Effect of dietary protein concentration on feed intake, body mass gain and carcass traits of Rhode Island Red chicken

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Abstract

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The effect of dietary crude protein (CP) concentration on dry-matter intake (DMI), body mass gain (BWG) and carcass traits of Rhode Island Red (RIR) chicken was determined through a 12-week feeding trial (10–93 days of age) in southern Ethiopia. Diets were formulated to contain 140 (T1), 160 (T2), 180 (T3), 200 (T4) and 220 (T5) g CP kg^{-1} DM from maize, wheat bran, soybean, sunflower cake, Niger seed (*Guizotia abyssinica*) cake, salt, rear premix, lysine and methionine. ME (14.36–14.84 kJ kg^{-1} DM) and other nutrients in diets were similar. Ten chicks were randomly distributed to each of four replicates of five treatment diets in a completely randomized design. Chicks were raised in groups, and the feed offer and refusal measured daily. Body mass was measured weekly. At the beginning of the experiment, four male (1 per replicate) and four female (1 per replicate) chicks whose body mass was closest to the mean body mass of their respective groups and sexes, were selected per treatment, fasted for 12 h, weighed, slaughtered and parts of the carcass weighed. Differences in DMI and BWG of chicks fed different levels of dietary CP were not significant. Diet T2 was as efficient as the higher CP diets but more efficient than T1 in DM utilization. Chicks fed on diet T2 had significantly ($P<0.05$) higher total non-edible offal (TNEO) than those fed on T1, and TNEO of chicks fed on diets T3, T4 and T5 were in between. Differences in carcass mass were not significant ($P<0.05$) among treatment groups. Chicks fed on diet T1 had significantly ($P<0.05$) higher dressing percentage than those on diets T3 and T5, but similar to those on diets T2 and T4. The highest net return was from diet T2, but it was close to T1. Mortality of chicks was observed only in T1 (2.5%) and T5 (12.5%). The results suggest that 160 g CP kg^{-1} DM is optimum for growing RIR chicks in tropical climates from 10–93 days of age.

Keywords: Dietary crude protein, carcass traits, feed efficiency, Rhodes Island Red chicken

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Introduction

Feed cost represents 65–75% of the total cost of intensive poultry production, depending mainly on the relative costs of feed constituents, labour, housing and miscellaneous items in particular situations (Gopalakrishnan & Lal, 2004). The optimal use of protein is essential in any feeding system, because protein supplements are usually much more expensive than energy feeds, and wasteful usage increases the cost of production. Excess protein if fed may increase elimination of N in faeces and urine, which has environmental implications (Church & Kellems, 2002). Therefore, economically as well as nutritionally it is imperative that balanced diets should be provided during the brooding, rearing and laying stages (Gopalakrishnan & Lal, 2004).

Although the National Research Council (NRC, 2003) recommended a feeding standard for chicken, this has not been totally practical in the tropics, for obvious reasons of environmental differences and type and quality of available feed ingredients. Furlan *et al.* (2004) reported that, in tropical areas, the feeding of high-protein diets to broilers was not recommended, because among dietary nutrients, protein has the highest heat increment. Consequently, for many years low-protein diets were recommended, to decrease the amount of heat produced and its harmful effects on birds' performance. On the other hand, when low feed intake of heat-stressed birds is associated with low-protein content of diets, there is a reduction in amino-acid intake. Moreover, the specific nutrient requirements of dual-purpose breeds have not been adequately researched (Blake, 2008). The aim of this study was thus to determine the level of protein for optimum growth and carcass yield of Rhode Island Red chicken under Ethiopian conditions.

Materials and methods

The study area

A feeding trial with Rhode Island Red (RIR) chicks was conducted at Wolaita Soddo Poultry Husbandry Centre (Southern Ethiopia), situated 400 km SW of the capital, Addis Ababa. The area is between 6.72º–6.99ºN lat. and 37.61º–37.88ºE long., 1884 m above sea level. Rainfall is bimodal. Mean annual rainfall is between 1201–1600 mm, and mean annual temperature is 22–24 ºC.

Experimental feed

The coarse feed ingredients were first ground in a feed mill; then all ingredients were thoroughly and uniformly mixed. Soybean meal, sunflower seed cake and Niger seed (*Guizotia abyssinica*) cake were the major protein sources used in the formulation of different protein concentrations. The level of protein in the diets was increased from 140.3 to 220.0 g kg^{-1} DM, by replacing maize and wheat bran with roasted soybean, sunflower seed cake and Niger seed cake. The calculated energy, crude fibre, Ca and P contents of the treatment diets were closely similar (Table 3). The proportion of feed ingredients and the nutrient composition of the experimental diets are given in Tables 1 and 2.

Management of experimental animals

Experimental rooms were cleaned with water and detergent, then disinfected with for-

Table 1. *The proportion of feed ingredients used in experimental diets*

	Treatment diets				
Ingredients, g kg^{-1}	T1	T2	T3	T4	T5
Maize (white)	387.0	362.0	308.0	297.0	250.0
Wheat bran	333.0	240.0	187.5	80.0	25.0
Soybean (roasted)	50.0	113.0	197.0	283.0	375.0
Niger seed cake	95.0	140.0	160.0	180.0	185.0
Sunflower seed cake	105.0	115.0	117.5	130.0	135.0
Limestone[a]	20.0	20.0	20.0	20.0	20.0
Salt	5.0	5.0	5.0	5.0	5.0
Rear premix[b]	4.0	4.0	4.0	4.0	4.0
Lysine	0.5	0.5	0.5	0.5	0.5
Methionine	0.5	0.5	0.5	0.5	0.5
Total	**1000**	**1000**	**1000**	**1000**	**1000**

Note
a) Limestone contains 35% Ca (Boushy & Van der Poel, 2000)
b) Rear premix contents per kg: ash 655 g, crude protein 135 g, crude fat 2 g, crude fibre 9 g, lysine 90 g, methionine 20 g, threonine 5 g, Ca 100 g, Na 135 g, Chloride 230 g, Cu 3000 mg, Fe 4000 mg Mn 6000 mg, Zn 5000 mg, Co 20 mg, I 80 mg, Se 15 mg, vitamin A 1,000,000 if, vitamin D3 200,000 if, vitamin E 1500 mg (Pre-Mervo, Utrecht. EXPVALK)

malin (37%, v/v) two weeks before the experimental chicks were housed. Feeding and watering troughs were cleaned with water and detergent twice a week during the trial. Each replicate of ten chicks was housed in a pen constructed from wood and wire mesh, with 1×1.5 m floor space. Sawdust was spread on the floor of pens to a depth of 5 cm.

In total, 250 unsexed day-old RIR chicks were purchased from Bonga Poultry Husbandry Centre (Southern Ethiopia) and electrically brooded at Wolaita Soddo Poultry Husbandry Centre for nine days. Then, after weak chicks had been discarded, 200 chicks were randomly divided into 20 replicates of ten chicks each, with initial body mass of 52±0.5 g. Finally, four replicates were randomly assigned to each of the five treatment diets (Table 3). Chicks were vaccinated against Newcastle disease at 7 and 21 days of age, and against infectious bursal disease (Gumboro) at 14 and 28 days of age. The drug COCOBAN was used to prevent and treat coccidiosis. Mortality was recorded throughout the entire experimental period.

Known amounts of experimental diets were offered daily in two equal portions, in the morning and afternoon. The daily offer of each group was increased by 10% above the previous day's offer. Water was available at all times. Daily feed refused at each pen was collected, weighed and recorded before the daily feed was offered at 08:00 h. The chicks were weighed at the beginning, every week during the trial and at the end of the experiment. Weighing took place in the morning before feed was offered.

Measurement of carcass characteristics

At the end of the experiment, two chicks (1 male + 1 female) from each replicate (8 chicks/treatment), whose body mass was closest to the mean body mass of their respective

Table 2. *Chemical composition of feed ingredients used in the experimental diets*

Nutrients, g kg^{-1} DM	Feed ingredients				
	Maize (white)	Wheat bran	Soybean (roasted)	Niger seed cake	Sunflower seed cake
Dry matter	877.4	886.0	922.2	935.6	947.3
Mineral matter	16.0	43.5	57.5	108.0	58.6
Crude fibre	29.0	155.6	81.2	265.6	272.3
Crude protein	86.5	140.1	310.8	282.4	293.3
Nitrogen-free extract	835.0	612.0	326.0	271.0	302.8
Fat	33.0	48.0	223.3	72.5	73.0
Calcium	0.62	4.5	2.8	6.0	3.1
Phosphorus	3.5	8.1	6.7	6.9	6.7
Amino-acids[a]					
Methionine	1.8	2.3	6.2	3.1	8.0
Lysine	2.6	6.1	26.9	9.0	12.4
Cystine	1.8	3.2	6.6	3.4	6.4
Threonine	4.0	4.9	14.1	7.9	12.9
Tryptophan	1.0	2.0	5.1	-	4.1
Isoleucine	4.0	5.8	15.6	8.6	14.3
Leucine	11.0	10.7	27.5	13.4	22.2
Phenylalanine	5.0	6.4	17.8	8.7	16.6
Tyrosine	-	4.5	13.4	3.5	9.1

Note
a) Amino acid content of feed ingredients (as fed basis) was obtained according to Tacon (1987), Lauridsen et al. (2004) and Perry et al. (2004). DM=dry matter

groups and sexes, were selected. The chicks were identified by means of a leg band, and were starved for 12 h to allow emptying of the gut to minimize influence of digesta on live body mass at slaughter. Each bird was weighed and immediately killed by severing the jugular vein. Blood was completely drained onto a dish, and weighed. The bodies were then scalded for one minute and feathers manually plucked. Feather mass was taken to be slaughter body mass minus carcass body mass without feathers and blood. Edible offal (liver, skin and gizzard) and non-edible offal (shank + claws, head, lungs, heart, spleen, pancreas, digestive organs) were weighed and recorded. The carcass was further apportioned into commercially important parts (two drumsticks, two thighs, two wings, back and breast), and weighed. The dressing percentage was calculated as (commercial carcass body mass / slaughter body mass) × 100. Gizzard, skin and liver are edible offal in Ethiopia, and these added to the commercial carcass were used to calculate another version of dressing percentage.

Data analysis

Data obtained on DM intake, body mass gain, DM conversion ratio and measurement of carcass traits, were subjected to ANOVA using the General Linear Model (GLM) procedure of SPSS version 13 using the following model: $Y_{ijk} = \mu + A_i + S_j/A_i + e_{ijk}$; where, Y_{ijk} = individual values of the dependent variables; μ = grand mean of the response variable; A_i = the effect of the *i*th crude protein level (*i*=1, 2, 3, 4, 5) on the dependent variable S_j/A_i = the effect of the *j*th replicate (*j*=1, 2, 3, 4) under the *i*th crude protein level and e_{ijk}= random variation in the response of individual chick. Means were separated using Duncan's multiple range test. Treatment differences were considered significant at the P<0.05 level.

Results and discussion

Chemical composition of feeds

The chemical composition of feed ingredients is presented in Table 3. The rations were formulated to have five levels of protein between 140.3 and 220.0 g kg^{-1} DM, by replacing maize and wheat bran with the protein supplements roasted soybean, sunflower seed cake and noug seed cake. The energy, crude fibre, C and P contents of the treatment diets were close to one another.

Dry-matter intake, growth performance and dry-matter conversion ratio

The influence of dietary crude protein (CP) level on the DM intake of Rhode Island Red chicks fed for 12 weeks is presented in Table 4. The mean daily DM consumption of the chicks fed the different treatment diets did not differ significantly (P>0.05). This probably was related to the closely similar energy content of the diets (Melesse, 2007), or possibly the palatability of the diets was not affected by CP levels (Pond *et al.*, 2005). This result is in agreement with the reports of Kamran *et al.* (2000) and Oyedeji *et al.* (2005), that dietary CP level did not significantly (P>0.05) affect the feed intake of chicken. In disagreement with the result of the present study, Urdaneta-Rincón & Leeson (2008) reported that chicks fed on low CP diet (170 g kg^{-1} DM) had significantly lower (P<0.05) feed intake than chicks fed dietary CP ranging between 190–250 g kg^{-1} DM. Pfeffer *et al.* (2000) reported that, when broiler chicks were fed diets containing 225, 210, 190, 172, 153 g CP kg^{-1} DM, more feed was consumed (P<0.05) by chicks fed on the lowest CP diet, possibly because chicks were not able to meet their CP and other nutrient requirements with small intake. Jiang *et al.* (2005) reported that increasing dietary essential amino-acids above NRC in fact caused a significant linear reduction in feed intake, possibly because chicks were able to meet their amino-acids, CP and other nutrient requirements with small intake.

The mean daily body mass gain of the chicks fed the five treatment diets did not differ significantly (P>0.05). The protein sources used in the study were of good quality plant protein sources, and the combination of these protein feeds might have complemented each other, and could have met the minimum amino-acid demand of the chicks (Perry *et al.*, 2004); also, the demand for amino-acids might have been satisfied by the addition of critical amino-acids (lysine and methionine) to the diets (Sainsbury, 2000).

The results of the present study agree with those of other studies, which indicated that reduction of dietary CP to 16% did not significantly affect the body mass gain of growing chicken. Oyedeji *et al.* (2005) concluded

Table 3. *Nutrient composition of the experimental diets*

	Treatment diets				
Nutrient composition [a]	T1	T2	T3	T4	T5
Dry matter (DM), g kg^{-1}	921.5	908.5	920.0	924.0	926.0
Crude protein, g kg^{-1} DM	140.3	160.2	180.4	200.4	220.0
ME, MJ kg^{-1} DM [b]	14.36	14.48	14.60	14.72	14.84
Crude fibre, g kg^{-1} DM	115.3	115.5	119.0	118.7	119.6
Calcium, g kg^{-1} DM	9.5	9.6	9.7	9.6	9.7
Total Phosphorus, g kg^{-1} DM	5.2	5.2	5.3	5.3	5.4
Methionine, g kg^{-1} DM	3.2	3.6	4.0	4.4	4.8
Lysine, g kg^{-1} DM	6.9	8.4	10.3	12.3	14.3
Cystine, g kg^{-1} DM	2.8	3.1	3.5	3.8	4.2
Threonine, g kg^{-1} DM	5.5	6.3	7.2	8.1	9.1
Tryptophan, g kg^{-1} DM	1.6	1.7	2.0	2.3	2.6
Isoleucine, g kg^{-1} DM	6.0	6.9	7.8	8.9	9.9
Leucine, g kg^{-1} DM	11.6	12.9	14.4	16.0	17.7
Phenylalanine, g kg^{-1} DM	6.9	7.8	8.9	10.1	11.2
Tyrosine, g kg^{-1} DM	3.2	3.8	4.8	5.6	6.7

Note

[a)] calculated according to information in Table 2.

[b)] ME = Metabolizable energy (kcal kg^{-1} DM) = 3951 + 54.40 fat – 88.70 crude fibre – 40.80 ash (Wiseman, 1987)

DM = dry matter; T1 = maize (387.0 g kg^{-1}) + wheat bran (333.0 g kg^{-1}) + roasted soybean (50 g kg^{-1}) + Niger seed cake (95.0 g kg^{-1}) + sunflower seed cake (105.0 g kg^{-1}) + limestone (20.0 g kg^{-1}) + salt (5.0 g kg^{-1}) + rear premix (4.0 g kg^{-1}) + lysine (0.5 g kg^{-1}) + methionine (0.5 g kg^{-1}); T2 = maize (362.0 g kg^{-1}) + wheat bran (240.0 g kg^{-1}) + roasted soybean (113.0 g kg^{-1}) + Niger seed cake (140.0 g kg^{-1}) + sunflower seed cake (115.0 g kg^{-1}) and same amounts of limestone, salt, rear premix, lysine and methionine as in T1; T3 = maize (308.0 g kg^{-1}) + wheat bran (187.5 g kg^{-1}) + roasted soybean (197.0 g kg^{-1}) + Niger seed cake (160.0 g kg^{-1}) + sunflower seed cake (117.5 g kg-1) and same amounts of limestone, salt, rear premix, lysine and methionine as in T1; T4 = maize (297.0 g kg^{-1}) + wheat bran (80.0 g kg^{-1}) + roasted soybean (283.0 g kg^{-1}) + Niger seed cake (180.0 g kg^{-1}) + sunflower seed cake (130.0 g kg^{-1}) and same amounts of limestone, salt, rear premix, lysine and methionine as in T1; T5 = maize (250.0 g kg^{-1}) + wheat bran (25.0 g kg^{-1}) + roasted soybean (375.0 g kg^{-1}) + Niger seed cake (185.0 g kg^{-1}) + sunflower seed cake (135.0 g kg^{-1}) and same amounts of limestone, salt, rear premix, lysine and methionine as in T1.

that a single diet of 180 g CP kg^{-1} DM fed to chicks from 0 to 8 weeks of age would be most suitable and convenient, rather than feeding differing CP contents during the brooding period. The authors also reported that the different feeding regimes did not significantly (P>0.05) affect the body mass gain of growing broilers. Kamran *et al.* (2000) suggested that, when diets were supplemented with critical amino-acids, dietary CP level could be reduced from 230 to 200 g CP kg^{-1} DM during the starter period, without any harmful effect on broiler performance. Pfeffer *et al.* (2000) reported that the feeding of broiler chicks on five diets containing 225 (control), 210, 190, 172, 153 g CP kg^{-1}, supplemented with essential amino-acids, resulted in no significant (P>0.05) influence on body mass gain.

Table 4. *Dry-matter intake, body mass gain and feed efficiency of Rhode Island Red chicks fed on different levels of dietary crude protein*

	Treatment diets					
Parameters	T1	T2	T3	T4	T5	SEM
Total dry-matter intake, g/chick	3401	3344	3473	3391	3299	118
Dry-matter intake, g/chick/d	40.49	39.82	41.35	40.37	39.29	1.40
Initial body mass, g/chick	51.73	51.75	51.75	51.78	51.78	0.48
Final body mass, g/chick	750	806	838	842	827	30.98
Total body mass gain, g/chick	698	754	786	791	775	30.92
Body mass gain, g/chick/d	8.31	8.98	9.36	9.42	9.23	0.37
Dry-matter conversion ratio	4.88^{b}	4.43^{a}	4.42^{a}	4.30^{a}	4.26^{a}	0.10

Notes
Means within the same row with different superscript letters are significantly different at P<0.05.
For composition of diets T1-T5, see Note to Table 3.

Although differences were not statistically significant, the daily body mass gain of chicks tended to increase linearly as the level of dietary CP increased from 140 up to 200 g CP kg^{-1} DM, then started to decline (Table 3). The difference in the trend of body mass gain increment was widest between 140 and 160 g CP kg^{-1} DM, but it was narrower between 180 and 200 g CP kg^{-1} DM, and became negative between 200 and 220 g CP kg^{-1} DM (Table 4).

Results for the dry-matter conversion ratio (DMCR), expressed as grams of daily dry-matter intake per gram of body-mass gain of the chicks fed on the treatment diets, indicated that chicks on the diet containing 140 g CP kg^{-1} DM required a significantly (P<0.05) larger amount of feed per unit of body mass gain, than those on other treatment diets. However, differences in DMCR among other treatments were not significant (P>0.05). This might be due to a lower concentration of amino acid per unit of DM in the 140 g CP kg^{-1} diet than in the other treatment diets, because the rest of the treatment diets contain larger amount of soybean with a good amino-acid profile, to achieve the same level of gain with the same amount of DM consumed. In agreement with the results of the present study, Pfeffer *et al.* (2000) reported that broiler chicks fed 153 g CP kg^{-1} diets had a poorer (P<0.05) feed-conversion efficiency. In disagreement with the results of the present study, the reduction of dietary CP to 16% did not significantly affect (P>0.05) the feed conversion ratio (Faria *et al.*, 2005; Kamran *et al.*, 2000; Kerr & Kidd, 1999; Oyedeji *et al.*, 2005).

Effect on carcass traits

Data on carcass traits of RIR chicks fed on different levels of dietary protein are presented in Table 5. Differences in slaughter body mass of chicks among treatment groups were not statistically significant (P>0.05). Total non-edible offal (TNEO) included feathers, blood, head, shank and claw, esophagus, crop, proventriculus, spleen, pancreas, kidney, heart, lung and intestines; and Total edible offal (TEO) included skin, gizzard and liver (Tera, 2007). Chicks on T1 had significantly (P<0.05) lower TNEO than those on T2.

Chicks on T3, T4 and T5 fell in between. Chicks on T1 and T2 had significantly ($P<0.05$) higher TEO than chicks on T3, T4 and T5. Total edible carcass (TEC) was calculated by adding the gizzard, skin and liver to back, drumsticks, thighs, wings and breast. Differences in TEC mass were not significant ($P>0.05$) among the feeding groups.

Dressing percentage, calculated from TEC, was affected by treatment. Chicks on T1 had a similar dressing percentage to those on T2 and T4, but had a significantly ($P<0.05$) higher dressing percentage than chicks on T3 and T5, presumably due to greater yield of skin of chicks on T1 ($P<0.05$) than those on T3 and T5. Hai and Blaha (2000) reported that reduction of dietary CP from 23 to 20% did not reduce the dressing percentage. The overall mean dressing percentage, including TEO as part of the carcass, was 63.1%. In agreement with this, Dana (1999) reported a similar dressing percentage (63%) for RIR hens kept on choice feeding of energy or protein feeds under intensive and semi-intensive management conditions in the central highlands of Ethiopia. Tera (2007) also reported that RIR chicks fed a diet containing about 200 g CP kg^{-1} DM had a dressing percentage of 56%.

Differences in dressing percentages calculated excluding TEO were, however, insignificant ($P>0.05$). The overall mean dressing percentage was 53.1%. In close agreement with the results of the present study, Tera (2007) reported a 55.6% dressing percentage for RIR chicks fed diets containing fish meal as a protein source. Contrary to the result of the present study, Maigualema & Gernat (2003) and Scanes *et al*. (2004) reported 70% dressing percentage for Arbor Acres × Arbor Acres Glastonbury broilers, probably due to breed differences.

There was no significant ($P>0.05$) difference among different treatment diets in commercial carcass yield In agreement with this, Hai & Blaha (2000) reported that reduction of dietary CP from 23 to 20% had no negative effect on the muscle proportion in live body mass. Nawaz *et al.* (2006) also reported that carcass mass did not vary significantly ($P>0.05$) between broiler chicks fed 160, 170 and 180 g CP kg^{-1} DM with 3000 kcal kg^{-1} ME, and 180, 190 and 200 g CP kg^{-1} DM with 3200 kcal kg^{-1} ME. Pfeffer *et al.* (2000) reported a similar result, that broiler chicks fed five iso-energetic (13MJ kg^{-1}) diets containing 225 (control), 210, 190, 172, 153 g CP kg^{-1} DM, and supplemented with essential amino-acids, exhibited no significant ($P>0.05$) influence on the relative body mass of various carcass cuts. As opposed to the results of the present study, Faria *et al.* (2005) and Zarate *et al.* (2003) observed a significant ($P<0.05$) decrease in carcass responses of broilers fed on a low CP diet. Kamran *et al.* (2004), however, reported higher carcass mass at 200 g CP kg^{-1} DM than at 230 g CP kg^{-1} DM, when low protein diets were supplemented with essential amino-acids in an ideal amino-acid pattern. The reason why carcass mass of chicks was not significantly affected by CP level may be that the lowest CP diet was sufficient for the synthesis of non-essential amino-acids, and thus RIR chicks fed on the low CP diet had low voluntary feed intake (Bregendahl *et al.*, 2002).

Economic analysis

As revealed by partial budget analysis of the economics of the operation, the level of dietary CP in the diet of growing RIR chicks moderately affects net return. Net return increased as the level of dietary CP increased from 140 to 160 g CP kg^{-1} DM, and decreased from then on. The highest net return was thus obtained from 160 g kg^{-1} DM dietary CP (Table 6).

Table 5. *Carcass characteristics of RIR chicken fed with different levels of dietary protein*

Variables, g/head	Treatment diets T1	T2	T3	T4	T5	SE
Slaughter mass	740	809	710	778	736	39
Blood	21.5^{b}	16.8^{ab}	14.3^{a}	17.9^{ab}	19.1^{b}	1.5
Feather	31^{a}	55^{b}	54.1^{b}	48.6^{ab}	48.5^{ab}	6.1
Head	35.5^{a}	42.5^{b}	37.1^{ab}	39.6^{ab}	39.5^{ab}	1.9
Skin	39.5^{c}	37.1^{bc}	27^{a}	32.6^{abc}	31^{ab}	2.5
Shank	39.5	40.4	35.9	38.6	36.3	2.5
Heart	4.4	4.4	4.1	4.8	4	0.37
Liver	17.5	18	17.1	19.6	18.4	1.1
Gizzard	24.9	26	21.4	22.5	24.3	1.4
Lung	6.6	5.6	4.8	5.1	5	0.7
Kidney	6	6	5.4	5.9	6.8	0.59
Small intestine	32^{ab}	33^{ab}	31^{a}	37^{b}	38^{b}	2.2
Large intestine	15^{a}	16^{ab}	14^{a}	18^{b}	17^{ab}	0.96
Pancreas	2^{ab}	2.6^{b}	1.8^{a}	2^{ab}	1.9^{a}	0.22
Spleen	2.1	2.6	1.8	2.4	2	0.19
Proventriculus	4.8^{a}	5.3^{a}	4.9^{a}	6.9^{b}	5.4^{a}	0.36
Crop	4.8^{a}	5.6^{a}	6.6^{a}	6.3^{a}	5.3^{a}	0.74
Esophagus	5.9	7	5.6	6.8	5.8	0.50
Drumstick	64.1	69.8	61.5	66.8	63.1	3.7
Thigh	78.6	80.6	71.8	78.3	72.6	4.9
Wing	59.1	63.5	53.1	60.4	54.6	4.0
Back	82.9	87.4	77.4	84.8	78.4	6.6
Breast	108	133	113	129	117	7.8
TNEO	212^{a}	283^{b}	221^{ab}	240^{ab}	234^{ab}	19.7
TEO	81.87^{b}	81.13^{b}	65.50^{a}	74.75^{ab}	73.63^{ab}	3.76
TEC	475	516	442	494	458	27.1
Dressing % [1)]	64.19^{b}	63.69^{ab}	62.22^{a}	63.55^{ab}	61.93^{a}	1.08
Carcass mass	393	435	377	419	385	26.3
Dressing % [2)]	53.11	53.63	52.96	53.87	51.89	1.09

Notes

Means within the same row with different superscript letters are significantly different (P<0.05)

GM=Grand mean, 1) Dressing % with total edible offal, 2) Dressing % without total edible offal.

For composition of diets T1–T5, see Note to Table 3.

Table 6. *Partial budget analysis of treatment diets*

Items	Treatment diets				
	T1	T2	T3	T4	T5
Total feed consumed, kg/chick	3.40	3.34	3.47	3.39	3.30
Final mass of chick, kg/head	0.75	0.81	0.84	0.84	0.83
Cost of feed, ETB/kg	3.20	3.80	4.50	5.30	6.10
Total cost of feed consumed, ETB (TVC)	10.88	12.69	15.62	17.97	20.13
Sale of chicks, ETB/head (GR)	35.00	37.00	39.00	39.00	39.00
Net return (GR–TVC), ETB	24.12	24.31	23.38	21.03	18.87

Notes
GR = Gross Revenue; TVC = Total Variable Cost; 1 ETB = 0.077 USD in March 2009.
For composition of diets T1–T5, see Note to Table 3.

Conclusions

The overall results of the present study revealed that RIR chicks fed diets with crude protein content of 160 g kg^{-1} DM were similar in body mass gain, feed efficiency and important economic carcass traits, to chicks fed higher levels of dietary CP; mortality was nil and net return highest. Therefore, feeding RIR chicks with 160 g CP kg^{-1} DM from early life up to 93 days of age is recommended for areas with similar climatic conditions to Wolaita, Southern Ethiopia.

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