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Dietary protein and energy requirements of Venda village chickens

Thomas Raphulu [a,b,*], Christine Jansen van Rensburg [a]

[a] *Department of Animal and Wildlife Sciences, University of Pretoria, Pretoria 0002, South Africa*
[b] *Limpopo Department of Agriculture and Rural Development, Mara Research Station, P/bag x 2467, Makhado, 0920, South Africa*

Abstract

The objective of this study was to determine the dietary protein and apparent metabolisable energy (AME) requirements of local chickens. Freshly laid eggs of scavenging chickens collected in rural villages were hatched and randomly distributed to 27 floor pens, 10 chicks per pen. Chicks were fed 9 experimental diets that were combinations of three CP levels (140, 170 and 190 g kg^{-1} DM) and three AME levels (11.0, 11.7 and 12 MJ kg^{-1}) during the starter phase (0–6 weeks) and combinations of three CP levels (120, 150 and 180 g kg^{-1} DM) and three ME levels (11.3, 12.0 and 12.4 MJ kg^{-1}) during the grower phase (7–17) weeks. Significant differences within means on CP × AME interaction effect were observed in all parameters measured, except feed intake during starter period and dressing percentage (%) and breast yield of 17 weeks old chickens. The results of the present study indicated that during the starter and grower phases, unsexed chickens would require dietary combinations of 170 g CP kg^{-1} and 11.0 AME MJ kg^{-1} and 150 g CP kg^{-1} and 12 AME MJ kg^{-1} in their diets to optimise weight gain and FCR, and 150 g CP kg^{-1} and 11.3 MJ kg^{-1} to optimise ash content of muscles, protein content of the breast and fat content of the leg muscle. Supplementation of 27 g CP kg^{-1} feed to grower scavenging chickens would be enough to improve chicken production in the rural villages.

Keywords: starter phase, grower phase, weight gain, feed conversion ratio

1 Introduction

Villages in the rural areas of the Vhembe District, Venda, South Africa, have relative high numbers of chickens which in most instances have to scavenge for feed. These chickens are mainly kept for religious and cultural reasons, income generation and a supply of high quality protein in the form of meat and eggs (Swatson *et al.*, 2001; Raphulu *et al.*, 2015a). The typical chicken population found in these areas are characterised by slow growth rate and late maturity, low egg production and small egg size (Melesse, 2000). Low husbandry input levels cause numerous nutritional and parasitic problems in these chickens. In a stress-free environment, given adequate access to essential nutrients, growth rate will increase until a genetically determined upper limit is reached (Campbell & Taverner, 1988). A few studies have been conducted to determine the nutrient requirements of indigenous chickens in Africa. Mbajiorgu (2010) reported that a diet containing a crude protein content level of 178 g kg^{-1} DM and energy level of 14 MJ ME kg^{-1} DM allowed for optimal utilisation of absorbed protein and energy for growth of Venda chickens between one and six weeks old. Alabi *et al.* (2013) fed Venda Indigenous chickens diets that were isonitrogenous with different energy levels and concluded that dietary energy levels of 12.42 and 12.66 MJ ME kg^{-1} DM, in a diet of 180 g CP kg^{-1} DM, supported optimum growth rates at starter (1–7 weeks) and grower phases (8–13 weeks) of Venda chickens, respectively. The dietary protein requirement of indigenous chickens in Kenya were found to be between 130 g kg^{-1} (Chemjor, 1998) and 160 g kg^{-1} (Kingori *et al.*, 2003) during 14–21 weeks of age and on average 170 g kg^{-1} during a 19 weeks growing period (Ndegwa *et al.*, 2001).

The improvement of chicken production in the rural areas of Venda can increase the availability of quality protein

* Corresponding author – thomas.raphulu@gmail.com
Phone (cell): 0828518296; Phone (work): 0159627200;
Fax: 0159627239

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in the form of meat and eggs to the communities, which will result in alleviation of malnutrition, increased household income and job creation. Because of the limited information on the nutrient requirements of the chickens in Venda, it is difficult to come up with nutrient supplementation strategies to assist the rural communities. The objective of this study was to determine the genetic growth potential of these chickens (eggs collected from the rural villages) under good environmental conditions and management, and to determine the nutrient requirements in terms of dietary protein and metabolisable energy to optimise its growth performance.

2 Materials and methods

The experiment was conducted at the University of Pretoria, Gauteng Province; South Africa (coordinates 25°15′28.9″ E, 25°45′03.6″ S). All procedures were approved by the University of Pretoria, Animal Use and Care Committee (EC008-08). Thousand freshly laid eggs of scavenging chickens collected in 6 rural villages of Venda in the Vhembe District, South Africa, were hatched at the University of Pretoria Experimental farm. Two hundred and seventy (270) chicks were randomly distributed to 27 floor pens, 10 chicks per pen. Chicks were fed 9 experimental diets that were combinations of three CP (140, 170, 190 and 120, 150 and 180 g kg^{-1}) and three AME (11.0, 11.7, 12.0 and 11.3, 12.0 and 12.4 MJ kg^{-1}) levels during the starter (0–6 weeks) and grower (7–17 weeks) phases, respectively (Tables 1 and 2).

Chickens were raised in an environmentally controlled house and temperature maintained at 30 to 33 °C and 23 to 25 °C during the starter and grower phase, respectively. Lighting was provided continuously. The chicks were vaccinated against Newcastle virus disease and infectious bronchitis. Feed and water were available ad libitum throughout the experiment. Feed intake, weight gain, and feed conversion ratio (FCR) were measured per pen weekly. Weight gain was calculated as the difference between the final and initial chicken body weight during each of the weighing periods. Feed conversion ratio was calculated by dividing feed intake by weight gain. Mortality was recorded as it occurred. At the end of the experiment, eight 17-week old chickens per treatment (4 males and 4 females) were randomly selected following a 12-hour fast and killed by bleeding from a neck cut. The chickens were scalded in water for 2–3 minutes to ease plucking. Head, neck, feet and the visceral organs were removed. The hot carcass was weighed

Table 1: *Composition of the experimental starter diets.*

Dietary CP/ME †	190/11	190/11.7	190/12.4	170/11	170/11.7	170/112.4	140/11.7	140/11.7	140/12.4
Ingredient (g kg^{-1} DM)									
White maize	605.4	677.6	612.3	626.6	702.8	694.9	658.3	734.6	808.4
Soya oilcake meal	226.8	281.3	98.9	158.8	180.5	119.9	56.9	78.6	120.3
Bran	76.8	0	0	119.7	21.4	0	184	85.7	0
Sunflower oilcake meal	50	0	0	50	50	0	50	50	20
Fullfat soya	0	0	247.5	0	0	140	0	0	0
Limestone	16.9	16.8	17.1	17.2	17.0	17.1	17.5	17.4	17.3
Monocalcium phosphate	10.3	11.2	11.3	10.7	11.5	12	11.2	12.1	13
Salt	3.9	4.0	4.0	3.9	4.0	4.0	3.9	3.9	4.0
Premix ‡	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lysine	2.9	2.1	1.8	4.7	4.4	3.6	7.5	7.2	6.6
Methionine	1.7	1.8	1.9	2.0	2.0	2.1	2.5	2.4	2.4
Threonine	2.1	2.1	2.0	3.0	2.9	2.7	4.4	4.2	4.0
Tryptophan	0.11	0.13	0.24	0.39	0.4	0.5	0.8	0.8	0.8
Calculated analysis (g kg^{-1})									
Calcium	10	10	10	10	10	10	10	10	10
Phosphorus	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5

† CP/ME, crude protein (g kg^{-1} DM) / metabolisable energy (MJ kg^{-1} DM)
‡ Composition of the broiler starter premix. Each 2.5 kg contained vitamin A , 13,000,000 IU, vitamin D_3, 3,500,000 IU, B_1 (Thiamine) 2000 mg, vitamin B_2 (Riboflavin) 6000 mg, vitamin B_6 (Pyrodoxine) 6000 mg, folic acid 1500 mg, vitamin B_{12} (Cobalamine) 20 mg, E 40,000 mg, betaine 500,000 mg, niacin 60,000 mg, pantothenic acid 15000 mg, Vitamin K_3 stab 4000 mg, biotin 150 mg, cobalt 500 mg, iodine 3000 mg, selenium 300 mg, manganese 70,000 mg, copper 20,000 mg, zinc 70,000 mg, iron 50,000 mg, antioxidant 200,000 mg.

Table 2: *Composition of the experimental grower diets.*

Dietary CP/ME †	180/11.3	180/12	180/12.4	150/11.3	150/12	150/12.4	120/11.3	120/12	120/12.4
Ingredient (g kg^{-1} DM)									
White maize	648.5	691.8	654.9	680.2	756.5	778.9	711.8	788.3	831.8
Soya oilcake meal	201.8	215.3	111.2	99.8	121.5	142.7	46.9	19.6	32.0
Fullfat soya	0	50.3	191.2	0	0	30.0	0	0	0
Bran	57.2	0	0	121.4	23.2	0	187	87.4	31.3
Sunflower oilcake meal	50	0	0	50	50	0	0	50	50
Limestone	17.0	17.0	17.1	17.4	17.2	17.2	17.8	17.6	17.5
Monocalcium phosphate	10.8	11.6	11.7	11.4	12.3	12.7	12.0	12.9	13.4
Lysine	3.7	2.9	2.7	6.5	6.2	5.5	9.3	9.0	8.8
Methionine	1.9	2.0	2.0	2.3	2.2	2.3	2.7	2.7	2.6
Threonine	2.5	2.3	2.4	3.9	3.7	3.5	5.2	5	4.9
Tryptophan	0.3	0.3	0.4	0.7	0.7	0.7	1.1	1.1	1.1
Salt (fine)	3.9	4.0	4.0	3.9	4.0	4.0	3.9	4.0	4.0
Premix ‡	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Calculated analysis (g kg^{-1})									
Calcium	10	10	10	10	10	10	10	10	10
Phosphorus	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5

† CP/ME, crude protein (g kg^{-1} DM) / metabolisable energy (MJ kg^{-1} DM)
‡ Composition of the broiler grower premix. Composition of each 2.5 kg contained vitamin A , 11,500,000 IU, vitamin D_3, 3,500,000 IU, vitamin E 40,000 mg, vitamin K_3, 35,000 mg, vitamin B_1, 2000 mg, vitamin B_2 and B_6, 55000 mg, vitamin B_{12}, 20 mg, niacin, 55,000 mg, calpan, 13,500 mg, folic acid 1250 mg, bictin, 100 mg, selenium, 300 mg, manganese, 700,000 mg, iron, 450,000 mg, iodine 3000 mg, zinc, 65,000 mg, copper, 20,000 mg, cobalt, 500 mg, phyzyme XP 10,000 TPT, 100,000 mg, choline, 400,000 mg, antioxidant, 200,000 mg and rovabio excel AP, 60,0000.

and dressing percentage calculated as weight of carcass divided by live body weight multiplied by 100. Carcass cuts (breast, thigh, drumstick and fat) were also weighed and expressed as proportions of the carcass weight. Dry matter, ether extract, crude protein and ash were evaluated in the breast and leg (thighs and drumstick) muscles according to the recommendation of AOAC Official Methods of Analysis (2000). Data collected were subjected to analysis of variance for a 3×3 factorial in a completely randomised design, using the General Linear Model procedure of SAS, version 9.3 (SAS Institute, 2016). Differences among means were determined by LSD‘s option of SAS.

3 Results

3.1 Performance

The influence of dietary protein and metabolisable energy on growth performance of the chickens is shown in Tables 3 and 4. During the starter period (0–6 weeks), average body weight at the start of the experiment was 28.67 g. There was no effect of CP and AME or their interaction on feed consumption ($p > 0.05$). Dietary CP, AME and CP × AME interaction had significant effect ($p < 0.05$) on weight gain and FCR of chickens during the starter phase. Weight gain and FCR improved with increasing levels of dietary protein ($p < 0.05$). Crude protein above 140 g kg^{-1} feed at all dietary AME levels resulted in improved weight gain and FCR in the chickens. Chickens that received CP of 170 and 190 g kg^{-1} at all AME levels had similar weight gain and FCR. However, at CP level of 170 g kg^{-1} weight gain and FCR numerically, but not significantly, decreased with an increase in dietary AME, with 11.0 MJ kg^{-1} maximising weight gain and FCR. The dietary combination of CP 170 g kg^{-1} × AME 11 MJ kg^{-1} yielded best weight gain and FCR.

During the grower period (7–17 weeks) there was no significant CP × AME effect ($p \geq 0.05$) observed on any of the traits measured, although significant differences within means were observed. Feeding above 120 g CP kg^{-1} at all AME levels improved weight gain and FCR. There were no significant differences observed between chickens that received CP of 150 and 180 g kg^{-1} at all dietary AME levels on weight gain and FCR. The lightest and heaviest chickens were observed on dietary combinations of 120 g CP kg^{-1} × 12.4 MJ AME kg^{-1} and 150 g CP kg^{-1} × 12.0 MJ AME kg^{-1}, respectively. The feed intake decreased with increasing dietary AME levels ($p < 0.05$). The dietary combination of 150 g CP kg^{-1} feed × 12.0 MJME kg^{-1} feed maximised weight gain and FCR.

Table 3: *The influence of dietary protein and metabolisable energy levels on growth performance of Venda chickens (0 to 6 weeks old).*

Parameter	*Feed intake* (g/bird/day)	*Weight gain* (g/bird)	*FCR* (g/g)
Protein (g kg^{-1} DM)			
140	27.11	258.49^{b}	4.44^{a}
170	28.00	342.38^{a}	3.48^{b}
190	26.32	372.47^{a}	3.00^{c}
SEM†	1.05	7.46	0.13
AME (MJ kg^{-1} DM)			
11.0	27.95	328.49^{a}	3.67^{ab}
11.7	26.92	347.53^{a}	3.32^{b}
12.4	26.56	297.32^{b}	3.92^{a}
SEM†	1.05	7.46	0.13
CP × AME			
140 × 11.0	29.07	261.50^{de}	4.67^{a}
140 × 11.7	26.99	292.64^{cd}	3.86^{abc}
140 × 12.4	25.28	221.34^{e}	4.79^{a}
170 × 11	27.56	371.80^{a}	3.12^{bc}
170 × 11.7	26.56	357.40^{ab}	3.14^{bc}
170 × 12.4	29.86	297.94^{ab}	4.20^{ab}
190 × 11	27.20	352.16^{abc}	3.25^{bc}
190 × 11.7	27.21	392.56^{a}	2.97^{c}
190 × 12.4	24.55	372.70^{a}	2.77^{c}
SEM†	1.81	12.92	0.22
P values			
CP	0.5410	< 0.0001	< 0.0001
AME	0.6338	0.0006	0.0218
CP × AME	0.3855	0.0194	0.0111

^{a,b,c,d,e} Means with different superscript within a column and a factor differ significantly ($p < 0.05$)
† Standard error of the mean; AME: apparent metabolisable energy; CP: crude protein

Table 4: *The influence of dietary protein and metabolisable energy levels on growth performance of Venda chickens (7–17 weeks old).*

Parameter	*Feed intake* (g/bird/day)	*Weight gain* (g/bird)	*FCR* (g/g)
Protein (g kg^{-1} DM)			
120	71.73	976.99^{b}	5.76^{a}
150	70.00	1262.53^{a}	4.34^{b}
180	67.32	1256.33^{a}	4.19^{b}
SEM†	2.08	38.68	0.09
AME (MJ kg^{-1} DM)			
11.3	72.59^{a}	1138.03	4.98^{a}
12.0	71.87^{a}	1219.91	4.79^{ab}
12.4	64.61^{b}	1137.91	4.50^{b}
SEM†	2.08	36.68	0.09
CP × AME			
120 × 11.3	75.47^{b}	1009.96^{bc}	5.77^{ab}
120 × 12.0	77.41^{a}	1010.85^{bc}	6.16^{a}
120 × 12.4	62.33^{c}	910.16^{c}	5.40^{b}
150 × 11.3	71.43^{abc}	1197.31^{ab}	4.64^{c}
150 × 12.0	73.93^{ab}	1392.28^{a}	4.24^{cde}
150 × 12.4	64.65^{bc}	1198.00^{ab}	4.16^{cde}
180 × 11.3	70.87^{abc}	1206.83^{ab}	4.52^{cd}
180 × 12.0	64.26^{bc}	1256.61^{a}	3.98^{e}
180 × 12.4	66.85^{abc}	1305.57^{a}	4.05^{de}
SEM†	3.60	66.99	0.16
P values			
CP	0.3408	< 0.0001	< 0.0001
AME	0.0257	0.2506	0.0149
CP × AME	0.2023	0.3062	0.0593

^{a,b,c,d,e} Means with different superscript within a column and a factor differ significantly ($p < 0.05$)
† Standard error of the mean; AME: apparent metabolisable energy; CP: crude protein

3.2 *Carcass parameters*

There was no effect of CP and ME or their interaction on dressing per cent and breast relative weight (RW) ($p > 0.05$), except thigh RW that decreased with increasing levels of dietary ME ($p < 0.05$) (Table 5). Dietary AME of 11.3 MJ kg^{-1} showed higher thigh RW and lower fat RW. The differences within means on CP × AME interaction effect were observed on thigh, drumstick and fat relative weights, but there was no convincing trend.

3.3 *Carcass chemical content*

The influence of dietary protein and metabolisable energy levels on the carcass chemical content of the 17-week-old Venda chickens is shown in Table 6. There was CP × AME interaction effect on dry matter of the breast and leg muscles, ash and protein of the leg muscle ($p < 0.05$). The highest ash content of the leg muscle was recorded on dietary combination of 180 g CP kg^{-1} × 12.0 MJ AME kg^{-1}. Means of CP × AME interaction on ash, fat and protein of the breast muscle and fat of the leg muscle differed significantly, but there was no convincing trend. The protein and ash content of the breast muscle improved with increasing levels of dietary CP ($p < 0.05$). The fat content of the leg muscle decreased with increasing levels of dietary CP ($p < 0.05$). The breast muscle showed more protein content and less fat than leg muscle at all CP and ME levels.

Table 5: *The effect of dietary crude protein and metabolisable energy levels on some carcass parameters (%) of 17 weeks old Venda chickens.*

Parameter	*Dressing*	*Breast RW*	*Thigh RW*	*Drumstick RW*	*Fat RW*
Protein ($g\,kg^{-1}$ DM)					
120	69.05	24.01	16.93^{a}	14.75	4.40
150	70.10	23.47	17.08^{ab}	14.7	3.18
180	69.04	23.92	17.45^{a}	14.29	3.64
SEM †	0.53	0.50	0.21	0.25	0.57
AME ($MJ\,kg^{-1}$ DM)					
11.3	68.89	23.65	17.65^{a}	14.82	2.98^{a}
12.0	70.21	23.83	17.30^{a}	14.29	4.47^{b}
12.4	69.59	23.90	16.63^{b}	14.64	3.48^{ab}
SEM †	0.53	0.50	0.21	0.25	0.58
CP × AME					
120 × 11.3	68.73	23.95	17.16^{ab}	14.77^{a}	3.23^{a}
120 × 12.0	69.87	24.50	16.94^{ab}	14.53^{a}	5.81^{b}
120 × 12.4	68.54	23.57	16.69^{ab}	14.95^{a}	4.13^{ab}
150 × 11.3	69.31	23.72	17.98^{a}	14.92^{a}	2.18^{a}
150 × 12.0	70.70	22.48	17.32^{ab}	15.12^{a}	5.16^{b}
150 × 12.4	70.28	24.21	15.95^{b}	14.20^{ab}	2.20^{a}
180 × 11.3	68.62	23.33	17.84^{a}	14.78^{a}	3.49^{ab}
180 × 12.0	70.06	24.52	17.63^{ab}	13.25^{b}	3.33^{ab}
180 × 12.4	69.95	23.94	17.26^{ab}	14.78^{a}	4.09^{ab}
SEM †	0.91	0.86	0.36	0.43	0.98
P values					
CP	0.3767	0.7102	0.0805	0.3024	0.2773
AME	0.2165	0.9408	0.0036	0.3293	0.0977
CP × AME	0.9306	0.4769	0.2055	0.0747	0.3375

^{a,b} Means with different superscript within a column and a factor differ significantly ($p < 0.05$)
† Standard error of the mean; AME: apparent metabolisable energy; CP: crude protein

4 Discussion

There was a highly significant interaction of dietary CP and AME on weight gain and FCR of six weeks old local chickens. Significant interaction between dietary CP and AME showed the importance of balanced protein to energy ratio to achieve optimum performance (Wang & Liu, 2002). Makinde & Egbekun (2016) reported a CP × AME interaction with high protein and energy levels resulting in higher body weight. In the present study, starter ration containing a CP content of 140 $g\,kg^{-1}$ at different AME levels yielded the lowest weight gain as compared to 170 or 190 $g\,kg^{-1}$ at all AME levels. The results suggest that Venda village chickens would require a dietary combination of 170 g CP kg^{-1} and 11.0 MJ kg^{-1} in the starter diet to maximise weight gain and FCR. These results imply that excess CP (190 g CP $g\,kg^{-1}$ feed) has no advantage in village chickens of 0–6 weeks old. The results are in agreement with the findings of Nguyen & Bunchasak (2005) who observed that 170–180 g CP kg^{-1} gave optimal results in Betong chickens of similar age. Previous studies however, reported higher optimal AME values than the present findings. Nakkazi *et al.* (2015) reported diet containing 180 g CP kg^{-1} and 11.7 MJ ME kg^{-1} were sufficient for rearing local chickens during the early growth phase (0–6 weeks), whereas Payne (1990) and Nguyen & Bunchasak (2005) recommended diets containing 11.46 and 12.56 MJ ME kg^{-1} respectively. Mbajiorgu (2010) observed that slightly higher dietary CP level of 178 $g\,kg^{-1}$ DM and higher energy level of 14 MJ kg^{-1} DM allowed for optimal nutrient utilisation for growth in Venda chickens between one and six weeks of age. Alabi *et al.* (2013) found that 12.42 MJ ME kg^{-1} DM

Table 6: *The influence of dietary protein and metabolisable energy levels on the carcass chemical content of the 17 weeks old Venda chickens.*

Parameter	*Breast muscle*				*Leg muscle*			
	Dry matter	*Ash*	*Fat*	*Protein*	*Dry matter*	*Ash*	*Fat*	*Protein*
Protein (g kg^{-1} DM)								
120	270.29^{a}	45.27^{b}	37.81	892.44^{b}	253.47^{a}	39.86^{b}	141.61^{a}	813.85
150	270.75^{a}	52.31^{a}	35.67	907.03^{a}	246.56^{b}	40.89^{b}	121.65^{b}	824.60
180	265.33^{b}	52.91^{a}	44.67	901.84^{a}	240.20^{b}	42.22^{a}	117.31^{b}	824.72
SEM	1.34	1.34	2.97	3.85	2.46	0.62	5.32	5.43
AME (MJ kg^{-1} DM)								
11.3	267.60	52.90^{a}	38.35^{a}	902.55^{a}	243.98	40.96^{ab}	132.75	816.26
12.0	269.75	50.80^{a}	48.04^{b}	891.33^{b}	249.23	41.76^{a}	128.52	819.28
12.4	269.02	46.80^{b}	31.75^{a}	907.43^{a}	247.03	40.24^{b}	119.30	827.65
SEM	1.39	1.37	2.75	3.62	2.44	0.45	5.29	5.22
CP × AME								
120 × 11.3	270.89^{abc}	46.43^{e}	34.50^{bc}	894.32^{abc}	243.83^{bc}	40.76^{b}	139.64^{b}	824.55^{ab}
120 × 12.0	273.74^{ab}	44.57^{e}	48.82^{ab}	882.87^{c}	263.70^{a}	39.20^{b}	142.06^{a}	813.41^{ab}
120 × 12.4	266.28^{bcd}	44.79^{e}	30.09^{c}	900.00^{abc}	252.89^{ab}	39.60^{b}	143.14^{a}	803.60^{b}
150 × 11.3	264.14^{cd}	58.83^{a}	38.77^{bc}	904.00^{abc}	246.71^{bc}	41.43^{b}	135.32^{c}	805.73^{b}
150 × 12.0	274.18^{a}	52.52^{abcd}	39.46^{bc}	902.39^{abc}	242.98^{bc}	40.37^{b}	118.20^{abc}	826.86^{ab}
150 × 12.4	273.36^{abc}	45.58^{de}	28.76^{c}	914.71^{a}	250.01^{bc}	40.87^{b}	111.44^{bc}	841.12^{a}
180 × 11.3	267.77^{abcd}	53.42^{abc}	41.78^{abc}	909.33^{ab}	241.39^{c}	40.70^{b}	123.31^{abc}	818.37^{ab}
180 × 12.0	260.80^{d}	55.29^{ab}	55.83^{a}	888.73^{bc}	241.00^{c}	45.71^{a}	125.30^{abc}	817.56^{ab}
180 × 12.4	267.41^{abcd}	50.03^{bcde}	36.40^{bc}	907.47^{ab}	238.21^{c}	40.23^{b}	103.32^{c}	838.24^{a}
SEM	2.41	2.36	4.76	6.22	4.22	0.78	9.15	9.04
P values								
CP	0.0098	0.0002	0.0901	0.0309	0.0015	0.0034	0.0044	0.2751
ME	0.5224	0.0074	0.0011	0.0141	0.3254	0.2349	0.1967	0.3110
CP × AME	0.0009	0.0845	0.6745	0.7680	0.0470	0.0109	0.4449	0.0446

^{a,b,c,d,e} Means with different superscript within a column and a factor differ significantly ($p < 0.05$)
AME: apparent metabolisable energy; CP: crude protein

and 12.66 MJ ME kg^{-1} DM at 180 g CP kg^{-1} DM supported optimum growth rate and FCR, respectively, in Venda chickens. In the present study, chickens obtained a FCR of 3.2, which was slightly better than the FCR value of 3.5 noticed by Alabi *et al.* (2013). Differences in responses to dietary CP and AME interactions by local chickens might be attributed to different dietary protein and energy levels in the diet used during experimentation and also breed differences.

Feed intake of the local chickens during both the starter and grower phases was not influenced by the dietary CP level, agreeing with findings of Nguyen & Bunchasak (2005) who also reported no differences in feed intake of Betongs chickens with varying CP levels. Similarly, Ndegwa *et al.* (2001) reported that indigenous growing chickens fed diets containing 170–230 g CP kg^{-1} had similar feed intake. On the contrary, Melesse *et al.* (2013) observed an increase in the level of feed consumption of Koekoek chickens with increasing levels of protein supplementation. The effect of dietary protein on feed intake in poultry species is inconsistent due to genotype, age, body weight, stage of maturity and sex of the bird.

The decrease of feed intake with increasing dietary AME levels may suggest that the birds regulated their intake according to dietary energy. Several authors have shown that chickens eat to satisfy their energy requirements (Scott *et al.*, 1982; Leeson *et al.*, 1996; Velkamp *et al.*, 2005; Nahashon *et al.*, 2006). Onwudike (1983) and Nawaz *et al.* (2006) also found that feed consumption in broilers was lower with higher energy diets. These observations seem to be applicable to the grower phase of the local chickens aged 7–17 weeks in the present study, as chicks aged less than six weeks old failed to adjust their feed intake to match AME in the diet. It can be suggested that the adjustment of feed intake according to dietary ME may be related to age and energy needs for maintenance, growth and production of birds.

In the grower phase, there was no significant interaction of dietary CP and AME levels on weight gain and FCR, but significant differences within means were observed. Weight gain improvement with increasing levels of dietary CP is in agreement with findings of several researchers that increased dietary protein content resulting in improved growth performance (Jackson *et al.*, 1982; Nguyen & Bunchasak, 2005). There were no significant differences observed between chickens that received CP levels of 150 and 180 g kg^{-1} at all dietary AME levels on weight gain and FCR. However, at 150 g CP kg^{-1} feed weight gain decreased with increasing dietary AME levels, with 12 MJ ME kg^{-1} supporting optimum weight gain and FCR. Optimal use of protein is imperative for any feeding system because protein supplements are usually more expensive than energy feeds and wasteful usage increases the cost of production besides leading to environmental degradation (Church & Kellens, 2002). Bikker *et al.* (1994) reported that feeding above the protein requirements did not result in an increase in protein deposition, but nitrogen excretion through the urine increased. Feeding beyond 150 g CP kg^{-1} feed DM, irrespective of AME levels, yielded no improvement in weight gain and FCR, suggesting 150 g CP kg^{-1} feed DM as a threshold level for optimum production of Venda chickens. It can be concluded that the dietary combination of 150 g CP kg^{-1} × 12.0 MJ ME kg^{-1} maximised weight gain and FCR during the grower phase of the local chickens used in the present study. Nguyen *et al.* (2010) reported no significant interaction effect between protein and energy on any performance parameters measured during the growing phase of Betong chickens and subsequently recommended 190 g CP kg^{-1} and 12.56 MJ AME kg^{-1}, which are higher than the present study findings. Makinde & Egbekun (2016) observed no CP × AME interaction on feed intake and weight gain for 6–12 weeks old Fulani ecotype chickens, but recommended 200 g CP kg^{-1} and 12.56 MJ ME kg^{-1}. The recommended AME in the grower phase is in accordance with those recommended by NRC (1994) (12.14 MJ kg^{-1}) and Tadelle & Ogle (2000) (11.99 MJ kg^{-1}). Variations in age, genotype of the chickens and the environment may explain observed differences in nutritional requirements between studies.

A study on the assessment of the nutrient adequacy from the crop contents of free-ranging indigenous chickens in the rural villages of the Vhembe District, South Africa observed CP content of 123 g kg^{-1} and 118 g kg^{-1} for growers and adults, respectively (Raphulu *et al.*, 2015b). According to NRC (1994), the recommended levels of CP in diets for growing chickens (not broilers) range from 150 g CP kg^{-1} DM to 200 g CP kg^{-1} DM and for mature chickens from 100 g CP kg^{-1} DM to 160 g CP kg^{-1} DM. It appears therefore as if the birds raised under village condition did not receive adequate levels of dietary protein to support efficient production. Protein deficit of 27 g kg^{-1} for growers between feed resource base for scavenging chickens in the rural villages and the required nutrients observed in the present study has to be compensated with supplemental feed. No information is available on the performance of adult indigenous chickens fed different protein and energy levels raised in closed confinement.

The improvement of FCR with increasing levels of energy is in close agreement with results of Nawaz *et al.* (2006) and Holsheimer & Veerkamp (1992). The obtained mean FCR during the grower phase in the present study was slightly better than that reported by Kingori *et al.* (2003) and Chemjor (1998), who found FCR values of 5.8 and 5.2, respectively, for indigenous chickens of 14–21 weeks old.

The shares of major basic carcass parts (breast, drumsticks and thighs) and the presence of certain tissues in them, as well as the chemical composition of the muscular tissue, are regarded as vital parameters determining broiler meat quality (Holcman *et al.*, 2003). Carcass relative weights of the local birds were not affected by dietary protein or AME levels, with the exception of thigh yield that decreased with increasing levels of dietary AME. The results of the present study confirm other reports where dietary protein did not affect carcass yields (Nguyen & Bunchasak, 2005; Iheukwumere *et al.*, 2007; Melesse *et al.*, 2013). Makinde & Egbekum (2016) observed no significant effect of dietary ME on carcass yield in Fulani Ecotype chickens. The observed decrease of thigh RW with increase in dietary AME is similar to the results of Nguyen *et al.* (2010) where high energy levels decreased wing and leg relative weights. Feeding above 120 g CP kg^{-1} DM improved ash content, protein content of the breast and decreased fat content of the muscle and these parameters were not affected by dietary AME levels. Furlan *et al.* (2004) also reported that carcass protein was affected by the level of protein in the diet. The increase in dietary protein improves carcass protein by reducing lipid deposition and increasing protein content (Gous *et al.*, 1990). An increase in protein intake induces a decrease in the protein to energy ratio that causes a reduction in energy intake relative to the protein intake, resulting in decreasing body fat percentage (Ghahri *et al.*, 2010). Feeding 150 or 180 g CP kg^{-1} feed DM at any AME level yielded similar values. Results in the present study imply that dietary combination of 150 g CP kg^{-1} feed DM and 11.3 MJ ME kg^{-1} feed DM may optimise carcass chemical composition of 17 weeks old chickens, since there was no dietary AME effect observed. The fat content of the leg muscle was influenced by the changes in dietary protein. Higher protein diets induce higher meat protein content, while reducing the fat content of muscles (Si *et al.*, 2001; Bogosav-Boskovic *et al.*, 2010). The influence of dietary protein on the carcass chemical content seems to be dependent on the specific portion. In the present study, the breast muscle showed higher protein and less fat content when compared to leg muscle at all CP and AME levels. Ferket & Sell (1990) reported that breast meat contains more protein than leg meat. Diaz *et al.* (2010) related the differences in CP effect on the very structure of these portions, with breast being mostly composed of white fibres, as opposed to drumstick made up of muscles that contain more red fibres, which differ in metabolic function.

5 Conclusions

During 0–6 and 7–17 weeks, unsexed local Venda chickens would require dietary combinations of 170 g CP kg^{-1} feed DM and 11.0 MJ ME kg^{-1} feed DM and 150 g CP kg^{-1} feed DM and 12 MJ ME kg^{-1} feed DM, respectively, in their diets to optimise body weight gain. Neither dietary CP and AME nor their interactions influenced carcass relative weights, except for thigh yield that decreased with increasing AME levels. The dietary combination of 150 g CP kg^{-1} feed and 11.3 MJ ME kg^{-1} feed optimised ash content of muscles, protein content of the breast and fat content of the leg muscle of the 17 weeks old local chickens. It can be recommended that supplementation of 27 g CP kg^{-1} feed to grower scavenging chickens, would be enough to improve chicken production in the rural villages. Locally available feed resources high in protein like groundnuts, beans, meat and bone scraps, and insects should be used as supplement to compensate the nutrient intake deficit of scavenging chickens and also to reduce input costs.

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