) breast muscle weights than in winter by 43.4 and 14.9g respectively. The highest difference was observed in chickens that were full-fed in the rearing phase. The findings of the present study reflect that chickens that were raised in summer outperformed the ones that were kept in winter irrespective of the quantity of feeds they were offered. The breast muscle weights of Koekoek chickens that were fed without restriction in winter were 10.8% less than those feed restricted in summer and 34.71% less than those that were full-fed in summer. Regardless of the breast muscle weights, chickens that were in the restricted feeding (RA and RR) during the summer had a higher (6%) breast muscle percentage while those that were full-fed had the lowest (3.7%) relative breast muscle percentage. The breast muscle percentage of the chickens that were full-fed in winter was 4.5% on average. An average breast muscle percentage of chickens that were under the RA and RR treatments in summer was 4.6%. These results indicate that chickens that were kept in winter but fed restrictedly had higher breast muscle percentage compared to chickens that were reared in summer and either full-fed or restricted fed. The differences in the breast muscle weights of chickens that were subjected to different interactive treatments were due to the differences in the slaughter weights of chickens rather than an effect of the feeding level and season.

During the laying phase (32 weeks), it was discovered that there were significant differences caused by feeding level and season interaction on the breast muscle weights of Koekoek chickens. The breast muscle weights of the chickens in the AA, AR, RA and RR treatments in summer differed from those in winter by 52.1, 19.7, 23 and 1.5g respectively. Despite the significant differences in the breast muscle weights it was revealed that feeding level and season interaction had no effect ($p>0.05$) on the breast muscle percentages of Koekoek chickens. This proves the point that the differences in the breast weights were mainly due to the differences that existed in the slaughter weights of chickens not necessarily because of the influence of the treatments effects.

The results obtained by Chen *et al.* (2007) are in agreement with the findings of the present study as they stated that the breast weight corresponds with the number of sunlight hours chickens are exposed to in a day. In that way, it would be expected that chickens that were reared in summer would have higher breast muscle weights, as it was the case in this study. This study cannot be compared with the findings of Aksit *et al.* (2006), Alleman and Leclercg (1997) who argued that broiler chickens that are exposed to high temperature had decreased breast weights. The reason being that the current research was conducted in a lower temperature than were previous studies.

Koekoek chickens that were full-fed (AA and AR) had wider ($p<0.05$) chest girths as compared to those that were subjected to restricted feeding. These results indicated that an average heart girth of restricted fed chickens was 7.7% less than on the full-fed diet. Therefore, there was a good relationship observed between feed consumption efficiency and chest girth because, the more feed consumed, the wider the chest (heart) girth attained. The heart girth was highly ($p<0.01$) correlated with the slaughter weight (r=0.723), carcass dressing weight (r=0.669) breast muscle weight (r=0.696), abdominal fat weight (r=0.633) and liver weight (r=0.404).

During the laying phase, heart girth measurements were 293.286mm, 271.857mm, 290.857mm and 267.75mm for birds in the treatments AA, AR, RA and RR respectively. Birds raised under full feeding (AA and RA) had wider chest girths than those raised under restricted feeding (AR and RR). These results imply that chickens with heavy body weights will finally have wider chest girths. The chickens that were in the AR treatment had their chest girths developing at a decreasing rate, which might be because of the shortage of feed intake. Koekoek chickens that were under feed restriction (RR) gave an impression that their chests have been constantly developing with age hence why chickens in AR and RR were insignificantly different during the laying phase which was not the case in the rearing phase.

A positive correlation (r=0.844) between the body weight and the heart girth of Koekoek chickens was highly significant ($p<0.01$). These results suggest that heavy chickens had wider chest girths and a positive relationship between body weight and heart girth was more pronounced, as chickens were ageing. The heart girth also had a positive correlation with defeathered weight (r=0.668), chest width (r=0.767), carcass dressing weight (r=0.765), breast muscle % (r=0.694), gizzard weight (r=0.564) and the skin weight (r=0.661). The heart girth was negatively correlated with intestine percentage (r= -0.490), liver percentage (r=-0.413) and gizzard percentage (r=0.391). This reflects that the heart girth can possibly be used as an indicator of performance in a number of carcass traits of Koekoek chickens.

These results are comparable to the results of Pishnamazi *et al*. (2008) who noted that the heavier breast muscle weight might contribute to the wider chest girth in *ad libitum* fed broiler chickens. Pishnamazi *et al*. (2008) also stated that broiler chickens that were offered *ad libitum* feeds had larger chest girths than those that were fed restrictedly. Furthermore, birds that were in the RA treatment had wider chest girth than other treatments because of compensatory growth.

The heart girths of chickens that were allocated to winter conditions were 4.3% less than those of chickens that were subjected to summer conditions at the age of 18 weeks. At 32 weeks of age the results indicate that the chest girths of chickens that were exposed to summer conditions were 9.22% higher than those that were subjected to winter conditions.

These results depict that the gap between the chest girths of chickens that were subjected to different season's narrows with the ageing of chickens. The reason for the difference between the chest girths of chickens that were raised in summer and winter to be wide at early age could be attached to the fact that chickens were using a considerable portion of energy to keep themselves warm instead of developing the chest muscles in winter. This could possibly be true as it is well known that at young age chickens' feathers are not yet fully developed, so that would mean chickens would need more feeds to generate their body heat. The results of the present study revealed that the heart girth was not affected ($p<0.05$) by the feeding level and season interaction during both rearing and laying phases.

During the rearing, the chest widths of Koekoek chickens that were full-fed were 7.2mm higher than those on the feed restriction. These results portray that the chest widths responded positively to the body weights of chickens. This can be attested to by the fact that the chest width was highly correlated ($p<0.01$) with slaughter weight ($r=0.776$), defeathered weight ($r=0.639$) and the carcass dressing weight ($r=0.665$). The chest widths of Koekoek chickens also had a positive correlation ($p<0.01$) with other carcass components such as shank width ($r=0.886$), heart girth ($r=0.615$) breast muscle weight ($r=0.751$), abdominal fat ($r=0.555$), abdominal fat % ($r=0.445$), intestine weight ($r=0.461$), liver weight ($r=0.542$) and skin weight ($r=0.773$). The chest width had an inverse relationship ($p<0.01$) with the shank length ($r= -0.500$), carcass dressing % ($r= -0.407$), breast muscle percentage ($r= -0.773$) as well as gizzard % ($r= -0.746$).

During the laying phase, chest width measurements were 65.2mm and 63.9mm for the AA and RA groups respectively which were higher ($p<0.05$) than those obtained in groups AR and RR being 61.4mm and 59.3mm respectively. The results showed that there were differences ($p<0.05$) between full-fed and restricted fed birds. It can be revealed from the findings of this study that in spite of chickens in the AA treatment having the highest chest widths, chickens in the RA treatment had highest (18.1mm) development of the chest widths from the 18^{th} to 32^{nd} week with chickens on the RR treatment (15.2mm) being second in chest development performance. Koekoek chickens on the AR treatment were lowest in chest widths growth as they managed to increase their chest widths by only 10.6mm for the period of 14 weeks while those that were on the AA treatment had an increase of 11.7mm for the same period of time.

It was observed that the chest widths were in proportion to the slaughter weights of Koekoek chickens. This means that the higher the chest width the higher the slaughter weight, defeathered weight and the carcass dressing weight as well the carcass dressing percentage. The results from the present study demonstrated a positive correlation ($p<0.01$) between the chest width and slaughter weight ($r=0.761$), defeathered weight ($r=0.615$), chest girth ($r=0.765$), carcass dressing weight ($r=0.765$), breast muscle % ($r=0.553$), gizzard weight ($r=0.556$) and the skin weight($r=0.438$). The results for correlations suggest that chicken carcass traits are dependent on each other in such a manner that selecting for broader chest widths would automatically go along with a number of improved carcass traits.

These results are in line with the results by Pishnamazi *et al*. (2008) who stated that broiler chickens fed *ad libitum* had greater chest widths than birds fed restrictedly.

The results for the chest widths of Koekoek chickens that were allotted to different seasons are presented in Table 3.6. The findings of the present study portray the chest width difference of 39.2% between chickens that were raised in summer and winter ($p<0.05$). The results clearly indicate that the cold conditions hindered the chest width development of chickens in the growing phase (18 weeks). During the laying phase (32 weeks), the results specified that the chest widths of Koekoek chickens that were subjected to summer conditions were 15.4mm higher than chickens that were subjected to winter conditions. Despite the average chest widths of chickens that were allotted to summer treatment being higher ($p<0.05$) than in winter at both 18 and 32 weeks of age, the results show that the older the chickens the lesser the difference in the chest widths between chickens that were kept in summer and winter seasons. This can be proved by the fact that the chest width difference between chickens that were kept in summer and the ones kept in winter was reduced by 17.6% from 18 to 32 weeks of age. This is authenticating that the chest width growth of Koekoek chickens is less affected by coldness in winter once their feathers are fully-grown.

The results of the present study show a non-significant interaction between feeding level and season on the chest width of chickens at the age of 18 weeks. An interaction ($p<0.01$) on the chest width was only observed at 32 weeks of age. The chest widths of Koekoek chickens in the AA, AR, RA and RR treatments in summer deviated from those in winter by 27.4%, 15.5%, 23.1% and 20.7% respectively. The chickens reared in summer had higher performance between all feeding regimes. The pattern of the chest width results seemed to tally with the ones portrayed by interaction between the feeding level and season on the slaughter weights of Koekoek chickens. This can be confirmed by a higher correlation ($p<0.01$) between the slaughter weight and the chest width ($r= 0.776$) as reflected in Table 4.4. This suggests that 60.2% ($r^2=0.602$) of the chest width could possibly be explained by the slaughter weigh

Table 3.4: Correlations between carcass characteristics of Koekoek chickens at the age of 18 weeks

Carcass traits	Shank length (mm)	Shank width (mm)	Slaughter weight (g)	Defeathered weight (g)	Defeathered %	Carcass dressing weight (g)	Carcass dressing %	Chest width (mm)	Heart girth (mm)	Breast muscle weight (g)	Breast muscle %	Skin %	Skin weight (g)
Shank length (mm)	1	-0.550**	-0.279*	-0.217	0.105	-0.163	0.334*	-0.500**	-0.172	-0.303	0.314*	-.0329*	-0.351**
Shank width (mm)	-550**	1	0.716**	-0.217	-0.184	0.607**	-0.390**	0.886**	0.436**	0.730**	-0.737**	0.407**	0.607**
Slaughter weight (g)	-0.279*	0.716**	1	-0.217	0.105	-0.163	0.334*	-0.500**	-0.172	.730*	-0.956**	0.357**	0.881**
Defeathered weight (g)	-0.217	0.594**	0.953**	1	0.424**	0.888**	-0.311*	0.639**	0.738**	0.673**	-0.900**	0.349**	0.884**
Defeathered %	0.105	-0.184	0.132	0.424	1	0.106	-0.067	-0.212	0.263	-0.083	0.033	0.089	0.133
Carcass dressing weight (g)	-0.163	0.607**	0.939**	0.888**	0.106	1	0.031	0.665**	0.669**	0.645**	-0.825**	0.275*	0.792**
Carcass dressing %	0.334*	-0.390**	-0.312*	-0.311*	-0.067	0.031	1	-0.407	-0.231	-0.316*	0.514**	-0.247	-0.358**
Chest width (mm)	-0.500**	0.886**	0.776**	0.639**	-0.212	0.665**	-0.407**	1	0.615**	0.751**	-0.773**	0.449**	0,773**
Heart girth (mm)	-0.172	0.436**	0.723**	0.738**	0.263	0.669**	-0.231	0.615**	1	-0.638**	0.696**	0.225	0.617**
Breast muscle weight (g)	-0.303	0.574**	0.730**	0.673**	0.033	0.645	-.316*	0.751**	0.696**	1	-0.642**	0.338*	0.692**
Breast muscle %	-0.303*	0.574**	-0.956**	-0.900**	-0.083	-.0825**	0.514**	-.0773**	-0.638**	-.0642**	1	-0.323*	-0.838**
Skin %	-0.329*	-0.407**	0.357**	0.349**	0.089	0.275*	-0.247	0.449**	0.225	0.338*	-0.323*	1	0.751**
Skin weight (g)	-0.351**	0.716**	0.881**	0.884**	0.133	0.792**	-0.358**	0,773**	0.617**	0.692**	-0.838**	0.751**	1
Abdominal Fat weight (g)	-0.182	0.495**	0.870**	0.887**	0.310**	0.833**	-0.223	0.555**	0.633**	0.615**	-0.802**	0.862**	0.405**
Abdominal fat %	-0.144	0.401**	0.784**	0.346*	0.768**	0.820**	-0.159	0.445**	0.550**	0.493**	-0.725**	0.795**	0.483**
Intestines	-0.352**	0.508**	0.471**	0.417**	-0.061	0.412**	-0.217	0.461**	0.214	0.418**	-0.477**	0.439**	0.213

weight (g)													
Intestines %	-0.103	-0.146	-0.446**	-0.461**	-0.192	-0.450**	0.074	-0.241	-0.432**	-0.214	0.415**	-0.361**	-0.098
Liver weight (g)	-0.199	0.543**	0.737**	0.739**	0.203	0.688**	-0.236	0.542**	0.404**	0.537**	-0.718	0.653**	0.260
Liver %	0.085	-0.181	-0.276*	-0.210	0.130	-0.264	0.087	-0.256	-0.377**	-0.171	0.262	-0.243	-0.110
Gizzard weight (g)	0.240	-0.140	0.104	0.158	0.207	0.245	0.369**	-0.171	0.056	0.048	-0.002	-0.067	-0.259
Gizzard %	0.379**	-0.690**	-0.765**	-0.678**	0.069	-0.636**	0.474**	-0.746**	-0.521**	-0.521**	0.816**	-0.752**	-0.419**

Table 3.4: continued

Carcass traits	**Abdominal Fat weight (g)**	**Abdominal fat %**	**Intestines weight (g)**	**Intestines %**	**Liver weight (g)**	**Liver %**	**Gizzard weight (g)**	**Gizzard %**
Abdominal Fat weight (g)	1	0.982**	0.315*	-0.479**	0.633**	-0.248	0.135	-0.561**
Abdominal fat %	0.982**	1	0.257	-0.466**	0.579**	-0.218	0.144	-.0561**
Intestines weight (g)	0.315*	0.257	1	0.570**	0.483**	0.078	0.090	-0.341
Intestines %	-0.479**	-0.466**	0.570**	1	-0.187	0.352**	-0.002	0.377**
Liver weight (g)	0.633**	0.579**	0.483**	-0.187	1	0.436**	0.080	-0.556**
Liver %	-0.248	-0.218	0.078	0.352**	0.436**	1	0.014	0.258
Gizzard weight (g)	0.135	0.144	0.090	-0.002	0.080	0.014	1	0.537**
Gizzard %	-0.625**	-0.561**	-0.341*	0.377**	-0.556**	0.258	0.537**	1

** Correlation is significant at the 0.01 level (2 tailed)

* Correlation is significant at the 0.05 level (2 tailed)

Table 3.5: Correlations between carcass characteristics of Koekoek chickens at the age of 32 weeks

Carcass traits	Shank length (mm)	Shank width (mm)	Slaughter weight (g)	Defeathered weight (g)	Defeathered %	Carcass dressing weight (g)	Carcass dressing %	Chest width (mm)	Heart girth (mm)	Breast muscle weight (g)	Breast muscle %	Skin weight (g)	Skin %
Shank length (mm)	1	0.324*	-0.155	-0.079	0.080	-0.106	-0.125	-0.460**	-0.252	-0.025	-0.125	0.089	0.351**
Shank width (mm)	0.324*	1	-0.158	-0.028	0.173	-0.136	-0.004	-0.347*	-0.181	0.008	-0.093	0.083	0.301*
Slaughter weight (g)	-0.155	-0.158	1	0.813**	0.000	0.936**	0.276*	0.761**	0.844**	0.067	0.717**	0.743**	-0.106
Defeathered weight (g)	-0.079	-0.028	0.813**	1	0.581**	0.760**	0.222	0.615**	0.668**	-0.211	0.409**	0.519**	-0.230
Defeathered %	0.080	0.173	0.000	0.581**	1	-0.001	-0.008	0.001	-0.033	-0.459**	-0.301*	0.519**	-0.230
Carcass dressing weight (g)	-0.106	-0.136	0.936**	0.760**	-0.001	1	0.597**	0.765**	0.767**	0.075	0.682**	0.681**	-0.127
Carcass dressing %	0.083	-0.004	0.279	0.222	-0.008	0.597*	1	0.341*	0.171	0.075	0.682**	0.169	-0.127
Chest width (mm)	-0.460**	-0.347*	0.761**	0.615**	0.001	0.765	0.341	1	0.765	0.062	0.553**	0.438**	-0.059
Heart girth (mm)	-0.252	-0.181	0.844**	0.688**	-0.033	0.767**	0.179	0.765**	1	0.185	0.694**	0.438**	-0.305*
Breast muscle weight (g)	-0.25	0.008	0.067	-0.221	-0.459**	0.075	0.046	0.062	0.185	1	0.737	0.228	0.285
Breast muscle %	-0.125	-0.093	0.717**	0.409**	-0.301*	0.682**	0.224	0.553**	0.694**	0.737**	1	0.648**	0.116
Skin weight (g)	0.089	0.083	0.743**	0.519**	-0.152	0.681**	0.169	0.438**	0.661**	0.228	0.648**	1	0.580**
Skin %	0.351**	0.301*	-0.106	-0.230	-0.257	-0.127	-0.103	-0.305*	-0.059	0.285*	0.116	0.580**	1
Abdominal Fat weight (g)	0.237	0.229	0.534**	0.422	-0.027	0.418**	-0.051	0.115	0.476**	0.049	0.384**	0.632**	0.304*
Abdominal fat %	0.358**	0.362**	0.103	0.063	-0.042	-0.005	-0.224	-0.280*	0.117	0.33	0.084	0.355**	0.423**
Intestines	0.164	0.037	-0.019	0.108	0.209	-0.048	0.065	-0.035	0.066	-0.013	-0.006	0.120	0.187

weight (g)													
Intestines %	0.205	0.119	-0.627**	-0.399**	0.190	-0.603**	-0.462**	-0.493**	-0.490**	-0.077	-0.462**	-0.386**	0.175
Liver weight (g)	0.311*	0.075	0.287*	0.298*	0.103	0.186	-0.108	0.024	0.286*	0.062	0.241	0.401**	0.241
Liver %	0.407**	0.185	-0.504**	-0.343*	0.109	-0.547**	-0.319*	-0.570**	-0.413**	-0.009	-0.339*	-0.218	0.283
Gizzard weight (g)	-0.296*	-0.155	0.592**	0.508**	0.039	0.564**	0.200	0.556**	0.531**	0.183	0.553**	0.327*	-0.235
Gizzard %	-0.142	-0.019	-0.487**	-0.361**	0.055	-0.435**	-0.075	-0.234	-0.391**	0.096	-0.234	-0.507**	-173

Table 3.5: Continued

Carcass traits	**Abdominal fat weight (g)**	**Abdominal fat %**	**Intestines weight (g)**	**Intestines %**	**Liver weight (g)**	**Liver %**	**Gizzard weight (g)**	**Gizzard %**
Abdominal Fat weight (g)	1	0.890**	0.033	-0.331*	0.364**	-0.120	0.120	0.107
Abdominal fat %	0.890**	1	0.037	-0.067	0.238	0.089	-0.169	-0.328*
Intestines weight (g)	0.033	0.037	1	0.776**	0.510**	0.468**	-0.169	-0.328
Intestines %	-0.331*	-0.067	0.776**	1	0.185	0.652**	-0.393**	0.276*
Liver weight (g)	0.364**	0.238*	0.510**	0.185	1	0.670**	0.027	-0.333
Liver %	-0.120	0.089	0.468**	0.652**	0.670**	1	-0.436**	0.063
Gizzard weight (g)	0.107	-0.169	-0.042	-0.393**	0.027	-0.0436**	1	0.402**
Gizzard %	-0.509**	-0.328*	-0.036	0.276*	-0.333*	-0.063	0.402**	1

** Correlation is significant at the 0.01 level (2 tailed)
* Correlation is significant at the 0.05 level (2 tailed)

Table 3.6: The effect of the interaction between feeding level and season on carcass characteristics of Koekoek chickens

Carcass traits	SAA	S.E	WAA	S.E	SAR	S.E	WAR	S.E	SRA	S.E	WRA	S.E	SRR	S.E	WRR	S.E
Rearing phase (18 weeks)																
Shank length (mm)	64. 8	0.70	68.4	0.70	64.1	0.70	66.4	0.70	65.43	0.70	66.4	0.70	63.0	0.76	68.33	0.76
Shank width (mm)	9.9	0.28	7.9	0.28	10.2	0.28	7.1	0.28	9.44	0.28	6.8	0.28	9.5	0.30	6.50	0.30
Slaughter weight(g)	1851	34.68	1636	34.68	1816	34.63	1578	34.68	1521	34.68	1158	34.68	1504	37.46	1219	37.46
Post Slaughter wt (g)	1770	34.98	1584	34.98	1771	34.98	1524	34.98	1471	34.98	1112	34.98	1458	37.78	1129	37.78
Defeathered weight(g)	1557	38.91	1428	38.9	1557	38.91	1385	38.91	1185	38.91	1015	38.91	1214	42.23	991.8	42.03
Defeathered %	85.1^{a}	1.35	87.4^{b}	1.35	85.7^{a}	1.35	87.8^{b}	1.35	77.77^{a}	1.35	87.7^{b}	1.35	80.6^{a}	1.46	81.3^{b}	1.46
Chest width (mm)	66.3	1.65	40.7	1.65	62.3	1.65	39.4	1.65	59.00	1.65	32.6	1.65	54.2	1.78	34.2	1.78
Chest Girth(mm)	277.4	5.42	254.6	5.41	267.4	5.41	259.6	5.41	255.0	5.41	243.9	5.41	241.0	5.85	238.2	5.85
Dressing weight(g)	1270^{a}	26.61	1188^{b}	26.61	1191^{a}	26.61	1145^{b}	26.61	1062^{a}	26.61	834.8^{b}	26.61	1041^{a}	28.74	839.7^{b}	28.74
Carcass dressing%	68.6^{a}	1.21	72.7^{b}	1.21	65.6^{a}	1.21	72.6^{b}	1.21	69.9^{a}	1.21	72.2^{b}	1.21	69.3^{a}	1.31	68.9^{b}	1.31
Breast Muscle wt(g)	136.7^{a}	5.64	78.7^{b}	5.64	113.6^{a}	5.64	84.7^{b}	5.64	93.6^{a}	5.64	80.7^{b}	5.64	89.7^{a}	6.09	72.7^{b}	6.09
Breast muscle %	3.7^{a}	0.15	4.5^{b}	0.15	3.6^{a}	0.15	4.7^{b}	0.15	4.6^{a}	1.15	6.3^{b}	0.15	4.6^{b}	0.16	5.7^{b}	0.16
Skin weight (g)	136.0^{a}	2.26	104.9^{b}	2.26	134.6^{a}	2.26	93.6^{b}	2.26	95.0^{a}	2.26	71.7^{b}	2.26	92.8^{a}	2.44	74.2^{b}	2.44
Skin %	7.4^{a}	0.21	6.4^{b}	0.21	7.4^{b}	0.21	5.9^{a}	0.21	6.3^{b}	0.21	6.2^{a}	0.21	6.2^{b}	0.23	6.1^{a}	0.23
Laying phase (32 weeks)																
Shank length (mm)	67.1	1.04	2.1	1.04	68.4	1.04	68.9	1.04	68.4	1.04	70.7	1.04	63.7	1.12	70.8	1.12
Shank width(mm)	12.1^{a}	0.36	12.1^{b}	0.36	10.3^{a}	0.36	11.4^{b}	0.36	10.4^{a}	0.36	12.3^{b}	0.36	10.2^{a}	0.36	12.5^{b}	0 .36
Slaughter weight(g)	2724^{a}	54.43	2020^{b}	54.43	1993^{a}	54.43	1784^{b}	54.43	2677^{a}	54.43	2025^{b}	54.43	1936^{a}	58.79	171^{b}	58.79
Defeathered wt(g)	2503^{a}	97.55	1936^{b}	97.55	1755^{a}	97.55	1709^{b}	97.55	2474^{a}	97.55	1945^{b}	97.55	1728^{a}	105.37	1338^{b}	105.33
Defeathered %	9188	4.98	95.9	4.98	88.2	4.98	95.8	4.98	92.40	4.98	96.0	4.98	89.3	5.38	80.3	5.38
Chest Width(mm)	75.6^{a}	0.96	54.9^{b}	0.96	66.6^{a}	0.96	56.3^{b}	0.96	72.3^{a}	0.96	55.6^{b}	0.96	66.2^{a}	1.03	52.5^{b}	1.03
Heart Girth(mm)	310.7	4.58	275.9	4.56	284.3	4.58	259.4	4.58	304.7	4.58	277.0	4.58	278.3	4.95	257.2	4.95
Dressing Weight(g)	2050^{a}	59.37	1400^{b}	59.37	1410^{a}	59.37	1320^{b}	59.37	2040^{a}	59.37	1380^{b}	59.37	1360^{a}	64.12	1170^{b}	64.12
Carcass dressing %	75.1	2.53	69.2	2.53	71.06	2.53	74.3	2.53	76.06	2.53	68.0	2.53	70.4	2.74	68.0	2.74

Breast muscle wt(g)	150.7[a]	8.64	98.6[b]	8.64	101.7[a]	8.64	82.0[b]	8.64	139.0[a]	8.64	116.0[b]	8.64	103.5[a]	9.33	102.0[b]	9.33
Breast muscle %	5.5	0.39	4.9	0.3	5.11	0.3	4.6	0.39	5.2	0.39	5.7	0.39	5.4	0.42	5.9	0.42
Skin weight (g)	190.0[a]	7.69	160.0[b]	7.69	127.7[a]	7.69	123.4[b]	7.69	174.6[a]	7.69	144.6[b]	7.69	118[a]	8.30	126.0[b]	8.30
Skin %	7.0[a]	0.34	7.9[b]	0.34	6.4[a]	0.3	6.9[b]	0.34	6.5[a]	0.34	7.2[b]	0.34	6.1[a]	0.36	7.3[b]	0.36

[ab] Means within a row with no common superscript differ significantly (p>0.05 and p<0.01)

Footnote:

SAA-full feeding during rearing and laying in summer season. SAR- full feeding during rearing and restricted during laying in summer season, SRA-restricted feeding during rearing and full feeding during laying in summer season, SRR-restricted during rearing and laying in summer season, WAA- full feeding during rearing and laying in winter season. WAR- full feeding during rearing and restricted during laying in winter season, WRA-restricted feeding during rearing and full feeding during laying in winter season, WRR-restricted during rearing and laying in winter season, S.E-standard error, sig- Significance level, wt- weight, the weight is in grams (g) while the length, width and girth are in millimeters (mm).

3.3.2 Effect of restricted feeding and season on organs and abdominal fat in Koekoek chickens at 18 and 32 weeks of age

The results on abdominal fat and organs characteristics of Koekoek chickens are presented in Tables 3.7 and 3.8. These results are for both rearing and laying phases of Koekoek chickens.

Table 3.7 Organs and abdominal fat characteristics of Koekoek chickens that were subjected to different feeding level treatments

	Treatments				
Parameters	**AA**	**AR**	**RA**	**RR**	**S.E**
Rearing phase (18 weeks)					
Abdominal Fat (g)	63.1^{a}	66.1^{a}	21.9^{b}	22.8^{b}	0.88
Abdominal Fat %	3.6^{a}	3.9^{a}	1.6^{b}	1.6^{b}	0.05
Intestine wt (g)	56.4	60.5	53.6	54.8	1.26
Intestine %	3.2^{a}	3.6^{a}	4.0^{b}	4.0^{b}	0.08
Liver wt (g)	32.0^{a}	31.4^{a}	26.0^{b}	26.3^{b}	0.52
Liver %	1.8	1.9	2.0	1.9	0.03
Gizzard wt (g)	38.7	37.4	35.6	36.0	0.66
Gizzard %	2.2^{a}	2.2^{a}	2.7^{b}	2.7^{b}	0.04
Laying phase (32 weeks)					
Abdominal fat (g)	125.1^{a}	71.1^{b}	104.2^{a}	73.8^{b}	4.07
Abdominal Fat %	5.3^{a}	3.8^{b}	4.5^{ab}	4.1^{b}	0.18
Intestine wt	74.1	70.1	68.6	63.3	1.88
Intestine %	3.2^{ab}	3.7^{a}	3.0^{b}	3.5^{ab}	0.09
Liver wt	40.9^{a}	33.9^{b}	41.1^{a}	31.8^{b}	0.85
Liver %	1.8	1.8	1.8	1.8	0.04
Gizzard wt	37.4^{a}	34.4^{b}	38.1^{a}	35.9^{b}	0.72
Gizzard %	1.6^{a}	1.8^{b}	1.7^{ab}	2.0^{b}	0.03

^{ab} Means within a row without a common superscript differ significantly (p<0.05).
Foot note:
AA-full feeding during rearing and laying. AR-full feeding during rearing and restricted during laying, RA-restricted feeding during rearing and full feeding during laying, RR-restricted during rearing and laying, S.E-standard error.

Koekoek chickens that were exposed to restricted feeding were not different (p>0.05) from those that were full-fed as far as the intestine weights are concerned. In spite of insignificant differences between chickens that were subjected to either full-fed or restricted fed it was noted that the intestine weights of chickens that were under full-fed treatment were 7.3% higher than the ones of chickens that were subjected to restricted feeding during the rearing phase (18 weeks). It was detected that chickens that were fed without restrictions had an average relative intestine percentage of 3.4% while an average relative intestine percentage of chickens that were feed restricted was 4%. The negative relationship between slaughter weight and relative percentage of the intestines demonstrate that the significant (p<0.05) differences in the intestinal weights were inherited from the chickens slaughter weights rather than being brought about by the effect of restricted feeding.

During the laying phase (32 weeks), the results indicate that Koekoek chickens had intestine weights of 74.1, 70.1, 68.6 and 63.3g for chickens that were in the AA, AR, RA and RR treatments respectively. The results on intestine weight performance were not significantly different (p>0.05) between the four feeding level treatments. The results show that Koekoek chickens that had heavier intestine weights at early age continued to surpass chickens that were on restricted feeding at the initial phase of the study. This suggests that the development of intestines was not affected by the amount of the feeds given to chickens during the laying phase. Regarding the relative percentage of the intestines, the results portrayed the non-significant differences between chickens that were subjected to different feeding levels (Figure 4.4). Koekoek chickens that were full-fed during rearing and later shifted to restricted feeding in the laying phase (AR) had a higher relative intestine percentage (3.8%) followed by chickens that were in feed restriction for the entire study (RR) with the relative intestine percentage of 3.5%. The proportion of the intestine weights relative to the body weight of chickens that were fed without any restriction during the laying phase (AA and RA) was 3.2% and 3% respectively. It can be seen from these results in both rearing and laying phases that chickens that were on 70% full feeding had a higher relative percentage of intestines hence a higher negative correlation (r=-0.776) between an intestine weight and the relative intestine percentage (p<0.01). The results indicate an insignificant correlation (r=-0.019) between the slaughter weight and intestine weight of Koekoek chickens at 32 weeks of age. On the other hand, an inverse relationship was seen between the slaughter weight and intestine percentage of the chickens. The findings of this study suggest that Koekoek chickens with small bodies at slaughter age (32 weeks) will proportionally have heavier intestinal weights.

The results of this study are not in accordance with the findings of Yagoub *et al*. (2008) who observed a difference (p<0.05) in the intestine weight of birds that were exposed to *ad libitum* and restricted feeding. The findings of Novele *et al.* (2008) stated that broiler chickens that were initially on restricted feeding and later shifted to *ad libitum* feeding had more intestine weight compared to birds that were either feed restricted or given feeds unlimitedly for the whole study.

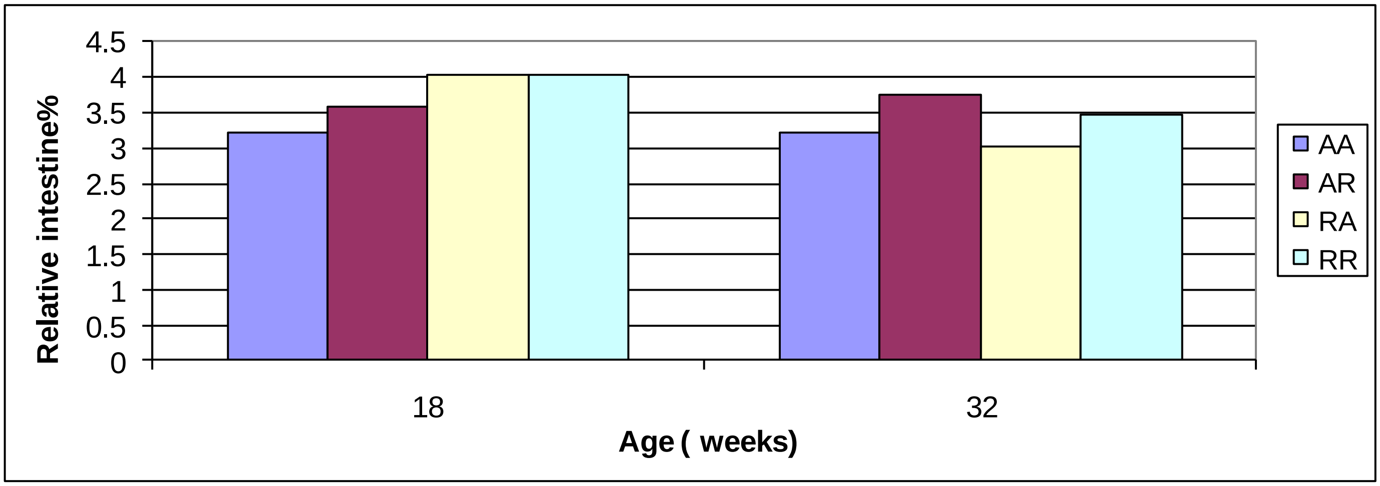

Figure 3.4: The relative intestine percentage in Koekoek chickens subjected to different feeding levels
Footnote:
AA-full feeding during rearing and laying. AR-full feeding during rearing and restricted during laying, RA-restricted feeding during rearing and full feeding during laying, RR-restricted during rearing and laying.

The reason for the results of the present study to vary from the previous ones could be due to the different types of chickens used as well as the age difference. The previous studies were conducted on broiler chickens that were slaughtered before the age of 18 weeks whilst that was not the case in this study.

The intestine weights of chickens were 61.5g and 51.1g for chickens that were under summer and winter treatments respectively. This indicates that an average intestine weight of chickens that were raised in summer was 10.3g higher than in winter. Seasonal effect reflected no significant ($p>0.05$) differences in the weight (3.7%) of the intestines as a percentage of slaughter weight. The results imply that the weight difference in chicken intestines was mainly because of the differences in the slaughter weights of chickens. The findings of the present study established a negative relationship ($r=-0.446$) between the intestine weight as a percentage of the body weight and the body weight of Koekoek chickens at 18 weeks of age.

At 32 weeks of age, the results illustrate that the intestine weights of chickens that were reared in summer were not significantly different from the intestine weights of those that were reared during the winter. Despite the non-significant differences in absolute intestine weights between chickens that were subjected to different seasons, there was an effect ($p<0.05$) of season on the relative intestine weight as the percentage of the body slaughter weight. The relative intestine percentages were 16.2% higher in winter than in summer.

The findings of the present study show that the effect of feeding level and season interaction was only observed in the relative intestine percentage of Koekoek chickens at 32 weeks of age (Table 3.9). The results reveal that the chickens that were under the AA and AR treatments in winter were higher than in summer by 27.8% and 7.7% respectively. On the RR treatment, the intestine percentage of birds in summer was 0.8% higher than those under winter treatment. It was observed from the present study that the intestine weights as the percentage of the slaughter weights were mostly higher in the full-fed chickens during the rearing phase in winter.

The results of this study for chickens at the age of 32 weeks seemed to tally with the findings of Rajini *et al*. (2009) who reported a longer intestine length of chickens in winter in comparison to an intestine length of chickens that were reared in summer. In support of these results, Keshavarz (1998) discovered that the length of the intestines was longer under a short light day regimen compared to a step-down light regimen.

The liver weights of chickens on full-fed treatment during the rearing phase (18 weeks) were 35g higher than those that were feed restricted. Regardless of the differences in the liver weights of Koekoek chickens that were subjected to different feeding levels the relative liver percentages were not different ($p>0.05$). These results suggest that the results pattern of the liver weights can be compared to the ones of the slaughter weights, hence there was a high correlation ($r=0.737$) between the two ($p<0.01$).

During the second phase (32 weeks) of the study, it was discovered that RA treatment improved the liver weight by 0.5%, 17.5% and 22.6% compared to the AA, AR and RR treatments respectively. The results indicate that Koekoek chickens that were fed without any restriction during their laying period had higher ($p<0.05$) liver weights compared to chickens that were in feed restriction during the same time. A compensatory growth of the liver weights was observed in chickens that were in the RA treatment. The non-significant differences were seen in Koekoek chickens that were either full-fed or restricted fed in terms of the relative liver percentages. The liver weight was positively related (r=0.670) to the liver percentage in Koekoek chickens that were subjected to different feeding levels (p<0.05). The results show that the liver weight corresponded positively (p<0.05) with the body weight of chickens hence the positive correlation (r=0.287) between the liver weight and the slaughter weight. It was also discovered that the relative liver percentage had an inverse association with the slaughter weight (p<0.01). This negative relationship explains that the different feeding level treatments failed to affect the liver weight as the percentage of the body weight.

The findings of this study are similar to those of Renema *et al*. (1999a) who reported that feed restriction resulted in decreased liver weights compared to the liver weights of broiler chickens that were fed *ad libitum*. Contrary to the findings of the present study Melnychuk *et al*. (2004) and Yagoub and Babiker (2008) stated no differences on liver weights between the chickens that were subjected to *ad libitum* feeding and restricted feeding. The findings of Pishnamazi *et al*. (2008) also discovered that the liver weights were higher in broiler chickens that were fed *ad libitum* as a percentage of body weight due to the generous feed allowance that is in conflict with the findings of the present study. In support of other research findings which are in conflict with the results of the present study Mahmood *et al.* (2007) concluded that the liver weights between *ad libitum* fed and restricted fed broiler chickens were not significantly different.

The results pointed out that an average liver weight of chickens that were exposed to summer conditions was 31.2g as opposed to 26.6g of chickens that were exposed to winter conditions at the age of 18 weeks. The results indicated that cold winter conditions hindered the liver weight performance by 4.6g. In terms of the liver weight as the percentage of slaughter weight it was discovered that chicken's performance was statistically similar (p>0.05). The findings of this study imply that the differences (p<0.05) in the liver weights were mainly because of the body weights.

During the laying phase (32 weeks), the differences in the liver weights were not significant. Despite the similarities in the weights of chickens that were subjected to different seasonal treatments it was observed that an average liver weight as a percentage of the slaughter weight differed significantly between chickens that were raised in summer and winter (p<0.05). The relative liver percentage of Koekoek chickens that were in winter treatment was 19.3% lower than in summer. Koekoek chickens in winter had an average liver weight as a percentage of slaughter weight the relative liver percentage of chickens that were reared in summer was 20% higher than in winter. The findings of this study portray an inverse relationship (($p<0.01$; $r=-0.504$) between the slaughter weight and the relative liver percentage of chickens. When comparing the liver weights of chickens at different ages it was recognized that the liver weights of chickens that were in winter treatment increased by 10.8g while the ones of chickens that were under summer treatment increased by 5.3g. This implies that the liver weights of chickens that were reared in winter grew twice more than the ones that were exposed to warm summer conditions.

Chickens that were in the RA and AA treatments in winter performed better. The lowest relative liver percentages were observed in Koekoek chickens that were allocated to the AA treatment in summer. The differences in liver percentages in the AA, AR, RA and RR treatments in summer and winter were 0.6%, 0.1%, 0.6% and 0.1% respectively. The difference between those that were in the AA and RA treatments during the laying phase was much greater compared to those in the AR and RR treatments. The results demonstrate that the relative liver percentages of chickens that were kept in winter outperformed their counterparts when subjected to equivalent feeding level treatments.

The results obtained in a study that was conducted by Rosa *et al*. (2007) are in accord with the finding of the present study who stated the decreased liver weights in chickens as the result of the high temperature. In support of these results, Blahova *et al*. (2007) added that liver weights of chickens were noticeably increased in low temperatures. Rajini *et al*. (2009) established that the liver weights of chickens were higher in winter.

In contradiction with the results of the present study, Chen *et al.* (2007) reported that the liver weights of chickens were not different regardless of the number of light light hours chickens were exposed to in a day.

Despite the insignificant differences between the gizzard weights of chickens that were full-fed and restricted fed, the findings of this study revealed a significant ($p<0.05$) difference between Koekoek chickens that were full-fed and those that were feed restricted as far as the relative gizzard percentages were concerned. The relative gizzard percentages of chickens that were under full (AA and AR) feeding was 2.2% while those that were subjected to restricted feeding (RA and RR) had the relative gizzard percentage of 2.7% (Figure 4.5). The slaughter weight had no relationship with the gizzard weight in chickens. A positive correlation (r=0.537) between the gizzard weight and the relative gizzard percentage ($p<0.01$) was noticed.

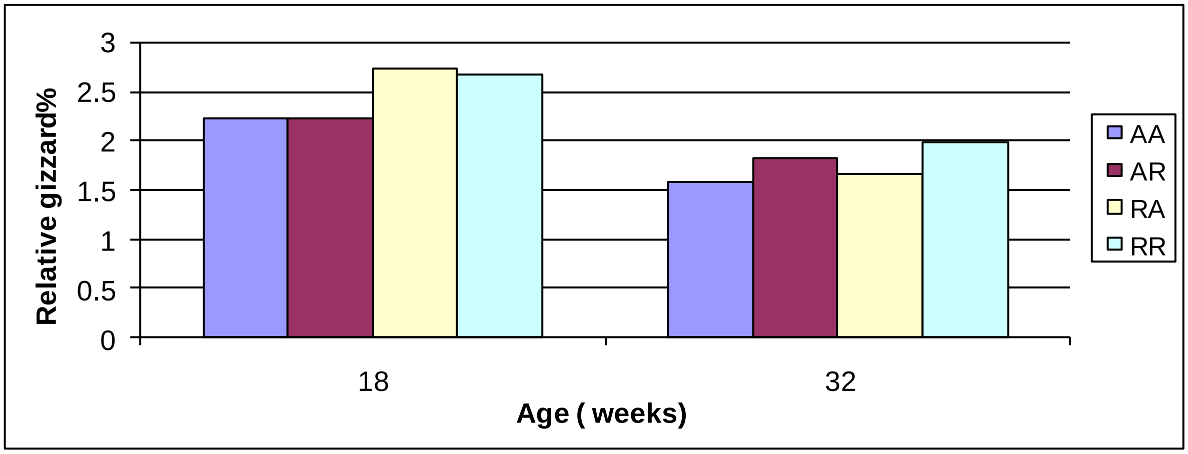

Figure 3.5: The relative gizzard percentage of Koekoek chickens subjected to different feeding levels

Footnote: AA-full feeding during rearing and laying. AR-full feeding during rearing and restricted during laying, RA-restricted feeding during rearing and full feeding during laying, RR-restricted during rearing and laying.

In the laying phase (32 weeks), the results demonstrate that Koekoek chickens that were subjected to the RA treatment were higher than those in the AA, AR and RR treatments by 1.8%, 9.7% and 5.5% respectively in terms of gizzard weights. These results clearly demonstrate that Koekoek chickens that were full-fed were on average 6.8% better than restricted fed chickens. With reference to the relative gizzard percentages at the age of 32 weeks Koekoek chickens that were under the AA, AR, RA and RR treatments had 1.6%, 1.8%, 1.7% and 2% respectively. Koekoek chickens that were full-fed only during the rearing phase (AR) had higher relative gizzard percentages in comparison with chickens that were in other treatment though they were not different ($p>0.05$) from chickens that were in the RA and RR treatments. The other observation was that chickens that were in the AA treatment had lower ($p<0.05$) relative gizzard percentages than the relative gizzard percentages of chickens that were in other treatments excluding chickens that were in the RA treatment. The findings of this study undoubtedly illustrate that the relative gizzard percentages of Koekoek chickens that were once introduced to restricted feeding at any stage of the study (AR, RA and RR) were statistically similar ($p>0.05$). Generally it was noticed that on average Koekoek chickens that were feed restricted during the laying period (AR and RR) had a higher relative gizzard percentage than chickens that had free access to feed (AA and RA). These results show that the gizzard weights were positively correlated ($p>0.01$) with the relative gizzard percentages ($r=0.402$) and slaughter weights ($r=0.592$).

The findings of the present study correspond with the results of Yagoub and Babiker (2008) who explained that the similarities between the gizzards weights of broiler chickens that were exposed to either restricted or *ad libitum* feeding were because of the muscular nature of the gizzard. Mahmood *et al.* (2007) also found no significant differences in gizzard weights between broiler chickens that were fed *ad libitum* and those that were feed restricted.

The results indicate the gizzard weights difference of 7.3% between Koekoek chickens that were reared in summer and winter with the latter having a higher ($p<0.05$) gizzard weight at 18 weeks of age. The relative gizzard weights as the percentage of the slaughter weight showed a similar pattern to the results as in absolute weights. This explains that the differences in the gizzards weights were not only related to the body weights of chickens but were mainly due to the treatment effects.

At the age of 32 weeks it was discovered that chickens that were exposed to warm summer conditions improved ($p<0.05$) the gizzard weights by 17.2% than in winter. With reference to the relative weight of the gizzards as a percentage of the slaughter weight it was detected that chickens that were in summer and winter treatments had statistically ($p>0.05$) similar relative gizzard percentages (1.8%). The insignificant differences in the relative gizzard weights as a percentage of the slaughter weight suggest that the differences of the absolute gizzard weights were mainly because of the slaughter weights rather than the seasonal effect. There were no effects ($p>0.05$) of feeding level and season interaction on the performance of the gizzards in absolute and relative terms at 18 and 32 weeks. The results obtained from the present study are in agreement with the findings of Rosa *et al.* (2007) who concluded that chickens that were exposed to heat had reduced gizzard weights.

The findings of the present study stated the differences ($p<0.05$) between Koekoek chickens that were full-fed and those that were under feed restriction at 18 weeks of age. The mean abdominal fat contents of chickens that were full-fed and restricted fed were 64.7 and 22.4g respectively. This implies that the abdominal fat of full-fed chickens was 65.4% higher ($p<0.05$) than the abdominal fat of those that were fed restrictedly. When considering abdominal fat as a percentage of body weight it was noted that full-fed chickens performed higher ($p<0.05$) than restricted fed chickens by 56.5% (Figure 4.6). The relative abdominal fat percentage of Koekoek chickens that were full-fed was different ($p<0.05$) from the relative fat percentage of chickens that were under restricted feeding. At this phase (18 weeks) of production it was discovered that the abdominal fat content was correlated ($p<0.01$) with the abdominal fat percentage ($r=0.982$) and the slaughter weight ($r=0.870$). This means that the differences in the abdominal fat content were primarily because of the effect of feeding level. It was also revealed from these results that 75.7% of the abdominal fat weight could be explained by the slaughter weight in Koekoek chickens. In this study, it was established that there was a positive relationship ($p<0.01$; $r=0.743$) between slaughter weight and skin weight because the more the birds had access to feed intake, the more the skin weight gained (Table 3.3).

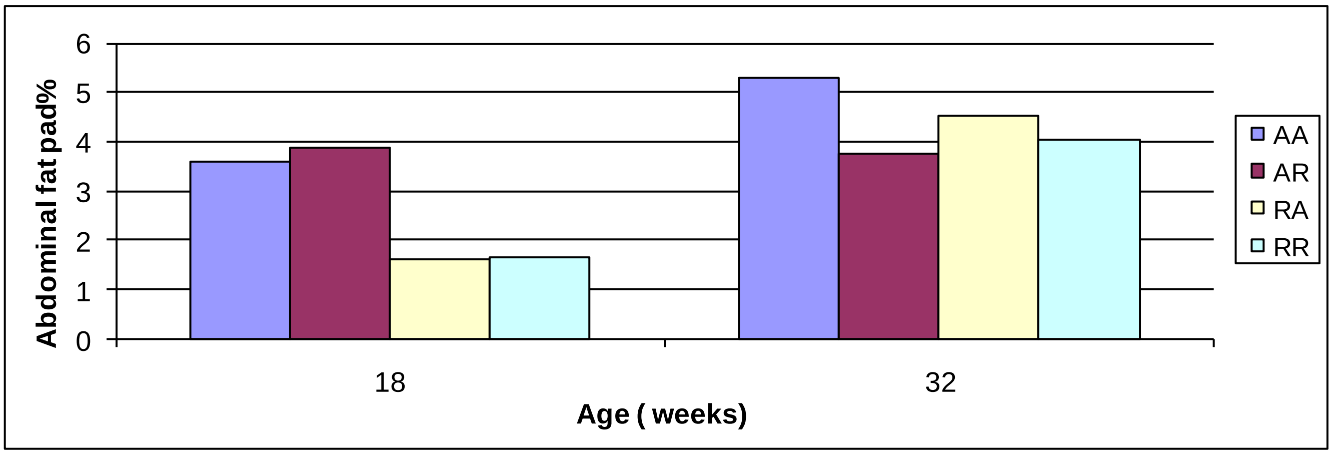

Figure 3.6: The relative abdominal fat percentage of Koekoek chickens that were subjected to different feeding levels
Footnote:
AA-full feeding during rearing and laying. AR-full feeding during rearing and restricted during laying, RA-restricted feeding during rearing and full feeding during laying, RR-restricted during rearing and laying, S.E-standard error.

During the laying phase (32 weeks) an average abdominal fat content of Koekoek chickens that were in the AA was higher than in the AR, RA and RR treatments by 54, 20.9 and 51.3g respectively. It was also observed that Koekoek chickens that were in the RA treatment gained more abdominal fat (82.4g) from the age of 18 to 32 weeks in comparison with chickens that were subjected to the AA, AR and RR treatments with the abdominal fat gains of 62g, 5.1g and 51g respectively. This implies that the fat accumulation process in the full-fed chickens was more rapid than in the feed restricted chickens. The amount of abdominal fat as a percentage of body weight followed a similar trend as the absolute abdominal fat content, hence a higher ($p<0.01$) correlation ($r=0.890$) between the abdominal fat content and the relative abdominal fat percentage. The relative abdominal fat of chickens that were allocated to the RA treatment was statistically ($p>0.05$) similar to all other treatments. The results for how different feeding management practices affected the abdominal fat pad demonstrate that differences in the fat content were primarily because of the feeding treatments rather than simply because of the different slaughter weights of Koekoek chickens. This can be confirmed by a high correlation between the slaughter weight and the abdominal fat content ($r=0.534$). This means that the slaughter weight contributed only 28.5% in the abdominal fat weight.

The results of the present study are in agreement with the findings of Novele *et al*. (2008) who stated that full-fed broiler chickens had excessive abdominal fat content than restricted fed ones. In addition, Mahmood *et al*. (2007) reported that restricted broilers had lower abdominal fat content at market age than those fed *ad libitum.* The same results were reported by Crounch *et al.* (2002c) and Richards *et al*. (2002). Renema *et al.* (1999a) confirmed a large difference in the relative fat pad with *ad libitum* fed broiler chickens representing a higher level of fat pad percent of body weight compared to restricted fed chickens. Nikoloval *et al*. (2007) stated that abdominal fat weight in broilers fed *ad libitum* increased significantly with age. This is in harmony with the results of the present study as it was noticed that the abdominal fat of *ad libitum* fed chickens was higher at 32 weeks age compared to when they were at 18 weeks of age. Attia *et al*. (1998) also reiterated that late feed restriction reduces the deposition of fat in broiler chickens as opposed to early feed restriction. Contrary to the findings of the present study, Saleh *et al*. (2005) reported that either abdominal fat content expressed as absolute or percentage of carcass weight was not affected by feed restriction.

Chickens that were subjected to summer treatment had an abdominal fat pad of 51.3g while those were in winter had 35.6g. The results indicate that an abdominal fat weight in chickens that were reared in summer was higher by 30.5% than the one of chickens that were kept in winter. The results suggest that an abdominal fat weight was positively associated ($r=0.87$) with the slaughter weight of chickens. This explains that 75.7% of an abdominal fat pad weight can be attached to the body weight of Koekoek chickens at slaughter age. The results on abdominal fat weight as the percentage of the slaughter weight indicate that chickens that were kept during the summer obtained heavier abdominal fat pad weight than those that were kept in winter. Koekoek chickens that were in summer treatment achieved the relative abdominal fat percentage of 3% compared to 2.4% of those that were reared in winter. The fact that the relative abdominal fat of chickens that were in summer treatment was higher (p<0.05) than the one for chickens that were subjected to cold environmental conditions suggests that the differences in the absolute abdominal fat were not mainly due to the different body weights but the different seasons contributed to the different abdominal fat performance. There were no feeding level and season interaction effects on abdominal fat pad characteristics in terms of abdominal fat weight and relative abdominal fat percentage on Koekoek chickens.

In support of the results of the present study, Wabeck *et al.* (1994) discovered that chickens that were reared in summer accumulated a higher amount of fat compared to the ones that were kept in winter. In an experimental study conducted by Rosa *et al.* (2007), a lower environmental temperature resulted in lower abdominal fat pad weight. Blahova *et al.* (2007) and Chen *et al.* (2007) also concluded that broilers that were kept under higher temperatures accumulated increased fat pad.

Table 3.8: Organs and abdominal fat characteristics in Koekoek chickens that were reared either in summer or winter

	Season		
Parameters	**Summer**	**Winter**	**S.E**
Rearing phase (18 weeks)			
Abdominal Fat wt (g)	51.3[a]	35.6[b]	1.77
Abdominal Fat %	3.0[a]	2.4[b]	0.11
Intestine wt (g)	61.5[a]	51.1[b]	2.53
Intestine %	3.7	3.7	0.16
Liver wt (g)	31.2[a]	26.6[b]	1.04
Liver %	1.9	1.9	0.06
Gizzard wt (g)	35.5[a]	38.3[b]	1.31
Gizzard %	2.2[a]	2.8[b]	0.08
Laying phase (32 weeks)			
Abdominal Fat wt (g)	91.3[a]	95.8[b]	8.14
Abdominal Fat %	3.8[a]	5.0[b]	0.37
Intestine wt (g)	69.0[a]	69.1[b]	3.77
Intestine %	3.1[a]	3.7[b]	0.20
Liver wt (g)	36.5	37.4	1.70
Liver %	1.6[a]	2.0[b]	0.08
Gizzard wt (g)	40.1[a]	33.2[b]	1.44
Gizzard %	1.8	1.8	0.06

[ab] Means within a row without a common superscript differ significantly (*p*<0.05), S.E=Standard Error

Table 3.9: The effect of the interaction between feeding level and season on organs and abdominal fat characteristics of Koekoek chickens

Carcass traits	SAA	S.E	WAA	S.E	SAR	S.E	WAR	S.E	SRA	S.E	WRA	S.E	SRR	S.E	WRR	S.E
Rearing phase (18 weeks)																
Abdominal fat wt(g)	73.0	2.45	53.1	2.45	75.6	2.45	56.6	2.45	26.7	2.45	17.0	2.45	29.8	2.65	15.8	2.65
Abdominal Fat %	4.0	0.15	3.3	0.15	4.2	0.15	3.6	0.15	1.8	0.15	1.5	0.15	2.0	0.16	0.3	0.16
Intestine wt (g)	60.7	3.50	52.0	3.50	64.4	3.50	56.6	3.50	59.3	3.50	48.0	3.50	61.5	3.79	48.0	3.79
Intestine %	3.9	0.22	3.2	0.22	3.6	0.22	3.6	0.22	3.9	0.22	4.2	0.22	4.1	0.24	3.9	0.24
Liver weight(g)	33.7	1.44	30.2	1.44	32.7	1.44	30.0	1.44	28.9	1.44	23.3	1.44	29.5	1.55	23.0	1.55
Liver %	1.8	0.09	1.9	0.09	1.8	0.09	1.9	0.09	1.9	0.09	2.0	0.09	2.0	0.09	1.9	0.09
Gizzard weight(g)	37.9	1.82	39.6	1.82	33.7	1.82	41.0	1.82	45.7	1.82	36.7	1.82	36.0	1.96	36.0	1.96
Gizzard %	2.1	0.11	2.4	0.11	1.9	0.11	2.6	0.11	2.9	0.11	3.2	0.11	2.4	0.12	2.9	0.12
Laying phase (32 weeks)																
Abdominal Fat wt(g)	132.1	11.28	118.0	11.28	66.7	11.28	75.4	11.28	107.0	11.28	101.4	11.28	59.3	12.19	88.3	12.19
Abdominal Fat %	4.9	0.51	5.7	0.51	3.3	0.51	4.2	0.51	4.0	0.51	5.0	0.58	3.1	0.55	5.0	0.55
Intestine wt(g(	69.9	5.22	71.1	5.22	71.1	5.22	69.1	5.22	64.7	5.22	72.6	5.22	70.2	5.64	56.3	5.64
Intestine %	2.6^{a}	0.27	3.6^{b}	0.27	3.6^{a}	0.27	3.9^{b}	0.27	2.4^{a}	0.27	3.6^{b}	0.27	3.6^{a}	0.29	3.3^{b}	0.29
Liver Weight(g)	39.1	2.36	42.6	2.36	35.0	2.36	32.7	2.36	39.1	2.36	43.1	2.36	32.8	2.55	31.0	2.55
Liver %	1.5^{a}	0.11	2.1^{b}	0.11	1.8^{a}	0.11	1.9^{b}	0.11	1.5^{a}	0.11	2.1^{b}	0.11	1.7^{a}	0.12	1.8^{b}	0.12
Gizzard Weight(g)	42.4	1.99	32.3	1.99	36.6	1.99	32.1	1.99	41.7	1.99	36.0	1.99	39.5	2.15	32.3	2.15
Gizzard %	1.6	0.08	1.6	0.08	1.8	0.08	1.8	0.08	1.6	0.08	1.8	0.08	2.0	0.09	1.9	0.09

^{ab} Means within a row with no common superscript differ significantly (p<0.05 and p<0.01).

Footnote:

SAA-full feeding during rearing and laying in summer season. SAR- full feeding during rearing and restricted during laying in summer season, SRA-restricted feeding during rearing and full feeding during laying in summer season, SRR-restricted during rearing and laying in summer season, WAA- full feeding during rearing and laying in winter season. WAR- full feeding during rearing and restricted during laying in winter season, WRA-restricted feeding during rearing and full feeding during laying in winter season, WRR-restricted during rearing and laying in winter season, S.E-standard error, sig- Significance level, wt- weight, the weight is in grams (g).

4.4 Conclusion

- Full feeding in the rearing phase improved the carcass characteristics of Koekoek chickens except for the breast muscle weight, intestine weight, liver weight and gizzard weight when expressed as percentage of the body weight as compared to restricted feeding.
- Warm summer conditions during the rearing phase increased the carcass characteristics except the dressing percentage, defeathered percentage, gizzard weight and shank length.
- Feeding chickens without restriction in summer proved to be the best option in terms of improved carcass dressing weight, carcass-dressing percentage, breast muscle weight and skin weight and percentage.
- Early feed restriction followed by full feeding improved the carcass characteristics during the laying phase.
- Rearing chickens in summer during the laying phase resulted in improved carcass characteristics with the exception of the shank length, shank width and the relative skin percentage.
- The cold winter conditions increased the abdominal fat weight and the percentage of the internal organs in Koekoek chickens during the laying phase.

4.5 Recommendations

- Based on the results of this research project it is recommended that Koekoek chicken be full-fed for the purpose of producing chicken meat in order to raise them to reasonable slaughter weight at 18 weeks of age.
- With reference to farmers who are keeping Koekoek chickens for laying purpose and also targeting meat production at the end of the laying period it is recommended that they should feed their birds unrestrictedly only during the laying phase since this will make them save some feed in the rearing stage.
- It is also recommended that birds should be raised under restricted feeding (RR) for purpose of producing lean meat at the end of the laying cycle. In order to have better results in terms of the majority of the carcass traits it would be more profitable if Koekoek chickens are reared in summer.

3.6 References

Aksit, M, S., Yalcin, S. Ozkan, K. Metin and D. Ozdemir. 2006. *Effects of temperature during rearing and crating on stress parameters and meat quality of broilers*. Poultry Science 85: 1867-1874.

Alleman, F and B. Leclercq. 1997. *Effect of dietary protein and environmental temperature on growth performance and water consumption of male broiler chickens*. British Poultry Science 38: 607-610.

Attia, F.M., A. A. Alsobayel and A. A. S. Aldabiby. 1998. *The effect of different feed festriction on performance and abdominal fat content of broilers.* Journal of King Saud University Agricultural Sciences 10 (1): 19-31.

Blahova, J, R., Dobsikova, E. Strakova and P. Suchy. 2007. Effect of low environment temperature on performance and blood system in broiler chickens (***Gallus domesticus***). Acta Veterinaria Brno 76: S17-S23.

Bochno Roman., Wtozimierz Makowski and Daria Murawska. 2007. *Effect of quantitatively restricted feeding on feed consumption and slaughter quality of young geese.* Polish Journal of Natural Sciences 22 (2): 204-213.

Bruno, L.D.G., B.C. Luguetti, R.L. Furlan and M. Macari. 2007. *Influence of early qualitative feed restriction and environmental temperature on bone development on broiler chickens.* Journal of Thermal Biology 32: 349-354.

Chen, H., R.L. Huang, H.X. Zhang, K.Q. Di, D. Pan and Y.G. Hou. 2007. *Effects of photoperiod on ovarian morphology and carcass traits at sexual maturity in pullets*. Poultry Science. 86: 917-920.

Crounch, A.N., J.L. Grimes, V.L. Christensen, and K.K. Kruegert. 2002c. Effect *of physical restriction during rearing on large white turkey breeder hens. 3. Body and Carcass composition*. Poultry Science 81: 1792-1797.

Deeb, N and A. Cahaner. 1999. *The effects of naked-neck genotypes, ambient temperature and feeding status and their interactions on body temperature and performance of broilers.* Poultry Science 78: 1341-1346.

Ingram, D. R and L. F. Hatten. 2001. *Effects of initiation age of skip-a-day feed restriction on skeletal development in broiler breeder males*. Journal of Applied Poultry Research 10: 16-20.

Jones, R. 1984. *A standard method of dissection of poultry for carcass analysis.* Technical Bulletin No. 222, West of Scotland Agricultural College, Scotland.

Keshavarz, K. 1998. *The effect of light regimen, floor space and energy and protein levels during the growing period on body weight and early egg size.* Poultry Science. 77: 1266-1279

Leeson, S and L.J. Caston. 1993. *Does environmental temperature influence body weight: Shank length in leghorn pullets?* Journal of Applied Poultry Research. 2: 245-248.

Mcgovern, R.H., J.J.R. Feddes, F.E. Robinson and J.A. Hanson. 2000. *Growth, carcass characteristics and incidence of ascites in broilers exposed to environmental fluctuation and oiled litter.* Poultry Science 79: 324-330.

Mahmood, S., Mehmood, F.Ahamad, A. Masoodi and R. Kuasar. 2007. *Effects of feed restriction during starter phase on subsequent growth performance, dressing percentage, relative organ weights and immune response of broilers.* Pakistan Veterinary Journal. 27(3): 137-141.

Melnychuk V.L., J.O. Kirby, Y.K. Kirby, D.A. Emmerson and N.B. Anthony. 2004. *Effect of strain, feed allocation program and age at photostimulation on reproductive development and carcass characteristics of broiler breeder hens.* Poultry Science 83: 1861-1867.

N'dri A.L., S. Mignon Grasteau, N. Sellier, C. Beaumont and M. Tixier- Bochard. 2006. *Interaction between the naked neck gene, sex and fluctuating ambient temperature on heat tolerance, growth, body composition, meat quality and sensory analysis of slow growing meat type broiers*. Livestock Science 110: 33-45

Nikolova, N., Z. Pavlovski, N. Milošević, and L. Perić. 2007. *The Quantity of Abdominal fat in broiler chicken of different genotypes from fifth to seven week of age.* Institute for Animal Husbandry, Belgrade-Zemun. Serbia. Website. www isotocar.bg.ac.yu/radoriz/38.pdf.

Novele, D.J., J.W. Ng'Ambi, D. Norris and C.A. Mbajiorgu. 2008. Effect of sex, level *and period of feed restriction during the starter stage on productivity and carcass characteristics of Ross 308 broiler chickens in South Africa*. Asian. International Journal of Poultry Science 7 (6): 530-537

Pishnamazi, A., R. A. Renema., 1, M. J. Zuidho and F. E. Robinson. 2008. *Effect of initial full feeding of broiler breeder pullets on carcass development and body weight variation.* Poultry Research. 17:505–514.

Plavnik, I. and S. Yahav. 1998. *Effect of environmental temperature on broiler chickens subjected to growth restriction at an early age.* Poultry Science 77: 870-872.

Rajini, R.A., D. Narahari and R. Kumararaj. 2009. *Influence of season, form of feed, dietary energy, age and sex on broiler organ biometry.* Indian Journal of Poultry Science. 44(15)

Renema, R.A. 1999b. *Effects of body weight and feed allocation during sexual maturation in boiler breeder hens. 2. Ovarian morphology and plasma hormone profiles* Poultry Science 78: 619-628.

Richards, M.P., S.M. Poch, C.N. Coon, R.W. Rosebrough, C.M. Ashwell and J.P. Mc Murtry. 2003. *Feed restriction significantly alters lipogenic gene expression in broiler breeder chickens*. Journal of Nutrition 1:707-715.

Robinson, F.E.,M.J.Zuidhof and R.A.Renema. 2007. *The reproductive efficiency and metabolism of female broiler breeders as affected by genotype feed allocation and age at photo stimulation. 1. Pullet growth and developments.* Poultry Science 86:2256-2266.

Rosa, P.S., D.E Faria Filho, F. Dahlke, B.S. Viera, M. Macari and R.L. Furlan. 2007. *Performance and carcass characteristics of broiler chickens with different growth potential and submitted to heat stress*. Brazilian Journal of Poultry Science. 9(3):181-186

Saleh, E., A. S. E. Watkins, A. L. Waldroup, 3 and P. W. Waldroup. 2005. *Effects of early quantitative feed restriction on live performance and carcass composition of male broilers grown for further processing*. Poultry Research 14: 87–93.

Wabeck C.J., L.E. Carr and V. Byrd. 1994. *Broiler drinker systems and seasonal effects on eviscerated carcass and leaf fat weights.* Journal of Applied Poultry Research. 3: 274-278.

Vakali, R and F. Akbarogli. 2000. *Effect of feed restriction method during rearing on Growth and blood indices of stress in broiler breeder*. www.cabi.org.

Yalcin, S., P. Settar, S. Ozkan and A. Cahaner. 1997a. *Comparative evaluation of three commercial broiler stocks in hot versus temperate climates*. Poultry Science 76: 921- 929.

Yagoub, M. Yagoub and Salih Ahmed Babiker. 2008. *Effect of compensatory growth on the performance and carcass characteristics of the broiler chicks*. Pakistan Journal of Nutrition 7: 497-499.

Yu, M.W., F.E Robinson and A.R Robblee 1992. *Effect of feed allowance during rearing and breeding on female broiler breeders. 1. Growth and carcass characteristics.* Poultry Science 71(10): 1739- 1744.